3.3 Bridge Design

3.3.1 Existing Bridge Conditions

Site investigation was conducted to determine the bridge structures along NR.57 alignment and the findings are described in this section. As defined in Chapter A-4, bridges are highway structures over a depression or obstruction and carrying traffic or other moving load with an opening measured along the road centerline of more than 6.0m. Therefore, the inventory covered herein includes only structures with opening greater than 6.0m (**Table 3.3.1**).

Table 3.3.1 Bridges Along NR.57

Ref. No.	Province	Station[1)]	Bridge Type	Length (m)	Width (m)	No. of Spans	Superstructure	Substructure	Load Limit (tons)	Condition[2)]
1	Battambang	002+900	RC Slab Bridge	14.0	6.8	3	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface); waterway section filled-up
2	Battambang	003+000	RC Slab Bridge	11.0	6.0	3	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface); waterway section filled-up
3	Battambang	003+150	RC Slab Bridge	14.0	7.0	3	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
4	Battambang	003+900	RC Slab Bridge	7.5	7.0	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
5	Battambang	009+700	RC Slab Bridge	7.3	6.3	2	RC continuous slab	Wall Masonry	-	Poor (worn-out slab surface; sagging slab)
6	Battambang	010+000	RC Slab Bridge	10.5	6.5	3	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
7	Battambang	014+800	RC Slab Bridge	11.0	6.2	2	RC continuous slab	Wall Masonry	-	Poor (partially collapsed)
8	Battambang	016+000	RC Slab Bridge	10.5	6.8	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
9	Battambang	016+300	RC Slab Bridge	9.0	6.8	2	RC continuous slab	Wall Masonry	-	Very Poor (1-span collapsed)
10	Battambang	016+400	RC Slab Bridge	10.0	6.5	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
11	Battambang	016+500	RC Slab Bridge	9.0	6.5	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
12	Battambang	016+800	RC Slab Bridge	9.0	6.5	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
13	Battambang	016+900	RC Slab Bridge	10.0	5.5	2	RC continuous slab	Wall Masonry	-	Very Poor (collapsed)
14	Battambang	017+100	RC Slab Bridge	9.0	6.0	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
15	Battambang	017+900	RC Slab Bridge	9.0	6.5	2	RC continuous slab	Wall Masonry	-	Fair (worn-out slab surface)
16	Battambang	023+100	RC Slab Bridge	7.0	5.8	2	RC continuous slab	Wall Masonry		Fair (worn-out slab surface)
17	Battambang	040+735	Bailey Bridge	12.0	4.2	1	Bailey truss with timber deck	RC abutment	-	Poor (superstructure)
18	Battambang	041+930	Bailey Bridge	24.0	4.2	2	Bailey truss with timber deck	RC abutment and timber post piers	-	Poor (superstructure and substructure)
19	Battambang	051+808	Bailey Bridge	27.0	4.2	1	Bailey truss with timber deck	RC abutment	-	Poor (superstructure)
20	Battambang	055+998	Bailey Bridge	12.0	4.2	1	Bailey truss with timber deck	Old RC abutment	-	Poor (superstructure)
21	Battambang	058+913	Bailey Bridge	24.0	4.2	1	Bailey truss with timber deck	RC abutment	-	Poor (superstructure); Landmine area
22	Battambang	060+081	Bailey Bridge	48.0	4.2	2	Bailey truss with timber deck	RC abutment and timber post piers	10	Very Poor (superstructure sagging and vibrating); Approach road fooded +0.5m; Landmine area
23	Battambang	063+252	Bailey Bridge	45.0	4.2	2	Bailey truss with timber deck	RC abutment and timber post piers	10	Very Poor (superstructure deformed out-of-plane; very serious conditon for collapse)
24	Pailin	065+414	Bailey Bridge	24.0	4.2	1	Bailey truss with timber deck	RC abutment	15	Poor (superstructure)
25	Pailin	068+363	Bailey Bridge	33.0	4.2	2	Bailey truss with steel deck	RC abutment and steel frame piers	25	Fair (superstructure - deformed deck plate); Landmine area
26	Pailin	073+121	Bailey Bridge	21.0	7.0	1	Bailey truss with steel deck	RC abutment	15	Fair
27	Pailin	073+352	Bailey Bridge	21.0	4.2	1	Bailey truss with timber deck	RC abutment	15	Poor (superstructure)
28	Pailin	073+549	Bailey Bridge	12.0	4.2	1	Bailey truss with steel deck	RC abutment	15	Fair
29	Pailin	074+505	Bailey Bridge	15.0	4.2	1	Bailey truss with steel deck	RC abutment	15	Fair
30	Pailin	075+574	Bailey Bridge	15.0	4.2	1	Bailey truss with timber deck	RC abutment	15	Poor (superstructure)
31	Pailin	082+128	RC Slab Bridge	28.3	7.3	3	RC slab (simple span)	RC multi-column pier and abutment	-	Poor (superstructure show sign of distress - sagging slab, diagonal cracks on top of slab)
32	Pailin	083+223	RC Slab Bridge	8.7	8.0	1	RC slab (simple span)	Old RC abutment	-	Poor (Deck slab rutting with exposed aggregates,bridge vibrating, slab on old abutment)
33	Pailin	090+071	RC Girder Bridge	72.0	7.0	4	RC girder with concrete deck	RC abutment	-	Fair; bridge is narrow and needs widening to accommodate standard section

Note: 1) Beginning point of station (Km 0+000) is at intersection of NR-5 and NR-57 in Battambang
2) Study Team site inspection was conducted on February 2006

As indicated in **Table 3.3.1**, there are thirty three (33) bridges or road structures with opening greater than 6.0m along NR.57. The description and conditions of these bridges are summarized in **Table 3.3.1** and shown in **Figure 3.3.1**.

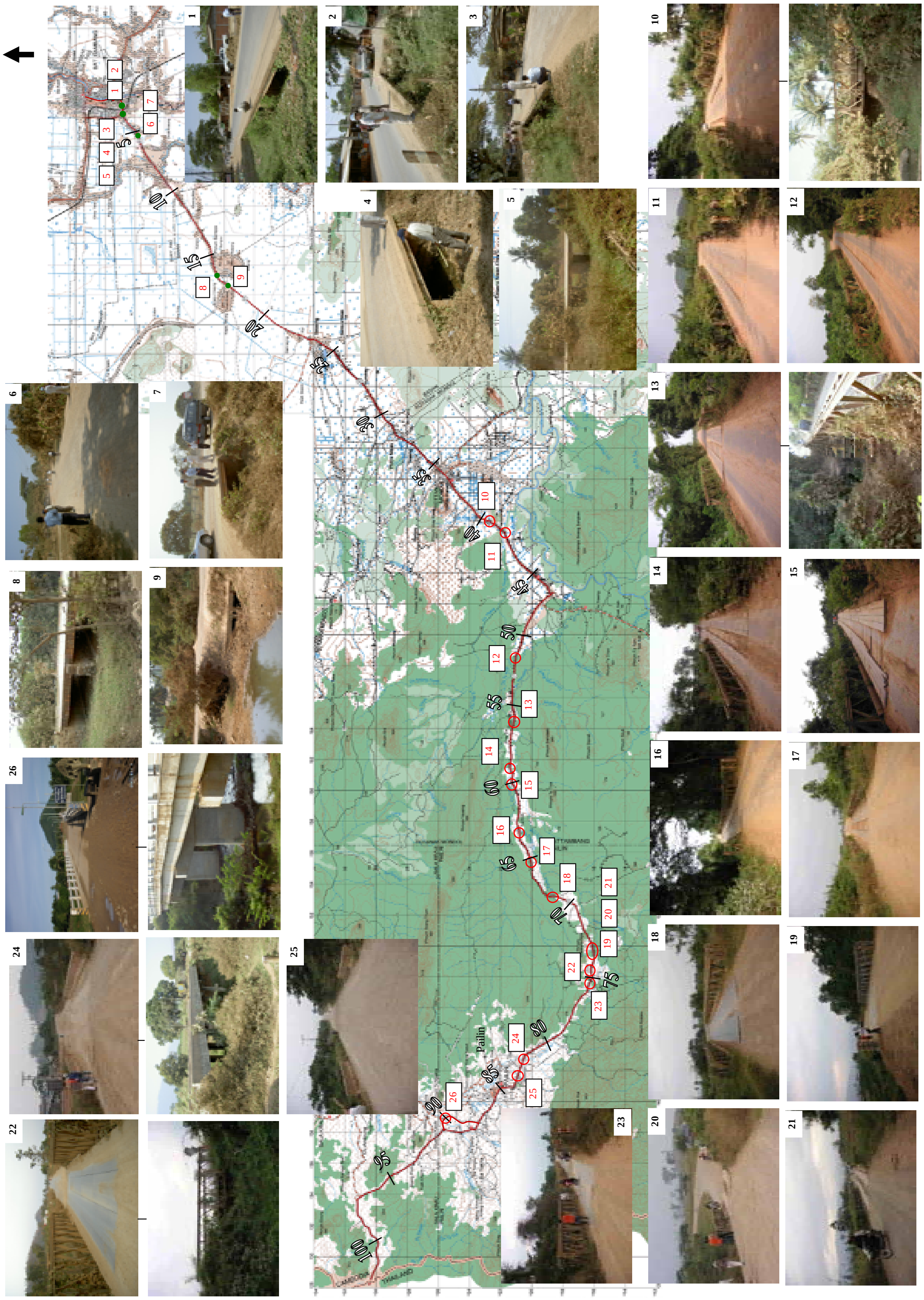


Figure 3.3.1 Existing Bridges Along NR.57

- Old RC Slab Bridges – there are sixteen (16) RC continuous slab bridges found to exist along the alignment with bridge lengths ranging from 7m to 14m (number of span varies from 2 to 3). The carriageway width for these bridges varies from 5.5m to 7.0m. Substructure types are mostly masonry abutment and wall type masonry piers. Although most of these bridges are in fair condition, at least three bridges have partial or full span collapsed and backfilled with embankment. Majority of these bridges have deck slabs with worn-out surface (exposed aggregates). See **Photo 3.3.1**.

3-Span RC Slab Bridge with Filled-up Waterway (Km2+900)

2-Span RC Slab Bridg (Km 9+700)

2-Span RC Slab Bridge with Collapsed Span (Km16+300)

2-Span RC Slab Bridge with Collapsed Span (Km16+900)

Photo 3.3.1 Typical Old RC Slab Bridges

- Steel Bailey Bridges – 14 Steel Bailey bridges exist along the alignment with bridge lengths from 12m to 48m (consisting of 1 and 2 spans). The carriageway widths of bailey bridges are on average 4.2m, except for one relatively new bridge at Km73+121 with 7.0m wide carriageway. Most of these bridges are constructed above old collapsed bridges so that previous piers and abutments of the old bridges still exist. Load limit for bailey bridges are posted at 10tons to 15tons with one bridge having a load limit of 25tons (Km68+363). Most of the bailey bridges are in poor condition except for the new bridge replacements in fair condition. Two of the bailey bridges (Km60+081 and Km63+252) are in very poor condition with load limits of 10 tons. The bridge at Km63+252 has deformed out-of-plane with some members buckling or sheared-off which makes it in very dangerous condition. See **Photo 3.4.2** for typical bailey bridges.


2-Span Bailey Bridge with Sagging Superstructure (Km 60+081)


2-Span Bailey Bridge with Heavily Damaged Superstructure (Km 63+252)


2-Span Bailey Bridge with Deformed Deck Plate (Km 68+363)


2-Span Bailey Bridge with Wide Carriageway (Km73+121)

Photo 3.3.2 Typical Bailey Bridges


3-Span RC Slab Bridge with Deflected Span (Km82+128)


Diagonal Cracks and Joint Opening (Km82+128)


1-Span RC Slab Bridge on Old Abutment (Km83+223)


Worn-out Deck Slab with Exposed Aggregate (Km83+223)

Photo 3.3.3 Typical New RC Slab Bridges

- <u>New RC Slab Bridge</u> – two relatively new reinforced concrete slab bridges are found with 8.7m (1-span at Km83+223) and 28.3m (3-span at Km82+128) bridge lengths. The bridge at Km83+223 is supported by the abutment of the old bridge while the bridge at Km82+128 has new concrete abutments and multiple column piers. The 1-span bridge (Km83+223) is in fair condition but with rutting and exposed aggregates at deck slab and exhibits excessive vibration during passage of heavy trucks. On the other hand, the 3-span bridge (Km82+128) exhibits signs of distress with visible diagonal cracks at the top of the deck slab and noted sagging of the spans. See **Photo 3.3.3**.

- <u>RC Girder Bridge</u> – one 4-span reinforced concrete girder bridge exist at Km90+071 (new road alignment), downstream of the original NR.57 alignment. The bridge is in good condition but has only 7.0m carriageway. Although this route is not the original NR.57 alignment, the bridge serves as the link to reach Thailand border. See **Photo 3.3.4**.

Photo 3.3.4 RC Girder Bridge

- There is no bridge existing at Km89+400 (Stueng Pailin river, see **Photo 3.3.5**) of the original NR.57 road alignment, except for a suspension foot bridge at 50m downstream. However, the new concrete girder bridge downstream of this point (Km90+300) serves as an alternate route of NR.57 towards the Thailand border.

(a) No Bridge at Original NR.57 Alignment

(b) Footbridge at 50m Downstream

(c) RC Girder Bridge at Km90+071 (New Road Alignment)

Photo 3.3.5 Stueng Pailin River (Km89+400)

3.3.2 Hydrologic Analysis and River Hydraulic

(1) Existing Condition

As a first approach, road structures with waterway opening greater than 6.0m are classified as bridges and conditions of these structures in relation to waterway discharge are noted. **Table 3.3.2** indicates that there are 33 sites with waterway opening greater than 6.0m. The conditions of the rivers, creeks or streams are summarized at these locations in the said table. It is noted that Bridge Ref. Nos. 1 to 16 are small waterways or canals with minimal discharges so that it is decided to replace such structures with standard box culverts.

However, the remaining bridge locations are observed to have longer existing bridges. The hydrologic aspects of these rivers are then analyzed based on the available topographic maps (Scale 1:100,000).

Table 3.3.2 Rivers on Existing Bridges

Ref. No.	Province	Station	Bridge Type	Length (m)	CA (km^2)	River / Stream / Creek		Remarks
						Name	Length (km)	
1	Battambang	002+900	RC Slab Bridge	14.0	-	-	-	Creek/Canal
2	Battambang	003+000	RC Slab Bridge	11.0	-	-	-	- do -
3	Battambang	003+150	RC Slab Bridge	14.0	-	-	-	- do -
4	Battambang	003+900	RC Slab Bridge	7.5	-	-	-	- do -
5	Battambang	009+700	RC Slab Bridge	7.3	-	-	-	- do -
6	Battambang	010+000	RC Slab Bridge	10.5	-	-	-	- do -
7	Battambang	014+800	RC Slab Bridge	11.0	-	-	-	- do -
8	Battambang	016+000	RC Slab Bridge	10.5	-	-	-	- do -
9	Battambang	016+300	RC Slab Bridge	9.0	-	-	-	- do -
10	Battambang	016+400	RC Slab Bridge	10.0	-	-	-	- do -
11	Battambang	016+500	RC Slab Bridge	9.0	-	-	-	- do -
12	Battambang	016+800	RC Slab Bridge	9.0	-	-	-	- do -
13	Battambang	016+900	RC Slab Bridge	10.0	-	-	-	- do -
14	Battambang	017+100	RC Slab Bridge	9.0	-	-	-	- do -
15	Battambang	017+900	RC Slab Bridge	9.0	-	-	-	- do -
16	Battambang	023+100	RC Slab Bridge	7.0	-	-	-	- do -
17	Battambang	040+735	Bailey Bridge	12.0	16.1	Creek Krab Ko	4.1	-
18	Battambang	041+930	Bailey Bridge	24.0	87.7	Creek Andoung	19.6	-
19	Battambang	051+808	Bailey Bridge	27.0	15.1	Creek Ta Krei	7.5	-
20	Battambang	055+998	Bailey Bridge	12.0	0.4	-	0.5	Tributary of Creek Thnoeng
21	Battambang	058+913	Bailey Bridge	24.0	4.8	-	1.3	-do-
22	Battambang	060+081	Bailey Bridge	48.0	168.6	Creek Traen	16.7	-
23	Battambang	063+252	Bailey Bridge	45.0	59.3	Creek Bang Roli	16.1	-
24	Pailin	065+414	Bailey Bridge	24.0	2.0	-	0.4	Tributary of Creek Bang Roli
25	Pailin	068+363	Bailey Bridge	33.0	1.9	Creek Ta Rut	0.9	-do-
26	Pailin	073+121	Bailey Bridge	21.0	0.5	-	0.5	-do-
27	Pailin	073+352	Bailey Bridge	21.0	0.1	-	0.5	-do-
28	Pailin	073+549	Bailey Bridge	12.0	0.2	-	0.7	-do-
29	Pailin	074+505	Bailey Bridge	15.0	0.8	-	0.5	-do-
30	Pailin	075+574	Bailey Bridge	15.0	1.2	-	0.5	-do-
31	Pailin	082+128	RC Slab Bridge	28.3	41.8	Creek Ta Vav	10.3	-
32	Pailin	083+223	RC Slab Bridge	8.7	9.3	-	2.9	Tributary of Creek Ta Vav
33	Pailin	090+071	RC Girder Bridge	72.0	69.0	-do-	12.7	-

(2) Hydraulic Design for Bridges

The hydrological analysis was conducted mainly to derive design flood discharge at each bridge's site. To estimate the magnitude of the design flood discharge, rational method is adopted in this study.

In Table 3.3.3, the results of the hydrological analysis are summarized to indicate the hydraulic design data for the corresponding bridges. However, further information on hydrologic analysis and hydraulic design at five (5) bridge sites (Bridge Ref. No. 20, 26, 27, 28 and 29) were excluded from the study because of small flood discharge.

The design flood level was respectively simulated to verify the above-mentioned past records of experienced flood high-water level (HWL). However, the experienced maximum flood water level is finally applied as the design flood level.

Table 3.3.3 Hydraulic Design Data on Bridges along NR.57

Ref. No.	Station (km+m)	Catchment Area (km²)	River / Creek Length (km)	Rainfall Intensity[1)] (mm/hr)	Runoff Coeff. C	Design Flood Discharge Q (m³/s)	Design Flood Level Elev. (m)	Approach Velocity (m/s)
17	040+735	13.0	4.1	68.5	0.20	49.0[2)]	47.264	2.69
18	041+930	30.0	19.6	68.5	0.20	114.0[3)]	38.900	2.47
19	051+808	15.1	7.5	68.5	0.20	57.0[2)]	55.950	2.84
20	055+998	0.4	0.5	68.5	0.20	2.0[2)]	-	-
21	058+913	4.8	1.3	68.5	0.20	18.0[2)]	76.845	1.73
22	060+081	150.0	16.7	68.5	0.20	571.0[3)]	83.850	3.08
23	063+252	59.3	16.1	68.5	0.20	225.0[3)]	93.224	3.12
24	065+414	2.0	0.4	68.5	0.20	8.0	106.172	1.22
25	068+363	7.0	0.9	68.5	0.20	27.0	119.351	2.54
26	073+121	0.5	0.5	68.5	0.20	2.0	-	-
27	073+352	0.1	0.5	68.5	0.20	0.5	-	-
28	073+549	0.2	0.7	68.5	0.20	1.0	-	-
29	074+505	0.8	0.5	68.5	0.20	3.0	-	-
30	075+574	1.2	0.5	68.5	0.20	5.0	196.221	1.78
31	082+128	41.8	10.3	68.5	0.20	122.0[3)]	182.386	3.1
32	083+223	9.3	2.9	68.5	0.20	35.0[2)]	181.119	2.83
33	090+071	69.0	12.7	68.5	0.20	396.0[3)]	143.272	3.91

Note : 1) Based on Road Design Standard, Part 3. Drainage, CAM PW.03.103.99

2) Estimated by Rational Method (C.A. ≦ 25 km²) and verified by flood mark.

3) Estimated by HEC-HMS method (C.A. > 25 km2) and verified by flood mark.

It should be noted that the hydraulic design data obtained in this study is limited to the available the rainfall intensity data based on the Cambodia Road Design Standard (Part 3. Drainage, Appendix A). No detailed topographic and river section survey was conducted. A more detailed investigation will be necessary during the detailed design stage.

3.3.3 Policy on Selection of Bridge Type

In this study, the most appropriate bridge type is selected by evaluating the various factors in bridge planning including economy, durability, vertical alignment, environmental impacts, constructability and maintainability. These factors are evaluated as follows:

- Economy : Bridge should be constructed at low cost to be cost effective. Concrete bridge structures tend to be more economical than steel structures and entails minimal maintenance cost. Concrete bridges are thus recommended for NR.57 bridges.

- Durability : Bridge type should be durable to withstand contemplated design loads based on the Cambodian Bridge Design Standard (CBDS). Heavy trucks are observed to pass this route to and from Thailand but the existing bridges have less capacity than required by CBDS. Moreover, proper type of revetment and river bed protection should be selected based on durability.

- Vertical Alignment : Since bridges to be constructed are located along existing road alignment, the existing road/bridge profile should be adjusted to clear the design flood level. Selection of structure type should minimize impact to roadside structures and adjustments to approach road.

- Environmental Impacts : Impacts to environment including surrounding communities (houses, traffic, pedestrians, etc.) should be minimized by selecting the proper bridge type and technology. Although for the case of NR.57, most of these bridges are located in rural areas with minimal social and environmental impact.

- Constructability : Bridge selection should consider ease and safe construction based on available technology. Since bridges along NR.57 are located far from each other, the choice of structure type should simplify construction planning. Cast-in-place concrete is recommended in most bridges since the span requirements are within the range for RC Slab and RC girder bridges. Only one bridge with large discharge and river section requires precast, prestressed girder.

- Maintainability : The choice of material and structural elements should consider minimal maintenance requirements at low cost. Since maintenance entails cost, it is recommended to use the bridge form that will require the least maintenance – that is, concrete structures are preferred over steel structures.

(1) Substructure Types

The choice of substructure depends on the type of foundation support at site, the scale of bridge, the cost of construction and the available technology. Since most of the bridges are in rural areas, impact to environment for foundation choice is minimal.

In Cambodia, the typical foundation types for recently constructed bridges include RC or PC Driven Piles and Cast-In-Place Piles (or commonly known as bored piles). Concrete pile foundation is preferred over steel piles (H-piles of steel pipe piles) for economic consideration. For the scale of bridges along NR.57, the possible foundation alternatives are presented in **Table 3.3.4**.

Table 3.3.4 Foundation Choices for Bridges

	TYPE	BEARING LAYER DEPTH (m) (0–100)	APPLICABLE DIAMETER (m)	APPLICABLE SPANS (m) < 20	20-50	> 50	APPLICATION / ADVANTAGE
F - 1	SPREAD FOUNDATION	0 / 5 / 10	-	●	●	●	FOR BEARING LAYER DEPTH < 5.0M; CAN SUPPORT LARGE VERTICAL AND HORIZONTAL LOAD CAPACITY; GOOD FOR ROCKS, COHESIVE SOIL WITH N>20 OR COHESIONLESS SOIL WITH N>30
F - 2	RC DRIVEN PILE	5 / 15 / 25	0.3 - 0.5	●	▲	×	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 25M; GOOD FOR SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; CAN SUPPORT SMALL VERTICAL LOAD
F - 3	PC DRIVEN PILE	5 / 40 / 60	0.35 - 0.5	●	●	▲	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 40M; GOOD FOR SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; ORDINARY VERTICAL LOAD CAPACITY;
F - 4	STEEL H DRIVEN PILE	5 / 40 / 60		●	●	▲	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 40M; APPLICABLE FOR SOFT AND HARD INTERMEDIATE LAYERS; SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; LARGE VERTICAL LOAD CAPACITY; EASY TO HANDLE DUE TO LIGHTER WEIGHT
F - 5	STEEL PIPE DRIVEN PILE	5 / 60	0.5 - 0.8	▲	●	●	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 60M; APPLICABLE FOR SOFT AND HARD INTERMEDIATE LAYERS; SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; LARGE VERTICAL LOAD CAPACITY; LARGER CAPACITY TO HORIZONTAL LOADS
F - 6	CAST-IN-PLACE PILE (ALL CASING METHOD)	5 / 40 / 60	1.0 - 1.2	▲	●	●	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 40M; GOOD FOR SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; LARGE VERTICAL & HORIZONTAL LOAD CAPACITY; GOOD FOR AREAS WITH DIFFICULTY IN STABILIZNG EXCAVATION OR SOIL LAYERS WITH FISSURES.
F - 7	CAST-IN-PLACE PILE (EARTH AUGER METHOD)	5 / 25 / 40	1.0 - 1.5	▲	●	▲	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 40M; GOOD FOR SOIL SUSCEPTIBLE TO LIQUEFACTION; ORDINARY VERTICAL & HORIZONTAL LOAD CAPACITY; LESS NOISE DURING CONSTRUCTION.
F - 8	CAST-IN-PLACE PILE (REVERSE CIRCULATION DRILL METHOD)	5 / 15 / 60	1.0 - 1.5	▲	●	●	FOR VERY SOFT SOIL WITH BEARING LAYER UNTIL 60M OR MORE; GOOD FOR SOIL SUSCEPTIBLE TO LIQUEFACTION; GROUND WATER NEAR SURFACE; LESS NOISE DURING CONSTRUCTION.

● HIGHLY APPLICABLE ▲ APPLICABLE × LESS APPLICABLE

Based on three boreholes conducted at existing bridge locations, the bearing layer is sandstone layer which is found at 2.5m to 10.5m below the river bed. With this bearing layer, the following foundation types are recommended:

- Spread Foundation – for foundation on sandstone layer less than 5.0m deep, and
- RC Driven Pile – for soft upper soil layers.

The above choice is based on cost and past bridge construction experience in Cambodia (see comparison of foundation types at Urgent Bridge Rehabilitation Section 3.3.3(1)). Since most bridges are in rural areas, noise produced during pile driving will not be a problem.

For RC Deck Girder or PC I-Girder Bridges with multiple spans, the pier type recommended is column type pier with thinner wall dimensions to minimize river obstruction. Moreover, since water level during ordinary time in most bridge locations are minimal (or practically none), the top of pier foundation (footing or pile cap) shall be located at least 1.0m below the river bed. Gabion mattress shall be provided to minimize local scouring on river bed.

For RC Slab Bridges with multiple spans, wall pier monolithic with superstructure is recommended since the slab bridge spans are typically shorter and requires no bearing supports. Moreover, to take advantage of the continuity between the superstructure and the substructure, the abutments for RC Slab bridges are made continuous with the superstructure – commonly called integral abutment. This eliminates the need for expansion joints at the abutments since the span lengths are shorter and bending moments produced at the superstructure are distributed to the rigid connection with the abutment.

(2) Superstructure Types

The choice of superstructure for the NR.57 bridges depends on the scale of the bridge (bridge length, bridge spans, etc.) which is based on the existing topography, river discharge and maximum flood level. The common forms of superstructure applicable to the range of bridges in this road section are presented in **Table 3.3.5**.

Table 3.3.5 Typical Superstructure Choices for Bridges

TYPE	SPAN LENGTH (M) 0 10 20 30 40 50 60 70	HEIGHT/ SPAN RATIO	CHARACTERISTICS: ADVANTAGES	CHARACTERISTICS: DISADVANTAGES
I. CONCRETE BRIDGE	SHORT SPAN / MEDIUM SPAN / LONG SPAN			
1. RC SLAB	5 – 15	1/20	SIMPLEST AND LEAST COST; CAN BE MADE CONTINUOUS WITH PIERS AND ABUTMENTS TO RESIST LATERAL LOADS; MINIMAL MAINTENANCE REQUIRED; NEAT AND SIMPLE IN APPEARANCE.	LIMITED TO SHORT SPAN RANGE; REQUIRES LONGER CONSTRUCTION TIME DUE TO FALSEWORK ASSEMBLY AND CONCRETING; DIFFICULT ON DEEP RIVERS AND HIGH PIERS
2. RC DECK GIRDER	10 – 20	1/15 - 1/18	ECONOMICAL FOR SPANS 10-20M; SUPERSTRUCTURE NORMALLY ON BEARING WITH PIERS; MINIMAL MAINTENANCE; NEAT AND SIMPLE IN APPEARANCE BUT MANY LINES ON UNDERSIDE.	ECONOMICAL UNTIL 20M RANGE; REQUIRES LONGER CONSTRUCTION TIME DUE TO FALSEWORK ASSEMBLY AND CONCRETING; DIFFICULT ON DEEP RIVERS AND HIGH PIERS; LESS AESTHETIC APPEARANCE THAN SLAB BRIDGES
3. PC I-BEAM (AASHTO)	10 – 40	1/15 - 1/18	COMPETITIVE FOR SPANS 20-40M; GIRDERS ARE PRECAST, LIFTED IN PLACE AND DECK SLAB CAST-IN-PLACE; CONSTRUCTION PERIOD SHORTER THAN CAST-IN-PLACE TYPE; GIRDERS NORMALLY SIMPLE SPAN BUT CAN BE MADE CONTINUOUS WITH LIVE LOAD; MINIMAL MAINTENANCE;	REQUIRES SPACE FOR FABRICATION OF GIRDERS; TRANSPORTATION OF LONG SEGMENTS CAN BECOME A PROBLEM; REQUIRES CRANE FOR LIFTING PRECAST SEGMENTS; SIMPLE BUT LOOKS CLUTTERED ON UNDERSIDE DUE TO MANY LINES.
II. STEEL BRIDGE	SHORT SPAN / MEDIUM SPAN / LONG SPAN			
1. PLATE GIRDER (Composite/Non-composite)	6 – 65	1/17 - 1/22	WIDELY USED FOR SPANS UP TO 30M; STEEL GIRDER IS SIMPLY SUPPORTED BUT COMPOSITE WITH DECK SLAB; CONSTRUCTION IS FASTER THAN CAST-IN-PLACE CONCRETE; STRUCTURE IS LIGHTER THAN CONCRETE AND REQUIRES LESS SUBSTRUCTURE SUPPORT;	REQUIRES PAINTING MAINTENANCE - COST AND HAZARD NEED TO BE CONSIDERED; REQUIRES LIFTING AND TRANSPORTATION OF GIRDERS; CAREFUL QUALITY AND SAFETY CONTROL REQUIRED; MORE EXPENSIVE THAN CONCRETE; SIMILAR LOOKS WITH AASHTO GIRDER BUT MORE SLENDER.

NOTE : 1. RC is Reinforced Concrete, normally cast-in-place
2. PC is Prestressed Concrete, this can be cast-in-place or pre-cast

In this study, concrete bridge is preferred over steel bridge basically because:

(1) concrete bridges requires minimal maintenance compared to steel bridges,

(2) steel bridges generally cost more than concrete bridges, and

(3) past experience in bridge construction in Cambodia is directed more on concrete bridges.

For bridge spans 12m or less, cast-in-place reinforced concrete slab bridge and slab bridge with integral abutment (for 1-span bridges) and rigid pier connection is preferred since:

(1) it requires less structure depth and advantageous in bridge sites where the existing road vertical profile has less room for adjustment,

(2) this type has the least cost at this span range,

(3) since the bridge scale is small, simple substructure like pile bents can be used to support the bridge,

(4) integral abutment does not need expansion joints.

For bridge spans greater than 12m until 20m, cast-in-place reinforced concrete girder bridge is preferred since this is most cost-effective at this range.

For bridge spans greater than 20m, precast prestressed I-girder is preferred since:

(1) this is cost competitive at this span range, and

(2) construction period is shorter since the girders are precast and erected in place to support the cast-in-place deck slab.

3.3.4 Bridge Planning

(1) Existing Bridge Location

Since national road NR.57 is an existing road, the bridge locations will more or less be on the same site except where improvement of the geometric alignment is made.

Table 3.3.6 presents the existing bridge location and river conditions.

Table 3.3.6 Existing Bridge Location and River Condition

Ref. No.	Station	Waterway	River Condition	Remarks
1	002+900	None	• Waterway is filled-up	• 1-ϕ1.0m replaces slab bridge
2	003+000	None	• Waterway is filled-up	• Slab bridge exists but no discharge
3	003+150	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
4	003+900	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
5	009+700	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location

Table 3.3.6 Existing Bridge Location and River Condition ...(Continued)

Ref. No.	Station	Waterway	River Condition	Remarks
6	010+000	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
7	014+800	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
8	016+000	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
9	016+300	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
10	016+400	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
11	016+500	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
12	016+800	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
13	016+900	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
14	017+100	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
15	017+900	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
16	023+100	Canal/ Small Stream	• Minimal discharge	• RC box culvert is sufficient at this location
17	040+735	River	• River opening is 12.0m wide • Flood level is 1.05m below deck level	• Bailey bridge is on top of collapsed 2-span slab bridge
18	041+930	River	• River opening is 21.0m wide • Flood level is 1.29m below deck level	• Bridge need to be relocated to improve road alignment
19	051+808	River	• River opening is 21.0m wide • Flood level is 2.45m below deck level	• Topography requires bridge
20	055+998	Stream	• Stream opening is 8.0m wide • No water during survey • Minimal discharge =2 m^3/s	• RC box culvert is sufficient at this location
21	058+913	Stream	• River opening is 21.0m wide • Flood level is 3.56m below deck level	• Topography requires bridge
22	060+081	River	• River opening is 41.0m wide • Flood level is 0.27m below deck level	• Need to relocate bridge to improve road alignment • Adjust bridge deck elevation to clear flood level
23	063+252	River	• River opening is 30.0m wide • Flood level is 2.59m below deck level	• Need to clear river opening
24	065+414	Stream	• River opening is 12.0m wide • Flood level is 1.78m below deck level	• 12m opening is sufficient
25	068+363	Stream	• River opening is 21.0m wide • Flood level is 3.79m below deck level	• Topography requires bridge to span river opening
26	073+121	River	• River opening is 14.0m wide • Small catchment area	• Topography requires bridge to span river opening
27	073+352	Stream	• Stream opening is 10.0m wide • No water during survey • Minimal discharge	• RC box culvert is sufficient at this location
28	073+549	Stream	• Stream opening is 8.0m wide • No water during survey • Minimal discharge	• RC box culvert is sufficient at this location
29	074+505	Stream	• Stream opening is 8.0m wide • No water during survey • Minimal discharge	• RC box culvert is sufficient at this location
30	075+574	Stream	• Stream opening is 6.0m wide • No water during survey • Minimal discharge = 5 m^3/s	• RC box culvert is sufficient at this location
31	082+128	Stream	• River opening is 27.0m wide • Flood level is 2.18m below deck level	• Need to replace existing bridge due to structural condition
32	083+223	River	• River opening is 7.0m wide • Flood level is 2.0m below deck level • Existing pier of old bridge constricts river flow; need to widen opening	• Replace existing slab bridge to increase river opening and improve bridge structure
33	090+071	River	• River opening is 69.0m wide • Flood level is 4.3m below deck level • Existing bridge opening sufficient for river discharge	• Construct new parallel bridge to increase traffic capacity (existing bridge is narrow)

At least two (Ref. Nos. 1&2) of the bridges' waterways have been filled-up so that bridge is no longer needed. Moreover, slab bridges from Sta. 03+150 to 23+100 (Ref. Nos. 3 to 16) have minimal discharges which can be replaced by RC box culverts (RCBC).

From Sta. 40+735 to 90+071, river and stream openings varies from 6.0m to 69.0m with five locations (Ref. Nos. 20, 27, 28, 29 and 30) having no water during site investigation. Moreover, discharge and topography at these locations indicate that box culverts are sufficient to maintain the waterway opening. On the other hand, although the preliminary discharge calculations for some streams and rivers (Ref. Nos. 21, 24, 25 and 26) indicate small river discharges, bridges are proposed on these locations due to topographic condition requiring bridge to span these sites.

(2) Bridge Length and Span Lengths

The bridge length is decided based on the existing topography at bridge site, existing bridge lengths and condition, river design flood discharge, maximum flood water level and the condition of the river and banks. Basically, the bridge length should span the river banks.

The span length is decided based on existing span lengths, river hydraulic and expected debris flow, depth of superstructure to minimize approach road profile adjustment and depth of existing water to minimize construction of piers on river.

As a guide policy, the minimum span length is recommended to be:

i. $S \geq 20 + 0.005Q$ for $500\ m^3/s < Q \leq 2{,}000\ m^3/s$

ii. $S \geq 30 + 0.005Q$ for $Q > 2{,}000\ m^3/s$

where : S = span length in meters

Q = river discharge in m^3/s

For the proposed NR.57 bridges, only one river has a discharge more than 500 m^3/s requiring a span length of about 24.0m. Other bridges may have spans less than 20.0m, depending on the site conditions.

On the other hand, the existing reinforced concrete deck bridge (RCDG) at Station 90+071 is in good condition but has narrow deck width. In order to meet the required bridge section for this road, a parallel bridge of similar type and configuration is proposed to be constructed next to this bridge. Under such condition, the span lengths shall be the same as the existing at 18.0m.

The existing and proposed bridge lengths and spans are presented and compared in **Table 3.3.7**.

(3) Deck Elevation

In this study, the geometric properties (horizontal alignment and vertical profile) of the national road NR.57 will be improved based on the functional requirements. As such, the approach roads' alignment and vertical profile leading to bridge sites will be improved. However, the minimum freeboard or vertical clearance requirement from the design high (flood) level to the bottom of the major structural element (girders or slab) shall be kept.

Table 3.3.7 Existing and Proposed Bridge Length and Spans

Ref. No.	Bridge No.	Station*	Existing Bridge		Discharge (m^3/s)	Min. Span Length (m)	Proposed Bridge		Remarks
			Length (m)	Span (m)			Length (m)	Spans (m)	
17	1	040+693 (040+735)	12.0	12.0	49	-	15.0	14.0	• Bridge length and span is slightly longer than existing
18	2	041+788 (041+930)	24.0	12.0	114	-	24.6	12.0	• Bridge length and span is same as existing
19	3	51+724 (051+808)	27.0	27.0	57	-	24.6	12.0	• Discharge is small so that span length is shortened to optimize bridge cost
21	4	058+814 (058+913)	24.0	24.0	18	-	18.6	18.0	• Discharge is small so that bridge length is shortened with 1-span RCDG
22	5	059+991 (060+081)	48.0	24..0	571	23	48.6	24.0	• Bridge length is maintained at minimum span length similar to existing
23	6	063+089 (063+252)	45.0	22.5	225	-	33.6	16.5	• Bridge length and span shortened based on river discharge and topography
24	7	065+279 (065+414)	24.0	24.0	8	-	14.0	13.0	• Although discharge is small, bridge is proposed with shorter length due to topography
25	8	068+198 (068+363)	33.0	16.5	27	-	24.6	12.0	• Bridge length and span is shortened due to small river discharge
26	9	072+946 (073+121)	21.0	21.0	2	-	18.6	18.0	• Discharge is small but shorter bridge is recommended due to topography
31	10	081+945 (082+128)	28.3	9.43	159	-	33.6	10.0/ 12.0	• Bridge of similar scale is proposed
32	11	083+060 (083+223)	8.7	8.7	35	-	13.0	10.0	• Longer bridge is proposed due to discharge
33	12	089+838 (090+071)	72.0	18.0	396	-	72.0	18.0	• Similar bridge scale is proposed for new bridge widening

Note: *Stationing of proposed bridges; figures in parenthesis () indicates survey station.

3.3.5 Bridge Design

From the identified bridge sites in **Table 3.3.1** only twelve sites are identified to require bridges based on river discharge, site condition and site topography. The rest of the stream or river sites will be provided with reinforced concrete box culvert with sufficient opening to discharge the anticipated flood water.

The preliminary design was undertaken to determine the outline form of bridges at identified location. This preliminary design is, however, based on the limited available topographic maps, site investigation undertaken by the study team, and the limited geotechnical survey conducted at three bridge location sites. No detailed topographic survey, as well as river cross-section survey was conducted during the study.

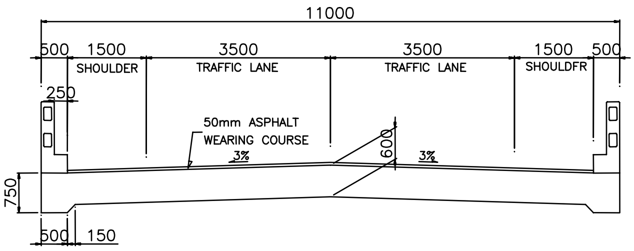
The proposed bridge structures and design considerations will be discussed in this section.

(1) Superstructure

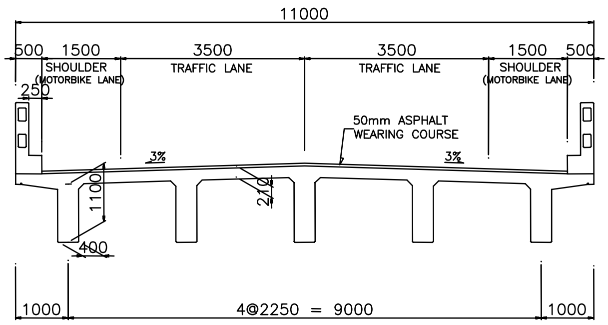
As discussed earlier, the choices of superstructure type follows the requirements for bridge planning which includes span lengths and bridge lengths. **Table 3.3.8** presents the proposed superstructure type and bridge lengths for the twelve bridges while **Figure 3.3.2** illustrates the basic bridge cross-sections for RC Slab, RCDG and PCDG bridges.

For shorter one-span bridges (Bridge Nos. 1, 7 & 11), RC Slab with integral abutment is proposed to optimize structural capacity and eliminate the use of expansion joint at the abutment. RC Slab with seat type abutments is proposed for other short-span bridges (Bridge Nos. 2, 3, 8 &10).

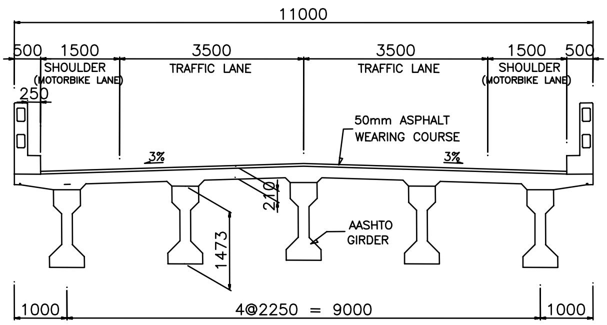
For span lengths from 16.5m to 18.0m, reinforced concrete deck girder (RCDG) is proposed (Bridges Nos. 4, 6, 9, & 12). Precast prestressed girder is proposed for longer span at 24.0m for Bridge No. 5.



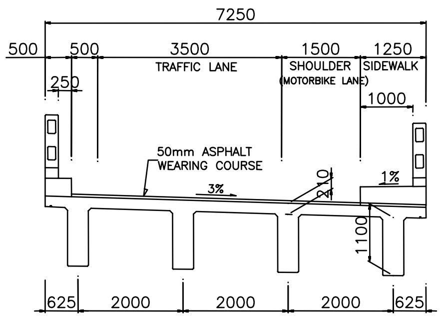
a. Typical RC Slab Bridge



b. Typical RCDG Bridge



c. Typical PCDG Bridge



d. RCDG Bridge Widening (Br. No. 12)

Figure 3.3.2 Basic Bridge Cross-Sections for NR.57

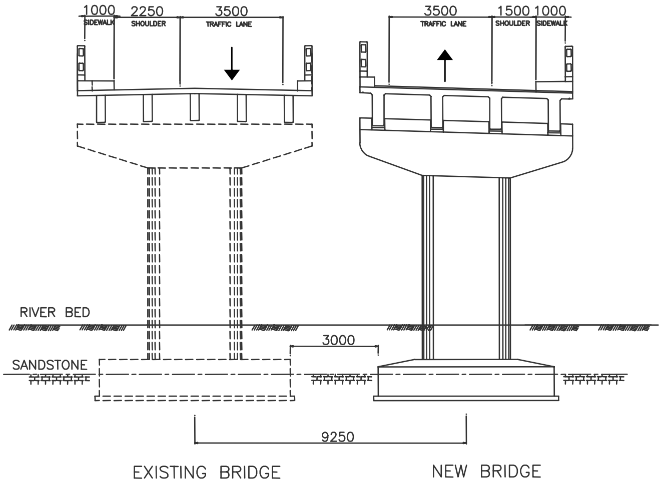
Table 3.3.8 Superstructure Design

Bridge No.	Station	Bridge Length (m)	Spans (m)	Proposed Bridge Elev. (m)	Super-structure Type	Remarks
1	040+693	15.0	1 @ 14	49.030	RC Integ. Slab (D=600)	Shorter span length requires only RC Slab which is cost-effective at this range. Integral abutment is utilized to optimize structural capacity.
2	041+788	24.6	2 @ 12	40.700	RC Slab (D=600)	Shorter span arrangement is chosen to minimize road profile adjustment which is sufficient for river discharge. RC Slab is most appropriate structure type for this span.
3	51+724	24.6	2 @ 12	59.294	RC Slab (D=600)	Shorter span arrangement is chosen to minimize road profile adjustment which is sufficient for river discharge. RC Slab is most appropriate structure type for this span.
4	058+814	18.6	1 @ 18	80.705	RCDG (D=1100)	RCDG type is most appropriate for this span range of bridge.
5	059+991	48.6	2 @ 24	86.770	PCDG (AASHTO Type IV-A)	Waterway discharge requires span arrangement at 24m where PCDG is most advantageous structure type. This minimizes waterway constriction and less substructure construction.
6	063+089	33.6	2 @ 16.5	95.965	RCDG (D=1100)	Waterway discharge and existing topography requires span arrangement where RCDG is most advantageous structure type. This minimizes waterway constriction and less substructure construction.
7	065+279	14.0	1 @ 13	108.250	RC Integ. Slab (D=600)	Small river discharge requires only one-span short bridge where RC slab with integral abutment is most appropriate.
8	068+198	24.6	2 @ 12	123.141	RC Slab (D=600)	Although river discharge is small, topography requires bridge with shorter spans as provided by RC slab bridge.
9	072+946	18.6	1 @ 18	169.600	RCDG (D=1100)	Single span bridge is require to cross this river although discharge is small. One-span RCDG bridge is most appropriate based on topography.
10	081+945	33.6	10+12+10	184.800	RC Slab (D=600)	Bridge of similar scale as the existing is proposed using RC Slab structure.
11	083+060	13.0	1 @ 10	183.119	RC Integ. Slab (D=600)	A one-span RC slab with integral abutment is required to span this opening providing greater river section than the existing.
12	089+838	72.0	4 @ 18	147.572	RCDG (D=1100)	A parallel bridge of similar type and spans is proposed for this bridge to increase traffic capacity of the existing bridge.

NOTE:
1. PCDG is Pre-cast Prestressed Concrete Deck Girder Bridge
2. RCDG is Reinforced Concrete Deck Girder Bridge
3. RC Slab is Reinforced Concrete Cast-in-Place Slab Bridge
4. RC Integ. Slab is Reinforced Concrete Cast-in-Place Slab with Integral Abutment

Widening of Bridge No.12 (Sta. 089+850)

In order to increase the traffic capacity of Bridge No.12 (Sta. 089+850), the bridge is proposed to be widened by constructing a parallel bridge of similar bridge configuration as the existing bridge. The new bridge is 7.25m wide as shown in **Figure 3.3.2(d)** with one traffic lane plus shoulder and sidewalk. The existing bridge will be reconfigured to accommodate one traffic lane plus shoulder and sidewalk as shown in **Figure 3.3.3**.



NOTE:
The new bridge shall be constructed to provide northbound traffic and motorcycle lane while the existing bridge will cater for southbound traffic and motorcycle lane. Sidewalk shall be provided on each bridge.

Figure 3.3.3 Widening of Bridge No.12 (Sta. 089+850)

(2) Substructure

The choice of foundation system for substructure depends on the type and depth of supporting soil layer for each bridge. Spread foundation or direct bearing is used for shallow sandstone layer (depth is less than 5m) where river bed scouring does not pose any problem. This foundation type is applied to piers where geotechnical investigation reveals the presence of sandstone at shallow depth in the river.

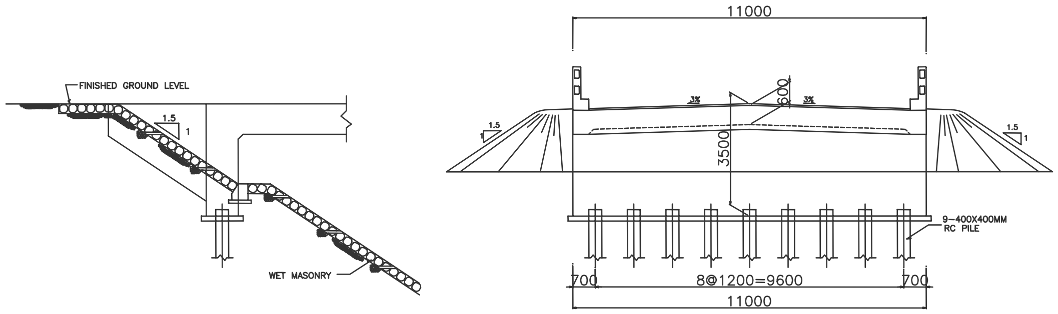
Only three boreholes or geotechnical investigation (Sta. 041+930, 060+081 and 090+071) were conducted for NR.57 to determine the underlying soil layers for structure foundations. It is noted that in the three boreholes, limestone and sandstone layers were encountered at rather shallow depth. Soil bearing layers are assumed on other bridge site locations based on the results of the three boreholes.

Spread foundation is proposed for bearing layers less than 5.0m while pile foundation is applied to bridges where soil bearing layers are found at depths greater than 5.0m. This is applied mostly at abutment locations to avoid constructing deep abutments.

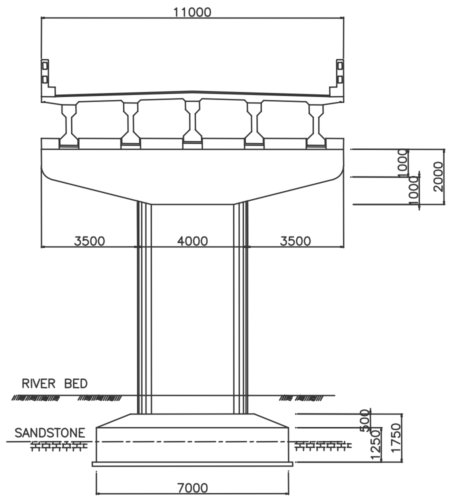
Table 3.3.9 and **Figure 3.3.4** presents the substructure types proposed for the bridges.

Table 3.3.9 Substructure Design

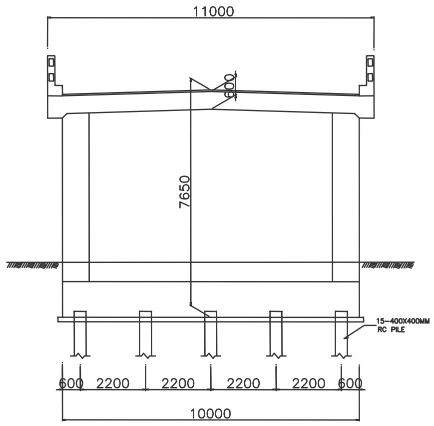
Bridge No.	Station	Soil Condition	Pier Type (m)	Abutment Type	Foundation Type
1	040+693	Soil investigation not conducted.	-	Integral Type	RC Driven Piles (0.4mx0.4m)
2	041+788	Upper soil layer consists of medium stiff to very stiff greenish-gray sandy CLAY with intermediate layer of dense yellow and light gray clayey SAND overlying very hard light-gray sandy CLAY. Gray SANDSTONE was encountered at 10.50m below borehole level.	Wall Pier (0.6x11.0m)	Seat Type Cantilever	RC Driven Piles (0.4mx0.4m)
3	51+724	Soil investigation not conducted.	Wall Pier (0.6x11.0m)	Seat Type Cantilever	RC Driven Piles (0.4mx0.4m)
4	058+814	Soil investigation not conducted.	-	Seat Type Cantilever	RC Driven Piles (0.4x0.4m)
5	059+991	Upper soil layer consists of medium dense yellow and gray SAND to very dense yellow greenish gray clayey SAND. Gray SANDSTONE was encountered at 5.30m below borehole level.	Column Pier (1.2x4.0m)	Seat Type Cantilever	Abutment – RC Driven Piles (0.4mx0.4m); Pier – Spread Footing
6	063+089	Soil investigation not conducted.	Column Pier (0.8x4.0m)	Seat Type Cantilever	Abutment – RC Driven Piles (0.4mx0.4m); Pier – Spread Footing
7	065+279	Soil investigation not conducted.	-	Integral Type	RC Driven Piles (0.4mx0.4m)
8	068+198	Soil investigation not conducted.	Wall Pier (0.6x11.0m)	Seat Type Cantilever	Abutment – RC Driven Piles (0.4mx0.4m); Pier – Spread Footing
9	072+946	Soil investigation not conducted.	-	Seat Type Cantilever	RC Driven Piles (0.4mx0.4m)
10	081+945	Soil investigation not conducted.	Wall Pier (0.6x11.0m)	Seat Type Cantilever	Abutment – RC Driven Piles (0.4mx0.4m); Pier – Spread Footing
11	083+060	Soil investigation not conducted.	-	Integral Type	RC Driven Piles (0.4mx0.4m)
12	089+838	Soil consists of stiff brownish-yellow sandy CLAY over hard to very dense gray and yellow medium SAND. Greenish gray SANDSTONE encountered at 5.3m below borehole level.	Column Pier (0.9x3.0m)	Seat Type Cantilever	Abutment and Piers on Spread Footing



a. Integral Abutment



b. Column Pier on RC Driven Piles



c. Wall Pier on RC Driven Piles

Figure 3.3.4 Typical Substructures for NR.57 Bridges

(3) River Protection

In order to protect the bridge foundations and abutments against high flood flow velocities and possible scour, wet masonry protection is provided in front of and around the abutments with gabion box cut-off perimeter at the toes of the wet masonry. Moreover, the top of pier footings and pile caps are located at a minimum depth of 1.0m below the river bed with 0.5m thick gabion mattress provided at the river beds (see **Figure 3.3.5**).

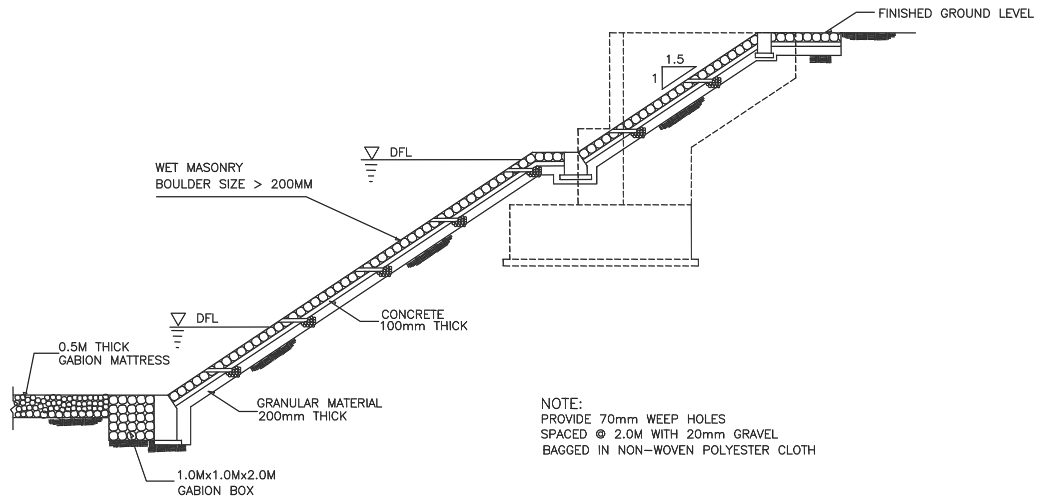


Figure 3.3.5 Typical River Protection Works

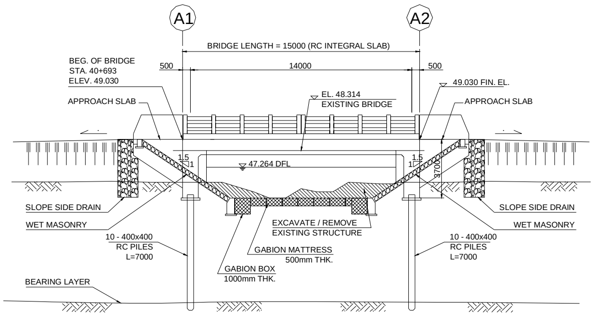
(4) Summary of Proposed Bridges

The proposed bridges along NR.57 is summarized and presented in **Table 3.3.10**. **Figure 3.3.6** shows the different bridges along NR.57.

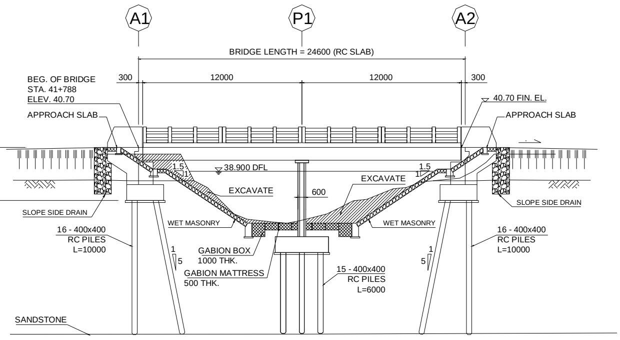
Table 3.3.10 Proposed Bridges Along NR.57

Bridge No.	Station	Deck Elev. (m)	Total Length (m)	Superstructure			Substructure	
				Type	Spans (m)	Deck Width (m)	Pier	Abutment
1	040+693	49.03	15.0	RC Integ. Slab (D=600)	1 @ 14	Shoulder : 2@1.50 Traffic Lane : 2@3.50 **Total : 10.00**	-	Integral Type on RC Driven Pile (0.4x0.40m)
2	041+788	40.70	24.6	RC Slab (D=600)	2 @ 12		Wall Pier on RC Driven Pile (0.4x0.40m)	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
3	051+724	59.29	24.6	RC Slab (D=600)	2 @ 12		Wall Pier on RC Driven Pile (0.4x0.40m)	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
4	058+814	80.71	18.6	RCDG (D=1100)	1 @ 18		-	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
5	059+991	86.77	48.6	PCDG (AASHTO Type IV-A)	2 @ 24		Column Pier on Spread Footing	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
6	063+089	95.97	33.6	RCDG (D=1100)	2 @ 16.5		Column Pier on Spread Footing	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
7	065+279	108.25	14.0	RC Integ. Slab (D=600)	1 @ 13		-	Integral Type on RC Driven Pile (0.4x0.40m)
8	068+198	123.14	24.6	RC Slab (D=600)	2 @ 12		Wall Pier on Spread Footing	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
9	072+946	169.60	18.6	RCDG (D=1100)	1 @ 18		-	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
10	081+945	184.80	33.6	RC Slab (D=600)	10+12+10		Wall Pier on Spread Footing	Seat Type Cantilever on RC Driven Pile (0.4x0.40m)
11	083+060	183.12	13.0	RC Integ. Slab (D=600)	1 @ 10		-	Integral Type on RC Driven Pile (0.4x0.40m)
12	089+838	147.57	72.6	RCDG (D=1100) 1-Lane Bridge	4 @ 18	Sidewalk : 1@1.00 Shoulder : 1.50+0.50 Traffic Lane : 1@3.50 **Total : 6.50**	Column Pier on Spread Footing	Seat Type Cantilever on Spread Footing

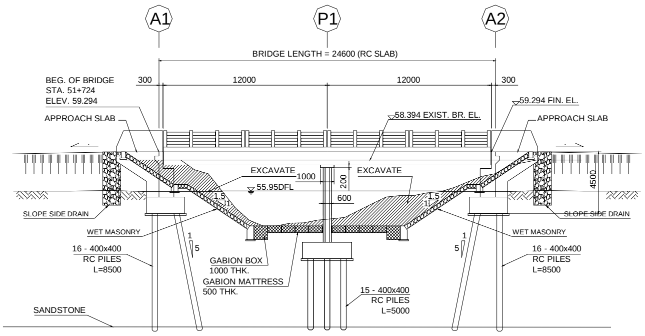
NOTES :
1. PCDG is Prestressed Concrete Deck Girder Bridge
2. RCDG is Reinforced Concrete Deck Girder Bridge
3. RC Slab is Reinforced Concrete Cast-in-Place Slab Bridge
4. RC Integ. Slab is Reinforced Concrete Cast-in-Place Slab with Integral Abutment



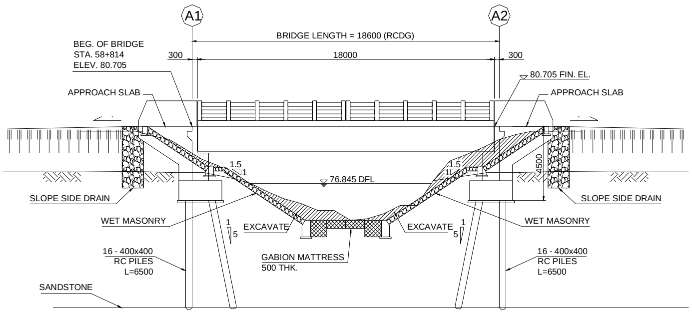
BRIDGE NO.1 REINFORCED CONCRETE INTEGRAL SLAB BRIDGE
STA. 40+693 BRIDGE LENGTH=15.00m



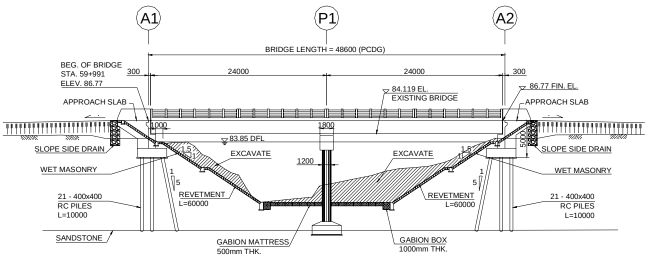
BRIDGE NO.2 REINFORCED CONCRETE SLAB BRIDGE
STA. 41+788 BRIDGE LENGTH=24.60m



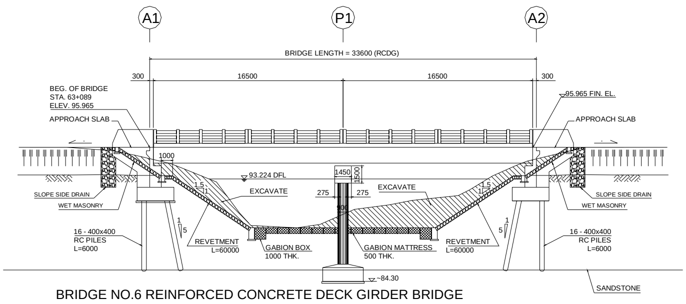
BRIDGE NO.3 REINFORCED CONCRETE SLAB BRIDGE
STA. 51+724 BRIDGE LENGTH=24.60m



BRIDGE NO.4 REINFORCED CONCRETE DECK GIRDER BRIDGE
STA. 58+814 BRIDGE LENGTH=18.60m

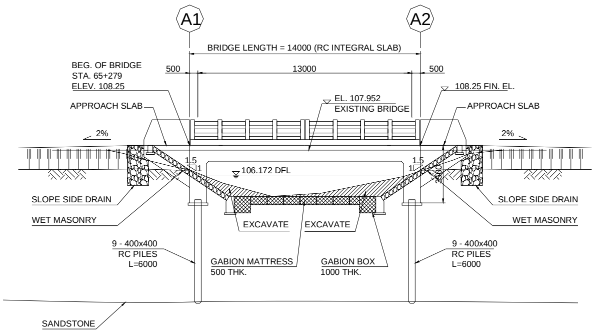


BRIDGE NO.5 PRESTRESSED CONCRETE DECK GIRDER BRIDGE
STA. 59+991 BRIDGE LENGTH=48.60m

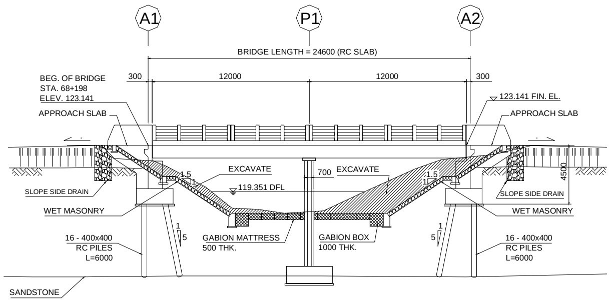


BRIDGE NO.6 REINFORCED CONCRETE DECK GIRDER BRIDGE
STA. 63+089 BRIDGE LENGTH=33.60m

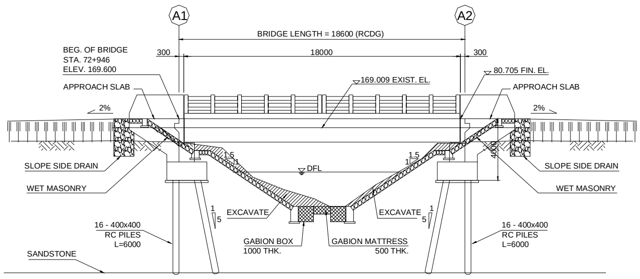
Figure 3.3.6(a) Proposed Bridges



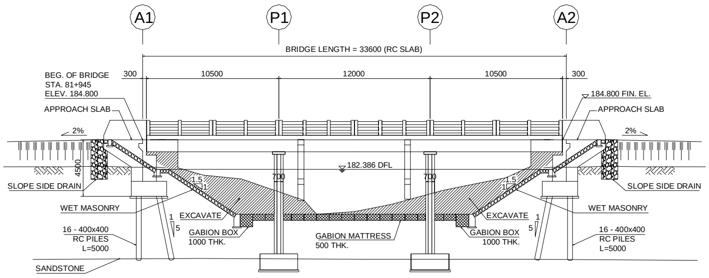
BRIDGE NO.7 REINFORCED CONCRETE INTEGRAL SLAB BRIDGE
STA. 65+279 BRIDGE LENGTH=14.00m



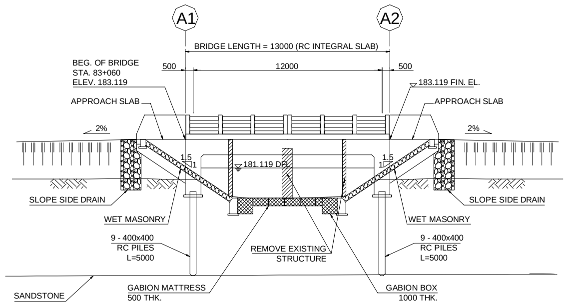
BRIDGE NO.8 REINFORCED CONCRETE SLAB BRIDGE
STA. 68+198 BRIDGE LENGTH=24.60m



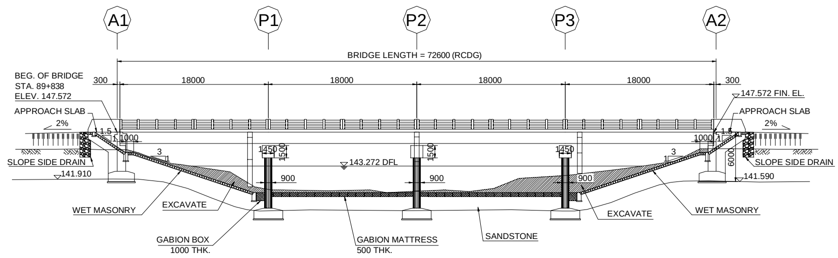
BRIDGE NO.9 REINFORCED CONCRETE DECK GIRDER BRIDGE
STA. 72+946 BRIDGE LENGTH=18.60m



BRIDGE NO.10 REINFORCED CONCRETE SLAB BRIDGE
STA. 81+945 BRIDGE LENGTH=33.60m



BRIDGE NO.11 REINFORCED CONCRETE INTEGRAL SLAB BRIDGE
STA. 83+060 BRIDGE LENGTH=13.00m



BRIDGE NO.12 REINFORCED CONCRETE DECK GIRDER BRIDGE
STA. 89+838 BRIDGE LENGTH=72.60m

Figure 3.3.6(b) Proposed Bridges

(5) Recommendations on Bridge Design

- The preliminary design for bridges along NR.57 was conducted based on the limited geotechnical and topographic survey conducted during the course of the study. It is obvious that during the detailed design, a more thorough and accurate geotechnical and topographic survey shall be conducted on each bridge site to finalize the bridge structures requirements.

- Likewise, the hydrologic and hydraulic study conducted is based on a very limited data so that a more accurate investigation is indicated. This will finalize the necessary bridge hydraulics that will determine the final bridge spans and length requirements.

- Based on the preliminary investigation, some existing bridges are recommended to be replaced by box culverts since preliminary river discharge volumes are quite small where box culvert capacities are sufficient. This bridge sites will have to be verified again during the detailed design stage.

- Two existing concrete slab bridges (Sta. 82+128 and 83+223) are recommended to be replaced in this study due to the following reasons:

    - These bridges show signs of distress (as evident by cracks, deck deformations and vibrations, etc.) which needs further assessment to verify its structural capacity. Due to insufficient time and level of study, detailed investigation was not carried-out,

    - These bridges are narrow and do not comply with the required bridge cross-section geometry.

    - Live load rating of the bridge maybe less than the new Cambodian live loading requirements.

  A more detailed bridge inspection will have to be conducted during the detailed design to determine the necessity for bridge rehabilitation, strengthening or replacement.

- The concrete girder bridge at Sta. 90+071 is recommended to be widened to comply with the bridge cross-section requirements. This is proposed to be done by constructing a parallel bridge which will cater for the northbound traffic while the existing bridge will function for the southbound traffic. When detailed design is to be done at this bridge site, it is necessary to conduct a detailed inspection of the existing bridge (although it looks alright by visual inspection) to determine its structural capacity, especially for the Cambodian live loading requirements. Moreover, the as-built condition has to be verified when deciding the positions of the substructures for the new bridge so that its construction will not affect the structural integrity of the existing bridge.