CHAPTER 12

Preliminary Design for Rehabilitation of Eastern Trunk Road

Chapter 12 Preliminary Design for Rehabilitation of Eastern Trunk Road

12.1 General

The purpose of this chapter is to determine and prepare the most appropriate preliminary design for the Project road and includes the design of the horizontal and vertical alignments, which are based on the geometric design criteria of the RDA. Note that this is carried out with an eye towards minimizing adverse impacts while maximizing the cost-effectiveness of the work to rehabilitate the Project road via a cost comparison of possible rehabilitation scenarios that considers reconstruction and overlaying.

12.2 Alignment & Geometric Design Criteria

12.2.1 Alignment

1) General

As described in Chapter 8, the vertical alignment of the Project road is almost flat except for the approach road sections of long bridges such as the Kallady Bridge and Oddaimavudi Bridge. Horizontal alignments also have sufficiently large radii except for sections bordering towns. Therefore, the rehabilitation work of the Project road shall basically keep to the existing alignment.

2) Design Policy for Water Levels at Inundation Sections

Road elevations to be rehabilitated shall basically be higher than the inundation levels during a heavy rainy season. According to the guideline of the RDA, "*A Guide to the Structural design of Roads under Sri Lankan Conditions, April 1999, Road Development Authority, Sri Lanka*", it is prescribed that the normal flood levels, which mean 1 year, shall not rise higher than 600 mm below a road's formation level.

Based on the calculation results of the existing water level, the guideline of the RDA, and discussions with the Technical Committee, the design policy for water levels on sections experiencing inundation was fixed as shown in Figure 12.2.1. In other words, water levels in Batticaloa lagoon areas were fixed at a height equal to flooding for a 1-year return period (or normal flood level) due to the small difference (0.8 m) between it and the flooding level for a 50-year return period. On the other hand, the water levels in Valachchenai lagoon areas were fixed at a point equal to the height of the road shoulder, which is the flooding level for a 50-year return period, due to the large difference (1.56 m) between this and the normal flood level.

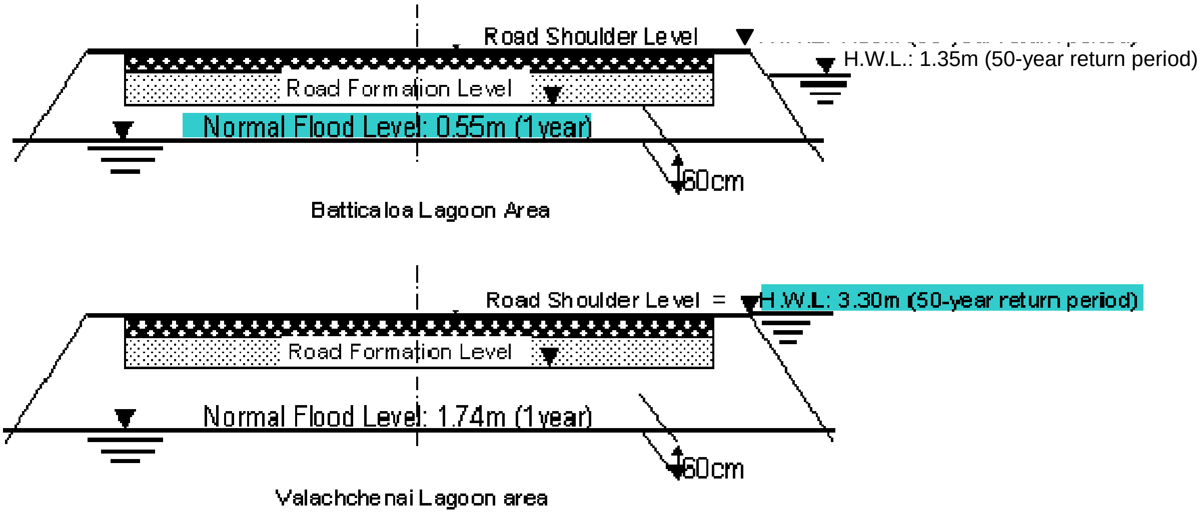


Figure 12.2.1. Water Levels for Inundated Sections (shaded parts)

3) Vertical Alignment Plans for Inundation Sections

a) South of Kalmunai Town on AA004

Inundation on some road surfaces south of Kalmunai town occurs every year in the rainy season. The main cause for this are inflows from the outskirts of the town. Therefore, drainage systems need to be installed on the outskirts of the town. Note that drainage systems for roads are ineffective without an overall area drainage system plan.

b) North of Batticaloa Town on AA015

Sections of low road elevation north of Batticaloa town shall apply the "Batticaloa Lagoon area" design policy to prospective vertical alignments as shown in Figure 12.2.1. The proposed road elevation and road length are as shown in Table 12.2.1.

Table 12.2.1. Proposed Elevations & Road Length (North of Batticaloa)

Km Post	Existing Road Elevation (m)	Proposed Road Elevation (m)	Difference (m)	Proposed Road Length (m)
2+860	1.914	2.167	+0.253	1,300
5+080	2.479	2.629	+0.150	3,780
9+590	1.880	2.130	+0.250	450
11+560	2.057	2.207	+0.150	480
		Total Proposed Road Length		6,010

c) North of Eravur Town on AA015

Sections of low road elevation north of Eravur town shall apply the "Valachchenai Lagoon area" design policy to prospective vertical alignments as shown in Figure 12.2.1. Each proposed road elevation and road length decided in consideration of inundation are presented in Table 12.2.2.

Table 12.2.2. Proposed Elevations & Road Length (North of Eravur)

KmP	Existing Road Elevation (m)	Proposed Road Elevation (m)	Difference (m)	Proposed Road Length (m)
15+700	3.277	3.327	0.050	620
16+460	3.427	3.557	0.130	400
17+620	3.352	3.530	0.178	660
18+580	3.410	3.560	0.150	640
19+450	3.360	3.510	0.150	1,910
33+280	3.376	3.526	0.150	610
34+280	3.377	3.529	0.152	570
Total Proposed Road Length				5,410

12.2.2 Right of Way (ROW)

1) Proposed ROW

In this Project, greater priority has been given to minimizing impacts on both the social and natural environments rather than ensuring the typical cross section usually required by the RDA Standards for a Class A road, which is 15.2 meters (carriageways = 2 x 3.5 m, cycle lanes = 2 x 1.5 m, shoulders = 2 x 2.0 m, drains = 2 x 0.6 m). Of course, traffic volume (PCU/day) as a Class A road is also one of the factors of carriageway and shoulder width. Thereby each road width, such as town, suburb and rural sections, may change in consideration of the existing roadside situation as a result of discussions with the RDA. That is, the rehabilitation work of the Project road will be implemented within a readily available existing ROW and satisfy minimum technical and traffic safety requirements by doing the following:

- There will be limited land acquisition with adequate compensation[1)].
- Walls, fences, & other incidental structures will be cleared or shifted as required from an existing and readily available ROW.
- Carriageway width for the Project road will be kept at 7.0m (3.5 × 2) along the entirety of the alignment to ensure driving safety.

[1)] Adequate compensation is as defined by the Ministry of Highways documentation on "People Affected by Highway Projects" published in the fall of 2005.

- The shoulders of the Project road will be adjusted as necessary to ensure that carriageway width is consistently 7m.
- Drains, such as roadside ditches, will be installed as necessary and be 50 cm in width and to connect to existing bridges and/or culverts. The drains are included as a part of ROW.

There are four types of ROW. The ROW proposed in line with the above-mentioned conditions for the Project road is as shown in Figure 12.2.2. Note that four typical ROWs of each section are defined as below:

- The ROW of towns, including the Eastern University section, shall keep to the outside of pedestrian paths and/or roadside ditches and will be more than 11m.
- The ROW of suburb sections shall be keep to the outside of private walls and/or fences and will be more than 11m.
- The ROW of paddy field and lagoon sections shall be embanked and will be more than 11m.
- The ROW of the narrower suburb sections shall avoid private buildings and thereby the width will be 9m.

2) ROW

The ROW of the Project road is as shown in Table 12.2.3. Note that the ROW of town, suburb, paddy field and lagoon, and narrower sections accounts for 24%, 58%, 14% and 4% of the Project road, respectively. In addition, compensation will be for 773m of parapet wall, 77.1m of wire fence, and 510.88 sq.m of acquired land.

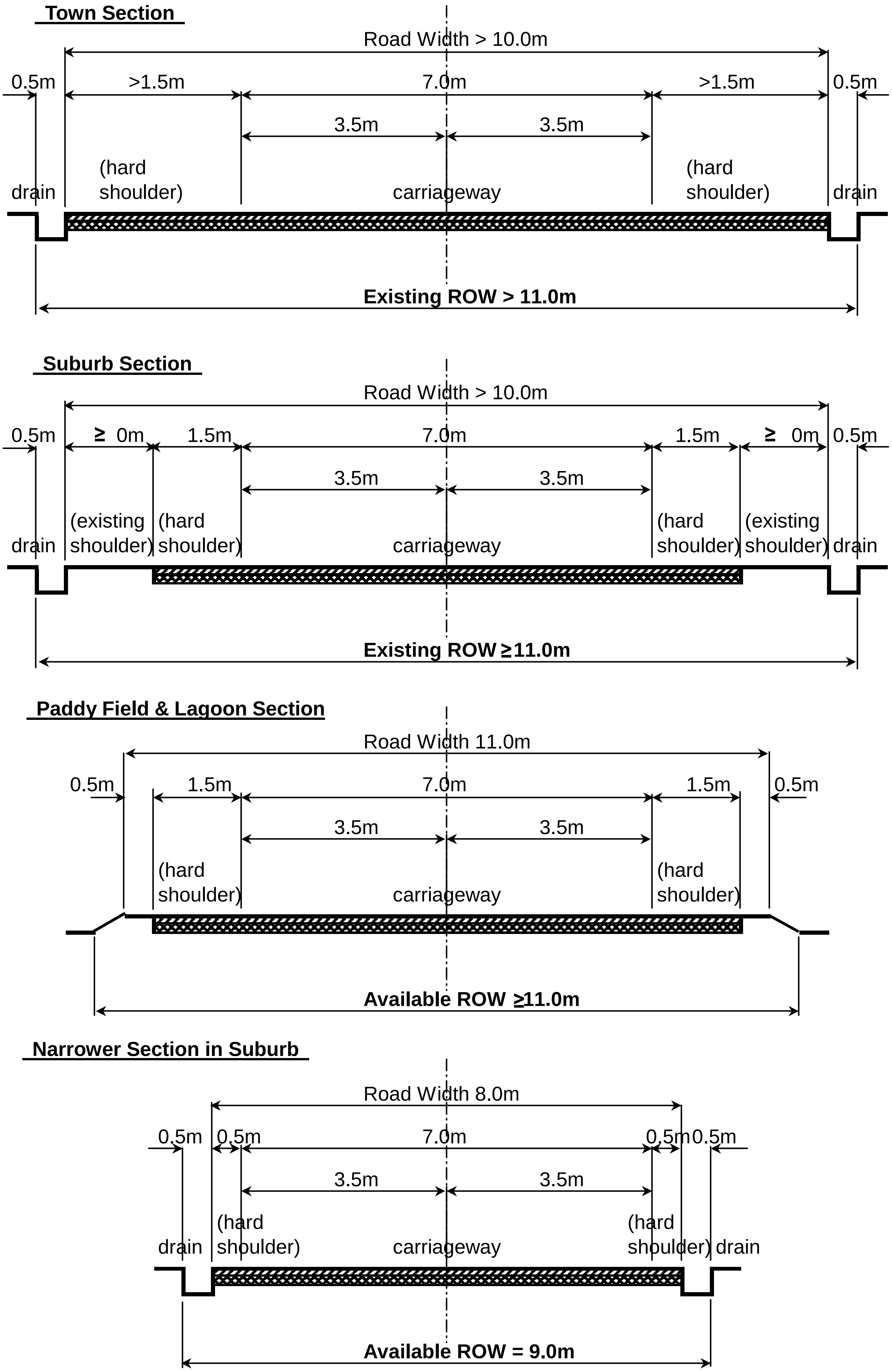
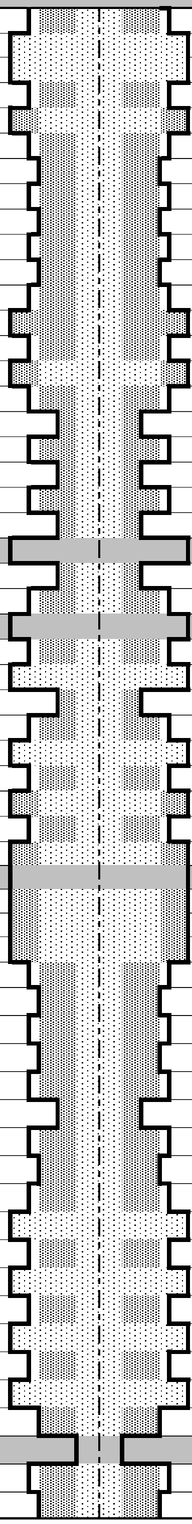


Figure 12.2.2. Proposed ROW for Project Road

Table 12.2.3. Available ROW for Project Road

No.	Road	Town	Km Post	Cum. Distance	Pavement Width		Available ROW	ROW Image Plan	Remarks
					Existing	Planned			
1	A04		364.00	860	W = 4.8m	W = 10.0m	W ≥ 11.0m		
2	A04	Akkaraipattu	364.86	2,400	W = 13.8m	W = 13.8m	W > 11.0m		
3	A04	Akkaraipattu	366.40	2,720	W = 13.8m	W = 13.8m	W > 11.0m		
4	A04		366.72	4,210	W = 4.8m	W = 10.0m	W ≥ 11.0m		
5	A04	Addalachchena	368.21	5,110	W = 7.0m	W = 14.0m	W > 11.0m		
6	A04		369.11	6,280	W = 5.4m	W = 10.0m	W ≥ 11.0m		
7	A04		370.28	6,880	W = 5.4m	W = 10.0m	W ≥ 11.0m		Paddy
8	A04		370.88	8,280	W = 4.9m	W = 10.0m	W ≥ 11.0m		
9	A04		372.28	12,980	W = 5.0m	W = 10.0m	W ≥ 11.0m		Paddy
10	A04		376.98	14,000	W = 5.8m	W = 10.0m	W ≥ 11.0m		
11	A04		378.00	14,540	W = 5.8m	W = 10.0m	W ≥ 11.0m		Paddy
12	A04		378.54	15,670	W = 5.3m	W = 10.0m	W ≥ 11.0m		
13	A04	Nintavur	379.67	19,000	W = 5.4m	W = 13.5m	W > 11.0m		
14	A04		383.00	19,590	W = 5.4m	W = 10.0m	W ≥ 11.0m		
15	A04	Karativu, Kalmunai	383.59	24,020	W = 5.5m	W = 13.5m	W > 11.0m		
16	A04		388.02	25,000	W = 5.3m	W = 10.0m	W ≥ 11.0m		
17	A04		389.00	25,400	W = 5.3m	W = 8.0m	W = 9.0m		
18	A04		389.40	26,160	W = 6.5m	W = 10.0m	W ≥ 11.0m		
19	A04		390.16	26,820	W = 6.5m	W = 8.0m	W = 9.0m		
20	A04		390.82	29,580	W = 5.4m	W = 10.0m	W ≥ 11.0m		
21	A04		393.58	31,320	W = 5.0m	W = 8.0m	W = 9.0m		
22	A04		395.32	31,920	W = 7.2m	W = 10.0m	W = 15.0m		Periya Kallar CW
23	A04		395.92	32,340	W = 5.4m	W = 8.0m	W = 9.0m		
24	A04		396.34	33,360	W = 5.9m	W = 10.0m	W ≥ 11.0m		
25	A04		397.36	33,930	W = 5.1m	W = 10.0m	W = 15.0m		Koddaia Kallar CW
26	A04		397.93	36,840	W = 5.6m	W = 10.0m	W ≥ 11.0m		
27	A04	Puddiruppu	400.84	37,110	W = 11.6m	W = 14.5m	W > 11.0m		
28	A04		401.11	37,220	W = 5.3m	W = 8.0m	W = 9.0m		
29	A04	Kaluwanchikudi	401.22	55,090	W = 6.6m	W = 10.0m	W ≥ 11.0m		
30	A04	Cheddipalaiyam	419.09	58,260	W = 11.8m	W = 14.4m	W > 11.0m		
31	A04	Talankuda	422.26	59,420	W = 7.0m	W = 10.0m	W ≥ 11.0m		
32	A04		423.42	61,080	W = 7.0m	W = 14.0m	W > 11.0m		
33	A04	Kattankudi	425.08	62,020	W = 7.4m	W = 10.0m	W ≥ 11.0m		
34	A04		426.02	62,260	W = 7.0m	W = 13.0m	W > 11.0m		
35	A04		426.26	62,550	W = 4.7m	W = 10.0m	W = 14.0m		New Kalladi Bridge
36	A04	Batticaloa	426.55	62,960	W = 6.5m	W = 14.0m	W > 11.0m		
37	A04	Batticaloa	426.96	63,203	W = 8.5m	W = 11.0m	W > 11.0m		
38	A15	Batticaloa	0.82	63,963	W = 7.0m	W = 14.0m	W > 11.0m		
39	A15		1.58	66,413	W = 6.0m	W = 10.0m	W ≥ 11.0m		
40	A15		4.03	66,913	W = 6.0m	W = 10.0m	W ≥ 11.0m		Paddy
41	A15		4.53	67,613	W = 6.0m	W = 10.0m	W ≥ 11.0m		
42	A15		5.23	71,153	W = 6.0m	W = 10.0m	W ≥ 11.0m		Paddy, Lagoon
43	A15		8.77	71,473	W = 5.8m	W = 10.0m	W ≥ 11.0m		
44	A15		9.09	71,503	W = 5.8m	W = 8.0m	W = 9.0m		House
45	A15		9.12	72,823	W = 5.8m	W = 10.0m	W ≥ 11.0m		
46	A15		10.44	74,483	W = 6.0m	W = 10.0m	W ≥ 11.0m		Paddy
47	A15		12.10	75,083	W = 5.8m	W = 10.0m	W ≥ 11.0m		
48	A15	Eravur	12.70	77,023	W = 6.5m	W = 14.5m	W > 11.0m		
49	A15		14.64	77,463	W = 6.0m	W = 10.0m	W ≥ 11.0m		
50	A15	Chenkaladi	15.08	78,123	W = 7.5m	W = 11.5m	W > 11.0m		
51	A15		15.74	79,143	W = 6.0m	W = 10.0m	W ≥ 11.0m		
52	A15	Eastern U.	16.76	79,883	W = 9.5m	W = 9.5m	W > 11.0m		
53	A15		17.50	94,053	W = 6.1m	W = 10.0m	W ≥ 11.0m		
54	A15	Valaichchenai	31.67	95,633	W = 11.8m	W = 11.8m	W > 11.0m		
55	A15		33.25	96,313	W = 6.8m	W = 10.0m	W ≥ 11.0m		
56	A15		33.93	96,553	W = 4.7m	W = 4.7m	W = 4.7m		Oddaimavudi Bridge
57	A15		34.17	97,203	W = 5.8m	W = 10.0m	W ≥ 11.0m		
58	A15		34.82	98,913	W = 5.3m	W = 10.0m	W ≥ 11.0m		



: Existing Pavement Area

Area Available for Widening of ROW

12.2.3 Public Utilities

Public utilities, such as electricity and telephone poles, exist within the ROW of the Project road. In the case of the Periya Kallar Causeway and Koddaia Kallar Causeway, however, they were completely destroyed. On the other hand, for the remainder of the Project road, utilities experienced almost no damage, and they will have to be relocated in order to carry out the rehabilitation work (see Table 12.2.4).

Table 12.2.4. Obstacle Utilities on the Road

Utilities	Unit	Quantity	Remark
Electric pole	No.	412	Including electric line
Telephone pole	No.	596	Ditto
High voltage electric pole	No.	417	Ditto

12.2.4 Geometric Design Criteria

1) General

The Project road shall be designed based on the *"Geometric Design Criteria of Roads, Road Development Authority, 1998"* (hereinafter referred to as "the Manual)". Furthermore, geometrical design criteria shall be established in consideration of the existing vertical and horizontal alignments of the Project road, as the work for the Project road shall basically keep to the existing alignment in order to minimize environment and social impacts.

2) Road Classification

The Project road is classified as an "A class road", by the RDA. The function of an "A class road" is described in the Manual as follows:

"A class roads are main arteries or long distance routes for moving traffic between different parts of the Country, normally the major Cities and towns."

Therefore, the Project road shall be have a sufficient carriageway width and suitable design to carry out the functions described above.

3) Design Criteria

The design criteria for the Project road, which is based on the Manual in consideration of existing road conditions, are specified in Table 12.2.5. According to Table 12.2.5, some of the existing road sections have not adhered to the curve radii and the curve lengths described in the Manual. However, as previously explained in 12.2.2, it is impossible for the entirety of the Project road to adhere to established standards without significant impacts. Therefore, the geometrical design of the road shall basically keep to the existing horizontal alignment. As for the vertical alignment, changes will be made at sections experiencing inundation.

Table 12.2.5. Summary of Geometric Design Criteria

Items		unit	Specified Values			Remarks
			Town	Suburb	Rural	
Design Speed		Km/h	60	70	70	
Width	Carriageway	m	2 x 3.5	2 x 3.5	2 x 3.5	
	Shoulder	m	(> 2 x 1.5)	(≥ 2 x 0.5)	2 x 1.5	(Minimum)
	Drain	m	2 x 0.5	2 x 0.5	--	
	R.O.W.	m	(> 11.0)	(≥ 9.0)	11.0	(Minimum)
Cross Fall		%	← 2.5 →	← 2.5 →	← 2.5 →	Asphalt pavement
Gradient		%	2.00(0+880)	2.29(397+320)	4.00(24+510)	Maximum = 4%
Curve Radius	Horizontal	m	50.0 (386+399.084~ 386+431.706)	40.0 (390+351.080~ 390+391.772)	30.0 (Oddaimavudi Bridge)	Minimum = 185m
	Vertical (Crest)	m	795.455 (0+840)	1749.316 (397+320)	1153.846 (24+470)	Minimum = 3000m
	Vertical (Sag)	m	1403.509 (0+880)	2105.263 (412+290)	1212.121 (24+470)	Minimum = 1300m
Curve Length	Horizontal	m	18.014 (12+850.647~ 2+868.660)	22.042 (390+285.407~ 390+307.449)	13.242 (23+709.744~ 23+722.986)	Minimum = 40m
	Vertical (Crest)	m	40.0 (13+000)	30.0 (14+640)	30.0 (4+710)	Minimum = 60m
	Vertical (Sag)	m	40.0 (12+800)	30.0 (14+670)	30.0 (4+680)	Minimum = 25m

12.3 Pavement Structure

12.3.1 Pavement Design Method & Standards

1) Applicable Pavement Design Standards

There are several well-known standards widely referred to in deciding pavement design and include the American Association of State Highway and Transportation Officials (“AASHTO”) Standards and the British Standards (“BS”). RDA prepared a document itself in April 1999 that provides guidance on pavement design for its roads known as *A Guide to the Structural Design of Roads under Sri Lankan Conditions* (hereafter referred to as the *RDA Road Design Guide*) and it is based on the BS. In this Study, the RDA’s Guide is applied in principle unless there are conditions that are insufficiently addressed. In such a case, the previously mentioned standards are applied in consultation with the RDA to ensure that Sri Lankan conditions are sufficiently taken into account. When necessary, Japanese Standards have also been referred to and/or applied.

The design of pavement, which consists of a surface layer, base course, and sub-base course, is decided applying a design chart. The chart is based on the *RDA Road Design Guide* for an asphalt-concrete road and is comprised of a catalogue of structures, with each structure being applicable to a range of traffic loads and sub-grade strength (CBR). In sections 12.3.2 and 12.3.3 of this chapter, the Study Team has analyzed both of these factors and calculated sub-grade strength and traffic loading for each section of the Project road.

2) Design Life

The design life of a road can have a large impact on the design specifications of its pavement structure and it is therefore important to decide an appropriate period. Usually, a 10-, 15-, or 20-year period is adopted, with the selection of an appropriate design life being dependent on the unique circumstances of the individual project.[1]

In the case of a long design life, the initial cost may be large in order for the road to be able to sustain the forecasted cumulative traffic loading over the lengthy period of time it will be in service. On the other hand, maintenance and rehabilitation costs would be lower over the long run, and usually a balance between initial and future investment costs is sought. However, there are uncertain factors with the use of a long design period, such as the difficulty in forecasting traffic over extended periods of time, especially in the case of unclear socioeconomic trends. Such a situation can lead to over-design and a misallocation of resources.

In the case of this Project, which is located in a politically unstable area with no historic traffic database available, the potential for making significant errors in long-term traffic forecasting is great. Given this, it is recommended that a 10-year design life be applied, and that the necessary maintenance and/or rehabilitation be carried out via the monitoring of traffic conditions to minimize the risk of over investment.

[1] According to the UK's Transport and Road Research Laboratory's *Overseas Road Note 5: A guide to project appraisal*, an analysis period of 15 years from the opening of a road is in most cases appropriate.

12.3.2 Traffic Load

1) Calculation Process & Assumptions

In this section, the traffic load for the 100-km Project road is derived to help determine the most appropriate pavement structure. Traffic load is expressed as cumulative equivalent standard axle load (ESAL) for the design life of a road and is calculated via the following process:

- Determine daily traffic flows for each relevant vehicle class.
- Determine average daily one-directional traffic flows.
- Forecast one-directional traffic flows.
- Determine the mean equivalence factor for each class of vehicle.
- Sum the products of the cumulative one-directional traffic flows for each vehicle class over the design life of the Project road and the mean equivalence factors to obtain the cumulative ESAL for deciding pavement structure. (The higher of the two directional values should be used for design.)

The formula that is applied to calculate ESAL is as follows:

$$\text{Cum. ESAL}_t^{y} = HV_t^{y_0} \times 365 \times ((1+\Upsilon)^y-1)/\Upsilon \times HVF_t \times LF_t$$

Where,

Cum. ESAL_t^{y} = Cumulative ESAL for a design lane in a single direction for heavy vehicles of type t after y years.

$HV_t^{y_0}$ = Average daily traffic for heavy vehicle type t in initial year y_0 (includes large buses, medium goods vehicles, and large goods vehicles) for both directions.

Υ = Average annual growth rate for heavy vehicle type t.

y = Design life of Project road.

HVF_t = Equivalency factor to convert heavy vehicle type t into ESA.

LF_t = Factor to convert bi-directional traffic to traffic for a design lane per direction.

Applying the above process and formula, the assumptions for calculating traffic load are as listed below.

- **Present daily traffic flows** for the Project road have been calculated in Chapter 11 and are based on the traffic volume and OD surveys carried out by the JICA Study Team in June 2005. Of those flows, vehicle classes with heavy axle loads having an impact on pavement structure are considered and are defined in this study as being medium goods trucks (6 wheels), large goods trucks (more than 6 wheels), and long buses (seating capacity of 40 or more passengers). Note that daily traffic flow estimates have removed the influence of Tsunami aid vehicles and it is assumed that the estimates are representative of traffic flows for a typical day.
- **Traffic growth**, due to a lack of historical data, considered a range of rates for heavy vehicle traffic (3% to 6% for trucks and 3% to 5% for large buses), which took into account RDA's 1999 "*A Guide to the Structural Design of Roads under Sri Lankan Conditions*" (see 11.4.3 of Chapter 11). Based on discussions with RDA, it was decided to apply the medium traffic growth scenario values contained in Chapter 7 of this report of 4% and 4.5% for buses and trucks, respectively, as the most likely values. Note that changes in traffic growth rates of around ±1% are insignificant in terms of traffic loading.
- **Pavement design life**, after holding discussions with the RDA, is assumed to be 10 years. This is because this area has experienced conflict for more than two decades, and it is difficult to forecast as there are many unknown factors that could affect future traffic volumes.
- **Equivalency factors**, which convert heavy vehicle traffic into equivalent standard axles (ESA), were derived applying the results of an axle load survey carried out in the spring of this year by the French Consultant BCEOM for highways in the proximity of the Project road for a total of 5 locations. The equivalency factors (EF) are as follows:

Table 12.3.1. Equivalency Factors by Vehicle Type

Vehicle Type	Average EF for Loaded Veh.	Average EF for Empty Veh.	Average EF
Med. Goods Veh.	2.19	0.04	1.44
Large Goods Veh.	6.33	0.11	4.29
Long Bus	-	-	0.31

Note: An EF for is calculated applying the formula $\Sigma(\text{Surveyed Axle load (kg)}/8160)^{4.5}$

- **Truck axle loads** are assumed to be constant over time.
- **The lane factor** is set at 0.5 since there is only 1 lane per direction and the analysis of directional flows below has indicated a 50/50 split (see Figure 11.2.1 for location of survey points).

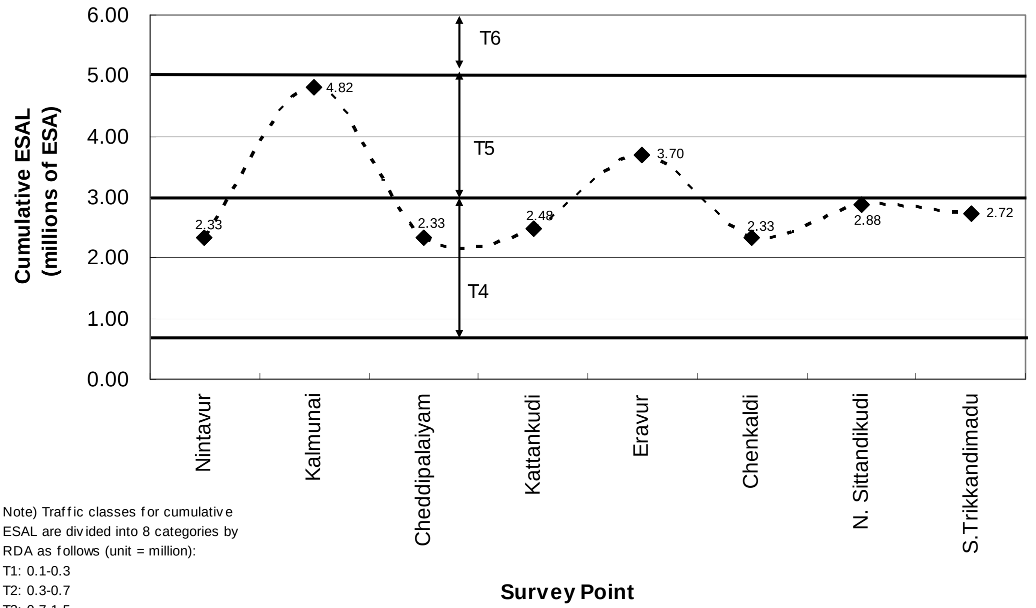
Table 12.3.2. Actual Traffic Flows by Direction (6am – 6pm)

Survey Point	Dir 1 (A)	Dir 2 (B)	Total (C)	A/C	B/C
D0	1984	2471	4455	0.4	0.6
D1	2684	2415	5099	0.5	0.5
D2	3487	3705	7192	0.5	0.5
D3	1623	1563	3186	0.5	0.5
D4	1851	2089	3940	0.5	0.5
D5	1746	1541	3287	0.5	0.5
D6	1212	1301	2513	0.5	0.5
D7	1005	1102	2107	0.5	0.5
D8 East	770	687	1457	0.5	0.5
D8 West	1399	1518	2917	0.5	0.5
V0	256	220	476	0.5	0.5
V1	385	442	827	0.5	0.5
V2	1708	1733	3441	0.5	0.5
V3	642	712	1354	0.5	0.5
V4	629	620	1249	0.5	0.5
V5	890	1068	1958	0.5	0.5
Average	-	-	-	0.5	0.5

Note: This includes all traffic types (including Tsunami aid vehicles).

2) Calculation Results

Based on the preceding, the cumulative ESAL for eight sampled sections of the Project road have been derived and are illustrated in Figure 12.3.1. As this figure indicates, the traffic class for six of the eight sections is T4 (i.e., 1.5 – 3.0 million ESA), and it is therefore recommended that they be designed as such. Note that there are a total of eight traffic classes (T1 to T8), with the higher traffic classes requiring a thicker pavement structure. The definition for traffic class is in accordance with the thinking of RDA's *Guide to the Structural Design of Roads under Sri Lankan Conditions,* which is based on the UK's Overseas Road Note 31. As for the two sections not categorized as T4, both (Kalmunai & Eravur) squarely fall into the T5 traffic class (i.e., 3.0 – 6.0 million ESA) and it is recommended that they be designed to this standard.



Note) Traffic classes for cumulative ESAL are divided into 8 categories by RDA as follows (unit = million):
T1: 0.1-0.3
T2: 0.3-0.7
T3: 0.7-1.5
T4: 1.5 -3.0
T5: 3.0 - 6.0
T6: 6.0 - 10.0
T7: 10.0 - 17.0
T8: 17.0 - 30.0

Figure 12.3.1. Cumulative ESAL & Traffic Class for Project Road
(Design Life: 10 Years, Traffic Growth: 4% for Buses & 4.5% for Trucks)

12.3.3 Sub-grade Strength

1) Design CBR

As mentioned in 1) of 12.3.1, the CBR (California Bearing Ratio), together with traffic loading, is used to determine the appropriate pavement structure for a road, with the design CBR value representing sub-grade strength for a homogenous section of road.

In the case of traffic loading, RDA has categorized CBR values (see Table 12.3.3), and these are applied in conjunction with traffic loading values in the form of a chart. Note that this categorization is based on the BS, but has been adjusted to take into account Sri Lankan conditions.

Table 12.3.3. Sub-grade Strength Classes

Class	Design CBR (%)
S1	2
S2	3,4
S3	5 – 7
S4	8 – 14
S5 (a)	15 – 19
S5 (b)	20 – 29
S7	30+

Source) RDA Road Design Guide

2) Surveyed CBR

Sub-grade CBR is usually decided based on the strength of soil at a point 1m below the surface. In this Study, however, existing pavement strength is confirmed by considering the strength of each soil layer that comprises a sub-grade over the depth of 1m for each of the survey points where the Study Team carried out its geological survey (see Chapter 6 for details). Note that the RDA, BS, or AASHTO does not apply such a detailed method for deriving CBR. For this reason, the following formula, which is contained in a Japanese Pavement Design Manual, is applied:

$$\mathbf{CBR_m\ (\%) = (((h_1 \times CBR_1^{1/3}) + (h_2 \times CBR_2^{1/3}) + \ldots\ldots + (h_n \times CBR_n^{1/3}))/100))^3}$$

Where, CBR_m: CBR of site m

CBR_n: CBR of layer n

h_n: Thickness (cm) of layer n

$h_1+h_2+\ldots.+h_n = 100cm$

The total CBR, together with the thickness and CBR of each soil layer, is as shown in Table 12.3.4 below. In Figure 12.3.2 total CBR is plotted, and from this it can be easily seen that the sub-grade strength class for the majority of the Project road is S4, with several locations having a CBR class of S5 (a), S5 (b), or S3. These results, together with those for traffic loading, are used for determining pavement structure.

Table 12.3.4. Sub-grade Strength by Soil Layer for Each Survey Site

Km Post	364		366		368		370		372		374		376		378		380		382		384		386		388	
Area	Akkaraipattu		Akkaraipattu Town		to Kalmunai		to Kalmunai		to Kalmunai		to Kalmun		to Kalmunai		Allimulai Jct.		Nintavur		Karativu		Kalmunnai Town		Kalmunai Town		Kalmunai Town	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Sub Grade Layer-1	100.0	9.0	100.0	11.5	52.0	6.6	66.0	10.7	100.0	8.4	100.0	5.1	39.0	26.5	24.0	23.1	25.0	23.1	24.0	27.7	20.0	34.9	28.0	18.6	25.0	32.3
Sub Grade Layer-2					48.0	13.4	34.0	15.2					61.0	6.4	25.0	32.3	75.0	9.9	19.0	20.6	31.0	17.5	72.0	11.1	75.0	17.3
Sub Grade Layer-3															51.0	8.7			57.0	12.1	49.0	14.3				
Sub Grade CBR	9.0		11.0		9.0		12.0		8.0		5.0		12.0		16.0		13.0		17.0		19.0		13.0		20.0	
Sub Grade Class	S4		S4		S4		S4		S4		S3		S4		S5(a)		S4		S5(a)		S5(a)		S4		S5(b)	

Km Post	390		392		394		396		398		400		402		404		406		408		410		412		414	
Area	Maruth Town		Maruth		Kallar		Kotte Kallar		Onthac Madam		Kaluwa Ndikudi		Thettatium		Kaluwa Wellei		Thettatium		Seththi Palyam		Kurukal Mabam		Kirankulam		Puthukku Diyiruppu	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Sub Grade Layer-1	28.0	7.1	21.0	15.9	17.0	15.1	12.0	15.0	34.0	17.5	21.0	18.6	30.0	14.6	40.0	8.1	22.0	9.1	50.0	11.1	20.0	22.9	28.0	10.8	100.0	16.7
Sub Grade Layer-2	11.0	16.4	79.0	10.4	83.0	10.4	33.0	11.5	66.0	13.6	44.0	7.9	70.0	10.1	60.0	7.9	27.0	7.3	50.0	14.2	31.0	14.9	72.0	7.8		
Sub Grade Layer-3	61.0	7.9					55.0	4.7			45.0	11.5					32.0	25.7			49.0	9.9				
Sub Grade CBR	8.0		11.0		11.0		8.0		15.0		15.0		11.0		8.0		7.0		13.0		14.0		9.0		17.0	
Sub Grade Class	S4		S4		S4		S4		S5(a)		S5(a)		S4		S4		S3		S4		S4		S4		S5(a)	

Km Post	416		418		420		422		424		426		0		2		4		6		8		10		12	
Area	Puthukku Diyiruppu		Thalankuda		Areimbathi		Kattankudy Town		Kattankudy Town		Kallady		Batticaloa Town		L.G.puram		Satturu Kondam		Satturu Kondam		Mahilam Pawadi		Kudiruppu		Eravur Town	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Sub Grade Layer-1	28.0	8.0	19.0	19.2	38.0	17.0	100.0	9.5	100.0	20.2	12.0	10.5	26.0	26.5	17.0	13.5	23.0	11.0	27.0	14.2	100.0	13.4	20.0	4.8	43.0	8.1
Sub Grade Layer-2	56.0	4.3	81.0	11.5	62.0	11.0					88.0	7.2	74.0	13.5	83.0	11.9	77.0	27.1	20.0	4.8			80.0	12.1	57.0	14.5
Sub Grade Layer-3	16.0	5.7																	53.0	10.3						
Sub Grade CBR	5.0		13.0		13.0		9.0		20.0		8.0		16.0		12.0		23.0		10.0		13.0		10.0		11.0	
Sub Grade Class	S3		S4		S4		S4		S5(b)		S4		S5(a)		S4		S5(b)		S4		S4		S4		S4	

Km Post	14		16		18		20		22		24		26		28		30		32		34		36	
Area	Commonthurai		Vantharumoolai		Mavadivembu		Morakothn Chennai		Santhiwadi		Kerahan		Kumburumunnai		Kondahenkani		Oddaimavudi		Oddaimavudi Bridge		Namaladi		Mehankulam	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Sub Grade Layer-1	100.0	12.7	26.0	24.4	100.0	25.3	17.0	15.1	20.0	15.4	19.8	20.6	16.0	16.1	20.0	7.4	26.0	41.8	34.0	19.9	35.0	13.1	20.0	19.5
Sub Grade Layer-2			74.0	9.9			83.0	9.6	80.0	10.8	80.2	12.7	84.0	12.3	80.0	5.1	74.0	13.3	66.0	6.6	12.0	77.1	30.0	25.6
Sub Grade Layer-3																					53.0	15.4	50.0	15.0
Sub Grade CBR	13.0		13.0		25.0		10.0		12.0		14.0		13.0		6.0		19.0		10.0		19.0		19.0	
Sub Grade Class	S4		S4		S5(b)		S4		S4		S4		S4		S3		S5(a)		S4		S5(a)		S5(a)	

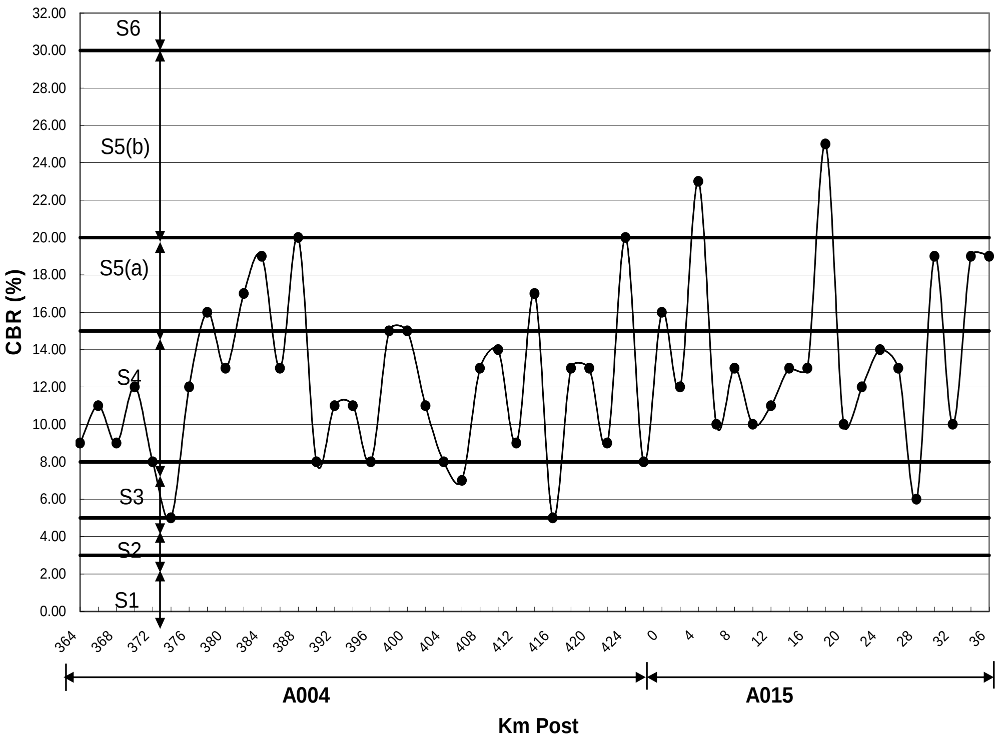


Figure 12.3.2. Average Total Sub-grade Strength of Each Survey Site

12.3.4 Suitable Pavement Composition in the Case of Reconstruction

The purpose of this section is to determine suitable pavement composition in the case of the Project road being reconstructed (i.e., where the existing road is excavated and completely replaced).

1) Application of Asphalt-Concrete

From the analysis in 12.3.2, the traffic class of the Project road can be classified into either T4 or T5. On the other hand, according to the *RDA Road Design Guide*, asphalt-concrete surfacing is not applied for anything lower than T6. However, it has been decided that asphalt-concrete will be applied to the Project road for the following reasons:

- Surface dressings are not durable compared to asphalt-concrete paving and require a strict maintenance regime throughout the life of the road.
- There is a lack of expertise in Sri Lanka with the construction and maintenance of a granular base/double bitumen surface compared with a granular base/asphalt-concrete surface.

- The coefficient of friction between tire and pavement is reduced.
- The structural strength of asphalt-concrete, which is about twice that of an equal thickness of double bitumen surface, reduces the required overlay thickness in the case of an unbound granular base.

In fact, based on the above logic, the RDA has in the past used asphalt-concrete for roads with a traffic class of less than T6 (see Table 12.3.5).

Table 12.3.5. Road Applied Asphalt Pavement in Under Class T5

Road	10 Year Design ESA Value/ [10^6]	Traffic Class
A 005 – Gampola – Nuwaraeliya	0.8775	T3
A 010 – Katugastota – Kurunagala	5.2778	T5
AB 013 – Gampola Nawalapitiya	1.604	T4
B 319 – Nawalapitiya – Ginigathhena	0.550	T2

2) Method for Determining Asphalt-Concrete Road Composition

As the *RDA Road Design Guide* does not provide guidance for designing the structure of an asphalt-concrete road in the case of the traffic class being T4 or T5, the Study Team had to determine this on its own. This was done applying the AASHTO process described in Figure 12.3.3, which is recommended by the *RDA Road Design Guide* in such a case as this.

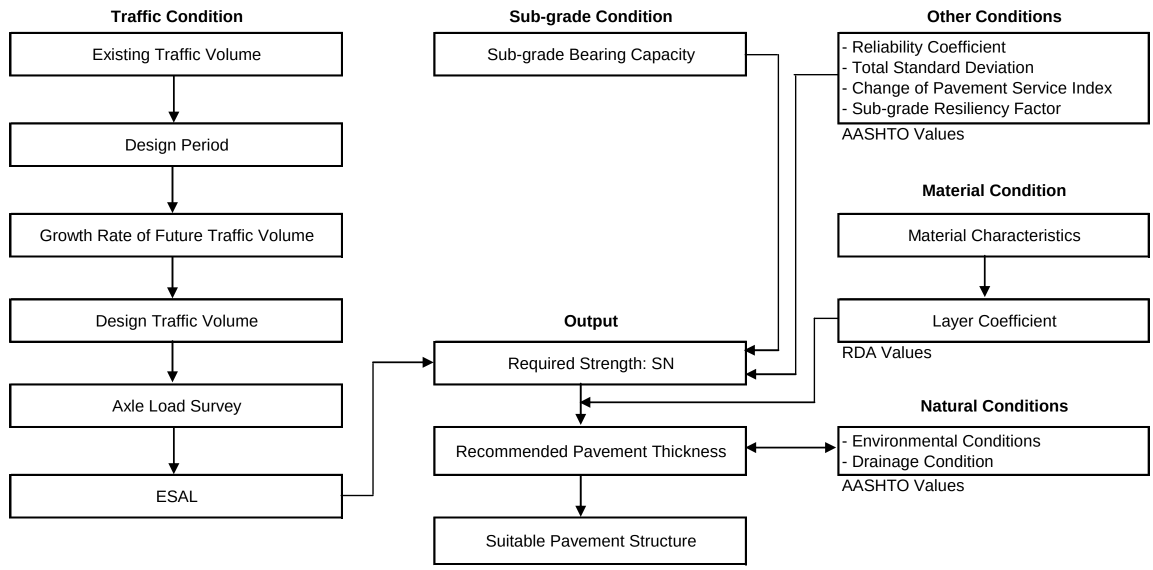


Figure 12.3.3. Pavement Design Flowchart(based on AASHTO)

As Figure 12.3.3 indicates, in order to determine necessary pavement thickness, the required structural number (SN) of the Project road must be calculated. This is done applying the results for traffic loading and sub-grade strength derived in 12.3.2 and 12.3.3 based on the traffic and geological surveys carried out by the Study Team here in Sri Lanka, while the other data inputs needed for this calculation are taken from AASHTO. This produces the required SN. However, in order to convert the required SN into actual thickness, it is necessary to apply layer coefficients representing the relative strength of construction materials here in Sri Lanka, which are available from the RDA Design Guide (see Table 12.3.6). Finally, the recommended pavement thickness is checked taking into consideration environmental and drainage conditions, which in this Project are deemed to be insignificant and therefore are not considered.

Table 12.3.6. Layer Coefficients for Project Road

Item	Layer		
	Sub-base	Base Course	Surfacing
Layer Coefficient	0.095	0.14	0.40

Source: *RDA Road Design Guide*.

3) Required Structure Number & Recommended Pavement Thickness

With the required SN, the thickness of the Project road is calculated using the following equation:

$$SN = \Sigma L_i T_i \qquad \text{Equation 12.3.1}$$

Where, L_i = Layer coefficient for layer i

T_i = Thickness (in.) of layer i

The results of this exercise are as shown in Table 12.3.7. Note that a thickness of 5 cm for surfacing was decided in consultation with the RDA taking into account cost and traffic loading. As for the base course, the Study Team decided that its thickness would be set at the same value (20 cm) as that of a road with a traffic class of T6 in order to ensure a sufficient margin of safety. This means that only the thickness of the sub-base course was adjusted in order to produce a SN equivalent to or larger than the required SN. The final structures that would be applicable to the Project road, which total seven, are illustrated in Table 12.3.8 and are shaded in gray.

Table 12.3.7. Recommended Thickness by Layer & Traffic Class

Traffic Class T4

Sub-grade Class	Required SN	Layer Coefficients			Recommended Thickness						Actual SN
		Sub-base	Base	AC	Sub-base		Base		AC		
S1	5.50	0.095	0.140	0.400	38	inch	8	inch	2	inch	5.53
					95	cm	20	cm	5	cm	
S2	4.80	0.095	0.140	0.400	32	inch	8	inch	2	inch	4.96
					80	cm	20	cm	5	cm	
S3	4.00	0.095	0.140	0.400	22	inch	8	inch	2	inch	4.01
					55	cm	20	cm	5	cm	
S4	3.40	0.095	0.140	0.400	16	inch	8	inch	2	inch	3.44
					40	cm	20	cm	5	cm	
S5(a)	2.70	0.095	0.140	0.400	10	inch	8	inch	2	inch	2.87
					25	cm	20	cm	5	cm	
S5(b)	2.40	0.095	0.140	0.400	6	inch	8	inch	2	inch	2.49
					15	cm	20	cm	5	cm	
S6	2.10	0.095	0.140	0.400	4	inch	8	inch	2	inch	2.30
					10	cm	20	cm	5	cm	

Traffic Class T5

Sub-grade Class	Required SN	Layer Coefficients			Recommended Thickness						Actual SN
		Sub-base	Base	AC	Sub-base		Base		AC		
S1	6.00	0.095	0.140	0.400	44	inch	8	inch	2	inch	6.10
					110	cm	20	cm	5	cm	
S2	5.30	0.095	0.140	0.400	36	inch	8	inch	2	inch	5.34
					90	cm	20	cm	5	cm	
S3	4.50	0.095	0.140	0.400	28	inch	8	inch	2	inch	4.58
					70	cm	20	cm	5	cm	
S4	3.80	0.095	0.140	0.400	20	inch	8	inch	2	inch	3.82
					50	cm	20	cm	5	cm	
S5(a)	3.00	0.095	0.140	0.400	12	inch	8	inch	2	inch	3.06
					30	cm	20	cm	5	cm	
S5(b)	2.70	0.095	0.140	0.400	10	inch	8	inch	2	inch	2.87
					25	cm	20	cm	5	cm	
S6	2.30	0.095	0.140	0.400	4	inch	8	inch	2	inch	2.30
					10	cm	20	cm	5	cm	

Table 12.3.8. Modified Structural Chart for AC Pavement

	Soil or Granular Subbase/ Crushed Stone Base/ Asphalt		Stabilized Subbase/ Granular Bese/ Asphalt Concrete		
	T4	T5	T6	T7	T8
S1			100 200 225 350	125 225 225 350	150 250 250 350
S2			100 200 225 200	125 225 225 200	150 250 250 200
S3	50 200 550	50 200 700	100 200 250	125 225 250	150 250 275
S4	50 200 400	50 200 500	100 200 175	125 225 175	150 250 175
S5(a)	50 200 250	50 200 300	100 200 100	125 225 100	150 250 100
S5(b)	50 200 150	50 200 250	100 200 100	125 225 100	150 250 100
S6			100 200	125 225	150 250

The shaded cells represent applicable pavement structures for the Project road and are based on a modification of the RDA's Chart 3 in its April 1999 "A Guide to the Structural Design of Roads under Sri Lankan Conditions".

12.3.5 Suitable Pavement Composition in the Case of an Overlay

Unlike the previous section, the purpose of 12.3.5 is to determine suitable pavement composition where an overlay is applied to the existing road. In order to establish what a suitable overlay would be it is first necessary to determine the strength of the existing pavement (or SN). The SN is calculated with Equation 12.3.1 using the results from the Study Team's geological survey and the layer coefficients given in Table 12.3.9 below.

Table 12.3.9. Layer Coefficients for Existing Pavement by CBR

	Sub-base or Base course					Macadam Surface
CBR (%)	10 - 20	20 - 30	30 - 80	80 - 110	110-plus	-
Layer Coefficient	0.090	0.095	0.110	0.120	0.140	0.30

Source: *RDA Road Design Guide*

In the case where the difference between the existing SN and required SN, which was calculated in the previous section, is negative, the strength of the existing pavement can be said to be insufficient to sustain the expected traffic loading and therefore requires an overlay. In the case where this difference is positive, it can be said that the strength of the existing road is sufficient and no overlay is required. The results of this calculation for the Project road are as shown in Figure 12.3.4.

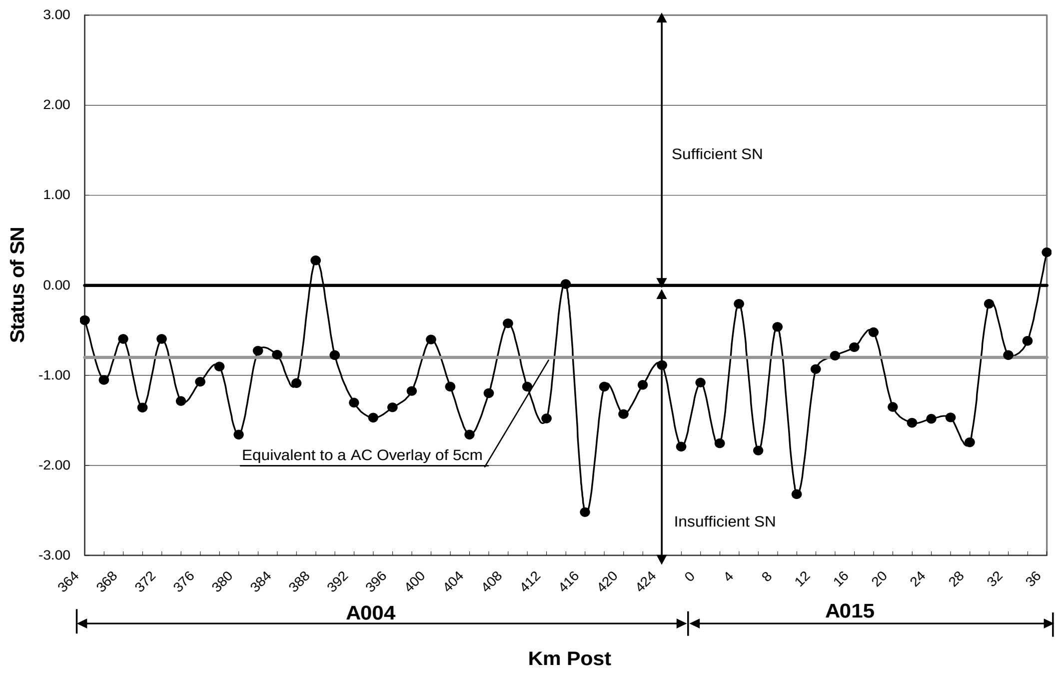


Figure 12.3.4. Status of SN for Existing/Unimproved Project Road

As the above figure indicates, the vast majority of the road (95%) requires an overlay. Given this, it is recommended that the entirety of the Project road receive an overlay should this scenario be chosen. Detailed calculations of existing strength are given in Table 12.3.10.

Table 12.3.10. Detailed Calculations of Existing Pavement Strength

Km Post	364		366		368		370		372		374		376		378		380		382		384		386		388	
Area	Akkaraipattu		Akkaraipattu Town		to Kalmunai		to Kalmunai		to Kalmunai		to Kalmun		to Kalmunai		Allimulai Jct.		Nintavur		Karativu		Kalmunnai Town		Kalmunai Town		Kalmunai Town	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Surface Layer (As)	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-
Material Coefficient	0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3	
Base or Subbase Layer-1	61.0	12.1	29.0	29.4	12.0	48.0	40.0	13.5	28.0	22.4	10.0	101.7	7.0	80.3	14.0	61.6	35.0	35.9	11.0	80.3	37.0	67.8	25.0	78.7	20.0	40.4
Base or Subbase Layer-2	6.0	26.5	17.0	16.7	46.0	20.4			30.0	25.7	38.0	47.1	9.0	228.9	20.0	28.0			27.0	42.5			23.0	37.5	34.0	88.3
Base or Subbase Layer-3													20.0	73.7												
Base or Subbase CBR	13.1		24.2		24.9		13.5		24.1		56.2		103.7		39.7		35.9		51.8		67.8		56.4		67.6	
Material Coefficient	0.090		0.095		0.095		0.090		0.095		0.110		0.120		0.110		0.110		0.110		0.110		0.110		0.110	
Sub Grade CBR	9.0		11.0		9.0		12.0		8.0		5.0		12.0		16.0		13.0		17.0		19.0		13.0		20.0	
Sub Grade Class	S4		S4		S4		S4		S4		S3		S4		S5(a)		S4		S5(a)		S5(a)		S4		S5(b)	
Traffic Class	T4		T4		T4		T4		T4		T4		T4		T5		T5		T5		T5		T5		T5	
Required SN	3.4		3.4		3.4		3.4		3.4		4.0		3.4		3.0		3.8		3.0		3.0		3.8		2.7	
Existing Total SN	3.0		2.3		2.8		2.0		2.8		2.7		2.3		2.1		2.1		2.3		2.2		2.7		3.0	
Status SN*	-0.4		-1.1		-0.6		-1.4		-0.6		-1.3		-1.1		-0.9		-1.7		-0.7		-0.8		-1.1		0.3	

Km Post	390		392		394		396		398		400		402		404		406		408		410		412		414	
Area	Maruth Town		Maruth		Kallar		Kotte Kallar		Onthac Madam		Kaluwa Ndikudi		Thettatium		Kaluwa Wellei		Thettatium		Seththi Palyam		Kurukal Mabam		Kirankulam		Puthukku Diyiruppu	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Surface Layer (As)	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-
Material Coefficient	0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3	
Base or Subbase Layer-1	46.0	34.0	34.0	50.8	35.0	27.4	38.0	24.2	21.0	33.2	34.0	46.3	19.0	69.8	30.0	20.7	31.0	49.8	22.0	58.8	18.0	66.3	30.0	31.8	19.0	49.0
Base or Subbase Layer-2													19.0	38.6			19.0	18.8	32.0	35.4	20.0	48.0			10.0	32.1
Base or Subbase Layer-3																									19.0	23.5
Base or Subbase CBR	34.0		50.8		27.4		24.2		33.2		46.3		52.7		20.7		35.7		44.0		56.2		31.8		34.2	
Material Coefficient	0.110		0.110		0.095		0.095		0.110		0.110		0.110		0.095		0.110		0.110		0.110		0.110		0.110	
Sub Grade CBR	8.0		11.0		11.0		8.0		15.0		15.0		11.0		8.0		7.0		13.0		14.0		9.0		17.0	
Sub Grade Class	S4		S4		S4		S4		S5(a)		S5(a)		S4		S4		S3		S4		S4		S4		S5(a)	
Traffic Class	T4		T4		T4		T4		T4		T4		T4		T4		T4		T4		T4		T4		T4	
Required SN	3.4		3.4		3.4		3.4		2.7		2.7		3.4		3.4		4.0		3.4		3.4		3.4		2.7	
Existing Total SN	2.6		2.1		1.9		2.0		1.5		2.1		2.3		1.7		2.8		3.0		2.3		1.9		2.7	
Status SN*	-0.8		-1.3		-1.5		-1.4		-1.2		-0.6		-1.1		-1.7		-1.2		-0.4		-1.1		-1.5		0.0	

Km Post	416		418		420		422		424		426		0		2		4		6		8		10		12	
Area	Puthukku Diyiruppu		Thalankuda		Areimbathi		Kattankudy Town		Kattankudy Town		Kallady		Batticaloa Town		L.G.puram		Satturu Kondam		Satturu Kondam		Mahilam Pawadi		Kudiruppu		Eravur Town	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Surface Layer (As)	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-
Material Coefficient	0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3	
Base or Subbase Layer-1	20.0	29.3	14.0	84.7	36.0	26.5	15.0	12.7	24.0	24.2	12.0	6.1	14.0	84.7	17.0	56.8	18.0	39.1	31.0	43.0	32.0	19.5	20.0	32.1	20.0	25.1
Base or Subbase Layer-2			24.0	33.5			32.0	16.1			24.0	17.3	16.0	49.6	21.0	10.8	8.0	118.7			44.0	15.2			43.0	16.8
Base or Subbase Layer-3																	17.0	55.1								
Base or Subbase CBR	29.3		48.8		26.5		15.0		24.2		12.7		64.4		25.5		56.6		43.0		16.9		32.1		19.2	
Material Coefficient	0.110		0.110		0.095		0.090		0.095		0.070		0.110		0.095		0.110		0.110		0.090		0.110		0.090	
Sub Grade CBR	5.0		13.0		13.0		9.0		20.0		8.0		16.0		12.0		23.0		10.0		13.0		10.0		11.0	
Sub Grade Class	S3		S4		S4		S4		S5(b)		S4		S5(a)		S4		S5(b)		S4		S4		S4		S4	
Traffic Class	T4		T4		T4		T4		T4		T4		T5		T5		T5		T5		T5		T5		T5	
Required SN	4.0		3.4		3.4		3.4		2.4		3.4		3.0		3.8		2.7		3.8		3.8		3.8		3.8	
Existing Total SN	1.5		2.3		2.0		2.3		1.5		1.6		1.9		2.0		2.5		2.0		3.3		1.5		2.9	
Status SN*	-2.5		-1.1		-1.4		-1.1		-0.9		-1.8		-1.1		-1.8		-0.2		-1.8		-0.5		-2.3		-0.9	

Km Post	14		16		18		20		22		24		26		28		30		32		34		36	
Area	Commonthurai		Vantharumoolai		Mavadivembu		Morakothn Chennai		Santhiwadi		Kerahan		Kumburumunnai		Kondahenkani		Oddaimavudi		Oddaimavudi Bridge		Namaladi		Mehankulam	
	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)	Thickness (cm)	CBR (%)
Surface Layer (As)	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-	5.0	-
Material Coefficient	0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3		0.3	
Base or Subbase Layer-1	7.0	94.6	22.0	94.6	24.0	31.6	21.0	52.0	44.0	23.7	23.0	44.1	37.0	17.0	21.0	21.6	10.0	26.5	46.0	37.5	15.0	37.4	56.0	41.2
Base or Subbase Layer-2	29.0	295.8	26.0	41.8	9.5	16.3	21.0	25.2			16.0	30.0			25.0	14.4	19.0	36.9			24.0	20.7		
Base or Subbase Layer-3					8.0	37.1											14.0	110.4						
Base or Subbase CBR	244.5		62.4		28.4		37.0		23.7		37.8		17.0		17.4		51.8		37.5		26.3		41.2	
Material Coefficient	0.140		0.110		0.095		0.110		0.095		0.110		0.090		0.090		0.110		0.110		0.095		0.110	
Sub Grade CBR	13.0		13.0		25.0		10.0		12.0		14.0		13.0		6.0		19.0		10.0		19.0		19.0	
Sub Grade Class	S4		S4		S5(b)		S4		S4		S4		S4		S3		S5(a)		S4		S5(a)		S5(a)	
Traffic Class	T4		T4		T5		T5		T5		T5		T4		T4		T4		T4		T4		T4	
Required SN	3.4		3.4		2.7		3.8		3.8		3.8		3.4		4.0		2.7		3.4		2.7		2.7	
Existing Total SN	2.6		2.7		2.2		2.4		2.3		2.3		1.9		2.3		2.5		2.6		2.1		3.1	
Status SN*	-0.8		-0.7		-0.5		-1.4		-1.5		-1.5		-1.5		-1.7		-0.2		-0.8		-0.6		0.4	

*) A negative value indicates insufficient existing pavement strength and a positive value indicates sufficient strength.

12.4 Drainage Structures

12.4.1 Existing Condition of Drainage Structure

Existing Project road drainage structures are classified into the following types:

1) Earthen roadside ditch
2) Concrete roadside ditch
3) Concrete pipe culvert crossing the road
4) Concrete box culvert
5) Bridge more than 3 m in length

1) Earthen Roadside Ditches

Earthen roadside ditches connect existing roadside ditches, culverts and irrigation canals in paddy fields, towns and suburb areas. The locations of these ditches are as shown in Table 12.4.1.

Table 12.4.1. Locations of Existing Earthen Roadside Ditches

KmP	Length (m)	Connected to	Remarks
372+200	40	Existing pipe culvert	Right side, In front of the wall fence
373+060	110	Existing irrigation canal	Left side, In front of the wall fence
374+820	140	Existing box culvert	Right side, To paddy field
374+890	40	Existing irrigation canal	Left side, To paddy field
377+460	160	Paddy field	Left side, To paddy field
379+260	10	Existing culvert (covered)	Left side, To mango plantation
384+050	120	Existing side ditch	Right side, Kalmunai town
388+700	10	---	Right side
426+650	320	Existing side ditch	Right side, After crossing the Kallady Bridge
003+380	200	Existing box culvert	Right side, To lagoon side
008+610	50	---	Right side
009+660	80	Existing box culvert	Right side, To lagoon side
017+070	30	Existing box culvert	Left side, Under construction of culvert
017+540	740	Existing side ditch	Right side, Eastern University
020+630	400	Existing box culvert	Right side
Total Length		2,450 m	

2) Concrete Roadside Ditches

Concrete roadside ditches connect existing culverts and irrigation canals in towns and suburb areas. The locations of these ditches re as shown in Table 12.4.2.

Table 12.4.2. Location of Existing Concrete Roadside Ditches

KmP	Length (m)	Connected to	Remarks
364+870	1,570	Existing box culvert	Both sides, Akkaraipattu town
366+240	2,910	Existing box culvert	Both sides, Akkaraipattu town
369+280	90	---	Right side, Akkaraipattu town
371+670	20	---	Right side, In suburb
379+670	100	Existing box culvert	Right side, Nintavur town
379+850	140	Existing box culvert	Right side, Nintavur town
379+910	560	Existing box culvert	Left side, Nintavur town
380+690	190	Existing culvert (covered)	Left side, Nintavur town
381+070	470	Existing pipe culvert	Right side, Nintavur town
381+810	980	---	Right side, Karativu town
383+570	190	Existing box culvert	Right side, Kalmunai town
383+830	220	---	Right side, Kalmunai town
384+200	20	---	Right side, Kalmunai town
384+230	140	---	Right side, Kalmunai town
384+460	810	---	Right side, Kalmunai town
384+500	440	---	Left side, Kalmunai town
385+020	290	---	Left side, Kalmunai town
385+240	90	---	Right side, Kalmunai town
385+490	650	Existing box culvert	Right side, Kalmunai town
385+540	140	Existing box culvert	Left side, Kalmunai town
385+910	900	Existing box culvert	Left side, Kalmunai town
385+930	190	Existing box culvert	Right side, Kalmunai town
385+960	110	Existing box culvert	Left side, Kalmunai town
386+140	310	Existing box culvert	Right side, Kalmunai town
386+300	510	Existing box culvert	Left side, Kalmunai town
386+500	400	Existing box culvert	Right side, Kalmunai town
386+930	210	Existing box culvert	Right side, Kalmunai town
386+960	100	Existing box culvert	Left side, Kalmunai town
387+140	310	Existing box culvert	Right side, Kalmunai town
387+300	720	Existing box culvert	Left side, Kalmunai town
387+500	270	---	Right side, Kalmunai town
387+820	190	---	Right side, Kalmunai town
400+840	270	Existing box culvert	Both sides, Puddiruppu town
419+090	3,170	Existing box culvert	Both sides, Talankuda town
423+430	1,650	Existing box culvert	Right side, Kattankudi
426+690	250	Existing culvert	Left side, Batticaloa town
427+090	100	Existing box culvert	Both sides, Batticaloa town
000+820	250	---	Left side, Batticaloa town
000+820	730	Existing box culvert	Right side, Batticaloa town
001+470	110	---	Left side, Batticaloa town
012+690	1,940	Existing box culvert	Both sides, Eravur town
015+000	740	Existing box culvert	Right side, Chenkaladi town
015+080	660	Existing box culvert	Left side, Chenkaladi town
016+760	780	Existing box culvert	Right side, Eastern University
016+880	640	Existing box culvert	Left side, Eastern University
031+670	1,580	Existing pipe culvert	Both sides, Valaichchenai town
Total Length		35,670 m	

3) Pipe/Box Culverts and Bridges

Culvert structures, which are either a pipe or a box type, are installed across the Project road. Bridges, which are over 3m in length, are also on the Project road. Note that some culverts are clogged with soil, weeds, or other debris. Culverts are connect to roadside ditches or small streams. The locations and existing conditions of culverts and bridges are as shown in Table 12.4.3.

Table 12.4.3. (1) Location of Existing Culverts and Bridges

Unit : m

No.	Road	ID No.	Km	Existing Structure			Imprvement Structure			
			(km)	Category	Inner size (Cell x)Length x Height	Structure width	Improvement Type	Category	Inner size (Cell x)Length x Height	Structure width
1	AA004	365/1	364.560	Box	1.85x1.80	8.75	D	Box		10.0
2	AA004	365/2	364.845	Box	1.40x0.55	15.68	F	Box		10.0
3	AA004	367/1	366.410	Box	2.05x2.30	15.00	F	Box		13.8
4	AA004	368/1	367.455	Box	1.90x0.90	8.15	D	Box		10.0
5	AA004	368/2	367.840	Pipe	dia. 0.60	11.00	F	Pipe		10.0
6	AA004	369/1	368.500	Pipe	dia. 0.60	9.50	E	Pipe		14.0
7	AA004	369/1b	369.115	Box	0.95x0.90	11.00	F	Box		10.0
8	AA004	370/1	369.655	Box	2.65x1.80	6.10	C	Box		10.0
9	AA004	371/1	370.360	Bridge	2x6.00x(1.90)	7.60	A	Bridge	2x2.50x2.00	9.4
10	AA004	371/2	370.500	Bridge	2x4.60x(1.95)	7.40	A	Bridge	3x2.50x2.00	9.4
11	AA004	371/3	370.875	Bridge	6.10x(0.80)	9.60	-	Bridge	Sidewalk	9.4
12	AA004	372/1	371.925	Box	1.00x1.00	6.22	C	Box		10.0
13	AA004	373/1	372.165	Pipe	dia. 0.90	8.72	E	Pipe		10.0
14	AA004	373/2	372.605	Pipe	dia. 0.60	11.00	F	Pipe		10.0
15	AA004	373/3	372.940	Pipe	2xdia. 0.90	6.60	E	Pipe		10.0
16	AA004	374/1	373.275	Pipe	2xdia. 0.90	6.63	E	Pipe		10.0
17	AA004	374/2	373.670	Pipe	3xdia. 0.60	6.44	E	Pipe		10.0
18	AA004	374/3	373.810	Pipe	dia. 0.60	9.00	E	Pipe		10.0
19	AA004	374/4	373.890	Box	2x0.60x0.90	5.90	C	Box		10.0
20	AA004	375/2	374.405	Pipe	dia. 0.90	9.05	E	Pipe		10.0
21	AA004	375/3	374.580	Pipe	dia. 0.90	6.45	E	Pipe		10.0
22	AA004	375/4	374.792	Box	1.00x1.70	11.45	F	Box		10.0
23	AA004	375/5	374.860		Causeway		A	Bridge	2x4x3.00x1.25	10.0
24	AA004	376/1	375.235	Pipe	2xdia. 1.20	8.65	E	Pipe		10.0
25	AA004	376/2	375.495	Pipe	dia. 0.60	8.50	E	Pipe		10.0
26	AA004	376/3	375.710	Box	3.20x1.50	6.65	C	Box		10.0
27	AA004	376/4	376.015	Pipe	2xdia. 0.90	9.25	E	Pipe		10.0
28	AA004	377/1	376.105	Box	2.40x1.80	9.15	C	Box		10.0
29	AA004	377/2	376.150	Box	1.80x1.20	5.50	C	Box		10.0
30	AA004	377/3	376.615	Pipe	2xdia. 0.90	9.10	E	Pipe		10.0
31	AA004	377/4	376.660	Pipe	dia. 0.45	6.00	E	Pipe		10.0
32	AA004	377/5	376.745	Pipe	2xdia. 0.90	13.55	F	Pipe		10.0
33	AA004	377/6	376.955	Box	1.25x0.90	6.00	C	Box		10.0
34	AA004	377/7	377.000	Bridge	2x8.80x(2.95)	7.70	A	Bridge	6x3.00x3.00	9.4
35	AA004	[377/8]	377.200	Non		-	B	Box	2.00x1.50	10.0
36	AA004	378/1	377.370	Box	0.75x0.25	5.90	C	Box		10.0
37	AA004	378/2	377.995	Bridge	7.90x(2.10)	6.80	A	Bridge	3x3.00x2.00	9.4
38	AA004	379/1	378.125	Box	2.70x1.40	9.40	D	Box		10.0
39	AA004	379/2	378.270	Box	0.95x0.85	6.35	C	Box		10.0
40	AA004	379/3	378.530	Pipe	dia. 0.90	8.55	E	Pipe		10.0
41	AA004	379/4	378.675	Pipe	dia. 0.60	8.55	E	Pipe		10.0
42	AA004	379/5	378.900	Pipe	dia. 0.60	8.70	E	Pipe		10.0
43	AA004	380/1	379.260	Box	0.90x0.60	6.10	D	Box		10.0
44	AA004	380/2	379.520	Box	2.40x1.00	6.80	C	Box		10.0
45	AA004	380/3	379.665	Box	1.50x1.00	6.10	C	Box		13.5
46	AA004	380/4	379.910	Box	1.20x1.00	15.00	F	Box		13.5
47	AA004	381/2	380.630	Pipe	dia. 0.60	6.10	E	Pipe		13.5
48	AA004	381/3	380.815	Pipe	dia. 0.60	7.00	E	Pipe		13.5
49	AA004	382/1	381.070	Pipe	dia. 0.60	5.80	E	Box		13.5
50	AA004	382/2	381.560	Bridge	6.00x(1.90)	5.85	A	Bridge	2x3.00x2.00	9.4
51	AA004	382/3	382.800	Box	1.20x0.90	14.00	F	Box		13.5
52	AA004	382/4	382.890	Box	2.60x1.50	16.00	F	Box		13.5
53	AA004	383/1	383.110	Box	1.10x1.25	10.10	F	Box		10.0
54	AA004	383/2	383.760	Box	1.35x1.50	17.00	F	Box		13.5
55	AA004	384/1	384.100	Box	1.20x1.10	10.20	F	Box		13.5
56	AA004	384/2	384.200	Pipe	6xdia. 1.20	8.25	F	Box		13.5
57	AA004	384/3	384.490	Box	1.35x1.30	16.10	F	Box		13.5
58	AA004	384/4	384.900	Box	1.20x(-)	-	-	Box	Under construction	13.5
59	AA004	385/1	385.100	Box	2.00x1.20	12.80	F	Box		13.5
60	AA004	385/2	385.300	Box	1.20x0.60	13.00	F	Box		13.5
61	AA004	385/3	385.585	Box	1.20x0.60	13.00	F	Box		13.5

Table 12.4.3.(2) Location of Existing Culverts and Bridges

Unit : m

No.	Road	ID No.	Km	Existing Structure			Imprvement Structure			
			(km)	Category	Inner size (Cell x)Length x Height	Structure width	Improvement Type	Category	Inner size (Cell x)Length x Height	Structure width
62	AA004	386/2	385.715	Box	1.20x0.60	14.00	F	Box		13.5
63	AA004	387/1	386.080	Box	1.20x0.80	13.70	F	Box		13.5
64	AA004	387/2	386.310	Box	1.20x0.60	17.50	F	Box		13.5
65	AA004	387/3	386.450	Box	1.40x0.70	17.00	F	Box		13.5
66	AA004	387/4	386.600	Box	1.50x0.60	18.40	F	Box		13.5
67	AA004	387/5	386.700	Box	1.20x0.60	15.30	F	Box		13.5
68	AA004	388/1	386.857	Box	1.20x0.50	14.00	F	Box		13.5
69	AA004	388/2	386.965	Box	0.90x0.50	17.30	F	Box		13.5
70	AA004	388/3	387.065	Box	1.40x0.50	18.00	F	Box		13.5
71	AA004	388/4	387.190	Box	1.20x0.50	17.00	F	Box		13.5
72	AA004	388/5	387.295	Box	1.20x0.60	18.10	F	Box		13.5
73	AA004	388/6	387.450	Box	1.60x1.20	18.00	F	Box		13.5
74	AA004	389/1	388.030	Box	1.50x1.40	12.50	F	Box		10.0
75	AA004	389/2	388.795	Pipe	dia. 0.90	13.00	F	Pipe		10.0
76	AA004	[389/3]	388.900	Box	-	-	-	Box	Planning by RDA	10.0
77	AA004	390/1	389.415	Box	1.40x1.20	12.80	F	Box		10.0
78	AA004	[390/2]	389.600	Box	-	-	-	Box	Planning by RDA	10.0
79	AA004	[390/3]	389.700	Box	-	-	-	Box	Planning by RDA	10.0
80	AA004	[390/4]	389.800	Box	-	-	-	Box	Planning by RDA	10.0
81	AA004	391/1	391.100	Box	1.20x0.60	13.30	F	Box		10.0
82	AA004	[391/1b]	391.300	Box	-	-	-	Box	Planning by RDA	10.0
83	AA004	391/2	391.480	Box	1.40x0.60	12.90	F	Box		10.0
84	AA004	392/1	391.490	Box	1.20x0.70	13.00	F	Box		10.0
85	AA004	392/2	391.675	Box	1.20x0.40	13.10	F	Box		10.0
86	AA004	[392/3]	391.700	Box	-	-	-	Box	Planning	10.0
87	AA004	393/1	392.100	Box	1.20x0.90	13.60	F	Box	Under construction	10.0
88	AA004	393/2	392.460	Box	1.20x0.65	14.50	F	Box		10.0
89	AA004	393/3	392.900	Box	-	12.50	-	Box	Under construction	10.0
90	AA004	394/1	393.275	Pipe	2xdia. 0.45	9.15	F	Box		10.0
91	AA004	[394/2]	393.900	Box	2.40x0.94	8.80	F	Box	Under construction	8.0
92	AA004	[394/3]	394.000	Box	2.17x0.85	8.50	F	Box	Under construction	8.0
93	AA004	395/1	395.010	Box	1.20x0.50	6.60	C	Box		8.0
94	AA004	396/1	395.200	Box	1.50x0.50	5.85	C	Box		8.0
95	AA004	399/1	398.750	Pipe	dia. 0.60	8.90	E	Pipe		10.0
96	AA004	400/1	399.240	Box	0.65x0.80	8.70	C	Box		10.0
97	AA004	400/2	399.600	Box	1.20x0.60	8.30	D	Box		10.0
98	AA004	401/1	400.570	Box	1.20x0.75	9.00	C	Box		10.0
99	AA004	401/2	400.840	Box	2.30x0.60	8.10	C	Box		14.5
100	AA004	402/1	401.050	Box	0.90x0.45	13.00	F	Box		14.5
101	AA004	402/2	401.115	Box	2.60x0.60	13.30	F	Box		8.0
102	AA004	402/3	401.340	Pipe	dia. 0.60	6.00	E	Pipe		10.0
103	AA004	403/1	402.140	Pipe	dia. 0.60	10.60	E	Pipe		10.0
104	AA004	404/1	403.000	Pipe	dia. 0.60	6.00	E	Pipe		10.0
105	AA004	404/2	403.315	Box	0.85x0.45	5.90	C	Box		10.0
106	AA004	405/1	404.080	Bridge	5.00x(1.20)	6.90	A	Bridge	2x2.50x1.50	9.4
107	AA004	406/1	404.945	Box	1.75x1.20	6.10	D	Box		10.0
108	AA004	406/2	405.195	Box	1.90x0.50	7.30	D	Box		10.0
109	AA004	406/3	405.305	Box	0.60x0.50	6.00	D	Box		10.0
110	AA004	406/4	405.365	Pipe	dia. 0.45	6.70	E	Pipe		10.0
111	AA004	407/1	406.535	Pipe	dia. 0.60	6.65	E	Pipe		10.0
112	AA004	409/1	407.995	Box	1.80x0.90	7.90	C	Box		10.0
113	AA004	409/2	408.085	Box	1.90x0.90	8.00	D	Box		10.0
114	AA004	409/3	408.430	Box	1.20x0.45	8.70	C	Box		10.0
115	AA004	409/4	408.525	Box	2.50x0.45	6.10	C	Box		10.0
116	AA004	409/5	408.730	Box	-	-	-	Box	Under construction	10.0
117	AA004	409/5	408.730	Box	3.00x1.20	-	-	-	Replased	10.0
118	AA004	410/1	409.230	Box	0.90x0.60	8.90	C	Box		10.0
119	AA004	411/1	411.730	Box	1.00x1.00	7.00	C	Box		10.0
120	AA004	412/1	412.323	Box	2x2.00x1.20	5.80	C	Box		10.0
121	AA004	413/1	412.970	Pipe	2xdia. 0.60	9.00	E	Pipe		10.0
122	AA004	414/1	413.480	Pipe	2xdia. 0.60	8.80	E	Pipe		10.0
123	AA004	414/2	413.695	Box	2.30x0.60	9.00	C	Box		10.0
124	AA004	415/1	414.610	Box	1.20x0.60	7.90	C	Box		10.0
125	AA004	417/1	416.535	Box	1.30x0.80	8.00	C	Box		10.0
126	AA004	417/2	416.840	Pipe	2xdia. 0.60	8.60	E	Pipe		10.0
127	AA004	418/1	417.072	Box	1.20x0.60	8.80	C	Box		10.0
128	AA004	419/1	418.505	Pipe	dia. 0.60	9.00	E	Pipe		10.0
129	AA004	419/2	418.765	Pipe	dia. 0.45	6.60	E	Pipe		10.0
130	AA004	421/1	420.045	Pipe	2xdia. 0.45	14.00	F	Pipe		14.4
131	AA004	424/1	423.480	Pipe	2xdia. 0.30	13.90	F	Pipe		14.0
132	AA004	424/2	423.720	Pipe	2xdia. 0.30	15.50	F	Pipe		14.0
133	AA004	425/1	424.875	Pipe	2xdia. 0.45	12.00	E	Pipe		14.0
134	AA004	426/1	425.520	Pipe	dia. 0.60	12.30	F	Pipe		10.0
135	AA004	427/2	426.822	Box	0.70x0.60	13.50	F	Box		14.0
136	AA004	428/1	427.084	Box	2.25x1.20	10.00	F	Box		11.0
137	AA015	0/1	0.840	Box	0.60x0.60	22.00	F	Box		14.0
138	AA015	2/1	1.302	Box	0.70x0.60	15.00	F	Box		14.0
139	AA015	2/2	1.900	Pipe	2xdia. 0.30	13.90	F	Box		10.0
140	AA015	4/1	3.042	Box	1.50x0.60	8.70	D	Box		10.0
141	AA015	4/2	3.180	Pipe	dia. 0.60	8.50	E	Pipe		10.0

Table 12.4.3.(3) Location of Existing Culverts and Bridges

Unit : m

No.	Road	ID No.	Km	Existing Structure			Imprvement Structure			
			(km)	Category	Inner size (Cell x)Length x Height	Structure width	Improvement Type	Category	Inner size (Cell x)Length x Height	Structure width
142	AA015	4/3	3.280	Box	1.40x0.80	8.60	C	Box		10.0
143	AA015	4/4	3.370	Pipe	dia. 0.60	8.60	B	Box	2.00x1.50	10.0
144	AA015	4/5	3.470	Box	1.25x0.60	8.50	D	Box		10.0
145	AA015	4/6	3.630	Pipe	2xdia. 0.45	8.60	E	Pipe		10.0
146	AA015	4/7	3.815	Box	1.40x0.60	8.30	D	Box		10.0
147	AA015	4/8	3.995	Box	3.00x0.60	8.40	D	Box		10.0
148	AA015	[4/9]	4.005	Non		-	B	Box	3.00x2.00	10.0
149	AA015	5/1	4.640	Box	1.45x1.40	13.20	F	Box		10.0
150	AA015	6/1	5.380	Box	3.10x0.80	7.30	D	Box		10.0
151	AA015	[6/1b]	5.390	Non		-	B	Box	3.00x2.00	10.0
152	AA015	6/2	5.545	Box	1.50x1.20	8.55	D	Box		10.0
153	AA015	6/3	5.820	Box	1.80x1.00	8.30	D	Box		10.0
154	AA015	[6/4]	5.830	Non		-	B	Box	3.00x2.00	10.0
155	AA015	7/1	6.105	Box	2.50x0.50	8.40	D	Box		10.0
156	AA015	7/2	6.305	Box	1.20x0.80	9.10	D	Box		10.0
157	AA015	7/3	6.560	Box	1.20x1.00	10.10	F	Box		10.0
158	AA015	7/4	6.680	Box	1.20x1.30	8.50	D	Box		10.0
159	AA015	7/5	6.850	Box	1.80x0.65	9.40	C	Box		10.0
160	AA015	8/1	7.250	Box	2x0.95x0.65	9.00	D	Box		10.0
161	AA015	[8/1b]	7.260	Non		-	B	Box	3.00x2.00	10.0
162	AA015	8/2	7.690	Box	1.20x0.60	8.70	D	Box		10.0
163	AA015	[8/3]	7.700	Non		-	B	Box	3.00x2.00	10.0
164	AA015	9/1	8.190	Box	1.20x1.00	8.60	C	Box		10.0
165	AA015	[9/1b]	8.200	Non		-	B	Box	3.00x2.00	10.0
166	AA015	9/2	8.480	Pipe	3xdia. 1.20	9.00	E	Pipe		10.0
167	AA015	[9/3]	8.490	Non		-	A	Box	2x3.00x2.00	10.0
168	AA015	10/1	9.710	Box	2x2.40x0.60	8.30	C	Box		10.0
169	AA015	11/1	10.550	Pipe	2xdia. 0.90	11.20	F	Pipe		10.0
170	AA015	11/2	10.865	Box	3x1.20x1.20	6.50	C	Box		10.0
171	AA015	12/1	11.200	Box	2.15x0.80	8.10	C	Box		10.0
172	AA015	12/2	11.560	Box	2.15x1.10	8.90	C	Box		10.0
173	AA015	12/3	11.760	Bridge	4.50x(2.00)	4.50	A	Bridge	2x2.50x2.00	9.4
174	AA015	12/4	12.035	Box	1.20x0.50	6.90	F	Box		10.0
175	AA015	12/5	12.140	Pipe	dia. 0.60	9.90	F	Pipe		10.0
176	AA015	13/1	12.700	Box	1.20x1.00	8.80	C	Box		14.5
177	AA015	13/2	13.135	Box	2.90x0.90	13.40	F	Box		14.5
178	AA015	14/1	13.425	Box	3.50x0.80	13.40	F	Box		14.5
179	AA015	14/2	13.870	Box	2.00x0.50	14.00	F	Box		14.5
180	AA015	15/1	14.450	Box	0.90x0.50	12.80	F	Box		14.5
181	AA015	15/2	14.630	Box	3.10x1.60	13.90	F	Box		10.0
182	AA015	15/3	14.990	Pipe	dia. 0.60	8.60	E	Pipe		10.0
183	AA015	16/1	15.740	Box	3.00x0.60	12.60	F	Box		10.0
184	AA015	17/1	16.320	Pipe	dia. 0.60	12.00	B	Box	3.00x2.00	10.0
185	AA015	17/2	16.840	Pipe	2xdia. 0.60	8.80	A	Bridge	2x3.00x2.00	9.5
186	AA015	17/3	17.100	Box	3.00x0.50	11.50	F	Box		9.5
187	AA015	18/1	17.735	Box	1.20x1.20	11.10	F	Box		9.5
188	AA015	18/2	18.160	Pipe	2xdia. 0.60	9.25	E	Pipe		10.0
189	AA015	19/1	18.865	Box	3.10x0.65	9.00	C	Box		10.0
190	AA015	19/2	19.060	Pipe	dia. 0.60	9.20	B	Box	2.50x1.50	10.0
191	AA015	21/1	19.500	Box	1.40x0.60	8.90	C	Box		10.0
192	AA015	[21/1b]	19.510	Non		-	A	Bridge	2x3.00x2.00	10.0
193	AA015	21/2	20.625	Pipe	dia. 0.60	8.70	A	Bridge	2x3.00x2.00	10.0
194	AA015	23/1	22.460	Pipe	dia. 0.60	8.70	E	Pipe		10.0
195	AA015	[23/2]	22.700	Non		-	B	Box	3.00x2.00	10.0
196	AA015	25/1	24.420	Pipe	dia. 0.60	8.80	E	Pipe		10.0
197	AA015	25/2	24.660	Bridge	7.50x(1.45)	6.80	A	Bridge	3x2.50x2.00	9.4
198	AA015	27/1	26.850	Pipe	dia. 0.60	8.90	E	Pipe		10.0
199	AA015	28/1	27.850	Box	3.00x1.20	8.60	C	Box		10.0
200	AA015	28/2	28.080	Pipe	6xdia. 0.90	8.91	E	Pipe		10.0
201	AA015	29/1	28.210	Box	1.20x1.00	10.30	C	Box		10.0
202	AA015	[29/2]	28.220	Non		-	B	Box	2.50x1.50	10.0
203	AA015	30/1	29.220	Box	1.65x1.40	8.50	C	Box		10.0
204	AA015	31/1	29.625	Box	0.75x0.50	7.20	C	Box		10.0
205	AA015	32/1	31.260	Pipe	dia. 0.60	8.90	E	Pipe		10.0
206	AA015	32/2	31.900	Pipe	dia. 0.60	15.00	F	Pipe		10.0
207	AA015	32/3	32.000	Box	0.80x0.70	14.50	F	Box		10.0
208	AA015	33/1	32.325	Pipe	dia. 0.60	13.80	F	Pipe		10.0
209	AA015	34/1	33.250	Pipe	dia. 0.90	14.00	F	Pipe		10.0
210	AA015	35/1	34.650	Box	3.00x1.50	8.00	D	Box		10.0
211	AA015	35/2	35.185	Box	0.70x0.50	8.80	C	Box		10.0
212	AA015	36/1	35.580	Box	2.00x1.70	8.40	C	Box		10.0
213	AA015	36/2	35.620	Box	0.65x0.90	9.00	C	Box		10.0
214	AA015	36/3	35.730	Box	1.50x0.60	8.80	C	Box		10.0
215	AA015	37/1	36.390	Pipe	2xdia. 0.60	8.80	E	Pipe		10.0

TYPE-A : Construction of Bridge (Box Culvert Type)
TYPE-B : Construction of Box Culvert
TYPE-C : Extension of Existing Box Culvert (Slab Type)
TYPE-D : Extension and Re-deck of Existing Box Culvert (Slab Type)
TYPE-E : Extension of Exisiting Pipe Culvert
Type-F : Cleaning Work

12.4.2 Establishment of Design Policy for Roadside Drainage

Existing roadside drainage, which consists of earthen and concrete structures, is mainly installed on the Project road in town and suburb sections as shown in Table 12.4.1 and 12.4.2. The design policy for new additional drainage is established based on the following:

- There are two types of drains: (1) roadside drainage for connecting to existing culverts or streams, and (2) canals for connecting paddy field sections to streams.
- New additional canals shall be established in paddy field areas in order to prevent impacts arising from the blockage of existing canals due to the widening of the Project road.
- New additional roadside ditches shall be installed on town and suburb sections to ensure smooth traffic flows during heavy rains and to prevent damage to the road structure.
- Taking into consideration costs, construction of canals shall be carried out with wet masonry materials. The sizes of typical canals are given below.
  - Width = 1500mm, Depth = 500mm
  - Width = 2000mm, Depth = 750mm
  - Width = 3000mm, Depth = 1000mm
  - Width = 5000mm, Depth = 1500mm
- Construction of roadside ditches shall be carried out with concrete materials in consideration of road surface safety. The cover of drains will not be installed in principle. The size of a typical ditch is as follows:
  - Width = 500mm, Depth = 500mm

12.4.3 Establishment of Design Policy for Culverts and Bridges

There are three types of drainage structures on the Project road (i.e., slab/box type culverts, pipe culverts, and bridges) as shown in Table 12.4.3. Design policy for the new provision or reconstruction of drainage structures across the Project road are given below.

- On sections experiencing inundation or raised-up road sections, a new box culvert shall be designed instead of using the existing narrow pipe culvert or non-drainage structure. The required size of the opening of a new box culvert is determined based on the overflow discharge of that area.

- Corresponding to the wider Project road (carriageway and shoulder), existing drainage structures shall be extended as necessary.
- Severely exposed reinforced bars and/or deteriorated concrete of the deck slab of an existing culvert shall be replaced with a new RC concrete slab.
- Bridge-type structures, which are defined as having a span longer than 3m, with insufficient width for the Project road, or with deteriorated or damaged girders, shall be replaced with a multi-cell type box culvert structure, taking into account cost and soft ground conditions.
- New drainage structures for sections experiencing inundation shall be designed as a single- or multi- cell box culvert taking into consideration cost and the soft soil.

12.5 Road Facilities

12.5.1 Design Policy for Road Facilities

The necessary road facilities will be installed to ensure traffic safety, which are classified as follows:

- Traffic signs
- Traffic markings
- Ancillary facilities

Note that the above items include the following, respectively:

- Kilometer posts and signboards
- Pedestrian crossings, lane markings, traffic directional markers, culvert or bridge markers
- Concrete kerbs

The design policy for road facilities is given below.

- Adherence to existing standards so as not to confuse drivers
- Easily understood by users including the pedestrians
- Easily maintained

12.5.2 Traffic Signs and Markings

1) Rules for Traffic Signs

Rules for traffic signs are defined in the Manual in the section on Traffic Control Devices of the RDA. The height of poles for traffic signboards from the carriageway surface to the bottom of the signboard is stipulated to be 2.1m as shown in Figure 12.5.1, with the distance from the edge of the carriageway to the edge of the signboard stipulated as 1.5m. The size of a signboard is as indicated in Figure 12.5.2. Note that materials are in accordance with RDA standards, and each signboard is generally installed on a foundation of concrete block to ensure sufficient stability against being turned over.

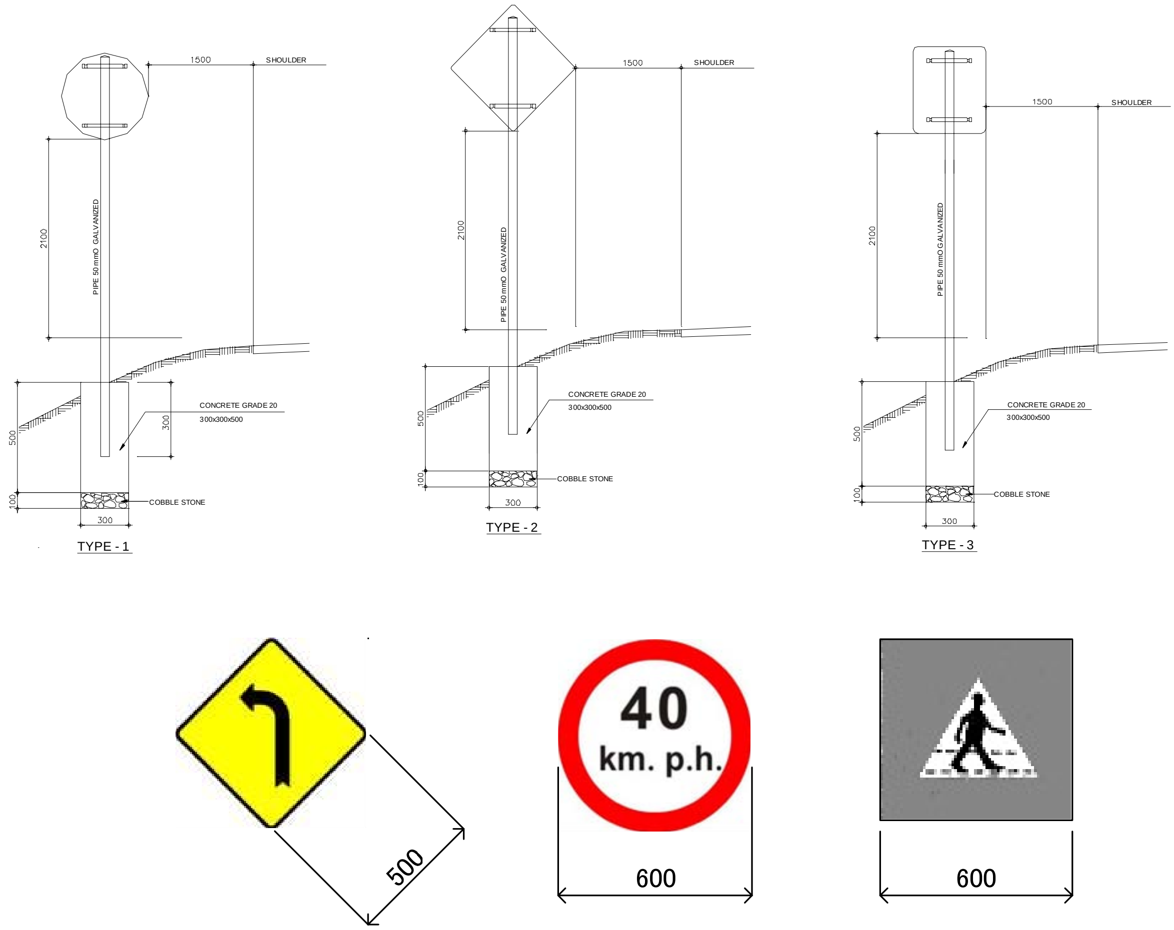
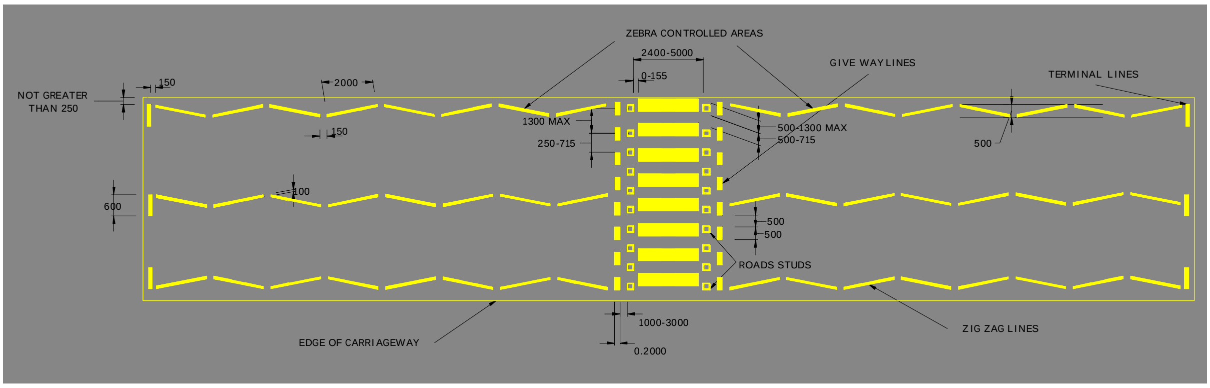


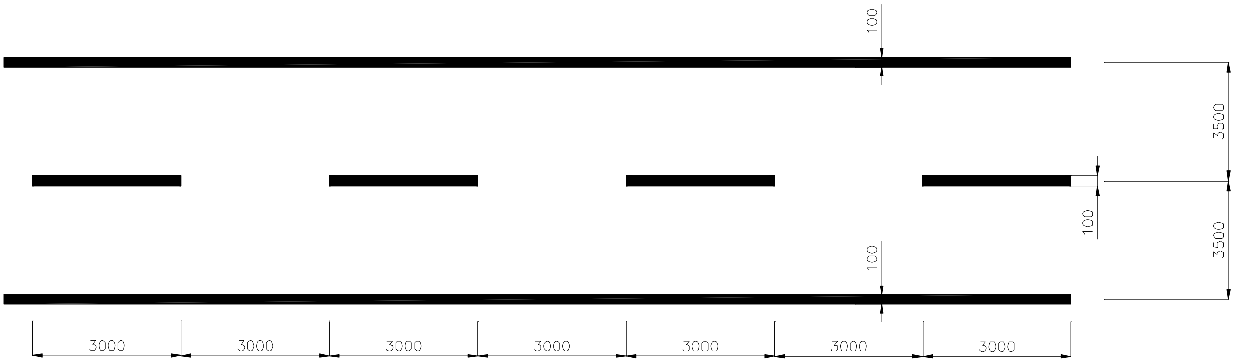
Figure 12.5.2. Size of Sign Boards

2) Rules for Markings

The existing method for line markings shall be applied to the Project road, which basically applies white-colored paint. Note that edge lines shall be marked on both edges of a carriageway with a single continuous line, and the centerline shall be marked in the center of the carriageway with dotted lines. Only pedestrian crossings will use yellow-colored paint. Typical line markings are as shown in Figure 12.5.3.



(1) Pedestrian Crossing



(2) Center Line and Edge Line Marking

Figure 12.5.3. Markings

12.5.3 Ancillary Facilities

A kerb is classified as an ancillary facility. In general, a kerb is made of pre-cast concrete or cast-in-situ concrete. Concrete used for pre-cast or cast-in-place units shall be Grade A or B in accordance with RDA specifications.

12.6 Preliminary Design Scenarios

The most suitable preliminary design scenario and its appropriateness from a costing viewpoint are examined in this section. This is considered sufficient as the social and environmental impacts of the Project road will be minimal.

12.6.1 Potential Scenarios

After considering past and ongoing projects, it was decided that there are three possible scenarios regarding the improvement of the Project road: (1) reconstruction; (2) asphalt overlay; and (3) asphalt overlay & aggregate base course (ABC). These scenarios are compared below.

12.6.2 Comparison of Scenarios

Scenario comparison is carried out as shown in Figure 12.6.1. As this figure indicates, the cost threshold between reconstruction and asphalt overlay in terms of pavement thickness is first determined. That is, the point at which the cost for reconstruction is as or less costly than asphalt overlay is derived. If reconstruction work is selected, then the entire Project road is rebuilt except for sections located in urban areas, which are simply overlaid with 50mm of asphalt. The reasons for only overlaying road sections in urban areas are: (1) these sections are in good condition; (2) reconstruction would have large adverse impacts on roadside residents and businesses; and (3) there are pre-existing drainage facilities.

On the other hand, if overlay work is selected, a further comparison is carried out to determine the most suitable type of overlay in terms of cost and structural strength. Note that in the case of overlay work reconstruction is still implemented, but only for areas prone to flooding that require the Project road be elevated. Based on prior road works in Sri Lanka, it was decided to compare the cost of an asphalt overlay with that of an asphalt overlay and an ABC. In the case of the latter, urban areas would still only be overlaid with 50mm of asphalt.

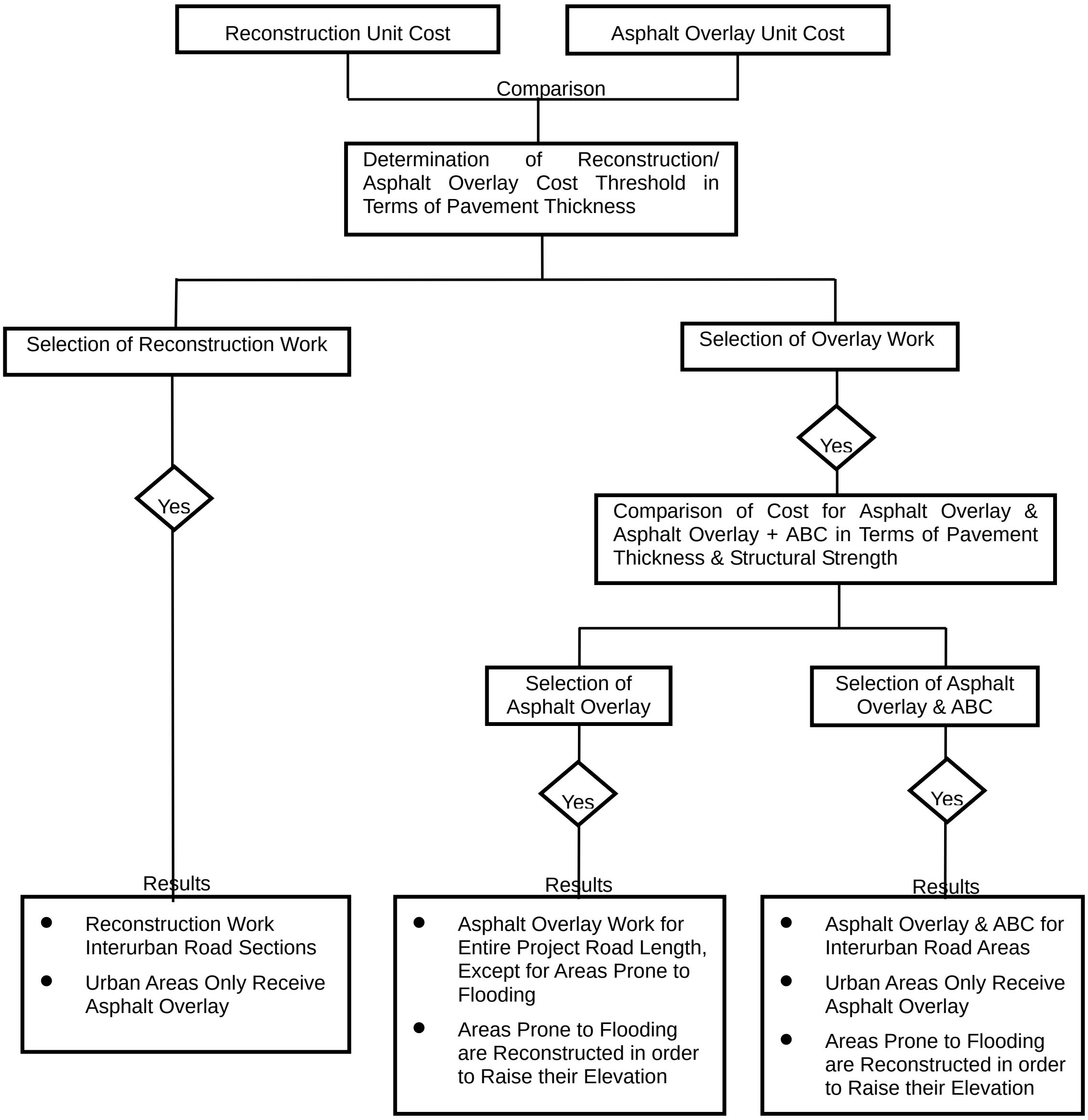


Figure 12.6.1. Process of Selecting Most Suitable Preliminary Design

12.6.3 Most Suitable Preliminary Design

Based on the process described in Section 12.6.2, the most suitable preliminary design is selected. First a comparison of the square meter unit cost for reconstruction and asphalt overlay is carried out as shown in Figure 12.6.2. As the figure indicates, it is less costly to overlay a road up to a thickness of 130mm than to reconstruct it. After this threshold is surpassed, it is more cost-effective to reconstruct a road then to overlay it. For this Project, the average overlay thickness required to improve the Study road is 80mm. Therefore, it has been decided that overlay and not reconstruction work will be implemented to improve the Project road.

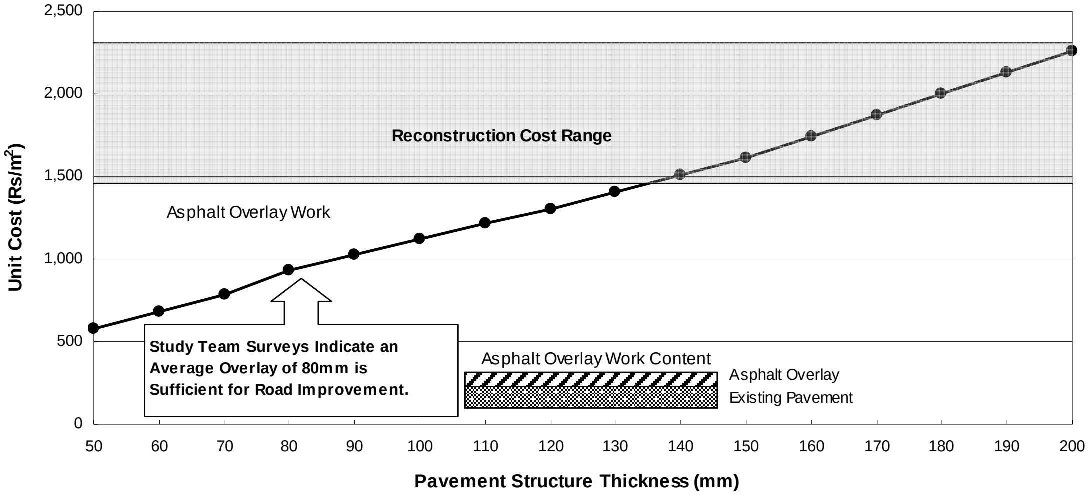


Figure 12.6.2. Reconstruction & Asphalt Overlay Unit Cost Comparison

Given the preceding, it is now necessary to compare whether asphalt overlay or asphalt overlay with an ABC is preferable. As Figure 12.6.3 shows, in terms of providing the same structural strength, the unit cost of asphalt overlay work is less costly than that of asphalt overlay + ABC for a pavement thickness of less than approximately 75mm. Since the average amount of overlay required to improve the Project road is 80mm, which will of course be exceeded on many sections, it is recommended that the asphalt overlay + ABC scenario be applied. Suitable pavement structure for this scenario for the different sections of road is illustrated in Figure 12.6.4. As mentioned previously, urban sections will only be overlaid only with asphalt and sections prone to flooding reconstructed, with these sections accounting for 24% and 7% of total road length, respectively. Note that a detailed breakdown of the application of this most suitable preliminary design to the Project road is shown in Table12.6.1.

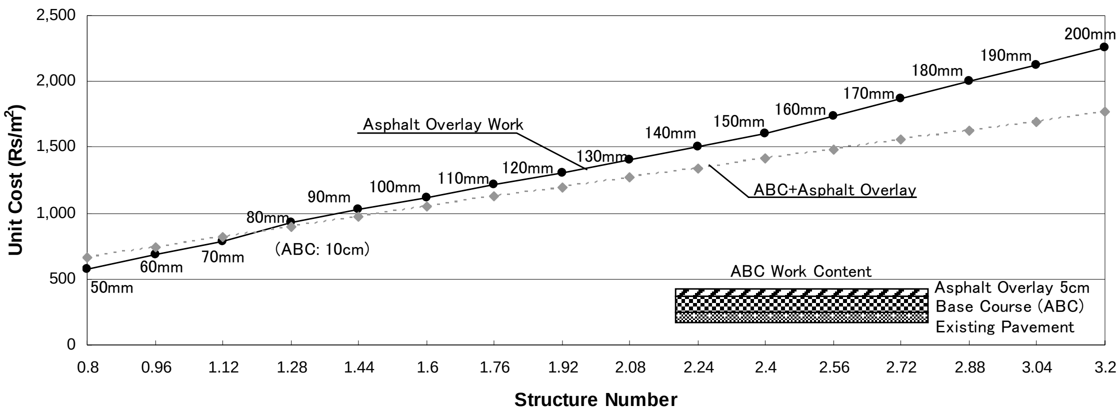


Figure 12.6.3. Asphalt Overlay & Asphalt Overlay +ABC Unit Cost Comparison

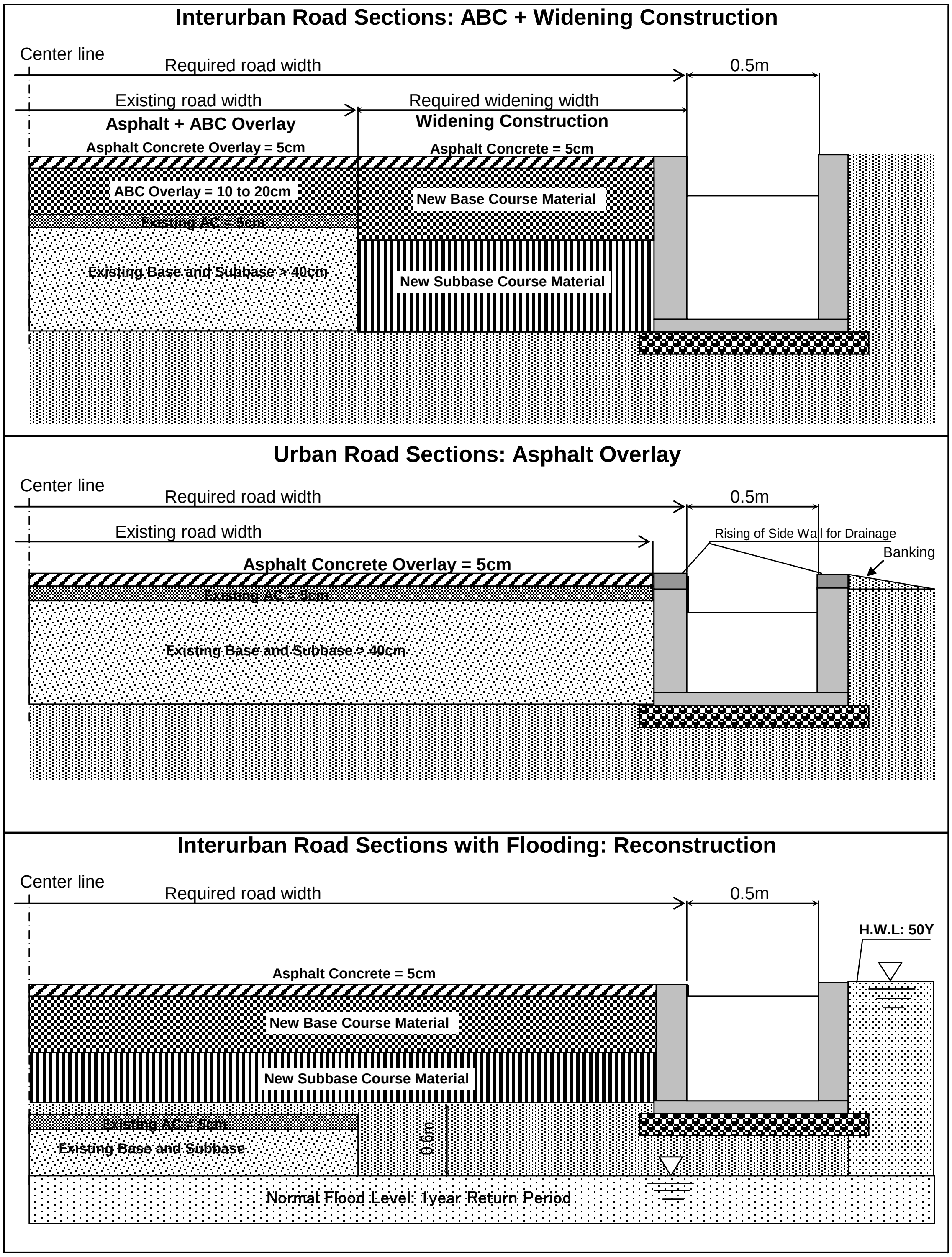


Figure 12.6.4. Suitable Pavement Structure

Table 12.6.1. Design Specifications for the Most Suitable Preliminary Design for the Project Road

No.	Road	Km-P	Proposed Pavement Composition	Subgrade Class	Traffic Class	Overlay (cm) AC	Overlay (cm) ABC	Reconstruction (cm) Base	Reconstruction (cm) Subbase	New Drain Facilities	Paving Image Plan	Return Period for Inundation Section	Remarks
1	A04	364.00	As Overlay+Widening Construction	S4	T4	5		20	40	O			
2	A04	364.86	As Overlay+Widening Construction	S4	T4	5		20	40				Akkaraipattu
3	A04	366.40	As Overlay	S4	T4	5							ditto
4	A04	366.72	ABC+Widening Construction	S4	T4	5	10	20	40	O			
5	A04	368.19	As Overlay+Widening Construction	S4	T4	5		20	40				Addalachchena
6	A04	369.11	ABC+Widening Construction	S4	T4	5	10	20	40	O			
7	A04	370.28	ABC+Widening Construction	S4	T4	5	10	20	40				Paddy
8	A04	370.88	ABC+Widening Construction	S4	T4	5	10	20	40	O			
9	A04	372.28	ABC+Widening Construction	S4	T4	5	10	20	40				Paddy
10	A04	373.00	ABC+Widening Construction	S3	T4	5	10	20	55				ditto
11	A04	375.00	ABC+Widening Construction	S4	T4	5	10	20	40				ditto
12	A04	376.98	ABC+Widening Construction	S5(a)	T5	5	10	20	30	O			
13	A04	378.00	ABC+Widening Construction	S5(a)	T5	5	10	20	30				Paddy
14	A04	378.54	ABC+Widening Construction	S4	T5	5	15	20	50	O			
15	A04	379.66	ABC+Widening Construction	S4	T5	5	15	20	50				Nintavur
16	A04	381.00	ABC+Widening Construction	S5(a)	T5	5	10	20	30				ditto
17	A04	383.00	ABC+Widening Construction	S5(a)	T5	5	10	20	30				
18	A04	383.59	As Overlay+Widening Construction	S5(a)	T5	5		20	30				Karativu, Kalmunai
19	A04	385.00	As Overlay+Widening Construction	S4	T5	5		20	50				ditto
20	A04	387.00	As Overlay+Widening Construction	S5(b)	T5	5		20	25				ditto
21	A04	388.02	ABC+Widening Construction	S4	T4	5	10	20	40	O			
22	A04	389.00	ABC+Widening Construction	S4	T4	5	10	20	40				
23	A04	389.40	ABC+Widening Construction	S4	T4	5	10	20	40				
24	A04	390.16	ABC+Widening Construction	S4	T4	5	10	20	40				
25	A04	390.82	ABC+Widening Construction	S4	T4	5	10	20	40	O			
26	A04	393.58	ABC+Widening Construction	S4	T4	5	15	20	40	O			
27	A04	395.32	-		T4								Periya Kallar CW
28	A04	395.92	ABC+Widening Construction	S4	T4	5	10	20	40				
29	A04	396.34	ABC+Widening Construction	S4	T4	5	10	20	40				
30	A04	397.37	-		T4								Koddaia Kallar CW
31	A04	397.94	ABC+Widening Construction	S5(a)	T4	5	10	20	25	O			
32	A04	399.00	ABC+Widening Construction	S5(a)	T4	5	10	20	25	O			
33	A04	400.84	As Overlay	S5(a)	T4	5							Puddiruppu
34	A04	401.11	ABC+Widening Construction	S4	T4	5	10	20	40				Kaluwanchikudi
35	A04	401.22	ABC+Widening Construction	S4	T4	5	10	20	40	O			Cheddipalaiyam
36	A04	403.00	ABC+Widening Construction	S4	T4	5	15	20	40	O			ditto
37	A04	405.00	ABC+Widening Construction	S3	T4	5	10	20	55	O			ditto
38	A04	407.00	ABC+Widening Construction	S4	T4	5	10	20	40	O			ditto
39	A04	409.00	ABC+Widening Construction	S4	T4	5	10	20	40	O			ditto
40	A04	411.00	ABC+Widening Construction	S4	T4	5	15	20	40	O			ditto
41	A04	413.00	ABC+Widening Construction	S5(a)	T4	5	10	20	25	O			ditto
42	A04	415.00	ABC+Widening Construction	S3	T4	5	20	20	55	O			ditto
43	A04	417.00	ABC+Widening Construction	S4	T4	5	10	20	40	O			ditto
44	A04	419.08	As Overlay	S4	T4	5							Talankuda
45	A04	421.00	As Overlay	S4	T4	5							ditto
46	A04	422.26	ABC+Widening Construction	S4	T4	5	10	20	40				
47	A04	423.42	As Overlay+Widening Construction	S5(b)	T4	5		20	15				Kattankudi
48	A04	425.08	Reconstruction	S4	T4	5	20	20	40				
49	A04	426.02	Reconstruction	S4	T4	5		20	40				
50	A04	426.12	-		T4	5							N. Kalladi Bridge
51	A04	426.66	Reconstruction	S4	T4	5		20	40	O			
52	A04	426.96	As Overlay+Widening Construction	S5(a)	T5	5		20	30				Batticaloa
53	A15	0.82	As Overlay+Widening Construction	S5(a)	T5	5		20	30				ditto
54	A15	1.57	ABC+Widening Construction	S4	T5	5	20	20	50	O			
55	A15	2.86	Reconstruction	S5(b)	T5	5		20	25	O		1Year	
56	A15	4.16	ABC+Widening Construction	S5(b)	T5	5	10	20	25	O			
57	A15	4.85	ABC+Widening Construction	S5(b)	T5	5	10	20	25	O			
58	A15	5.08	Reconstruction	S4	T5	5		20	50	O		1Year	
59	A15	8.82	ABC+Widening Construction	S4	T5	5	10	20	50				ditto
60	A15	9.09	ABC+Widening Construction	S4	T5	5	20	20	50				House
61	A15	9.12	ABC+Widening Construction	S4	T5	5	20	20	50	O			
62	A15	9.59	Reconstruction	S4	T5	5		20	50	O		1Year	
63	A15	10.02	ABC+Widening Construction	S4	T5	5	20	20	50	O			
64	A15	10.45	ABC+Widening Construction	S4	T5	5	20	20	50				Paddy
65	A15	10.88	ABC+Widening Construction	S4	T5	5	10	20	50				ditto
66	A15	11.56	Reconstruction	S4	T5	5		20	50			1Year	ditto
67	A15	12.00	ABC+Widening Construction	S4	T5	5	10	20	50				
68	A15	12.69	As Overlay+Widening Construction	S4	T4	5		20	40	O			Eravur
69	A15	14.63	ABC+Widening Construction	S4	T4	5	10	20	40				
70	A15	15.07	As Overlay+Widening Construction	S4	T4	5		20	40	O			Chenkaladi
71	A15	15.73	Reconstruction	S4	T4	5		20	40	O		50Year	
72	A15	16.83	As Overlay+Widening Construction	S5(b)	T5	5		20	25			50Year	Eastern U.
73	A15	17.74	ABC+Widening Construction	S5(b)	T5	5	10	20	25	O		50Year	
74	A15	19.00	Reconstruction	S4	T5	5	10	20	50	O		50Year	
75	A15	20.50	ABC+Widening Construction	S4	T5	5	10	20	50	O		50Year	
76	A15	21.00	Reconstruction	S4	T5	5		20	50	O		50Year	
77	A15	21.32	ABC+Widening Construction	S4	T5	5	15	20	50	O			
78	A15	23.00	ABC+Widening Construction	S4	T5	5	15	20	50	O			
79	A15	25.00	ABC+Widening Construction	S4	T4	5	15	20	40	O			
80	A15	29.00	Reconstruction	S3	T4	5	20	20	55	O		50Year	
81	A15	31.00	ABC+Widening Construction	S5(a)	T4	5	10	20	40	O			
82	A15	31.39	As Overlay	S4	T4	5							Valaichchenai
83	A15	33.25	ABC+Widening Construction	S5(a)	T4	5	10	20	40	O		50Year	
84	A15	33.44	Reconstruction	S5(a)	T4	5		20	40			50Year	
85	A15	33.90	-		T4								Oddaimavudi Bridge
86	A15	34.19	ABC+Widening Construction	S5(a)	T4	5	10	20	25	O		50Year	
87	A15	34.58	Reconstruction	S5(a)	T4	5		20	25	O		50Year	
88	A15	34.82	ABC+Widening Construction	S5(a)	T4	5	10	20	25	O			

: AC Overlay
: ABC
: Widening Construction
: Reconstruction

12.6.4 Appropriateness of Preliminary Design

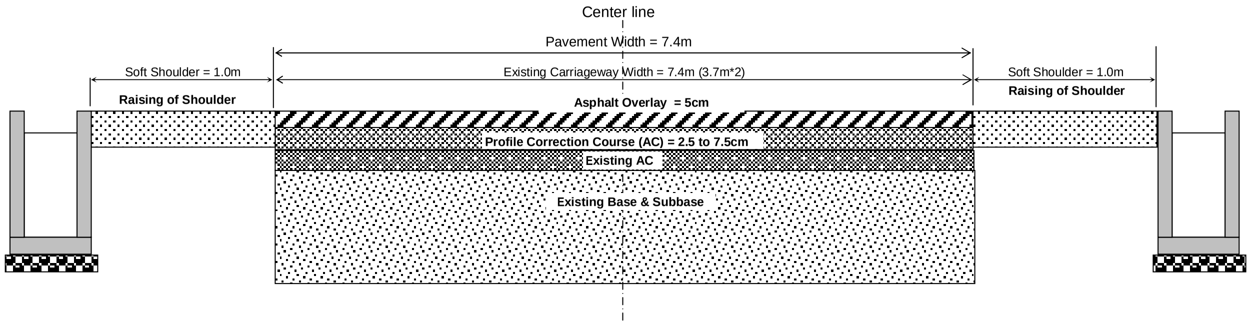
The appropriateness of the selected preliminary design is checked in terms of the cost of the technology to be applied, as environmental and social considerations have been deemed insignificant (see Chapter 9 for details). At the suggestion of the RDA, it was decided to compare the design and estimated construction cost of the Project road with the design and estimated construction cost of a project to rehabilitate the section of road between Nittambuwa and Kandy. Note that this comparison includes price escalation and physical contingency costs, but does not consider the cost for the relocation of utilities, design costs, or supervision costs.

As Figure 12.6.5 indicates, the unit kilometer cost for A Project (Rs. 22 million/km) is less than that of the Study Team's Project (Rs. 26 million/km). This is due to the fact that the scope of work for the former is significantly smaller than that of the latter. That is, A Project has no widening work, the road shoulders are unpaved, and only a simple asphalt overlay on an existing carriageway is carried out, while the Study Team's Project includes substantial amounts of widening (which provides for asphalt-concrete paved shoulders) and an asphalt-concrete overlay with an aggregate base course.

Given that the scope of work for A Project is significantly smaller than that of the Study Team's Project, it is natural for the unit km cost of the latter to be higher than that of the former. Therefore, in order to get a better feel for the actual costs of these two projects, the unit square meter cost for the paved portions of the respective roads were examined. As Figure 12.6.4 indicates, the unit square meter cost for the Study Team's Project road is actually lower than that of A Project road by about 12 percent.

As a result of the above analysis, it can be said that the proposed most suitable preliminary design for the Project road ensures a structure that is both technically sufficient and cost-effective.

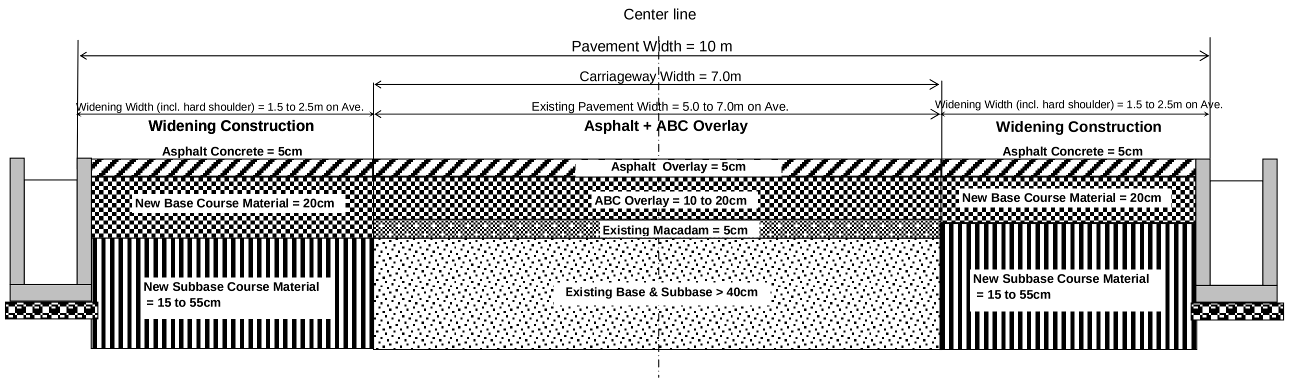
A Project



Evaluation Indices:

- **Cost/km: Rs. 22 million/km**
- **Pavement Area per 1km: Ave 7.4m x 1000m = 7,400 sq.m**
- **Cost per sq.m = Rs. 2,973/sq.m**

JICA Project : Recovery, Rehabilitation and Development Project for Tsunami Affected Trunk Roads on the East Coast



Evaluation Indices:

- **Cost/km: Rs. 26 million/km**
- **Pavement Area per 1km: Ave 10m x 1000m = 10,000 sq.m**
- **Cost per sq.m = Rs. 2,600/sq.m**

Note : 1) Costing includes price and physical contingencies.
2) The shoulder for the JICA project is paved while that for A project is unpaved. Despite this, the unit sq.m cost for the JICA project is approximately 12 % lower.

Figure 12.6.5 Comparison of A Project & JICA Road Rehabilitation Project Construction Cost

CHAPTER 13

Preliminary Design of New Kallady Bridge

Chapter 13 Preliminary Design of New Kallady Bridge

13.1 General

This chapter deals with the preliminary designs of road bridge alternatives for the New Kallady Bridge, which crosses the Batticaloa Lagoon on AA004. Based on an on-site reconnaissance and topographical, geological, and hydrological surveys, a review of the existing Kallady Bridge and the selection of a new route, geometric design, and preferable bridge structure type and span length from an economical viewpoint are carried out.

13.2 Conditions of the Existing Kallady Bridge

13.2.1 Site and Bridge Structure Conditions

AA004 is the most important trunk road in Eastern Province and connects the capital city Colombo on the West Coast with the main cities on the East Coast. Note that the existing Kallady Bridge is located on AA004 south of Batticloa and was constructed with one lane in the 1920s during the colonial reign of the United Kingdom. Although maintenance work ceased in 1987 due to the lack of a budget, serious deterioration has not been observed, and the Bridge still possesses sufficient strength. Furthermore, since it has enough freeboard against high water levels (refer to 10.3.3), it faces no problems with flooding.

13.2.2 Traffic Characteristics and Safety Conditions

1) Traffic Characteristics

The existing Kallady Bridge plays the role of both a community and trunk road. Most users are commuters and students riding on motorcycles and bicycles heading to the Batticaloa area where the commercial center is and to the south where there are many religious buildings and schools. Figure 13.2.1 shows the results of a traffic survey conducted.

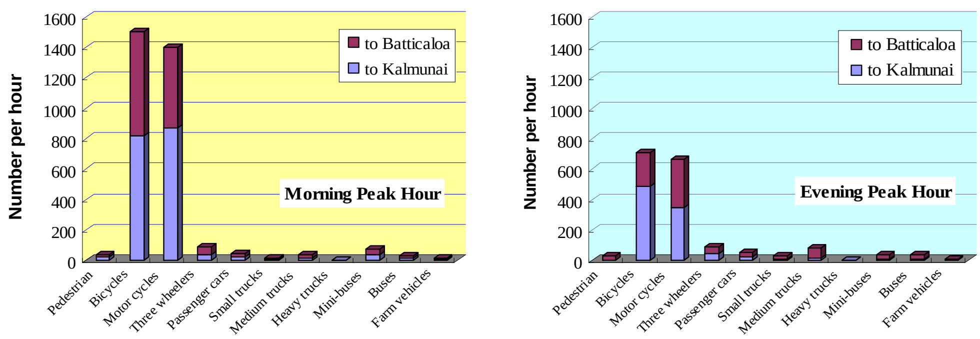


Figure 13.2.1. Results of Bridge Traffic Survey on a Weekday

2) Average Waiting Time

Since the existing Kallady Bridge is a one-lane structure, traffic has to take turns to cross it. Average waiting time is 3-6 minutes during off-peak times and 5-10 minutes during peak times according to the RDA Batticaloa District Office. The longest waiting time is about 10-15 minutes and can be observed when people are visiting religious facilities.

3) Traffic Safety

The annual number of traffic accidents on the existing Kallady Bridge based on documents submitted by the Batticaloa Police Station HQ is around ten. However, there are probably numerous minor accidents that occur but are not reported. Especially, during peak times when there is a mix of motorized and non-motorized traffic, traffic safety is rather poor (see Figure 13.2.2).

Figure 13.2.2. Interlaced traffic during the peak time

4) Traffic Restriction

No weight height limit has been set for the existing Kallady Bridge. On the other hand, it is not possible for a loaded trailer 4.3m in height to pass over the Bridge. Figure 13.2.3 shows the clearance and a loaded trailer.

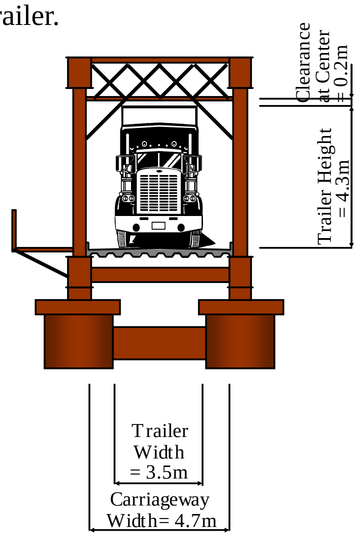


Figure 13.2.3. Clearance and Loaded Trailer

13.3 Basic Policy for Rehabilitation of Kallady Bridge

The existing Kallady Bridge has only one lane and therefore does not meet the standard for a Class A road and is a serious bottleneck. Moreover, because of the relatively large amount of traffic with its mix of slow and fast vehicles, as well as motorized and non-motorized traffic, it does not provide sufficient safety. On this basis, RDA decided as a basic policy that the New Kallady Bridge would have 2 lanes in accordance with the standard for a Class A road. On the other hand, it was decided that the removal of the existing Kallady Bridge would not be included in the Project, since it is not suffering serious structural deterioration and this would require an enormous amount of money and time. Note that another reason for RDA keeping the existing bridge is its historic background.

13.4 Examination of Bridge Location

13.4.1 Alternative Plans

A couple of alternatives for the location of the New Kallady Bridge were considered: a by-pass plan that would alleviate traffic jams in the center of Batticaloa and a route modification plan to improve the alignment on AA004 to AA015. However, in discussions with the RDA, it was concluded that land acquisition and resettlement should be minimized. Since the former plan is densely populated with housing, stores, religious facilitates, government offices and other buildings, it was decided that this plan is impractical. As for the latter plan, the alignment is adjacent to and parallel with the existing bridge and poses no problems regarding resettlement or relocation.

13.4.2 Examination of Adjacent Location to the Existing Bridge

Because of the army camp on the southern bank of the lagoon on the east side of AA004, a new bridge cannot be constructed on the seaside of AA004. On the other hand, there is government land with sufficient space on the other side. Although a church is located on the northern bank, it is possible to avoid land acquisition and relocation by setting the length and the longitudinal location of the new bridge to be the same as the existing bridge, and bending the alignment of the approach road in between. Under these conditions, the location of the new bridge has been decided to be on the western side of the existing bridge. Figure 13.4.1 shows the proposed alignment of the New Kallady Bridge and its approach roads.

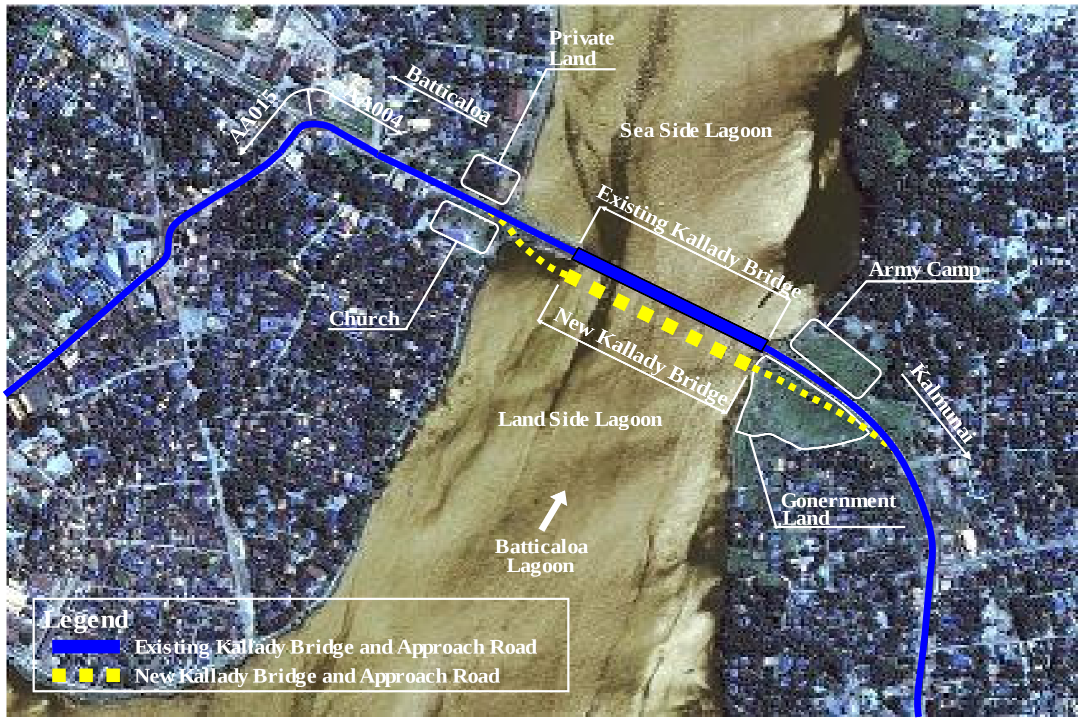


Figure 13.4.1. Proposed Alignment of New Kallady Bridge & Approach Roads

13.4.3 Selection of Optimum Location

The foundations of the new bridge will be constructed on the same line in the direction of the lagoon flow as those of the existing bridge (refer to 13.5.2). Accordingly, it is necessary to consider the impact of the new bridge's construction on the existing bridge and to secure sufficient distance between the new and existing bridges to avoid undesirable influences on each other. Generally, when studying adjacent bridge construction, consideration on the influence to the existing structure caused by ground displacement during the construction of new foundations is needed. In a worst-case scenario, the existing structure could collapse without due care.

In this Project, a plan was prepared in accordance with the Design and Construction Manual for Adjacent Foundations published by the Public Works Research Institute of Japan. Note that many governmental institutions have their own guidelines or specifications regarding adjacent construction. Note that since the Project is to be implemented as a design-build system, the Contractor can propose a different design from that of this report, which proposes cast-in-situ piles. For comparative purposes, the effective area of new bridge foundation construction in the case of cast-in-situ piles and caissons is shown below in Figure 13.4.2 and 13.4.3. In case of the open caisson, a distance of 20m is required for the space between the centerlines of carriageways of the new bridge and the existing bridge, taking into account the margin for error of construction. Furthermore, in this case, a distance of about 8m to be secured between the superstructures can be used for constructing the new superstructure and is advantageous for removing an existing bridge.

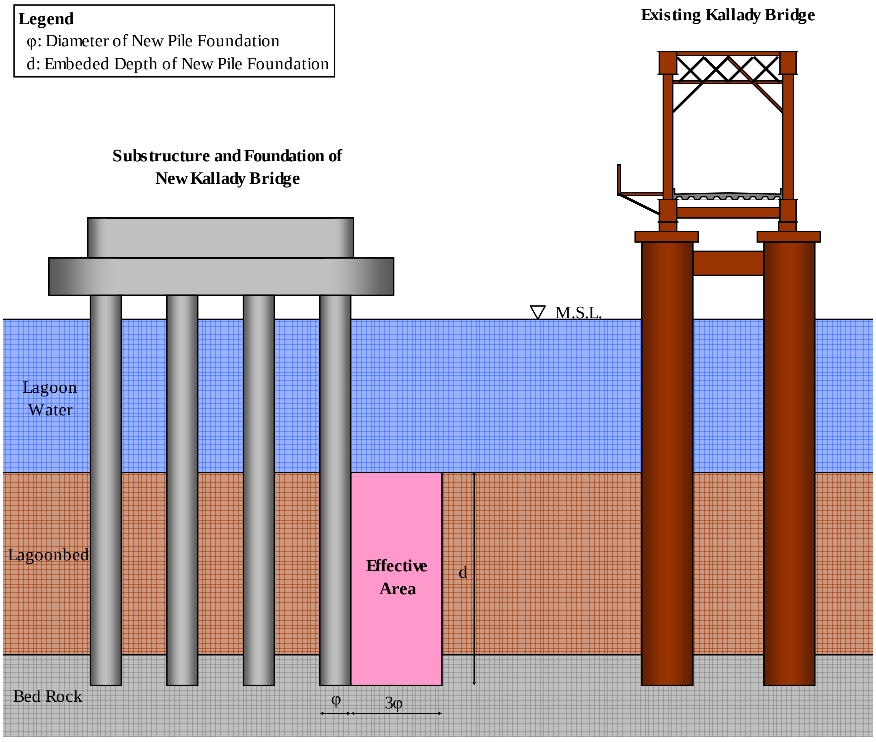


Figure 13.4.2. Effective Area of New Bridge Foundation Construction (Case of New Foundation being Cast-In-Situ Pile)

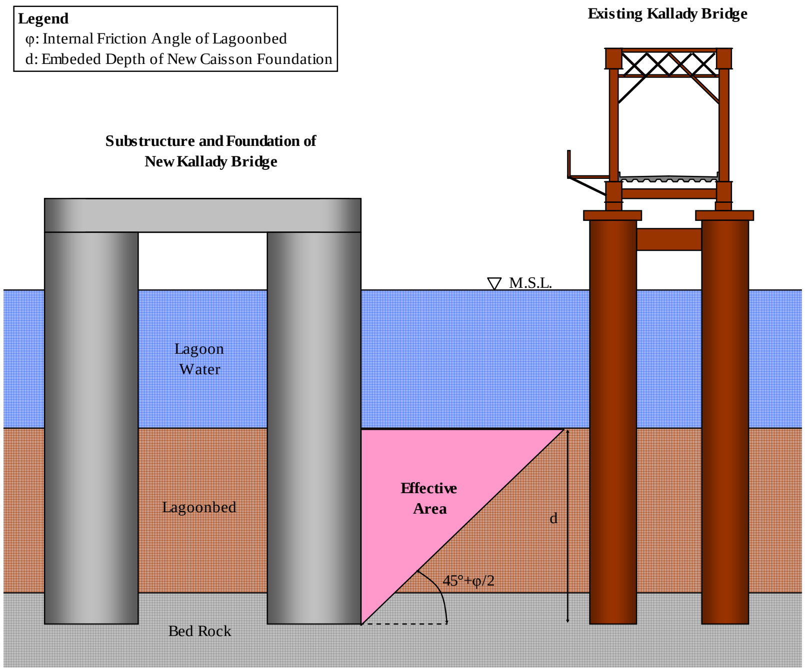


Figure 13.4.3. Effective Area of New Bridge Foundation Construction (Case of New Foundation being Caisson)

13.5 Preliminary Design of New Kallady Bridge

13.5.1 Applicable Design Criteria and Conditions

1) Geometric Design Criteria

The design criteria for the bridge structure and approach roads of the New Kallady Bridge are based on the RDA's 1998 Geometric Design Standard of Roads, and are summarized in Table 13.5.1.

Table 13.5.1. Summary of Geometric Design Criteria

Elements			Unit	Applicable Value		Basis of Application
				Bridge	Appr. Road	
Road Class			-	A (R3)		A (R3)
Classification of Road Location			-	Rolling		Rolling
Location			-	Open		Open
Design Speed			km/h	70		70
Width	Carriageway		m	2×3.7=7.4	2×3.5=7.0	Typical Width (2 lanes A Class Road)
	Cycle Lane/Hard Shoulder		m	2×1.5=3.0	2×1.5=3.0	
	Side Walk/Soft Shoulder		m	2×1.8=3.6	2×2.0=4.0	
	Total		m	14.0	14.0	
Cross Fall	Adverse Cross Fall		%	2.5	2.5	2.5 (Asphalt Pavement)
	Superelevation		%	-	2.5	Max. 6.0 (Built-up) Max. 8.0 (Open)
Max. Gradient			%	1.0	6.0	6.0 (Rolling)
Min. Curve Radius	Horizontal	Adverse Cross Fall	m	Infinity	Infinity	860 (Built-up) 1105 (Open)
		Superelevation	m	-	250	Min. 225
	Vertical	Crest	m	3000	1400	Min. 3000
		Sag	m	-	1600	Min. 1300
Min. Curve Length	Horizontal			-	80	Min. 40
	Vertical	Crest	m	60	60	Min. 60
		Sag	m	60	60	Min. 25

Note that the new bridge violates the minimum vertical curve radius for an approach road. This is due to the need for adjusting the structure to d the height of the existing road on the Batticaloa side.

2) Determination of Width

a) Applied Bridge Width

The proposed width of the carriageway is 7.4m (2@Lane3.5m+2@Shoulder0.2m) based on the typical cross section for a 2-lane bridge for a Class A road, with two 1.5m cycle lanes and two 1.8m sidewalks on both sides, resulting in the total width of 14.0m. Motorized and non-motorized traffic will be fully separated by installing a kerb that is in compliance with the RDA standard at the edge of the carriageway and cycle lane and sidewalk will be mounted up. Handrails of pre-cast concrete complying with the RDA standard will be installed at the edge of sidewalk for pedestrian safety. The bridge cross section is as shown in Figure 13.5.1.

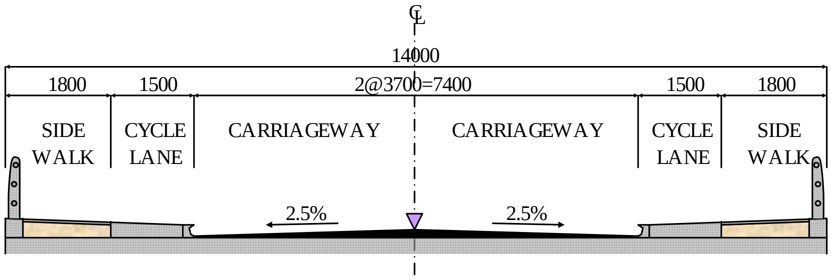


Figure 13.5.1. Bridge Cross Section

b) Applied Approach Road Width

The proposed width of an approach road is 7.0m (2@Lane3.5m) based on the typical cross section for 2-lane roads for a Class A road facility, with two 1.5m hard shoulders having the function of a cycle lane on either side and two 2.0m soft shoulders beyond that, resulting in a total width of 14.0m. The approach road cross section is as shown in Figure 13.5.2.

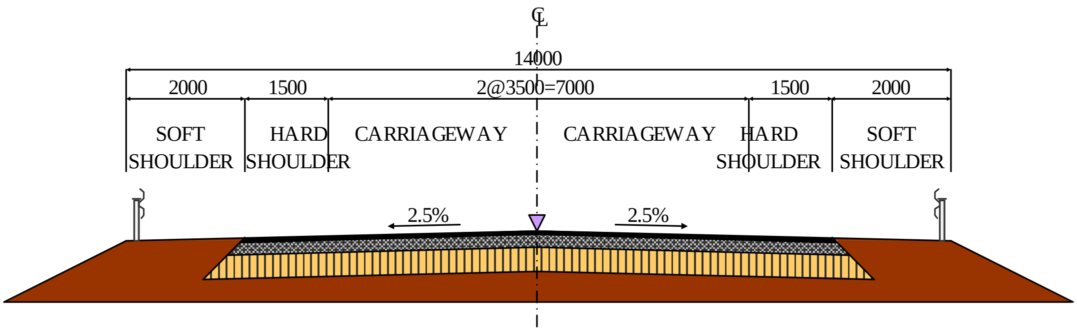


Figure 13.5.2. Approach Road Cross Section

3) Hydrological and Geological Design Conditions

The hydrological and geological design conditions for the bridge structure are summarized in Table 13.5.2.

Table 13.5.2. Summary of Hydrological and Geological Design Conditions

Items		Specified Values	Remarks
Hydrological Conditions	Lagoon	Batticaloa Lagoon	
	Discharge	2,160m^3/s	when H.W.L.
	High Water Level (Design Water Level)	1.42m (from M.S.L.)	100 years return period (RDA Bridge Design Manual)
	Normal Flood Level	0.55m (from M.S.L.)	1 years return period
	Mean Sea Level	0.00m	
	Max. Water Velocity	2.5m/s	100 years return period
	Min. Free Board	1.2m (from H.W.L.)	
	Local Scouring	2.0m (at Pier Foundations)	Calculated based on HEC (US Army Corps of Engineers)
	Required Min. Span Length (Reference Value)	31m	Japanese Standard (Regulation for River Facilities)
	Driftwood	Non	
Navigation Clearance	Min. Navigation Clearance	3.93 m (from M.S.L.)	Girder soffit height (Existing Bridge)
	Opening Height	3.38 m (from N.F.L.)	
Geological Conditions	Riverbed	Granular Soil	
	Bedrock	Un-weathered Gneiss (6-7m below riverbed)	

Items not mentioned in Chapter 10 but included in the above list are explained below.

a) Local Scouring

Local scouring of the bridge foundation should be estimated to identify the magnitude and depth of possible erosion in order to design countermeasures if necessary. Modified versions of Loursen’s live bed scour equation recommended by the Hydrological Engineering Center (HEC) of the US Army Corps of Engineers is applied. Note that the local scouring of the bridge foundation is around 2.0m and was estimated with the modified version of Loursen’s live bed scour equation given below.

$y_s = y_2 - y_0$

$y_2 = y_1 \times [Q_2/Q_1]^{6/7} \times [W_1/W_2]^{k1}$

Where,

y_s : Average depth of contraction scouring in m.

y_2 : Average depth after scouring in the contracted section (m). This is taken as the section inside the bridge at the upstream end in the HEC-RAS (Section BU)

y_1 : Average depth in the main channel or floodplain at the contracted section before scouring (m).

y_0 : Average depth in the main channel or floodplain at the contracted section before scouring (m).

Q_1 : Flow in the main channel or floodplain at the approach section that is transporting sediment (m^3/s).

Q_2 : Flow in the main channel or floodplain at the contracted section that is transporting sediment (m^3/s).

W_1 : Bottom width in the main channel or floodplain at the approach section (m). This is approximated as the top width of the active flow area in HEC-RAS.

W_2 : Bottom width of the main channel or floodplain at the contracted section less pier widths, m. This is approximated as the top width of the active flow area.

k_1 : Exponent for mode of bed material transport.

V_*/ω	k_1	Mode of Bed Material Transport
< 0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
> 2.0	0.69	Mostly suspended bed material discharge

V_* : $(gy_1S_1)^{1/2}$, shear velocity in the main channel or floodplain at the approach section, m/s

Ω : Fall velocity of bed material based on D_{50}, m/s

G : Acceleration of gravity, m/s^2

S_1 : Slope of the energy grade line at the approach section, m/m

b) Required Minimum Span Length (Reference)

The minimum span length required for flood control is calculated based on the Japanese Ordinance on the Structure of Facilities for River Management. Based on this, it was determined that a minimum length of 31m for the New Kallady Bridge is required. However, since this is a Japanese regulation, it should be used only as a reference for the span arrangement and the plan for the New Kallady Bridge should not be restricted by this result. The formula to calculate the minimum length stipulated in the Ordinance is as follows:

$L=20+0.005Q$

Where,

L: Minimum span length (m)

Q: Planning flood (m^3/s)

4) Bridge Design Criteria

For the bridge design criteria for the New Kallady Bridge, both the RDA's 1997 Bridge Design Manual and the BS 5400 are applied. The standards are supplemented with the following items with details given in subsequent sub-clauses.

- Design loads
- Properties of materials
- Stability analysis of pile foundation

a) Design Loads

Bridges shall be able to resist the effects of the loads listed below.

- Dead loads and superimposed dead loads
- Live loads
- Braking and traction of vehicle load
- Earth pressure
- Water current
- Temperature
- Shrinkage and creep
- Buoyancy

The following loads shall be considered in accordance with site conditions or structure type and the designer's judgment.

- Wind loads
- Floating debris and log impact

There is no record of earthquakes in Sri Lanka and therefore they are not taken into consideration in the design.

i) Dead Loads and Superimposed Dead Loads

The dead load, including self-weight, kerbs, handrails, and superimposed dead load, is calculated as in Table 13.5.2.

Table 13.5.2. Dead Load Intensity

Category	Item	Unit	Value
Dead load	Reinforced concrete	kN/m^3	25.0
	Pre-stressed concrete	kN/m^3	25.0
	Plane concrete	kN/m^3	23.5
	Asphalt pavement	kN/m^3	23.0
	Steel	kN/m^3	78.5
	Compact sand	kN/m^3	19.0
	Loose sand	kN/m^3	16.0
Super-imposed Dead load	Public Utilities	-	Proper weight

ii) Live Loads

HA loadings are applied in the design of all bridges and HB loadings for Class A and B roads are combined with HA loadings.

HA Load

Three kinds of HA loads are considered in the design:

- Nominal uniformly distributed load (UDL)
- Nominal knife-edge load (KEL)
- Single nominal wheel load alternative to UDL and KEL

HB Load

Only one HB loading is required to be considered on any superstructure or on any substructure supporting two or more superstructures. According to RDA's Bridge Design Manual, 30 units of HB loading should be applied in design.

HB and HA Loading combined

HB and HA loadings are combined and applied as specified in BS 5400 Part 2. However, note that the HB loading always straddles two (2) notional lanes in accordance with RDA's Bridge Design Manual.

Footway and Cycle Track Live Load

HB and/or HA loadings shall be applied in the design of sidewalks or footways and cycle lanes on bridges as specified in BS 5400 Part 2.

iii) Braking and Traction of Vehicle Load

Longitudinal Force

The longitudinal load resulting from traction or braking of vehicles shall be taken as the more severe of nominal loads of the HA or HB type that is applied to the road surface and parallel to it in one notional lane only.

Skidding Load

Horizontal load of 250 kN due to skidding shall be taken into account in the design using the HA load.

iv) Earth Pressure

Only active earth pressure acting on the abutment shall be considered, without taking into account the resistance by passive earth pressure.

v) Water Current

The horizontal force generated by water current shall be calculated according to the Bridge Design Manual of RDA.

vi) Temperature

Effective Bridge Temperature

Effective bridge temperature shall be considered in accordance with the RDA's Bridge Design Manual for continuous bridges in the calculation of temperature stress.

Frictional Bearing Resistance Force by Temperature Change

Ten percent of the dead load from superstructure shall be considered in the design of substructures (longitudinal direction). This value is the minimum friction coefficient of a gum type sliding bearing (Japanese design standards).

vii) Shrinkage and Creep

Loss of pressure by shrinkage and creep shall be considered in the calculation of pre-stressing force, bending moment and deflection of girders.

viii) Buoyancy

The appropriate water level shall be taken into account in computing the effect of buoyancy.

ix) Differential Settlement

Potential settlement difference between a structure having a pile foundation and the structure/approach road with a non-pile foundation shall be taken into consideration in designing.

b) Design of Structures

i) Design Class for Pre-stressed Concrete Structures

The bridges of this Project are located on a coastal area and are significantly affected by seawater. Hence, the bridges are to be designed as Class 1 structures.

ii) Properties of Materials

Concrete

Table 13.5.3. Concrete Strength

Classification	Characteristic Strength (N/mm^2)		Young's Modulus (kN/mm^2)	
	At transfer	Serviceability	At transfer	Serviceability
PC Box Girder	36	50	29.8	34.0
Abutment, Pier	-	40	-	31.0
Cast-in-situ RC Pile	-	40	-	31.0

Poisson's Ratio : 0.20

Temperature Coefficient : 12 * 10^{-6}

Stress-Strain Curve for Design : BS 5400 Part 4, Figure-1

Steel

Table 13.5.4. Steel Strength

Classification	Characteristic Strength (N/mm^2)		Young's Modulus (kN/mm^2)	
	At transfer	Serviceability	At transfer	Serviceability
G460	-	460	200	200
12S15.2B 12S12.7B	-	1,850	200	200
1S28.6 1S21.8	-	1,800	200	200

Poisson's Ratio: 0.30

Temperature Coefficient: 12 * 10^{-6}

Stress-Strain Curve for Design: BS 5400 Part 4, Figure 2 (Reinforcement), Figure 3 (PC Strand)

Constants of Backfill Soil

Internal friction of angle: φ = 30 degree

Unit weight: γ = 19 kN/m^3

Cohesion: c = 0 kN/m^2

c) Stability Analysis of Pile Foundation

The method for stability analysis for pile foundations is not specified in the BS 5400 and BS 8004. Hence, the displacement method, which is commonly used in Japan, is adopted. The pile reaction and amount of displacement can be calculated by the displacement method. Stability of piles is examined to ascertain the following 3 conditions:

- Axial compressive force on a pile does not exceed the allowable axial compressive bearing capacity of the pile.
- Axial pull-out force on a pile does not exceed the allowable pull-out capacity of the pile.
- Horizontal displacement of a pile does not exceed 15 mm to avoid plasticity of the ground.

i) Allowable bearing capacity of piles

The allowable bearing capacity of a pile is to be calculated in accordance with the equation set up in BS 8004 as follows:

Ultimate Bearing Capacity of a Pile:

$$R_u = f * A_s + A_b * q$$

Where, R_u: ultimate bearing capacity (kN)

A_s: surface of pile shaft (m^2)

A_b: area of pile tip (m^2)

F: average skin friction or adhesion per unit area of shaft in the condition of full mobilization of frictional resistance (kN)

Q: ultimate value of resistance per unit area of pile tip due to shearing stress of soil (kN/m^2)

$f * A_s = \Sigma f_i * U * l_i$

Where, f_i : skin friction (kN/m^2)

Sand $f_i = 5 * N$ ($f_i <= 200$)

Clay $f_i = 10 * N$ ($f_i <= 150$)

Skin friction of soft soil (N<=2) is to be neglected.

N: blow count of SPT

Allowable Bearing Capacity of a Pile:

$$R_a = 1/n * (R_u - W_s) + W_s - W$$

Where, R_a: allowable bearing capacity of a pile (kN)

N: safety factor (=2.5)

The safety factor 2.5 is normally used for foundation verification in the case of standard conditions. Therefore n = 2.5 is used for this design (Pile Design and Construction Practice, M.J. Tomlinson)

W_s: effective weight of soil to be replaced with a pile

W: effective weight of a pile in the ground

Allowable Uplift Capacity of a Pile:

$$P_a = 1/n * P_u$$

Where, P_a: allowable uplift capacity of a pile (kN)

n: safety factor (=6)

Safety factor 6 is normally used for verification of foundation in case of standard condition, therefore n = 6 is used for this design (Pile Design and Construction Practice, M.J. Tomlinson)

P_u: ultimate uplift resistance of a pile

$P_u = f * A_s$

ii) Allowable horizontal displacement

Horizontal displacement at the top of a pile shall be checked in order to prevent adverse effect on the superstructure and to avoid plasticity of the ground in front of the pile. The allowable horizontal displacement shall generally be less than 1.0% of the pile diameter or 15mm, whichever is bigger in order to assure safety against lateral force.

13.5.2 Examination of Preferable Bridge Length and Type

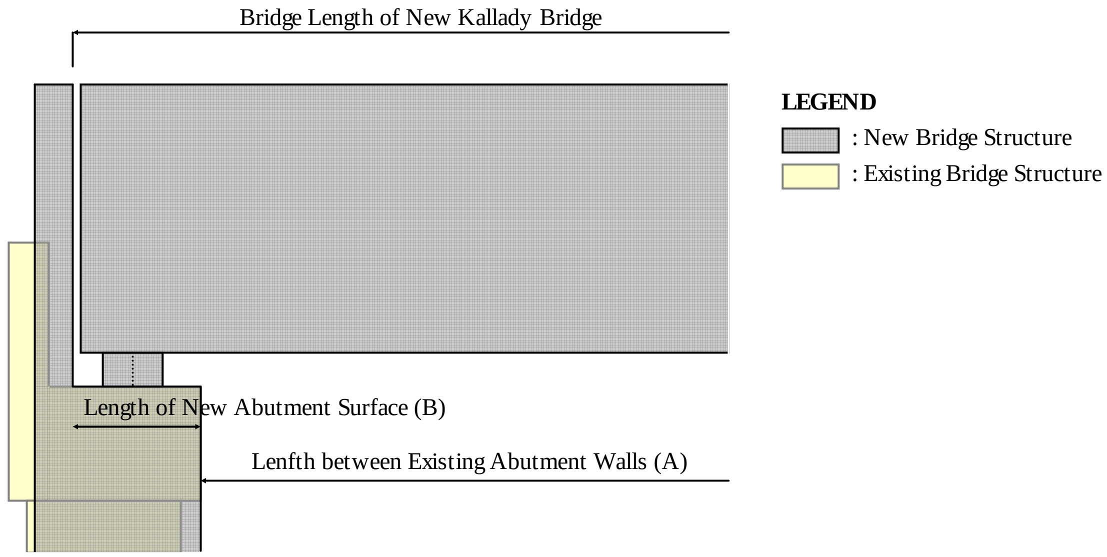
1) Determination of Bridge Length

As mentioned before, the existing Kallady Bridge has sufficient clearance above the high water level and there are no hydrological issues of importance. Therefore, it is not necessary to have the length of the New Kallady Bridge longer than that of the existing Kallady Bridge.

On the other hand, in case that the length of the New Kallady Bridge is shorter than that of the existing Kallady Bridge, it will be necessary to embank and construct the approach roads into the lagoon further than the existing bridge. This will result in the following issues:

- Since water depth at the New Kallady Bridge will be deeper due to the location of its abutment, countermeasures against erosion of the abutment and approach roads will be necessary.
- A narrower flow channel due to the embankment will cause erosion at the pier of the new and existing bridges.
- A change in the water flow in the lagoon will affect the ecosystem.

Based on the preceding analysis, it is proposed that the New Kallady Bridge have the same length as that of the existing Kallady Bridge(see Figure13.5.3 for details). Note that the front surface of the abutment of the new and exiting bridges will be on the same line in the direction of the flow of the lagoon. Therefore, the length of the New Bridge will be 289.5m.



Bridge Length of New Kallady Bridge = A+2B = 286.5+2×1.5 = 289.5m

Where,

A: Length between Existing Abutment Walls (mersured on the topographic data) = 286.5m
B: Length of New Abutment Surface = 1.5m

Figure 13.5.3. Calculation of Length of New Kallady Bridge

2) Selection of Bridge Types for Comparison Study

The New Kallady Bridge will be constructed in the immediate vicinity and upstream of the existing Kallady Bride. Therefore, the span length of the New Kallady Bridge is planned to be the same as the existing Kallady Bridge, which is approximately 48m. It is desirable for the sub-structure and foundation to be located on the same line as the existing Kallady Bridge in the direction of the flow of the lagoon for the following reasons:

- The required minimum span length (31m) can be secured only in case they are located on the same line.
- Impacts on the change in the flow and ecosystem of the lagoon can be minimized, and the same obstruction rate to the river can be maintained.

However, since the required minimum span length (31m) is based on a Japanese regulation, its application may not be suitable from a cost perspective. Therefore, the span length of the New Kallady Bridge should be selected based on the same plan as that of the existing Kallady Bridge (48m) and a plan half the length of the existing bridge (24m), taking into consideration the construction method and cost and maintenance cost. First, the case where the of span length is double that of the Existing Kallady Bridge, 96m, was investigated but eliminated, since it would obviously present difficulties in terms of construction and cost. Furthermore, although standard pre-tension PC girders are used widely in Sri Lanka, they are eliminated from the proposed plans for the following reasons:

(1) Reducing the number of sub-structures and foundations contributes to cost savings in case the water depth of the lagoon is as large as this site, and
(2) Post-tension obviously has an advantage to pre-tension in terms of tension efficiency in the case of the same span length.

The following four types of bridges were finally selected as candidates for comparison from the typical/economical span length of bridge types, as shown in Table13.5.5.

- Continuous PC Box Girder (Constant Height, Span Length 48m)
- Continuous Steel Plate Girder (Span Length 48m)
- Continuous Steel Box Girder (Constant Height, RC Slab, Span Length 48m)
- Connected PC I-Shaped Girder (Span Length 24m)

3) Comparison Study of Bridge Types

a) Superstructure

The constructability, initial construction cost and maintenance cost are compared for four types of superstructure as mentioned above in 2). The general results are shown below in Table 13.5.6.

Constructability/Construction Period

Superstructures will be installed from the back of the abutment for all types because of the depth of the lagoon (from 6 to 7 m), as the construction cost of the temporary road and landing bridge would be quite high. The launching construction method is selected for the two types of steel girder bridge. Launched construction is a method where girders are manufactured in a factory and then erected on the back of the abutment. On the other hand, the extruded construction method is selected for continuous PC box girders. The extruded construction is a method to install box girders on the back of the abutment, perform tensioning and erect girders gradually by pushing forward. For connected PC I-shaped girders, an erection girder construction method is selected. It is a method to build girders on the back of the abutment, perform tensioning and install them span by span from the back of the abutment using an erection girder.

Since steel girders are fabricated in a factory, their constructability is better than that of others. However, the horizontal members of steel girders need to be built, bolted together, and painted on site together with slab work. Contrarily, since slab work on site is not necessary for continuous PC box girders, continuous PC box girders are more reliable and safer than steel girders. For connected PC I-shaped girders, there is much on site work, such as that for the cross girders, although the formwork for the base slab can possibly be omitted. Therefore, the constructability of connected PC I-shaped girders is no better than that of steel girders.

The construction period for steel girders is slightly shorter than that for continuous PC box girders. The construction period for connected PC I-shaped girders is longer than that of all other types due to the larger number of substructures and foundations.

Initial Construction Cost

The initial construction cost for continuous PC box girder is the lowest since everything is available in Sri Lanka except the post tension cable system. For steel girders, the initial construction cost is higher because materials, manufacturing and transportation need to be procured from abroad. For connected PC I-shaped girders, the cost for superstructure work is the lowest, but the number of substructures and foundations is large. As a result, the overall cost for connected PC I-shaped girders is slightly higher than that for continuous PC box girders.

Maintenance Cost

For the two types of PC girder bridges, except for accessory facilities such as expansion joints and bearings, they are maintenance free. On the other hand, the two types of steel girder bridges require repainting in addition to the maintenance of accessory facilities, and the maintenance cost for steel girder bridges is higher than that for PC girder bridges.

Overall Evaluation

The two types of steel girder bridges are slightly better than the PC girder bridges with respect to the construction period. However, considering constructability, initial construction cost, and maintenance cost, it is concluded that the continuous PC box girder is the most appropriate design for the New Kallady Bridge.

Table 13.5.5. Typical/Economical Span Length of Bridge Types

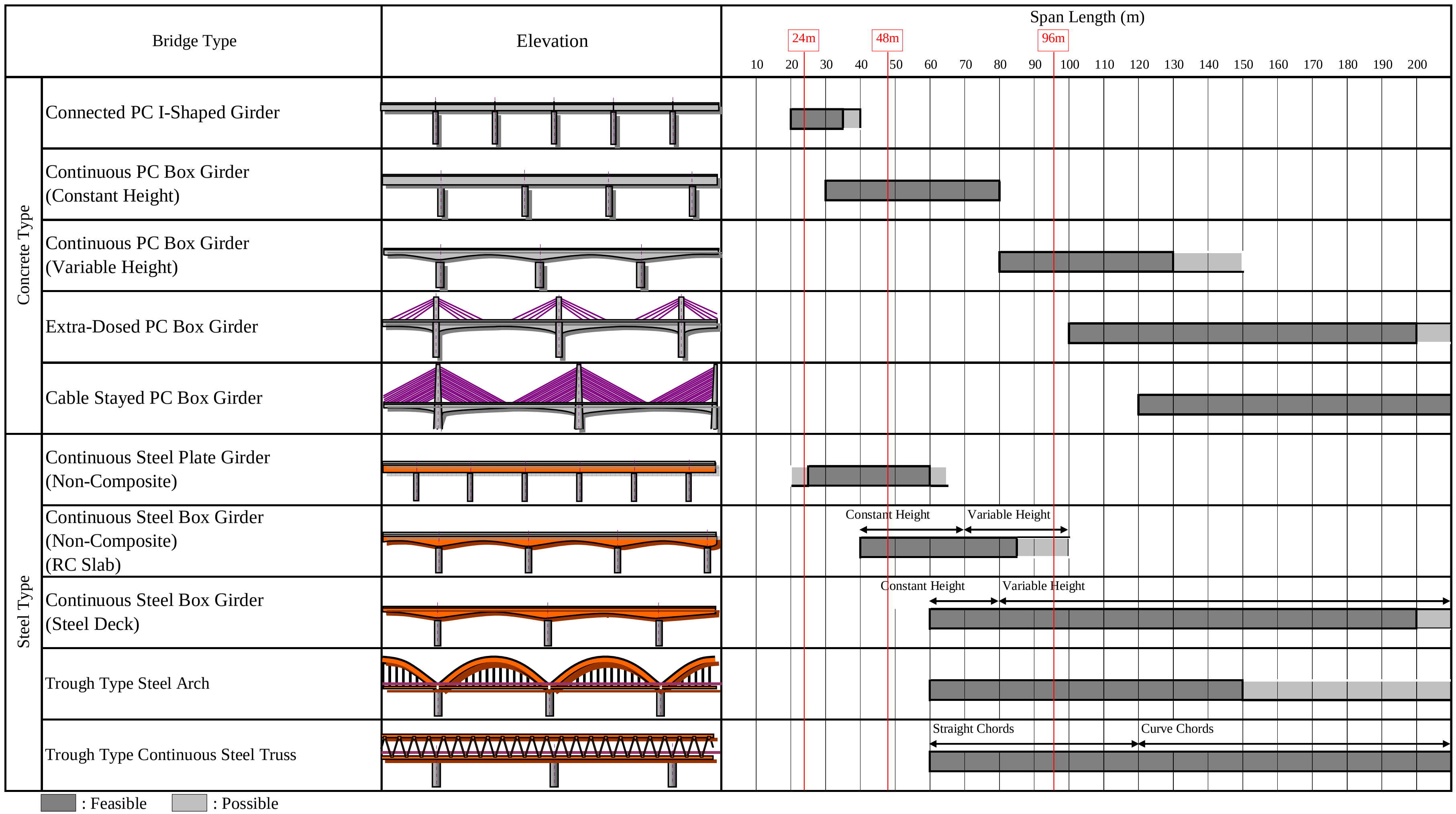
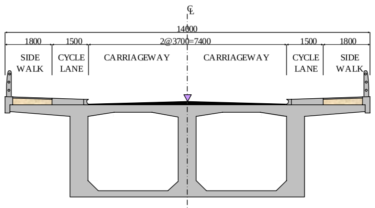
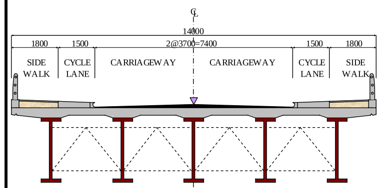
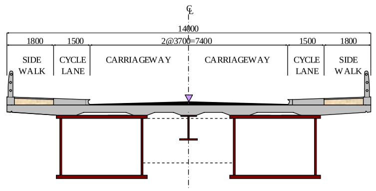
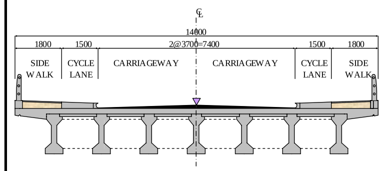


Table 13.5.6. Comparison Study of Superstructure Types for New Kallady Bridge

Alternatives	1		2		3		4	
Structure Type (Composite/Non) (Section) (Others)	Continuous PC Box Girder - (Constant Height) (Precast & Post-Ten. at Const. Yard)		Continuous Steel Plate Girder (Non-Composite) - -		Continuous Steel Box Girder (Non-Composite) (Constant Height) -		Connected PC I-Shaped Girder (Composite) - (Precast & Post-Ten. at Const. Yard)	
Outline View								
Span Arrangement	0.600+6@48.050+0.600=289.500m						0.600+12@24.025+0.600=289.500m	
Constructability/ Const. Period	Extruded const. is suggested. Const. period is longer than steel girders due to inefficiency of the girder casting and erection. Superst. works are unnecessary at the planned position.	○	Launched const. is suggested. Const. period is shorter than concrete girders due to efficiency of the girder fabrication and erection. However field splicing and slab work are necessary at the planned position.	◎	Launched const. is suggested. Const. period is shorter than concrete girders due to efficiency of the girder fabrication and erection. However field splicing and slab work are necessary at the planned position.	◎	Erection girder const. is suggested. The period is the longest in all of the alternatives due to the number of subst. and complicated works of superst. at the planned position such as girder connection and cross girder works.	△
Initial Const. Cost	Cost of superst. is lower than steel girders. The subst. & foundation is slightly higher than steel girders due to weight of the girder.	◎	Cost of superst. is higher than concrete girders due to import the girder. The subst. & foundation is the lowest in all of the alternatives.	○	Cost of superst. is higher than Steel Plate Girder due to the girder weight. The subst. & foundation is lower than concrete girders.	△	Cost of superst. is the lowest. The subst. & foundation is extremely higher than other alternatives due to those numbers.	○
Maintenance	No maintenance work are required except for accesory facilities such as expansion joints and bearings.	○	Add to maintain accessory facilities, repainting for steel members is also required.	△	Add to maintain accessory facilities, repainting of steel members is also required.	△	No maintenance work are required except for accesory facilities such as expansion joints and bearings.	○
Overall Evaluation	Most appropriate plan suggest from the viewpoint of economic and constructability.	◎	Const. cost is higher than PC Box Girder. Maintenance cost is also high due to repainting for the steel members.	○	Const. cost is extremely high in all of the alternatives. Maintenance cost is also high due to repainting for the steel members.	△	Const. cost is higher than PC Box Girder. Const. period is the longest in all of the alternatives.	△

◎: Very good ○: Good △: Poor

b) Substructure and Foundation

The constructability, initial construction cost, and maintenance cost for the four types of substructures and foundation works mentioned above in (2) are compared. The general results are described as below and in Table 13.5.7.

Constructability/Construction Period

For all types of substructure and foundation, a jetty will be installed in the lagoon due to its depth (from 6 to 7 m), as the construction cost for a temporary road and landing bridge is quite large for the superstructure.

Considering constructability, the wall type RC pier with a cast-in-situ protruding RC pile (hereon referred to as "Althernative-1") is the most superior design since it does not require any large-scale temporary works. About the pile cap, construction is easy to do in the dry season as long as 1.0 m from the M.S.L. is ensured. On the other hand, for the pile bent type RC pier (hereon referred to as "Alternative-2"), since it is difficult to precisely extend piles above the water surface, the reliability of Alternative-2 is less with respect to precision and simplicity. On the other hand, the construction period of Alternative-2 is shorter than Alternative-1 due to the greater concrete volume of the latter.

Large-scale temporary coffering is required for the wall type RC pier with cast-in-situ RC piles (hereon referred to as "Alternative-3") and for the RC beam type with cast-in-situ RC caissons (hereon referred to as "Alternative-4"). As a result, the construction period for these two types is much longer than for the other two types above.

Initial Construction Cost

Initial construction cost for Alternative-2 is slightly less than Althernative-1 due to the difference in the volume of concrete. The costs for Alternatives-3 and -4 are higher than the other two alternatives due to the number and construction period for temporary works.

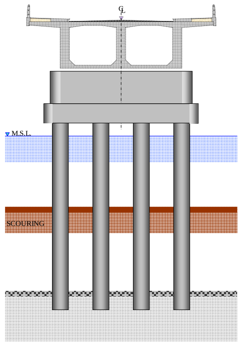
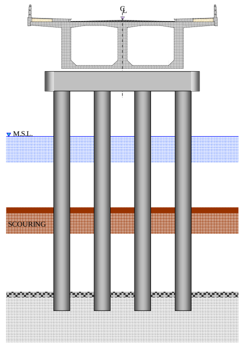
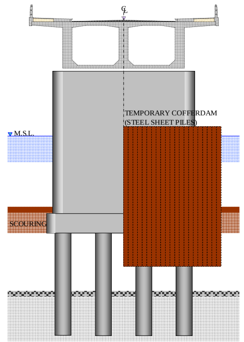
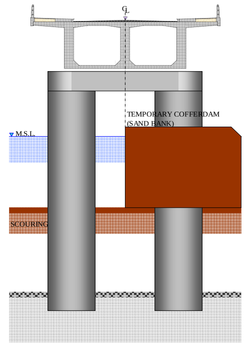
Maintenance Cost

Regular maintenance of scouring is required for all types.

Overall Evaluation

Although Alternative-2 is slightly better with respect to construction period and initial construction cost, Alternative-1 is the most appropriate design for the New Kallady Bridge taking into account constructability.

Table 13.5.7. Comparison Study of Substructure and Foundation Types for New Kallady Bridge

Alternatives	1		2		3		4	
Structure Type	Wall Type RC Pier with Cast in Situ Protrusion RC Pile		Pile Bent Type RC Pier (Cast in Situ RC Pile)		Wall Type RC Pier with Cast in Situ RC Pile		RC Beam with Cast in Situ RC Caisson	
Outline View								
Constructability/ Const. Period	Const. period is slightly longer than Pile Bent Type RC Pier. The pile cap can construct in dry season as long as keep min. 1.0 meter height from M.S.L. to the pile cap bottom.	○	Const. period is the shortest in all of the alternatives. However, it is difficult to extend piles precisely which are on the casted piles.	△	Pile cap is located below the water level, steel sheet pile cofferdam is necessary to install so the const. period is extended.	△	Const. of caisson is necessary to build sand bank higher level than the water level. The const. period is extended due to installation for casted concrete step by step.	△
Initial Const. Cost	Const. cost is slightly higher than Pile Bent Type RC Pier due to increase the concrete volume.	○	Const. cost is the lowest in all of the alternatives.	◎	Const. cost is high due to installation cofferdam of steel sheet piles and necessary long const. period.	△	Const. cost is high due to installation cofferdam of sand bank and necessary long const. period.	△
Maintenance	Maintenance of riverbed scoured around piles is necessary periodically.	△	Maintenance of riverbed scoured around piles is necessary periodically.	△	Maintenance of riverbed scoured around column and pile cap is necessary periodically.	△	Maintenance of riverbed scoured around caissons is necessary periodically.	△
Overall Evaluation	Most appropriate plan suggest from the viewpoint of economic and constructability.	◎	Most economical plan in all of the alternatives. However, the reliability of const. precision is inferior to the other alternatives.	△	Const. cost is high due to installation cofferdam of steel sheet piles and necessary long const. period.	△	Const. cost is high due to installation cofferdam of sand bank and necessary long const. period.	△

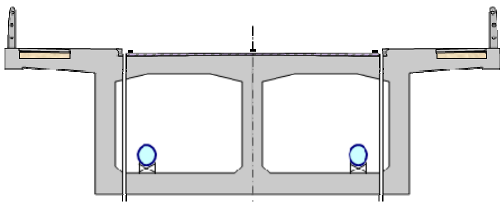
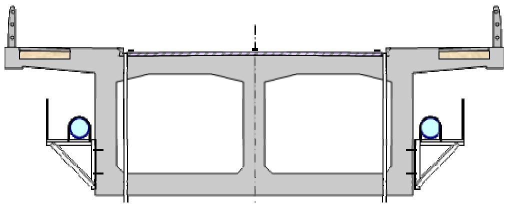
◎: Very good ○: Good △: Poor

13.5.3 Public Utility Plan

1) Water Pipe Line

Water pipe lines (2pipes × diameter of 450mm) are being planned for the New Kallady Bridge by the "National Water Supply and Drainage Board" as part of an ADB Project. Based on the comparative analysis in Table 13.5.8, it is recommended that these water pipes be installed on the outside of the box girders and not the inside.

Table 13.5.8. Comparison of Location of Water Pipe Line on the Bridge

Alternative	Cross Section	Remarks
Alternative-1 Setting at inside of the box girder		- Economical for setting - Easy operation of pipe - Hard to monitor the pipe line condition - Hard to secure the structure from the water leakage
Alternative-2 Setting at outside of the box girder		- Easy to find unusual condition of pipe - Completely protect from water leakage of the pipe line - Initial cost is higher than Alternative-1 - Maintenance cost for re-painting of metal supports are required

2) Road Lighting

Road lighting will be installed on the New Kallady Bridge using electrical bulbs similar to that of the existing bridge. The proposed arrangement of the road lighting poles on the New Bridge is shown in Figure 13.5.4. The lighting pole bases shall be erected on the outside of curbs upright between the handrails for easy installation and operation. The interval recommended for lighting poles is 48m the same as the new bridge span length and just above piers and abutments.

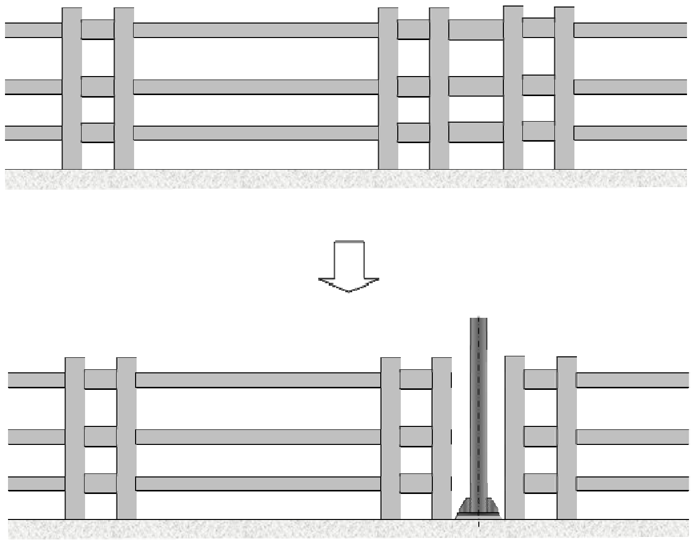


Figure 13.5.4. Installation Plan for Road Lighting Poles between Handrails

3) Other Utilities

The following public utilities are considered for possible installation in the PVC conduit pipe (ϕ 100mm) buried under the footpath of the mounted-up sidewalk of the bridge.

- Electric cable for road lighting
- Electric lines
- Communication lines

13.5.4 Outline of Bridge Plan

The structural facilities planned on the basis of this preliminary design are as shown in Table 13.5.9 and Figure 13.5.5.

Table 13.5.9. Facility Plan

Items				Plan
Improvement Method				The bridge will be constructed at parallel with the existing bridge
Bridge Design	Length	Bridge Length		289.5m
		Span Arrangements		6@48.05m
	Type	Superstructure		6-spans continuous PC box girder (extruded construction)
		Abutments		RC reversed-T type
		Piers		RC wall and pile cap (oval shape)
		Foundation	Pier	Cast-in-situ protrusion RC pile with steel tubular pipe (dia. 1.2m)
			Abutment	Cast-in-situ RC pile (dia. 1.2m)
		Pavement	Carriageway	Asphalt concrete
			Cycle Lane	Cast-in-situ concrete
			Sidewalk	Pre-cast concrete panel
	Accessory	Expansion Joint		Steel finger type joint on A1 and A2 abutments
		Bearing		Elastic rubber type bearings
Riverside Protection		Bank Protection		A1 side: soil embankment A2 side: grouted riprap
		Riverbed Protection		Non
Incidental Facilities		Safety Barriers	Handrail	Pre-cast concrete rail (Sri Lankan typical type)
			Kerb	Pre-cast concrete kerb at edge of sidewalks
		Drainage		Steel pipe type vertical drain
		Road Marking		Center and shoulder lines
Utility Plan		Road Lighting Poles		Keep spaces in handrail for future installation
		Water Pipe		Water pipes (2×dia.450mm) will be installed on brackets of both outsides of girder web
		Utility Space		Future installation space under mounted-up sidewalks
Approach Road		Length		Kalmunai side: approx. 145m Batticaloa side: approx. 105m
		Pavement		Asphalt concrete
		Bank Protection		A1 side: Soil embankment A2 side: Wet masonry (grouted riprap)
		Safety Barriers		Steel guard rail on embankment higher than 2m

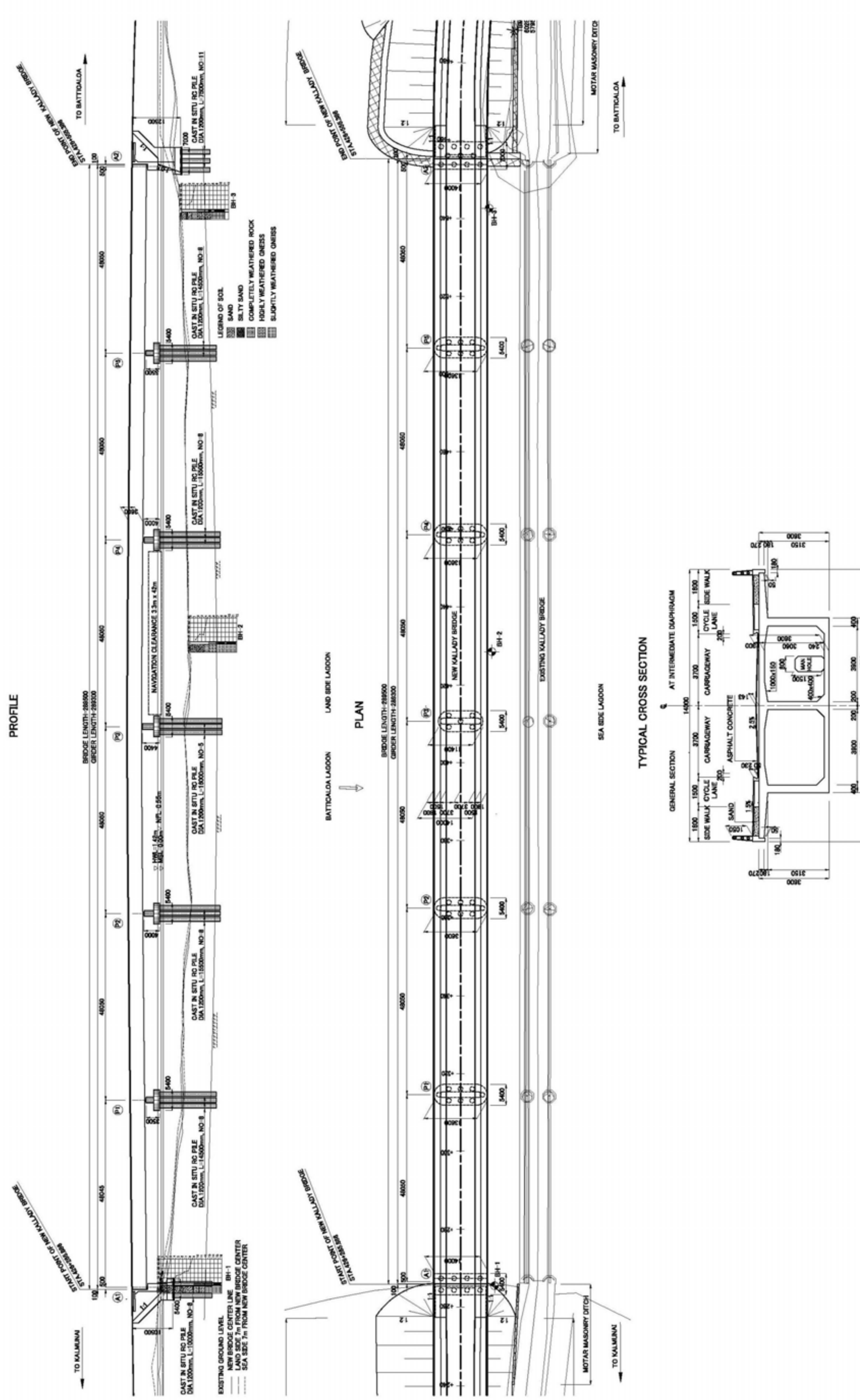
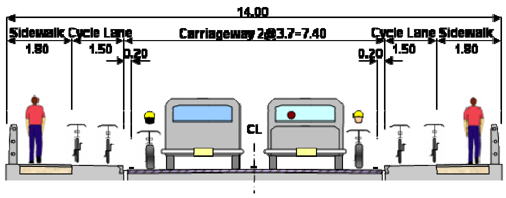
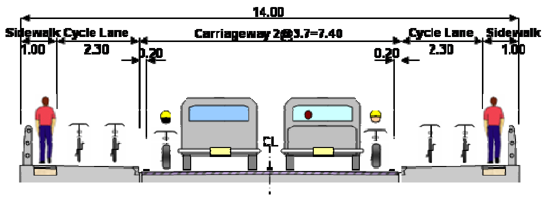
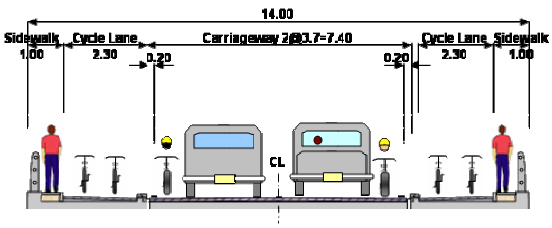


Figure 13.5.5. Outline Drawing of New Kallady Bridge

13.6 Suggestions for Next Stage

The cross section of the New Kallady Bridge will consist of a dual carriageway (2×3.7m) as stipulated in RDA’s “Bridge Design Manual” and the sidewalks and cycle lanes shall be 2×3.3m, meaning that the total width of the Bridge shall be 14.0m. The footpath and cycle lanes are planned for both sidewalks. The sidewalk layout and type are determined by actual traffic count survey results shown in Figure 13.2.1. The cycle lane shall be segregated from vehicles and motorcycles due to the difference in running speeds and for cyclists’ safety. As shown in Table 13.6.1, Alternative-1 or -2 shall have mounted-up belts for the sidewalk and cycle lane in order to prevent motorcycles and bicycles from crossing into each other’s lane.

Table 13.6.1. Comparison of Side Lane Combination on the Bridge

Alternatives	Cross Section	Remarks
Alternative-1		- Mounted-up sidewalk for pedestrians and bicycles Recommended
Alternative-2		- Mounted-up sidewalk for pedestrian and bicycle - Minimized footpath width of 1.0m Recommended
Alternative-3		- Mounted-up footpath and flat type of cycle lane - Kerb concrete or steeled guard rail separated off bicycle and other vehicles Not acceptable

The above is in compliance with the standards for a Class A road, but it is recommended that the most suitable road width be reconsidered in the implementation stage, based on the usage of the existing bridge.