CHAPTER 5. TOLL COLLECTION FACILITY

5.1 SCOPE OF WORKS

Geometric design, operation of the toll collection, and necessary facilities for the operation are considered for the basic design of the tollgate facility of the Bago River Bridge. The design which had been considered in the supplemental survey for this project was reviewed, and the needed modifications were considered.

5.2 DESIGN CONDITION

5.2.1 Design Standard

- "General Technical Standard of Tollgate Facility on the Metropolitan Expressway" (Metropolitan Expressway Company Limited in Japan, February 2016)
- "Standard Drawings of Tollgate" (Metropolitan Expressway Company Limited in Japan, May 2016)
- "Design Standard of Road Geometric Design" (East Nippon Expressway Company Limited / Central Nippon Expressway Company Limited / West Nippon Expressway Company Limited)
- "Design Standard of Architecture" (Metropolitan Expressway Company Limited in Japan, July 2016)
- "Building Foundation Structure Design Guidelines" (Architectural Institute of Japan, 2001)
- "Installation Criteria for Road Markings" (Metropolitan Expressway Company Limited in Japan, August 2009)
- "Traffic Engineering and Management" (National Program on Technology Enhanced Learning in India)
- "Installation Criteria for Toll Collection Facilities" (Ministry of Construction in Japan, March 1999)
- "Specification of ETC Roadside Antenna" (Common Specifications among Expressway Companies in Japan, April 2014)
- "General Specification of ETC in Metropolitan Expressway" (Metropolitan Expressway Company Limited in Japan, July 2011)
- "Standard Drawings of Tollgate" (Metropolitan Expressway Company Limited in Japan, May 2016)

5.2.2 Traffic Condition

For the calculation of the number of lanes at the tollgate, the traffic volume forecasted in the Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA) Master Plan (in 2035) shown in Table 5.2.1 below is used.

Table 5.2.1 Forecasted Traffic Volume by Vehicle Type (Year of 2035)

For Yangon	BC/MC/ Car/Taxi	Van	Pass Truck & Small Bus	Large Bus	Small Track	Truck (2axles)	Truck (3axles)	Truck (4axles, and more)	Total
Veh/Day	19,063	3,460	944	292	971	249	306	67	25,352
Ratio	97.5%					**2.5%**			100%

For Thanlyin	BC/MC/ Car/Taxi	Van	Pass Truck & Small Bus	Large Bus	Small Track	Truck (2axles)	Truck (3axles)	Truck (4axles, and more)	Total
Veh/Day	12,925	2,730	1,438	6	735	645	445	75	19,004
Ratio	93.9%					**6.1%**			100%

Source: Extracted from YUTRA by the JICA Study Team

According to the traffic survey conducted by the JICA Study Team of YUTRA, the peak hour ratio at the targeted area was 6.9%. Considering the ration of large vehicles to the total number of traffic shown in the above table, the traffic volume at peak hour by vehicle type (non-large / large) can be calculated as the below Table 5.2.2.

For large vehicles, it is planned to install track scales and be charged a toll amount which depends on the weight. Therefore, lane dedicated to large vehicle is to be set. Considering the service time which is assumed by each vehicle type, the required number of lanes by vehicle type is calculated as shown in below Table 5.2.2.

Table 5.2.2 Number of Vehicles by Type (Non-Large / Large) and Required Number of Lanes

Direction	Vehicle Type	Number of Vehicle	Service Time (sec)	Total Time (sec)	Number of Lanes	Unit Strength of Traffic per 1 lane	
For Yangon	Non-large	1,706	8	13,648	4	0.95	< 1.0
	Large	43	20	860	1	0.24	< 1.0
For Thanlyin	Non-large	1,231	8	9,848	4	0.68	< 1.0
	Large	80	20	1,600	1	0.44	< 1.0

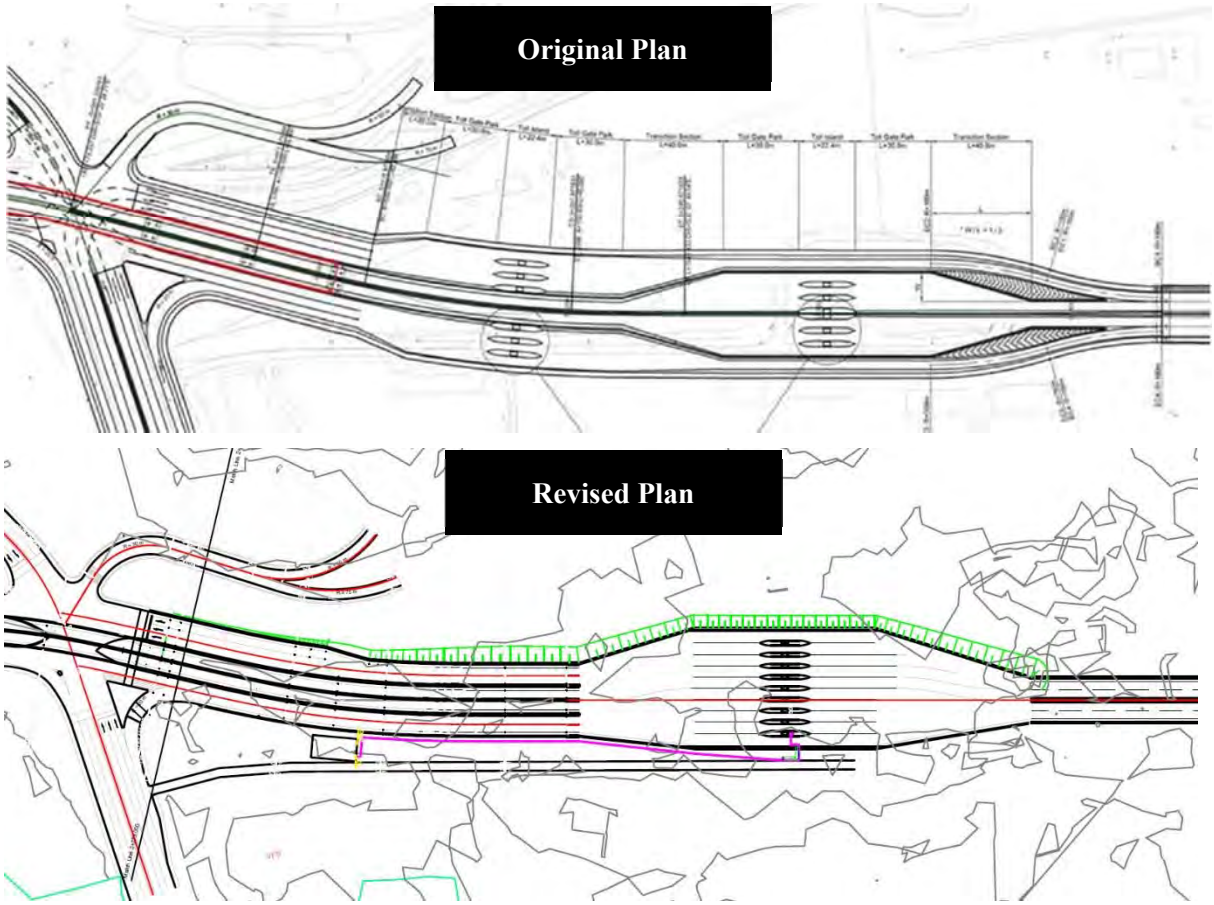
Source: JICA Study Team

5.3 TOLLGATE WORKS

5.3.1 Plan of Tollgate Facility

Tollgate consists of large roof, toll island, toll booth (toll collection booth, machinery booth), staircase for access, administrative office, etc.

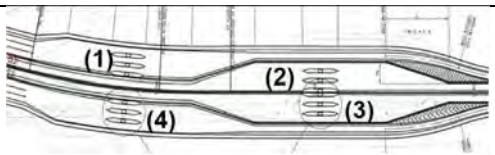
The preliminary design of tollgate in the supplemental survey was reviewed in terms of efficiency and safety for the operation of traffic and toll collection according to the latest condition. Then the layout of the tollgate was revised as shown in the below Figure 5.3.1. The tollgate facilities are aggregated as much as possible, then the number of tollgates are reduced from 4 to 2. This revision is made possible with the shift of road alignment of the through traffic itself to the north to avoid the community road located south of the tollgate.



Source: JICA Study Team

Figure 5.3.1 Revision of Tollgate Facility Layout

Table 5.3.1 Revision of Tollgate Plan

Items	Revised Plan	Original Plan
Number of Tollgate	2 tollgates	4 tollgates
	(1) Tollgate (For Taketa) (2) Tollgate (For Thanlyin)	(1) Tollgate for Approach Ramp (For Taketa) (2) Tollgate for Through Traffic (For Taketa) (3) Tollgate for Through Traffic (For Thanlyin) (4) Tollgate for Approach Ramp (For Thanlyin)
Number of Lane	5 lanes × 2	3 lanes × 2
Number of Toll Collection Booth	9 toll collection booths in total	12 toll collection booths in total
Facility Layout		

Source: JICA Study Team

The outline of the revised tollgate facility is stated as follows:

- Total number of lanes: 10 lanes
  (This was calculated using the traffic volume at peak hour.)
- Total number of toll booths: 9 toll collection booths
  (Both sides of traffic are handled at the 5th booth located at the middle of 10 lanes.)
- Basically, each toll booth is designed for left-hand drive cars. However, taking the current situation of considerably high volume of right-hand drive cars into account, windows are set both sides of the toll booth to cope with right-hand drive cars.
- Lanes between the 4th and 7th which are located at the center of tollgates are designed to be applicable for reversible lane to adjust the future traffic condition and keep the traffic smooth. Because of that, structures such as mount-up type median is not installed in the toll plaza.
- In the toll collection booth, the equipped function is limited to collect toll. (The resting room for napping and toilet is placed in the Administrative Office, which is located near the tollgate facility.)
- Large roof is installed to avoid rains.
- The structure and specification are decided as discussed below in consideration of construction work and cost economy.

5.3.1.1 Large Roof

- Structure: Steel construction, which is lightweight and can reduce the construction works at the site.
- Story: One-story
- Total Area of Shed: 650.4 m^2 (54.2 m x 12.0 m)
- Clearance Limit (Height): 6.0 m
- Auxiliary Facility: Lighting facility
- Others: Installation of the ceiling is canceled to allow for drop out.

  The power cable is to be taken to each toll booth via rack crawling on the inferior surface of roof and duct attached to the booth.

5.3.1.2 Toll Island

- Structure: Reinforced concrete is applied, which has high durability.
- Number of lanes: 10 lanes
- Length: 25.0 m (The required space for the future installation of ETC is considered.)
- Width: -Lane for the non-large vehicle: 3.2 m
  -Lane for the large vehicle: 4.6 m

5.3.1.3 Toll Booth (Toll Collection Booth)

- Structure: Steel construction, which is lightweight and can reduce the construction works at the site.

- Story: One-story
- Area of a Toll Booth: Approx. 4.5 m^2
- Number of Booths: 9 booths
- Auxiliary Facility: Air conditioning facility, lighting facility
- Others: Toll booths between the 4th and 6th are designed to be applicable for reversible operation to adjust for future traffic conditions. Sliding door is applied.

5.3.1.4 Toll Booth (Machinery Booth)

- Structure: Steel construction, which is lightweight and can reduce the construction works at the site.
- Story: One-story
- Area of a Toll Booth: Approx.7.7 m^2
- Number of Booths: 1 booth
- Auxiliary Facility: Air conditioning facility, Lighting facility
- Others: The power cable is to be taken to machinery booth first. Power distribution to each toll booth is equipped in machinery booth.

5.3.1.5 Staircase

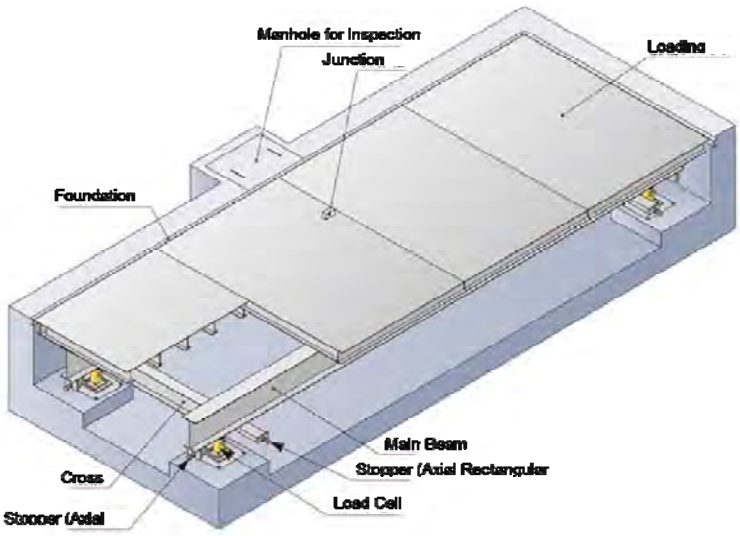
- Structure: Steel construction
- Size: Stair tread is 260 mm, Height of the riser is 180 mm
- Auxiliary facility: Lighting facility

5.3.1.6 Truck Scale

- Type: Pit type

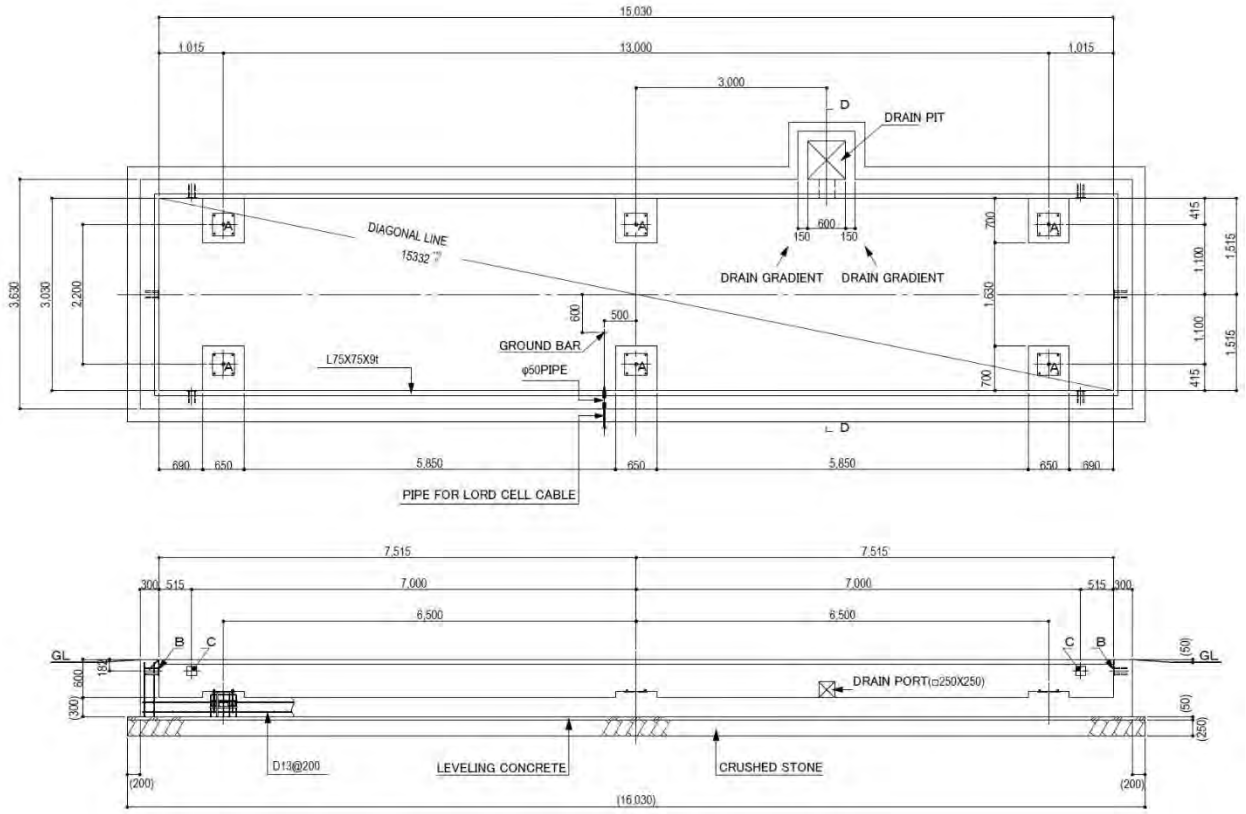
  (The loading surface is at the same level with the ground surface and there is no slop.)
- Maximum measurable weight: 60 t
- Size of the box for blockout:

  (width) 3,500 mm x (length) 15,630 mm x (depth) 1,700 mm
- Number of truck scales: 2 sets (1st lane and 10th lane)
- Drain Pit: (width) 600 mm x (length) 600 mm x (length) 1,700 mm



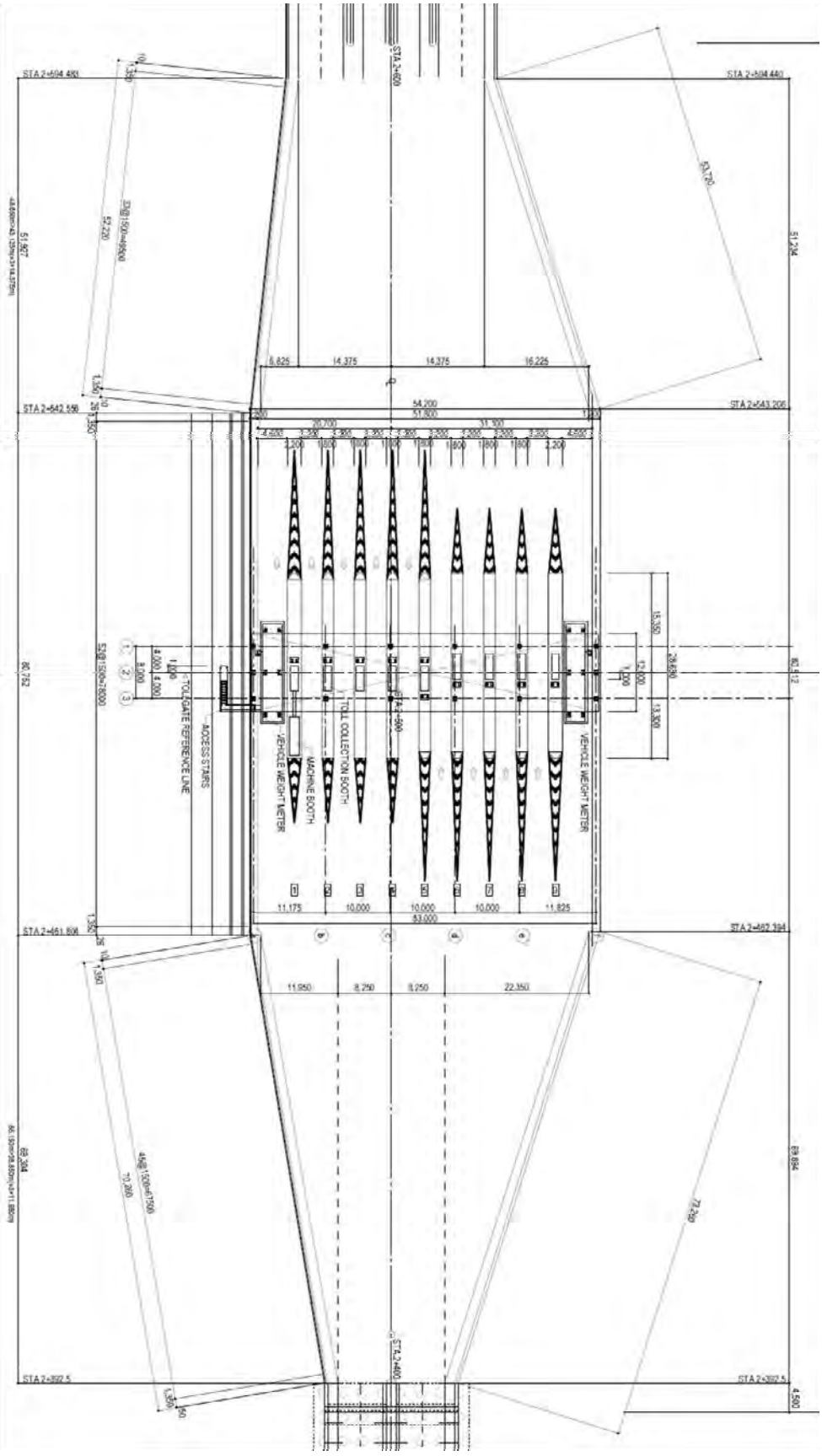
Source: Website of Kamacho Scale Co., Ltd.（http://www.kamacho.co.jp/products/truckscale/lineup/ts.html）

Figure 5.3.2 Layout Image of Truck Scale



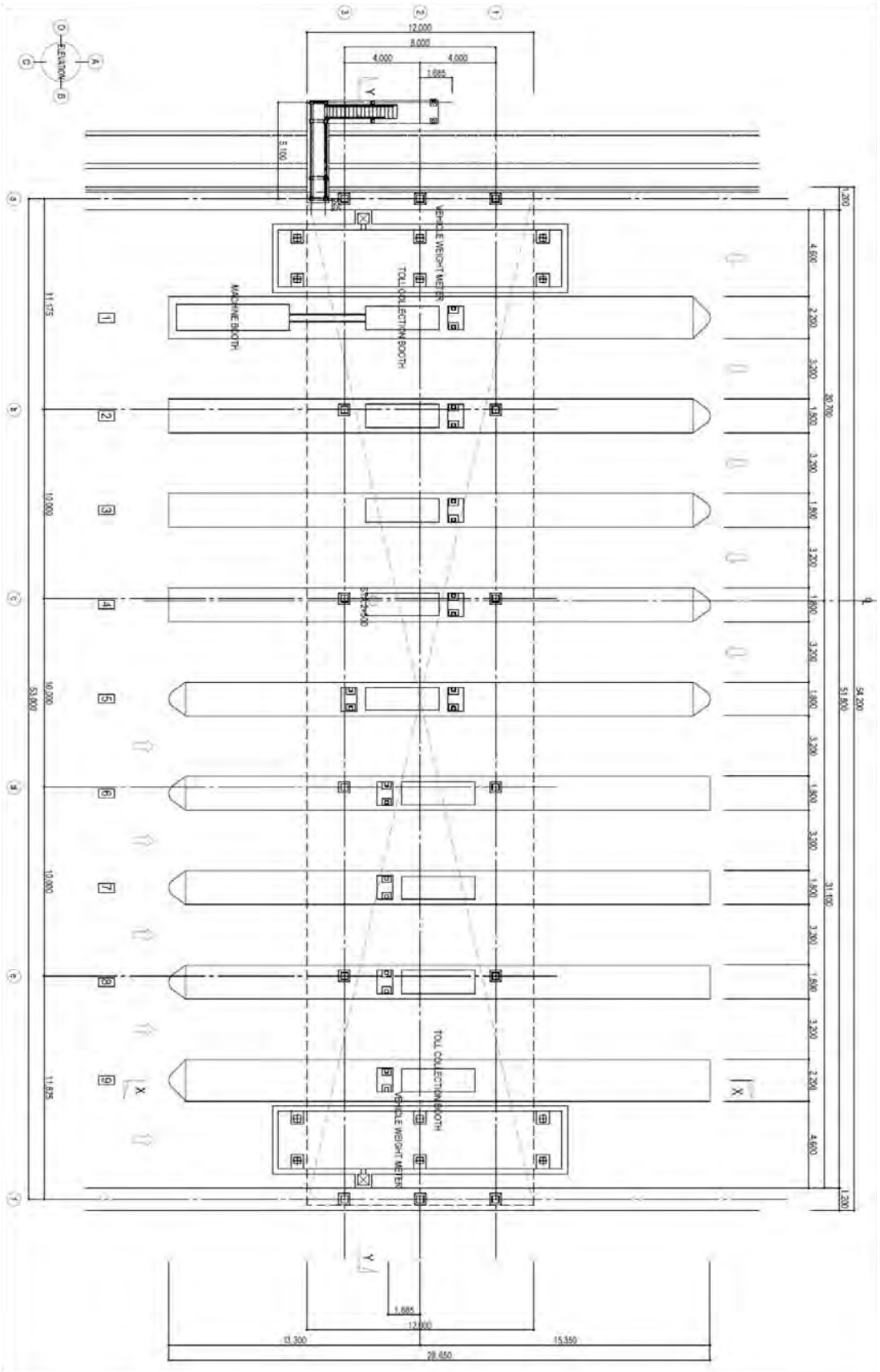
Source: JICA Study Team

Figure 5.3.3 Plan and Elevation of Truck Scale



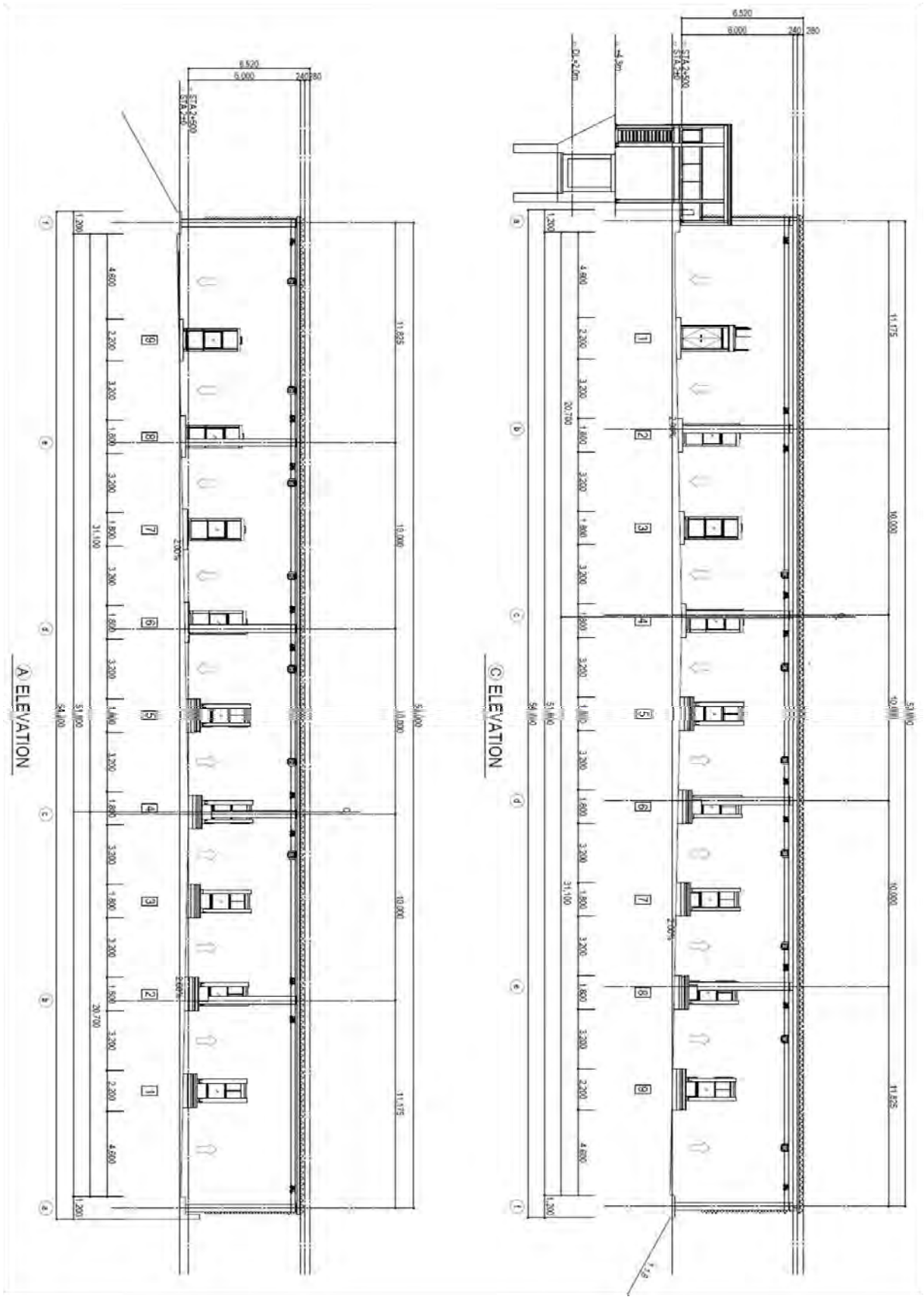
Source: JICA Study Team

Figure 5.3.4 Layout of Tollgate



Source: JICA Study Team

Figure 5.3.5 Plan View of Tollgate



Source: JICA Study Team

Figure 5.3.6 Elevation View of Tollgate

5.3.2 Materials to Be Used

Used materials for tollgate facilities are shown in Table 5.3.2.

Table 5.3.2 Used Materials for Tollgate Facilities

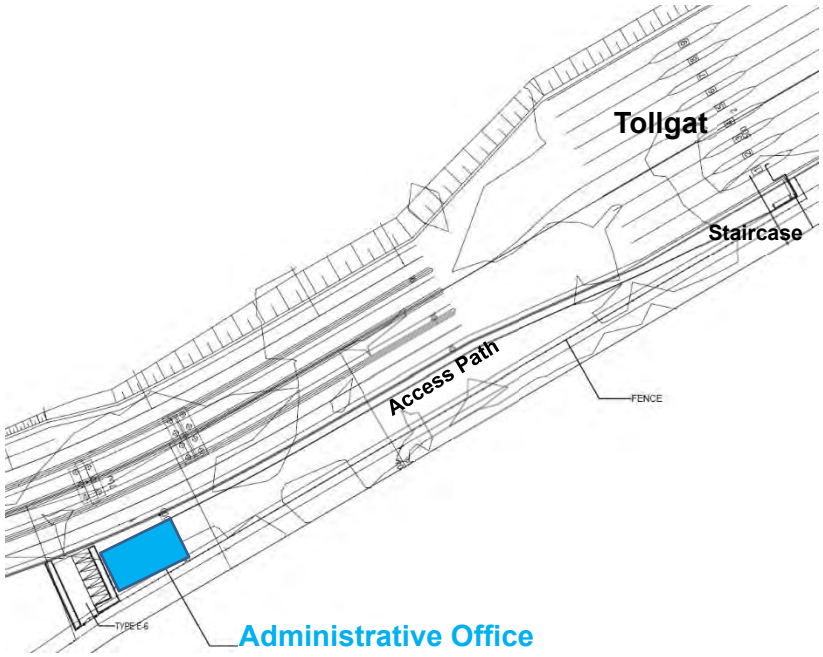
Facility	Part	Material
Large Roof	Roof	- Bolting Folded Plate (Steel), Steel Shingle board Height 150 mm, Thickness 0.8 mm - Eaves: Decorative plate is set at the edge of the upper side eaves - Roof: Exposed folded plate
	Column	- Rectangular Steel Pipe
	Wall	- Perforated Folded Plate (Steel) Width 200 mm, Height 88.2 mm
	Gutter	- Eaves Gutter (Rigid polyvinyl chloride) with overflow hole - Vertical Gutter (Rigid polyvinyl chloride)
Toll Island	Floor, Protective Barrier	- Concrete
	Protection Pole	- Concrete, Rectangular Steel Pipe
	Pit	- Installed between the 1st toll collection booth and machinery booth
Toll Booth (Toll Collection Booth)	Footing Beam	- Steel (c-200 x 90 x 8.0 x 13.5)
	Column	- Rectangular Steel Pipe (100 x 100)
	Wall	- External Steel Plate: Thickness 2.3 mm - Internal Steel Plate: Thickness 0.7 mm
	Floor	- Steel Plate: Thickness 3.2 mm
	Roof	- Steel Plate: Thickness 2.3 mm
Toll Booth (Machinery Booth)	Footing Beam	- Steel (c-200 x 90 x 8.0 x 13.5)
	Column	- Rectangular Steel Pipe (100 x 100)
	Wall	- External Steel Plate: Thickness 0.8 mm - Internal Steel Plate: Thickness 0.5 mm
	Floor	- Steel Plate: Thickness 3.2 mm
	Roof	- Bolting Folded Plate (Steel): Height 85 mm, Thickness 1.0 mm
Staircase	Column	- Rectangular Steel Pipe
	Roof	- Bolting Folded Plate (Steel): Height 85 mm, Thickness 0.8 mm
	Handrail panel	- Aluminum resin laminated composite plate: Thickness 4.5 mm
	Gutter	- Eaves Gutter (Rigid polyvinyl chloride) with overflow hole - Vertical Gutter (Rigid polyvinyl chloride)

Source: JICA Study Team

5.4 ADMINISTRATIVE OFFICE WORKS

5.4.1 Plan of Administrative Office Facility

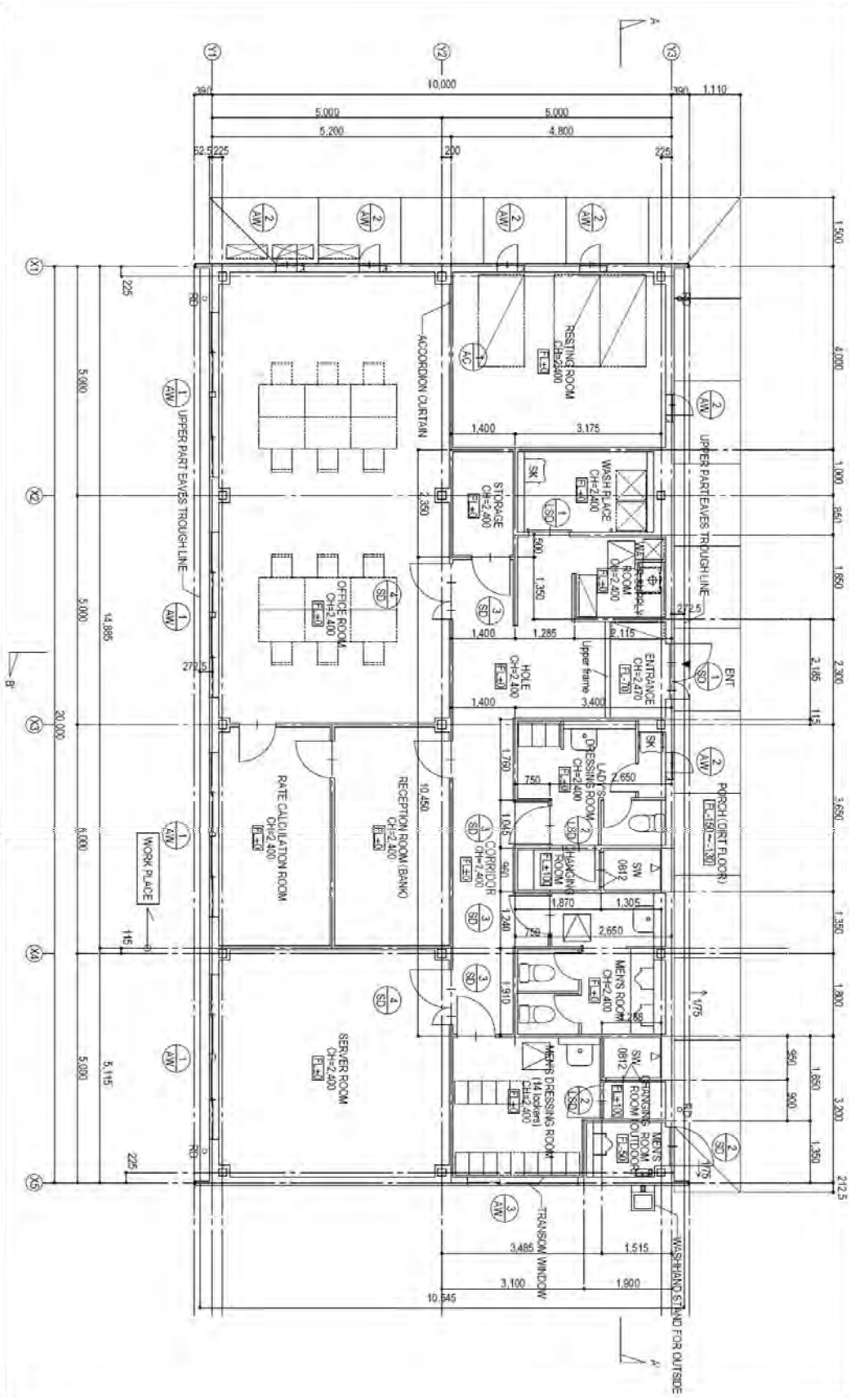
For the purpose of managing and monitoring the tollgate and toll collectors, holding collected cash temporarily, providing the resting place for toll collectors, etc., an administrative office shall be built near the tollgate at the location shown in Figure 5.4.1.



Source: JICA Study Team

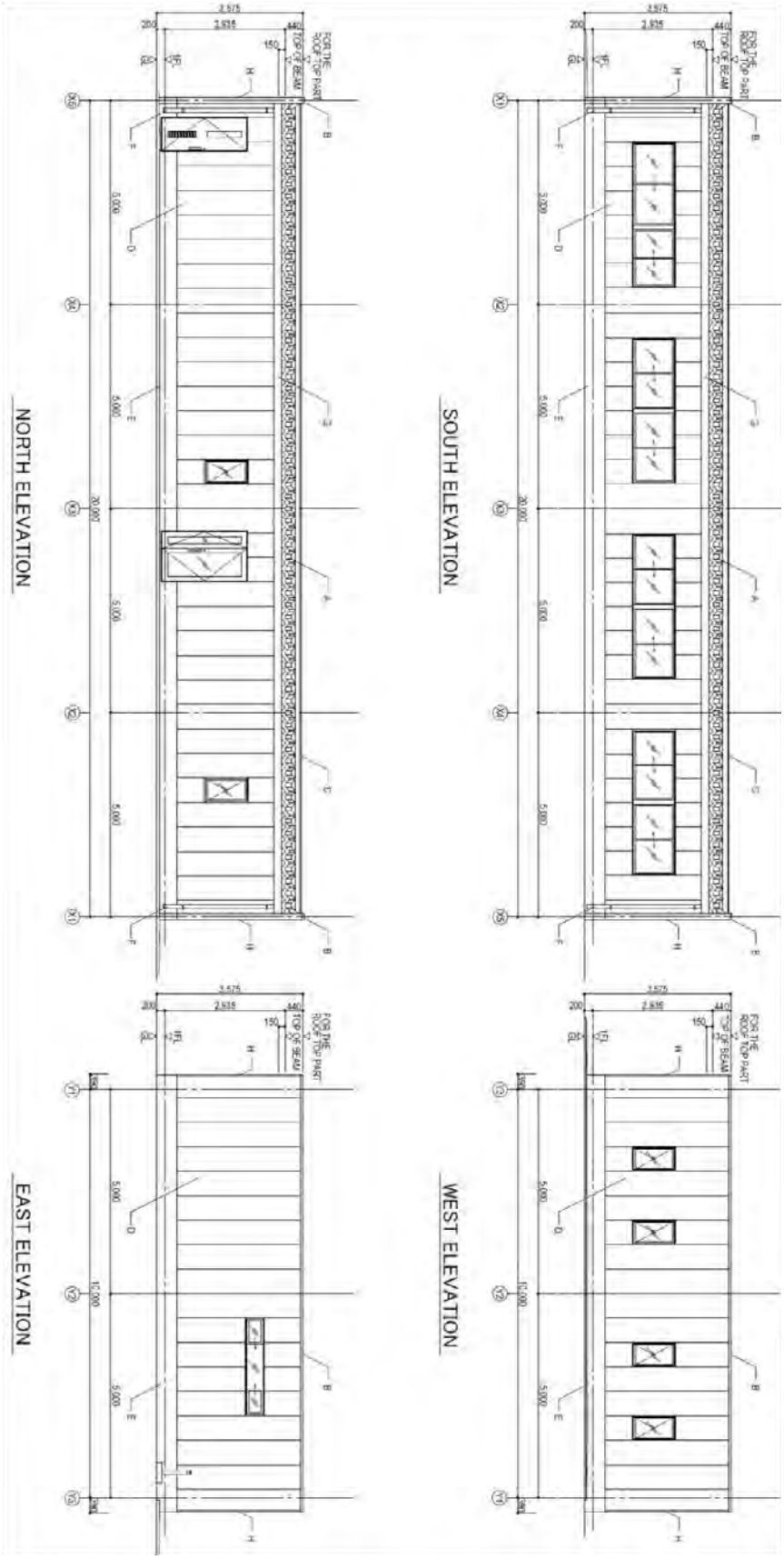
Figure 5.4.1 Location Map of Administrative Office

- Structure: Steel construction, which is lightweight and can reduce the construction works at the site.
- Story: One-story
- Total Area of Floor Space: 210.9 m^2
- Rooms: Office Room, Counting Room, Reception Room, Server Room, Resting Room, Toilet, Locker Room (Men/Women), Shower Unit, Hot Water Supply Room, Storage
- Others: Septic Tank, etc.



Source: JICA Study Team

Figure 5.4.2 Plan View of Administrative Office



Source: JICA Study Team

Figure 5.4.3 Elevation View of Administrative Office

5.4.2 Equipment and Materials

Materials to be used for the Management Office are shown in the following Table 5.4.1.

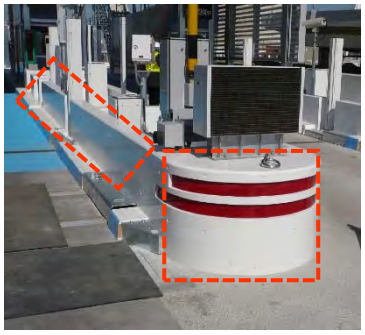
Table 5.4.1 Materials to be Used for Administrative Office

Part	Material
Roof	Folded Plate (Galvalume board)
External Wall	Autoclaved Lightweight Concrete
Foundation	Concrete
Gutter	Eaves Gutter (Aluminum), Vertical Gutter (Hard Vinyl Chloride Resin)
Boundary Fence	Wire Fence

Source: JICA Study Team

5.5 SAFETY MEASURE

To avoid the accidental contact of vehicle to the toll booth, the barrier, side protection for island, and protection pole are set up as shown in below Photos 5.5.1 and 5.5.2.



Source: JICA Study Team

Photo 5.5.1 Barrier and Side Protection

Photo 5.5.2 Protection Pole

5.6 FUTURE UPGRADE PLAN

This chapter describes, in preparation to utilization of the Electronic Toll Collection (ETC) system in the future, comparison of ETC types, list of assumed equipment, example of installation position of ETC equipment around toll booths and considerations for implementation.

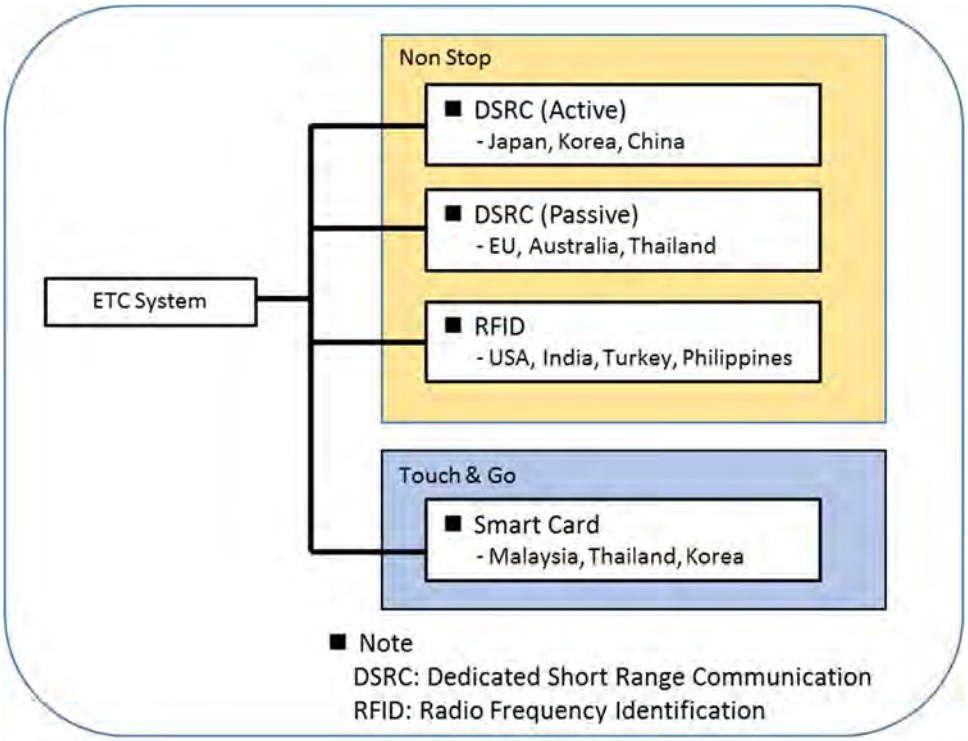
5.6.1 Electronic Toll Collection System (ETC)

5.6.1.1 Definition of ETC

ETC is one of the Intelligent Transportation Systems (ITS) that enables drivers travelling on the toll road to pay toll fee by radio communication system between roadside equipment and onboard units equipped in the vehicles. This system allows drivers to pay toll fees without preparing cash and pass tollgates without stopping (or only with short stop) at the tollgates; hence, it is able to maintain smooth traffic flow, and mitigate traffic congestion heading to the tollgates.

5.6.1.2 Types of ETC

Currently, various types of ETC exist due to the difference of wireless communication methods between Roadside Unit (hereafter referred to as "RSU") installed at toll plaza and On-Board Unit (hereafter referred as "OBU"). General classification of major ETC types are shown in the following Figure 5.6.1.



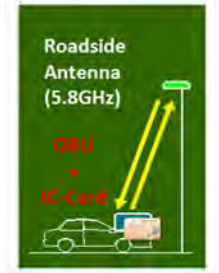
Source: JICA Study Team

Figure 5.6.1 Types of ETC Implemented in Various Countries

5.6.1.3 Characteristics of Each ETC System

(1) DSRC Active

In this method, both RSU and OBU have functions to emit radio waves and communicate with each other. Radio waves at a frequency band of 5.8 GHz is often used. As each unit can emit radio waves, output (wattage) of radio waves can be saved. In addition, it allows high-speed and high-capacity communication, e.g., 1,000 Kbps (kilobits per second) approximately both in uplink (OBU to RSU) and downlink (RSU to OBU). Japan, Korea, China, among others employ this method.

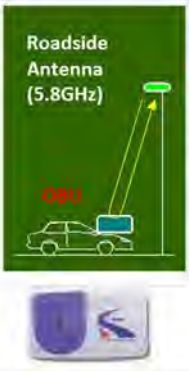
DSRC Active		
	Features	◆ Two-way communication ➢ OBU can receive & send information
	Entrance	◆ Antenna → OBU ➢ Entrance information
	Exit	◆ OBU → Antenna ➢ Entrance information ➢ Vehicle type ➢ IC card information ◆ Antenna → OBU ➢ Toll fee information
	OBU	Two pieces (OBU + IC Card)

Source: JICA Study Team

Figure 5.6.2 DSRC Active Method

(2) DSRC Passive

In this method RSU has the function to emit radio waves, but not OBU. The reflection of radio waves emitted by RSU is used to communicate between them. This method mainly uses radio waves at a frequency of 5.8 GHz. This is widely employed in the world, largely in Europe. In general, OBU is composed of main board only, which communicates with RSU. Each communication speed is: 250 kbps in uplink (OBU to RSU) / 500 kbps in downlink (RSU to OBU).

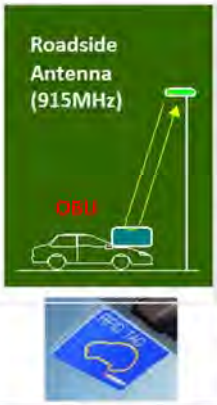
DSRC Passive		
	Features	◆ One way communication ➢ Radio wave sent from antenna to OBU is reflected back to antenna
	Entrance	➢ Antenna reads ID number of OBU ➢ This ID number & entrance number are sent to the Center ➢ The center sends above information to all exit
	Exit	➢ Antenna reads ID number of OBU ➢ Information from the Center is compared with ID number ➢ Compute toll fee & balance
	OBU	One piece

Source: JICA Study Team

Figure 5.6.3 DSRC Passive Method

(3) RFID

In this method, RSU has the function to emit radio waves, but not OBU. The reflection of radio waves emitted by RSU is used to communicate between them. This method mainly uses radio waves at the frequency band of 915 MHz. There is a card type OBU to be stuck on the front screen. It is mainly operated in the United States of America (USA) and India, which has the specifications as national standard system of ETC established by the government. In general, OBU is composed of only main board, which communicates with RSU, same as passive method of DSRC. Its communication speed is up to its specification, and approx.500 kbps both in uplink and downlink at the maximum.

RFID		
	Features	◆ One way communication ➢ Radio wave sent from antenna to OBU is reflected back to antenna
	Entrance	➢ Antenna reads ID number of OBU ➢ This ID number & entrance number are sent to the Center ➢ The center sends above information to all exit
	Exit	➢ Antenna reads ID number of OBU ➢ Information from the Center is compared with ID number ➢ Compute toll fee & balance
	OBU	One piece of card (attached to from glass)

Source: JICA Study Team

Figure 5.6.4 RFID Method

(4) Smart Card (Touch and Go)

This method requires users to bring Smart Card into contact with card reader / writer at the toll booths for data communication. Although Smart Card is a non-contact IC card, it requires to be placed very close to the card reader/ writer in order to send/receive data, that is, it makes drivers stop at every tollgate. In this regard, it is different from the other methods mentioned above (non-stop at the tollgate).

Smart card (Touch & Go)		
 Card Reader/Writer  Smart Card	Flat rate	➢ Vehicle class is determined manually ➢ Read ID number and deduct toll fee ➢ Balance is recorded in the card
	Distance based toll rate	◆ Entrance ➢ Entrance information is recorded in the card
	Exit	◆ Exit ➢ Vehicle class is determined manually ➢ Read ID number and entrance information ➢ Calculate toll fee ➢ Deduct toll fee and record balance in the card
	OBU	One piece of card (attached to from glass)

Source: JICA Study Team

Figure 5.6.5 Smart Card Method

Smart Card method is adopted in some toll roads in Manila and Bangkok. In Myanmar, some of the toll roads managed by Max Highway Co., Ltd have been operating it on trial basis.

Source: JICA Study Team

Figure 5.6.6 Trial Operation of Smart Card System by Max Highway Co., Ltd.

5.6.1.4 Comparison of Characteristics of ETC System

Table 5.6.1 shows the comparison of characteristics in terms of ETC system.

Table 5.6.1 Summary of Characteristics of ETC System

		DSRC Active	DSRC Passive	RFID	Smart Card
Technical Specification		• Flat rate • Distance based	• Flat rate • Distance based	• Flat rate	• Flat rate • Distance based
Technical Specification	International standard	• ITU-R M.1453 • ISO15628	• ITU-R M.1453 • ISO15628	• ISO18000 -6C	• ISO14443 type-A
	Frequency of band	5.8 GHz	5.8 GHz	915 MHz	13.56 MHz
	Data communication speed	Down link 1,000 Kbps Up link 1,000 Kbps	Down link 500Kbps Up link 250 Kbps	Max. 500 Kbps	Vehicle remains until transaction is completed
	OBU type	2 Pieces (OBU+IC Card)	1 Piece (OBU)	1 Piece (OBU)	IC Card
	Transmission power	0.01 W	10 W	2 W	—
	OBU Durability	Long	OBU needs to be replaced after 4-5 years	Long	Long
Accuracy of System	Communication reliability (in specification)	≧99.9999%	99～99.9%	99.9%	—
	Average communication error rate (actually)	0.003%	0.5%	N/A	—
	Communication errors (for 100,000 transactions)	3	500	N/A	—

		DSRC Active	DSRC Passive	RFID	Smart Card
Operation	User Payment Method	Post payment (Credit Card) and Prepaid	Prepaid & Post payment	Prepaid	Prepaid
	Balance information record at	IC card and center	Center	Center	IC card and center
	Updating Speed of Balance after payment or reloading	Instantly	There is time-lag (depending on system design)	There is time-lag (depending on system design)	Instantly
	Alternative payment method in case of OBU or RSU problem	IC card and cash	Cash	Cash	IC card and cash
Cost	Facility cost (incurred by road administrator)	Medium	Medium	Medium	Low
	OBU price (USD)	Medium-High (40–90)	Medium (20–60)	Low (2-15)	Low (2–5)
Use for other payments for railways, restaurants, etc.		Possible (IC card can be used for other purposes)	No (No IC card)	No (No IC card)	Possible (IC card can be used for other purposes)

Source: JICA Study Team

Among others, DSRC Active is the most accurate method with the fastest communication processing speed. In addition, as its OBU is a separable two-piece type: on-board unit and IC card, which allows drivers to use the same IC card on various vehicles. There is a high-performance type card with flexible use other than for ETC, such as railways and buses. Although DSRC Active method requires initial cost, because its OBU cost is relatively higher than others, it records registration information of user/ vehicle on IC cards and OBU, thereby it facilitates implementation of toll fee system such as distance-based fee and vehicle-type classified fee in the future.

OBU of DSRC Passive method is cheaper, thus its initial cost is comparatively inexpensive. On the other hand, its communication area is narrower and communication errors are higher than DSRC Active method, because of its lower communication speed. Prepaid balance information cannot be updated immediately after passing the tollgate or transaction of top up, as it is being processed in the central system. This time lag can cause some troubles, for example, drivers cannot pass the tollgates for lack of balance; charging transaction of distance-based toll system cannot work correctly for short-distance travelers. Therefore, it is necessary to discuss also about settlement method including deferred payment associated with credit cards or bank accounts. Furthermore, as its apparatus tends to be portable, which can be replaced in other vehicles easily, taking countermeasure against illegal vehicles will become imperative when introducing vehicle classification toll system.

As the OBU cost of RFID method is the cheapest, its initial cost can be saved. On the other hand, as its communication speed is as same level as DSRC Passive method, communication area is narrower than the Active one. Remaining balance information and passage history cannot be updated immediately after transactions, because data cannot be written on RFID tags, but will be processed in the central systems. This time lag will provide issues when introducing distance-based toll fee system as well as DSRC Passive method. Besides, current major types of RFID tag do not allow repeated use on other vehicles once it is taken off.

5.6.2 Layout Consideration

5.6.2.1 Facility List

The following Table 5.6.2 shows a facility list of ETC system in general.

Facilities to be installed on roadside vary by ETC methods and design concepts. The following shows an example referred from cases of DSRC Active (Japan), DSRC Passive (Thailand), and RFID (Indonesia).

Table 5.6.2 Units of ETC Facility by System Method

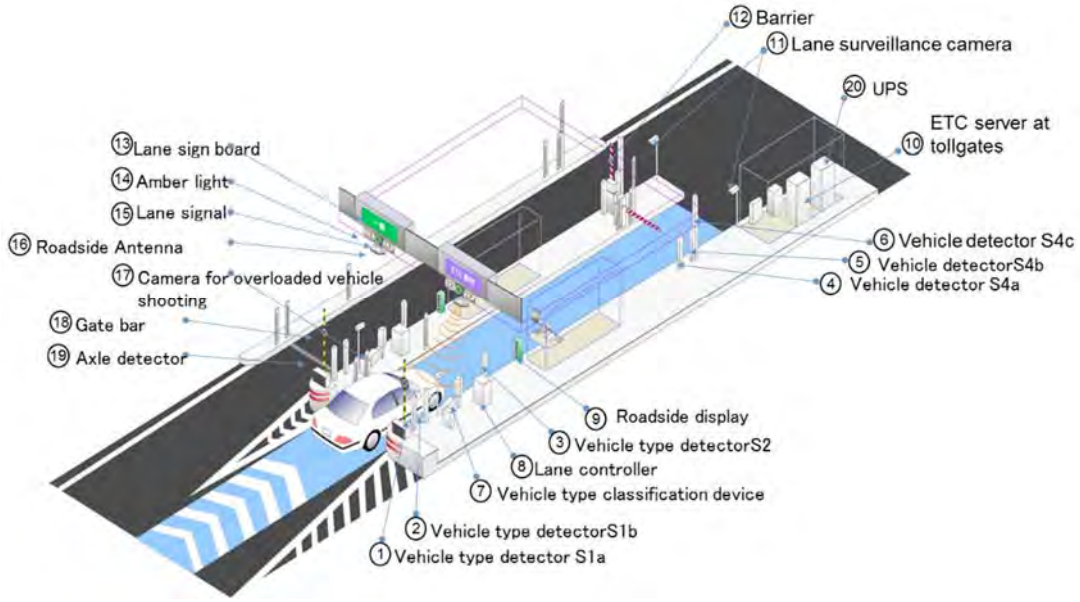
	Unit	Purpose	DSRC Active	DSRC Passive	RFID
1	Vehicle Detector	Detect entering / exiting vehicles	✓	✓	✓
2	Vehicle Type Classification Device	Classify vehicle type	✓	–	–
3	Lane Controller	Control each equipment at toll lane	✓	✓	✓
4	Roadside Display	Display “Go” or “Stop” to vehicle	✓	✓	✓
5	ETC Server at Tollgate	Gather information from Lane Controller	✓	✓	✓
6	Lane Surveillance Camera	Shoot images of lane	✓	✓	✓
7	Barrier	Control passes of entering vehicles with barrier	✓	✓	✓
8	Lane Sign Board	Display operational status of the lane (ETC / Cash)	✓	–	✓
9	Amber Light	Call attention in case of lane closure	✓	–	–
10	Lane Signals	Display operational status of the lane (Open/ Close)	✓	✓	✓
11	Roadside Antenna (RSU)	Communicate to OBU	✓	✓	✓
12	Gate Bar	Closes off the lane to intercept vehicle from passing when lane closure	✓	✓	✓
13	Axle Detector	Count the number of axles	✓	✓	–
14	UPS for ETC	Supply electric power in stable	✓	✓	✓

Source: JICA Study Team

5.6.2.2 Examination of Installation Layout (Facility Layout)

As mentioned in Section 5.6.1, there exist several types of ETC methods. Therefore, it is necessary to consider what type of ETC will be employed in the future. The purpose of this section is to check the facility-installation space for current design plan of tollgates when ETC system will be introduced in the future. This study examined DSRC Active as a model, which has the largest number of components and the highest system accuracy among the methods mentioned. The result shows that the space in the drawings can cover the required area for future installation of ETC facilities.

The following Figure 5.6.7 indicates a concept image of the facility layout.



Source: JICA Study Team

Figure 5.6.7 Concept Image of ETC Facility Layout

Examination of installation layout was carried out for the facilities shown in the following Table 5.6.3.

Table 5.6.3 Units of ETC Facility

No	Image	Items	Outline of Item
(1)~(6)		Vehicle Detector	・Detect entering/ exiting vehicles by optical sensor ・Several detectors are installed according to the purpose of detection（S1a, S1b, S2, S4a, S4b, S4c）
(7)		Vehicle Type Classification Device	・Take photos of the rear-end number plate ・Recognize the number information ・Measure number plate size
(8)		Lane Controller	Control each ETC equipment installed at a toll lane ・Communicate with on-board unit. ・Communicate with ETC server at tollgate and data transmission. ・Judge status of ETC vehicles (procession is done successfully, or not completed)
(9)		Roadside Display	Display permission/ prohibition of passage to vehicles entering a toll lane.
(10)		ETC Server at the Tollgate	・Gather information from Lane Controller ・Send and receive data to an ETC central system

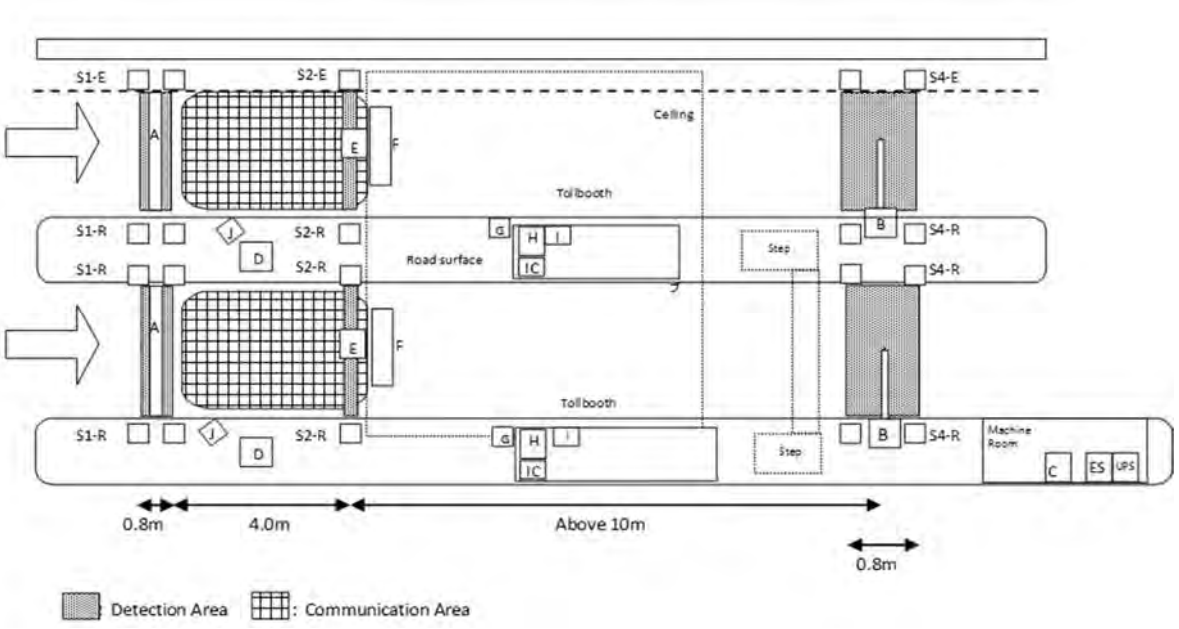
No	Image	Items	Outline of Item
(11)		Lane Surveillance Camera	・Shoot image of vehicles passing the lane and store the image for a certain period. (Countermeasures for illegally passing vehicles)
(12)		Barrier	・Control passes of entering vehicles with barrier ・Control vehicle speed by setting operation time of barrier to open/close.
(13)		Lane Sign Board	・ Installed at the main roof of tollgate and display operational status of the lane to vehicles (ETC, Cash, ETC and Cash)
(14)		Amber Light	・Flash when lane is closed to call drivers' attention in order to prevent vehicles from entering by mistake
(15)		Lane Signal	Displays operational status of the lane with graphics signs to vehicles entering a toll lane
(16)		Roadside Antenna	・ Communicate with On-Board Unit equipped in the vehicle.
(17)		Camera for Overloaded Vehicle Shooting	・Take pictures of illegal overloaded vehicles.
(18)		Gate Bar	・Close off the lane in order to prevent vehicles from approaching to closing lane
(19)		Axle Detector	・ Count the number of axles of passing vehicles by footboard sensor installed on the ground.
(20)		UPS for ETC	・Supply stable electric power for ETC facilities in the event of power flicker and electrical outage.

Source: JICA Study Team

Considerations for facility installation are as follows:

- Secure a space for maintenance;
- Determine the positioning of facilities taking into account system linkage (e.g., vehicle detector and barrier);
- Make sure that the purpose of each device is achieved (e.g., lane surveillance camera should be installed where it enables to shoot plate number of vehicles);
- Consider the influence of reflection of radio waves emitted from road side antenna, on lane sign board and lane signals; and
- Install radio wave absorber where necessary.

The following Figure 5.6.8 shows the layout plan of the facility.



Code	Name	Code	Name
S1-E	Vehicle detector (S1 Emitting section)	D	Lane controller
S1-R	Vehicle detector (S1 Receiving section)	E	Lane controller (antenna unit)
A	Axle detector	F	Lane signboard
S2-E	Vehicle detector (S2 Emitting section)	G	Roadside display
S2-R	Vehicle detector (S2 Receiving section)	H	Lane-monitoring console
S4-E	Vehicle detector (S4 Emitting section)	I	Monitor in tollbooth
S4-R	Vehicle detector (S4 Receiving section)	IC	IC card reader
B	Barrier system (including voice guidance device)	J	Vehicle type detector
ES	Tollgate ETC server	UPS	UPS for tollgate
C	Equipment holding lack		

Source: JICA Study Team

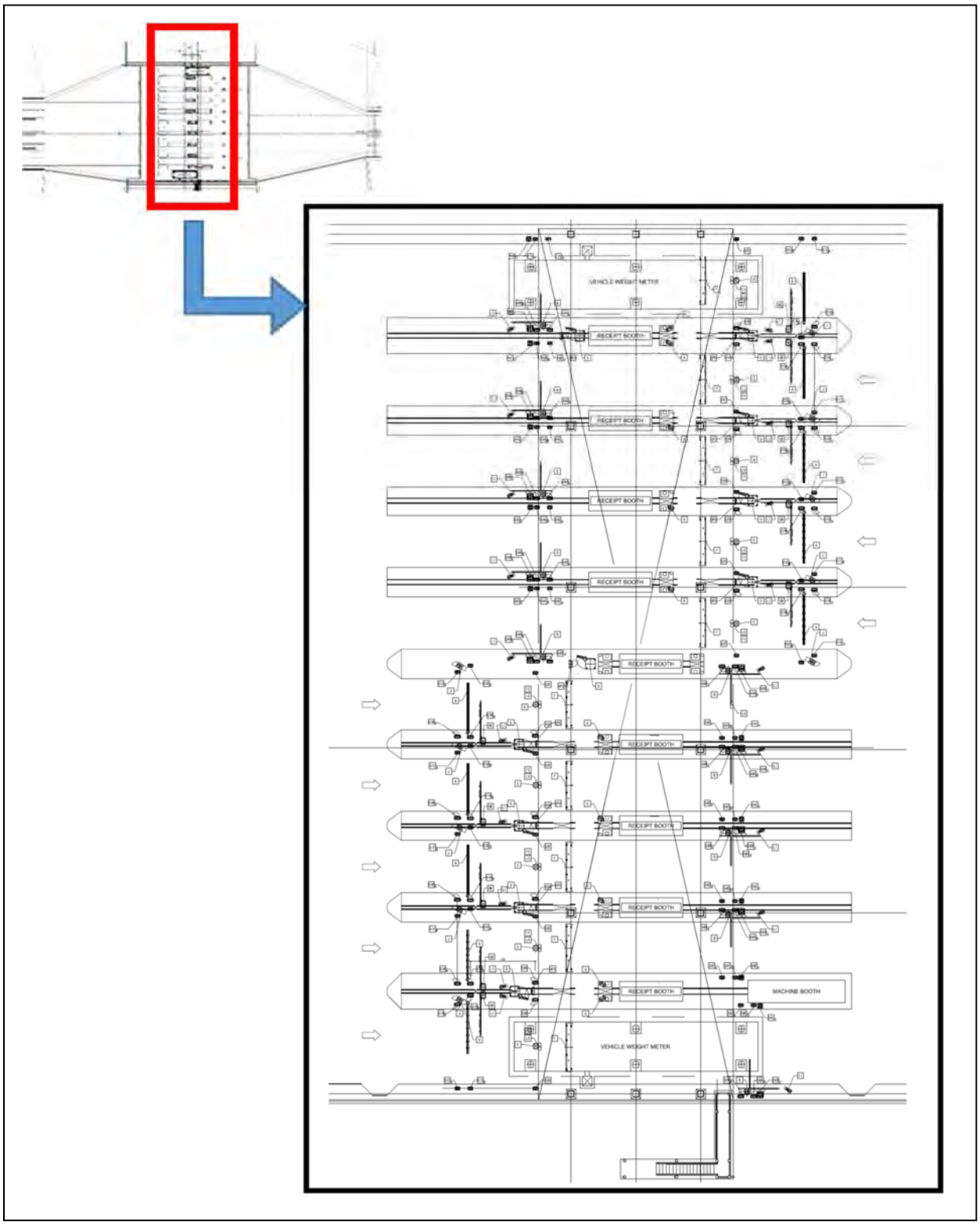
Figure 5.6.8 Layout Plan of ETC Equipment

Standard installation position of devices are as follows:

- Distance between Vehicle Detector S1a and Vehicle Detector S1b: 0.8 m
- Distance between Vehicle Detector S4a and Vehicle Detector S4b: 0.8 m
- Distance between Vehicle Detector 1 and Vehicle Detector 2: 4.0 m
- Distance between Vehicle Detector 2 and Barrier System: above 10 m
- Distance between Vehicle Detector 4 and Barrier System: certain space secured for maintenance works
- Installing the height of vehicle detector should be where enables detection of 200 mm at the lowest from road surface of the center of lane.
- Position of Roadside Display: In front of the tollbooth as a rule: in the light of good visibility from vehicle
- Position of ETC Lane Signboard:

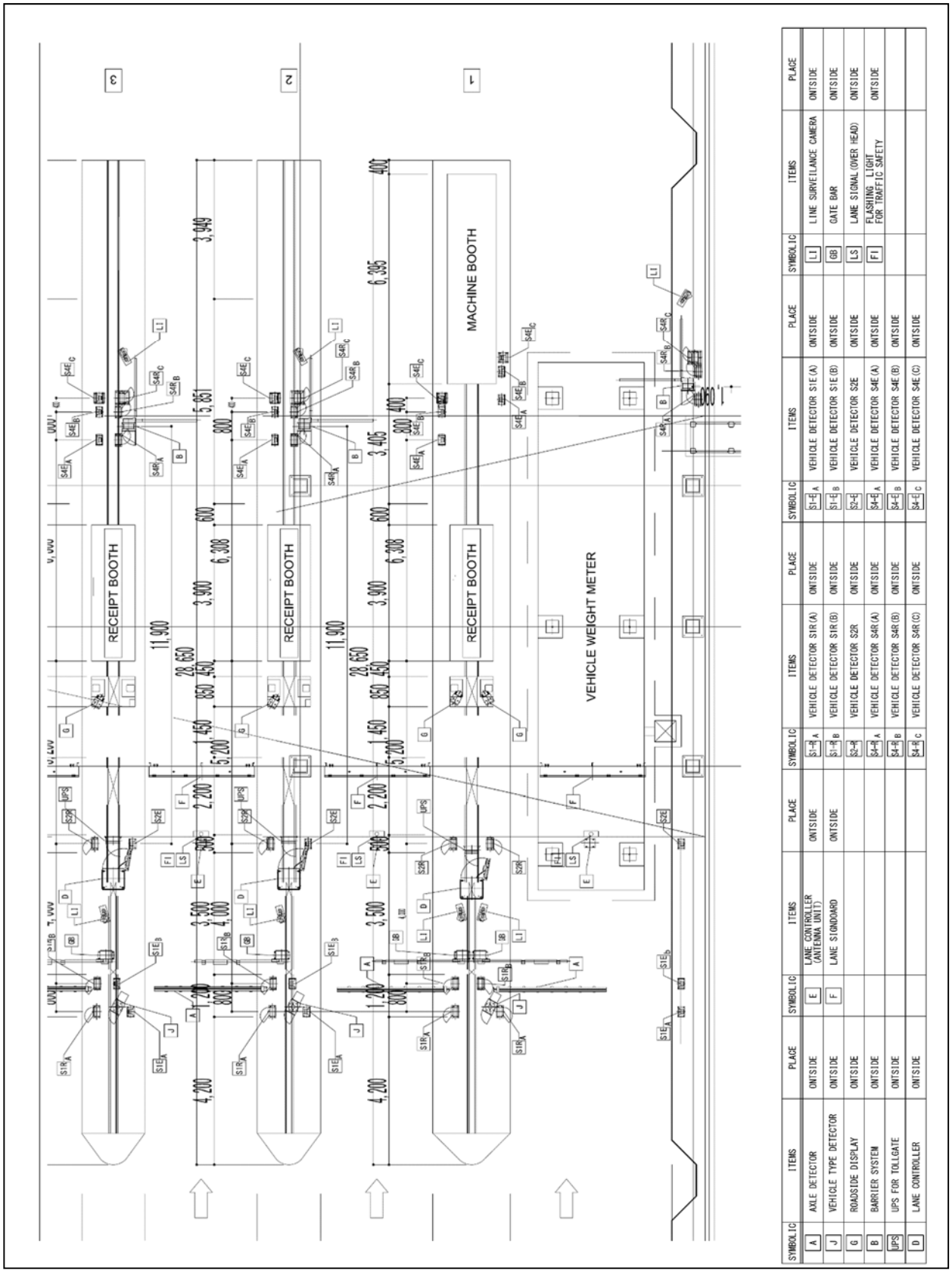
  On the rooftop, as a rule: in the light of visibility and radio wave reflection.

Figure 5.6.9 shows a layout of ETC equipment at the tollgate of the Bago River Bridge. Enlarged view of No.1-No.3 lanes and elevation views of tollgate are shown in Figure 5.6.10 and Figure 5.6.11, respectively. The drawings indicate that ETC equipment is located properly so that the space allotted for them will cover the requirement for future installation.



Source: JICA Study Team

Figure 5.6.9 Lane Layout of Tollgate Equipped with ETC Facility



SYMBOLIC	ITEMS	PLACE
A	AXLE DETECTOR	ONTSIDE
J	VEHICLE TYPE DETECTOR	ONTSIDE
G	ROADSIDE DISPLAY	ONTSIDE
B	BARRIER SYSTEM	ONTSIDE
UPS	UPS FOR TOLLGATE	ONTSIDE
D	LANE CONTROLLER	ONTSIDE
E	LANE CONTROLLER (ANTENNA UNIT)	ONTSIDE
F	LANE SIGNBOARD	ONTSIDE

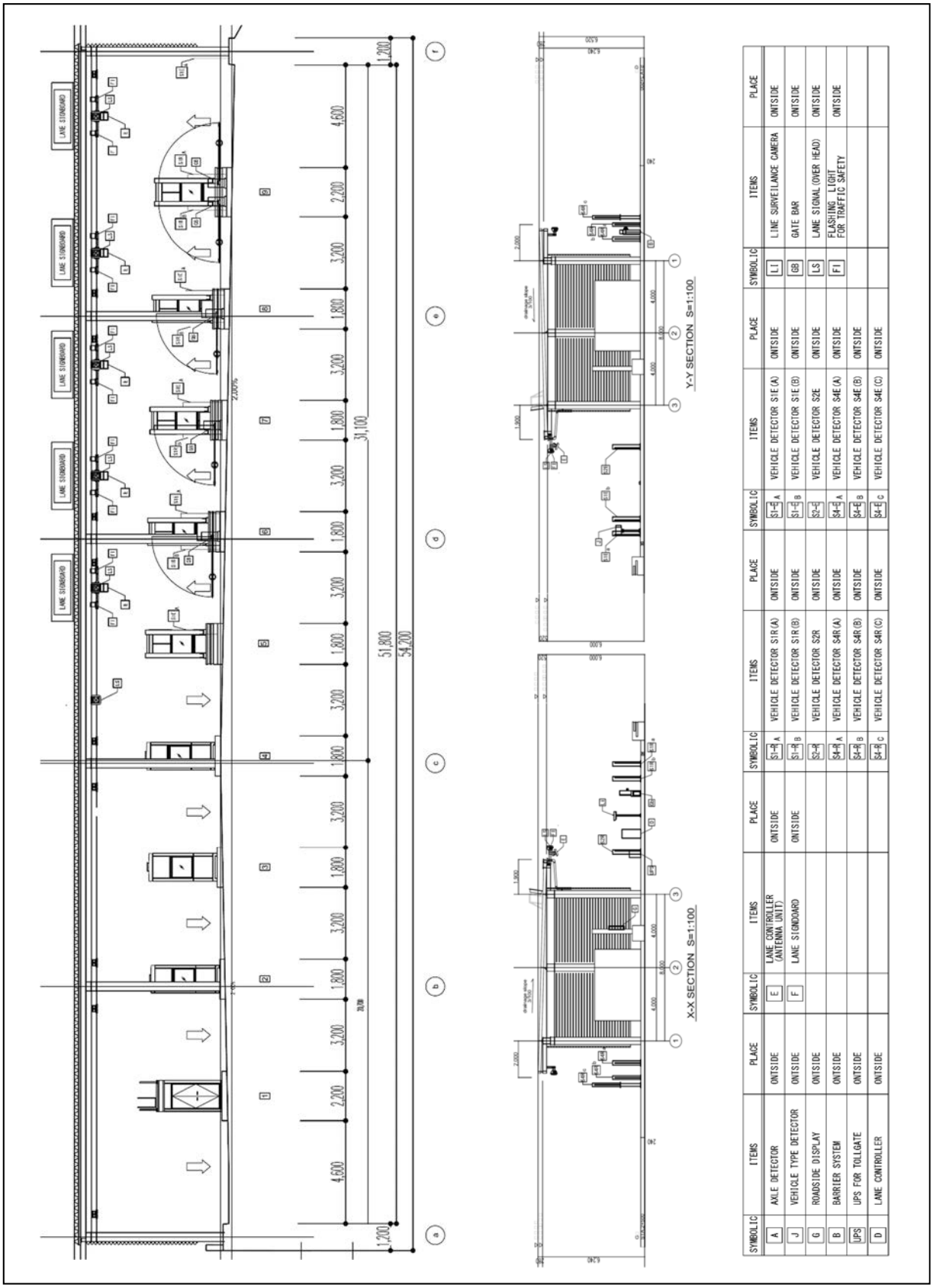
SYMBOLIC	ITEMS	PLACE
S1-R A	VEHICLE DETECTOR S1R(A)	ONTSIDE
S1-R B	VEHICLE DETECTOR S1R(B)	ONTSIDE
S2-R	VEHICLE DETECTOR S2R	ONTSIDE
S4-R A	VEHICLE DETECTOR S4R(A)	ONTSIDE
S4-R B	VEHICLE DETECTOR S4R(B)	ONTSIDE
S4-R C	VEHICLE DETECTOR S4R(C)	ONTSIDE

SYMBOLIC	ITEMS	PLACE
S1-E A	VEHICLE DETECTOR S1E(A)	ONTSIDE
S1-E B	VEHICLE DETECTOR S1E(B)	ONTSIDE
S2-E	VEHICLE DETECTOR S2E	ONTSIDE
S4-E A	VEHICLE DETECTOR S4E(A)	ONTSIDE
S4-E B	VEHICLE DETECTOR S4E(B)	ONTSIDE
S4-E C	VEHICLE DETECTOR S4E(C)	ONTSIDE

SYMBOLIC	ITEMS	PLACE
LI	LINE SURVEILLANCE CAMERA	ONTSIDE
GB	GATE BAR	ONTSIDE
LS	LANE SIGNAL (OVER HEAD)	ONTSIDE
FI	FLASHING LIGHT FOR TRAFFIC SAFETY	ONTSIDE

Source: JICA Study Team

Figure 5.6.10 Enlarged View of Tollgate No.1 – No.3



SYMBOLIC	ITEMS	PLACE
A	AXLE DETECTOR	ONTSIDE
J	VEHICLE TYPE DETECTOR	ONTSIDE
G	ROADSIDE DISPLAY	ONTSIDE
B	BARRIER SYSTEM	ONTSIDE
UPS	UPS FOR TOLLGATE	ONTSIDE
D	LANE CONTROLLER	ONTSIDE
E	LANE CONTROLLER (ANTENNA UNIT)	ONTSIDE
F	LANE SIGNBOARD	ONTSIDE

SYMBOLIC	ITEMS	PLACE
S1-R A	VEHICLE DETECTOR S1R(A)	ONTSIDE
S1-R B	VEHICLE DETECTOR S1R(B)	ONTSIDE
S2-R	VEHICLE DETECTOR S2R	ONTSIDE
S4-R A	VEHICLE DETECTOR S4R(A)	ONTSIDE
S4-R B	VEHICLE DETECTOR S4R(B)	ONTSIDE
S4-R C	VEHICLE DETECTOR S4R(C)	ONTSIDE
S1-E A	VEHICLE DETECTOR S1E(A)	ONTSIDE
S1-E B	VEHICLE DETECTOR S1E(B)	ONTSIDE
S2-E	VEHICLE DETECTOR S2E	ONTSIDE
S4-E A	VEHICLE DETECTOR S4E(A)	ONTSIDE
S4-E B	VEHICLE DETECTOR S4E(B)	ONTSIDE
S4-E C	VEHICLE DETECTOR S4E(C)	ONTSIDE
LI	LINE SURVEILANCE CAMERA	ONTSIDE
GB	GATE BAR	ONTSIDE
LS	LANE SIGNAL (OVER HEAD)	ONTSIDE
FI	FLASHING LIGHT FOR TRAFFIC SAFETY	ONTSIDE

Source: JICA Study Team

Figure 5.6.11 Elevation View of Tollgate and Lane

5.6.3 Items for Consideration

Items for consideration when introducing ETC are as follows:

(1) Standardization of ETC System

Considering efficient management of toll roads and accessibility of road users, standardization of ETC system is compulsory at the time of introduction of ETC.

In cases where public sectors entrust toll collection management to private companies, which provide operation and management (O&M) services, each company might adopt their own ETC system. In such case, the following issues could arise, which should be eliminated beforehand by establishing standardization of ETC system:

- There is a possibility that companies entrusted with O&M (O&M Companies) employ their own system;
- In such case, there is no interoperability;
- Road users should purchase OBU from each toll road company;
- This imposes much expense on users, and consequently impedes diffusion of ETC;
- In the case of prepaid method, as management of balance and deposit for each toll road is troublesome, it will impair convenience of road users; and
- Different ETC specifications among O&M companies, by which drivers even with ETC cannot pass all of the tollgates, will be an obstacle to a seamless and efficient driving through several toll roads.

In addition to above matters, the following items are necessary to consider before the introduction of ETC:

(2) Interoperability among O&M companies in the light of (toll) settlement

(3) Selection of OBU (On-board unit)

(4) Countermeasures against illegal passage

(5) Dealing with the various toll systems such as "Distance-based toll fee system", etc.

(6) Promotional activities for ETC diffusion after introduction

CHAPTER 6. ELECTRIC WIRING AND LIGHTING FACILITY

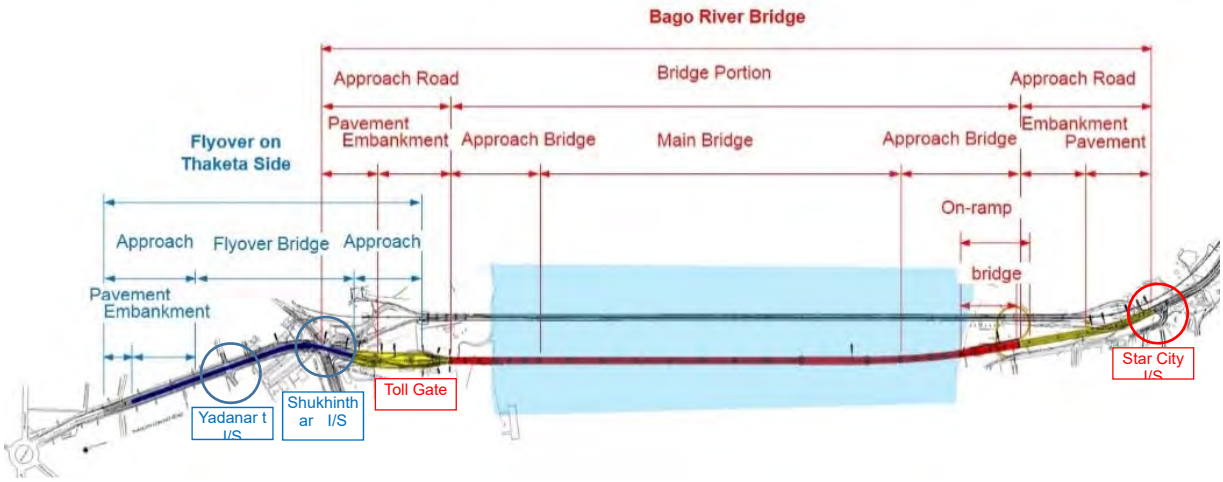
6.1 GENERAL

Road lighting is an essential function to ensure road safety and comfortability of road users. This section provides the basic design for roadway lighting and electric wiring for the project bridge and road.

6.2 SCOPE OF WORK

The scope of work for road lighting and electric wiring design is as follows:

(a) Road Lighting for the Bago River Bridge
(b) Road Lighting for the Flyover (on Thaketa Side)
(c) Road Lighting for the Thanlyin Chin Kat Road
(d) Road Lighting for On-ramp
(e) Tollgates Area Lighting
(f) Shukhinthar Intersection Lighting
(g) Yadanar Intersection Lighting
(h) Star City Intersection Lighting
(i) Bridge Nightscape Lighting
(j) Obstruction Lights
(k) Traffic Signal System
(l) Temporary Traffic Signal System



Source: JICA Study Team

Figure 6.2.1 Scope of Work for Roadway Lighting and Electric Wiring Design

6.3 DESIGN CONDITION

6.3.1 Design Standards

Design standards applied to this project are as follows:

- The Standards Japan Highway Design Manual
- LED Road and Tunnel Lighting Guidelines 2011, MLIT Japan
- Express Highway Research Foundation of Japan (EHRF)
- Japan Road Association (JRA) Standards

- Japan Electric Association (JEAC), Regulations
- Nippon Expressway Company Limited (NEXCO), Design Manual 2004
- Annex 14, International Civil Aviation Organization (ICAO)
- International Association of Marine Aids to Navigation and Lighthouse Authority (IALA) Guidelines

6.3.2 Design Condition

(1) Road Lighting Aims and Requirements

The aim of the road lighting is to ensure safety and smooth road traffic at night time and in poor weather conditions. Good lighting also improves traffic volume capacity.

The road lighting system must be able to function at low power consumption and low running costs.

Design principles are:

1) Arrange lighting depending on road alignment;
2) Provide adequate lighting for driving;
3) Provide adequate lighting to see other road users;
4) Provide sufficient lighting to see and avoid parked vehicles or obstruction; and
5) Provide adequate lighting to see roadside facilities.

(2) Performance Index of Road Lighting

The major factor of the performance index is the average road surface luminance, which are classified in JRA according to type of road and surrounding areas along the road as shown in Table 6.3.1 below.

Table 6.3.1 Average Road Surface Luminance

Unit: cd/m^2

External Condition / Type of Road		Surrounding Areas along the Road		
		A	B	C
Expressway		1.0	1.0	0.7
National road	Major arterial road	1.0	0.7	0.5
	Collector and local road	0.7	0.5	0.5

Note) External Conditions:
A: Refers to the condition of a road or route in the residential and city areas.
B: Refers to the condition of a road or route in the area dotted with lights.
C: Refers to the condition of a road or route in the area where light almost does not exist.

Source: Japan Road Association (JRA) Standards

Although the review was carried out to pass along the existing bridge parallel to Bago Bridge, the condition of B was observed at night time. In the detailed design (D/D), to save electricity for lighting, 0.7 cd/m^2 is applied for the average road surface luminance instead of 1.0 cd/m^2 in the basic design.

(3) Total Uniformity Ratio

Luminance distribution on the road surface is not uniform; therefore, the uniformity of distribution is evaluated in the total uniformity ratio and the uniformity ratio on the road centreline. Total

uniformity ratio (Uo) on the road surface is calculated using the following equation and evaluated by the criteria as specified in Table 6.3.2.

$$U_o = L_{min}/L$$

Where, L is average luminance on road surface.

Lmin is minimum luminance on road surface.

Table 6.3.2 Total Uniformity Ratio (Uo) on Road Surface

Type of Road		Total Uniformity Ratio on Road Surface
Expressway		0.4 above
National road	Major arterial road	
	Collector and local road	

Source: Japan Road Association (JRA) Standards

The uniformity ratio on the road centerline (Uc) is calculated using the following equation and evaluated by the criteria as specified in Table 6.3.3.

$$U_c = L_{max}/L_{min}$$

Where, Lmax is maximum luminance on the road centerline.

Lmin is minimum luminance on the road centerline.

Table 6.3.3 Uniformity Ratio (Uc) on Road Centerline

Type of Road		Uniformity Ratio on Road Centerline
Expressway		0.7 above
National road	Major arterial road	0.5 above
	Collector and local road	N/A

Source: Japan Road Association (JRA) Standards

(4) Disability Glare

This refers to the light brightness that adversely affects the view and cause discomfort or fatigue. Discomfort causing glare is called disability glare, while that which adversely affect the way an object looks is referred to as view-affecting glare. Therefore, the disability glare was set in principle based on a relative threshold rise of not more than 10, as given in Table 6.3.4. Accordingly, the method of the threshold increment (TI) value is applied for the evaluation of disability glare. In the evaluation of disability glare, TI value recommended by the International Commission on Illumination (CIE), which is 10% to 20% for 1.0 cd/ m^2 of the average road surface illuminance, shall be taken into account in the evaluation of disability glare for this project.

Table 6.3.4 Criteria for TI Value

Type of Road		TI (%)
Expressway		10 less
National road	Major arterial road	15 less
	Collector and local road	

Source: Japan Road Association (JRA) Standards

(5) Service Condition

The project area has a hot, humid and tropical atmosphere. Moreover the surrounding environment has a high degree of salinity. All electrical equipment, cables, accessories and fittings which form

part of the electrical installation shall be fully suitable for use in the following specified service conditions:

(1) Altitude above mean sea level (approx.) : +4.99m

(2) Ambient temperature - Maximum : 40℃、- Minimum: 10℃

(3) Relative humidity - Maximum: 90%

(4) Climatic atmosphere: Tropical

(5) Wind pressure: Maximum 44.4m/second

(6) Earthquake: The lateral seismic coefficient of 0.03 for equipment is designed.

(7) Salt contamination : the design for salt contamination of the insulators and bushings shall be applied at 5.0 mg/sq.cm.

6.4 ROAD LIGHTING

6.4.1 Introduction

Road lighting shall ensure clear visibility to surely grasp road conditions and traffic conditions by drivers; hence, road safety and smooth road traffic can be secured by the installation of road lightning.

6.4.2 Selection of Equipment and Material

(1) Luminaire Supports

1) Types of Lightning Pole

In B/D, according to the comparative study as shown in Table 6.4.1, the steel type lighting pole has been recommended for the road lighting in this project.

Table 6.4.1 Comparison Study on Types of Lighting Pole

Items	Alt-1 Steel Pole	Alt-2 Concrete Pole
Schematic view		
Installation	Easy mounting on concrete foundation Strong foundation support Applicable for bridge lighting	Needs excavation and backfilling Weak foundation support Not applicable for bridge lighting
Wiring	Pole interior wiring applicable Easy maintenance Safety considerations	Only overhead wiring applicable Subject to environmental damage
Visibility	Good	Poor
Cost	3.5 times	Cheaper
Construction acceptability	Widely used	Seldom used
Evaluation	**Recommended**	Not recommended

Source: JICA Study Team

In D/D, the result of comparative study was reviewed and “steel pole” was adopted for the design.

2) Figures of Lightning Pole

In B/D, according to the comparative study as shown in Table 6.4.2in terms of illuminance rate, forward visibility and comfortable driving, the straight-line type had been recommended for the road lighting in this project.

Table 6.4.2 Comparative Study on the Figures of Lighting Pole

Items	Alt-1 Straight Line Type	Alt-2 Arm Type
Schematic view		
Luminaire support	Top of pole	End of arm
Illumination rate	Big	Small
Forward visibility in raining	Good	Poor visibility on shoulder
Comfortable driving	High	Low
Local lighting	Complied	Not complied
Evaluation	**Recommended**	Not recommended

Source: JICA Study Team

In D/D, the result of comparative study was reviewed and “straight-line type” was adopted for the design.

3) Height and Spacing of Lighting Pole

When luminaires are arranged based on JRA standards, glare depression, proper uniformity ratio, and clear road alignment can be ensured by means of the road lighting. In D/D, pole height is 12 m for the lighting of river bridges, approach bridge, and approach road, on the other hand, 11 m for flyover bridge and 9 m for the lighting of on-ramp, taking into consideration Table 6.4.3 below.

Table 6.4.3 Applicable Height and Spacing of Lighting Pole

Type of Luminaire	Cutoff type		Semi Cutoff type	
Type of Arrangement	Height (H)	Spacing (S)	Height (H)	Spacing (S)
One-sided arrangement	H ≧1.0 W	S≦3.0 H	H≧1.1 W	S≦3.5 H
	H ≧1.5 W	S≦3.5 H	H≧1.7 W	S≦4.0 H
Two-sided staggered arrangement	H ≧0.7 W	S≦3.0 H	H ≧0.8 W	S≦3.5 H
Two-sided opposite arrangement	H ≧0.5 W	S≦3.0 H	H ≧0.6 W	S≦3.5 H
	H≧0.7 W	S≦3.5 H	H≧0.8 W	S≦4.0 H

Note) W : Road Width

Source: JICA Study Team

Spacing of lighting poles for the curved road such as ramp way is specified in Table 6.4.4.

Table 6.4.4 Spacing of Lighting Poles on Curved Road Section

Item		Spacing			
Curving radius (m)		300 m≧R	250 m≧R	200 m≧R	R<200 m
Height(H)					
Spacing (S)	Less than 12 m	35	30	25	20

Source: Japan Road Association (JRA) Standards

4) Type of Luminaire

Based on the condition of the lights along road: B, the type of luminaire adopted is cutoff type as shown in Table 6.4.5.

Table 6.4.5 Selection of Luminaire Type

Surrounding Areas along the Road		A	B	C
Expressway		Semi cutoff	Cutoff	Cutoff
National road	Major arterial road	Semi cutoff	Cutoff	Cutoff
	Collector and local road	Semi cutoff	Semi cutoff	Cutoff

Source: Japan Road Association (JRA) Standards

Table 6.4.6 Comparative Study on the Types of Luminaire

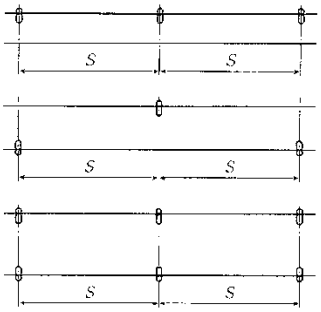
Item	Alt-1 Cutoff Type	Alt-2 Semi Cutoff Type
Schematic View		
Horizontal Light Distribution	Completely limited	Partially limited
Installation Area	Area dotted with lights	Residence and city
Glare to Driver	Ignore	Weaken
Lighting Pole Spacing	Narrow	Wide
Evaluation	Not recommended	**Recommended**

Note) The amount of glare generated by a luminaire is strongly influenced by the intensity (candle-power) emitted at angles close to horizontal angle. The cutoff classification is based on the intensity of rays emitted at 80 degrees and 90 degrees vertical angle.

Source: JICA Study Team

5) Lighting Pole Arrangement

In B/D, according to the comparative study shown in Table 6.4.7, "One-sided Arrangement" has been recommended to be the optimum pole arrangement for the main line.



Note) S : Spacing of Lightning Poles

Source: JICA Study Team

Figure 6.4.1 Types of Lightning Pole Arrangement

Table 6.4.7 Comparative Study on Lighting Pole Arrangement

Items	Alt-1 One-sided Type	Alt-2 Two-sided Staggered Type	Alt-3 Two-sided Opposite Type
Luminaire	○	○	○
Straight line pole	○	○	○
Uniformity ratio (< 0.4)	◎	○	◎
Disability glare (15 %<)	◎	○	◎
Road alignment	◎	△	◎
Low construction cost	◎	△	○
Evaluation	**Recommended**	Not recommended	Not Recommended

◎:Widely used ○:Usable △:Not practicable

Source: JICA Study Team

In D/D, the result of comparative study was reviewed and "One-sided type" was adopted for the two lanes of the Bago River Bridge including its approach bridges, flyover bridge, and approach road.

(2) Luminance (Luminous Source)

In B/D, considering the quality of lighting, installation and operation costs, type of luminance had been selected. In D/D, final selection of luminance was then decided based on the result of the calculation of road illumination. The results of selection in B/D and D/D are discussed below.

1) Types of Luminance Source

Light Emitting Diode (LED) luminance has been practically adoptedas an eco-energy type illumination for indoor and outdoor use. LED luminance has been improved enough to be used for road lighting and its development is progressing in terms of higher technology, price reduction, and reliable supply sources.

In the field of road lighting, the LED luminance has an outstanding longer operating life and higher luminous efficacy. These advantages can reduce CO_2, environmental load, and maintenance cost. Moreover, its optical characteristics simulate daylight conditions and provide better view along the road than other lighting sources. The following shows comparison between LED lamps and HPS lamps:

- Initial cost of LED lamp use is higher than the cost of HPS lamp use.
- Especially, the maintenance cost of HPS lamp use is more than twice the cost of LED lamp use.
- Overall cost of HPS lamp use is higher than the cost of LED lamp use.
- LED lamp use has less CO_2 emission than HPS lamp use.

The advantages in terms of operating life, luminous efficacy, and color temperature are realized as significant. Therefore, LED luminaire is applied for the road lighting system of the project. Meanwhile since luminous efficacy of LED is still under development, HPS lamp with more than 350 W is used for the lighting of toll plaza areas.

The following tables show the luminous efficacy, color temperature, and operating life of LED.

Table 6.4.8 Luminous Efficiency (lm/W)

Type of Lamp	lm/W	Remarks
White LED	30～100	249 lm/W under developing
White power LED	20～80	100 lm/W under developing
Mercury lamp	50	
High pressure sodium lamp	110～130	
Metal halide lamp	60～130	

Source: Summary from four Japanese LED manufacturer's specifications

Table 6.4.9 Color Temperature

Type of Lamp	Color Temperature (K)	Remarks
LED road lighting	5,000～6,000	Sunlight at noon: 6,000 K
Metal halide lamp	4,300	
Mercury lamp	4,100	
High pressure sodium lamp	2,100	Sunset/Sunrise: 2,500 K

Source: Summary from four Japanese LED manufacturer's specifications

Table 6.4.10 Operating Life

Type of Lamp	Rating Operating Life (Hours)
LED	60,000
Mercury lamp	8,000
High pressure sodium lamp	24,000
Metal halide lamp	9,000

Source: Summary from four Japanese LED manufacturer's specifications

Based on the data of LED luminaire in the catalog, LED luminaire character for road lighting is available as follows:

Table 6.4.11 LED Luminaire Character

LED Manufacturer	Wattage (W)	Light Flux (lm)
Inaba	102	16,200
Iwasaki	137	16,500
Seiwa	129	16,000
Maruwa shomei	N/A	16,690

Source: LED Luminaire Catalogs

The performance of LED luminaire is greatly different among the luminaires that are already out in the market.

To cope with this reality, in accordance with LED Road and Tunnel Lighting Guidelines 2015, MLIT Japan, D/D of the road lighting is based on the following:

- Utilization factor: 0.4 assumed
- Maintenance factor: 0.7 assumed
- Pole spacing: 40 m assumed

6.4.3 Calculation of Average Road Surface Luminance

(1) Formula

The following formula is applied for the road lighting with one-sided arrangement.

$$L_r = (F \times U \times M \times N)/(\mathrm{S} \times W \times K) \quad (\text{Unit: } \mathrm{cd/m^2})$$

Where, L_r is the average luminance on road surface ($\mathrm{cd/m^2}$)

F is the lumens (lm)

U is the utilization factor (**0.4** assumed for LED luminance)

M is the maintenance factor (**0.7** assumed for LED luminance)

N is the arrangement factor (1.0 for one-sided, 2.0 for two-sided opposite)

W is the width of road (m)

S is the pole spacing (**40** m assumed for LED luminance)

K is the conversion factor (15.0 for asphalt pave)

(2) Criteria for Calculation

The criteria for calculation are as follows:

- LED luminaire: 16,500 lm for pole height of 12 m
- LED luminaire: 6,200 lm for pole height of 9 m (on-ramp)
- Uniformity ratio is calculated based on the light distribution curve using IWASAKI free software.

(3) Design Results

Based on the design conditions mentioned above, the number of lighting poles, the required lamp wattage, and the pole spacing are determined in D/D as shown in Table 6.4.12.

Table 6.4.12 Result of Calculation

Type of Road	Required Lr ($\mathrm{cd/m^2}$)	Lane	W (m)	Calculation	
				Lr ($\mathrm{cd/m^2}$)	Uniformity Ratio
River bridge	≥0.7	4	22	0.7	*0.433
Approach bridge	≥0.7	4	20	0.77	*0.413
On-ramp	≥0.7	2	4.5	*≥0.7	*0.662
Flyover bridge	≥0.7	2	11.75	*≥0.7	*0.456
Side road/Approach road	≥0.7	2	10.5	0.73	*0.470

Source: JICA Study Team

6.4.5 Light Distribution Curve in Lux

The performance of lighting system complies with the requirements for road lighting as follows:

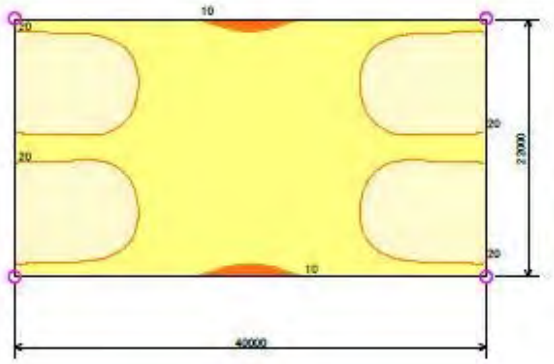
- River Bridge

  Luminance : LED

  Flux : 16,500 lm

  Pole arrangement :two-sided opposite

  Pole spacing : 40 m



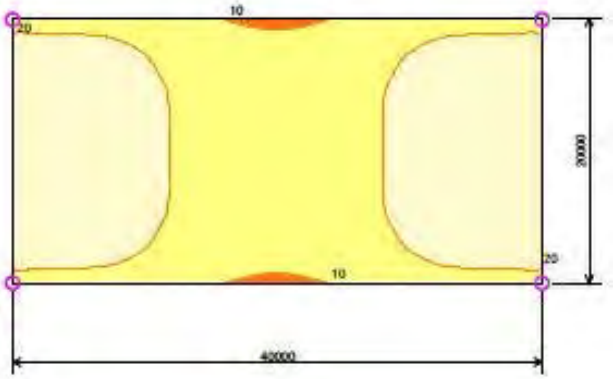
- Approach Bridge

  Luminance : LED

  Flux : 16,500 lm

  Pole arrangement :two-sided opposite

  Pole spacing : 40 m



- On-ramp

  Luminance : LED

  Flux : 6,200 lm

  Pole arrangement : one-sided

  Pole spacing : 25 m

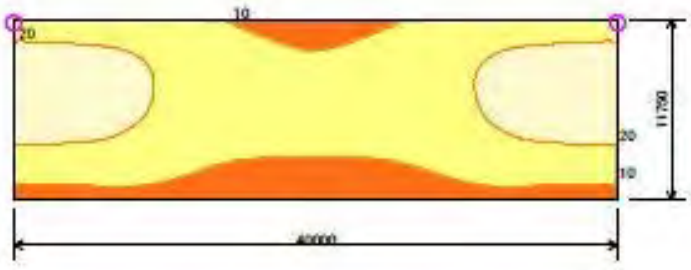
- Flyover Bridge

  Luminance : LED

  Flux : 16,500 lm

  Pole arrangement : one-sided

  Pole spacing : 40 m



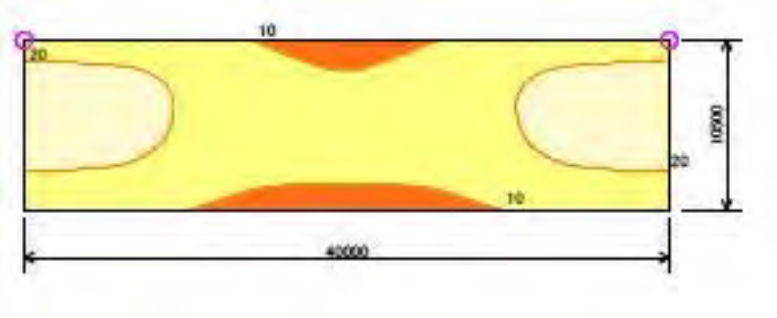
- Thanlyin Chin Kat Road/Approach Road

Luminance : LED

Flux : 16,500 lm

Pole arrangement : one-sided

Pole spacing : 40 m



6.4.6 Intersection Lighting

(1) Introduction

In addition to the visual recognition effects of continuous road lighting, such fixtures should also be installed at intersections so that drivers can be aware of the existence of intersections and road conditions in/adjacent to the intersection.

(2) Design Criteria

For the design of intersection lighting, the following average illuminance is widely utilized for the evaluation criteria as shown in Table 6.4.13 and Table 6.4.14.

.

Table 6.4.13 Average Illumination for Intersection Lighting

Road Classification				National Road (one way)		
				1-lane road	2-lane road	3-lane road
Design Condition						
Intersection	Crossroad	2-lane x 2-lane	20 lx	×		
	Crossroad	2-lane x 2-lane	15 lx	○		
	Crossroad	2-lane x 2-lane	10 lx	○		
	Crossroad	4-lane x 2-lane	20 lx	○		
	Crossroad	4-lane x 2-lane	15 lx	○		
	Crossroad	4-lane x 4-lane	20 lx	○		
	Crossroad	4-lane x 4-lane	15 lx	○		
	Crossroad	6-lane x 4-lane	20 lx	×		
	Crossroad	6-lane x 4-lane	15 lx	○		

○: Available for LED luminance ×: Not capable

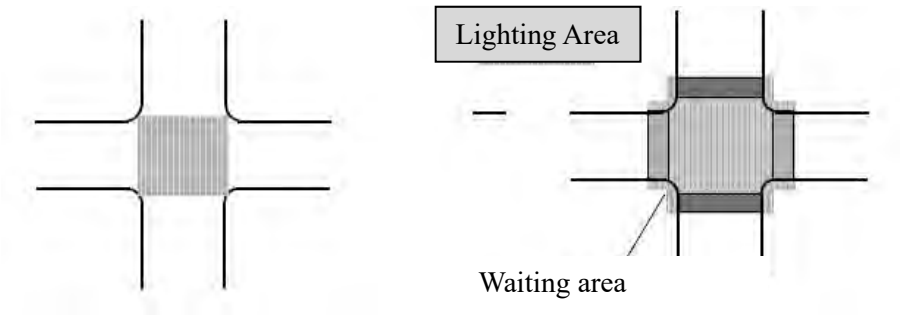
Source: Summary of four Japanese LED manufacture's specifications

The illuminance in lux for intersection lighting is as follows:

- The illumination of one-lane road is used for the illumination of national roads and two-lane roads in the above table.
- Number of lanes in the above table means the total number of lanes for each road crossing at an intersection.

- The illuminance in lux for the total of designed lanes is referred to as the illuminance for the closest number of lanes in the above table.

1) Lightning Area



Intersection without crosswalk Intersection with crosswalk

Source: Japan Road Association (JRA) Standards

Figure 6.4.2 Lightning Area at Intersections

2) Average Illumination

Based on information in

Table 6.4.13, the required average illuminance is given in

Table 6.4.14.

Table 6.4.14 Criteria of Average Illumination

Name of Intersection	Total Lanes of Intersection	Average Illuminance (lux)
Shukhinthar Intersection	28	15
Yadanar Intersection	16	15
Star city Intersection	19	15

Source: JICA Study Team

(3) Design Result

The following formula is applied for determining average illumination, which were calculated in the D/D stage.

$$N \times F = E \times A / U \times M$$

Where, N is the number of road light

F is the lumens (ℓm)

U is the utilization factor (0.4 assumed for LED luminance)

M is the maintenance factor (0.7 assumed for LED luminance)

E is the average illumination (15 ℓx)

A is the illumination area (m^2) including pedestrian crossings

The results of calculation in D/D are shown in Table 6.4.15.

Table 6.4.15 Results of Calculation

Name	Area (m^2)	E (lx)	Luminaire		Pole	
			Type	F (lm)	H (m)	N (set)
Shukhintar	3,726	15	HID	39,000	12	5
Yadanar	1,387	15	LED	19,800	12	4
Star City	2,060	15	LED	19,800	12	5

Source: JICA Study Team

6.4.7 Tollgates Lighting

(1) General

The requirements for tollgates lighting are as follows:

- Illumination range for the approach area should be from 10 m to 50 m in distance on both sides of the gate centerline
- Illumination range for the area for identification of vehicles should be from 10 m to 30 m in distance in front of the gate centerline, where the entry area is via a national road and the exit area is via an expressway.
- Average vertical plane illumination should be the illumination on the plane forming a right angle to the driving centerline and at 0.5 m elevation.

(2) Design Criteria

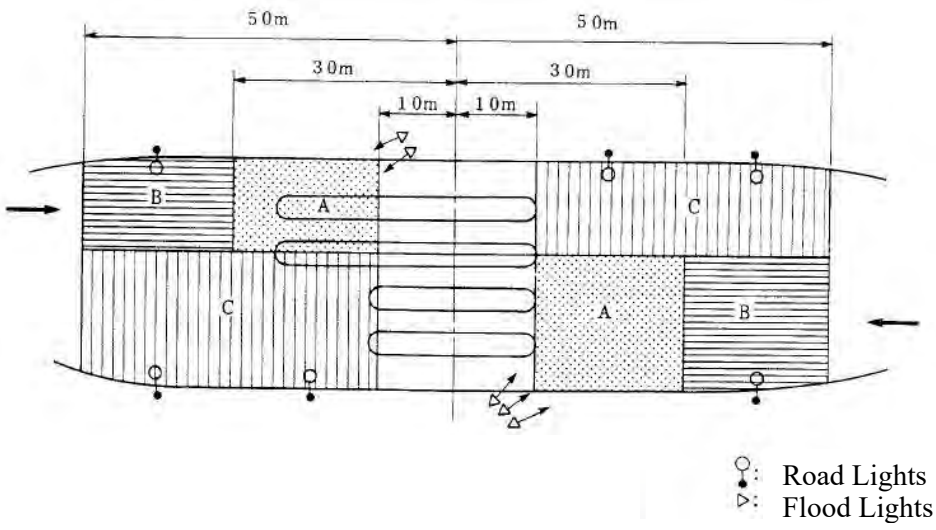
The average illuminance and vertical plane illuminance are utilized for the evaluation of tollgate lighting. The criteria for tollgates lighting design is given in

Table 6.4.16.

Table 6.4.16 Tollgates Lighting

Location	Criteria		Illumination Area
Approach area of tollgates	Average illuminance	: 20 lux	B, C
Area for the identification of vehicles	Average vertical plane illuminance	: 40 lux	A

Source: EHRF Standard



Source: EHRF Standard

Figure 6.4.3 Illumination Area Classification

(3) Design Result

1) Height of Lighting Mast

According to EHRF, the height of lighting mast was determined as 25 m in D/D.

2) Average Illumination

The following formula is used for the calculation of average illumination.

$$N \times F = E \times A / U \times M$$

Where, N is the number of flood light

F is the lumens (ℓm)

U is the utilization factor

M is the maintenance factor

E is the average illumination (ℓx)

A is the illumination area (m^2)

Average illuminance is computed for tollgate area lighting.

3) Vertical Plane Illumination

The following formula is applied for the calculation of vertical plane illumination:

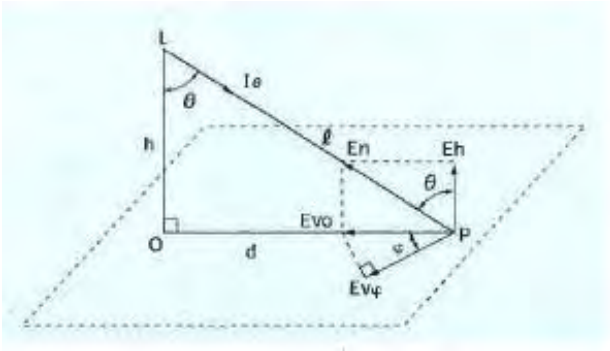
$$E_{vo} = (I_\theta / l^2) \cdot \sin\theta \qquad \text{Unit: cd/m}^2$$

Where, E_{vo} is the vertical plane illumination (cd/m^2)

I_θ is the candela of luminaire (cd): θ direction value

l is the slant distance from luminaire to the point on pavement

θ is the angle between the slant line and the vertical line at a point



Source: Japan Road Association (JRA) Standards

Figure 6.4.4 Calculation of Vertical Illumination by Point-By-Point Method

If the sight level of the driver of a vehicle is 1.5 m, and the ascending vertical angle is less than 25 degrees, the driver's vision may be glared by the lighting mast. Therefore, the height and location of the mast should be selected to limit the glare due to lighting.

Table 6.4.17 Height of Lighting Mast

Name of Area	Height of Mast (m)
Toll plaza area	H ≧ 0.5W

Note) W: Total width including all of the entry and exit lanes

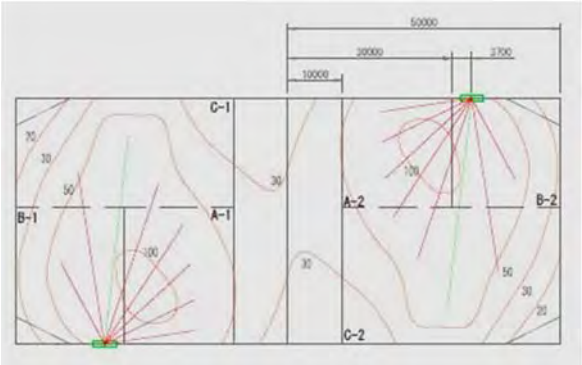
Source: EHRF Standard

Average vertical plane illuminance is computed for tollgate area lighting.

4) Results of Calculation

The light distribution curve and the results are as shown below.

Luminaire	LED 380 W
Flux (lm)	35,000l m
Pole height	25 m
Vertical illumination	45.9 lux
Average illumination	45.5 lux



6.4.8 Traffic Signal Systems

(1) General

Requirements for installation of traffic signals according to the Road Traffic Law Act, Japan, are specified as follows:

- Except for one-way traffic, to ensure enough space for a vehicle to pass beside a vehicle stopped at an intersection waiting to turn.
- Ensure a waiting place for the safety of pedestrians.
- Maximum traffic volume of two-directional traffic on a major arterial road per hour should be 300 or over.
- Location of the nearest traffic signal is more than 150 m away from the signal of intersection.
- Ensure the location of pole mounted traffic signal for drivers and pedestrians to enable the view of signals.
- Data for selection condition are as follows:
  - Number of accidents resulting in injury or death is more than two accidents in yearly record.
  - As a result of a study and/or analysis, installation of signal should be only one potential solution.
  - To ensure the safety of people coming from schools, hospitals, nursing homes, etc.
  - Demand of pedestrians is many and an overhead crossing should not be nearby.

(2) Pedestrian Traffic Signal

As stated in the Road Traffic Law Act, Japan, in case of intersection with crosswalks controlled by traffic signals, pedestrian traffic signals should be installed.

(3) Vehicle Traffic Signal

Generally, each approach of traffic lane needs only one traffic signal. In the point of view of layout of intersection and road width, in order to ensure the visibility of traffic signals, two sets of traffic signals should be installed according to the Road Traffic Law Act, Japan.

(4) Traffic Signal Phasing

The control of traffic signals is based on cycle, split, and offset performances at the traffic signal phasing to put smooth traffic flow into practice.

- Cycle: Cycle length (Blue-Yellow-Red cycle) depends on the traffic volume, size of intersection, pedestrian crossing time, etc.
- Split: Percent (%) depends on the traffic volume to be divided for arterial street and minor street.
- Offset: Blue signal is actuated in a different time of blue signal of the nearest intersection for smooth and continuous driving.
- Pedestrian crossing time: Actuated blue signal time and flashing blue signal time are enough to complete crossing roads.

The components of traffic signal system are as follows:

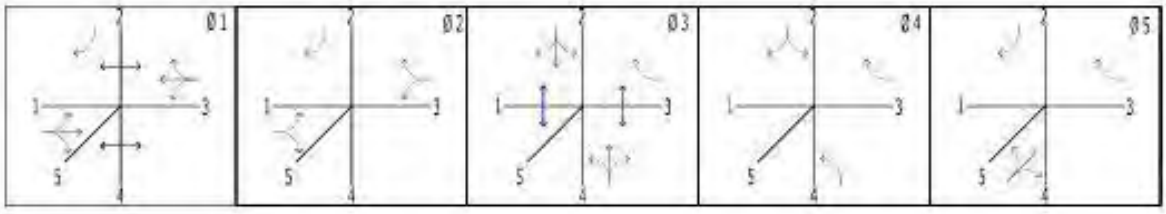
- Vehicle traffic signal (blue-yellow-red)
- Arrow sign traffic signal
- Vehicle detector
- Traffic signal controller
- Connection box
- Pedestrian signal lamp device
- Push-button box
- Steel pipe support with signal arm for traffic signal
- Steel pipe support for pedestrian device
- Conduit and wires
- Grounding

1) Shukhinthar Intersection

Shukhinthar Intersection consists of the following roads:

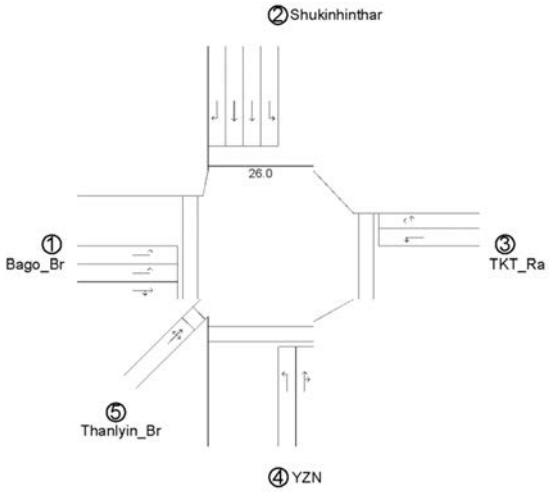
1. Thanlyin Chin Kat Road for the Bago River Bridge
2. Shukhintar Myopat Road for Shukhinthar
3. Thanlyn Chin Kat Road for Thaketa Roundabout
4. Nawarat Road for Yuzana Garden City
5. Approach Road from the existing Thanlyin Bridge

The assumed traffic signal phasing sequence is shown in Figure 6.4.5. Shukhintar Myopat Road and Thanlyin Chin Kat Road are assumed to be arterial streets in traffic signal phasing at the intersection. The layout of the intersection determined in D/D is shown in Figure 6.4.6.



Source: JICA Study Team

Figure 6.4.5 Traffic Signal Phasing at Shukhinthar Intersection



Source: JICA Study Team

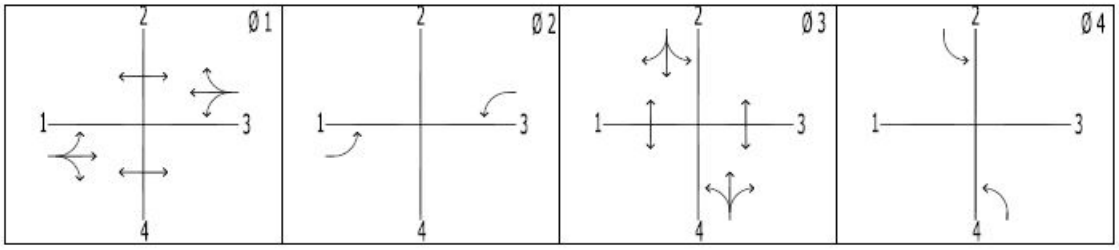
Figure 6.4.6 Layout of Shukhinthar Intersection

2) Yadanar Intersection

Yadanar Intersection consists of the following roads:

1. Thanlyin Chin Kat Road for Bago Bridge
2. Yadanar Road for Shukhintar
3. Thanlyin Chin Kat Road for Thaketa Roundabout
4. Nawarat Road for Yuzana Garden City

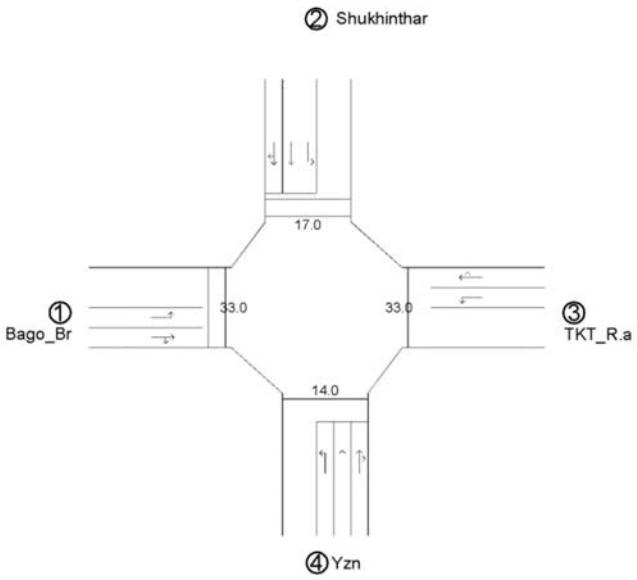
The assumed traffic signal phasing is shown in Figure 6.4.7. Thanlyin Chin Kat Road is assumed to be an arterial street in traffic signal phasing at the intersection. The layout of the intersection determined in D/D is shown in Figure 6.4.8.



Source: JICA Study Team

Figure 6.4.7 Traffic Signal Phasing at Yadanar Intersection

The layout of the intersection is as follows:



Source: JICA Study Team

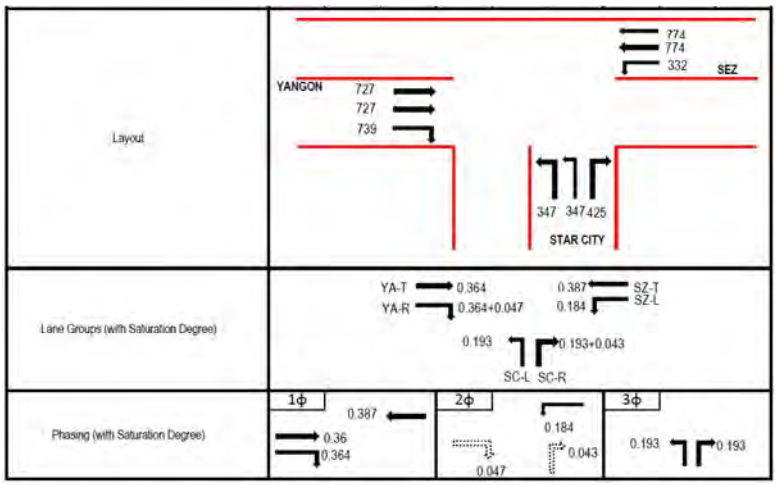
Figure 6.4.8 Layout of Yadanar Intersection

3) Star City Intersection

Star City Intersection consists of the following roads:

1. Kyaik Khak Pagoda Road for Bago Bridge
2. Road for the existing Thanlyin Bridge
3. Road for Thanlyin Roundabout
4. Road for Star City

The traffic signal phasing and the layout of the intersection determined in D/D is shown in Figure 6.4.9. Kyaik Kahauk Pagoda Road is assumed to be an arterial street in traffic signal phasing at the intersection.



Source: JICA Study Team

Figure 6.4.9 Layout of the Intersection

4) Temporary Intersection for Existing Shukhintar Intersection under Construction

The use of a temporary traffic signal in a construction zone will be determined on a project-by-project basis. An official action must be coordinated through the district traffic engineer.

Locations where a temporary signal installation may be used include the following:

1. intersection where an existing signal must be maintained

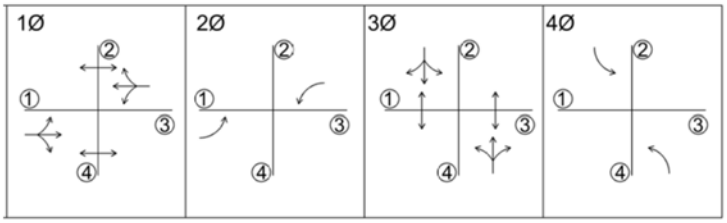
2. existing non-signalized intersection or drive where construction patterns and traffic volume now warrant a signal

3. temporary haul road or other temporary access point

4. long-term one lane, two-way traffic operation (e.g., bridge lane closure) or

5. crossroad or ramp intersection where there is an increase in traffic or there is a decrease in capacity due to the construction.

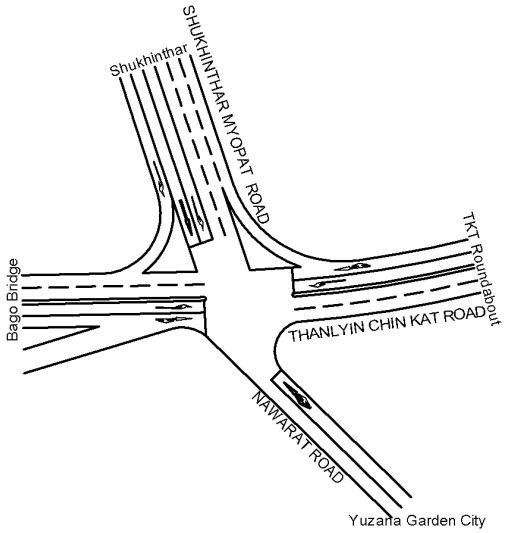
Suggested traffic signal phasing is shown in below.



Source: JICA Study Team

Figure 6.4.10 Suggested Traffic Signal Phasing for Existing Shukinthar Intersection

The existing intersection layout is shown below.



Source: JICA Study Team

Figure 6.4.11 Layout of Existing Shukhinthar Intersection

In reviews of the construction patterns in the existing intersection renovation works, the suggested traffic signal phasing and present traffic volume will be warranted by a planned temporary traffic signal layout as shown in the drawings.

(5) Traffic Signal Control System

1) Signal Head

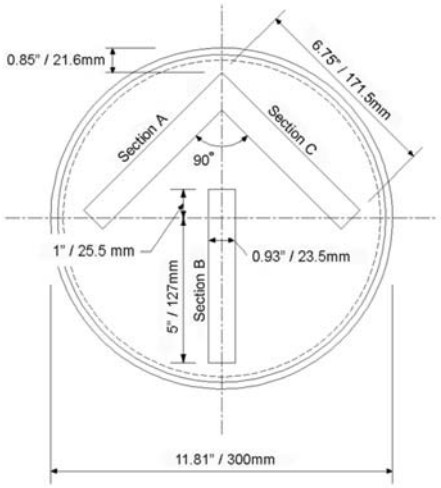
The 300 mm dia. signal is adopted to increase the visibility of driver with the following minimum luminous intensity.

Table 6.4.18 Signal Head

Vertical Angle	Horizontal Angle (Left and Right)	300 mm Signal (cd)		
		Red	Yellow	Green
2.5° up	17.5°	58	115	115
	2.5°	220	441	441
-2.5° down	2.5°	339	678	678
	7.5°	251	501	501
	12.5	141	283	283
	17.5	77	154	154
-7.5° down	2.5	226	452	252
	7.5	202	404	404
	12.5	145	291	291
	17.5	89	178	178

Source: JICA Study Team

The configuration of the arrow icon for the LED arrow lens is illustrated below.



Source: JICA Study Team

Figure 6.4.12 Configuration of the Arrow Icon for the LED Arrow Lens

LED modules shall provide the maximum wattage as shown below.

Table 6.4.19 LED Modulus

Modules	Wattage
300 mm Red Ball	10 or less
300 mm Yellow Ball	22 or less
300 mm Green Ball	12 or less
300 mm Yellow Arrow	11 or less
300 mm Green Arrow	5 or less

Source: JICA Study Team

2) Signal Support Poles

− Requirements for Galvanized Steel Mast Arm Poles and Galvanized Steel Mast Arms

The Contractor shall submit copies of design drawings unless otherwise specified. Contractor's estimated weights of the various units shall appear in the design drawings. The Contractor shall be required to submit shop drawing for approval.

− Pedestal Poles

The pedestal poles shall consist of one upright pole with suitable base and any other accessories or hardware as required to make a complete installation.

− Concrete Poles

The concrete polls shall be used for the temporary traffic signal system to make overhead span between concrete poles with messenger wire and other accessories and hardware as required.

3) Signal Cable

All multi-conductor control cables (three or more conductors) shall have individual conductor size no. 2.0 mm^2, high molecular weight polyethylene color-coded insulation, suitable fillers and binder tape with a SVV overall jacket and be rated at 600 volts. These cables shall be suitable for use in conduit, duct, aerial, or direct burial installations.

For temporary traffic signal system, the SVV including messenger wire shall be used for overhead cabling between the concrete poles.

4) Controllers and Cabinets

1) Type of signal operation: Pre-timed operation

2) Traffic Signal Controller Functions

(1) Control:

- Single intersection
- Closely spaced multiple intersections
- Midblock crosswalk

(2) Electrically switches signal indications:

- Red
- Yellow
- Green
- WALK
- DON'T WALK

(3) Assures appropriate right-of-way assignments in accordance with pre-timed intervals or phases

(4) Times fixed clearance intervals such as:

- Flashing DON'T WALK
- Yellow
- Red clearance

(5) Times greens and green arrows for:

- Fixed-duration (pre-timed control)
- Variable duration up to a predetermined maximum

(6) Times special function timed intervals such as:

- Lane controls
- Turn controls
- Blank out signs

3) The phase features shall provide the following capabilities:

- 16 vehicle phases
- 20 pedestrian phases
- Timing rings
- 16 overlaps

4) The time base scheduler features shall be provided:

- 10-week program
- 50-day program
- 120-event capacity
- Dimming per phase by phase output

6.5 OBSTRUCTION LIGHTS

6.5.1 Aviation Obstruction Lights

(1) Installation Policy

Aviation obstruction light is a device to warn aircraft of potential danger from above ground level structures like towers, smokestacks, tall buildings, etc. In some cases, it is also called Aircraft Warning Light. When it comes with a controller to realize the extra functions like sending an alarm signal, flash synchronizing, and auto switch-on at night, it can also be called Aircraft Warning Light System.

(2) Equipment to be Installed

1) Design Criteria

Design criteria for aviation obstruction lights is basically quoted from ICAO Annex 14, Chapter 6 as follows:

Clause 6.3.7: Recommendation. - medium-intensity obstacle light, types A, B, or C, should be used where the object is an extensive one or its height above the level of the surrounding ground is greater than 45 m; medium-intensity obstacle lights, types A and C, should be used alone, whereas medium-intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.

Table 6.5.1 Characteristics of Obstacle Lights

Light Type	Color	Signal Rate (Flash Rate)	Peak Intensity (cd) at a Given Background Luminance			
			Above 500 cd/m^2	50 to 500 cd/m^2	Blow 50 cd/m^2	Vertical Beam Spread (degree)
Medium-Intensity Type A	White	Flashing (20 to 60 fpm)	20,000 ±25%	20,000 ±25%	2,000 ±25%	3.0
Medium-Intensity Type B	Red	Flashing (20 to 60 fpm)	N/A	N/A	2,000 ±25%	3.0
Medium-Intensity Type C	Red	Fixed	N/A	N/A	2,000 ±25%	3.0
Recommendation	**Type A**					

Source: ICAO Annex 14, Chap. 6, Table6-3

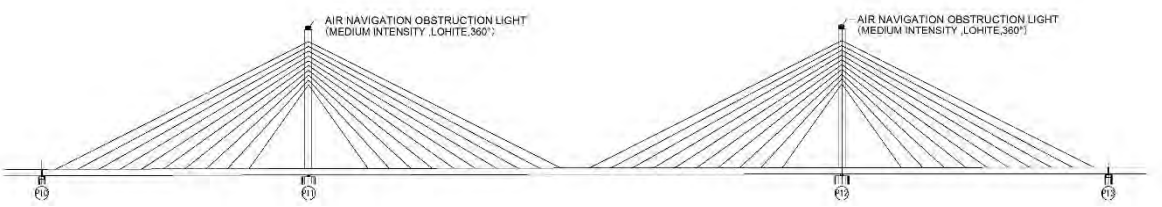
Source: Philips Product

Figure 6.5.1 Outside View of Type A

Table 6.5.2 ICAO Recommendation and Practice

Object	Height	Night Only Operation	Day and Night
Tower	45 m up to 105 meters	Plan B: 1 or 2 medium intensity lights Type B at the top. 3 low intensity lights Type B at intermediate levels at 120°	1 or 2 white medium intensity Type A at the top.
Recommendation		**1 white medium on top of pylon**	

Source: ICAO Annex 14



Source: JICA Study Team

Figure 6.5.2 Installation Location

6.5.2 Navigation Lateral Marks and Obstruction Lights

(1) Installation Policy

National aids to navigation authorities are generally established to provide a navigational safety regime that facilitates trade and economic development. The primary services are therefore directed towards the needs of commercial trading vessels. In some areas, authorities may provide additional services for ferries, fishing and recreational vessels, and specialized maritime activities.

1) Navigation Methods

The International Maritime Organization (IMO) defines navigation as “The process of planning, recording, and controlling the movement of a craft from one place to another”.

The principal methods of marine navigation are as follows:

- **Dead Reckoning**: navigation based on speed, elapsed time, and direction from a known position. The term was originally based on course steered and speed through the water, however, the expression may also refer to positions determined by the use of course and speed expected to be made over the ground, thus making an estimated allowance for disturbing elements such as current and wind. A position that is determined by this method is generally called an estimated position.
- **Piloting (or Pilotage)**: navigation involving frequent or continuous determination of position or a line of position relative to geographic points or aids to navigation, and may also require close attention to the vessel's draught with respect to the depth of water. It is practiced in the vicinity of land, dangers, etc., (i.e., “restricted” waters) and requires good judgement and almost constant attention and skill on the part of the navigator.
- **Terrestrial Navigation**: navigation by means of information obtained by earth-based aids to navigation.
- **Celestial or Astronomical Navigation**: navigation using information obtained from celestial bodies (i.e., sun, moon, planets, and stars).
- **Satellite Navigation**: involves the use of radio signals from orbiting or geostationary satellites to determine a position (e.g., Global Positioning System (GPS), Global Navigation Satellite System (GLONASS)).
- **Radio-navigation**: navigation using radio signals to determine a position or a line of position (e.g., Loran-C).
- **Radar Navigation**: involves the use of radar equipment to determine the distance (range) and direction (bearing) of an object or terrestrial feature.

2) Criteria for Navigation Method

The general guide for selecting proper systems for navigation lights are as follows. In B/D, "Piloting method" had been recommended, and was adopted in D/D.

Table 6.5.3 Criteria for Navigation Method

Method	Inland	Harbour/Approach	Costal	Ocean
DR	○	○	○	○
Piloting	○	○	○	
Celestial			○	○
Radio		○	○	○
Radar	○	○	○	
Satellite	○	○	○	○
Recommendation	**Piloting method is recommended**			

○: Recommended

Source: International Association of Marine Aids to Navigation and Lighthouse Authority (IALA) Standard

3) IALA Lateral Marks System

The world has been subdivided in two regions as follows, where Myanmar is classified as Region A.

- IALA "A": Europe, Africa, Australia, New Zealand, and most of Asia (Myanmar) except for Japan, North and South Korea, and the Philippines
- IALA "B": North, Central and South America plus Japan, North and South Korea, and the Philippines

Table 6.5.4 Criteria for Lateral Marks

Region	Instrumentation	Location in Upstream Direction	Shape	Color	Light Rhythm
A	Port Hand	Left	Square	Red	Flashing
	Safe Water	Mid channel	Pillar or spar	Red and white vertical strips	Flashing
	Starboard Hand	Right	Triangular	Green	Flashing

Source: IALA Standard

Port Hand Safe Water Starboard Hand

Source: IALA Standard

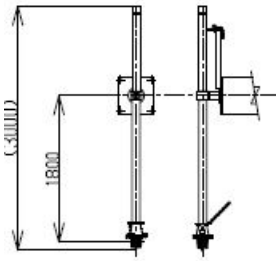
Figure 6.5.3 Lateral Marks Specified in IALA Standard

(2) Equipment to be Installed

The standards for navigation lights shall comply with the International Association of Marine Aids to Navigation and Lighthouse Authority (IALA).

Navigation lights (white/red/green colors) shall be installed at adequate locations on the project bridge together with signal plates. Six navigation lights per shipping water ways (SWW), three on the upstream side of the SWW, and the other three on the downstream side shall be installed on the Bago River Bridge.

Navigation Lights



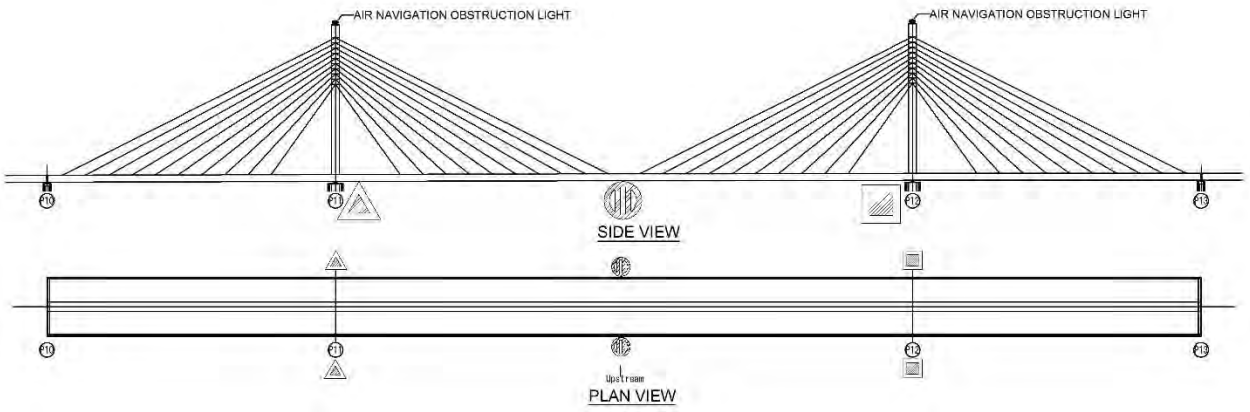
Location of Navigation Lights

Source: IALA Standard

Figure 6.5.4 Location of Navigation Lights

Navigation lights should be suspended below the bridge deck and supported on a hinged swing arm with retrieval chain and locking rod to allow the light to be swung up to deck level for maintenance.

Planned installation layout is shown in Figure 6.5.5.



Source: JICA Study Team

Figure 6.5.5 Layout of Navigation Lateral Marks

6.6 BRIDGE NIGHTSCAPE LIGHTING

6.6.1 Purpose of Nightscape Lighting

Based on the concepts of fascination by lighting and suppression of lighting, the bridge which is lit-up is useful for the following reasons:

- To highlight the landmark
- To increase the fascination of a city
- To revive the landform and history
- To protect against darkness
- To highlight production
- To protect individuality

6.6.2 Effect of Nightscape Illuminance

The effects of nightscape illuminance are as follows:

- To show the silhouette of the bridge
- To light up the parts cast in shadow during daytime
- To light up pylons
- To highlight vertical elements

Table 6.6.1 Effects of Nightscape Color

Items	Effects
Color Temperature	Expression of the atmosphere : Warm, cool, solid
Color Rendering Property	Color looks : Faithful, splendid, beautiful

Source: Technical Report (Iwasaki Electric Co., Ltd.)

6.6.3 Elements of Nightscape Illumination

(1) Design Criteria

The criteria of nightscape illumination proposed in B/D is as shown in Table 6.6.2. The illuminance should be a vertical plane illuminance because it is similar to a horizontal line of sight.

Table 6.6.2 Criteria for Nightscape Illumination

Peripheral Lightness		Bright	Medium	Dark
Illumination Conditions		- Urban area - Office building district - Crowded advertising boards area	- Small town area - Small business district with a few advertising boards	- Dark district - Area of a few advertising boards
Surface Material	Reflection factor (%)	12 cd/m^2	**6 cd/m^2**	4 cd/m^2
White marble Cream color China White plaster	70 to 85	150 (lx)	**100 (lx)**	50 (lx)
Concrete Light grey marble Rough surface brick	45 to 70	200 (lx)	150 (lx)	100 (lx)
Middle grey marble Yellow brown brick	20 to 45	(300 lx)	200 (lx)	150 (lx)
Dark reddish-brown stone Dark brown brick	10 to 20	500 (lx)	300 (lx)	200 (lx)
Evaluation		**12 cd/m^2, 150 lx**		

Source: CIE 94 1993 and Lightning Handbook (Iwasaki Electric Co., Ltd.)

In D/D, the criteria were reviewed and shown as follows:

- Peripheral Lightness: Medium, 6 cd/m^2
- Illumination Conditions: Small town area, small business district with a few advertising borads
- Minimum Illumination: 100 (lx)
- Material Reflection Factor (%):70 to 85

(2) Color of Illuminant

Comparative list for the color of illumination in B/D is as follows:

Table 6.6.3 Comparative List for Color of Illuminant

Finishing of Pylon	Illuminant
White, Red, Orange	High pressure sodium lamp Incandescent lamp, Halogen lamp
Between above and below	High color rendering high pressure sodium lamp High color rendering metal halide lamp Colored lamp
White, Blue, Green	Metal halide lamp Mercury lamp
Evaluation	**High color rendering high pressure sodium lamp**

Source: Lightning Handbook (Iwasaki Electric Co., Ltd.)

In D/D, the color of illuminant was determined as white through the discussion with MOC. The following Figure 6.6.1 shows the perspectives:

Source: JICA Study Team

Figure 6.6.1 Perspective with Night Scape Illumination

6.6.4 Equipment to be Installed

The sets of equipment to be installed determined in D/D are shown in Table 6.6.4.

Table 6.6.4 List of Equipment to be Installed

Flood Lights Setting		Descriptions
Pylon	Height (H) of pylon above the road	H=58 m
	Pole location (L) from pylon	L=58/R=11m R: constant
	Top of lighting pole installed on median	4.5 m height
	Light-up on both sides of pylon	1,500 lx for pylon (steel box)
Pier	Distance from top of pier under main girder	5 m
	Light-up on both side of pier	100 lx

Source: JICA Study Team

6.7 LIGHTING PROTECTION SYSTEM (LPS)

(1) General

LPS consists of air termination, conductors, and earth terminations. The components of LPS should be useable for tropical climatic areas. In order to counteract the effects of the lightning stroke current, electrical apparatus included in the bridge metal structures should be protected from electrical and magnetic fields on metal assemblies.

(2) Design Standards and Codes

- JIS A4201:2003 (IEC 61024-1)
- IEC 364-5-54/1980; IEC 479-1/1984

(3) Component of Lightning System

- Air terminal: more than 4,000 mm long, solid copper 10 mm^2 diameter.
- Conductor: bare soft-drawn copper, 38 mm^2 diameter.

(4) Grounding Resistance and Protection Angle

- Grounding resistance should be not more than 10 ohms.
- Protection angle of the air terminal should be not more than 60 degrees.

(5) Continuity of Grounding

The continuity tests should be carried out to confirm the continuity from air terminal through RC pier. The connection of the lightning system should be through Air Terminal→Pylon→Main girder→Pin bearing→Anchor frame of pin bearing→Re-bars of RC pier.

(6) Facilities in Pylon

For the maintenance of the lighting system and AOL, the facilities which consist of the lighting system and power outlets system were proposed in B/D.

In D/D, based on the review of B/D, lighting system, exposure outlets system, exposure switch, and box, were cancelled.

6.8 WIRING PLANNING

(1) General

In consideration of the power distribution for long distance, LED single phase load and the voltage fluctuation, the power distribution system shall be 415 V/240 V on two feeder systems.

The lighting panel at site shall manage the 50% lighting operation by means of timer and photo cell.

Further, the voltage drop on distribution wiring should be in the range of the steady light-on, not to decrease remarkably the rated lumens and luminance efficiency.

(2) Electric Systems

The wiring cost should be for the most economical electric system, and the layout of the branch circuits for light control should be considered to influence the supply voltage, line voltage drop, and distance to each lamp.

The wiring cost can be reduced with higher supply voltage and line voltage drop by means of the single-phase three-wire system or three-phase four-wire system. Single-phase 240 V is widespread in Yangon. In the point of view of single-phase loads, three-phase four-wire system: 240 V/415 V is applicable for the electrical loads in long distances.

(3) Incoming Power Receiving Voltage

At the project site, the voltage fluctuation on 240 V lines is from 240 V to 140 V. The main distribution system should be equipped with an open-phase relay to protect 240 V equipment from the fluctuation. In B/D, considering the availability of incoming power line at the project area, 6.6 KV lines had been recommended for the project as shown in Table 6.8.1, in the case of an emergency.

Table 6.8.1 Comparative Study on Incoming Power Voltage

Items	11 KV	6.6 KV
Component parts	Expensive	Cheaper
Short circuit current (KA)	Big	Small
Grounding method	Neutral point	Ungrounded
Power incoming capacity (MVA)	10	1.0
Connection fee	High	Low
Lines availability in the area	Far away	Near
Evaluation	Not recommended	**Recommended**

Source: Japanese Electric Power Company Reports

In D/D, the incoming power receiving voltage was reviewed and determined, following the existing MV overhead lines due to availability.

Thaketa area: 11 KV lines

Thanlyin area: 6.6 KV lines

(4) Capacity of Emergency Generator

Each incoming power receiving point has an engine generator to back-up the power for 50% road lighting and the lighting of intersection.

Load list for the back-up by engine generator is shown below.

Table 6.8.2 Load List for the Back-up by Engine Generator

Facilities	Load (VA)	No. of Feeder	Factor	Require Cap. (VA)	Remarks
Site Substation in the Thaketa Area					
River bridge	2,080	1	1.3		3-phase, 4-wire 415 V/240 V
App. bridge	2,240	2			
Flyover bridge	1,760	1			
App. road	3,200	2			
IS	3,277	1			
Total	12,557			16,324	
Site Substation in the Thanlyin Area					
River bridge	2,080	1	1.3		3-phase, 4-wire 415 V/240 V
App. bridge	1,800	2			
On-ramp	1,920	1			
App. road	1,920	2			
AOL	2,400	1			
Nav. light	1,000	1			
IS	2,500	1			
Total	13,620			17,706	

Source: JICA Study Team

The capacity of engine generator is required for less than 30 KVA with 3-phase, 4-wire, 415 V/240 V.

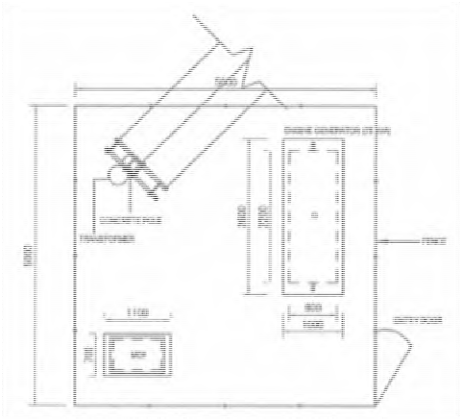
(5) Power Receiving Equipment

Electric power is required for the operations of electrical systems including toll plaza systems and road lighting. MV primary line extension from the nearest existing lines is considered and the primary voltage steps down to 415 V/240 V available for the project.

Components of MV Incoming and Power Receiving System are as follows:

- Primary cut-out switch
- Lightning arrestor
- Power transformer pole-mounted type
- Watt-hour meter
- Terminal concrete poles
- MV pole assembling
- Emergency engine generator
- Fence for site substation

The following figure shows the site substation layout.



Source: JICA Study Team

Figure 6.8.1 Site Substation Layout

Regarding the power receiving equipment for toll operation building, the components of MV Incoming Power Receiving System are as follows:

- Primary cut-out switch
- Lightning arrestor
- Terminal concrete poles
- MV pole assembling
- MV cubicle type panel
- Emergency engine generator

The following Table 6.8.3 shows the power demand for the operation building.

Table 6.8.3 Power Demand for the Operation Building

Loads	TOB (KVA)	Generator (KVA)	Remarks
Tollgate (booths)	37.5	37.5	
Tollgate (future)	75	75	
Building (light, etc.)	24.6	24.6	
Building (AC, pump, et.c)	9.8	9.8	
Building (toll operator)	45	45	

Source: JICA Study Team

(6) Power Transformer

The power transformer is applied to transfer power and to transform it in rated voltage, rated current, and rated frequency.

The specifications of the transformer are as follows:

- Rating capacity: referred from the total load and to select the capacity available in the market.
- Primary winding: Delta connection
- Secondary winding: Y connection
- Cooling system: Air-cooling type
- Short circuit impedance: more than 7%

- Winding taps: Principal tapping
- Transformer insulation: Oil-immersed type

(7) Main Distribution Panel

The main feeder distribution system is a hub power distributor where the main distribution panel (MDP) distributes power by each circuit breaker (MCCB) to each lighting contactor panel (LPs).

System components of Main Distribution Panel (MDP) are as follows:

- Outdoor-type steel case (IP-65)
- Main mold-case breaker (MCCB)
- Branch mold-case breaker (MCCB)
- Related instrumentation
- Concrete foundation for the MDP
- Underground cabling with PVC conduit connecting to each LP

(8) Lighting Control Panel (as Lighting Panel)

The lighting control panel is applied for the road lighting system if necessary for the reduction of number of luminaires. The lighting control panel is controlled by clock timer and photocell detector when the lighting power is assumed at 100% from 18:00 hours to 24:00 hours and 50% from 24:00 hours to 06:00 hours.

The control circuit is arranged as follows:

- Main feeder has at least 16 branch circuit breakers (MCCB) and are divided into two groups for luminance reduction.
- One lighting circuit divided into two circuits for alternative lighting.
- Each circuit has one magnetic contactor connected in serial.
- Magnetic contactor is operated by timer and photocell detector for power on-off.
- On-off operation period is adjustable by timer and photocell detector.

(9) Wire and Conduit

1) Line Voltage Drop

In terms of simple method, realistic simulation and satisfactory results, the formula of JEAC is applied for the calculation of lighting loads.

$$e = 17.8 \times L \times I / 1000 \times A \quad \text{Unit: V}$$

Where, e is the voltage drop (V)

17.8 is the constant for three-phase four-wire system

L is the total wire length from output terminal of breaker to load (lamps) (m)

I is the current in wire (A)

A is the cross section of conductor (mm^2)

2) Tolerance of Line Voltage Drop

The line voltage drop is specified as follows:

Voltage drop in percentage = e (V) /Rated Voltage (240 V)

Table 6.8.4 Line Voltage Drop

Distance from 2nd terminal of TR or incoming point to the electric load at the end of feeder (m)	Line Voltage Drop (%)	
	To receive power from TR in the premise	To receive LV power from power company
	Total line voltage drop on branch and main line	Total line voltage drop on branch and main line
120 over to 200 less	6.0 less	5.0 less
200 over	7.0 less	6.0 less

Source: JEAC Regulations

3) Wire Insulator

In accordance with the application of JEAC formula, the wire insulator is specified as follows:

- Cross-linked polyethylene insulated PVC sheathed cable (CV) or equivalent (XLPE)
- Vinyl insulated Vinyl sheathed cable (VV)

4) Conduit Size

According to Tousley Coefficient, conduit sizes are specified by number of wires as shown in Table 6.8.5.

Table 6.8.5 Conduit Size

No. of Wire	Ratio between the inner section diameter of conduit and the total of overall diameter of wires with insulator (%)
1	56
2	32
3	42
4	40
5 over	37

Source: Japan Electric Association Code

5) Results of Calculation

The results of calculation in D/D are shown in the following Table 6.8.6.

Table 6.8.6 Results of Calculation

Facilities	Power Distribution System	Number of Feeder	Electrical Load (VA) per Feeder	Cable Size	Voltage Drop (V)
River bridge	3 P, 4 W	2	2,400	XLPE 35 mm^2-4 C	8.4
Approach bridge-N	3 P, 4 W	2	1,120	XLPE 4 mm^2-4 C	2.5
Approach bridge-S	3 P, 4 W	2	900	XLPE 6 mm^2-4 C	3.5
On-ramp	3 P, 4 W	2	1,920	XLPE 25 mm^2-4 C	4.1
Flyover bridge	3 P, 4 W	2	1,760	XLPE 16 mm^2-4 C	8.9
Approach road-N	3 P, 4 W	2	1,600	XLPE 16 mm^2-4 C	6.6
Approach road-S	3 P, 4 W	2	960	XLPE 6 mm^2-4 C	4.0
AOL	2 P, 3 W	*1	2,400	XLPE 10 mm^2-3 C	14.2
Navigation light	2 P, 2 W	*1	1,000	XLPE 8 mm^2-2 C	10.0
Light-up	3 P, 4 W	2	24,000	XLPE 35 mm^2-4 C	20.0
Tollgate area light	3 P, 4 W	2	2,681	XLPE 8 mm^2-4 C	7.5
Shukhinthar IS	3 P, 4 W	1	2,571	XL 7 0 PE 8 mm^2-4 C	5.7
Yadanar IS	3 P, 4 W	1	706	XLPE 4 mm^2-4 C	1.3

Note: *: power supply only

Source: JICA Study Team

6.9 FACTORY INSPECTION, SITE TESTS AND MAINTENANCE REQUIREMENTS

(1) Factory

- Luminaire IP inspection
- Panel components inspection
- Power transformer inspection

(2) Site

- Continuous line test
- Insulation test
- Grounding resistance measurement
- Timer operation test
- Watt-hour measurement
- Height of luminaire measurement
- Illuminance measurement (1 span)

(3) Maintenance

- Spare parts
- Operation test results
- As-built drawings
- Maintenance manuals

CHAPTER 7. CONSTRUCTION PLANNING

7.1 CONSTRUCTION PLANNING OF THE RIVER BRIDGE SECTION

The construction planning of the river bridge section is predicted based on the detailed design. The planning is mainly focused on construction methods for foundation and substructure; and erection of superstructures of bridges in the river section. Temporary facilities and construction methods for precast PC box girder bridge and on-ramp bridge are also planned.

7.1.1 Project Outline

The Project in the river bridge section consists of steel cable-stayed bridge of 448 m with 224 m of center span and seven span continuous steel box girder bridges of 776 m with 112 m span. The approach bridge on both sides is a continuous PC box girder bridge to be installed using span-by-span method with 300 m on the Thaketa side and 507 m on the Thanlyin side. The ramp bridge of PC I-girder with composite panels is 120 m in total with four spans.

7.1.1.1 Work Content and Tentative Construction Schedule

The Project works in the river bridge section are divided into two packages.

(1) Package 1

Package 1 includes the following work items, and erection and construction methods as shown inTable 7.1.1. Meanwhile tentative construction schedule is shown in Figure 7.1.1~Figure 7.1.2.

Table 7.1.1 Work Items and Construction Methods for Package 1

Work Items	Contents (Methods)
Steel cable-stayed bridge	Bent in side span and balancing cantilever method in center span
SPSP foundation	Driving steel pipe using two large crane barges
Precast continuous PC box bridge	Span-by-span erection using large erection girder
Fabrication of precast block	Short-line match casting method in large casting yard near the site
Ramp bridge (PC T-girder)	Casting T-girder near the erection site and erecting by crawler and track crane
Concrete placing for substructure	Concrete mixing plant ship

Source: JICA Study Team

(2) Package 2

Package 2 includes the following work items, and erection and construction methods as shown in Table 7.1.2. Meanwhile tentative construction schedule is shown in Figure 7.1.3~Figure 7.1.4.

Table 7.1.2 Work Items and Construction Methods Package 2

Work Items	Contents (Methods)
Steel continuous box girder	Bent erection using large crane barge
SPSP foundation	Driving steel pipe using two large crane barges
Precast continuous PC box bridge	Span-by-span erection using large erection girder
Fabrication of precast block	Short-line match casting method in large casting yard near the site
Concrete placing for substructure	Concrete mixing plant ship

Source: JICA Study Team

Source: JICA Study Team

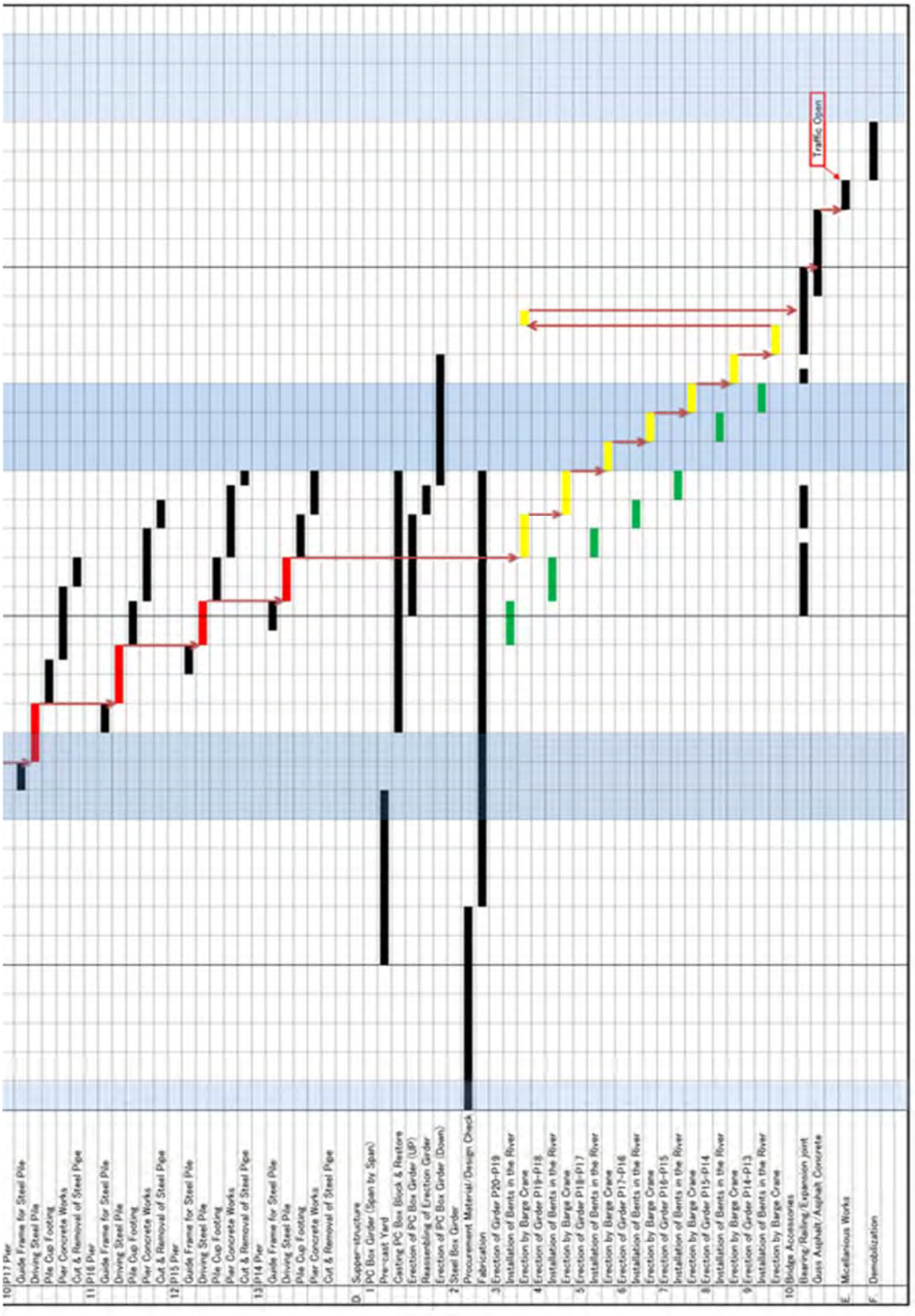
Figure 7.1.1 Construction Schedule for Package 1 (1/2)

Source: JICA Study Team

Figure 7.1.2 Construction Schedule for Package 1 (2/2)

Source: JICA Study Team

Figure 7.1.3 Construction Schedule for Package 2 (1/2)



Source: JICA Study Team

Figure 7.1.4 Construction Schedule for Package 2 (2/2)

7.1.1.2 Major Materials to be Incorporated in the Works

(1) Package 1

Package 1 includes the following materials to be incorporated in the works as shown in Table 7.1.3.

Table 7.1.3 Major Materials to be Incorporated in the Works for Package 1

Work Items	Contents (Methods)
Steel cable-stayed bridge	Steel plate, stay cable, and anchor and guess asphalt from Japan
SPSP foundation	Steel pipe φ1.2 m from Vietnam
Precast continuous PC box bridge	PC cable from Japan and cement and aggregate from Myanmar
Fabrication of precast PC block	Cement and aggregate from Myanmar
Ramp bridge (PC T-girder)	PC tendon from Japan and cement and aggregate from Myanmar
Concrete placing for substructure	PC tendon from Japan and cement and aggregate from Myanmar

Source: JICA Study Team

(2) Package 2

Package 2 includes the following materials to be incorporated in the works as shown in Table 7.1.4.

Table 7.1.4 Work Items and Construction Methods for Package 2

Work Items	Contents (Methods)
Steel continuous box girder	Steel plate and guess asphalt from Japan
SPSP foundation	Steel pipe φ1.2 m from Vietnam
Precast continuous PC box bridge	PC cable from Japan and cement and aggregate from Myanmar
Fabrication of precast block	Cement and aggregate from Myanmar
Concrete placing for substructure	Cement and aggregate from Myanmar

Source: JICA Study Team

7.1.2 Temporary Facilities

7.1.2.1 Outline of Temporary Construction Yard

(1) Package 1

Site-A in Figure 7.1.5 is proposed for construction yard, which is now a private land. It is confirmed that the possibility to use it for temporary facility yard will be on a lease basis. The reclamation area is approximately 49,000 m^2 and is used as construction yard for continuous PC box girder bridge and ramp to Star City. The reclamation level is 4.300 m considering a five-year return period based on the river hydrological study.

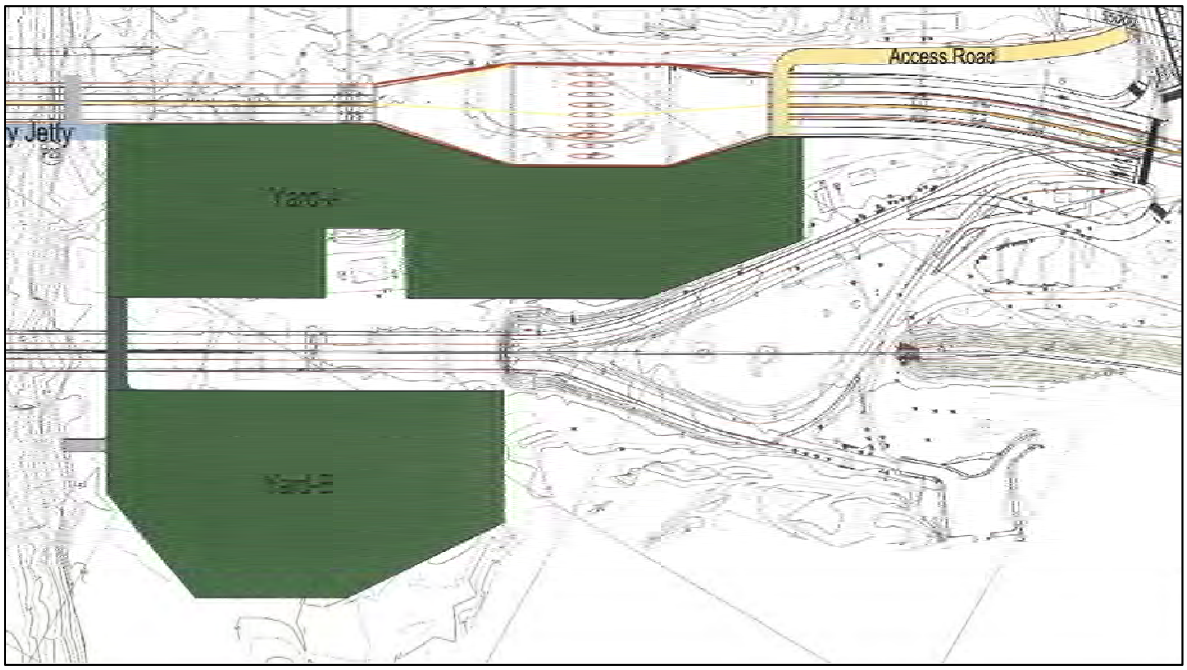
Source: JICA Study Team

Figure 7.1.5 Outline of Temporary Facilities for Package 1

(2) Package 2

Temporary facility yard for Package 2 is planned in two areas as shown in Source: JICA Study Team

Figure 7.1.6. Yards A and B owned by YRW are secured for temporary yard. For access road to the temporary yard, only one route is provided from the existing road. For approach to construction yard of bridge structures and erection area of superstructure in the river, temporary jetty should be provided for on-shore works using marine equipment such as crane barge and tugboat. Area of Yards A and B is approximately 25,000 m^2 and 18,500 m^2, respectively, with a total area of 43,500 m^2.



Source: JICA Study Team

Figure 7.1.6 Outline of Temporary Construction Yard for Package 2

7.1.2.2 Construction Facilities

(1) Package 1

Temporary construction facilities for Package 1 are planned in two areas as shown in Figure 7.1.7. The temporary facilities for each site are allocated as follows:

Site-A: Reassembling yard for steel girders,

Temporary jetty plans in front of Site-A,

Offices for contractor, laboratory, and canteen, and

Fabrication yard for PC precast block of span-by-span.

Reclamation area is mainly used for construction yard and its height is estimated at +4.300 m considering five-year return period based on the river hydrological study. Main facilities in this area are as follows:

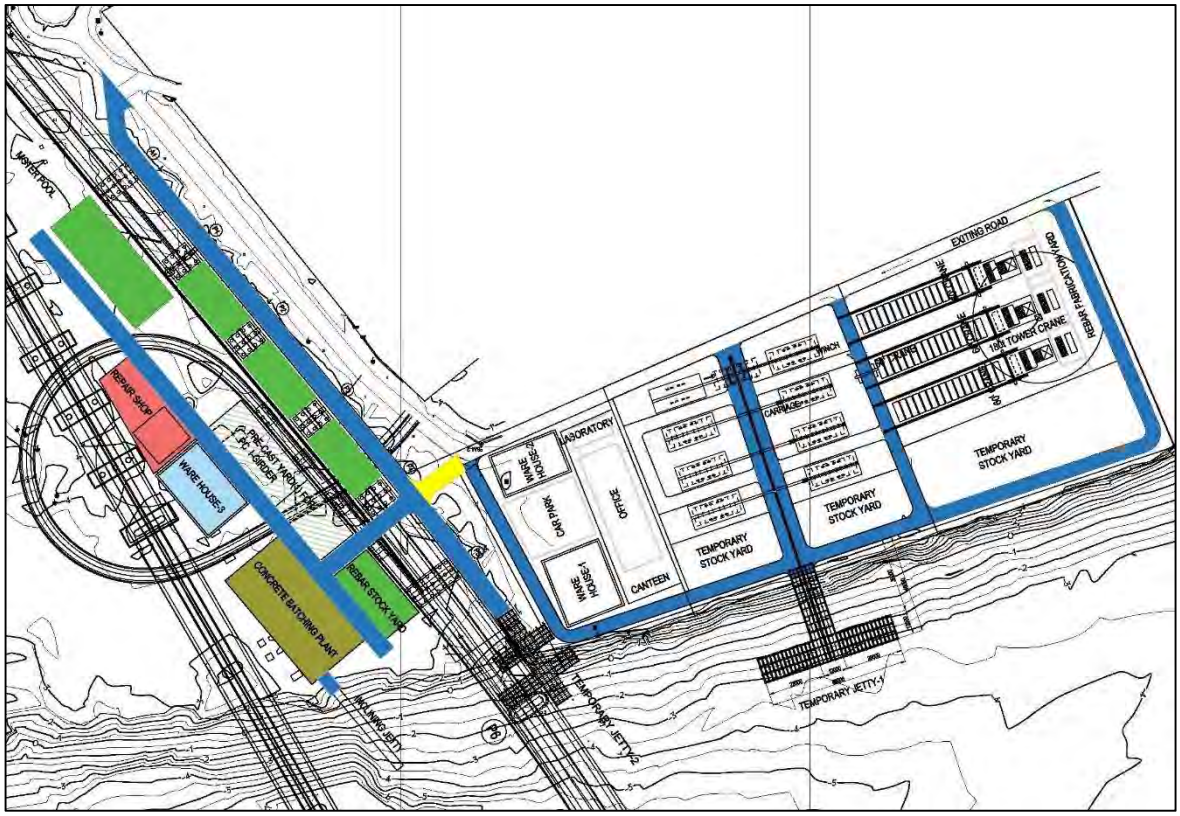
Motor poor /Repair shop and warehouse/stock yard,

Concrete batching plant and inclining jetty,

Pre-cast yard for PC I-girder, and

Temporary stock yards for PC box segment under the bridge.

Construction roads will be provided beside and along the bridge to erect box girder blocks by erection girder. The areas, especially the reclaimed site are on soft ground and thus surface ground improvement is required before construction facilities are constructed. Soil improvement with mixed cement is applied under each facility selected from the three types namely Type-1: improvement depth 1.0 m, Type-2: improvement depth 0.5 m, and Type-3 compaction depth 1.0 m considering soil condition and facility's loading condition.



Source: JICA Study Team

Figure 7.1.7 Tentative Facilities of Construction Yard in Package 1

(2) Package 2

Construction Yard A is located near the construction site. It is situated in a limited area and is planned to be allocated with the following main facilities as shown in Figure 7.1.8 .

Yard-A: Contractor's office, warehouse, carpark

Motor pool/repair shop,

Reassembling yard for steel girder

Temporary jetty

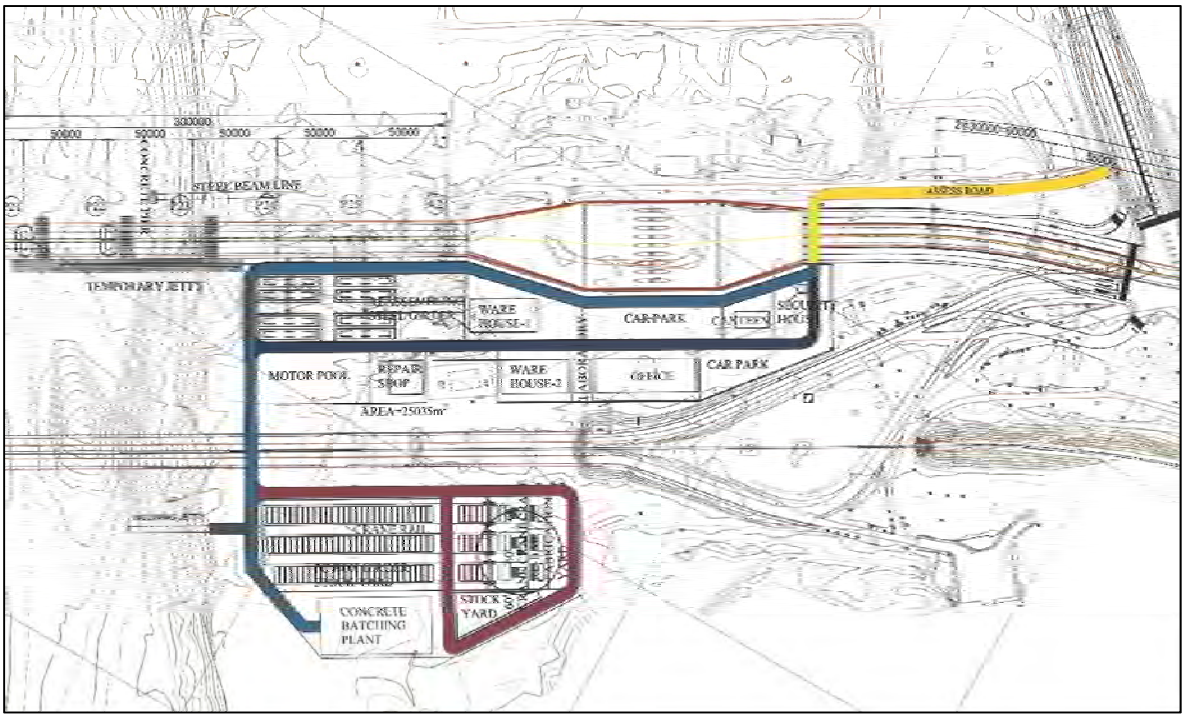
The reassembling yard is very limited and narrow area. This area is only used for assembling steel girder, and the stockyard provided is outside the construction yard.

Yard-B: Precast casting yard for PC box girders, stockyard of the casted blocks

Concrete bathing plant and re-bar assembling yards

Inclined Jetty

Yard-B, especially the reclaimed area is on soft ground and thus surface ground improvement is required before construction facilities are constructed. Soil improvement with mixed cement is applied under each facility selected from the three types namely, Type-1: improvement depth 1.0 m, Type-2: improvement depth 0.5 m, and compaction depth 1.0 m considering soil condition and facility's loading condition.



Source: JICA Study Team

Figure 7.1.8 Tentative Facilities of Construction Yard in Package 2

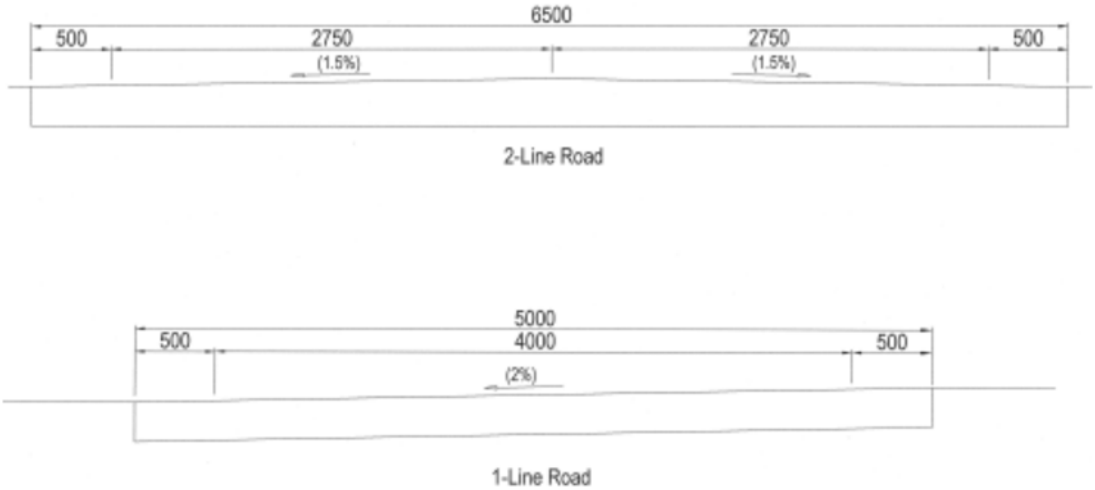
7.1.2.3 Temporary Facilities

(1) Temporary Construction Roads

Construction road in the yard is mainly 6.5 m in width for 2 lines and 5.0 m for single lines as shown in

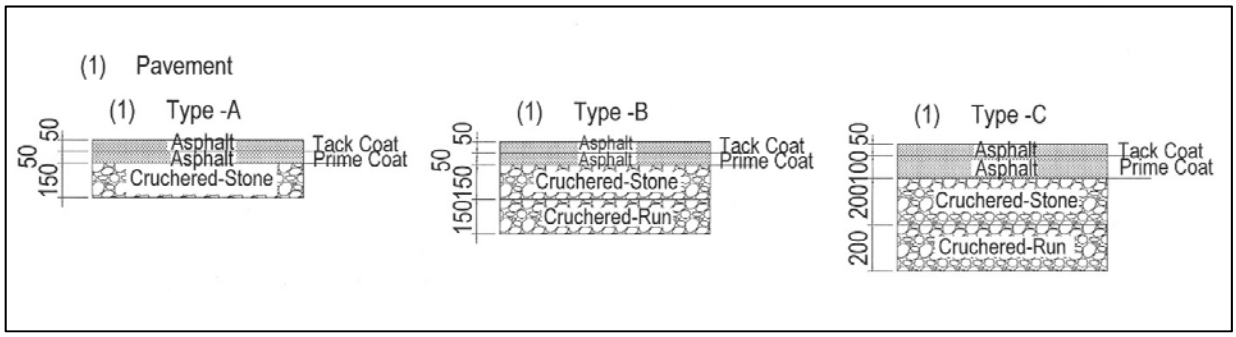
Figure 7.1.9. Pavement is classified into three types considering soil and loading conditions as shown in

Figure 7.1.10.



Source: JICA Study Team

Figure 7.1.9 Carriageway of Construction Road

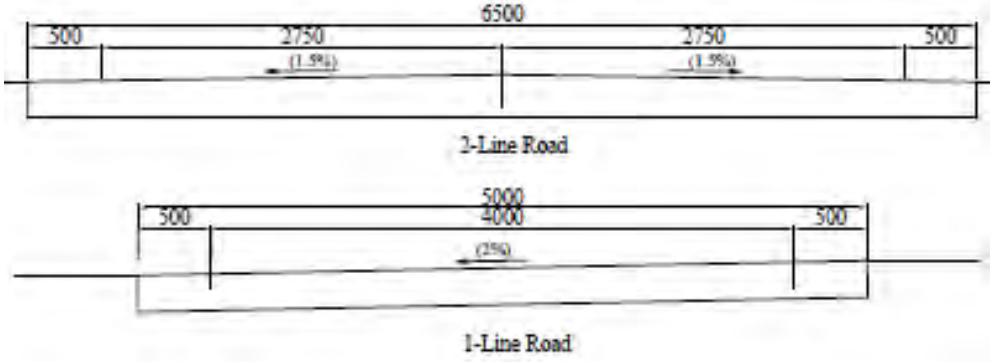


Source: JICA Study Team

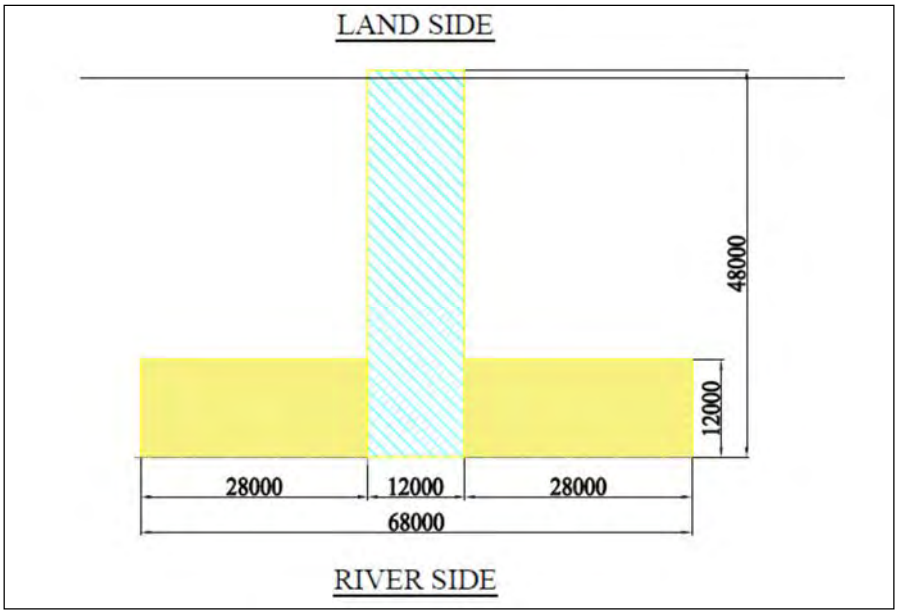
Figure 7.1.10 Pavement Structure of Temporary Road

(2) Temporary Jetty

A temporary jetty is provided each for Package 1 and Package 2 in order to construct foundations and substructures and/or loading and unloading steel girder blocks or segments. Steel members mostly

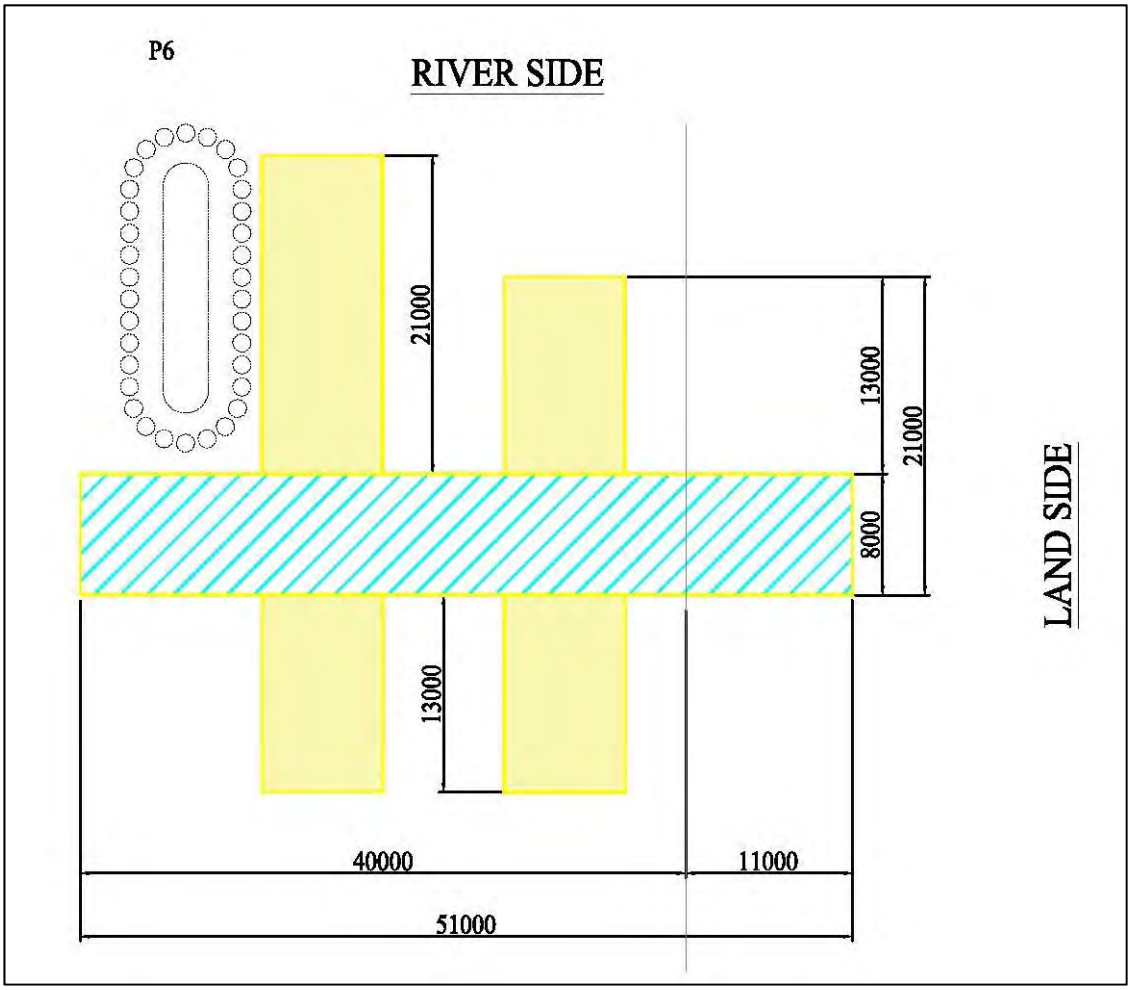


consist of steel H-beam and steel slabs. A part of the jetty, is used for staging heavy equipment of 200 t crawler crane that is reinforced with high horizontal rigidity and floor beam. The staging portion of the jetty colored in yellow is as shown in Figure 7.1.11 Figure 7.1.12 and Figure 7.1.13.



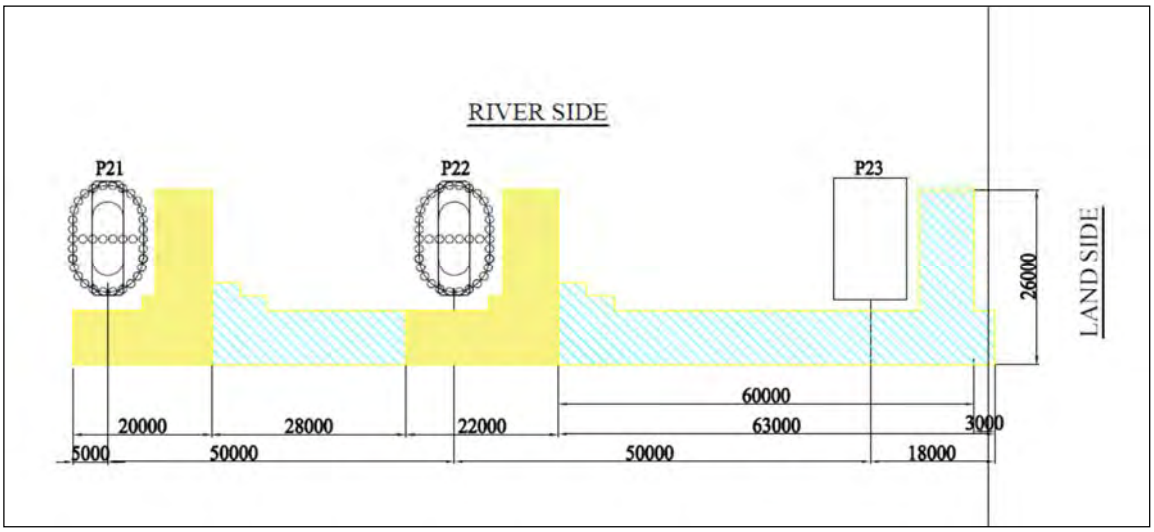
Source: JICA Study Team

Figure 7.1.11 Temporary Jetty in Package 1 (1/2)



Source: JICA Study Team

Figure 7.1.12 Temporary Jetty in Package 1 (2/2)



Source: JICA Study Team

Figure 7.1.13 Temporary Jetty in Package 2

(3) Concrete Batching Plant

Concrete batching plants are provided each for Package 1 and Package 2. The total concrete volumes for Package 1 and Package 2 are 58,800 m^3 and 32,600 m^3, respectively. Main concrete components are pre-cast PC box girder and concrete substructure for on and off shore works. Capacity of batching plant is 60 m^3/hour minimum, considering transportation capacity to the farthest pier in the river, and is located at the riverside and near pre-cast fabrication yard. Reserved batching plants are located in Thaketa City for Package 2 and inDagon and Thilawa SEZ for Package 1.

(4) Concrete Transportation in the River and Placing Facilities

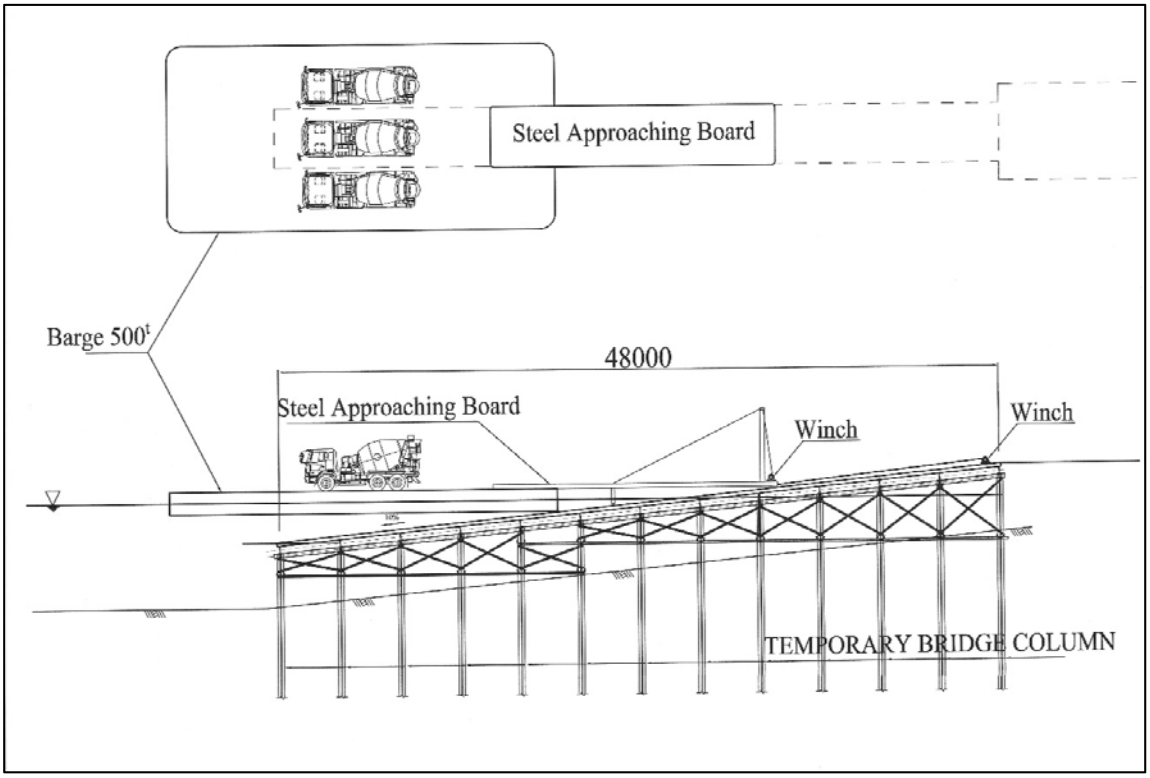
Concrete placing method for structures in the river is considered in the following two plans:

Plan-A : Concrete Batching Plant Barge with a Capacity of 60 m^3/hr

Plan-B : Agitator Truck on Barge-pulling Tug Boat and Placing Concrete by 2.5 m^3 Bucket

Regarding Plan-A, concrete volumes for river structures of approximately 22,900 m^3 in Package 1 and 18,100 m^3 in Package 2 that are relatively small in quantities for providing concrete batching plant barges from Singapore or other countries are very costly. On the other hand, Plan-B has the following advantages:

- Distance between a batching plant on land and river structures is within 750 m
- Although inclined jetties are provided for both packages, they can reduce concrete placing cost.
- The inclined jetty copes with the fluctuation of river water level as shown in Figure 7.1.14.

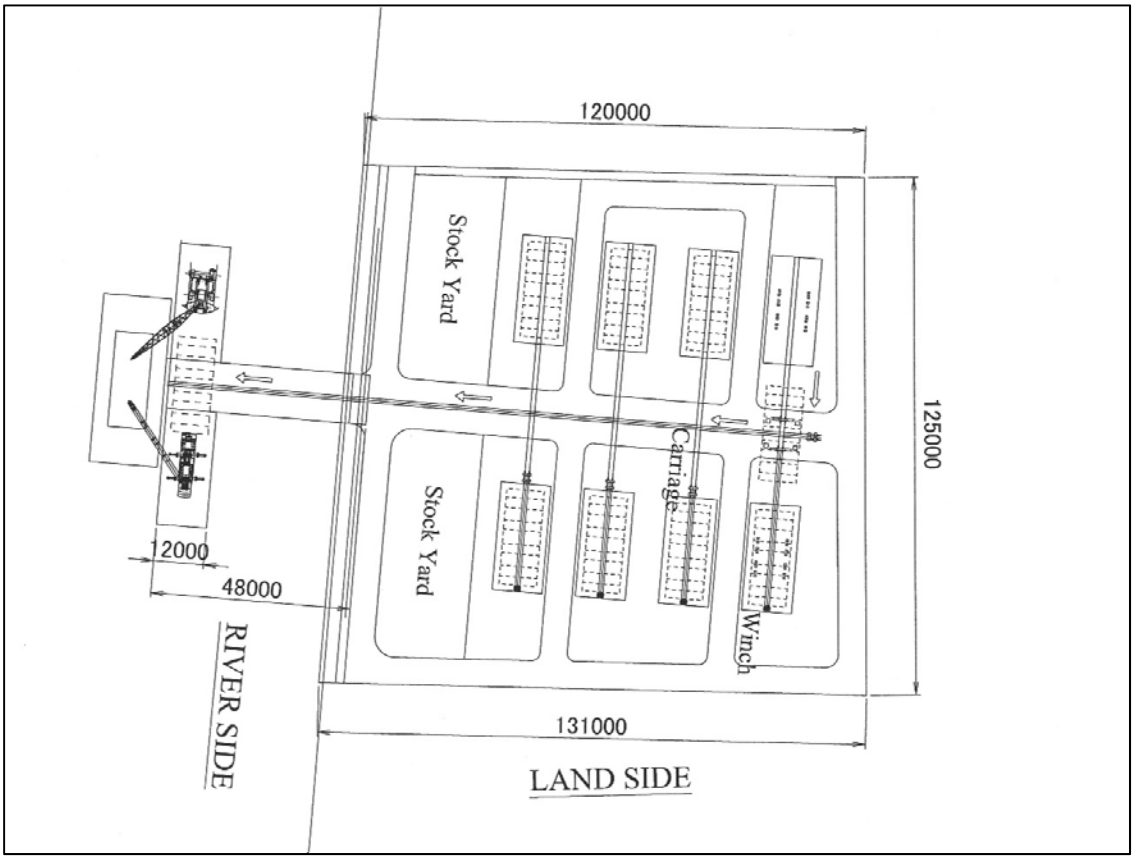


Source: JICA Study Team

Figure 7.1.14 Inclined Jetty for Agitator Truck on Barge

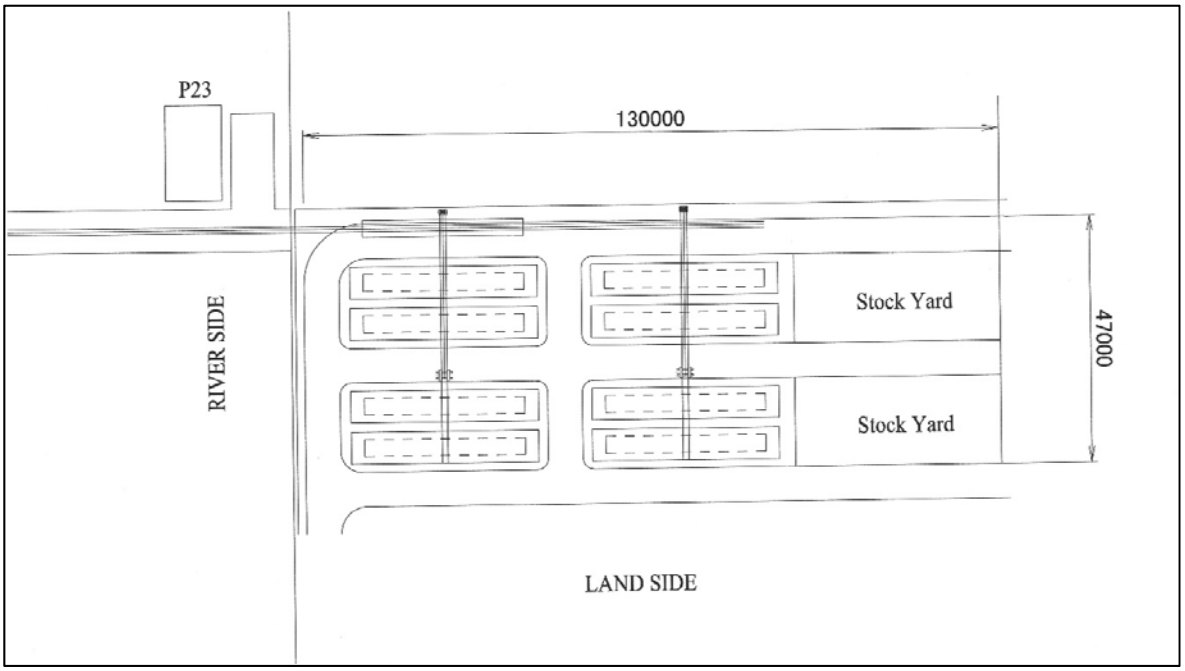
(5) Reassembling Yard for Steel Girder Blocks

Reassembling yards in Package 1 and Package 2 are mainly used for reassembling steel girder blocks to erection segments, welding steel pipes used in SPSP to use bents for girder erection, and temporary stock pile. Steel girder blocks for cable-stayed and continuous steel box girder bridges are fabricated out of the construction yard and transported to the reassembling yard by barge. Loading steel blocks and pipes on the jetty is conducted by crawler crane and transported to the reassembling yard by trailer or carriage. Assembled erection segments on carriage are pulled out of the yard to the temporary jetty by winches jacks as shown in Figure 7.1.15 and Figure 7.1.16.



Source: JICA Study Team

Figure 7.1.15 Reassembling and Stock Yard for Steel Girder in Package 1



Source: JICA Study Team

Figure 7.1.16 Reassembling and Stock Yard for Steel Girder in Package 2

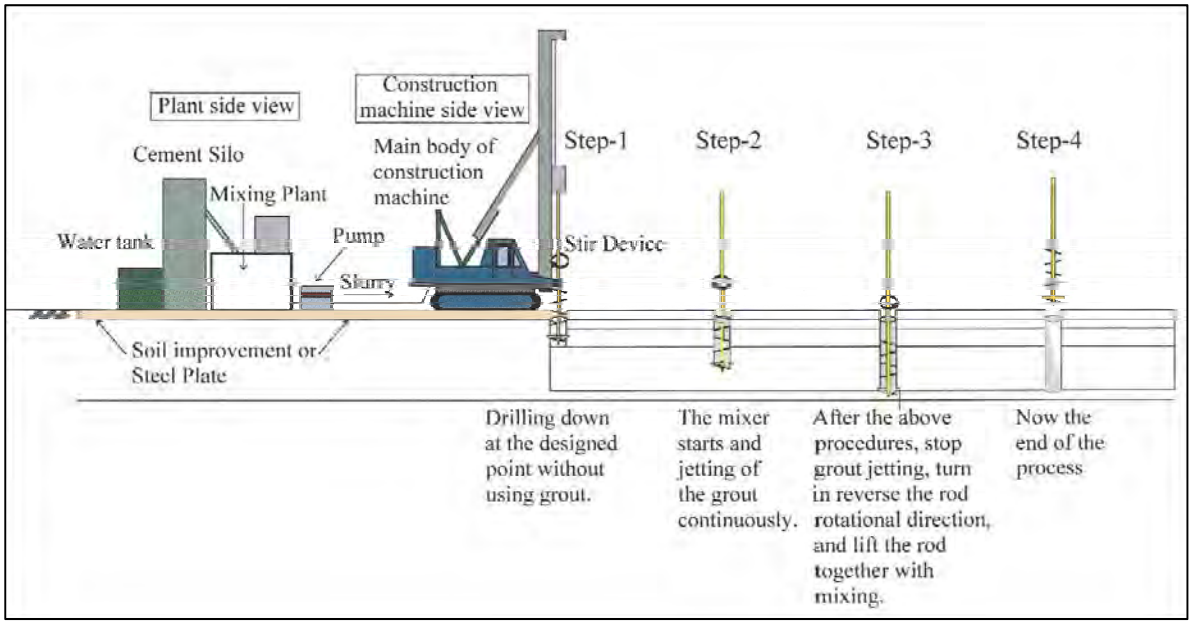
7.1.3 Road Works

7.1.3.1 Works for Soft Soil Treatment

Approach road for both Thanlyin and Thaketa side and toll plaza located on soft ground will require soft soil treatment. Considering construction period and cost, the treatment will be carried out through combination of deep soil mixing method and preloading method.

(1) Deep Soil Mixing Method

Approach road in the Thanlyin side located on soft ground requires improvement of clay, sandy clay, and silty sand layers. The improvement depth is 30 m in maximum for Package 1 and 20 m for Package 2. Deep soil mixing method is selected in consideration with deep improvement depth. The formation of equipment and procedure for construction are illustrated in Figure 7.1.17 .



Source: JICA Study Team

Figure 7.1.17 Formation of Deep Soil Mixing Equipment and Procedure for Construction

(2) Pre-loading Method

Preloading method is subdivided into: only preloading using surcharge; and preloading using surcharge and vertical drain considering time taken for consolidation of soft soil. For the soft soil area, where the time for consolidation is more than 16 months for Package 1 and 12 months for Package 2 including filling period in total construction period, preloading using surcharge method is applied to reduce cost. Filling material of surcharge is transported by barge from borrow pit 6.0 km upstream of the Bago River.

7.1.3.2 Works for Embankment and Retaining Walls

(1) Workable Day for Embankment

Workable day for embankment is approximately 178 days a year as shown in Table 7.1.5. However, in the rainy season from June to September, workable days are very limited, therefore, embankment works should be cancelled during this season in consideration of soil conditions.

Table 7.1.5 Workable Days for Each Work

Average (2013 - 2015)											Unit: day		
Rainfall	Jan.	Feb.	March	April	May	June	July	Aug.	Set.	Oct.	Nov.	Dec.	Total
0-1mm	31	28	30	29	21	5	4	7	12	18	27	31	212
1mm- 5mm	0	0	0	0	2	5	3	6	4	2	1	0	23
5mm-10mm	0	0	0	0	1	2	4	3	4	2	1	0	17
Over 10mm	0	0	0	0	7	17	20	14	9	9	2	0	78
Enbankment	31	28	30	29	22	8	7	11	15	20	28	31	229
Concrete Work	31	28	30	29	28	21	20	22	23	26	30	31	288
Steel Work	31	28	31	30	29	25	25	27	27	28	30	31	311
Sunday & Holiday	6	4	5	6	13	6	6	5	5	5	6	6	67
Estimated Workable Day											Unit: day		
Enbankment	25	24	25	23	12	5	4	9	13	16	22	25	178
Concrete Work	25	24	25	23	18	20	19	20	21	24	24	25	243
Steel Work	25	24	26	24	16	21	21	22	22	23	24	25	248

Source: JICA Study Team

7.1.3.3 Diversion of Existing Traffic during Construction

(1) Intersection at the Beginning Point for Package 1

Existing traffic at the intersection of the beginning point is mainly through Thaketa–Thanlyin Road and from Star City. During the construction of new intersection, these traffic flows are diverted into the following steps and as shown in Figure 7.1.18.

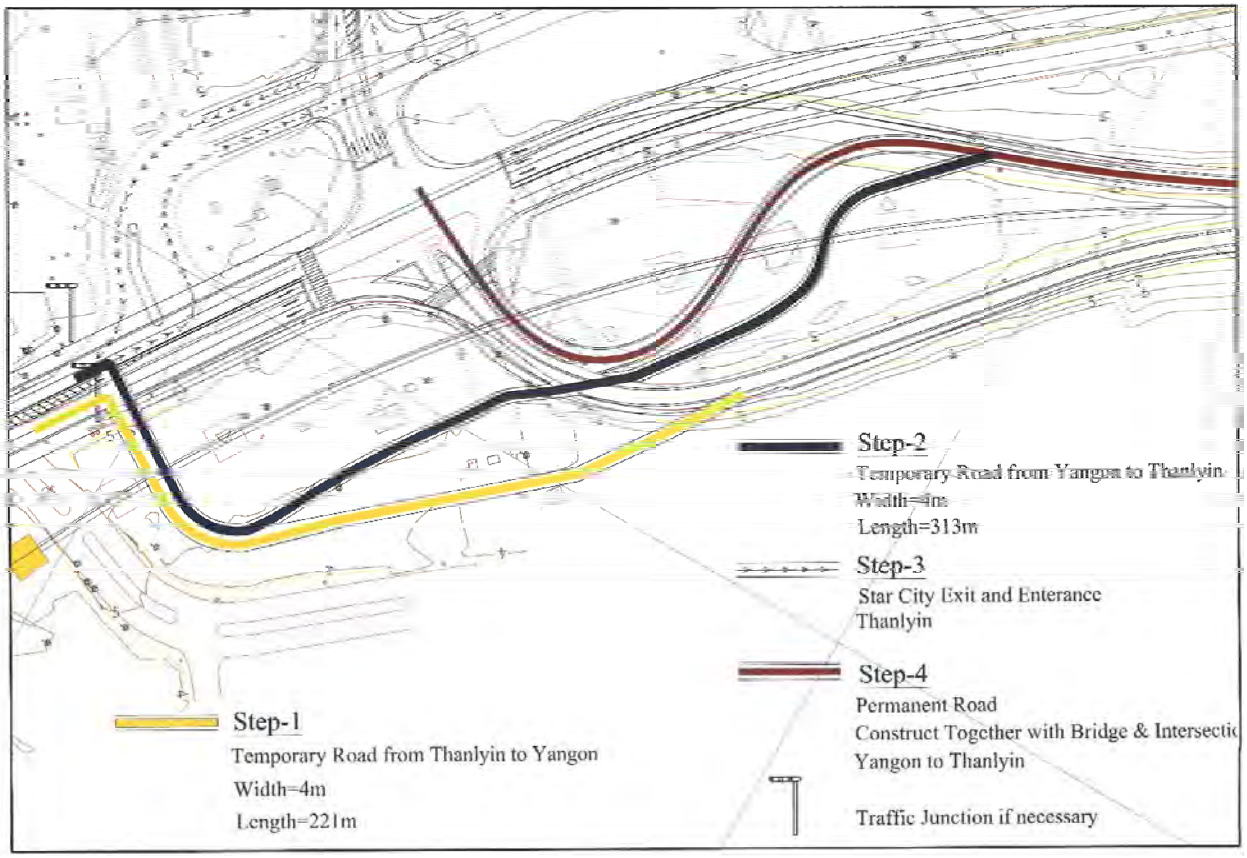
Step 1: Traffic from Thanlyin to Thaketa is diverted to temporary road colored in yellow.

Step 2: Traffic from Thaketa to Thanlyin is diverted to temporary road colored in blue.

Step 3: Traffic from Star City to Thaketa is U-turn at the roundabout and uses temporary road colored in yellow.

Step 4: Traffic from Thaketa to Star City is diverted to temporary road colored in blue and crosses the intersection.

Step 5: After completion of new road colored in red and approach road, all traffic are diverted to new intersection.



Source: JICA Study Team

Figure 7.1.18 Diversion of Existing Traffic during Construction of Intersection

(2) Approach Road to the Existing Thanlyin Bridge

The approach road is a new road to the existing Thanlyin Bridge after opening the new Bago Bridge construction. The construction is related to the schedule for improvement of intersection and construction of approach roads from the toll plaza. The process of construction is as per the following steps, and as shown in Figure 7.1.19 to maintain the existing traffic smoothly.

Step 1: Realigned road is constructed at the section so as not to disturb the existing traffic flow (Yellow section)

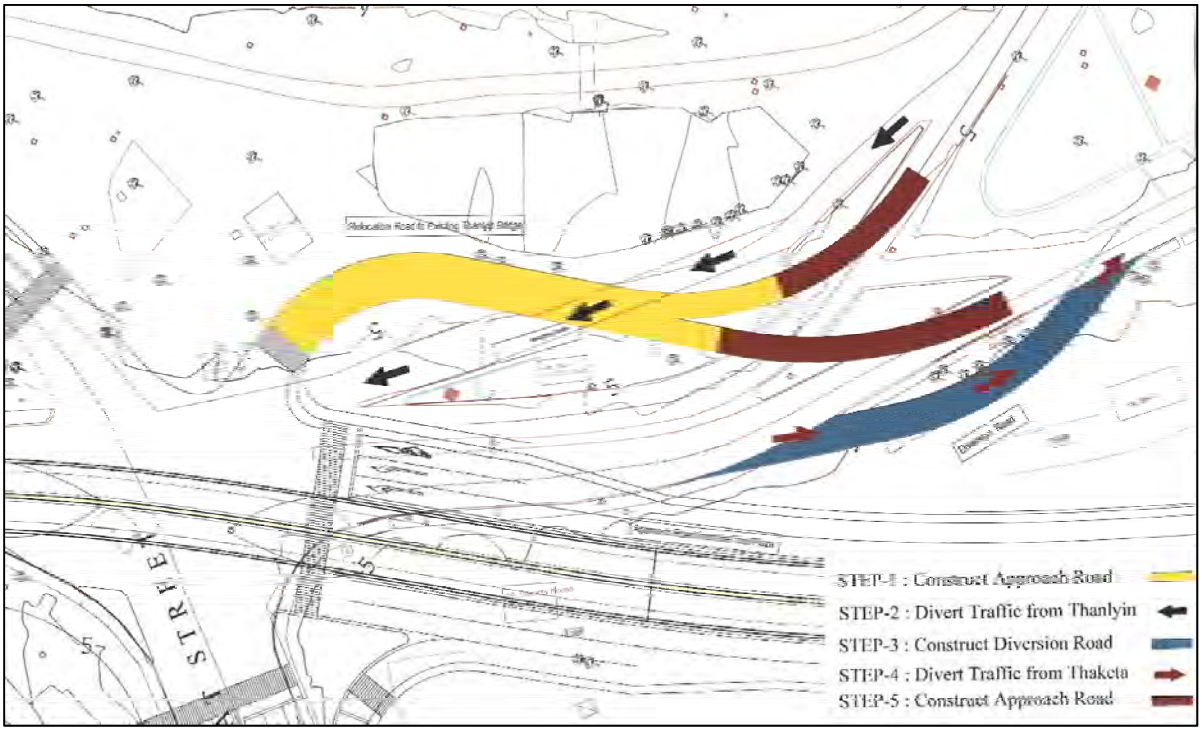
Step 2: Existing traffic flow from Thanlyin side is diverted to detour road that crosses the constructed realigned road (Black arrow).

Step 3: Temporary road is constructed for diverting traffic (Green section).

Step 3: Existing traffic flow to Thanlyin side is diverted to the temporary road (Red arrow).

Step 4: Remaining section of relocated road will be constructed and completed before intersection improvement (Blue section).

Step 5: After completing the improvement of intersection, both upward and downward lines of the relocated road will be opened and then the approach road to and from the toll plaza will be constructed.



Source: JICA Study Team

Figure 7.1.19 Diversion of Existing Traffic during Construction of Relocated Road

7.1.4 Cable-stayed Bridge

7.1.4.1 Outline of Cable-stayed Bridge Works

(1) Alternative Study for Erection of Cable-stayed Bridge

Erection method for cable-stayed bridge is determined considering the points namely: Constructability, Construction period, Navigation Safety, Erection Cost and Technology Transfer.

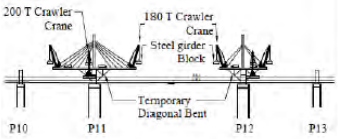
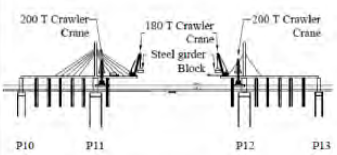
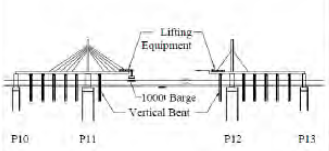
Possible erection methods in the comparative study are selected as follows:

- Diagonal Bent + Balancing Erection Method
- Vertical Bent + Balancing Erection Method (Block Erection)
- Vertical Bent + Balancing Erection Method (Segment Erection)

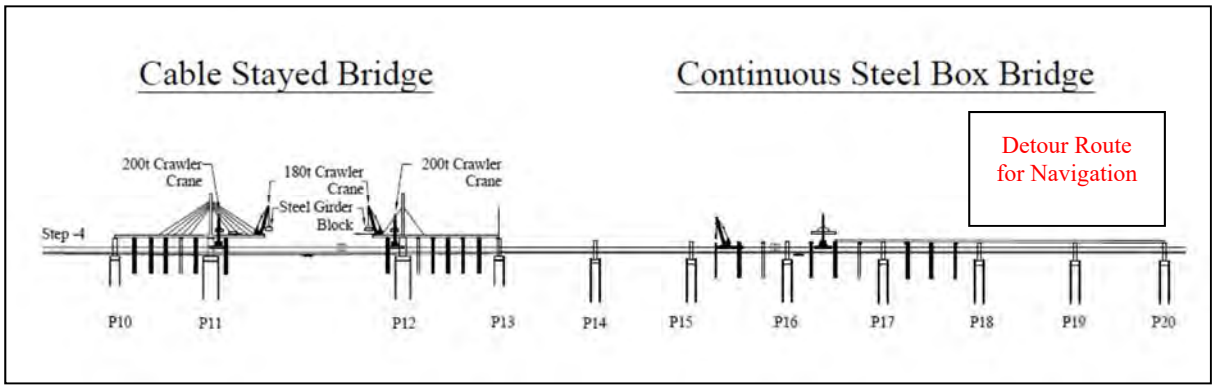
Important factor is mainly to minimize construction period requested by MOC and maintain navigation traffic. Vertical bent + Balancing erection with segment is most recommended because construction period can be shortened and disturbance to navigation traffic is minimized (Period of lifting segment is from 3 to 4 hours in high tide and number of times; 21 times) as shown in Table 7.1.6.

In addition, detour navigation route will be secured in the Thaketa side as shown in Figure 7.1.20.

Table 7.1.6 Work Alternative Studies for Erection of Cable-stayed Bridge

Type	Diagonal Bent + Balancing Erection Method		Vertical Bent +Balancing Erection(Block)		Vertical Bent +Balancing Erection(Segment)	
Figure						
Constructability	・Diagonal bent is not efficient usability	△	・Simple and repeating works are workability	◎	・Simple and repeating works are workability	◎
Construction Period	・Not suitable for tight construction period ・36 months	△	・Catch up Tight Construction Period ・Approximate 34 months	○	・Catch up Tight Construction Period ・Approximate 32 months	◎
Navigation	・No disturbance to Navigation traffic	◎	・No disturbance to Navigation traffic	◎	・Slightly disturbance in lifting girder segments	○
Erection Cost	・Newly designed diagonal bents is costly. 200t crane and girder block loading jetty are required. ・1.05	○	・Reutilize top part cut steel pipes of SPSP for the temporary bents. 200t crane and girder block loading jetty are required. ・1.05	○	・Reutilize top part cut steel pipes of SPSP for the temporary bents. 350t crane and girder segment loading jetty are required. ・1.00	◎
Technology Transfer	・Other steel cable stayed bridge having high clearance may be applicable.	○	・Simple and combination of different erection systems is good for the first steel cable stayed bridge	○	・Erection method using large crane barge and fabrication and loading jetty	○
Evaluation	Less Recommended		Recommended		Most recommended	

Source: JICA Study Team



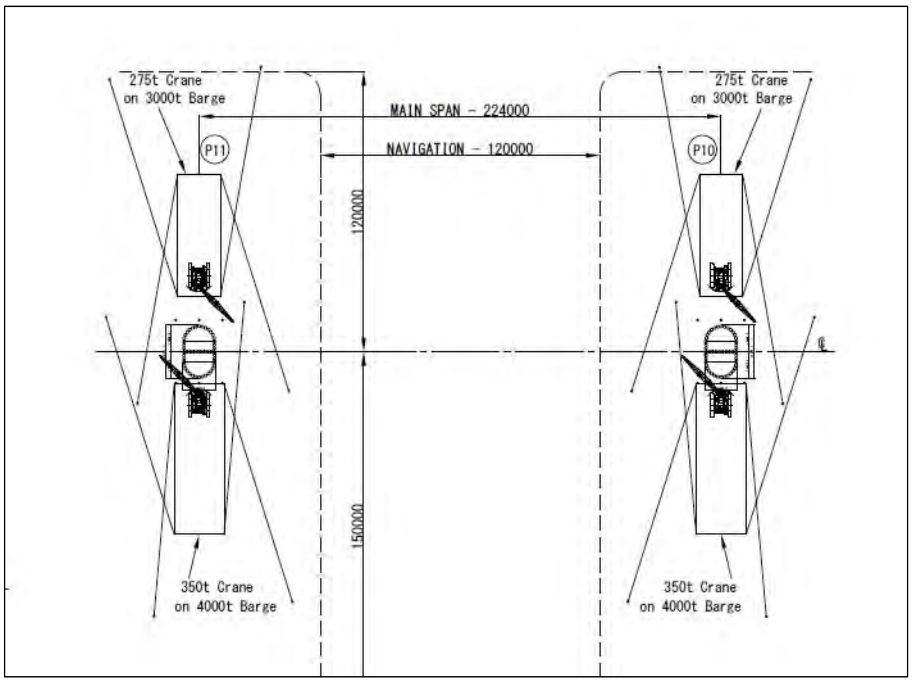
Source: JICA Study Team

Figure 7.1.20 General View during Erection of Center Span of Cable-stayed Bridge

7.1.4.2 Foundation Works

(1) Maintenance of Navigation Route during Foundation Works

The foundation of cable-stayed bridge is planned to consist of steel pipe sheet piles (SPSP) with steel pipe of φ1.2 m to maintain the navigation route. The size of SPSP is large (15 m x 23 m) and steel pipe is as long as 60 m so that two large crane barges are required for the execution. For the security of navigation route, two crane barges of 350 t and 275 t are arranged in flow direction as shown in Figure 7.1.21 . Considering anchor setting temporarily in riverbed, a minimum of 120 m is secured for the navigation width.

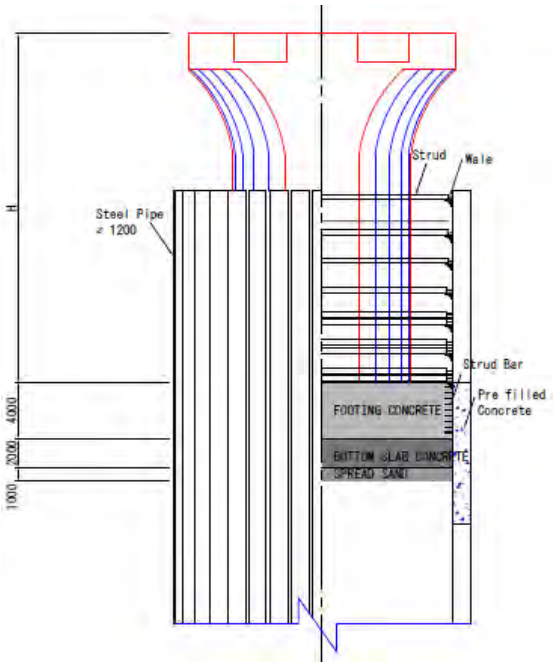


Source: JICA Study Team

Figure 7.1.21 Arrangement of Two Crane Barges for SPSP Execution

(2) SPSP Foundation

All 6,220 t of steel pipes used for the SPSP foundation are fabricated based on JIS standards and Japanese fabricator in Vietnam. The SPSP foundation has an oval shape and measures 14.130 m x 22.820 m. Steel pipe pile is 1.20 m and 12-16 mm in thickness as shown in Figure 7.1.22. The maximum length is 62.0 m in Package 1 including temporary pipes for cofferdam and the total number of steel pipes including separation wall pipe is 184 for four foundations. The position of steel pipes is determined by using temporary guide-frame. Hydraulic vibration hammer is firstly used for driven steel pipes and finally it is driven into bearing stratum by using a diesel driven hammer. A driven steel pipe pile verifies the ultimate bearing capacity by impact loading testing (PDA).

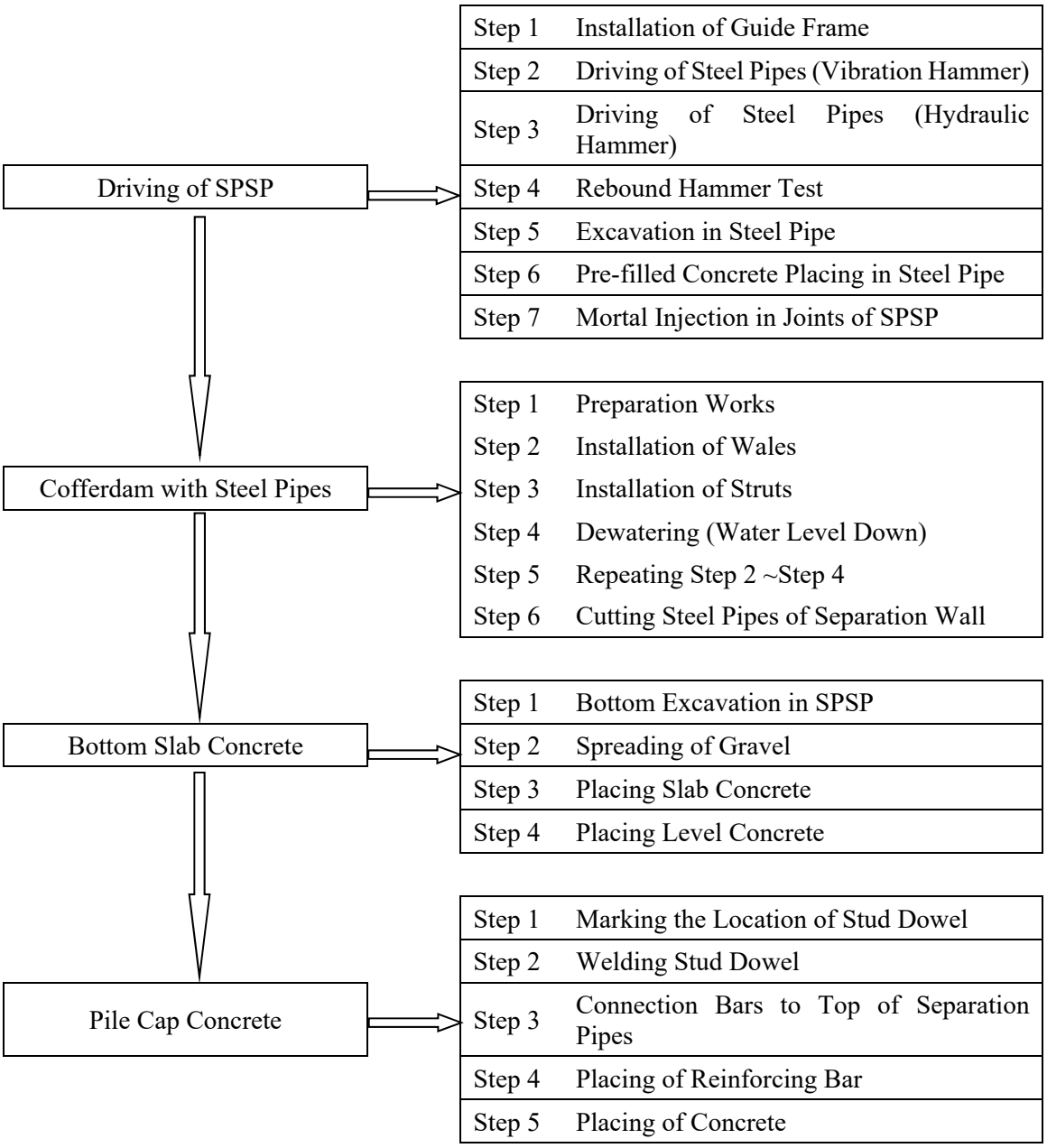


Source: JICA Study Team

Figure 7.1.22 Configuration of SPSP Foundation

(3) Construction Sequence of SPSP

Construction of SPSP mainly is divided into four works and is carried out in the following sequence. Each work is sub-divided into several steps to complete the process as shown in Figure 7.1.23.



Source: JICA Study Team

Figure 7.1.23 Sequence in the Construction of SPSP

7.1.4.3 Substructure Works

(1) Concrete Plant and Transportation Method of Concrete

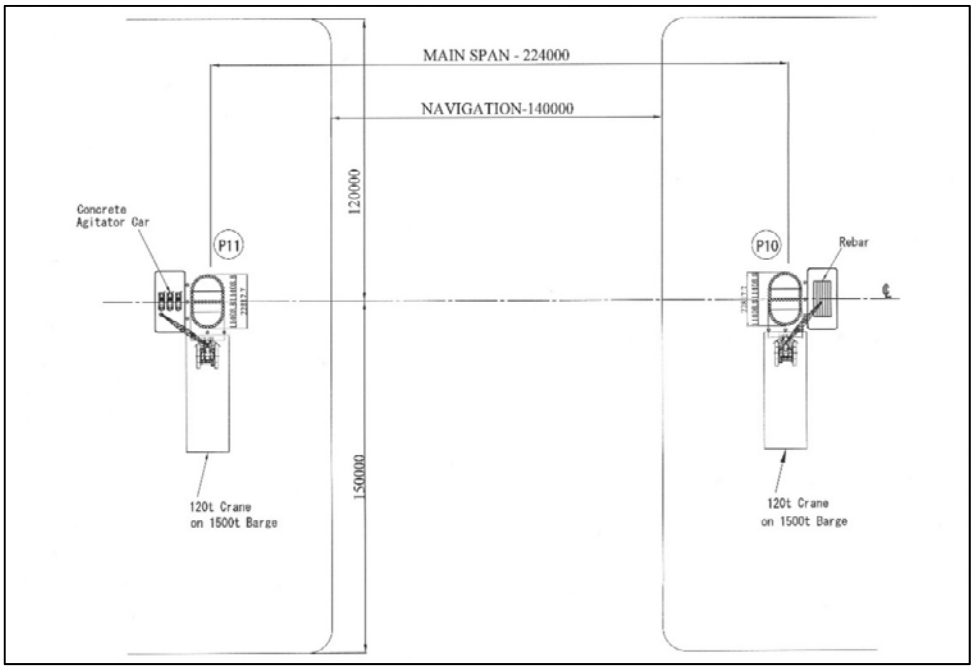
Concrete batching plant is provided near the riverside and ensures smooth access to the substructure in the river for both packages. Concrete agitator trucks on barge are the transporting method through inclined jetty as shown in Figure 7.1.24. Transportation distance from jetty to the farthest pier is approximately 500 m and the time cycle is 20 minutes. In case of 3-agitator on barge, the capacity of 45 m^3/hr (15 m^3 x60/20=45 m^3/hr) is estimated as the maximum. Two sets of transporting barges are

provided for concrete placement in the river, and a capacity of 60 m^3 /hr can be ensured in consideration of time cycle allowance.

(2) Concrete Placing Method in SPSP

Construction of concrete slab and pier structures is executed by using SPSP cofferdams, which is used for the top part of SPSP foundation. The false-work system is designed for dry constructability in the river. The concrete of bottom slab is placed by a concrete bucket of 2.5 m^3 attached to 100 t crawler crane on barge. During placing of the concrete in the SPSP, concrete agitator on barge and 100 t crawler crane on barge are arranged in position as shown in Figure 7.1.24. After the SPSP is carried out in the dry and stud dowel welds on steel pipe to connect the pile cap, concrete is placed by the same method.

The reinforced concrete columns of pier are constructed by using a shuttering form with an integration of a working platform. A crawler crane with a capacity of 100-ton barge anchors on the cofferdam for material handling. Each typical pouring height is 3~4 m. In the construction planning, a 4-day cycle time for each lift is estimated.



Source: JICA Study Team

Figure 7.1.24 Arrangement of Barges during Sub-structure Works

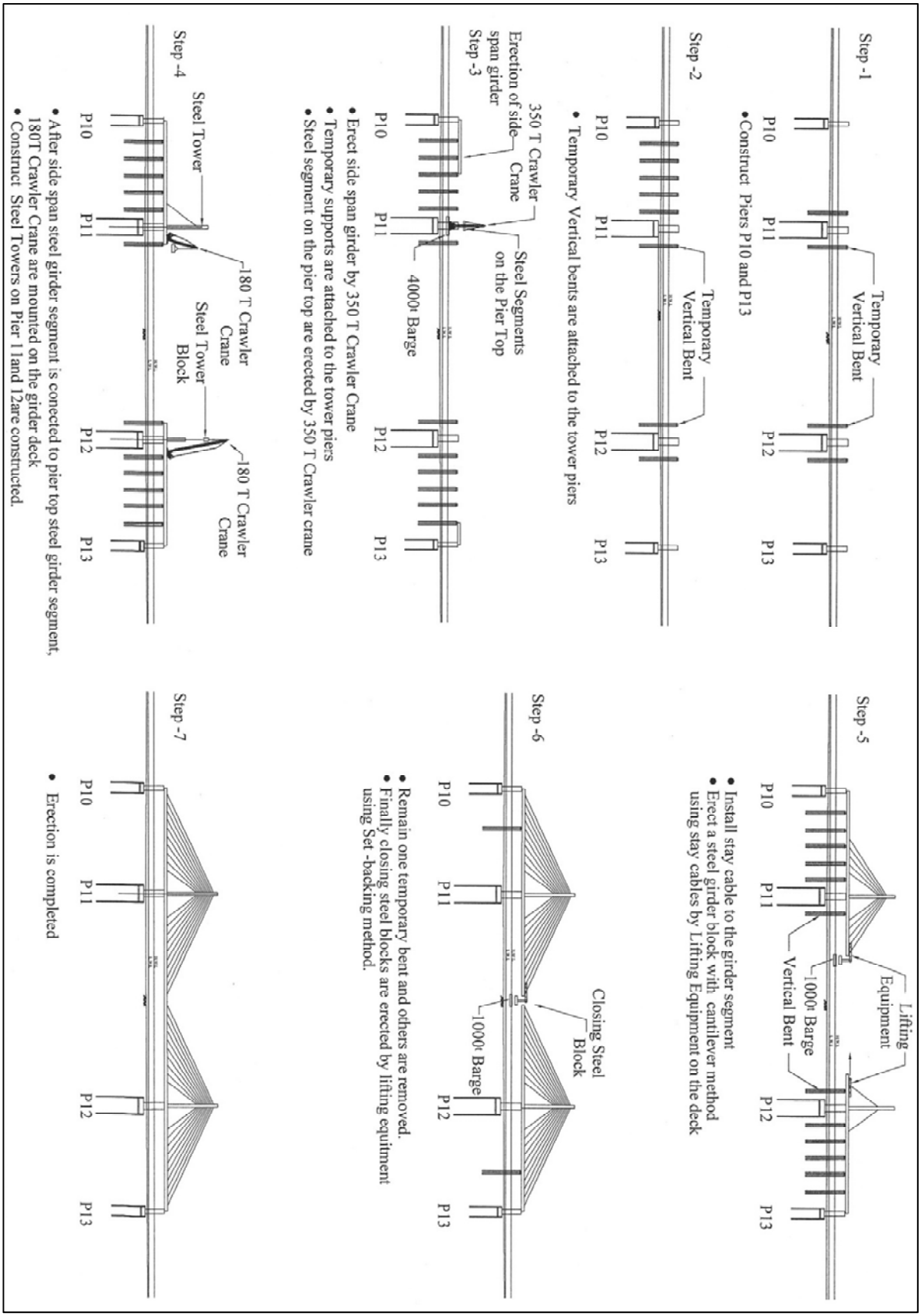
(3) Bracket for Scaffolding of Coping Concrete

After pier shaft concrete is completed, shuttering formwork is removed and then steel pipes above pile cap concrete are cut and removed. The removed pipes are connected and welded for reuse as temporary pile bents at side span of cable-stayed bridge. Brackets for scaffolding of a hammer head coping concrete are provided on pier column. The brackets consist of fabricated H-beam.

7.1.4.4 Superstructure Erection Works

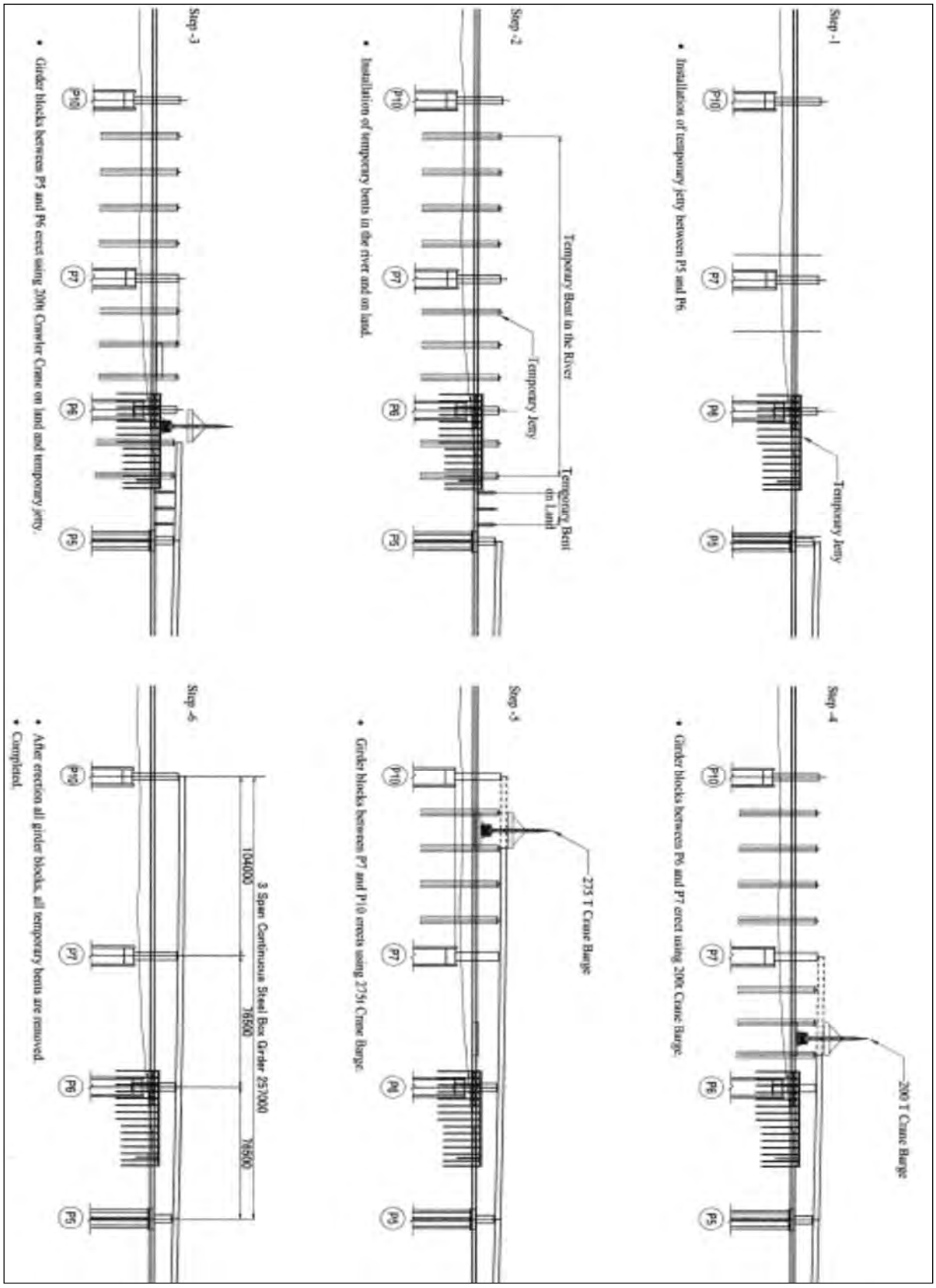
(1) Erection Sequence for Cable-stayed and Continuous Steel Box Bridges

Erection sequence for a cable-stayed and continuous steel box bridges are illustrated as shown in Figure 7.1.25 and Figure 7.1.26.



Source: JICA Study Team

Figure 7.1.25 Erection Sequence for Cable-stayed Bridge

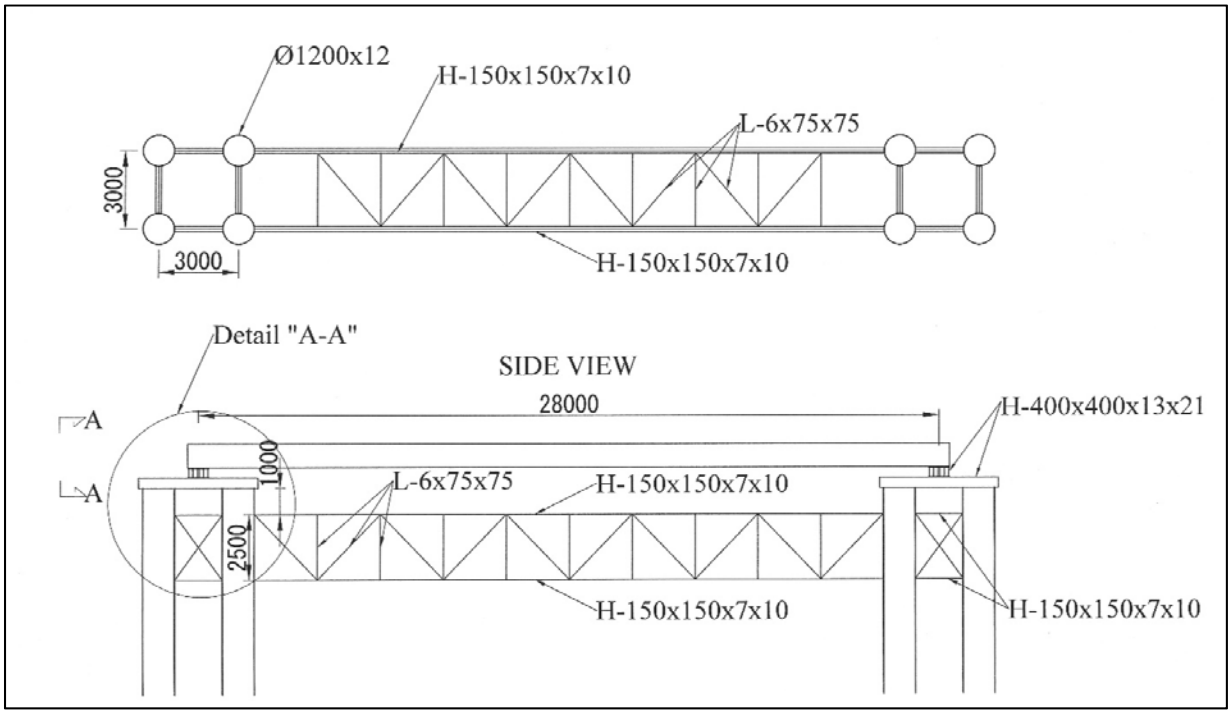


Source: JICA Study Team

Figure 7.1.26 Erection Sequence for Continuous Steel Box Girder Bridge

(2) Erection of Side Span Girder

Prior to erection of center span, side span girders are erected by using temporary bents as shown in Figure 7.1.27 to minimize the construction period during construction of pier head and steel tower. The top part of steel pipes of SPSP is reused for bent. Cross beams, which temporarily support steel block loading, are made up of two H-beams welded together at their flanges. Erection blocks with 18 m length are fabricated at the factory, transported on barge to the site, and erected on the bent using 350 t or 275 t barge crane. These bents of side span are removed after completion of erection of cables.



Source: JICA Study Team

Figure 7.1.27 Image of Bent in the River for Side Span of Cable-stayed Bridge

(3) Erection of Tower

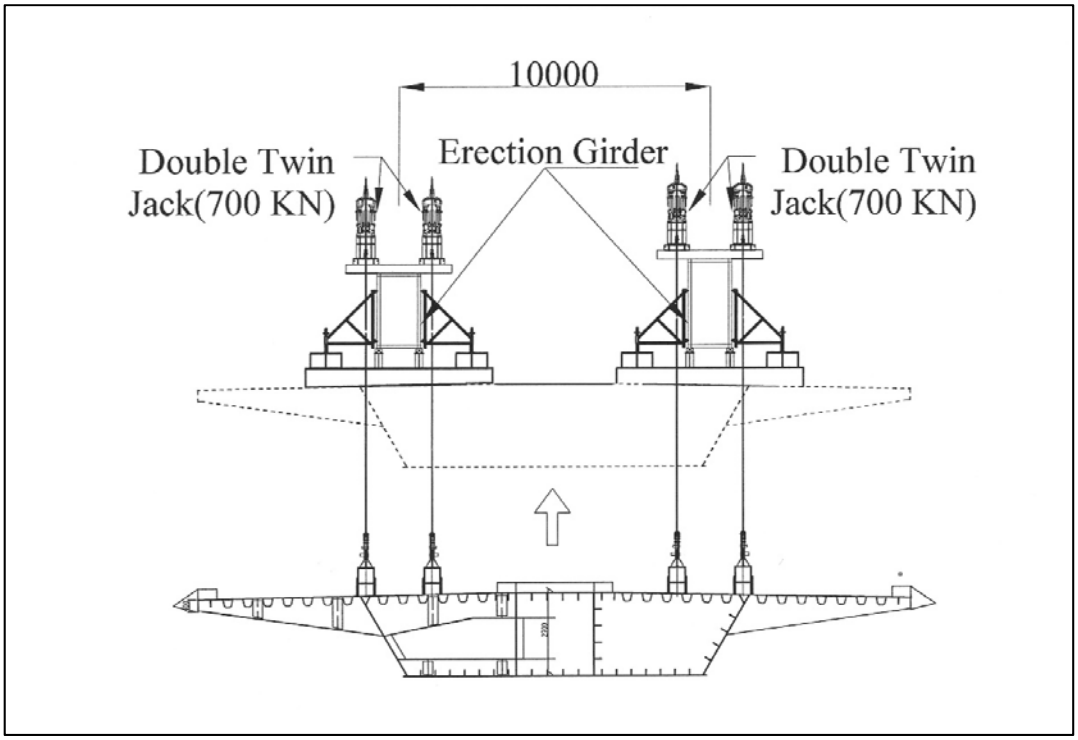
Each tower is a single steel pylon that is supported rigidly with steel girder on Pier 11 and P12. Each pylon has a box section with outer dimension of 3.0 m x 2.5 m and 58.0 m height above the carriageway. Steel grade is a SM490Y used for the tower. The tower is divided into 21-fabrication segment considering transportation. Stay cable anchorage is located and fixed in the tower. Two fabricated tower blocks are connected by welding at the reassembling yard for erection. Ten tower segments erected by 200 t crawler crane mounted on carriageway and welded at the site. The site welding is undertaken under control of experienced competent welding coordinator. The provisions such as fire-retardant sheet and scaffolding provide for protection against inclement weather and good access needed for both welding and inspection.

(4) Erection of Center Span

(5) Erection Girder

Center span girder is divided into 25 segments including closing segment and is erected using the balancing cantilever method. There is single vertical plane of stay cable, wherein 20 cables are anchored on erecting segments.

After the side span construction using bent supports and tower completion, erection girder installed at the head of main steel girder of center span is as shown in Figure 7.1.28. Considering the transportation capacity by track, each segment is separated in to 9~10 small steel blocks and fabricated at the factory. These steel blocks are transported to the reassembling yard near the site and assembled to the erection segment. The erection segment is transported at the erection site by barge, and pulled up to connection point using 4-double twin jacks. The steel closure segment set using the erection girder utilizes guiding closure segment jigs in order to set smoothly.

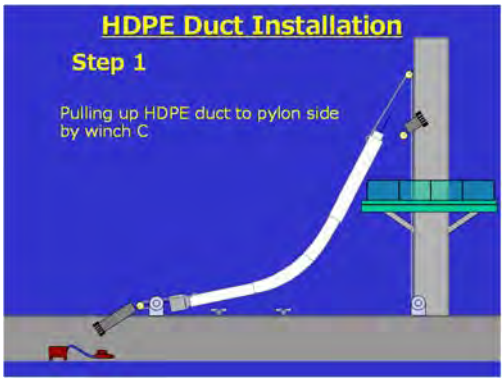


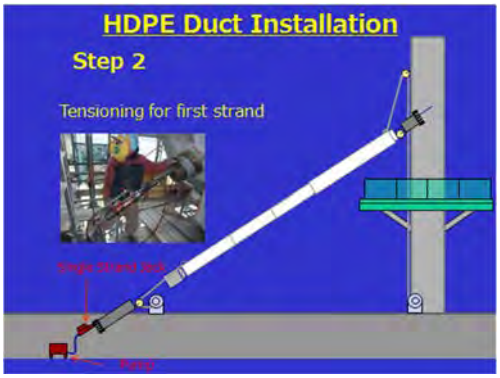
Source: JICA Study Team

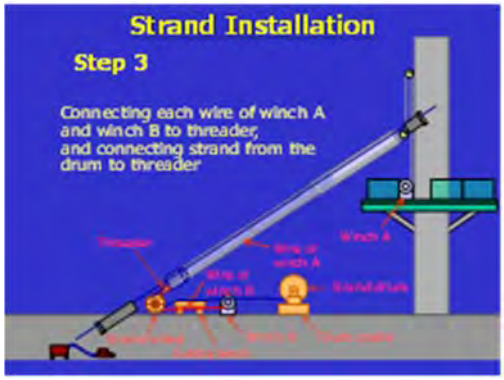
Figure 7.1.28 Erection Method of Center Span Segments Using Erection Girder

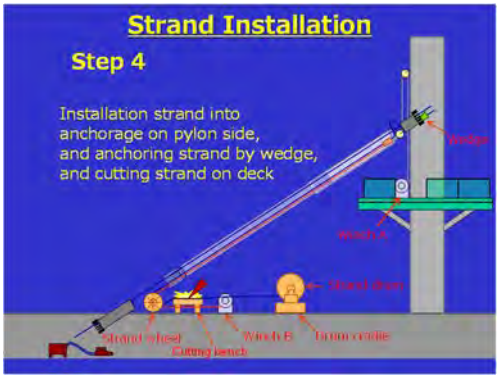
1) Stay Cable Construction

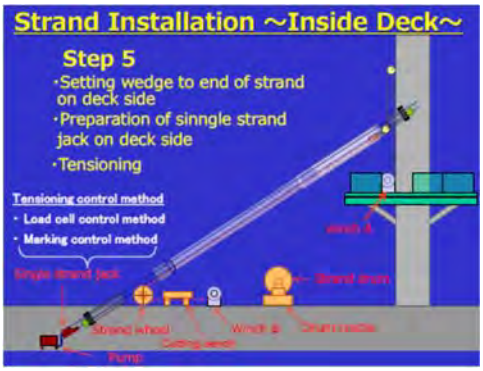
Two stay cable systems are composed of 44 strands and 70 strands, with each strand having a diameter of 15.6 mn. The stay cable is fabricated strand by strand at the site as shown in Figure 7.1.29. The first strand has a load-cell to suit the first strand's tensioning force. Each strand is subject to the first tensioning force designed. All strands are tensioned strand by strand with single strand jack. Each strand is anchored inside the pylon using wedge and tensioned at the end of strand on deck side with single strand jack. In case that adjustment is required for girder erection, second tensioning is carried out using single strand jack or multi jack.

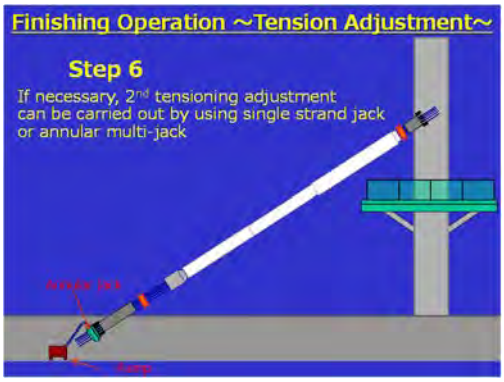


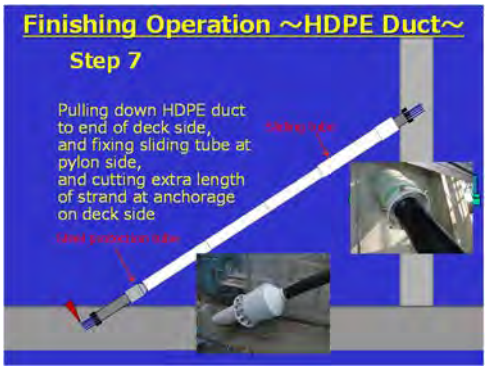












Source: JICA Study Team

Figure 7.1.29 Cable Erection Sequence for Cable-stayed Bridge

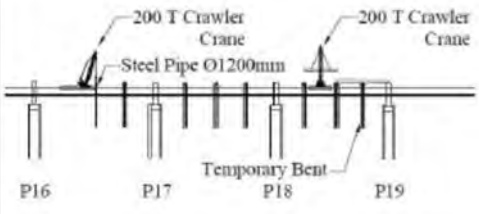
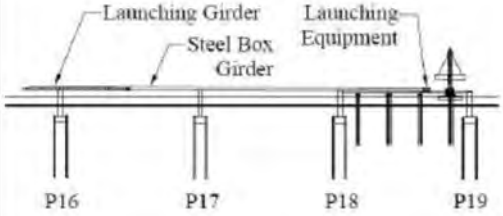
7.1.5 Steel Box Girder Bridge

7.1.5.1 Outline of Steel Box Girder Works

(1) Alternative Study for Steel Box Girder Works

The erection of steel box girder bridge is executed using bent erection method considering the merit of construction period and erection cost as shown in Table 7.1.7.

Table 7.1.7 Alternative Studies for Erection of Steel Box Girder Bridge

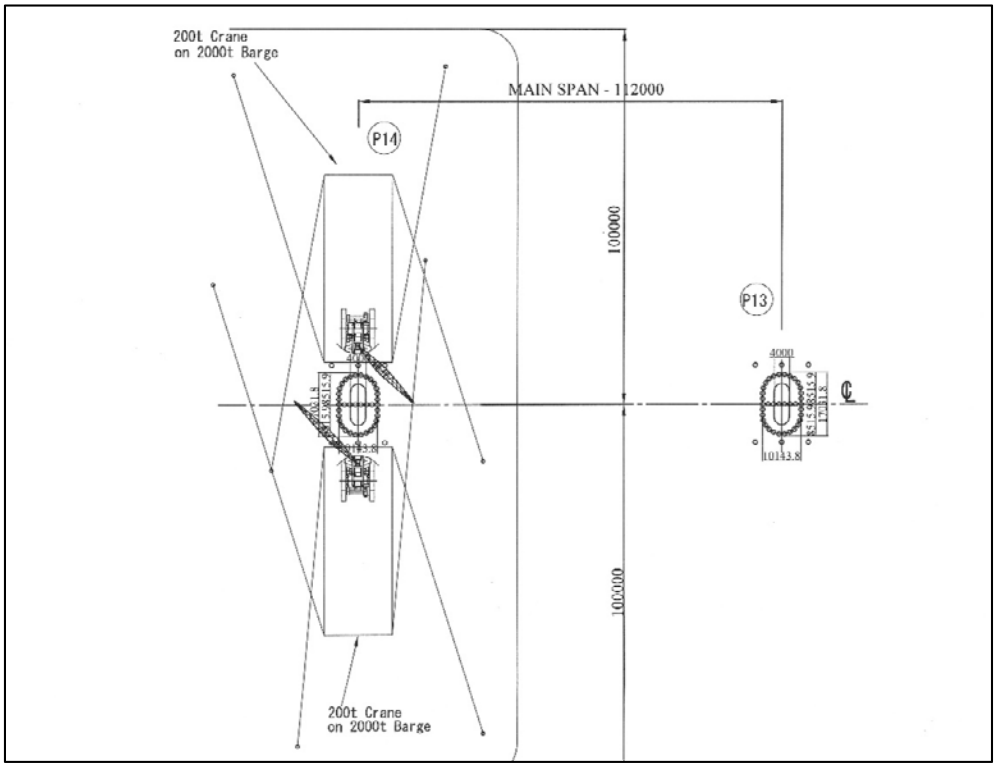
Type	Bent Erection Method		Launching Girder Erection	
Figure				
Constructability	・Simple and repeating works are very workability	○	・Limited launching yard is not efficient usability	△
Construction Period	・Catch up Tight construction Period ・Approximate 32 months	◎	・As launching yard is limited, erection speed is slow. ・Approximate 36 months	△
Navigation	・As not main navigation route, bents may not interfere with navigation. At least 3 spans out of 7 spans are used for erection.	○	・As not main navigation route, bents may not interfere with navigation. At least 1 span out of 7 spans is used for erection.	◎
Erection Cost	・Reutilize top part cut steel pipes of SPSP for the temporary bents. As 200t crawler cranes for erection are procured in Myanmar, erection cost could be minimized.	◎	・All launching apparatus and equipment are imported. To catch up target construction period, many launching sets are required. Erection cost could be increased.	△
Technology Transfer	・Marine erection using barge crane. ・Usability of temporary bent.	○	・Launching erection method using launching girder	○
Evaluation	Most recommended		Less recommended	

Source: JICA Study Team

7.1.5.2 Foundation Works

(1) Maintenance of Navigation Route during Foundation Works

Foundation of cable-stayed bridge is planned to consist of SPSP with steel pipe of φ1.2 m to maintain the navigation route. The size of SPSP is large (10 m x 17 m), and the steel pipe is long (60 m); therefore, large crane barges are required for the execution. For the security of navigation route, two crane barges of 200 t are arranged as shown in Figure 7.1.30.

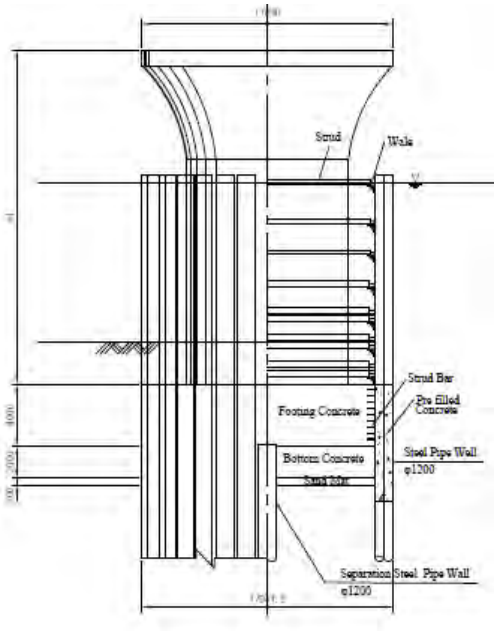


Source: JICA Study Team

Figure 7.1.30 Arrangement of Crane Barge for SPSP Execution

(2) SPSP Foundation

All 8,700 t of steel pipes used for SPSP foundation are fabricated based on JIS standards and Japanese fabricator in Vietnam. Configuration of SPSP foundation is shown in Figure 7.1.31. The SPSP foundation is oval in shape and measures 30 m x 35 m. Steel pipe pile is 1.20 m and 12-16 mm in thickness. The maximum length is from 52.5 m to 57.0 m in Package 1 including temporary pipes for cofferdam and the total number of steel pipes including separation wall pipe is 216 for the six foundations. The position of steel pipes is determined by using temporary guide-frame. Hydraulic vibration hammer firstly uses for driven steel pipes and finally driven into bearing stratum using a diesel driven hammer. A driven steel pipe pile verifies the ultimate bearing capacity by impact loading testing (PDA).



Source: JICA Study Team

Figure 7.1.31 Configuration of SPSP Foundation

(3) Construction Sequence of SPSP

Construction sequence of SPSP is the same as shown in Figure 7.1.20.

7.1.5.3 Substructure Works

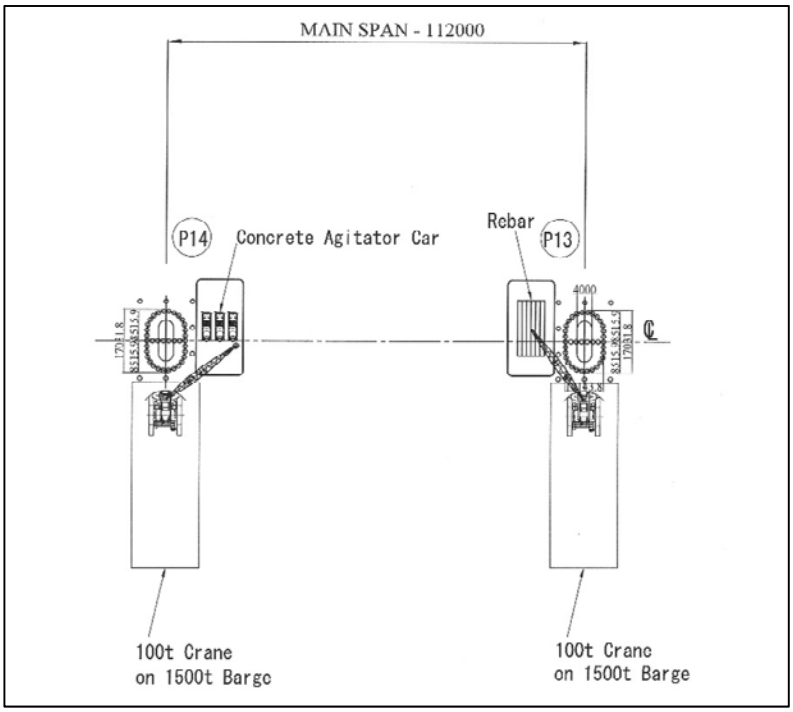
(1) Concrete Plant and Transportation Method of Concrete

Concrete batching plant is provided near the riverside and ensures smooth access to the substructure in the river for both packages. Concrete agitator trucks on barge are the transported through inclined jetty as shown in Figure 7.1.24. The transportation distance from jetty to the farthest pier is approximately 750 m and the time cycle is 25 minutes. In case of 3-agitator on barge, capacity of 36 m^3/hr (15 m^3 x60/25=36 m^3/hr) is estimated as the maximum. Two sets of transporting barges are provided for concrete placement in the river, and a capacity of 60 m^3 /hr can be ensured in consideration of time cycle allowance.

(2) Concrete Placing Method

Construction of concrete slab and pier structures is executed using SPSP cofferdams, which is used for the top part of SPSP foundation. The false-work system is designed for dry constructability in the river. Concrete of bottom slab is placed using a concrete bucket of 2.5 m^3 attached to 100 t crawler crane on barge. During placing of concrete in the SPSP, concrete agitator on barge and 100 t crawler crane on barge are arranged in position as shown in Figure 7.1.32. After the SPSP is carried out in the dry and stud dowel is welded on steel pipe to connect the pile cap, concrete is placed by the same method.

The reinforced concrete columns of pier are constructed by using a shuttering form with an integration of a working platform. A crawler crane with a capacity of 120 ton barge is anchored on the cofferdam for material handling. Each typical pouring height is 3~4 m. In the construction planning, a 4-day cycle time for each lift is estimated.



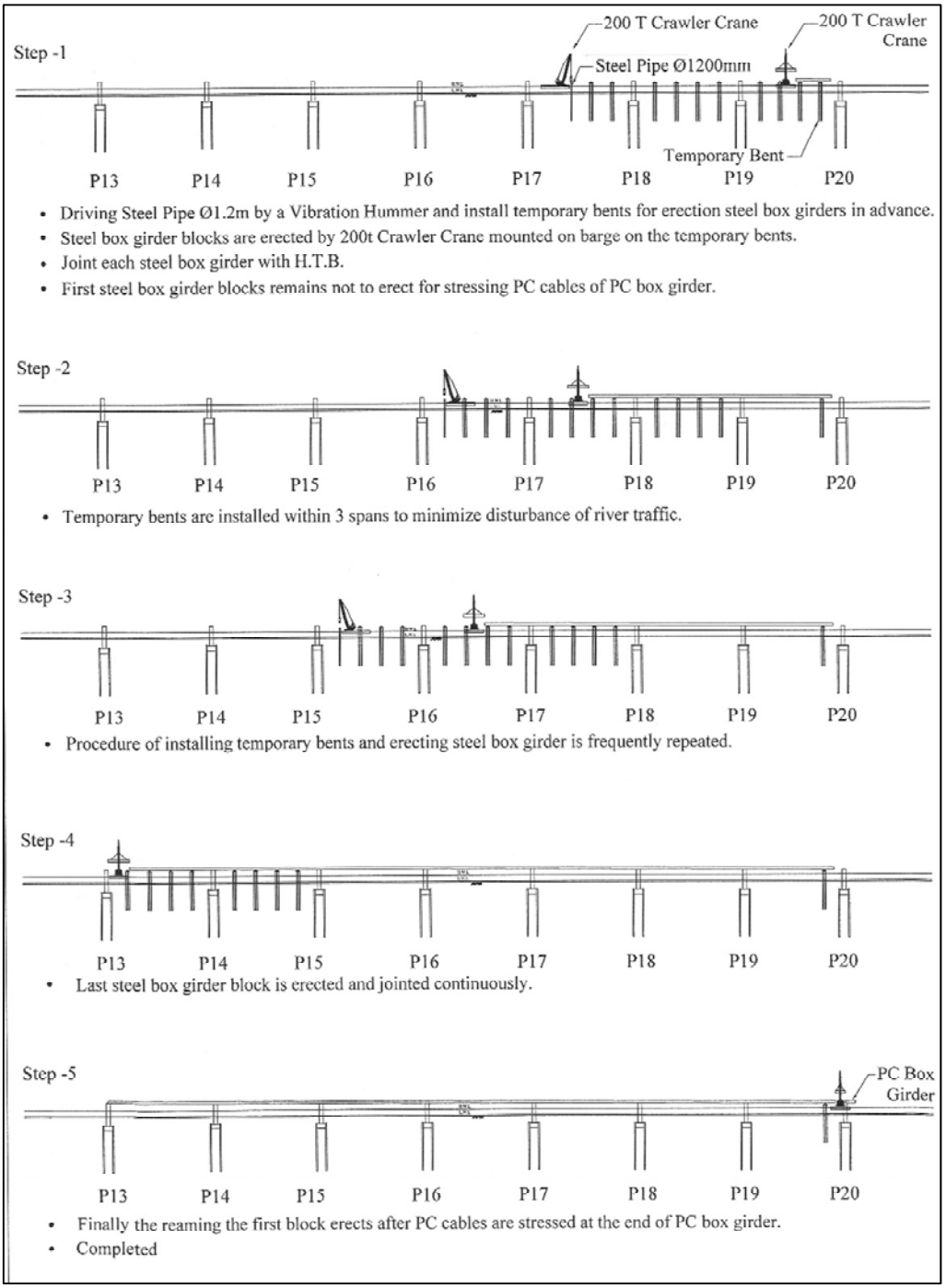
Source: JICA Study Team

Figure 7.1.32 Concrete Placed Method for Substructure

7.1.5.4 Superstructure Works

(1) Erection Sequence of Steel Box Girder

Erection sequence of steel box girder is illustrated in Figure 7.1.33.

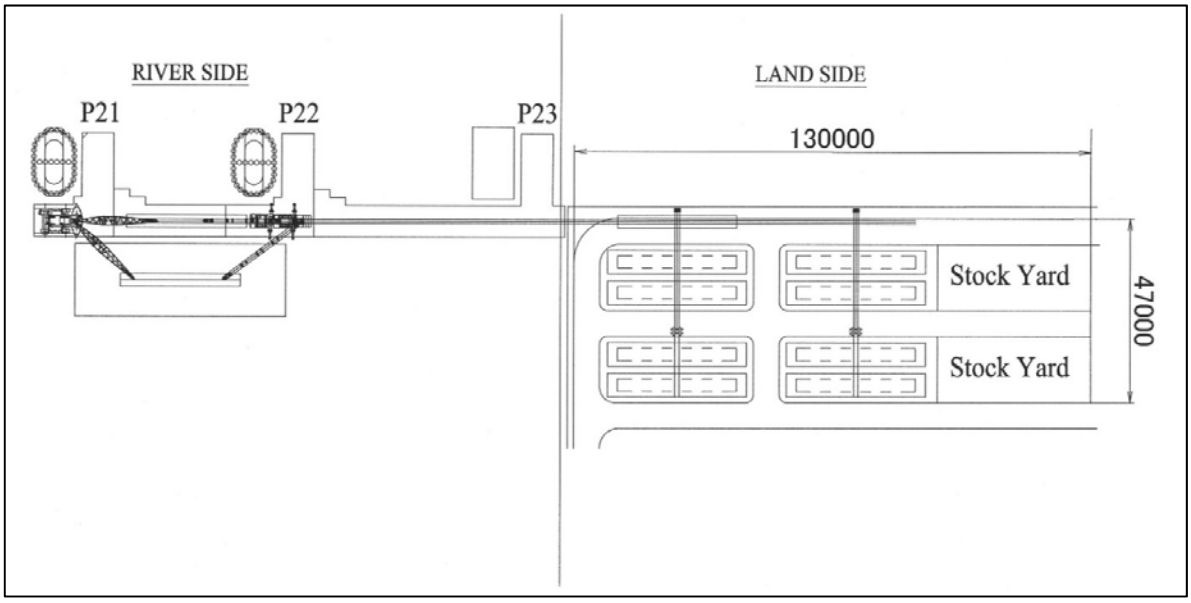


Source: JICA Study Team

Figure 7.1.33 Erection Sequence for Steel Box Girder Bridge

(2) Reassembling Steel Girder Blocks and transporting Erection Segment

Steel box girder of 112 m for one span is divided into ten blocks and fabricated in the factory, which is less than 12 m for inland transportation. These blocks are jointed into two sets for one segment for erection at the reassembling yard. The jointed steel block segment for erection is pulled out to the temporary road by carriage on rail and winch and transferred on the self-moving carriage on rail. The carriage transports the segment to the unloading position through the temporary jetty as shown in Figure 7.1.34.

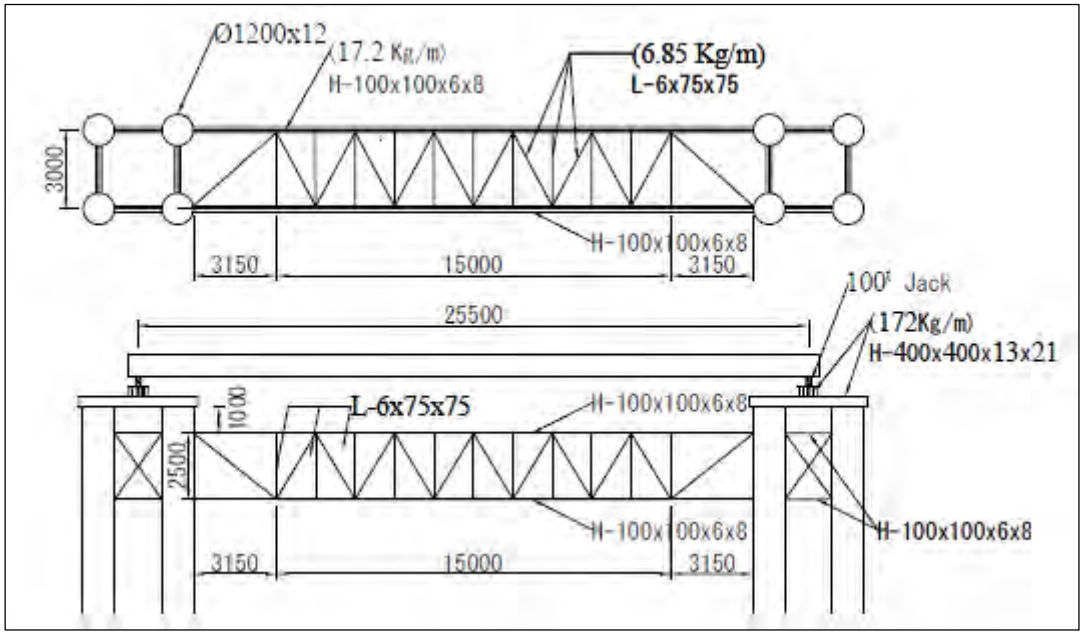


Source: JICA Study Team

Figure 7.1.34 Transportation of Steel Box Segment for Erection

(3) Bents in the River for Erection Steel Box Girders

Temporary bents in the river support the assembled steel girders temporarily to join another steel girder. For one span of 112 m length, the steel box girder is divided into five segments for erection so that four sets of bents are required for supporting one span loading. Maximum weight of steel box segment is 58.0 t. The temporary bents consist of 8-number of steel pipes with diameter 1.2 m and are reused from the top part of SPSP as shown in Figure 7.1.35. Cross beams, which temporarily support steel segments loading, are made up of two H-beam welded together at their flanges. Fifteen sets of bents for three spans are fabricate dand use repeatedly for the other span after completion of one span erection.



Source: JICA Study Team

Figure 7.1.35 Image of Bent in the River for Erection of Steel Box Girder

7.1.6 PC Box Girder Bridge

7.1.6.1 Outline of Approach Bridge Works

Approach bridge consists of a precast continuous PC box girder using a span-by-span erection method. Package 1 has five spans with total length of 250 m while Package 2 has six spans with total length of 300 m. Bored piles and SPSP foundations support the piers.

7.1.6.2 Foundation Works

The foundation of the precast segmental approach bridge is composed of 94 bored piles with diameter of 1.5 m and 2.0 m in Package 1 and 50 bored piles with diameter of 1.5 m and 2.0 m in Package 2. The number and length of piles, and size of each pile cap are shown in Table 7.1.8 All the piles are designed as both bearing and friction piles with the founding levels ranging from 53.0 m to 62.0 m in Package 1 and 32.5 m to 47.0 m in Package 2. There are three SPSP foundations supported by 32 steel piles with diameter of 1.2 m in Package 2. Length of pipes varies between 42.5 m and 43.5 m.

Table 7.1.8 Number and Length of Piles and Size of Pile Cap

No	Type of Pile	Dia. Pile (m)	Number of Pile	Pile Length (m)	Size of Pile Cap (m)
Package 1					
A1	RCD	1.5	28	53.8	12.0x21.0 x1.9
P1	RCD	2.0	12	58.0	12.0x19.0 x1.9
P2	RCD	2.0	12	62.0	12.0x19.0 x1.9
P3	RCD	2.0	12	57.0	12.0x19.0 x1.9
P4	RCD	2.0	12	58.0	12.0x16.0 x1.9
P5	RCD	2.0	18	55.5	12.0x24.0x1.9

No	Type of Pile	Dia. Pile (m)	Number of Pile	Pile Length (m)	Size of Pile Cap (m)
Package 2					
P20	SPSP	1.2	32	43.5	11.373x17.164
P21	SPSP	1.2	32	43.5	8.535x17.222
P22	SPSP	1.2	32	42.5	8.535x17.222
P23	RCD	2.0	12	32.5	12.0x16.0x2.2
P24	RCD	2.0	12	47.0	12.0x19.0x1.9
P25	RCD	2.0	8	38.0	9.0x19.0x1.9
A2	RCD	1.5	18	31.5	10.5x20.7x1.0

Source: JICA Study Team

The temporary steel casings used for bored pile construction form consist of 12 mm thick tubular section, and are installed at the top portion from cap to -10 m below riverbed. The length varies from 15 m to 25 m depending on the geological condition. A vibration hammer drives the casings.

After completion of drilling and initial base cleaning, the prefabricated reinforcement cages (8 numbers of 12 m long per unit) are installed using a 100 t crawler crane. Placement of concrete after final cleaning of the pile base is carried out using a 273 mm diameter tremie pipe. For 50 m long piles, it requires a 3-day construction cycle from commencement of drilling to completion of concreting works.

7.1.6.3 Substructure Works

(1) Cofferdam/ Excavation for Substructure

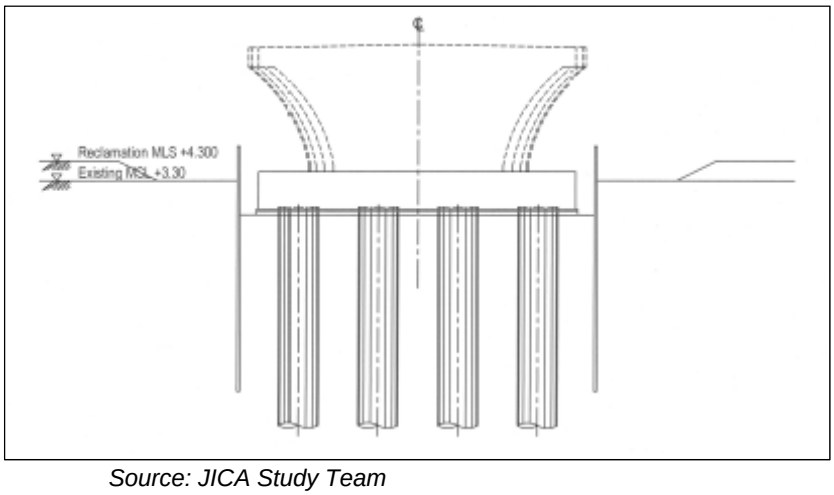
Excavation of substructure is relatively shallow, and hence cofferdam to be used consists of self-supporting steel sheet piles without waling members as shown in Figure 7.1.36. The structural excavation process is as follows:

Step 1: Cast-in-placed concrete piles is constructed on the reclamation revel MS +4.300.

Step 2: Outside area of steel sheet piles is excavated up to MS +3.300 to reduce lateral earth pressure.

Step 3: Inside area of steel sheet piles is excavated up to bottom of foundation.

Step 4: After completion of concreting, the excavated space is backfilled up to MS +4.300.



Source: JICA Study Team

Figure 7.1.36 Cofferdam for Pile Cap of Piers

(2) Concrete Placing Method

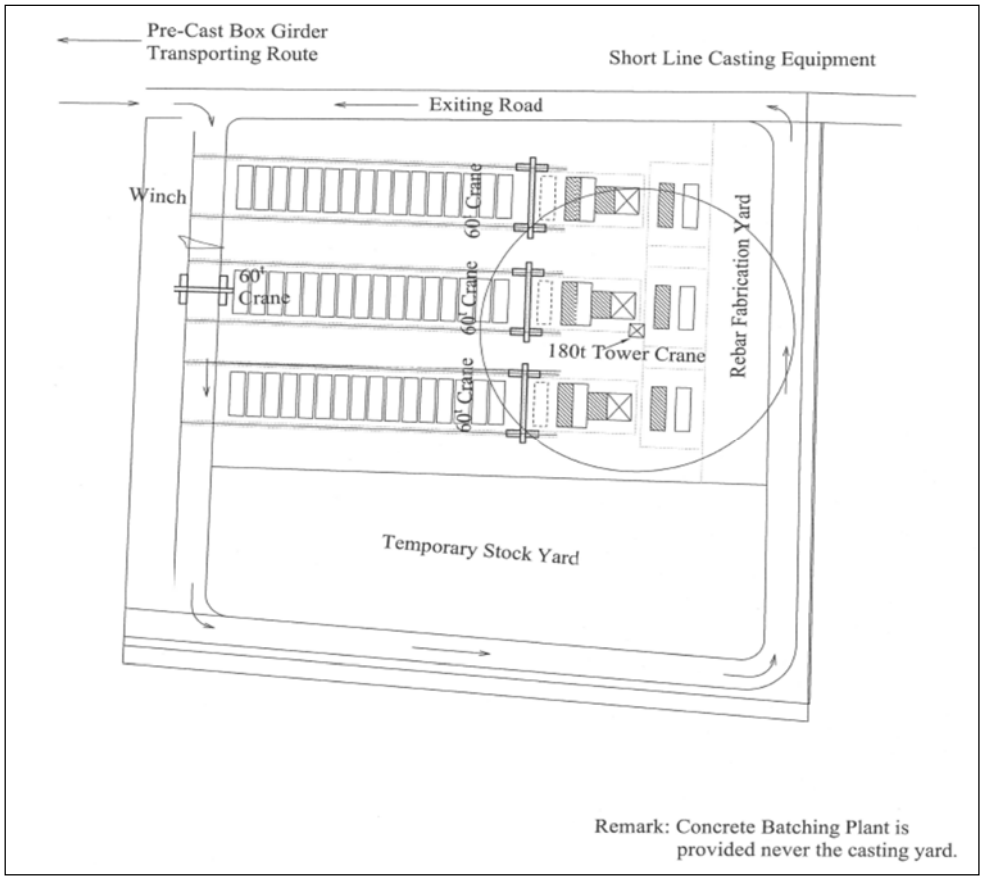
A concrete pumping equipment on MS +4.300 m is used to place concrete of sub-structure. The capacity of the pumping equipment is over 60 m^3/hr.

7.1.6.4 Fabrication of PC Box Segments

(1) Package 1

The PC box segments cast in a casting yard is located at the riverbank of the Thanlyin site. The yard belongs to Htut Khaung Family Co. Ltd., which is a favorable location to facilitate transportation of heavy segments to the erection site.

One hundred seventy-two segments are fabricated in a period of seven months in Package 1. To reduce the construction period, three sets of short-line casting cells are installed under a conservative assumption of 3-day casting cycle. In the dry season, a 2.5-day cycle can be maintained. The casting yard is about 17,000 m^2 and equipped with a 60-ton portal cranes for segment handling and a 180 t/m tower crane for light duty tasks, such as placing the reinforcement cage as shown in Figure 7.1.37. The casting yard has a storage capacity of 96 segments based on a two-layer stacking. Area of the stockyard is limited and thus, the remaining 76 segments are stocked at the area under the bridge.



Source: JICA Study Team

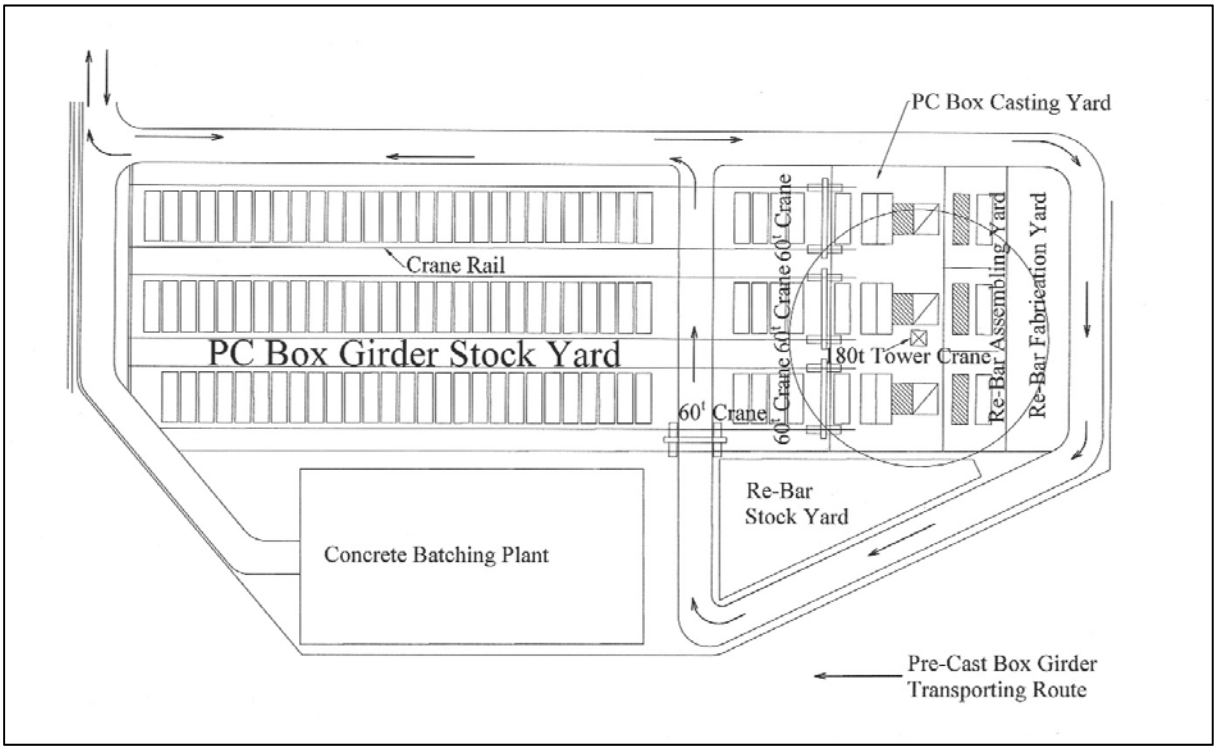
Figure 7.1.37 Plan of Segment Casting Yard for Package 1

(2) Package 2

The segments cast in a casting yard located at the riverbank of the Thaketa site. The yard belongs to MR, which is a favorable location to facilitate transportation of the heavy segments to the erection site.

In this project, 206 segments are fabricated in a period of nine months. To reduce the construction schedule, three sets of short-line casting cells are installed under a conservative assumption of 3-day casting cycle. In the dry season, a 2.5-day cycle can be maintained. The casting yard is about 18,500

m^2 and equipped with a 60-ton portal cranes for segment handling and a 180-t/m tower crane for light duty tasks, such as placing the reinforcement cage as shown Figure 7.1.38. The casting yard has a storage capacity of 166 segments based on two-layer stacking. A batching plant of 60 m^3 /hr capacity is installed at the casting yard. The PC segments are casted using short-line match-casting method. It is a new technology used in Myanmar for concrete segmental bridge.



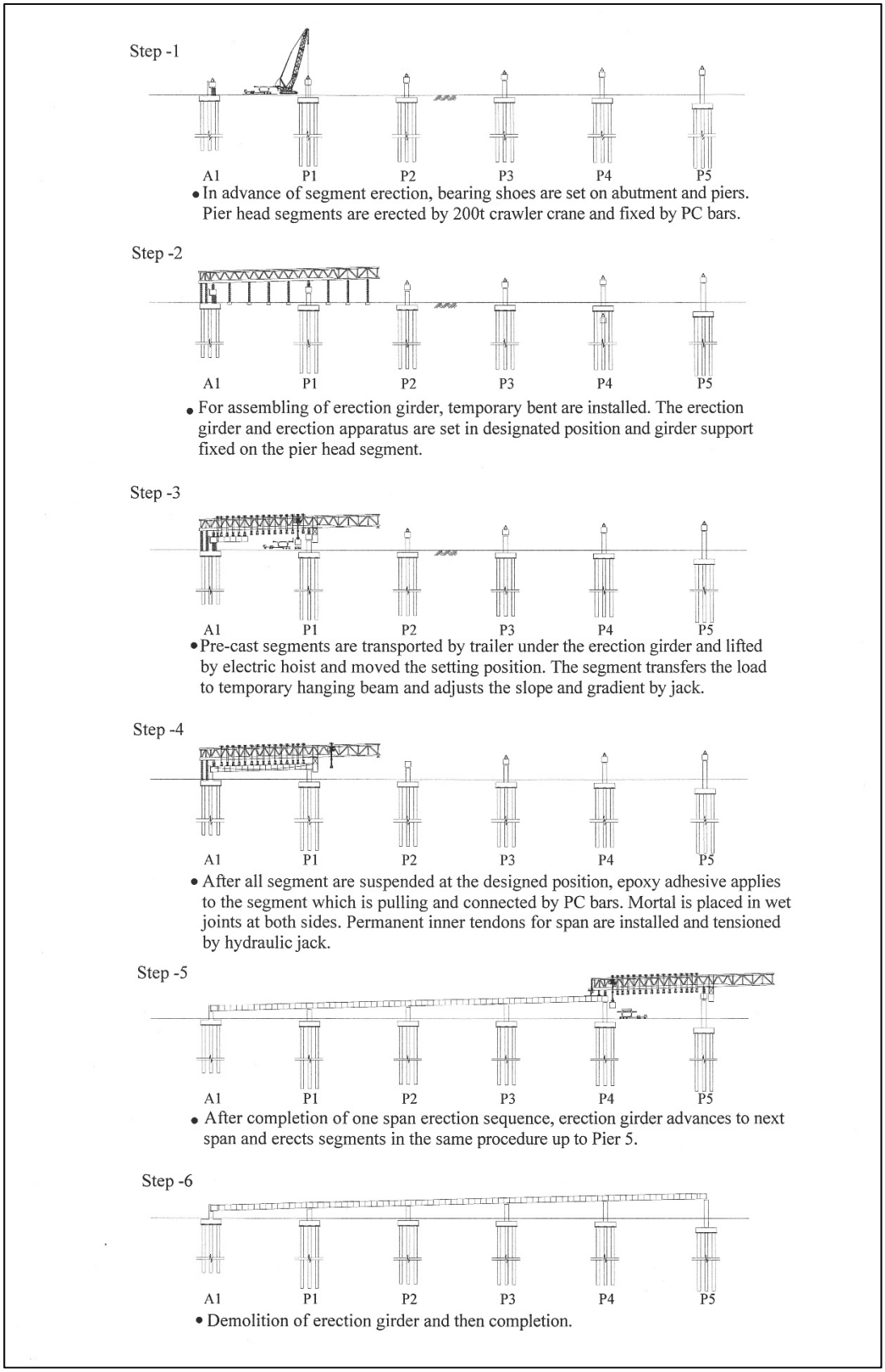
Source: JICA Study Team

Figure 7.1.38 Plan of Segment Casting Yard for Package 2

7.1.6.5 Superstructure Works

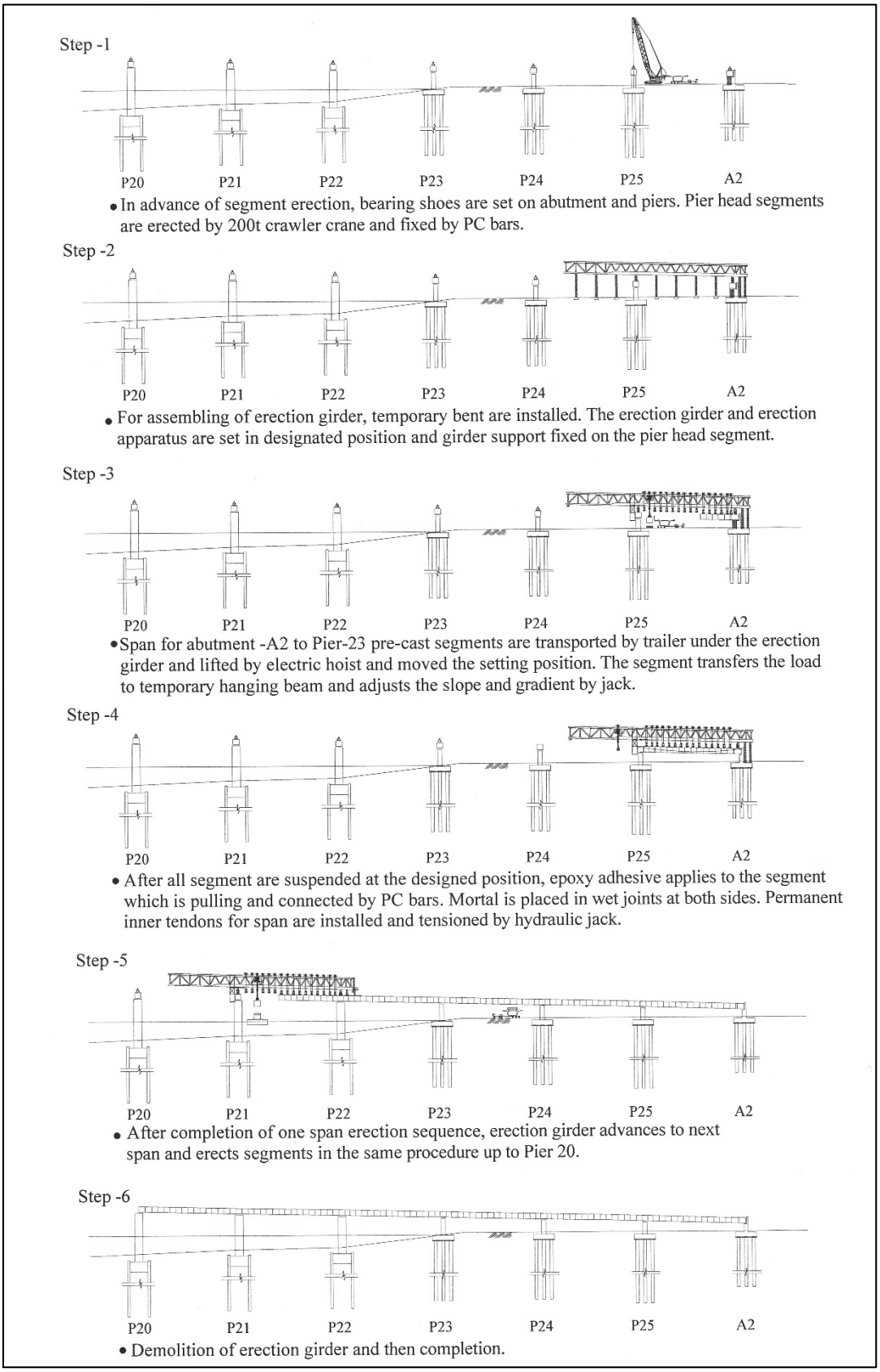
(1) Erection sequence for Approach Bridge

Erection sequences for Approach Bridge in Package 1 and Package 2 are illustrated as shown in Figure 7.1.39 and Figure 7.1.40, respectively.



Source: JICA Study Team

Figure 7.1.39 Erection Sequence for Approach Bridge in Package 1

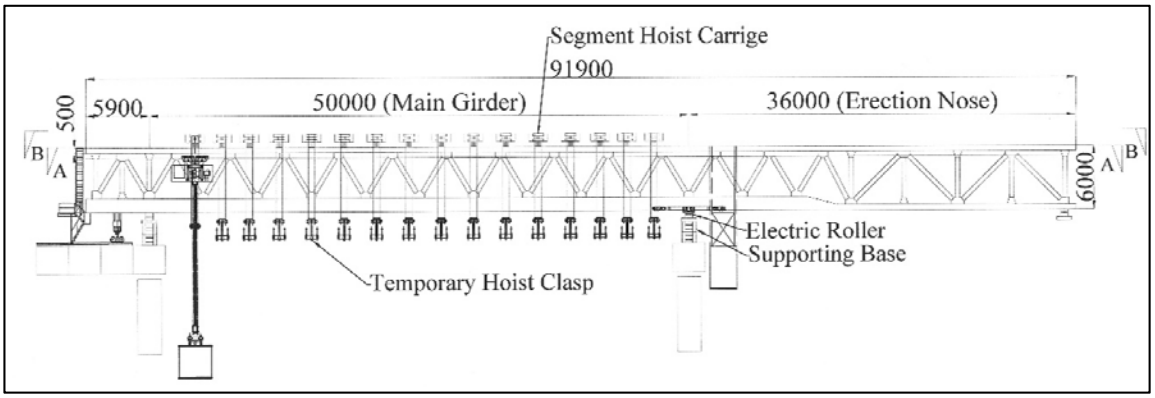


Source: JICA Study Team

Figure 7.1.40 Erection Sequences for Approach Bridge in Package 2

(2) Erection Girder

Erection girder for span-by-span method consists mainly of truss or box structure types. For the construction in foreign countries, the truss structure type is selected for span-by-span method considering transportation and easy fabrication and assembly. The erection girder planned for Package 1 and Package 2 is shown in Figure 7.1.41. Truss structure type is also preferred in high-wind region such as Myanmar due to low wind resistance.

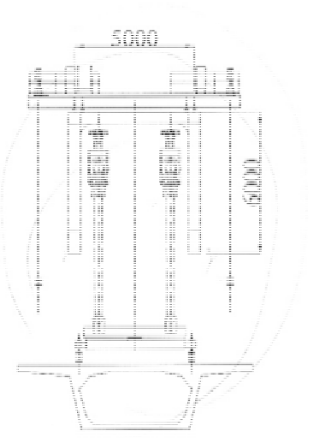
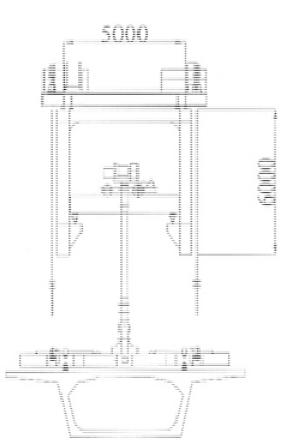


Source: JICA Study Team

Figure 7.1.41 Image of Erection of Girder using Span-by-Span Method

Equipment for lifting a precast PC box segment consists mainly of hoist or winch types and its function is for lifting and moving in longitudinal direction. Comparison of these two types is evaluated in Table 7.1.9. The hoist type is the most recommended considering the advantage in terms of structural stability and versatility to use.

Table 7.1.9 Comparison of Lifting Equipment

Lifting Type	30 t Electric Hoist x2	60 t Winch Trolley
Figure		
Constructability	○	○
Structural Stability	◎	△
Versatility to Use	○	△
Cost	○	○
Evaluation	Most Recommended	Less Recommended

Source: JICA Study Team

(3) Installation of Erection Girder

Prior to starting pre-cast segment erection by erection girder, temporary girder support jacks and erection girder supporting base are positioned on the pier head segment at the center moving to longitudinal and transversal directions. The distance between the erection girder supports is 50.0 m according to the designed span length. The supporting base is used for operation of jacks to advance the erection girder. The temporary girder support jacks of 400 t capacity fixed on the pier head segment and additionally vertically 6 number of PC bar φ32 install to ensure moment resistance. In case of this project, supporting base installed on the A1 (A23) abutment head segment, temporary support bents are provided at the back and front of abutment.

(4) Precast Segment Erection

1) Lifting Work and Load transfer to hanging steel bar

Segment suspended by hoist beam is transferred to proper position using main hoists. Lifting procedure is as follows:

a) Preparation of lifting jig, hanging bar, shackle and hooks on the pre-cast segment,

b) Start lifting by hoists about 200mm from trailer and check condition of segment,

c) Adjust the transverse slope horizontally for transferring movement, and

d) Move to the proper position by hoist and transfer the segment load to temporary segment hanging beam.

2) Adjustment of Slope and Gradient

Slope and gradient of segment suspended from the temporary hanging beam are adjusted using hydraulic jack installed on the hanging beam in vertical direction and sliding plate in transversal direction.

3) Application of Epoxy Adhesive

Epoxy adhesive is applied to the previous segment. The adhesive contains two kinds of materials. The amount of epoxy application is approximately 2 kg/m^2 (1 mm in thickness/m^2).

4) Stitching Works

After epoxy application, the lever block is set on segments, which are then pulled for stitching. φ32 PC bars installed on the stitched segments and pre-stressed up to 300 kN for stitching.

5) Casting Concrete of Wet Joint

a) Installation of Formwork

For keeping distance between the pier head and the first or end segments, supporting beam is installed on the bottom slab before installation of formworks. After the installation of formwork to both wet joints, non-shrinkage mortal is cast immediately.

b) Casting Wet Joint

After non-shrinkage mortal reaches the required strength, PC bars are installed between pier top segment and 1st segment, then pre-stressing works are executed. The pre-stressing force applied is 150 kN/pc.

(5) Pre-stressing Work of Internal and External Cables

1) Internal Cable

After the mortal strength reaches the required strength, the permanent inner tendons of 12T12.7 for

each span are installed and tensioned with hydraulic jack from a stressing platform attached to the forward segment. After pre-stressing the tendons, sheath is filled with grout.

2) External Cable

For continuous spans, external cables are provided inside continuous box girder to connect and to secure continuous connection. The external cables consist of 19T15.2 strands, which are bent with several deviator blocks to make it highly eccentric and anchored on diaphragms at intermediate and end supports. Multi-strand jack tensions the tendons of external cable, which is a non-grout type.

(6) Advancing of Erection Girder

Prior to the advancing works of erection girder, its support is set on the forward pier head segment, which is used for the operation of hydraulic jack system. The system composes of two hydraulic jacks for pushing device and four endless sliding equipment for wedging of lower member.

7.1.7 On-ramp Bridge

7.1.7.1 Outline of On-ramp Works

On-ramp works consist of embankment and bridge portions. The embankment portion requires soft soil treatment before placing the embankment. The bridge portion is almost straight, which consists of 4-span PC I-girder with composite slab. Its foundation is a bored pile installed using a reverse circulation drilling method (RCD).

7.1.7.2 Foundation Works

Soft soil treatment is executed with the same method done for the approach road because of close similarity in soil condition. The number and length of piles and sizes of each pile cap are shown in Table 7.1.10 .

Table 7.1.10 Number and Length of Piles and Size of Pile Cap for Ramp Bridge

No.	Type of Piles	Dia. Piles (m)	Number of Piles	Pile Length (m)	Size of Pile Cap
A1	RCD	1.5	9	56.5	9.0x9.0 x1.9
P1	RCD	2.0	5	57.0	10.4x9.0x1.9
P2	RCD	2.0	4	55.5	8.0x8.0x1.9
P3	RCD	2.0	4	58.0	8.0x8.0x1.9

Source: JICA Study Team

7.1.7.3 Fabrication of PC I-Girders

Eight PC I-girders are fabricated near the erection site. Two fabrication beds are provided in parallel to the ramp bridge at the first span. Two I-girders are cast simultaneously for one span, and repeated for four times. PC I-girders casted at the first span and transported to the second span using a rail and winch installed parallel to the bridge line, and then continued to the fourth span. Moving distance is approximatly100 m.

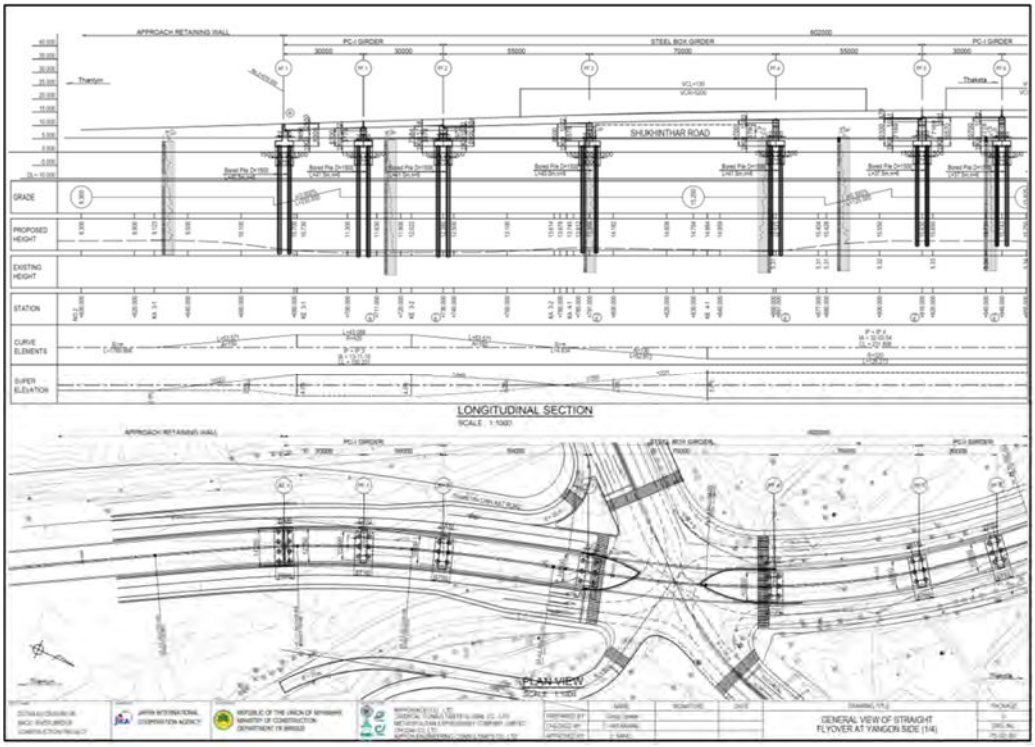
7.1.7.4 Erection of PC-I-Girder

Two track cranes with lifting capacity of 200 t are ued to erect PC I-girders casted and transported in front of the erecting span. The erected I-girders connected with cross beam and precast PC boards, with the concrete slab placed on the PC boards. The PC board and slab act as composite section. As the number of the PC board in this package is small in quantities, it is considered to be imported or procured from local PC fabricator.

7.2 CONSTRUCTION PLANNING OF FLYOVER BRIDGE

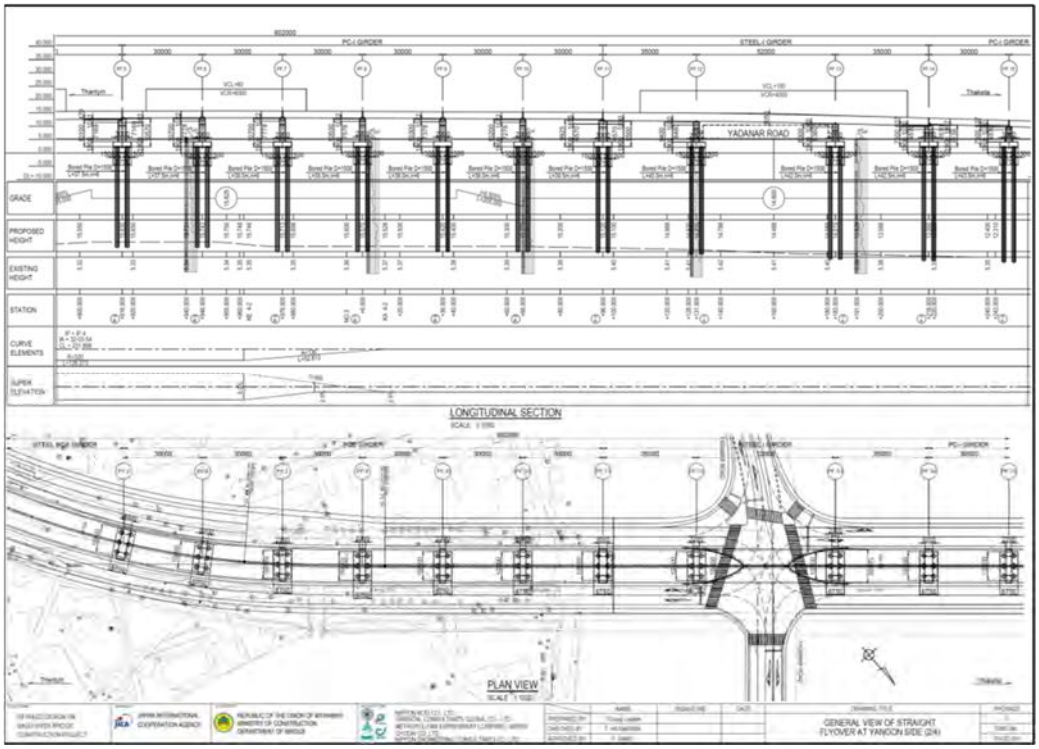
7.2.1 Project Outline

The flyover section has approximately 600 m in length plus a 225 m long earthwork section, totaling an approximate length of 825 m. Moreover, there is an approximately 780 m long side road. The project general view is shown in Figure 7.2.1 to Figure 7.2.3.



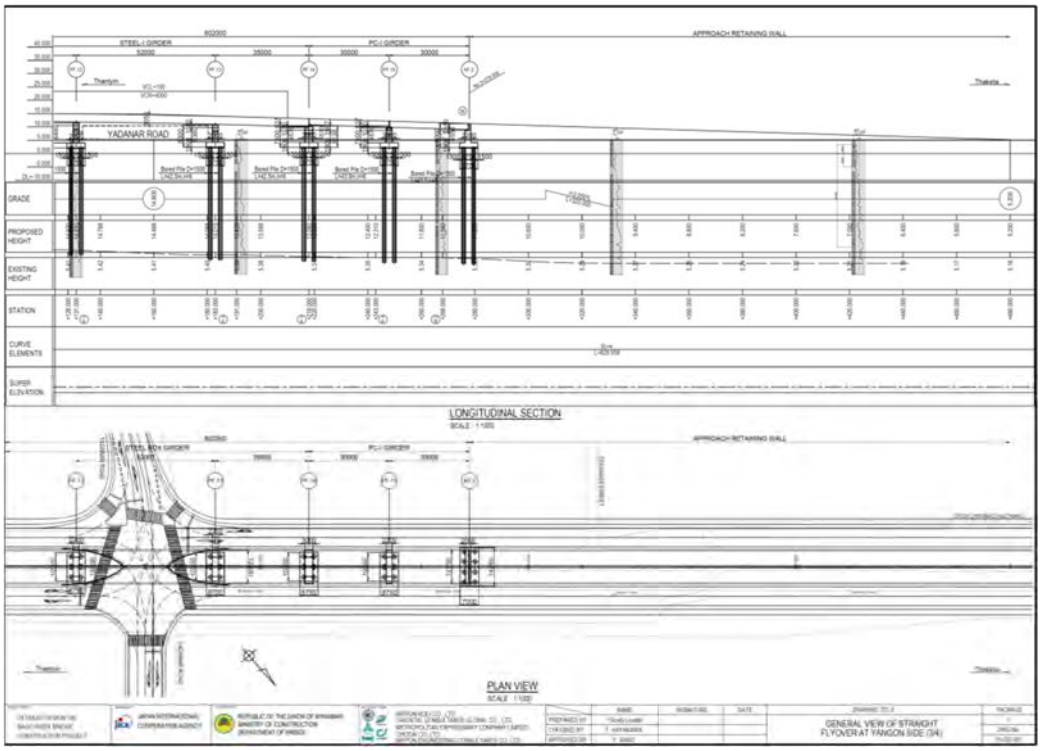
Source: JICA Study Team

Figure 7.2.1 General View (1/3)



Source: JICA Study Team

Figure 7.2.2 General View (2/3)



Source: JICA Study Team

Figure 7.2.3 General View (3/3)

7.2.2 Civil Works Scope

The civil works scope for the flyover section is shown in Table 7.2.1. Note that the AF.1 side approach section was considered in Package 2 and side road section construction is undertaken by MOC before the commencement of civil works for Package 3.

Table 7.2.1 Project Scope

Section	Specification	Unit	Quantity
Bridge Section	2 spans continuous PC-I girder	m	60.0
	3 spans continuous steel box girder	m	180.0
	2 spans continuous PC-I girder	m	60.0
	4 spans continuous PC-I girder	m	120.0
	3 spans continuous plate steel girder	m	122.0
	2 spans continuous PC-I girder	m	60.0
Approach Section (AF.2 side)	Mechanically stabilized earth wall	m	114.2
	L type retaining wall	m	103.9
	RC wing	m	3.9
Side Road Section		m	782.0

Source: JICA Study Team

7.2.3 Main Material Procurement Plan

The main materials in the procurement plan for Package 3 are shown in Table 7.2.2.

Table 7.2.2 Procurement for Main Materials

Material	Specification	Remarks	Origin
Steel	SM400	Steel girder	Japan
	SM490Y	Steel girder	
	SS400	Steel girder	
	S10T	Bolt	
PC Strand	7S15.2 mm	PC-I girder	
	4S15.2 mm	Cross girder	
Rebar	SD345		3rd country
Concrete	C40	PC-I girder	Myanmar
	C30	RC slab	
	C24	Substructure	
	C18	Levelling	
Cement		For mortar	
Bearing		Bridge ancillaries	Japan
Expansion joint			
Balustrade			
Drainage system			
Asphalt concrete	AC15	Pavement	Myanmar
	AC20		
Road bed materials	M-30		
	C-40		
Illumination system		Road ancillaries	Myanmar
Traffic system			Japan

Source: JICA Study Team

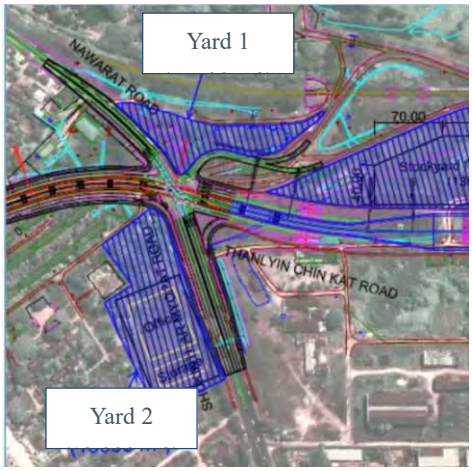
7.2.4 Temporary Installations

7.2.4.1 Temporary Access Road

The project is located in an existing road area; therefore, temporary access road is not required.

7.2.4.2 Temporary Yard Location

The flyover section is divided in three sections: steel bridge, PC bridge, and road section. Regarding the construction yard, two areas were identified in the B/D stage as shown in Figure 7.2.4. The Yard 2– from Myanmar Railways – with approximate 13,000 m^2 was selected as temporary yard facility.



Source: JICA Study Team

Figure 7.2.4 Temporary Yard Location

7.2.4.3 Temporary Yard Outline

The following structures are expected to be constructed in the temporary yard:

- Construction office, rest area for construction staff;
- Motor pool;
- PC girder fabrication/storage area, PC precast panels fabrication/storage area;
- Steel girder assembling area
- Material storage area, etc.

Yard 2 is located on a marshland area over a soft soil zone; differential settlement is expected in this area. Constructing an embankment, soil stabilization treatment and a 20 cm concrete pavement are necessary in order to use the area as a fabrication yard for PC-I girders and precast slab panels. The temporary yard facilities are shown as reference in Figure 7.2.5.

Source: JICA Study Team

Figure 7.2.5 Temporary Yard Facilities (As reference only)

7.2.4.4 Steel Bridge Assembly

The erection of the steel bridge was planned using temporary bents and crane. After the PC girders erection, the space in the temporary yard can be used for storage of the steel girder blocks and for assembling the blocks. Since the steel sections are over the intersection, erection can only be done during night time when the girder is transported to the erection site by trailer.

7.2.4.5 PC Bridge Precast Elements

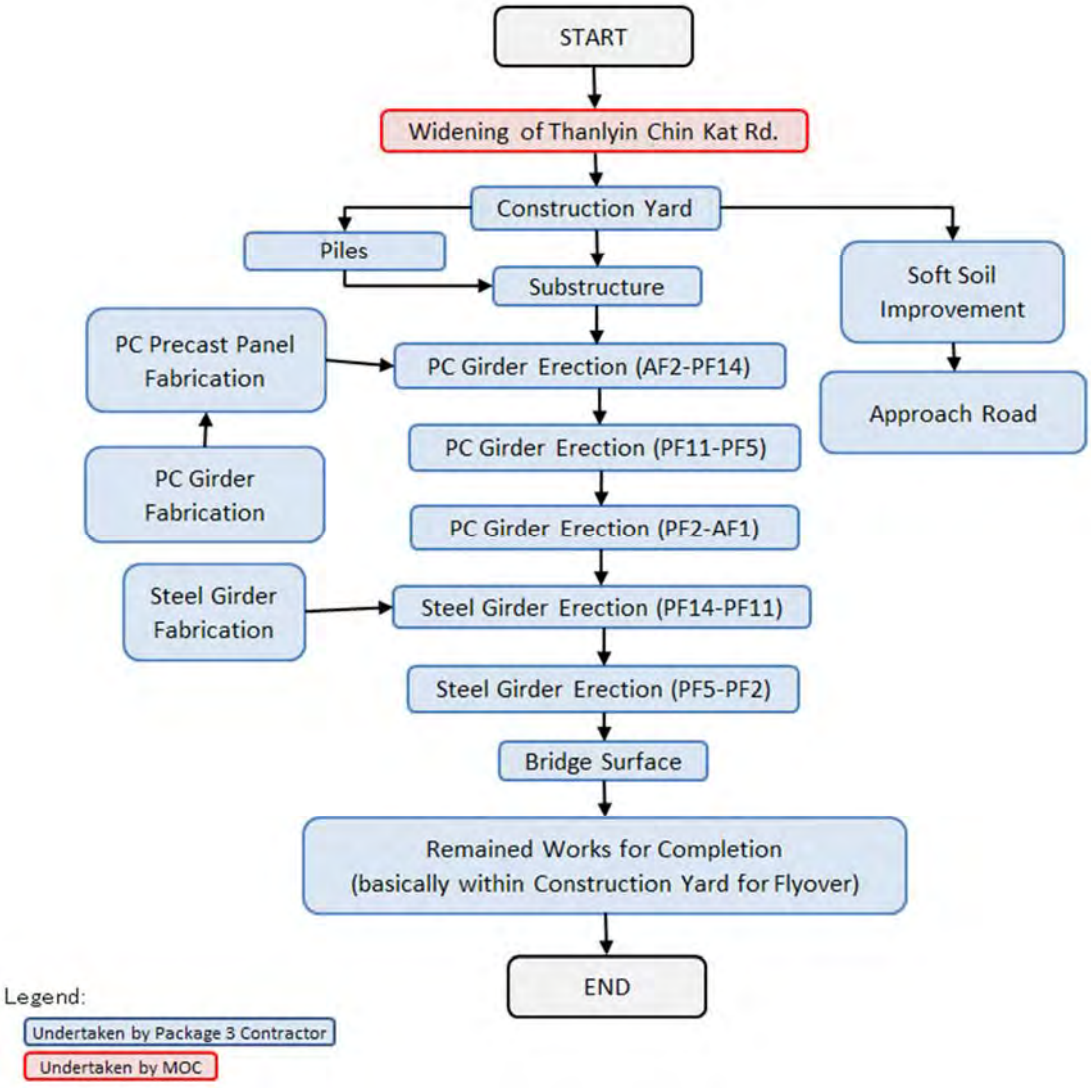
Precast elements such as the PC girder and PC panels were planned to be fabricated and stored in the temporary yard. Gantry cranes or truck cranes are necessary to move the materials during the fabrication. After the fabrication of all girders, these should be transported to the erection site by trailer.

7.2.5 Construction Site

The flyover construction site is the area between the abutment width plus 1.125 m as shown in Figure 7.2.10. The construction site shall be fenced with a temporary steel construction enclosure, except on the intersection area. The approach section is expected to be used as construction access during the pavement and bridge ancillary works. Furthermore, the space between the piers can be used for temporary storage of materials and equipment.

7.2.6 Outline of Construction Sequence

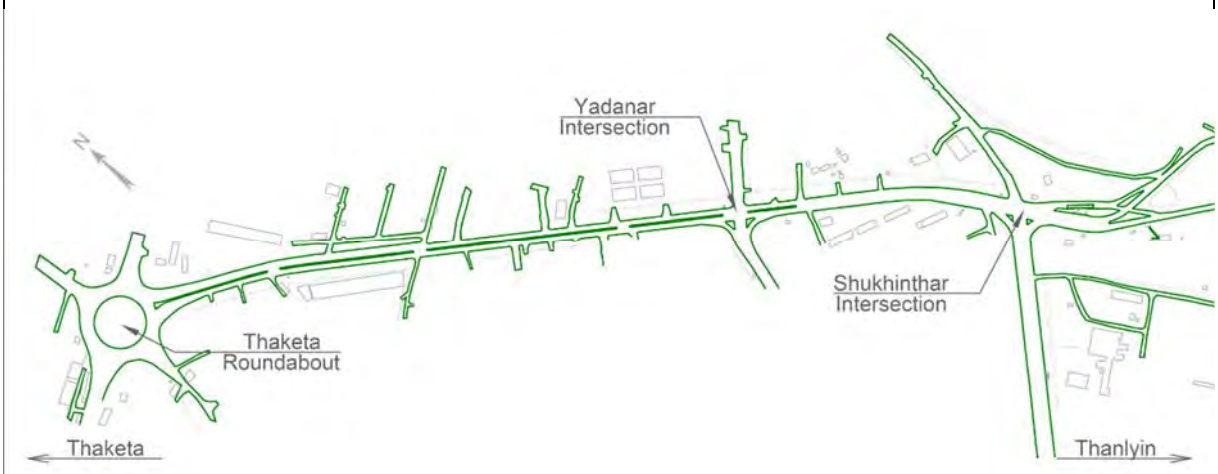
The main steps in the construction of the flyover section are shown in Figure 7.2.6 flowchart, and in Figure 7.2.7 to Figure 7.2.9. More details are described in the following sections.



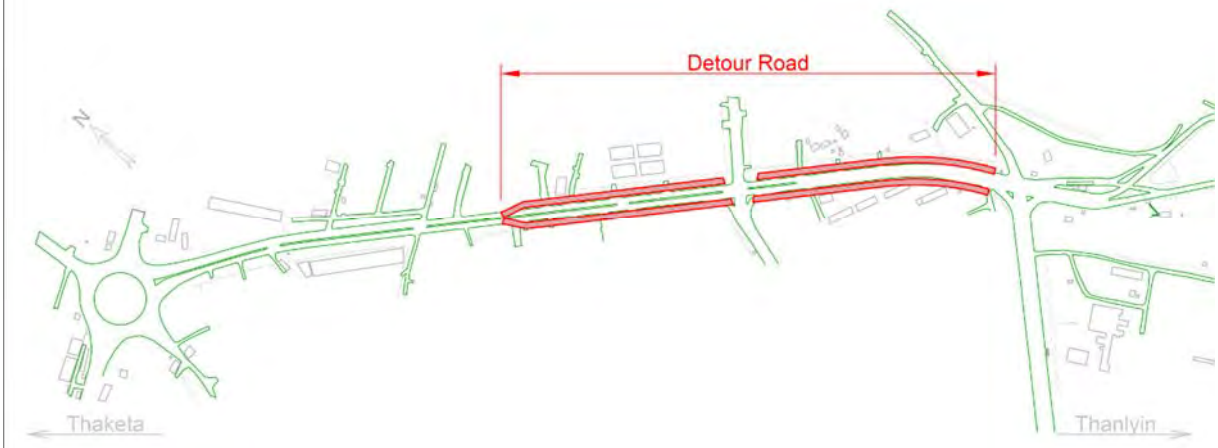
Source: JICA Study Team

Figure 7.2.6 Construction Flowchart

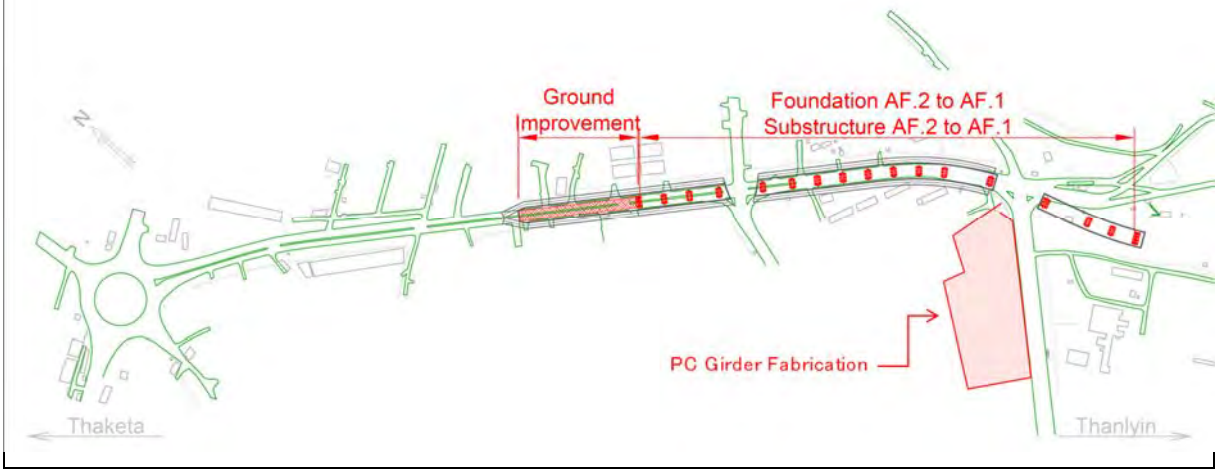
Step 0: Current situation



Step 1: Widening of Thanlyin Chin Kat Road by MOC



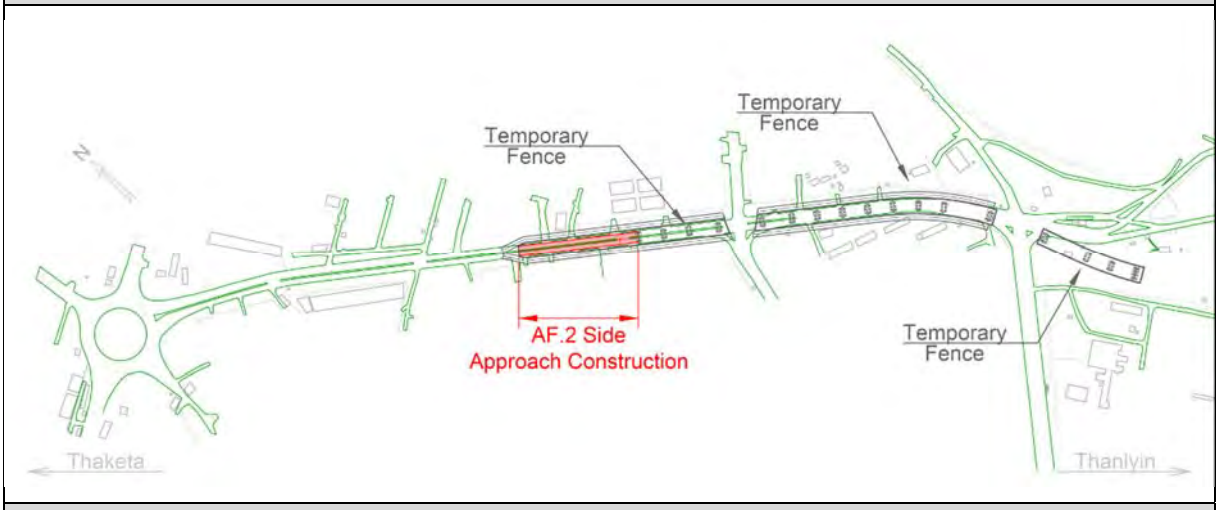
Step 2: Soft ground treatment and foundation/substructure



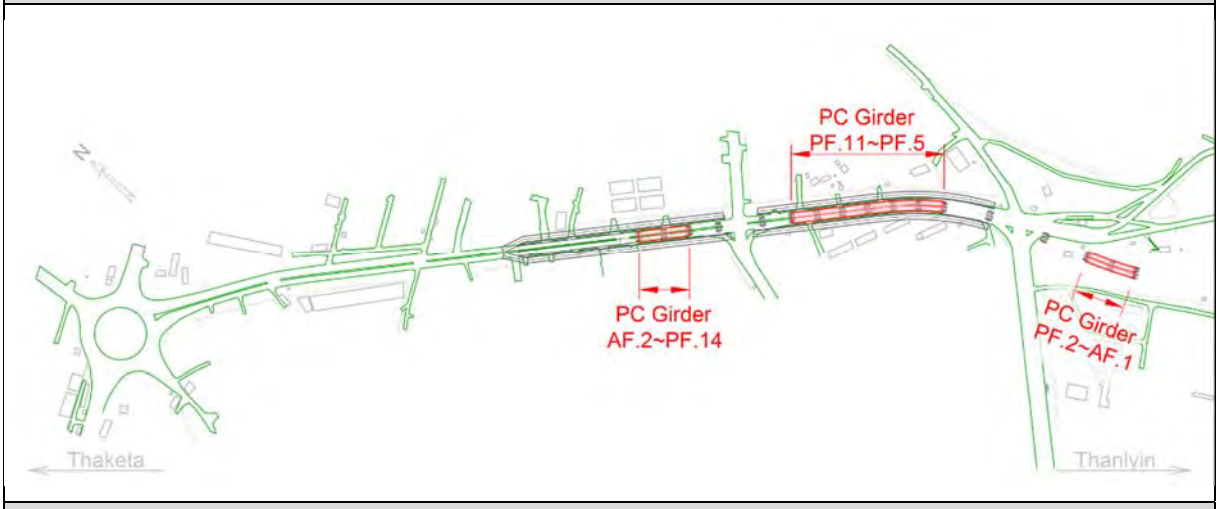
Source: JICA Study Team

Figure 7.2.7 Construction Steps Outline (1/3)

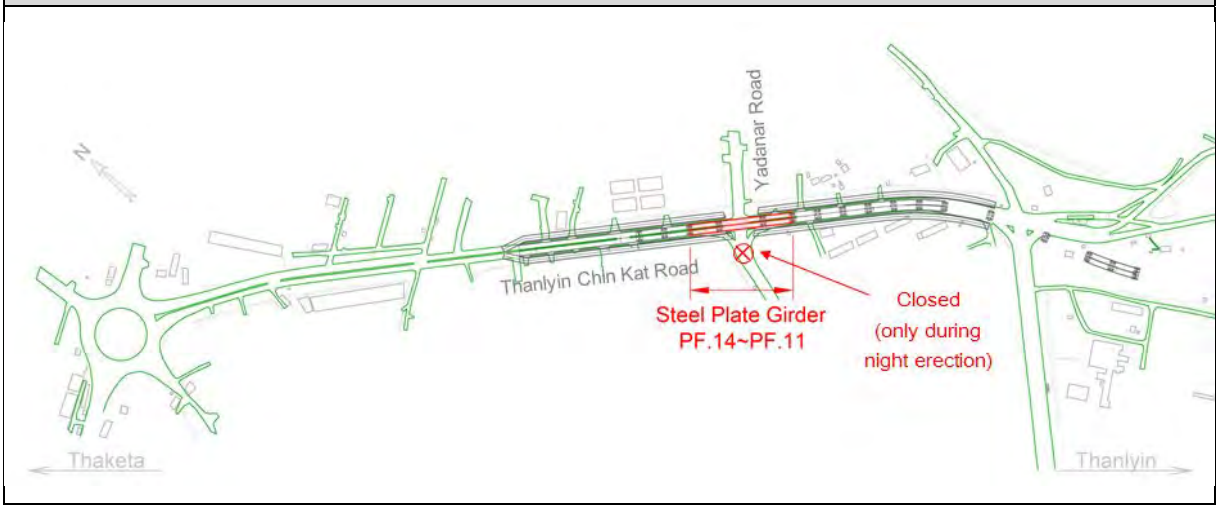
Step 3: Reinf. earth wall & AF.2 approach construction



Step 4: PC girder erection



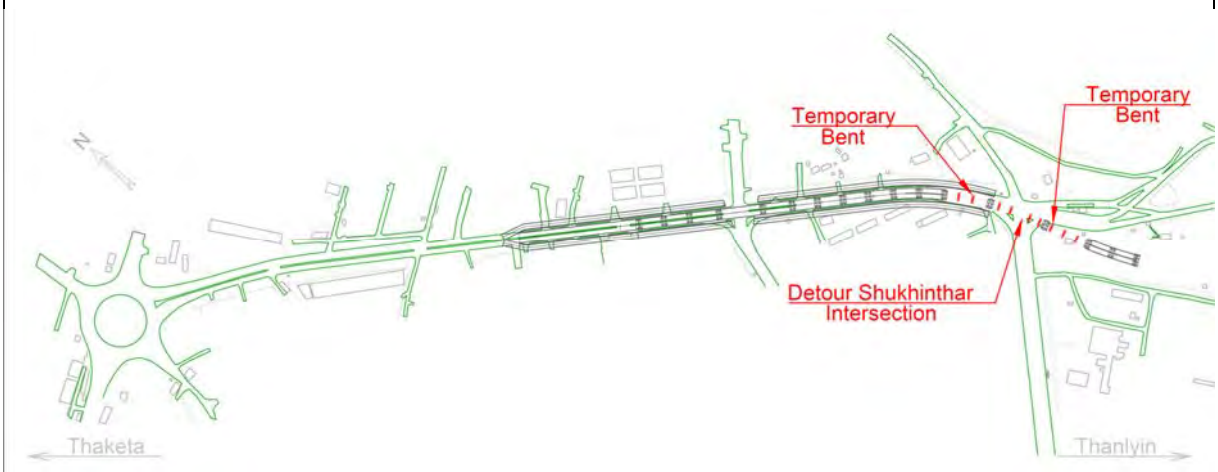
Step 5: Steel plate girder erection



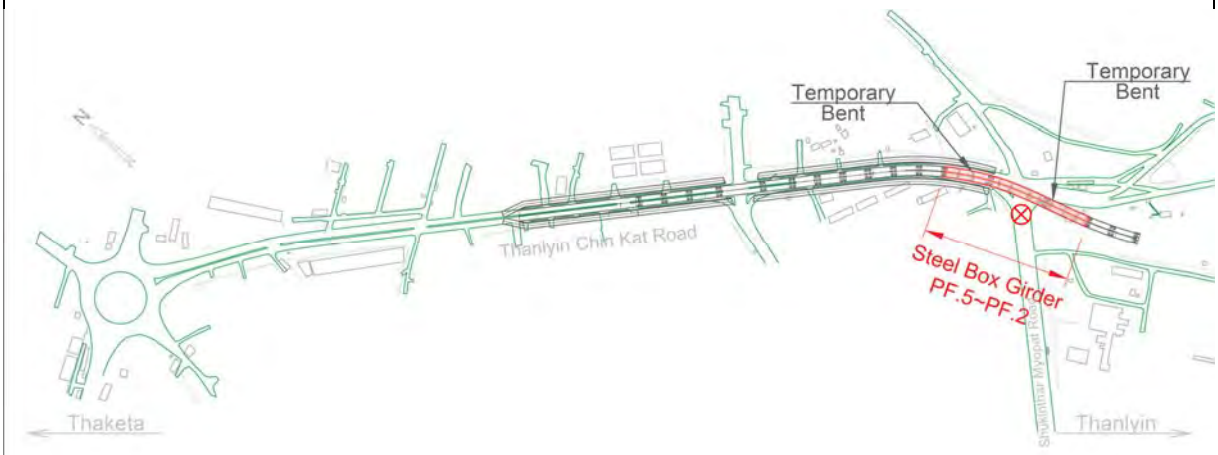
Source: JICA Study Team

Figure 7.2.8 Construction Steps Outline (2/3)

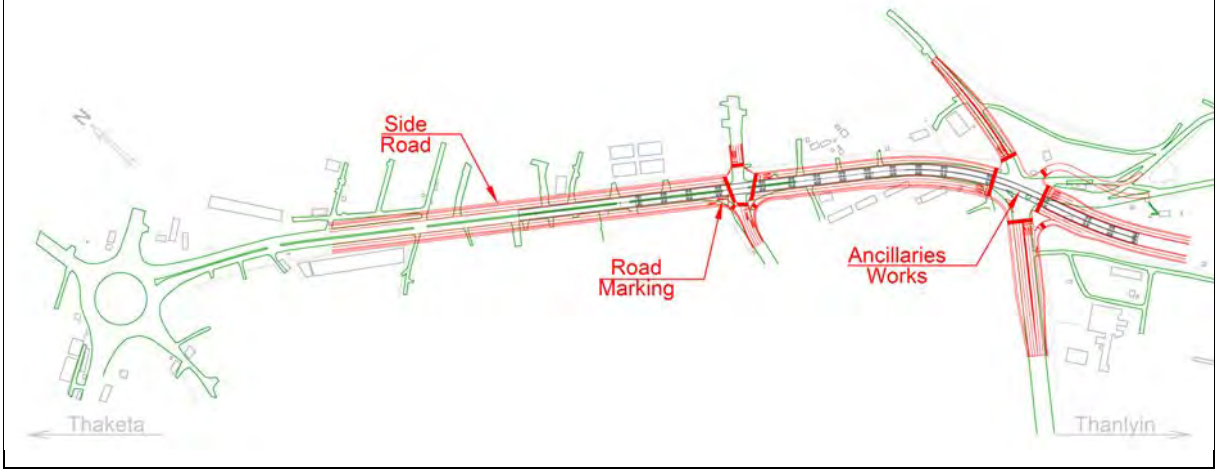
Step 6: Temp. bents installation at Shukhinthar Intersection



Step 7: Steel box girder erection



Step 8: Pavement, drainage, side road, ancillaries, etc.



Source: JICA Study Team

Figure 7.2.9 Construction Steps Outline (3/3)

7.2.7 Road Works

7.2.7.1 Road Works Outline

The road works are divided into two sections, namely: approach section and side road section. Also included are drainage works, road ancillaries installation, and others works as shown in Table 7.2.3.

Table 7.2.3 Road Works Outline

Construction Activity	Work	Specification	Unit	Approximate Quantity
Embankment	Approach Road		m^3	7,000
Retaining Wall	Mechanically-stabilized earth wall	H=3.0～6.85 m	m	180
	L type retaining wall	H=0.5～3.0 m	m	21
Pavement	Carriageway	AC pavement	m^2	30,000
	Sidewalk	Concrete Plate	m^2	2,300
Concrete Curb	Carriageway-sidewalk boundary	Type A	m	3,400
	Boundary block	Type C	m	1,400
Drainage System	Open ditch	W=500~1500 H=500~1700	m	1,100
	Box culvert	W=1000, 1500 H=1000, 1500	m	520
	Catch basins		nos	50
Traffic Line Mark		W = 10 cm	m	8,800
Illumination Pole			nos	65
Traffic Signal			nos	18

Source: JICA Study Team

7.2.7.2 Weak Soil Treatment

The approach after the AF.2 abutment is composed of an embankment section. Since the space between the approach section and the side road section is very narrow, the embankment shall be confined with an L type retaining wall (H=0.0～1.5m) and after that with a reinforced earth wall, same as the AF.1 abutment section in the toll gate side. Differential settlement and lack of bearing capacity are expected in the approach section with embankment, due to a silty layer. Therefore, it is necessary to make a deep layer ground improvement; and thus, the alternative adopted is a cement deep mixing method (dual shaft type φ1200 mm), which is a relatively expensive improvement method. The main components – slurry plant and rough terrain crane – can be installed and operated inside the construction site.

- Ground improvement pile: n = 1,416 piles
- Daily construction productivity: d = 7.47 piles/day
- Construction period: M = 1,416 piles／(7.47 piles/day×30 days)×1.35 ≒ 8.5 months

Considering the construction period, it is necessary to only use one set of equipment for ground improvement.

Table 7.2.4 Main Equipment for Soft Soil Treatment

Construction Activity	Equipment	Specification	Source
Ground Improvement	Deep Layer Mixing Machine	2 axis･1200mm･Up to 20m	Japan
	Cement Slurry Plant	20m3/h	
	Truck Crane	25t	Myanmar

Source: JICA Study Team

7.2.7.3 Mechanically Stabilized Earth Wall and Embankment

The adopted retaining walls are the mechanically stabilized earth wall and L-type retaining wall cast in situ. The embankment material distribution/compaction is one of the most important procedures and controls the quality of retaining wall. In addition, to ensure the quality of the embankment it is necessary use an adequate soil material, compaction method, and control during construction (specifically, the compaction degree control shall be done as a standard).
Mechanically stabilized earth wall precast panels can be locally sourced or can be fabricated in situ. The equipment necessary for the construction are shown in Table 7.2.5. The construction steps are shown below.

① Foundation work

② Concrete panels erection

③ Reinforcement material installation

④ Earthworks (soil spreading, levelling, and compacting)

Repetition of steps ① to ④ until completion

Table 7.2.5 Main Equipment for Mechanically Stabilized Earth Wall Construction

Construction Activity	Equipment	Specification	Source
Embankment	Bulldozer	15 t	Myanmar
	Tire roller	8～20 t	
Panel Erection	Truck crane	5 t	

Source: JICA Study Team

7.2.7.4 Pavement

The pavement type adopted in the road/bridge sections is the concrete asphalt mix, which can be locally sourced from near asphalt plants. The equipment necessary for the construction are shown in Table 7.2.6.

Table 7.2.6 Main Equipment for Pavement Construction

Range	Construction Activity	Equipment	Specification	Source
Carriage	Asphalt pavement	Asphalt finisher	2.4～6.0 m	Myanmar
		Road roller	Macadam 10～12 t	
		Tire roller	8～20 t	
		Hand Compactor	If necessary	
	Roadbed	Motor grade	3.1 m	
		Road roller	Macadam 10～12 t	
		Tire roller	8～20 t	
Sidewalk	Interlocking pavement			

Source: JICA Study Team

7.2.8 Bridge Works

7.2.8.1 Bridge Works Outline

The bridge section can be divided into four types according to girder span and the materials shown in Table 7.2.7. For all four types, the truck crane erection method is considered for the superstructure construction.

Table 7.2.7 Bridge Types

Type	Unit	Bridge Length	Construction Method
3 spans continuous steel plate girder	m	180	Truck crane erection method
3 spans continuous steel box girder	m	122	
2 spans continuous PC-I girder	m	60	
4 spans continuous PC-I girder	m	120	

Source: JICA Study Team

7.2.8.2 Foundation

Considering economics, constructability, and other factors, the reverse circulation drilling method shall be adopted for the foundations. The designed pile diameter is 1500 mm as studied in Section 4.6.1.5. Since the construction site is enclosed by two detour roads, the available working space is limited; therefore, the pile construction shall be done with only one crane. Regarding the construction sequence, since the approach road is expected to be constructed first, the foundations should be constructed from AF.2 to AF.1 abutment. The equipment necessary for the construction is shown in Table 7.2.8.

Table 7.2.8 Main Equipment for Foundation Construction

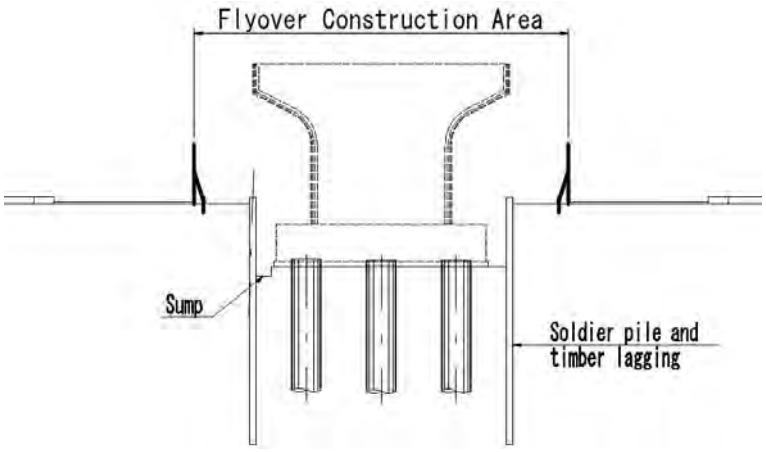
Equipment	Specification	Source
Reverse Circulation Drill	Max. diameter 3,200 mm	Third Country
Extraction Jack	Diameter 1,480 mm	
Crawler Crane	40 t	Myanmar
Backhoe	0.5m^3	

Source: JICA Study Team

7.2.8.3 Substructure

(1) Structural Excavation

Structural excavations for the construction of piers/abutments have 3 m deep, and hence can be directly excavated by a backhoe. Considering the poor ground conditions and to guarantee traffic safety on the surrounding detour road, the excavation method adopted is the self-supporting excavation trench with soldier pile and timber lagging. However, for the footings with 4 piles that are smaller, it was considered to adopt open-cut method. On the longitudinal direction, the open-cut method was adopted since the excavation zone is inside the construction site area and is not influenced by local traffic. The water level is high so countermeasures against water inflow – i.e., sump excavation and drainage pump installation – might be necessary. The excavation cross section is shown in Figure 7.2.10.



Source: JICA Study Team

Figure 7.2.10 Excavation Cross Section

The soldier piles are expected to be used a few times, therefore, can be locally sourced and sold as recyclable scrap after use. Furthermore, the excavated soil has poor quality and need to be transported to a nearby dump area. The estimated transport distance is 5 km. The equipment necessary for the construction is shown in Table 7.2.9.

Table 7.2.9 Main Equipment for Structural Excavation

Construction Activity	Equipment	Specification	Source
Excavation	Backhoe	0.8m^3	Myanmar
Backfilling	Vibration Roller	Hand Guide 0.8～1.1t	
Soldier	Vibro Hammer	60kw	
	Crawler Crane	50～55t	
Substructure	Concrete Pump Truck	90～110m3/h	
	Truck Crane	15～16t	

Source: JICA Study Team

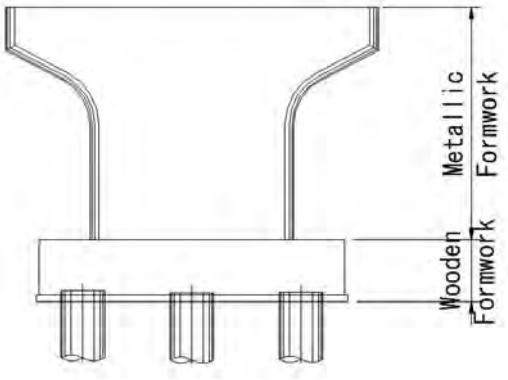
(2) Bottom Surface

A 20 cm crush stone layer plus a 10 cm concrete C18 layer shall cover the bottom surface to guarantee the stability of the rebar arrangement.

(3) Main substructure elements

The main substructure elements are divided in the footing, column, and pier head. Note that the column should be concreted from 2.5~3.0 m high steps. Ready mix concrete can be locally sourced and casted using a concrete pump.

Wooden formwork was adopted for the footing and abutment construction, since those elements are composed of plane surfaces. For pier columns and pier head, metallic formwork shall be adopted to guarantee the constructability and surface quality of the curved/variable sections of those elements as shown in Figure 7.2.11. Four sets of metallic formwork shall be fabricated in Japan and transported to the construction area, and shall be reused for the construction of all piers and then discarded as recycling scrap after use.



Source: JICA Study Team

Figure 7.2.11 Formwork Type Division

7.2.8.4 Superstructure

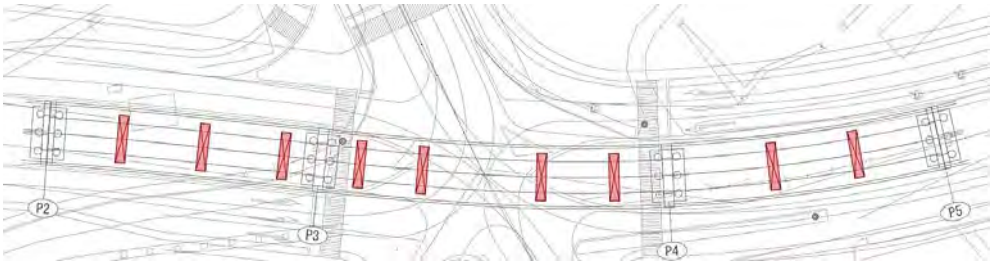
The flyover section is planned over the existing road section and the only construction clearance to be preserved is at the intersections. Since this is a relative low bridge, the construction method adopted is crane erection. The side road is used by the cranes during the erection; therefore, the construction should be done only during night time when the traffic is restricted.

(1) Steel Box Girder

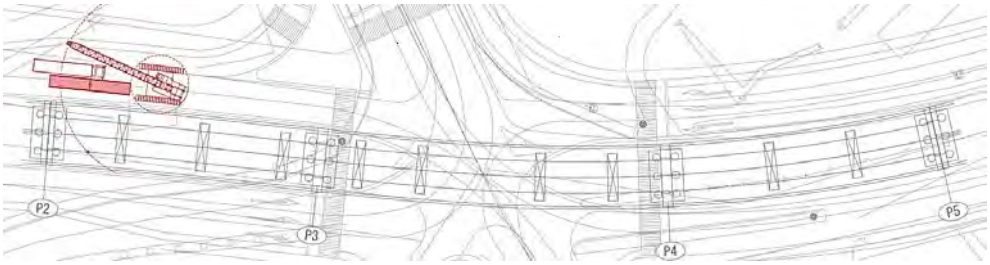
Raw materials for steel box girder are expected to be procured from Japan. Then the girders should be fabricated in Myanmar or near countries, assembled into a larger block in the construction yard. During night time, the block is transported to the site using a heavy load transport truck and erected in position using a 200 t crawler crane. There is enough space for crane activities as shown in Figure 7.2.12. The steel box girder superstructure is constructed in five steps: first, the two main box girders are set in place, after that the two external and the internal girder are installed. The box girder superstructure erection steps are shown in Figure 7.2.13. The erection requires a temporary bent structure; therefore, the traffic in Shukinthar intersection shall be detoured during the girder erection (only night time for approximately 1 week) as shown in Figure 7.2.22.

The slab construction is carried out after the girders erection. Scaffold, formwork, and rebar are installed, and then finally, the concrete is casted in situ. Those activities can be done during daytime.

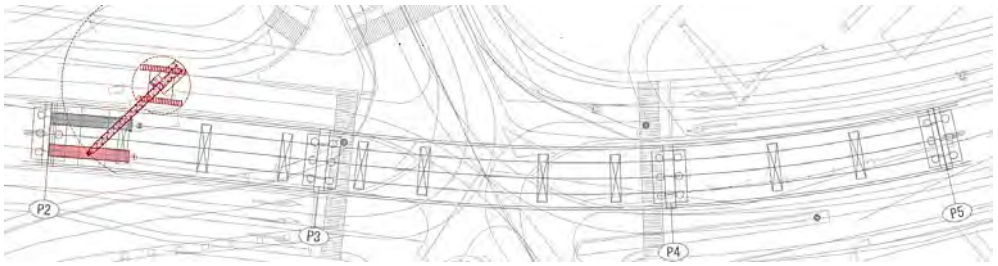
Step 1: Erect the temporary bent structures



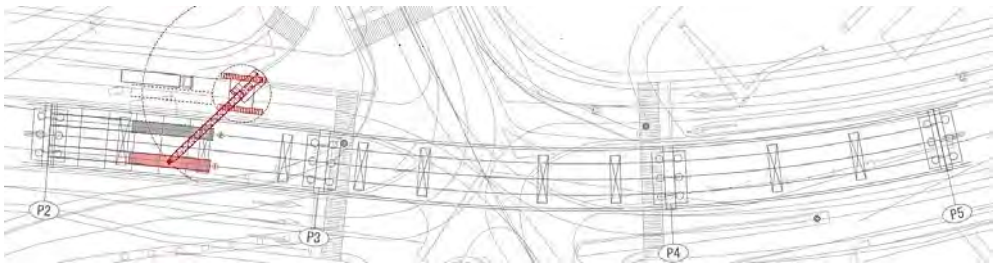
Step 2: Girder block temporary assemble on the ground



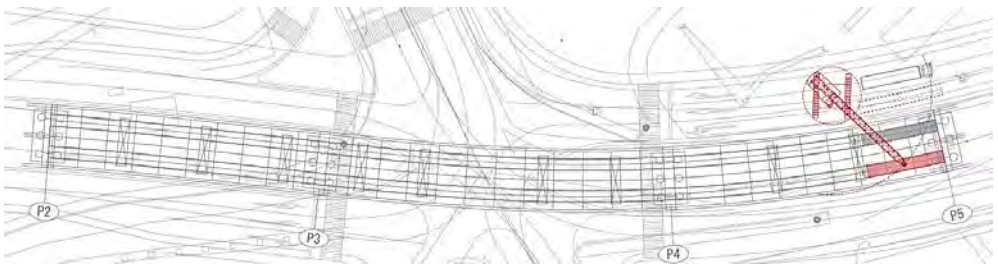
Step 3: Erection of main girders block (1)



Step 4: Assemble on the ground / Erection of main girders block (2)

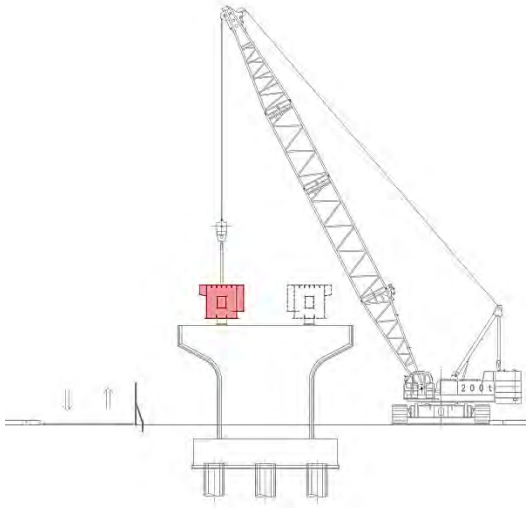
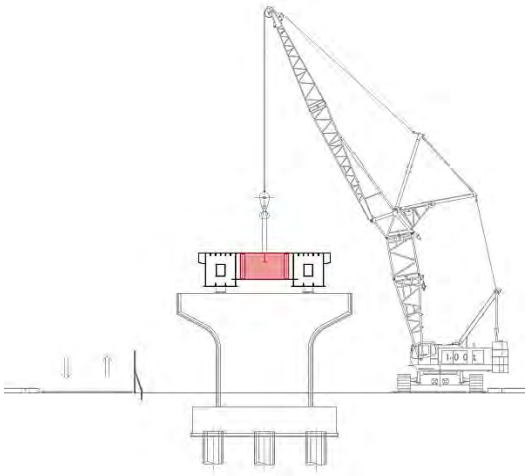
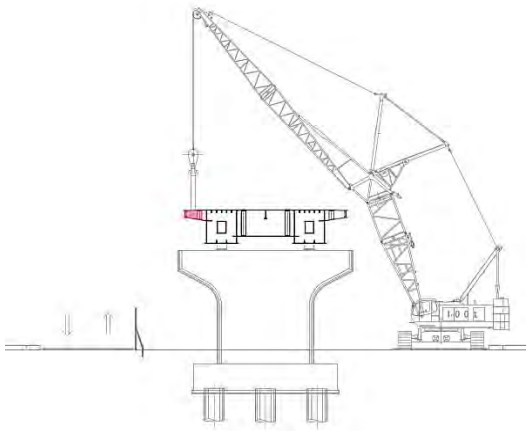
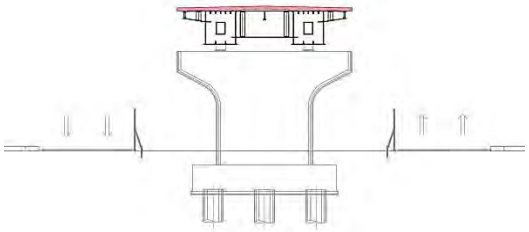


Step 5: Assemble on the ground / Erection of main girders block (3 to 12)



Source: JICA Study Team

Figure 7.2.12 Box Girder Erection Outline

Step 1: Erection of the main girders	Step 2: Erection of the inner girder
	
Step 3: Erection of the outer girders	**Step 4: Concrete RC slab casting**
	

Source: JICA Study Team

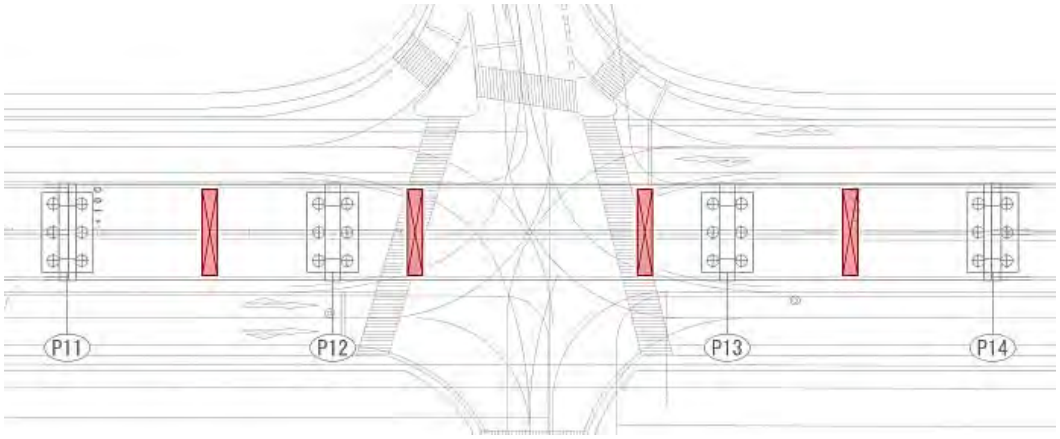
Figure 7.2.13 Box Girder Superstructure Construction Steps

(2) Steel Plate Girder

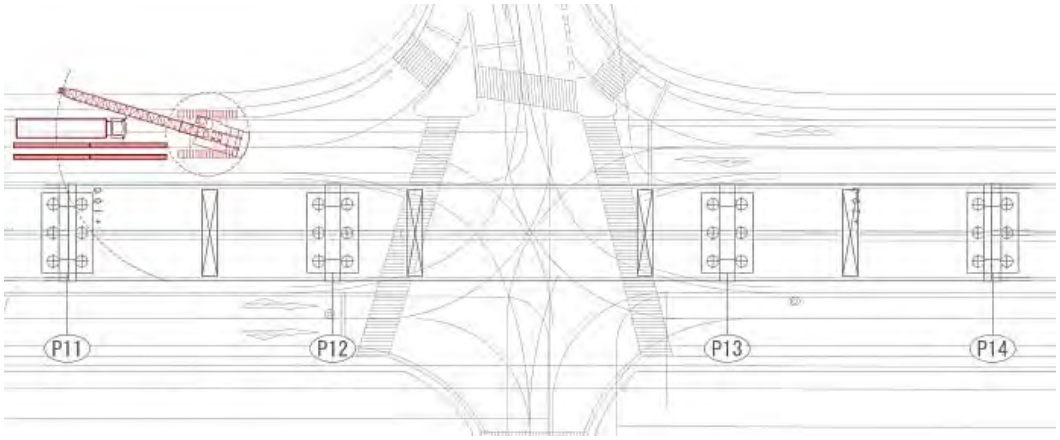
Similar to the steel box girder, the steel plate girder parts imported from Japan are assembled into a larger block in the construction yard. During night time, the block is transported to the site using a heavy load transport truck and erected in position using the 100 t crawler crane. There is enough space for crane activities as shown in Figure 7.2.17. The steel plate girder superstructure is also constructed in five steps: five main girders are installed one at a time. The plate girder superstructure erection steps are shown in Figure 7.2.14 to Figure 7.2.16. The adopted large block erection method does not require a temporary bent structure inside the intersection; however, traffic in Yadanar Intersection shall be detoured during the girder erection (only night time for approximately 1 week) as shown in Figure 7.2.23.

The slab construction is carried out after the girders erection. Scaffold, formwork, and rebar are installed, and finally the concrete is casted in situ. Those activities can be done during daytime.

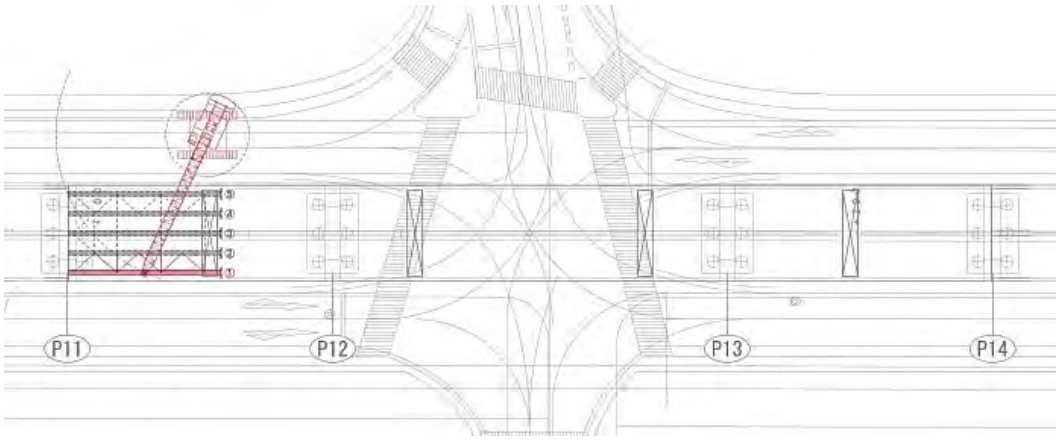
Step 1: Erect the temporary bent structures



Step 2: Girder block temporary assemble on the ground



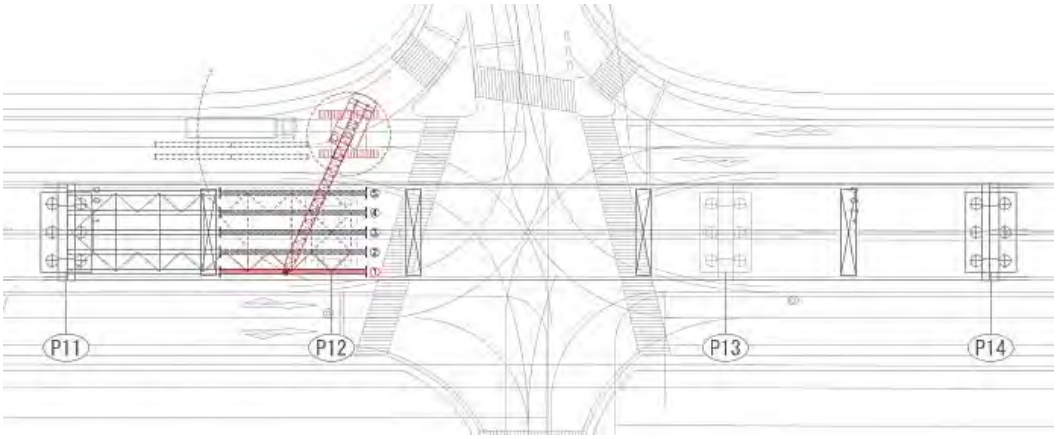
Step 3: Erection of main girders block (1)



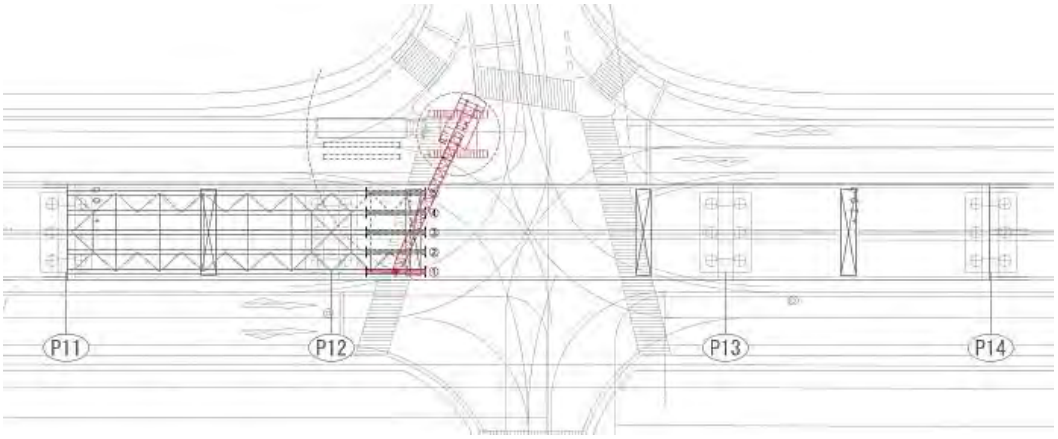
Source: JICA Study Team

Figure 7.2.14 Plate Girder Erection Outline (1/3)

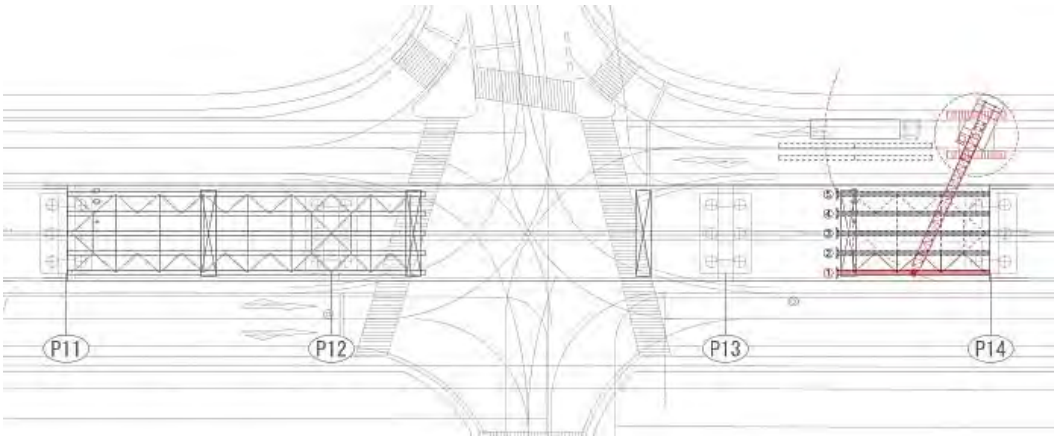
Step 4: Assemble on the ground / Erection of main girders block (2)



Step 5: Assemble on the ground / Erection of main girders block (3)



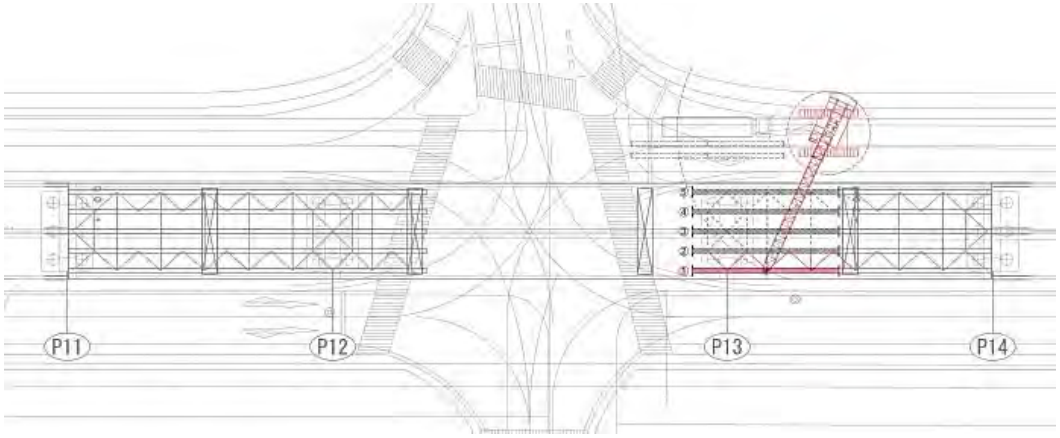
Step 6: Assemble on the ground / Erection of main girders block (1')



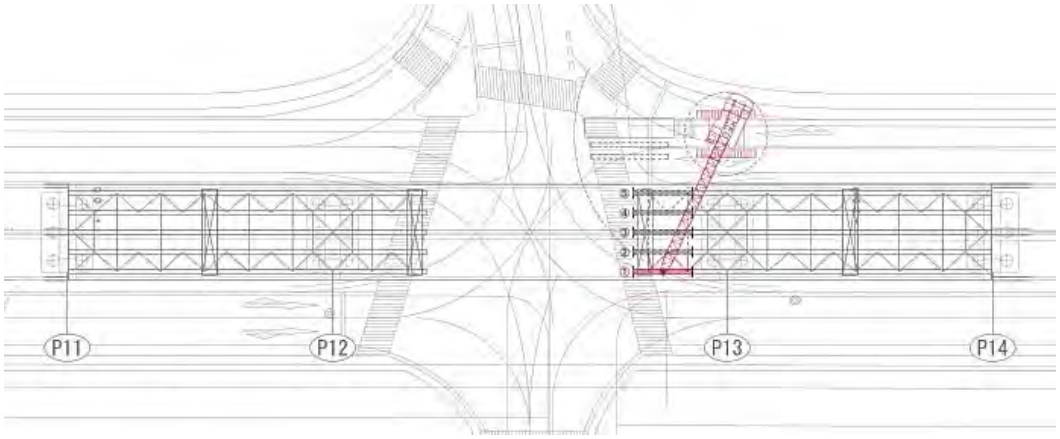
Source: JICA Study Team

Figure 7.2.15 Plate Girder Erection Outline (2/3)

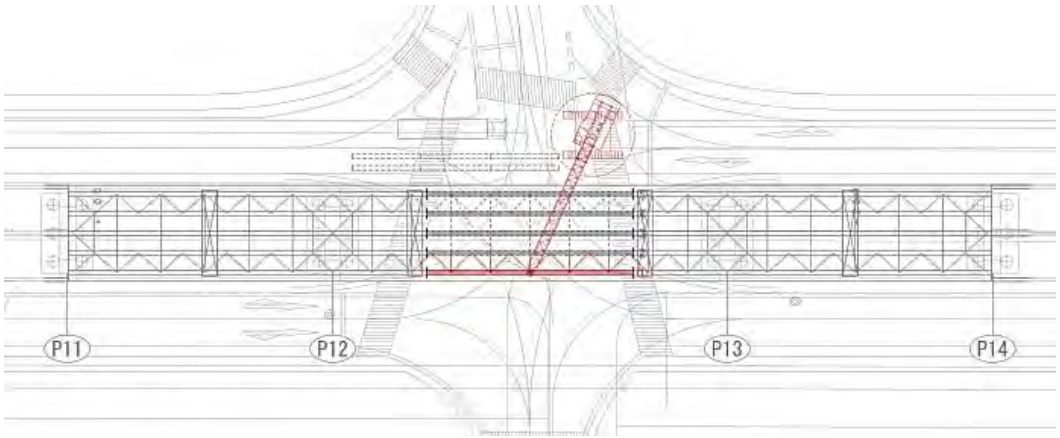
Step 7: Assemble on the ground / Erection of main girders block (2')



Step 8: Assemble on the ground / Erection of main girders block (3')

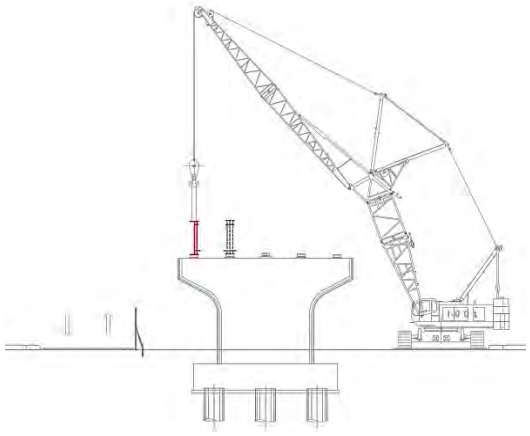
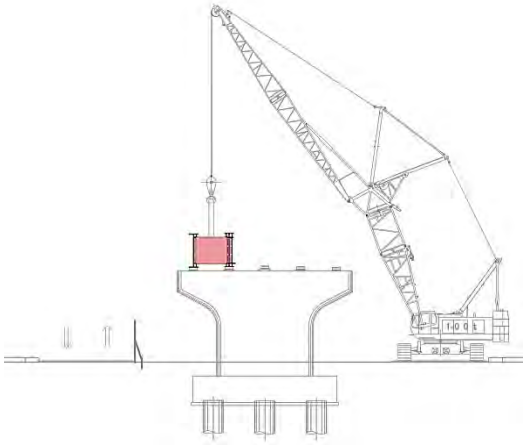
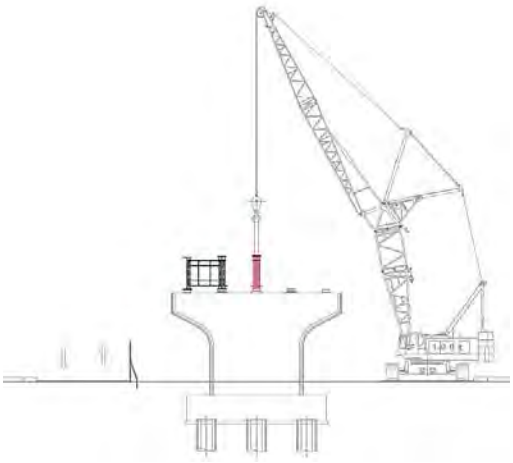
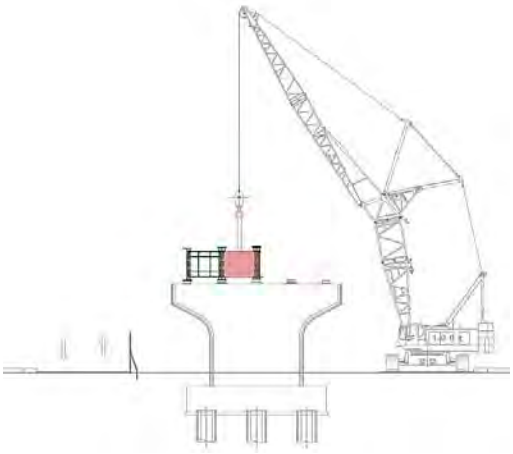
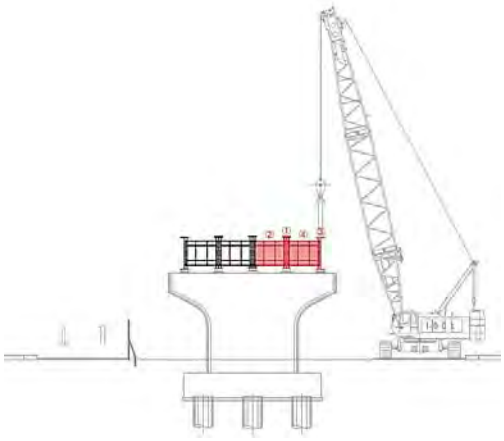
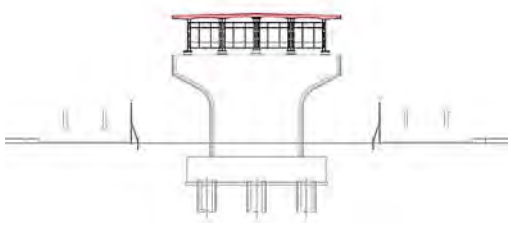


Step 9: Assemble on the ground / Erection of main girders block (4)



Source: JICA Study Team

Figure 7.2.16 Plate Girder Erection Outline (3/3)

Step 1: Erection of the main girders	Step 2: Erection of the cross girder
	
Step 3: Erection of the main girder	**Step 4: Erection of the cross girder**
	
Step 5: Repeat steps 3 and 4 twice	**Step 6: Concrete RC slab casting**
	

Source: JICA Study Team

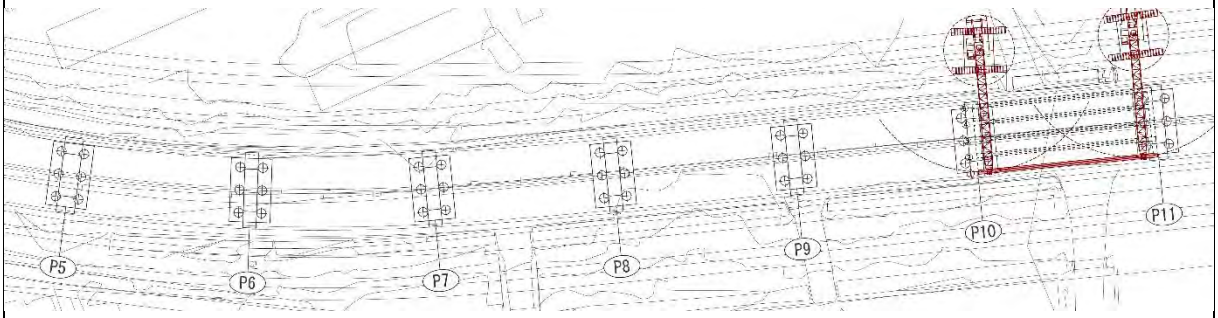
Figure 7.2.17 Plate Girder Superstructure Construction Steps

(3) PC-I Girder

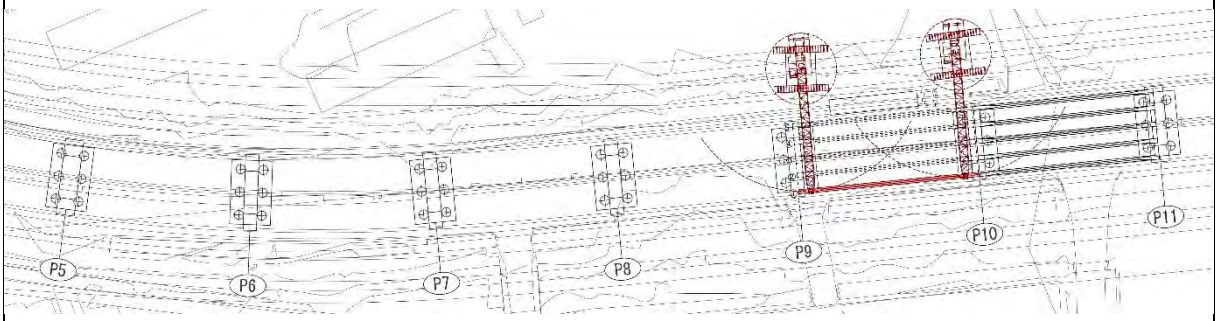
Post tensioned PC-I girder and the precast slab panels are fabricated and stored in a temporary yard. During night time, each girder is transported to the site using a heavy load transport truck. Since each girder weighs approximately 80 t; one 180 t crawler crane is not able to lift the girder due the lack of space, therefore, it is necessary to use two 180 t crawler cranes. The PC superstructure erection steps are shown in Figure 7.2.18 and Figure 7.2.19.

The traffic is restricted to the northern side during the girder erection, as shown in Figure 7.2.20. To shorten the traffic restriction period the slab construction is carried out in parallel with the girders erection and the precast panels are set in position using a truck crane positioned on the southern side. Scaffold, formwork, and rebar are installed, and finally the concrete is casted in situ. Those activities can be done during daytime.

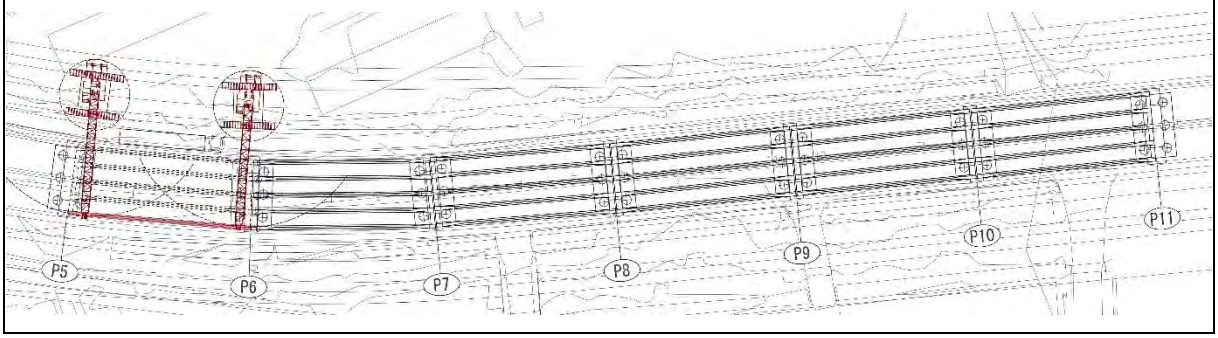
Step 1: Erection of main girders (A2~ P14 / P11~P10)



Step 2: Erection of main girders (P10~P9)

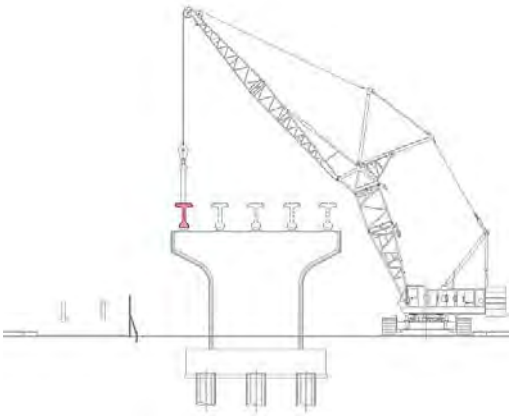
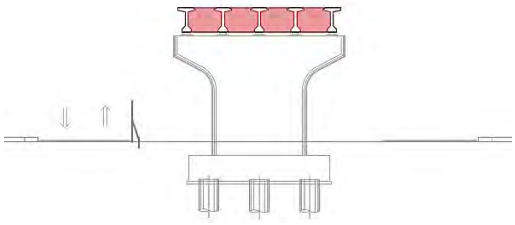
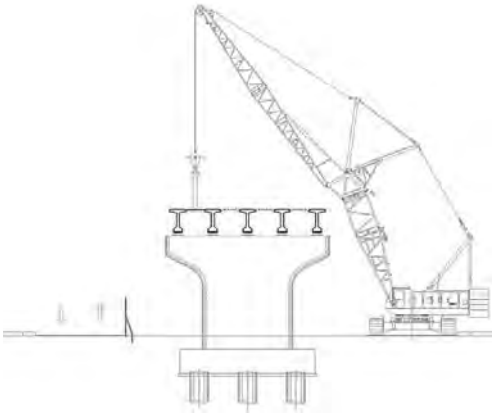
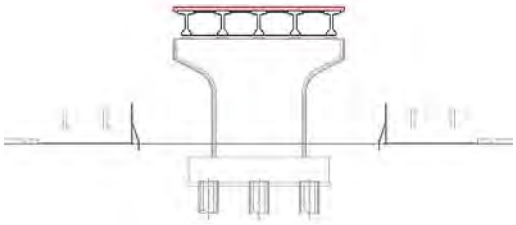


Step 3: Erection of main girders (P8 to P5 / P2~A1)



Source: JICA Study Team

Figure 7.2.18 PC Girder Erection Outline

Step 1: Erection of the main girders	Step 2: Erection of the cross girder
	
Step 3: Setting precast panels	**Step 4: Concrete RC slab casting**
	

Source: JICA Study Team

Figure 7.2.19 PC Girder Superstructure Construction Steps

(4) Bridge Deck Works

The bridge deck work area can be accessed using the approach road side. The activities that compound the bridge deck works are shown in Table 7.2.10, and should start from the AF2 abutment.

Table 7.2.10 Bridge Deck Works Outline

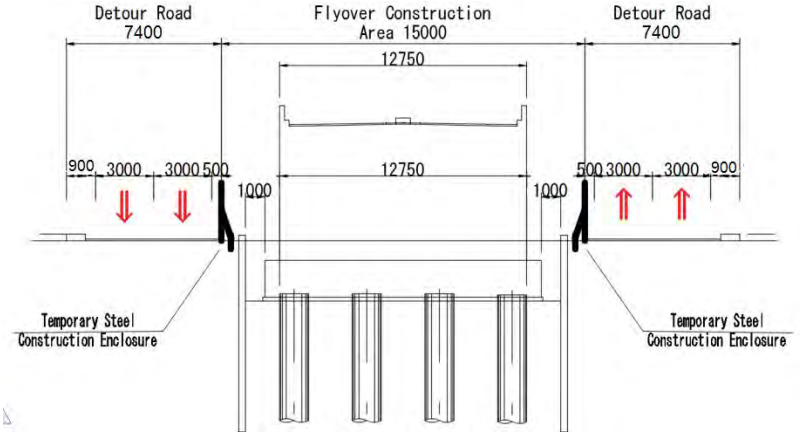
Construction Activity	Work	Unit	Quantity
Waterproofing Works	Waterproof Coating System	m^2	6,650
Pavement Works	Asphalt Concrete 4 cm+4 cm	m^2	5,450
Drainage Works		m	3,100
Parapet Works	Width 400 mm Height 40 cm	m	1,204
Traffic Line Works	Width 15 cm	m	1,300

Source: JICA Study Team

7.2.9 Traffic Diversion Plan

7.2.9.1 Thanlyin Chin Kat Road Diversion Plan

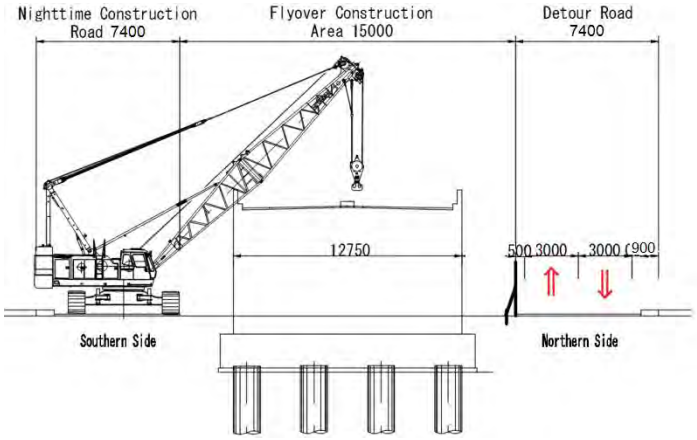
The construction site of the flyover section is located over the central area of an existing 4-lane road. The existing road shall be diverted in a similar position of the final configuration as the first step of construction. The detour road has the same four lanes as the existing road as shown in Figure 7.2.20. The construction site shall be fenced with a temporary steel construction enclosure and all temporary road access points shall have a flagman assigned in order to ensure traffic safety during the construction period.



Source: JICA Study Team

Figure 7.2.20 Detour Road Cross Section

During the erection of the bridge girders, the southern side of the detour road shall be used during the night time as construction road and yard. During this period, the traffic circulation shall be restricted to the northern side of the detour road as shown in Figure 7.2.21. The restriction from four lanes to two lanes shall be indicated by appropriate traffic signals, traffic cones and flagman in order to guarantee traffic/site safety.

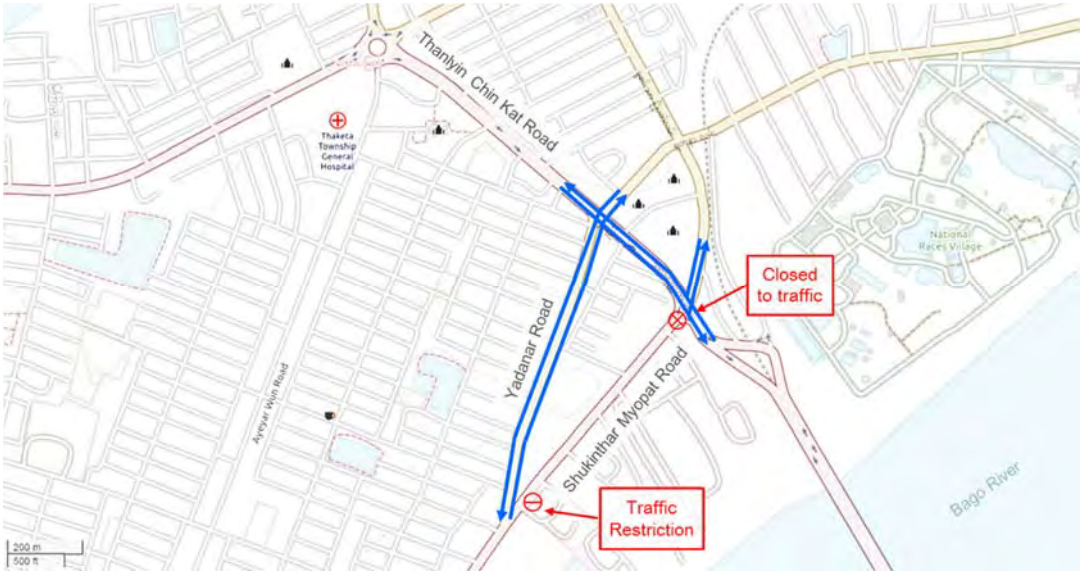


Source: JICA Study Team

Figure 7.2.21 Girder Erection Time – Detour Road Condition

7.2.9.2 Shukinthar Myopat Intersection Diversion Plan

The traffic to/from Shukinthar Myopat intersection shall be detoured and/or restricted during night time at approximately 1 week for steel box girder erection as shown in Figure 7.2.22.



Source: JICA Study Team

Figure 7.2.22 Steel Box Girder Erection – Shukinthar Myopat Intersection

7.2.9.3 Yadanar Intersection Diversion Plan

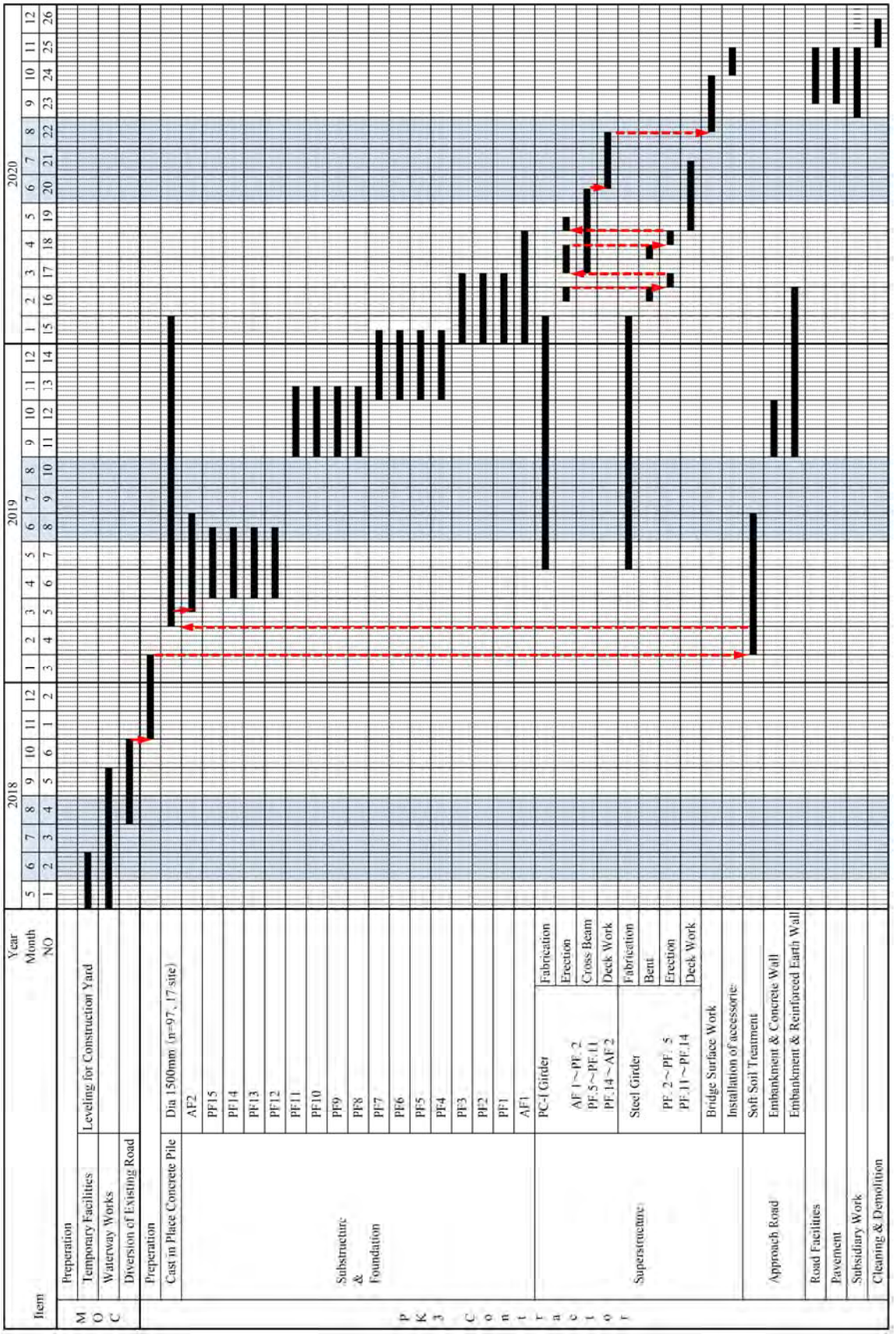
The traffic in Yadanar intersection shall be detoured and/or restricted during night time at approximately 1 week for steel plate girder erection as shown Figure 7.2.23.

Source: JICA Study Team

Figure 7.2.23 Steel Plate Girder Erection – Yadanar Intersection

7.2.10 Construction Schedule

The flyover section undertaken by Package 3 contractor is planned to be constructed within 26 months. To complete the project in the period proposed, it is necessary to have one team for ground improvement and foundation, three teams for substructure and one team for superstructure. The construction schedule is shown in Figure 7.2.24.



Source: JICA Study Team

Figure 7.2.24 Construction Schedule

7.3 TAX AND CUSTOMS CLEARANCE

7.3.1 Taxation (Non-eligible Portion)

Taxation is owned by the government (Non-eligible portion). Mainly "Commercial tax: 5% for total project cost" and "Import tax: 5% for foreign portion".

7.3.2 Customs Clearance

According to "Myanmar Import/Export Procedure" by JETRO, the followings steps are necessary for custom clearance.

1) Establish a trade business company

2) Apply for import/exporter registration in the Department of Trade from the Ministry of Commerce

3) Join the Union of Myanmar Federation of Chambers of Commerce and Industry

4) Obtain import licence if necessary

5) After opening a foreign currency account in a Myanmar's bank for settlement, is possible to submit necessary documents for clearing out custom

The following points should be noted:

a) It's necessary to open a local company for import and export, since foreign companies are prohibited to establish a trade company.

b) The custom procedures – declaration, inspection, duties payment and license – are electronic and the cargo items need to be register in MACCS (Myanmar AutomatedCargo Clearance System) before custom clearance.

c) It's necessary to check items that require import license in the Import Negative List Order issued by the Department of Trade from the Ministry of Commerce.

d) To receive tax exemption, it's necessary an exemption letter from the Ministry of Finance, after obtaining an introduction letter issued by the relevant authority from custom.

CHAPTER 8. STUDY ON SAFETY MEASURES DURING CONSTRUCTION

8.1 SIGNIFICANCE OF SAFETY MEASURES AND PURPOSES FOR SAFETY PLAN

8.1.1 Significance of Safety Measures

Safety measures must be the top priority in the Project.

The stakeholders are therefore obliged to comply with the relevant laws and regulations of the recipient country in order to establish a safe and health-conscious working environment and purpose complying with the Japan International Cooperation Agency (JICA) Safety Guideline, September 2014.

It is also necessary to establish a "culture of safety" whereby all organizations and individuals involved in the works clearly understand and prioritize safety, set up a mechanism that automatically promotes active implementation of occupational safety measures in the relevant organizations, and enhances people's awareness of safety.

8.1.2 Purposes of Safety Plan

As for the Project, in order to prevent the occurrence of industrial accidents and hazards in public areas, it is necessary to develop a set of principles of safety management and safety specifications for all construction workers to follow and prevent in advance of occupational accidents pertaining to the construction of roads, bridges, and hazards in public areas, which will eventually contribute to the development of Myanmar.

The bridge across the Bago River is a long-span bridge. Therefore, it is necessary to take into account navigation safety for the ships in the river area where the bridge is constructed by establishing a safety plan.

In addition, there is an important and dense population area in Thaketa Flyover construction site. Hence, construction of the flyover while maintaining the existing transportation of Thanlyin Chin Kat Road, Yadanar Intersection, and Shukhinthar Intersection has high potential safety risks. Assuming all risks and identifying hazards and dangers in the construction site will help in the evaluation of priorities to implement appropriate mitigation measures.

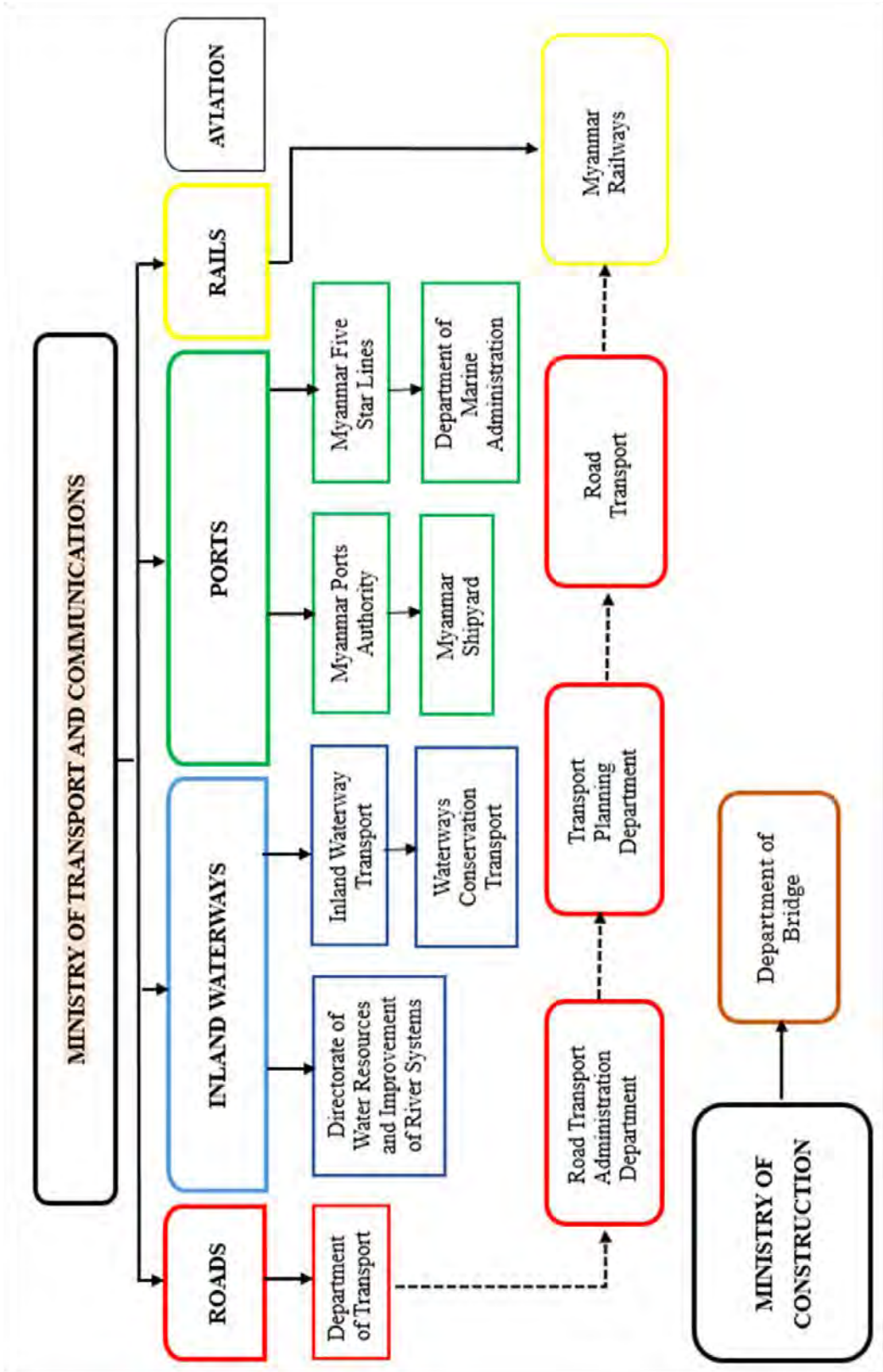
8.2 GOVERNMENT AGENCIES FOR CONSTRUCTION SAFETY

Prior to the formulation, construction safety and health plan must follow the investigation of the feasibility study (F/S), basic design (B/D), and detailed design (D/D). In order to promote consensus and understanding with government agencies, information from government labor laws, traffic laws, environmental regulations, and opinions about construction safety and health plan policy have to be checked carefully as well as taking into account other examples of Myanmar.

The major counterparts of Myanmar relevant authorities including Ministry of Commerce (MOC) and, depending on the situation, the Department of Water Resources and Improvement of River Systems (DWIR), Yangon City Development Committee (YCDC), Yangon Region Development Committee (YRDC), Myanmar Railways (MR), Myanmar Port Authority (MPA), Ministry of Natural Resources and Environmental Conservation (MONREC), etc.

The government authority is divided into different fields, including road, railway, inland waterways, ports and aviation. There is no main agency controlling in general because there are many separated management agencies in charge of specific task exist.

- Ministry of Transport and Communications: traffic in general, transport by land, inland waterways, ports, and aviation
- Ministry of Rail Transport: traffic in land and inland waterway
- Ministry of Construction: construction of road and bridge, maintenance



Source: JICA Study Team

Figure 8.2.1 Relevant Authorities in Myanmar

8.3 CONSTRUCTION SAFETY LAWS AND STANDARDS IN MYANMAR

Major laws and standards concerning vehicles, mandatory driver's license acquisition, penalties for traffic rules violation, compulsory insurance, car production method, vehicle inspection, license issuance, acquisition procedures, and signal lights are regulated by "Automobile Regulations (Motor Vehicle Law, enacted in 1964 and amended in 1989)" and other regulations.

The Road Transport Administration Department (RTAD) performs the enforcement of relevant regulations. Myanmar Traffic Police Bureau performs the enforcement of relevant laws and regulations. In addition, Traffic Rules Enforcement Supervisory Committee is established in each region. Traffic control is considered by actual situations in each region

The contractor shall at all time comply with all the existing statutes in Myanmar concerning safety, security, and health for the implementation of the works. Such statutes include, but are not limited to the following:

Table 8.3.1 Safety Regulations/Laws and Specifications

No	Enacted Laws	Available Version	Law No.	Notification No.
1	Motor Vehicle Law	RTAD		Revised 1989
2	Motor Vehicle Rules	RTAD		1989
3	The Highway Law	MOTC	No.24	2015
4	The First Amended Highway Law	MOTC	No.60	2015
5	The Second Amended Highway Law	MOTC	No.62	2015
6	The Amended Utilization of Roads and Bridge Law	MOTC	No.25	2014
7	The YCDC Rules and Regulations	YCDC	No.3	2001
8	The YCDC Law	YCDC	No.6	2013
9	The Law Relating to Private Health Care Services	MOL	No.5	2007
10	Accidents and Injury Prevention Law	MOL	No.53	2014
11	The Amended Law for Leave and Holiday Act	DOL	No.30	2014
12	The Amended Settlement of Labor Dispute law	DOL	No.40	2014
13	The Social Security Rules	DOL	No.15	2012
14	The Amended Law for Factories Act	DOL	No.12	2016
15	The Myanmar Fire Brigade Law	MFSD	No.11	2015

Source: JICA Study Team

-JICA Guidance for the Management of Safety for Construction Works September 2014.

-The Traffic Regulations, standards where the Association of Southeast Asian Nation (ASEAN) countries are referenced.

Table 8.3.2 Related River Laws and Regulations

No	Enacted Laws	Available Version	Law No.	Notification No.
1	The Conservation of Water Resources and River Law	MM/EN	8/2006	
2	The Conservation of Water Resources and River Rule	MM		14/2013
3	The Law of Inland Water Transport Board	MM	51/2014	
4	The Rule of Inland Water Transport	MM		158/2015
5	The Law regarding the Inland Water Vessels	MM	29/2015	
6	The Law Amending the Water Blockade Act	MM	26/2013	
7	The Myanmar Port Authority Law	MM	21/2015	
8	The Law Amending the Lighting House Act	MM/EN	1/2016	

Source: JICA Study Team

-JICA Guidance for the Management of Safety for Construction Works, September 2014

8.4 PROCEDURES OF PERMISSION AND APPROVAL FOR SAFETY

The Contractors shall survey all relevant laws and regulations applicable to construction work in the recipient country prior to the commencement of the BAGO Bridge Construction Project.

The Employer/Engineer shall provide information on the relevant authorities to the Contractor and provide assistance to the Contractor on the procedures of permission/approval that they should take as per the relevant laws and regulations.

Basic Procedures for permission and approval matters

(1) Request of permission/approval: From Contractor to MOC/ENG

(2) Documents checked by ENG: Instruct of revision and correction to Contractor

(3) Request of permission/approval: From MOC to relevant authorities

(4) Issue Permission/Approval: From relevant authorities to MOC and Contractor/ENG (c/c)

(5) Notice to agencies: From MOC/ ENG to agencies.

Table 8.4.1 Permission and Approval of Relevant Authorities (Safety Relevant Laws)

No.	Permission/Approval Items	Permission/Approval			Notice/Concentration Permission/Approval	
1	Temporary traffic sign boards and temporary signal (Ramps)	MOTC	YCDC	MTPB	TRESC	PS
2	Temporary roads (Outside)	MOTC	YCDC	MTPB	TRESC	PS
3	Diversion roads/widening roads	MOTC	YCDC	MTPB	TRESC	PS
4	Restrict traffic and traffic closed to vehicles (include same time)	MOTC	YCDC	MTPB	TRESC	PS
5	Construction vehicles (Notice)	MOTC	YCDC	MTPB	TRESC	PS
6	Special vehicles (traffic on public roads)	MOTC	YCDC	MTPB	TRESC	PS
	Fire prevention measures	MFSD	FS	-	PS	-
7	List of all engineers and labor(Notice)	MLI	DOL		PS	-
8	List of foreign engineers and foreign labor	MLI	DOL		PS	DOI
9	Other requests	Each relevant authority			-	-

Source: JICA Study Team

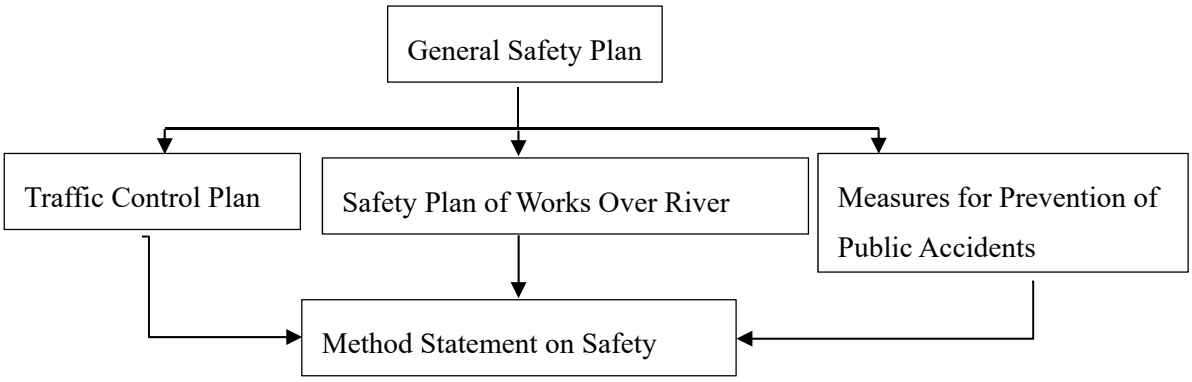
Table 8.4.2 Permission and Approval of Relevant Authorities (Safety River Laws)

No.	Permission/Approval Items	Permission/Approval			Notice/Concentration Permission/Approval	
1	Establish temporary fairway	DWIR	MPA	IWT	MMPS	-
2	Restrict construction areas (no trespassing area)	DWIR	MPA	IWT	MMPS	-
3	Type of navigation buoy (beacon) and lighting facilities	DWIR	MPA	IWT	MMPS	-
4	Construction method on the river	DWIR	MPA	IWT	MMPS	-
5	Construction vessels(Notice)	DWIR	MPA	IWT	MMPS	-
6	Special construction vessels	DWIR	MPA	IWT	MMPS	-
7	Fire prevention measures	MFSD FS	DWIR	MPA IWT	MMPS	
8	Other requests	Each relevant authority			-	-

Source: JICA Study Team

8.5 COMPOSITION OF SAFETY PLAN

As for the Project, in addition to a comprehensive construction safety plan, to create safety plan for each item, the contractor must set up the framework for the construction safety plan before the tender/the beginning of construction to express his intention for safety working.



Source: JICA Study Team

Figure 8.5.1 Construction Safety Plan

8.6 GENERAL SAFETY PLAN

The general safety plan is positioned as the basic principle for safety management of the project at site and establishes basic policies on the general safety management and operation for the works at site.

8.6.1 Preliminary Site Investigation (Environment Safety Conditions on Site)

Based on practical existing data of the F/S, B/D, and D/D on preliminary investigation and complying with the safety regulations of Myanmar, in order to consider regional characteristics and safety construction purposes, safety plans and construction methods of properties around the site should be prior formulated, surveyed, and reflected in the technical specifications.

Leveraging existing data of the F/S, B/D, and D/D on preliminary investigation and complying with safety laws and regulations of Myanmar in consideration of regional characteristics and safety construction purposes, the contractor shall prepare the details prior to the formulation of comprehensive safety plans and construction plans of properties around the site to reflect into the general safety plan.

Contents of Preliminary Site Investigation:

The employer and the engineer shall provide F/S, B/D, and D/D data and apply permit (for example of drilling test permit application) for the contractor. Investigation and land access must be cooperated by the related parties.

(1) Underground utilities or facilities: type, location (depth and cross-section), management, related laws and regulations.

(2) Aerial route or other aerial utilities: type, location (depth and cross-section), management, related laws and regulations.

(3) Transportation route of materials and machines: type, location (depth and cross-section), management, related laws and regulations.

(4) Surrounding environment of temporary storage (plan) of materials and machines: surrounding terrain, environmental residence, drainage facilities.

(5) Public facilities (schools, hospitals, school roads, etc.): scope of facilities, type of facilities.

(6) Production of dangerous substances at nearby construction sites: chemicals, explosive substances, and storage.

(7) Traffic conditions at construction site: traffic volume, characteristic of vehicles, road width, road surface condition, durability, rush hour.

(8) River and navigation vessel: traffic volume and types of ships, waterways, surrounding terrain, geological features, utilities under riverbed.

(9) Predicting vibration and noise at construction site: related laws and regulations, safe distance, construction method.

(10) Disposal of construction waste and dumping places: quantity and type of waste.

(11) Unexploded bomb and explosive: information from related parties, examples of past cases.

(12) Toxic substance around the construction area: accumulation of decaying substances, examples of past cases.

(13) Regional weather conditions: past consequences of natural disasters such as storms, earthquakes, etc.

8.6.2 Basis Policies for Safety Management

The contractor shall determine the basic policies for safety management applied during construction (hereinafter referred to as the "Basic Policies") in accordance with the scope of work, the environment where the works perform under relevant laws and regulations of the recipient country, contract documents and other applicable documents or data incorporated into the contract. It is also necessary to describe the basic policies of the main office.

(1) Basic Policies of Contractor Site Office (Safety Management)

1) Establishment of safe policies
2) Execution and operation of safety plan
3) Sharing responsibilities and evaluation of safety management capacity of persons-in-charge
4) Responsibility identification and plan of safety management system
5) Safety activities and education
6) Emergency contact and communication system
7) Rescue drill and evacuation route

8) Plan and application of risk assessment
9) Measures for fire prevention and fire drill
10) Measures for earthquake/natural disasters and refuge drill
11) Measures for public health and health care of laborers
12) Measures for maintaining security
13) Measures for maintaining the surrounding environment of the construction site
14) Countermeasures for industrial accidents/injuries and natural disasters
15) Record and documentation (document file)

(2) Basic Policies of Contractor Main Office (Safety Management)

1) Establishment of safe policies
2) Execution and operation of safety plan, etc.
3) Evaluation of safety management capacity of persons-in-charge
4) Plan and application of risk assessment
5) Safety public relations (PR) activities and education
6) Emergency contact and communication system
7) Rescue drill and evacuation route
8) Regular, monthly, and periodic inspections of machinery and records
9) Identified causes of industrial accidents/injuries and improvement
10) Record and documentation (document file)

8.7 GENERAL RULES OF RISK ASSESSMENT (PROPOSAL)

8.7.1 Purpose of Risk Assessment

Hazardous and harmful construction work site must be identified as the top priority. Risk assessment will be planned and executed to implement appropriate risk mitigation measures based on a reasonable basis. As a result, those will form and improve smooth operation of business activities, a comfortable working environment and avoid occupational accidents and health hazards.

8.7.2 Implementation for Risk Assessment

Main construction contractor and all subcontractors shall implement risk prediction activities (RPA) and risk assessment (RA). Site managers must understand/identify the situations at site and the risk of occurrence of occupational accidents and health problems for all construction workers. It is also necessary to comply with disaster prevention measures proposed by the main contractor.

8.7.3 Execution System and Persons in Charge

The project manager has the responsibility and authority of the following risk assessment implementation:

(1) Implementation of risk assessment for progress control;

(2) Ensure all workers and subcontract workers to participate in implementation of risk assessment;

(3) Determination of the priority of risk mitigation measures;

(4) Instructions for measures of risk assessment; and

(5) Fill out the risk assessment implementation activities (Table 8.6.1 ~ Table 8.6.4). Manage and record subcontractor's risk estimation, risk mitigation measures, and countermeasures for each work.

8.7.4 Practice of Risk Mitigation Measures (Plan)

Matters regulated by laws must be ruled with higher priority in consideration of risk evaluation results. Additionally, the JICA Study Team must study and practice risk mitigation measures.

Matters as provided for/by safety law must be conducted, based on the results of the risk assessments. Risk reduction measures in the following order of precedence or priority are shown below.

Priority-1: Remove hazardous work and risks from the planning stage of work

Priority-2: Physical measures of scaffolding, handrail, machines, and safety devices

Priority-3: Arrangement of site managers, qualified persons

Priority-4: Use of personal protective equipment (PPE) safety belt, protective mask, and life jacket

Table 8.7.1 Classify Injury and Wound

Suffering Degree		Evaluation (One as Standard)
Mortal, Serious	3	・ Death and eternal physical handicap ・ Suffered more than one month ・ Suffered more than three persons/time
Intermediate	2	・ Suffered less than one month ・ Suffered more than two persons/time
Slight	1	・ Hospitalized within three days and scratch

Source: Corporation Japan Labor and Health Consultant

Table 8.7.2 Classify Possibility of Injury and Wound

Suffering Degree		Evaluation (One as Standard)
High Possibility	3	・ Those who are often exposed to danger or hazards everyday ・ Difficult to avoid, carefully pay attention but leading to accidents
Possibility	2	・ Something exposed to danger and harmful effects in non-routine works such as repair or replacement, etc. ・ Inattentive actions leading to accidents
Few Possibility	1	・ Very few exposure to danger and harmful effects ・ Do not lead to accidents under normal conditions

Source: Corporation Japan Labor and Health Consultant

Table 8.7.3 Estimate Suffering Risk

Suffering Degree / Happened of Possibility			Degree of Injury and Disease		
			Mortal, Serious	Intermediate	Slight
			3	2	1
Possibility of Injury and Disease	High Possibility	3	9－III	6－III	3－III
	Possibility	2	6－III	4－II	2－I
	Few possibility	1	3－II	2－I	1－I

Source: Corporation Japan Labor and Health Consultant

Table 8.7.4 Establishing Priority

Priority	Risk	Establishing Priority	
Priority-1	III 9-6	Immediate countermeasures Serious risk：III	The suspended work shall be performed until implemention of countermeasures. Fund for measurement is necessary.
Priority-2	II 4-3	Prompt risk reduction measures: II	Monitor work until implementing the measures. Measure expenses and manpower are necessary.
Priority-3	I 2-1	Take actions for risk reduction measures: I	Re-examine skills for safety control system.
Priority-4	I 2-1	Re-education for workers: I	Intensify toolbox meeting.

Source: Corporation Japan Labor and Health Consultant

8.8 TRAFFIC CONTROL PLAN

The Project will comply with Myanmar traffic regulations in the construction area and public roads; and establish prevention measures of hazards in public areas and traffic accidents.

The employer / engineer will review the traffic safety plan submitted by the contractor from his perspective before issuing approval.

Since the items that constitute in the traffic safety plan as described below generally applied to all construction safety. The contractor shall incorporate all these items into his traffic safety plan.

Below is the composition of traffic control plan.

(1) Organizing safety committee: roles and responsibilities of safety committee and police authorities and cooperation;

(2) Appoint appropriate personnel: including a supervisor responsible for safety management, traffic control management, and arrange traffic watchman.

(3) Emergency contact and communication system: cooperate with hospitals and police stations and prepare carrying methods for victims.

(4) Follow the traffic regulations and laws: distribute traffic rules to all parties.

(5) Measures for traffic control of all construction sites: mark traffic lanes, set up traffic signboards, and establish internal traffic rules.

(6) Measures for traffic control of public roads: permit transportation through public roads for relevant authorities and arrange nighttime lighting and set up traffic signboards.

(7) Transportation through public roads of special vehicles: permit transportation through public roads of special trucks and considers leading and guiding cars.

(8) Arrangement of traffic watchman: consider appropriate places and patrol frequency or patrol routes.

(9) Measures for transportation routes of materials: traffic volumes, road width, conditions of road surface and durability, method of road reinforcement.

(10) Measures for working through motorcars of the project parties: check-up health for drivers and periodical inspection of motorcars and require attention to nighttime commuters.

8.9 SAFETY PLAN FOR WORKS OVER THE RIVER

The Bago River Bridge construction will comply with Myanmar water transport laws and regulations in

waterways and river areas and will establish prevention measures of water-related disasters and construction accidents on the sea/river.

The employer / engineer will review the safety plan of construction works over river submitted by the contractor from his perspective before issuing approval.

Since the items that constitute in the safety plan of construction work over water as described below generally apply to all construction safety, the contractor shall incorporate all those items into his safety plan of construction work over water.

8.9.1 Composition of Safety Plan for Works over the River

(1) Organize safety committee: roles and responsibilities of safety committee and cooperation of relevant authorities.

(2) Appoint appropriate personnel: including a supervisor responsible for safety management, navigation control management, and arrange navigation watchman.

(3) Follow the Myanmar water transport laws and regulations: educate seminars of safety work over river and distribute waterway regulations.

(4) Permit navigation of construction vessels: permit navigation through waterways for relevant authorities and consider watchman and leading ships.

(5) Arrange safety navigation signboards: indicate temporary fairway, restrict construction area, and nighttime lighting for construction area.

(6) Measures for transportation routes of materials: loading volumes, types of materials, and schedule of transportation plan.

(7) Refuge plan of construction vessels of refuge place and evacuation route: permit construction vessel refuge plan and notify to relevant authorities.

(8) Check system of works over the river for safety control: arrange guard ships, lifesaving equipment, protective equipment, and patrol temporary fairway and construction area on the river.

(9) Measures for abnormal weather: emergency contact and communication network when abnormal weather or earthquake happen and consider work suspension rules.

(10) Efficiency of cranes and heavy machines on the barge: inspection certification, licenses of operators and insurance against loss.

(11) Efficiency of construction barges: stability analysis and mooring method.

(12) Diving work: inspection of equipment for diving and diver licenses, and health states of divers are determined in advance.

8.9.2 Establish Temporary Fairway

(1) Establishing temporary fairway plan and restrictions are required to ensure navigation safety during the construction period.

(2) The Bago River Bridge place is in seasonal variation, surveys of water-way depth and velocity shall be carried out by the contractor for safety control of the temporary fairway and related access waterway.

(3) As per prior consultation with DWIR, water depth in the temporary fairways shall be surveyed regularly and the lowest at 5 m depth of the water must be always secured. In addition, the temporary fairways width is required at least 140 m for heavy barges sailing. Therefore, periodically observing the depth and flow velocity of the temporary fairway to ensure safe

navigation is necessary. In particular, water depth measurement in the dry season and low tide is an indispensable item.

(4) As per prior consultation with MPA, an access waterway connecting with the safe waterway on the upstream and downstream in the dry season is necessary. In addition, installation of beacons at the mentioned access waterway and leading ship is also required.

(5) Installation of buoys and beacons shall be performed in accordance with Myanmar standards. The specific plan of the contractor shall be included to obtain permission from the relevant authorities.

Construction Stage 1:

- Construction of all foundation and substructures in the river and launching girders from P16 to P18
- Planning temporary fairway-1 at P11~ P12 (span-224 m)
- Width of temporary fairway is 140 m (shown in Appendix Drawings: P1-REF-0002)

Construction Stage 2:

- Relocation of temporary fairway-2 at P16~P18
- Launching girders of the cable-stayed bridge from P10 to P13 and erection of all girders in the river side.
- Width of temporary fairway-2 is 70 m for one lane (shown in Appendix Drawings: P1-REF-0003)
- The contractor is possible to navigate the temporary fairway-1 when launching girders of the cable-stayed bridge in emergency cases.

8.9.3 Cautious System and Arrangement of Guard Ships (Navigation Control Station)

(1) The contractor shall arrange guard ships to ensure safety during the construction period in the Bago Bridge construction and promote accident prevention works over the river for safety.

(2) The contractor shall necessarily arrange guard ships, equipment, and emergency facilities. Safety plan of works over river must be submitted for review and approval by the employer and engineer.

(3) The tug-boat is practicable for safety control of the drifting ships and breakdown ships in the construction area. In addition, unifying information, instructions, and emergency contact of the tug - boat on the bases is necessary (Navigation Control Station).

Table 8.9.1 Arrangement of Required Facilities and Equipment

Name of Equipment's	Unit	Navigation Control Station		Remarks
		Quantity Tugboat	Quantity Speed boat	
Tugboat with capacity equal to 190 CV	No	1	-	Control station
Speedboat with capacity equal to 50 CV	No	-	1	Upstream Leading all ships
Speedboat with capacity equal to 50 CV	No	-	1	Downstream Leading all ships
ICOM MR 1000	No	1	-	Watch Radar
VHF M72 hand-held device	No	2	2	Communication
ICOM M402 communication device	No	1	2	Emergency contact

1000 w headlight	set	1	-	Warning, watch
Binoculars	set	2	2	Watching vessels
Sign fire gun	set	3	2	Warning, leading ships
Pennant	set	2	2	Warning, leading ships
Electric loud speaker	set	2	2	Warning, leading ships
Life jacket, life buoy	set	5	4	Prevention drown
First- aid kits	set	1	2	First –aid treatment
Fire extinguisher	set	3	2	Early stage extinguishes

Source: JICA Study Team

8.10 MEASURES FOR PREVENTION OF PUBLIC ACCIDENTS

The contractor shall prepare and undertake the work according to the measures for prevention of public accidents on safety that was prepared by themselves. Whenever the measures for prevention of public accidents on safety need to be amended in consideration of the latest site conditions, traffic situations, and natural environmental conditions and/or any other relevant particulars, the contractor shall update and maintain the documents for review and approval by the employer and the engineer.

Since the items that constitute in the measures for prevention of public accidents described below generally apply to all construction safety, the contractor shall incorporate all these items in his measures for prevention of public accidents.

The composition of measures for prevention of public accidents is shown in the following aspects:

(1) Prevention of entry to material stockyards or parking lots: installation of temporary enclosures and fences, periodic patrols of security guard

(2) Measures for the area around the entrance of construction sites: arrangement of security guard and set up “no- trespassing” boards and gates

(3) Understand neighboring construction area: explanation of construction contents and period to the neighbors and seeking their agreement

(4) Cleanliness and tidy up on site: lodging patrols, sanitation control

(5) Measures for prevention of the accidents caused by flying or falling objects for the third party: protection of houses, protection of public roads

(6) Measures for prevention of dust separation: reducing the amount of dust separation, protection of cover sheets on truck

(7) Prevention of noise and vibration: mitigate sources of noise or vibration, examination of reduced method, consideration of sound-proof wall

(8) Installation of nighttime lighting: consider brightness of lighting and lighting place

(9) Night and early morning works: explain the construction contents to the nearby residents and seek their agreement

(10) Site patrols: safe keeping patrol records

8.11 METHOD STATEMENT ON SAFETY PLAN

The method statement on safety shall define a detailed plan to implement and manage safety in the Project and include specifications for the safe execution of works and safety measures for each type of work in accordance with the execution plans specifying the method or sequence of implementation.

The employer / engineer will review the method statement on safety plan submitted by the contractor from his perspective before issuing approval.

The composition of method statement on safety plan is shown in the following aspects:

(1) In accordance with the safety regulations: safety regulations and standards in Myanmar and original rules of the Contractor.

(2) Appointment of foreman and safety manager: the chain of command on site, voluntary safety management activities, and safety education.

(3) Arrangement plan of workers and qualification: arrange the workforce and number and qualification of skilled workers.

(4) Used of suitable machines and inspection certificate: standard of construction machines and devices and number.

(5) Execute morning gathering: roll calling on start work and closing work, confirmation on the state of health and personal protective equipment.

(6) Procedures of construction method for each work item: construction method and foreseeing hazardous activities shall be informed to all workers.

(7) Foreseeable risks: all foreseeable risks for each work item.

(8) Precautionary measures: the contractor shall review and include precautionary measures to prevent occurrence of foreseeable risks, including information on the type of protective gear required for the works.

(9) Establishment of signal and make a sign: posted in the construction site for signal and sign and uniform of signer clothes.

(10) Notice of device and machines: approved in advance.

(11) Safekeeping of dangerous substance: keeping place and the person in-charge, method of safekeeping and kind/number.

(12) Emergency device: lifesaving equipment and measures of rescue, refuge place, rules of suspension work for the notice on site.

8.12 KEY POINTS OF CONSTRUCTION SAFETY PLAN (REQUIRED ATTENTION MATTERS)

8.12.1 Construction of Bago River Bridge

The Bago Bridge construction belongs to a contract of two packages. However, all information from relevant authorities such as weather conditions, precautionary, warnings, or information on strange/special vessels shall be shared and confirmed as well as joint meetings/inspections/patrols shall be carried out by both packages: Package 1 and Package 2.

Special required attention for Bago Bridge construction will be given to the following:

(1) Join weekly and monthly meeting by Package 1 and Package 2: the employer, the engineer, and the contractor

(2) Join weekly or monthly patrol by Package 1 and Package 2: the employer, the engineer, and the contractor

(3) Emergency communication system: the contact system for both packages and responsible person in-charge

(4) Report system of accidents: systematize rescue works (if accidents happened including outsiders)

(5) Rescue training and education: joint training, cooperation of Package 1 and Package 2 if disasters happened and arrangement of lifesaving equipment

(6) Measures for abnormal weather and information of strange/special vessels: precautionary or warning for the both packages at the same time

(7) Rules of work suspension (abnormal weather or earthquake): settle same rules of work suspension for Package 1and Package 2.

8.12.2 Construction of Thaketa Flyover

In addition, there is an important and dense population area in Thaketa Flyover construction site. Hence, construction of the flyover while maintaining the existing transportation of Thanlyin Chin Kat Road, Yadanar Intersection, and Shukhinthar Intersection has high potential safety risks. Assuming all risks and identifying hazards and dangers in construction site in order to evaluate priorities based on a reasonable basis, the contractor shall implement appropriate mitigation measures from risks.

Required attention to Thaketa Flyover construction is shown in the following aspects:

(1) Reduce vibration and noise: select low vibration and noise machines.

(2) Measures for prevention of accidents involving flying or falling objects: measures for installation of safety nets and work conducted at different heights or work with rotating machines.

(3) Prevention of collapse: temporary structures, temporary material storage.

(4) Protection of underground utilities and aerial utilities: consideration of protection methods.

(5) Prevention on entering site area: boundary fence on site, arrangement of security guard man.

(6) Measures for traffic regulation: traffic restriction on detour roads and at night time, drive safely on the temporary road.

(7) Measures for prevention of dust separation: preventing dust from scattering to the close area, reducing the amount of dust separation.

(8) Arrangement of traffic watchman and traffic guide: speed limit of the construction vehicles and indicating public roads.

(9) Explanatory meetings for the residents annoyed by the construction: inform traffic restriction and detour roads to the residents nearby the construction site. Agreement by the residents is required if the construction works have to carry out on the early morning or nighttime.

8.12.3 Approach Road and Tollgates

Approach roads and tollgates are near the right bank and left bank of the Bago River. In addition to consideration of Thaketa Flyover construction, safety measures and protective measures as well as in particular, flood safety measures in the area should be noted as follows:

Required attention to approach roads and tollgates are the following:

(1) Past damaged flood record: damaged causes, water levels, and tide levels

(2) Preparation of stockyard at the construction yard: design elevation, scoured protection

(3) Observation of high water level: arrangement of watchman and water level indicator

(4) Prevention of collapse: temporary structures, temporary material storage

(5) Publicity work for refuge and evacuation route: preliminary warning signal and contact method

CHAPTER 9. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

9.1 OBJECTIVES OF THE TASKS ON ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The Environmental Impact Assessment (EIA) Procedure established in December 2015 in Myanmar (EIA Procedure 2015) stipulates to implement EIA for constructing a new bridge with a length of more than 2 km and to implement an Initial Environmental Evaluation (IEE) for a new bridge with a length of less than 2 km. The construction of a new viaduct of less than 2 km needs to implement IEE, while EIA is necessary in case the length is more than 2 km according to the EIA Procedure 2015.

As for the Project, the length of Bago River Bridge was designed less than 2 km and the intersection in Thaketa side was also designed as less than 2 km at the time of Feasibility Study (F/S) and Supplemental F/S. Accordingly, the IEE report for construction of the Bago River Bridge and improvement of intersections was prepared in F/S and Supplemental F/S respectively by conducting field survey. Under this situation, the objectives of environmental and social considerations of the Project are:

i) Update the two separate IEE reports (i.e., the report for construction of Bago River Bridge and the report for improvement of intersections, which were prepared at F/S and Supplemental F/S, respectively) by conducting field survey to the latest project design and by holding a consultation meeting,

ii) Support the Ministry of Construction (MOC) to proceed the official procedure for obtaining Environmental Compliance Certificate (ECC) for the Project[1].

iii) Finalize the draft Abbreviated Resettlement Action Plan (A-RAP) prepared in the F/S and Supplemental F/S by conducting necessary survey in the project area and holding consultation meeting with Project Affected Persons (PAPs).

Updating the two separate IEE reports and support MOC for obtaining ECC are explained in Section 9.2 and finalizing the draft A-RAP is explained in Section 9.3.

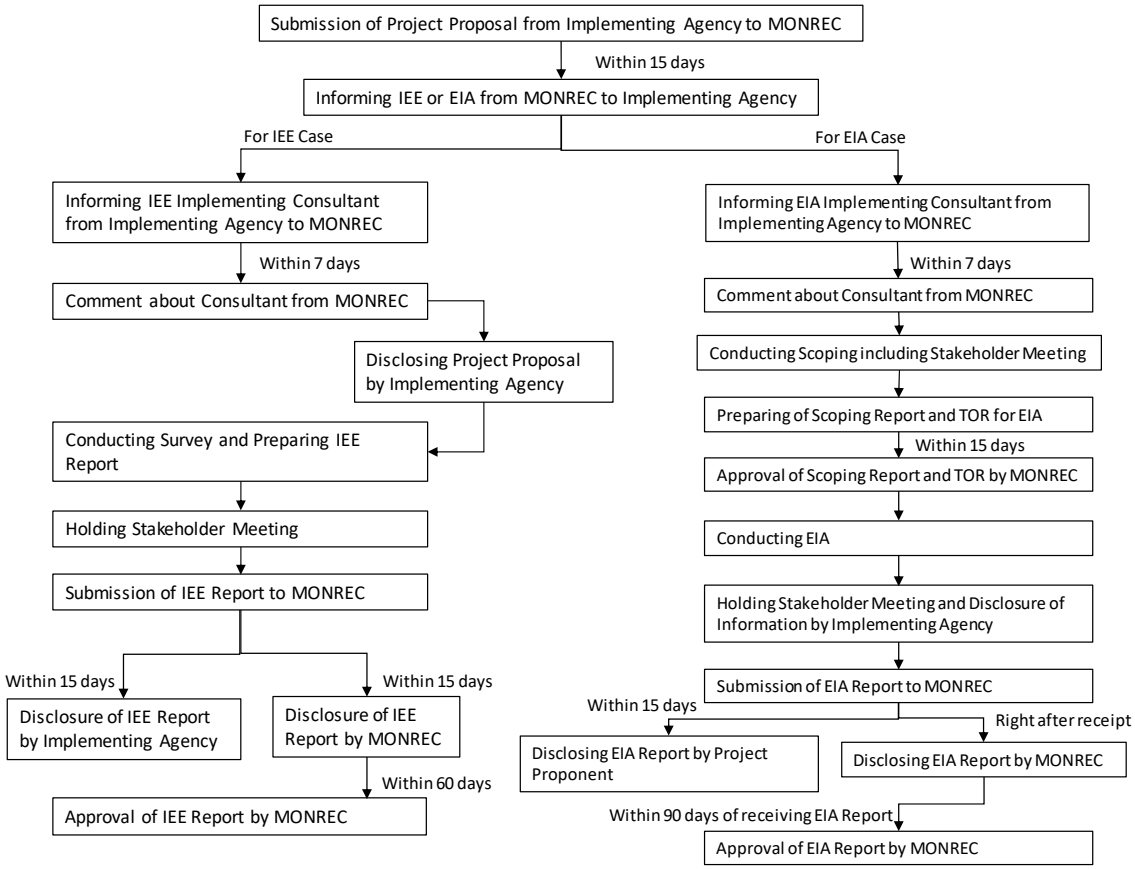
9.2 ENVIRONMENTAL CONSIDERATIONS

9.2.1 Review IEE Report and Approval by MONREC

The two separate IEE reports (i.e., the report for bridge construction and the report for improvement of intersections) were submitted from MOC to the Ministry of Natural Resources and Environmental Conservation (MONREC) in March 2017. Meanwhile, two separate IEEs conducted in F/S and Supplemental F/S were updated in basic design (B/D) by reviewing these reports and conducting field survey to the latest project design for checking the latest environmental condition in and around the project area.

After submission of the two separate IEE reports, MONREC regarded bridge construction and intersection improvement as the sole project, and therefore, preparation of one EIA report in accordance with EIA Procedure was required. Thus, the Japan International Cooperation Agency (JICA) Study Team supported MOC to combine the two separate IEE reports into one EIA report to satisfy the requirements stipulated in the EIA Procedure. The Scoping Report was submitted from MOC to MONREC in the middle of July 2017 as the initial step in the EIA Procedure (December 2015), and comments to the submitted report was issued by MONREC dated 27 September 2017. Following to Scoping Report, MOC submitted EIA report to MONREC on 8 November 2017, and the report is now reviewed by MONREC. Details are explained in the Section 9.2.3.

[1] ECC is issued by the Ministry of Natural Resources and Environmental Conservation (MONREC), and is necessary for constructing structure.



Source: Compiled by the JICA Study Team based on the Environmental Impact Assessment Procedure (EIA Procedure 2015) in Myanmar established in December 2015

Figure 9.2.1 IEE and EIA Steps based on EIA Procedure 2015

9.2.2 Environmental Survey

9.2.2.1 Survey Schedule

Table 9.2.1 shows the contents of field survey conducted in this B/D for updating the IEE reports. Field survey for the first season, which was in the rainy season in 2016, was conducted in October-November 2016. The field survey for the second season, in the dry season in 2017, was conducted in January-February 2017.

Table 9.2.1 Field Survey Plan for Environmental Study for Updating IEE

Field Survey Items	Location	Method Period	Parameters
Air quality	Five locations	・Rainy and dry seasons ・Continuous 24 hours at each location (1 weekday)	NO2、SO2、CO、PM10、PM2.5
Noise	–Same as above-	・Dry season ・Continuous 24 hours at each location (1 weekday)	Equivalent sound level (Leq)
Water quality	Five locations ※Crossing point at the river (3 points) Downstream (3 points)	・Rainy and dry seasons	Temperature 、 turbidity (NTU), pH, BOD5, COD, SS, DO, oil and grease, T. coliform, T. nitrogen, T. phosphorous, salinity
Bottom sediments	Same as above	・Dry season	As, Pb, Cr, Cd, Cu, Zn, Oil

Field Survey Items	Location	Method Period	Parameters
			and grease
Soil	Five locations	・Dry season	Cd, pH, Cu, Zn, Pb, Mn, As, Fe and Cr
Flora and fauna	Vegetation on each side of the Bago River at the bridge crossing point	・Rainy and dry seasons ・Reviewing existing data ・Hearing to relevant institutions	Record of endangered species (IUCN Red List), breeding colonies, rare habitat, regional park, photos
Inventory for affected trees along the road	Right-of-way (ROW) and construction yards	・Hearing survey ・Field survey (no. of trees to be cut) ・Reviewing existing information	No. of trees, species, tree height, diameter (Dbh), photos

Source: JICA Study Team

Note: BAN-1-5: Air and noise sampling points, BSW-1-6: Water and bottom sediment sampling points, Soil Pt-1-5: Soil sampling points

Source: JICA Study Team

Figure 9.2.2 Sampling Points for Pollution Parameters Measurement (Air, Noise, Water, Sediment, and Soil)

9.2.2.2 Air Quality and Noise Measurement

(1) Scope of the Survey

Prior to the field measurement, the survey points for the air quality and noise measurement have been determined at the most suitable location to be monitored for environmental air quality in the area. For the selection of the points, the following criteria is referred:

1) Representative points for the area.

2) Potentially affected area.

3) The point where the object to be preserved exists.

4) Points where the environment has already deteriorated.

5) Places where pollution is currently progressing.

The measurement sites were also selected avoiding direct interference of obstacles such as walls and tree shed.

Considering the field condition affected by proposing project activities, the following locations are selected in the Thaketa and Thanlyin sides:

Table 9.2.2 Sampling Points for the Air Quality and Noise Survey

No.	ID	Coordinate	Location
1	BAN-1 (Thaketa)	N16°48'3.72", E96°13'39.68"	At the boundary of the National Race Village; one of the representative points where the air environment has retained comparatively good condition.
2	BAN-2 (Thaketa)	N16°48'8.45", E96°13'29.61"	At the boundary of Pyae Loe Chan Thar Min Nanda Pagoda; one of the representative points where it is located along the road to be improved and it is one of the sensitive receptors located adjacent to the project site.
3	BAN-3 (Thaketa)	N16°47'58.17",E96°13'32.01"	At the boundary of the Bridge Special Unit 11 Office in DOB in MOC, one of the representative points where the developing works are in progress.
4	BAN-4 (Thanlyin)	N16°46'46.51", E96°14'17.88"	At the boundary of Htut Khaung Family Co. Ltd.'s Housing Area; one of the representative points potentially affected by bridge construction.
5	BAN-5 (Thanlyin)	N16°46'39.39",E96°14'29.22"	At the boundary of the Tharyar Kone Monastery Education School; one of the representative points in the area where it is located close to the intersection in Thanlyin and it is one of the sensitive receptors located adjacent to the project site.

Source: JICA Study Team

(2) Result of the Air Quality Measurement

All results in CO and NO_2 are under standard values in Japan in both the rainy and dry seasons. All results of SO_2 in the rainy season exceeded the standard values in Myanmar (all standards); however, those in the dry season slightly exceeded the standard value. The results of the PM10 and PM2.5 in the dry season significantly exceeded the standard value although all results in the rainy season are under standard value.

Table 9.2.3 Result of Air Quality Measurement

Parameter	Date	BAN-1	BAN-2	BAN-3	BAN-4	BAN-5	Guideline Value in EQG - Myanmar (24 hrs.)	Environmental Standards - Japan (24 hrs.)	Environmental Standards - Thailand (24 hrs.)	WHO Standards
		Unit: ppm								
SO2	Rainy season Oct. 22-31, 2016 (24-hour average)	0.19	0.21	0.15	0.12	0.17	<0.02	<0.04	<0.12	<0.02
	Dry season, Jan. 13-17, 2017 (24-hour average)	0.04	0.05	0.03	0.04	0.06				
CO	Rainy season Oct. 22-31, 2016 (24-hour average)	0.24	0.2	0.2	0.1	0.25		<10		
	Dry season, Jan. 13-17, 2017 (24-hour average)	0.7	0.52	0.92	0.68	0.97				
NO2	Rainy season Oct. 22-31, 2016 (24-hour average)	0.034	0.057	0.054	0.016	0.015		0.06		
	Dry season, Jan. 13-17, 2017 (24-hour average)	0.016	0.031	0.031	0.020	0.019				
PM10	Rainy season Oct. 22-31, 2016 (24-hour average)	0.005	0.005	0.02	0.007	0.01	0.05	0.1	0.12	0.05
	Dry season, Jan. 13-17, 2017 (24-hour average)	0.13	0.06	0.20	0.18	0.16				
PM2.5	Rainy season Oct. 22-31, 2016 (24-hour average)	0.006	0.014	0.023	0.007	0.008	0.025	0.15	0.05	0.025

Parameter	Date	BAN-1	BAN-2	BAN-3	BAN-4	BAN-5	Guideline Value in EQG - Myanmar (24 hrs.)	Environmental Standards - Japan (24 hrs.)	Environmental Standards - Thailand (24 hrs.)	WHO Standards
		Unit: ppm								
	Dry season, Jan. 13-17, 2017 (24-hour average)	0.041	0.063	0.051	0.17	0.04				

Source: JICA Study Team

(3) Result of Noise Measurement Survey

Ambient noise level in the project area is high and it only clears the standards level in the Industrial Area even at night time. Among the areas, the result at the Pyae Loe Chan Thar Min Nanda Pagoda (BAN-2) on the road side of the Thanlyin Tin Kat Road shows the lowest level than the others and result at the boundary of the Bridge Special Unit 11 Office in DOB in MOC, one of the representative points where the developing works are on progress (BAN-3), shows the highest level both at daytime and night time.

Table 9.2.4 Result of Ambient Noise Measurements

Station	BAN-1	BAN-2	BAN-3	BAN-4	BAN-5	Ambient Noise Standards (Japan)**			Guideline Value in EQG***	
Daytime/ Nighttime	Sound Level (dB)					Sensitive Area (AA)	Residential Area	Commercial and Industrial Area (C)	Residential, Institutional Education	Industrial Area
Daytime (6 am - 10 pm)	67.4	61.1	69.9	65.2	68.4	50 dB	55 dB	60 dB	55 dB	70dB
Nighttime (10 pm - 6 am)	66.2	58.7	67.7	62.9	63.5	40 dB	45 dB	50 dB	45 dB	70 dB

Note (**): Ministry of Environment, Japan (1998): Environmental Quality Standards for Noise
Note (***): Daytime in EQG in Myanmar is from 7:00 a.m. to 10:00 p.m.(10:00 a.m. to 10:00 p.m. for public holidays) and night time is from 10:00 p.m. to 7:00 a.m.(10:00 p.m. to 10:00 a.m. for public holidays).
Source: JICA Study Team

9.2.2.3 Water Quality and Bottom Sediment Measurement

(1) Scope of the Survey

Referring to the existing result of the water quality survey, surface water samples from the Bago River were taken for the analysis in this period at the rainy season (October 20, 2016) and dry season (February 6, 2017). The measuring points were located at the approximate area for the alignment of the bridge structures and its approximately 1,200 m of the downstream. With the measurement of the water depths to grasp approximate water flow and considering those effects to the result, water samples from the right side, left side, and middle points of the river were taken and analyzed.

Table 9.2.5 Monitoring Points for Water Quality and Bottom Sediment Measurements

No.	ID	Coordinate	Location
1.	BSW-1	N 16°47'35.70", E 96°13'50.28"	Right side of the river flow at approximate new bridge location
2.	BSW-2	N 16°47'25.39", E 96°13'57.67"	Middle of the river flow at the approximate new bridge location
3	BSW-3	N 16°47'14.87", E 96°14'1.94"	Left side of the river flow at approximate new bridge location
4	BSW-4	N 16°47'15.15", E 96°13'13.77"	Right side of the river flow at downstream of the new bridge location
5	BSW-6	N 16°47'0.20", E 96°13'26.16"	Left side of the river flow at downstream of the new bridge location

Source: JICA Study Team (data obtained in 2017)

(2) Result of the Water Quality and Bottom Sediment Measurement

Water in the area in the rainy season shows a characteristic of contaminated water with very high suspended solid (SS) having a range of 372-652 mg/l, low dissolved oxygen (DO) having a range of 1.94-2.80 mg/l, and high total coliform having a range of 30,000-90,000 MPN/100 ml and comparatively high BOD and COD in both seasons having a range of 1.94-2.80 mg/l and 1.0-5.7

mg/l, respectively. Especially for the SS, the result in the rainy season shows seven times higher than the standard level in Myanmar (50 mg/l) in the lowest value.

Similar to the rainy season, water in dry season shows a characteristic of contaminated water with very high SS having a range of 950.00-4,056.00 mg/l, very high total coliform having a range of 35,000-more than 160,000 MPN/100 ml, and high COD having 2.9-24.0 mg/l. The difference between the results of two measurement periods is very high, especially in terms of SS, DO, BOD, COD, and total coliform.

Table 9.2.6 Results of Water Quality Measurements (Rainy Season)

No	Parameter	Unit	BSW-1	BSW-2	BSW-3	BSW-4	BSW-6	Environmental Standards		Guideline Value Set in EGQ
								Japan	Vietnam	
1	Temperature	˚ C	20.4	20.9	21.0	21.2	21.2	-	-	-
2	Turbidity/ Transparency		400.64	392.91	353.29	347.40	382.10	-	-	-
3	Water Depth (channel)	m	5.25	4.36	5.14	9.04	1.6	-	-	-
4	Depth (of sample taken)	-	Surface	Surface	Surface	Surface	Surface	-	-	-
5	pH	S.U[a]	6.9	6.8	6.8	6.9	6.9	6.5~8.5	5.5～9	6-9
6	BOD5	mg/l	2.01	2.68	2.80	1.94	2.25	3	15	30
7	Suspended Solids (SS)	mg/l	452	372	436.00	494.00	652.00	25	50	50
8	Dissolved Oxygen (DO)	mg/l	3.02	2.50	1.87	2.86	2.05	>=5	>=4	-
9	Oil and Grease	mg/l	<3.1	<3.1	<3.1	<3.1	<3.1	-	10	10
10	E. Coli	MPN/100 ml						-	-	
11	Fecal Coliform	MPN/100 ml						-	-	-
12	Total Coliform	MPN/100 ml	30,000	90,000	50,000	30,000	90,000	5 x 10^3	7.5 x10^3	400
13	COD	mg/l	3.7	4.3	5.7	1.6	1.0	5	30	125
14	Total Nitrogen	mg/l	1.9	2.3	2.6	2.1	2.3	-	-	10
15	Total Phosphorous	mg/l	0.412	0.360	0.516	0.412	0.544	-	-	2
16	Salinity	%	0.01	0.01	0.01	0.01	0.01	-	-	-

Source: JICA Study Team (data obtained in 2017)

Table 9.2.7 Results of Water Quality Measurements (Dry Season)

No	Parameter	Unit	BSW-1	BSW-2	BSW-3	BSW-4	BSW-6	Environmental Standards		Guideline Value Set in EGQ
								Japan	Vietnam	
1	Temperature	˚ C	28	27.3	27.3	26.7	27	-	-	-
2	Water Depth (channel)	m	7.62	5.8	7.5	13	3	-	-	-
3	Depth (of sample taken)	-	3.81	2.9	3.75	6.5	1.5	-	-	-
4	pH	S.U[a]	8.01	8.09	8.08	8.07	7.97	6.5~8.5	5.5～9	6-9
5	BOD5	mg/l	4.72	2.88	4.09	4.62	6.78	3	15	30
6	Suspended Solids (SS)	mg/l	2,600	950.00	4,056.00	1,008.00	2,292.00	25	50	50
7	Dissolved Oxygen (DO)	mg/l	7.42	7.06	7.97	6.86	7.06	>=5	>=4	-
8	Oil and Grease	mg/l	13.80	<3.1	7.00	<3.1	6.57	-	10	10
9	E. Coli	MPN/100 ml	17.0	94.00	24.0	17.0	4.0	-	-	
10	Total Coliform	MPN/100 ml	35,000	>160,000	160,000	35,000	92,000	5 x 10^3	7.5 x 10^3	400
11	COD	mg/l	24.0	7.6	20.0	2.9	18.0	5	30	125
12	Total Nitrogen	mg/l	9.2	5.6	0.9	2.9	5.0	-	-	10
13	Total Phosphorous	mg/l	1.440	0.602	0.378	0.596	0.820	-	-	2
14	Salinity	%	0.50	0.50	0.44	0.40	0.39	-	-	-

Source: JICA Study Team (data obtained in 2017)

For the bottom sediment, there are no particular official standard values presented by the government. As reference, Long et al., 1995, presents the guideline value which some chemical content levels appear in the biological effect at the lower level as Effect Range Law (ERL) and at the median level as Effect Range Median (ERM), corresponding to 10-percentile and 50-percentile based on the database. The contents of the lead, chromium, cadmium, copper, and zinc in the sediment are exceeding the ERL, which

some effects are possibly appearing in the biological environment. However, those levels are still not exceeding ERM level at all which is recognized as critical level.

Table 9.2.8 Results ofthe Bottom Sediment Survey

Sr. No.	Parameter	Bottom Sediment					Unit	Sediment Quality Guideline (Long et al, 1995)	
		BSD-1	BSD-2	BSD-3	BSD-4	BSD-6		ERL(ppm)	ERM(ppm)
1	Arsenic (As)	ND	ND	ND	ND	ND	ppm	8.2	70
2	Lead (Pb)	60.90	66.29	46.58	64.29	30.93	ppm	46.7	218
3	Chromium (Cr)	180.52	204.47	176.13	267.86	135.08	ppm	81	370
4	Cadmium (Cd)	3.57	3.79	2.60	4.56	1.76	ppm	1.2	9.6
5	Copper (Cu)	36.10	38.94	21.19	44.64	6.26	ppm	34	270
6	Zinc (Zn)	211.27	281.55	129.75	305.56	40.92	ppm	150	410
7	Natural Moisture Content	61.13	80.35	36.05	86.93	13.82	%	-	-
8	Specific Gravity	1.314	1.926	1.203	1.752	2.191	-	-	-
9	Oil and Grease	ND	413	ND	153	547	mg/kg	-	-

Source: JICA Study Team (data obtained in 2017)

9.2.2.4 Soil Measurement

(1) Scope of the Survey

Referring to the drawing of project affected area (received in November), soil survey points were selected to grasp the representative soil situation in the area. The soil survey is aimed to have a baseline data for the impact on soil contamination by the Project. The soil specimens were sampled on February 7, 2017 in dry season. The entire project area is divided two, namely, the Thanlyin side and Thaketa side. In Thanlyin side, the project affected area is divided into two (i.e.,east side and west side of the existing bridge). In Thaketa side, project affected area is divided into three (i.e., the river side area, road side, and additional work yard) as shown below.

Table 9.2.9 Monitoring Points for the Soil Survey

No.	ID	Coordinate	Location
1.	S-1	N 16°46'57.01", E 96°14'20.35"	East side of the existing road (Bridge) within the affected area (Thanlyin)
2.	S-2	N 16°46'57.48", E 96°14'15.07"	West side of the existing road (Bridge) within the affected area (Thanlyin)
3	S-3	N 16°47'50.57", E 96°13'43.06"	West side of existing road and east side of the new road within the affected area (Thaketa)
4	S-4	N 16°47'59.10", E 96°13'34.12"	Near the existing road within theaffected area (Thaketa)
5	S-5	N 16°48'2.96", E 96°13'30.92"	West side of Thanlyin Chin Kat Road and north side of Shukinthar Mayopat Road at expecting work yard (Thaketa)

Source: JICA Study Team (data obtained in 2017)

(2) Result of the Soil Analysis

There is no standard related to soil in Myanmar, and Japanese standard on soil was referred to evaluate the current soil condition. From the observed condition, it is evaluated that soil condition in the project area was not contaminated.

Table 9.2.10 Result of the Soil Survey

Sr. No.	Parameter	S-1	S-2	S-3	S-4	S-5	Unit	Soil Standard (Japan)
1	Lead	42.74	54.71	54.11	37.02	89.42	ppm	150 mg/kg
2	Chromium	174.83	455.99	613.02	736.49	687.41	ppm	-
3	Cadmium	2.53	4.16	3.00	2.97	3.35	ppm	150 mg/kg
4	Copper	10.49	24.58	32.35	27.57	28.36	ppm	125 mg/kg
5	Zinc	123.54	259.66	299.52	306.87	386.05	ppm	-
6	Manganese	0.09	0.17	0.14	0.15	0.1	%	-
7	Iron	2.72	3.96	5.33	4.29	3.94	%	-
8	Arsenic	N.D	N.D	N.D	N.D	N.D	%	150 mg/kg
9	pH Value	7.23	7.02	7.1	6.54	8.21		-

Source: JICA Study Team (data obtained in 2017)

9.2.2.5 Flora and Fauna

(1) Scope of the Survey

The field surveys covering two different seasons, namely; rainy and dry seasons were conducted (October 28 to November 10, 2016 for rainy season, and January 23 to 27, 2017 for dry season). Survey included interview survey for fish species, flora survey by transect, and fauna survey by trapping.

(2) Result of Flora Survey

No critical disturbance for the habitat of endangered species identified in the study. The area is already developed for the city and most of trees are planted for shade. Based on the updated project area, similar to the previously informed two tree species, three artificially introduced endangered tree species included in the International Union for Conservation of Nature (IUCN) Red List were newly found on the road side plantation. The trees are not native species and brought to be planted for road side trees and no critical adverse impact is envisaged to disturb their natural habitats. These are listed below.

Table 9.2.11 Tree Species Listed in the IUCN Red List in the Survey Area

Scientific Name	Family Name	Myanmar Name	Habit	IUCN Red List Category	Remarks
Delonix regia (Bojer ex Hook.) Raf.	Caesalpiniaceae	Seinban	Tree	Least concern	(previously vulnerable 1998)
Swietenia macrophylla King	Meliaceae	Mahogani	Tree	Vulnerable A1cd+2cd	Native in South America
Pterocarpus indicus Willd.	Fabaceae	Padauk	Tree	VulnerableA1d	Native in South and Southeast Asia widely used for plantation
Mangifera indica L.	Anacardiaceae	Thayet	Tree	Data deficient	Native in India
Borassus flabellifer L.	Arecaceae	Htan	Tree	Endangered B2ab (iii);D	Native in Madagascar

Source: JICA Study Team (data obtained in 2017)

(3) Result of Fauna Survey

No particular natural habitat for endangered species or remarkable natural feature to be affected by the project identified during the survey in F/S and Supplemental F/S. To secure the previous survey conducted during F/S and Supplemental F/S, field surveys on the fauna were conducted in two seasons (dry and rainy seasons). All species were identified by field observation by the wildlife specialist, confirming at the site observation based on the prior prepared checklist through interview with the residents and survey literatures review. There were 38 birds (38 species in the rainy season, 28 species in the dry season) one reptile (rainy and dry seasons), three amphibians (rainy and dry seasons), and 100 fishes (57 species in the rainy season and 42 species in the dry season) identified

in the survey area. Among the fish species, two introduced exotic species, which are listed in the IUCN Red List, were found at the survey and those might be introduced for aquaculture as food source.

Table 9.2.12 Fish Species listed in the IUCN Red List in Survey Area

Scientific Name	Family Name	Common Name	Myanmar Name	IUCN Red List Category	Remarks
Cyprinus carpio	Cyprinidae	Common carp	Jaun-soun-nga-kjin	VulnerableA2ce	Native in Central Asia
Pangasius sutchi	Pangasiidae	Striped cat fish	Nga-dan	Endangered A2bd+4bcd	Native in the Chao Phraya River and Mekong River

Source: JICA Study Team (data obtained in 2017)

9.2.2.6 Inventory for Affected Trees along the Road and Construction Yards

Inventory for affected trees was conducted for the project area (i.e., road and approach road to the Bago River Bridge, intersections, and the candidate sites for construction yard). Based on information collected through inventory of affected trees, MOC would start the official procedure for tree cutting in Thaketa Township and Thanlyin Township.

Source: JICA Study Team

Figure 9.2.3 Location of the Suvey Area for Tree inventory (Thaketa)

Source: JICA Study Team

Figure 9.2.4 Location of the Suvey Area for Tree Inventory (Thanlyin)

Table 9.2.13 TreeSurvey Area and Survey Contents

Area No.	Land Ownership	Survey Area (m^2)	Survey Area	No. of Trees
①	Myanmar Railways	8,200	Area at the corner between Shukhinthar Mayopat Road and Thanlyin Chinkat Road in Thaketa	90 trees
②	Department of Urban Housing Development (DUHD), MOC	5,500	Area along Shukhinthar Mayopat Road adjacent to above ① in Thaketa	24 trees
③	YCDC	42,000	Existing ROW along the Thanlyin Chinkat Road in Thaketa	325 trees
④	YCDC and Myanmar Railways	5,600	Area at the junction between Nawarat Road and Approach Road to the existing bridge in Thaketa	149 trees
⑤	Myanmar Railways	67,300	Area at the west side of the existing bridge and east side of the small access road to MOC Office in Thaketa	80 trees
⑥	DUHD, MOC	19,000	Area at the east side of the existing bridge (Starting point from the pier of existing bridge (approximate coordination point 16° 47′ 57.8″ N, 96° 13′ 44.0″ E). End point is 200 m from starting point) in Thaketa	61 trees
⑦	Department of Water Resources and Improvement of River System (DWIR)	10,000	Area at the east side of the existing bridge at the river bank adjacent to above ⑥ in Thaketa	57 trees
⑧	Myanmar Railways	111,000	Area of the west side and east side of the existing bridge surrounding by local roads in Thanlyin	395 trees
⑨	Myanmar Port Authority	34,500	Area of the west side of the existing bridge at the Bago River bank adjacent to the above ⑧ in Thanlyin	664 trees

Source: JICA Study Team (data obtained in 2017)

9.2.3 Update of IEE Report to EIA Report

Two IEE reports prepared separately in F/S and Supplemental F/S were submitted from MOC to MONREC in the middle of July 2017. In parallel with submission of two IEE reports to MORENC,

environmental conditions were updated to examine environmental impact based on the latest project description and surrounding environmental conditions.

It was informed verbally by the interview from MOC to MONREC at the end of May 2017 that the Project is requested to conduct EIA as explained in the Section 9.2.1, which was also informed by MONREC with the official letter dated 3 August 2017. Accordingly, two separate IEE reports are necessary to be compiled into one EIA report.

The Scoping Report including: i) the project description, ii) the legal framework, iii) EIA study team organization, iv) surrounding environmental conditions, v) potential environmental impacts and mitigation measures, vi) stakeholder meeting and vii) conclusion and recommendations) was initially prepared according to the requirement in EIA Procedure (December 2015), which was submitted from MOC to MONREC in the middle of July 2017. Comments to the submitted Scoping Report dated 27 September 2017 were provided by MONREC. Major comments are summarized below. These comments were reflected in to the Revised Scoping Report, which was submitted to MONREC on 25 October 2017.

- Describe schedule of project implementation and public consultation
- Describe materials and machines to be used and power source
- Describe summary of the residual impacts and mitigation measure.
- Announcement of the project to public

Field survey was conducted in the rain season of 2016 and the dry season of 2017 based on the results of scoping to update IEE prepared during F/S and Supplemental F/S. The results of field survey were used for examination of environmental impact, and EIA report was prepared based on examination results. EIA report is composed of the result of examination on environmental impact and environmental management plan including mitigation measures and monitoring plan, and it was submitted from MOC to MONREC on 8 November 2017.

9.2.3.1 Evaluation of the Environmental Impact

Possible impacts by construction of the Bago River Bridge were identified and the extent of the impacts was also evaluated one by one and rated against each environmental item under six main components of social environment, natural environment, and environmental pollution with the following criteria. Results are shown together with the results of scoping and survey. Impact evaluation was not conducted to the decommissioning, closure, and post-closure stages since the road development project is not a life-limited development which is defined in the draft Administrative Instruction of Environmental Impact Assessment Procedure.

A (+/-): Significant positive/negative impact is expected.

B (+/-): Positive/negative impact is expected but not significant.

C (+/-): Extent of impact is unknown or not clear. Further examination is needed. It should be taken into consideration that impacts may become clear as the study progresses.

D or Blank: Negligible or no impact is expected. No further study is required.

Table 9.2.14 Identification and Evaluation of Anticipated Impacts for the Project

Category	Scoping Item	Scoping		EIA		Reason for Scoping Evaluation
		BC/CS	OS	BC/CS	OS	
Pollution	Air Quality	B-	B-	B-	B+/B-	**BC:** There will not be any activities to deteriorate air quality. **CS:** Temporary impact on air quality due to operation of construction machineries and traveling of construction vehicles is anticipated. **OS:** Emission of air pollutants originated from heavy traffic will be improved by reducing idling time and traffic jam. Meanwhile, since traffic volume is estimated as increase after opening Bago River Bridge, pollutants may probably increase at small extent.

Category	Scoping Item	Scoping		EIA		Reason for Scoping Evaluation
		BC/CS	OS	BC/CS	OS	
	Water Quality	B-	C	B-	D	**BC:** There will not be any activities to deteriorate water quality. **CS:** Impact on water quality from muddy water from construction works and wastewater from worker's camp and construction office inflowing to the river is anticipated. **OS:** There will not be any activities on operation and maintenance to cause negative impact to water quality. Runoff water from the road and bridge surface will be consolidated in the drainage to be installed along the road and bridge, and it will be discharged into Bago River. Since runoff water from the road surface is not newly caused by the Project, significant negative impact on water quality originated from runoff water from road and bridge surface is not anticipated.
	Waste	B-	D	B-	D	**BC:** There will not be any activities to generate waste. **CS:** Solid waste from construction work and human-generated waste from worker's camp will be generated. **OS:** Although waste will be generated from the administrative office, it will be disposed at the designated place at each township. Thus, significant negative impact is not anticipated.
	Soil Contamination	B-	D	D	D	**BC:** Excavation work is planned due to relocation of public utilities located underground. However, since soil contamination was not observed according to field measurement results, soil contamination due to excavation work is not anticipated. **CS:** Same as before construction stage, soil contamination due to civil work is not anticipated. **OS:** There will not be any activities to cause soil contamination.
	Noise and Vibration	B-	B-	B-	B+/B-	**BC:** There will not be any activities to generate noise and vibration. **CS:** Increase of noise and vibration levels due to construction machineries and traveling of construction vehicle would temporarily occur. **OS:** There will be a positive impact to improve noise originated from idling as well as traffic congestion. However, it is also anticipated that noise level will be increased as traffic volume is increased though its impact level is considered as small.
	Ground Subsidence	D	D	D	D	**BC/CS/OS:** Activities to be caused ground subsidence is not planned. The Project plans to use ground water for construction activities by building temporary wells in the Project area. However, ground subsidence related to exceeding use of groundwater is not anticipated since usage of ground water is supervised regularly.
	Offensive Odor	D	D	D	D	**BC/CS/OS:** There will not be any activities to cause negative impact to offensive odor.
	Bottom Sediment	D	D	D	D	**BC/CS/OS:** There will not be any activities to cause negative impact to bottom sediment.
Natural Environment	Protected Areas	D	D	D	D	**BC/CS/OS:** There is neither protected nor environmentally sensitive area in and around the project area at both of the site for bridge construction and for improvement of intersections.
	Flora/Fauna and Ecosystem	B-	D	B-	D	**BC:** No endangered endemic plant and animal species have been identified in the project area. Cutting trees in the Project area for bridge construction and improvement of intersections is necessary before construction starts. Among trees to be cut, there are 5 exotic plant species of globally threatened in IUCN Red List. They were not endemic to the area but were introduced for ornamental and vegetation purpose Thus significant impact to these species is not anticipated. **CS:** Due to cutting trees in the Project area for bridge construction and improvement of intersections, habitats of birds and/or others in the area might be changed though it is small degree. It is anticipated that construction work in Bago River will not cause degradation of water quality which will affect aquatic ecosystem in Bago River since the construction method to be applied (i.e. SPSP) will not leak or infiltrate to/from the construction area. As for wastewater from the construction yard or worker's camp, it will be discharged after proper treatment such as silt pit or septic tank. Thus, significant impact to water quality which will affect aquatic ecosystem in Bago River is not anticipated. **OS:** There will not be any activities to cause negative impact to flora/fauna and ecosystem including aquatic ecosystem.
	Hydrology	B-	B-	B-	D	**BC:** There will not be any activities to cause negative impact to hydrological conditions in Bago River.

Category	Scoping Item	Scoping		EIA		Reason for Scoping Evaluation
		BC/CS	OS	BC/CS	OS	
						CS: There will be a small change in water flow only at the area of bridge foundation and pier though it will not change entire water flow or hydrological condition in Bago River. **OS:** There will not be any activities on operation and maintenance which will cause impact on hydrology.
	Topography and geology	D	D	D	D	**BC/CS/OS:** The scale of dredging and excavating river bed is expected to be too small to change the topographical and geological features
Social environment	Involuntary Resettlement	B-	D	B-	D	**BC:** There is no private land acquisition since land to be used belongs to public authorities. However, approx. total 36 households living in the project area of improvement of intersections are needed to be relocated. **CS:** No negative impact is anticipated. **OS:** No negative impact is anticipated.
	Vulnerable Groups	B-/B+	B+	B-/B+	B+	**BC:** There is a possibility that vulnerable households will be affected due to relocation. **CS:** Job opportunity as construction workers will be increased for vulnerable groups living near the Project area. **OS:** Job opportunity as workers of maintenance of road and bridge will be increased for vulnerable groups living near the Project area.
	Livelihood and Local Economy	B+	B+	B-/B+	B+	**BC:** Some of households who own shops in the project area and need to relocate will lose their income source due to relocation. **CS:** Beneficial impacts such as creation of employment opportunity for construction works are expected. **OS:** Through the construction of the Bago River Bridge and improvement of intersections, existing traffic congestion between Yangon and Thanlyin area will be solved. Thus, improved road network may raise the living condition and make social services easily accessible, leading to the enhancement of the local economy.
	Land Use and Utilization of Local Resources	D	D	D	D	**BC/CS/OS:** The Project area is mostly located inside the ROW, and construction works will not alter land use at surrounding areas. The Project plans to use groundwater for construction activities by building temporary wells in the Project area. However, impact related to exceeding use of groundwater is not anticipated since usage of ground water will be supervised regularly.
	Water Use	B-	D	B-	D	**BC:** There will not be any activates to cause impact on water use. **CS:** Bridge construction works such as riverbed dredging may disturb water transport due to change in navigation channel though the extent of change is anticipated as small. In addition, there are some people who are doing fishing in the bridge construction area though they do not have proper fishing license. Fishing activities for these people will be temporary limited. **OC:** Negative impact to water use to be caused by the Project is not anticipated.
	Existing Social Infrastructures and Services	B-	A+/B-	B-	A+	**BC:** There are public utilities such as high voltage electrical lines and water pipes in the site of bridge construction and intersection improvement. Relocation of these facilities may cause limitation or disturbance at the surrounding communities. **CS:** Traffic congestion due to increase of construction vehicles is anticipated. Temporary limitation of accessibility to school and pagoda near the Project area is anticipated. **OS:** New bridge has at least same clearance (i.e. vertical and horizontal clearance) compared with the current condition in Thanlyin Bridge No. 1. Thus, limitation or disturbance of water transport due to installing new bridge foundation and piers by the Project will not be anticipated. The Project is considered to bring a positive impact on improvement of regional road network.
	Misdistribution of Benefit and Damage	B-	B-	B-	B-	**BC/CS/OS:** Misdistribution of benefit and damage would be occurred since there are PAPs who need to relocate, while there are people who would get job opportunity as workers related to the Project.
	Local Conflict of Interests	B-	B-	B-	B-	**BC/CS/OS:** Local conflict of interests would be happened if job opportunity increased by the Project is mis-distributed to PAPs and the surrounding community.
	Cultural Heritage	B-	D	B-	D	**BC:** There are 2 small private religious facilities in the Project area for the Bridge construction. Although these facilities are not used by surrounding communities, their relocation is necessary.

Category	Scoping Item	Scoping		EIA		Reason for Scoping Evaluation
		BC/CS	OS	BC/CS	OS	
						CS: There are a group of pagoda near the Project area for the improvement of intersections. Temporary limitation of access to these pagoda is anticipated by the construction activities. **OS:** Negative impact is not anticipated.
	Landscape	B-	B-/B+	B-	B-/B+	**BC:** Trees at the Project area for the bridge construction and improvement of intersections will be cut. Thus, landscape will be changed. **CS:** Landscape in the Project area will be changed due to storing construction machines in the Project area for Bridge construction and improvement of intersections. **OS:** Landscape would be changed due to construction of new bridge and improvement of intersections (i.e. changing from at-grade intersection to flyover intersection) of the Project area and its surrounding area. On the other hand, the Bago River Bridge has a possibility to establish the new attractive landmark by harmonizing with Thanlyin No. 1 Bridge. This can be a new visiting point in Yangon area attracting visitor routes.
	Sunlight shading	D	D	D	D	**BC/CS:** Negative impact is not anticipated. **OS:** Impact on sunlight shading caused by flyover will be only limited short time in the morning and limited small area. People living in the area originally create a shadow area by planting tree or roof. Based on these conditions, impact on sunlight shading due to flyover is very minor.
	Gender	D	B+	D	B+	**BC/CS:** Negative impact is not anticipated. **OS:** Both gender can get benefits from the Project as they are encouraged to commute to schools, universities, works and social activities by using smoother road connection as a result of implementation of the Project.
	Children's Rights	B-	B+	B-	B+	**BC:** Due to the relocation, children's education would be temporarily disrupted. **CS:** A school is located near the Project area of improvement of intersections. There is a possibility that access to a school is temporary disturbed due to construction activities. **OS:** Children at the surrounding communities would be indirectly influenced by the improvement of traffic condition in the area.
Health and Safety	Risks for Infectious Disease such as HIV/AIDS	B-	B-	B-	D	**BC:** Negative impact is not anticipated. **CS** There is possibility to increase the risks of infectious disease due to influx of construction workers into the Project area. **OS:** Negative impact is not anticipated.
	Occupational Health and Safety	B-	B-	B-	D	**BC:** Negative impact is not anticipated. **CS:** Impact on the working conditions of the workers is anticipated if construction and maintenance activities are not implemented properly. **OS:** Negative impact is not anticipated.
	Community Health and Safety	B-	B-	B-	B-	**BC:** Negative impact is not anticipated **CS:** Impacts on community health and safety are anticipated due to influx of construction workers, increase of vehicle traffic and operation of construction machineries. **OS:** There is a possibility to increase a risk of traffic accident due to smooth traffic.
Emergency Risk	Flood Risk	B-	B+	B-	B+	**BC:** There is a possibility that decreasing green area due to cutting tree will enhance flood after heavy rain. However, since the existing drainage is able to control drainage water after heavy rain, risk of flood due to decreasing green area is not anticipated. **CS:** Implementing the Project will not increase a risk of flood. However, there is a risk of flood at the work camp and construction yards after heavy rain because the project site is located close to the riverbank. Since the worker's camp and construction yards are designed with sufficient highest, risk of flood is considered as low. **OS:** Due to installing drainage and improving existing drainage, runoff of rainwater from road surface after heavy rain will be improved from the current condition.
	Risk of Fire	B-	B-	B-	B-	**BC:** Negative impact is not anticipated. **CS:** There is a possibility to increase a risk of fire due to the construction work. **OS:** There is a possibility to increase a risk of fire originated from human activity and/or short circuit at the administrative office.
Other	Global Warming	D	D	D	D	**BC:** Negative impact is not anticipated. **CS:** Small scale and temporary generation of greenhouse gases like CO_2 are expected due to construction vehicles and machines. However, impact on transboundary and climate change is negligible

Category	Scoping Item	Scoping		EIA		Reason for Scoping Evaluation
		BC/CS	OS	BC/CS	OS	
						OS: Increase in greenhouse gases like CO_2 is expected in a small scale due to increase of traffic volume. However, impact on trans-boundary and climate change is negligible.

Source: JICA Study Team (data obtained in 2014 and June 2016 and updated in January 2017)

9.2.3.2 Environmental Management Plan

Mitigation measures, which may avoid, minimize, eliminate, and/or reduce the abovementioned negative impacts were examined for respective item in the planning, construction, and operation stages, as well as the whole stages. Mitigation measures are necessary to achieve the intended objectives while minimizing the accompanied environmental and social impacts. In addition, the Environmental Management Plan (EMP) was prepared by incorporating the mitigation measures and monitoring as well as the roles of implementing organization, responsible, and supervising organizations.

Table 9.2.15 Mitigation Measures against Negative Impacts and Environmental Management Plan (EMP) for the Project at the Pre-Construction Phase

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package[1]	Implementing Organization	Responsible Organization	Necessary Input
Social Environment	Involuntary Resettlement	- Relocation of 36 households and 34 stalls	- Preparation of appropriate plan and holding consultation with affected people in timely manner.	PKG 3	Compensation Committee and PMU	YRG and MOC	Handout for consultation
	Vulnerable Groups	- Relocation of 6 households classified vulnerable group	- Preparation of appropriate plan and holding consultation with affected people in timely manner.	PKG 3	Compensation Committee and PMU	YRG and MOC	Handout for consultation
	Existing Social Infrastructure and Services	- Temporary disturbance or limitation of road traffic due to relocation of public utilities above ground and underground	- Preparation of appropriate relocation plan, and - Informing relocation works in the communities in timely manner.	All package	Each agency maintaining public utilities	Each agency maintaining public utilities	Cost for relocation of public utility
	Landscape	- Changing landscape due to cutting trees	- Limit tree cut only at the project area	All package	PMU	MOC	Cost for tree cut
	Cultural Heritage	- Relocation of 2 small private religious facility	- Consult with facility owners	PKG 1	PMU	MOC	Miscellaneous cost
	Children's Right	- Possibility of temporary disturbance of children's education due to relocation	- Provide administrative support for transferring school as necessary	PKG 3	Compensation Committee and PMU	YRG and MOC	Miscellaneous cost
Emergency Risk	Flood	- Possibility of increasing risk of flood due to cutting trees	- Limit tree cut only at the project area	All package	YCDC (Thaketa Tonwship area) and PMU (Thanlyin Township area)	MOC	Cost for tree cut
Natural	Flora, Fauna and	- Possibility of small impact on flora, fauna and	- Limit tree cut only at the	All package	YCDC (Thaketa Tonwship area) and	MOC	Cost for tree cut

Environment	Ecosystem	ecosystem due to cutting trees	project area		PMU (Thanlyin Township area)		

Note: PKG stands for Package.
Source: JICA Study Team

Table 9.2.16 Mitigation Measures against Negative Impacts and Environmental Management Plan (EMP) for the Project at the Construction Phase

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
Social Environment	Water Use	- Possibility to disturb water transport due to change in navigation channel though the extent of change is anticipated as negligible level. - Possibility of temporary limitation at fishing activity in the bridge construction area though fishing people do not have proper fishing license.	- Inform construction plan and schedule to the concerned authorities managing Bago River - Inform construction plan and schedule to fishing people	PKG 1 and 2	Contractor	MOC	Miscellaneous cost
	Existing Social Infrastructures and Services	- Possibility of temporary traffic congestion due to temporary closure, detour or access limitation due to construction work	- Arrange sufficient numbers of traffic signal or watchman for traffic control as necessary, - Arrange a staff in charge of complaints, and - Arrange pedestrian way to secure accessibly to social infrastructure as necessary	All package	Contractor	MOC	Miscellaneous cost
	Cultural Heritage	- Temporary limitation of access to pagoda due to construction work	- Same as "Existing Social Infrastructure and Services"	PKG 3	Contractor	MOC	Miscellaneous cost
	Landscape	- Possibility of temporary disturbance on surrounding landscape due to storing construction machines and	- Store construction machines and materials properly, and - Arrange design of a	All package	Contractor	MOC	Miscellaneous cost

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
		materials	blindfold board in the construction area to be integrated in the surrounding environment as necessary				
	Children's Right	- Possibility of temporary access limitation on school commuting due to construction works	- Arrange sufficient numbers of traffic signal or watchman for traffic control as necessary, - Arrange a staff in charge of complaints, and - Arrange pedestrian way to secure accessibly to social infrastructure as necessary	PKG 3	Contractor	MOC	Miscellaneous cost
Health and Safety	Infectious Disease such as HIV/AIDS	- Increasing risk of infectious disease due to influx of construction workers in the construction site	- Prepare and implement HIV/AIDS prevention plan	All package	Contractor	MOC	Cost for education to workers and surrounding communities
	Occupational Health and Safety	- Increase risk of safety for construction workers due to mishandling of equipment or accidents of construction vehicles	- Prepare and implement a safety plan, - Provide education to construction workers on safety at the construction site	All package	Contractor	MOC	Cost for education to workers
	Community Health and Safety	- Increasing risk of safety at surrounding communities due to increase of construction vehicles and machines	- Prepare and implement safety plan	All package (mainly PKG 3)	Contractor	MOC	Cost for education to surrounding communities
Emergency Risk	Flood	- Possibility of flood risk at the construction yard and work's camp	- Prepare and implement safety plan	All package	Contractor	MOC	Miscellaneous cost

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
	Fire	- Increasing fire risk at the construction yards	- Prepare and implement safety plan	All package	Contractor	MOC	Cost for education to workers
Natural Environment	Flora, Fauna and Ecosystem	- Possibility of temporary impact to aquatic fauna due to deterioration of water quality by wastewater from construction yards and worker's camp	- Same as mitigation measures explained in water quality	PKG 1 and 2	Contractor	MOC	
Pollution	Air Quality	- Temporary increase of air pollutants from construction vehicle and machines and civil works	- Use construction machines and vehicles with good conditions, - Provide environmental education to construction workers to enhance importance on environmental protection, - Sprinkle water timely	All package	Contractor	MOC	Cost for education to workers, and Cost for sprinkle water
	Water Quality	- Possibility of turbidity and chemical compounds from construction yards,	- Proper treatment of water pollutants generated from construction works in accordance with YCDC regulations, - Arrange silt traps or sedimentation basin not to discharge wastewater from construction sites to public water cannels directly, - Shelter scattered river mud from dredging works by using submerged fence as necessary	All package	Contractor	MOC	Miscellaneous cost
	Waste	- To be generated soil waste from construction works,	- Prepare and implement appropriate waste	All package	Contractor	MOC	Cost for education to workers

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
		and - To be generated human-related waste from daily life at the worker's camp and construction offices	management plan, - Dispose waste at the designated place, - Provide education on waste management to construction workers				
	Noise & Vibration	- Possibility of increase noise and vibration level due to construction work though extent of increase is anticipated as small	- Working during sensitive hours and placing construction machines close to sensitive receptors are basically avoided as much as possible, - Use equipment with low-noise and vibration as much as possible, - Install noise reduction walls/acoustic enclosures as necessary, and - Assign staff in charge of complaints	All package	Contractor	MOC	Cost for maintenance of equipment

Note: PKG stands for Package.
Source: JICA Study Team

Table 9.2.17 Mitigation Measures against Negative Impacts and Environmental Management Plan (EMP) for the Project at the Opeation Phase

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
Health and Safety	Community Health and Safety	- Possibility of increase a risk of traffic accident due to smooth traffic	- Provide education of traffic and driving rules to driver	All package	YCDC, DOB and DOH	YRG and MOC	Handout for education
Pollution	Air Quality	- Possibility of increase pollutants due to increase of traffic volume though it	- Sufficient control of traffic volume and flow by proper maintenance of road and	All package	MOC	MOC and YCDC	Cost for maintaining road, bridge and other

		will be small extent	bridge and other equipment such as traffic signal				equipment
	Waste	- To be generated waste from office management	- Dispose waste in accordance with YCDC regulations	PKG 2	MOC	MOC	Miscellaneous cost
	Noise and Vibration	- Possibility of increase level of noise and vibration due to increase of traffic volume though it will be small extent	- Sufficient control of traffic volume and flow by proper maintenance of road and bridge and other equipment such as traffic signal	All package	MOC	MOC and YCDC	Cost for maintaining road, bridge and other equipment

Note: PKG stands for Package.
Source: JICA Study Team

Table 9.2.18 Mitigation Measures against Negative Impacts and Environmental Management Plan (EMP) for the Project at the Entire Phase

Category	Items	Identified Potential Impact	Mitigation Measures	Relevant Package	Implementing Organization	Responsible Organization	Necessary Input
Social Environment	Misdistribution of Benefit and Damage, Local Conflict of Interests	- Possibility of conflict between people in and around the project area due to inequality	- Consult with project affected persons timely, - Assign a staff in cage of complain, and - Examine appropriate measures by holding consultation among concerned parties	All package	Compensation Committee and MOC	YRG	Handout for consultation

Note: PKG stands for Package.
Source: JICA Study Team

Environmental Monitoring Plans (EMoP) for the Project were developed to secure the above Environmental Management Plan (EMP). The plans were compiled in EIA report subject to review by MONREC.

Table 9.2.19 Frequency and Locations of Environmental Monitoring at Pre-Construction Phase

Item	Monitoring Item	Monitoring Method	Monitoring Place	Frequency	Package	Responsibility
1. Social Environment						
Involuntary Resettlement*	Progress of relocation and payment in accordance with A-RAP	Check relocation and payment records	Project sites	Weekly	PKG 3	PMU
Vulnerable Groups*	Ditto	Ditto	Ditto	Ditto	PKG 3	Ditto
Existing Social Infrastructure and Service	- Progress of relocation - Complaint from surrounding communities	- Check progress records - Check complaint records	Project sites	As necessary	All package	PMU
Landscape	Progress of tree cut	Check tree cut records	Project site	Once	All package	PMU
Cultural Heritage	Complaints from owners	Check complaint records	Project site	As necessary	PKG 1	PMU
Children's Right	Complaints from concerned households	Check complaint records	Project site	As necessary	PKG 3	PMU
2. Emergency Risk						
Flood	Condition of flood	Check the site conditions	Project site	As necessary	All package	PMU
3. Natural Environment						
Flora, Fauna and Ecosystem	Condition of vegetation	Check the site conditions	Project site	As necessary	PKG 1 and 2	PMU

* Monitoring for Involuntary Resettlement and Vulnerable Groups is to be done by Internal Monitoring defined in A-RAP.

Source: JICA Study Team

Table 9.2.20 Frequency and Locations of Environmental Monitoring at Construction Phase

Item	Monitoring Item	Monitoring Method	Monitoring Place	Frequency	Package	Responsibility
1. Social Environment						
Existing Social Infrastructure and Service	Complaint from surrounding communities	Check complaint records	Project sites	As necessary	All package	Contractor
Water Use	Complaint from vessels using navigation channels, People doing fishing near the project area	Check complaint records	Project sites	As necessary	PKG 1 & 2	Contractor
Cultural Heritage	Complaint from surrounding communities	Check complaint records	Project sites	As necessary	PKG 3	Contractor
Landscape	Condition of storing construction machines and materials	Check the site condition Check the record of storing construction machines and materials	Project site	Once	All package	Contractor
Children's Right	Complaints from	Check complaint	Project site	As necessary	PKG 3	Contractor

Item	Monitoring Item	Monitoring Method	Monitoring Place	Frequency	Package	Responsibility
	surrounding communities	records				
2. Health and Safety						
Infectious Disease	Awareness of infectious disease	Check records of awareness activities on infectious disease	Project site	As necessary	All package	Contractor
Occupational Health	Record of accidents in the construction site	Check record of accidents in the construction site	Project site	As necessary	All package	Contractor
Community Health and Safety	Records of traffic accidents in the surrounding communities	Check records of traffic accidents in the surrounding communities	Project site	As necessary	All package	Contractor
3. Emergency Risk						
Flood	Condition of flood	Check the site conditions	Project site	As necessary	All package	Contractor
Fire	Condition of fire	Check the site conditions	Project site	As necessary	All package	Contractor
4. Natural Environment						
Flora, Fauna and Ecosystem	Condition of vegetation	Visual check of vegetation condition	Project site	As necessary	PKG 1 and 2	Contractor
5. Pollution						
Air Quality	i) Record of watering ii) Level of NO_2, PM10, PM2.5, SO_2	i) Check the site conditions ii) Site measurement	i) Project site ii) Total 4 points in the project site (shown in Figures below)	i) Weekly ii) Once a year in the dry season	All package	Contractor
Water Quality	i) Visual observation ii) Level of BOD5, COD, Oil and Grease, pH, Total coliform bacteria, Total suspended solids (TSS)	i) Check the site condition ii) Site measurement	i) Project site ii) Total 4 points in the project site (shown in Figures below)	i) As per construction activity ii) Once a year in the dry season	All package	Contractor
Waste	Record of waste disposal and site condition	[Construction Yard] Check records of amount and type of waste, and disposal method [Worker's Camp] Check solid waste	Project site	As per disposal of waste	All package	Contractor
Noise and Vibration	i) Complaint from surrounding communities (for noise and vibration) ii) Sound level (for noise)	i) Check records of complaint (for noise and vibration) ii) Site measurement (for noise)	i) Project site ii) 4 points in the project site (shown in Figures below)	i) As necessary ii) Once a year in the dry season	All package	Contractor

Source: JICA Study Team

Table 9.2.21 Frequency and Locations of Environmental Monitoring at Operation Phase

Item	Monitoring Item	Monitoring Method	Monitoring Place	Frequency	Package	Responsibility
1. Health and Safety						
Community Health and Safety	Accident records	Check accident records	Project site	As necessary	All package	MOC and YCDC
2. Pollution						
Air Quality	i) Complaint from surrounding communities ii) Level of NO_2, PM10, PM2.5, SO_2	i) Check complaint record ii) Site measurement	i) Project site ii) Total 4 points in the project site (shown in Figures below)	i) As necessary ii) 1 time in dry season	All package	MOC
Waste	Record of waste disposal and site condition	Check records of waste disposal and site condition	Project site	As necessary	PKG 2	MOC
Noise and vibration	i) Complaint from surrounding communities (for noise and vibration) ii) Level of sound (for noise)	i) Check complaint record (for noise and vibration) ii) Site measurement (for noise)	i) Project site ii) Total 4 points in the project site (shown in Figures below)	i) As necessary ii) 1 time in dry season	All package	MOC

Source: JICA Study Team

Table 9.2.22 Frequency and Locations of Environmental Monitoring at Entire Phase

Item	Monitoring Item	Monitoring Method	Monitoring Place	Frequency	Package	Responsibility
1. Social Environment						
Misdistribution of Benefit and damage, Local Conflict of Interests	Complaints from surrounding communities	Check complaint records	Project site	As necessary	All package	PMU

Source: JICA Study Team

Provisional monitoring points are shown at the figures below.

Note: PK1-AN is for an air quality and noise monitoring point. PK1-W is for a water quality point.
Source: JICA Study Team

Figure 9.2.5 Provisional Monitoring Points for Noise, Air Quality and Water Quality (Package 1)

Note: PK-2AN-1 and PK-2AN-2 are air quality and noise monitoring points. PK2-2W-1 and PK2-2W-2 are water monitoring points.
Source: JICA Study Team

Figure 9.2.6 Provisional monitoring points for Noise, Air Quality and Water Quality (Package 2)

Note: PK-3-AN is for an air quality and noise monitoring point. PK-3-W is for a water quality monitoring point.
Source: JICA Study Team

Figure 9.2.7 Provisional monitoring points for Noise, Air Quality and Water Quality (Package 3)

9.2.3.3 Cost for the Environmental Management

(1) Pre-construction stage (By MOC)

Prior to the construction works, related to the land clearance permission of tree cutting by the competent authority, the Forest Department in Thanlyin Township and Yangon City Development Committee, is required. Costs are estimated based on the instruction made by these authorities. However, the affected areas should be adjusted based on the final decision for ROW and work yards.

Table 9.2.23 Cost on Tree Cut for Package-1 at the Pre-construction Stage

Items	Location	Unit	Quantity	Amount (MMK)	Amount (USD)	Packages
Permission for the tree cutting Forest Department, Thanlyin Township	Construction bridge ⑧ Myanmar Railway(MR), YRDC (21 over 2 ft /376 under 2ft trees/ 100 seedlings)	Set	1	4,657,500	3,582	PK-1
	Work Yard ⑨ Myanmar Port Authority(MPA) (1 over 2 ft / /663 under 2ft trees)	Set	1	6,662,500	5,125	PK-1
	Total			11,320,000	8,707	
	Rounded			-	8,800	

Note: USD 1 = MMK 1,300, The cost was estimated based on the instruction of Thanlyin Township Forest Department using MOC's tree cutting unit price (2016-2017). Tree numbers should be adjusted based on the final construction design.
Source: JICA Study Team

Table 9.2.24 Cost on Tree Cut for Package-2 at the Pre-construction Stage

Items	Location	Unit	Quantity	Amount (MMK)	Amount (USD)	Packages
Permission for the tree cutting	Construction Intersection ⑤ MR, YCDC (6 big/17 medium/57 small trees)	Set	1	1,810,000	1,392	PK-2

YCDC						
	Work Yard ⑥ DUHD, MOC (10 big/ 28 medium/16 small trees)	Set	1	1,820,000	1,400	PK-2
	Total			3,630,000	2,792	
	Rounded			-	2,800	

Note: USD 1 = MMK 1,300, Definition: Big tree (Diameter =>2ft), Medium tree (2>D>1), Small tree (D<=1) The cost is calculatedbased on the YCDC's tree cutting cost. Tree numbers should be adjusted based on the final construction design
Source: JICA Study Team

Table 9.2.25 Cost on Tree Cut for Package-3 at the Pre-construction Stage

Items	Location	Unit	Quantity	Amount (MMK)	Amount (USD)	Packages
Permission for tree cutting YCDC	Construction Intersection ③along Thanlyin Chinkat RD (27 big/ 83 medium/215 small tree cutting) YCDC	Set	1	7,750,000	5,962	PK-3
	Work Yard ①MR, YCDC at the Junction Thanlyin Chinkat RD and Shukintar RD(7 big/ 2 medium trees)	Set	1	490,000	377	PK-3
	Work Yard ②Department of Urban Housing Development(DUHD) MOC, west of above ①, (22 big/ 47 medium/ 102 small trees)	Set	1	4,495,000	3,458	PK-3
	Total			12,735,000	9,797	
	Rounded			-	9,800	

Note: USD 1 = MMK 1,300.Definition: Big tree (Diameter =>2ft), Medium tree (2>D>1), Small tree (D<=1). The cost is calculated based on the YCDC's tree cutting cost. Tree numbers should be adjusted based on the final construction design
Source: JICA Study Team

(2) Construction Stage

At the construction, the environmental monitoring works should be conducted by the contractors based on the Environmental Monitoring Plan. Here, the cost estimated for the three-year construction period is presented below and it will be adjusted depending on each work period.

Table 9.2.26 Environmental Management Cost for the Construction Stage

Items	Unit	Quantity (Times)	Unit price (USD)	Amount (USD)
1. Package-1 Environmental Monitoring Cost - Air quality monitoring (SO2, NO2, PM10, PM2.5) 1 points - Water quality monitoring (Turbidity, pH, BOD5, SS, DO) 1 point - Noise monitoring 1 point	Times	4	2,500	10,000
2. Package-2 Environmental Monitoring Cost - Air quality monitoring (SO2, NO2, PM10, PM2.5) 2 points - Water quality monitoring (Turbidity, pH, BOD5, SS, DO) 2 points - Noise monitoring 2 points	Times	4	3,900	16,000
3. Package-3 Environmental Monitoring Cost - Air quality monitoring (SO2, NO2, PM10, PM2.5) 1 point - Water quality monitoring (Turbidity, pH, BOD5, SS, DO) 1 point - Noise monitoring 1 point	Times	4	2,500	10,000
Grand Total			-	36,000

Note: Survey times are estimated for one baseline survey at the construction commencement, precedent three years construction (two times of the dry season) and at the completion of the construction. The unit costs are not considered price increases due to inflation.
Source: JICA Study Team

(3) Operation Stage (By MOC)

At the operation stage the following items are planned to be monitored by the project proponent, Ministry of Construction (MOC). Here, the approximate cost for the monitoring are presented below and the amount was calculated in March 2017.

Table 9.2.27 Environmental Management Cost for the Operation Stage

Items	Unit	Quantity (Times)	Unit Price (USD)	Amount (USD)
Environmental Monitoring Cost (for approach road to bridge in Thaketa and Thanlyin Township, and bridge) - Air quality monitoring (SO2, NO2, PM10, PM2.5) 3 points - Noise monitoring 3 points	Times	1	4,800	5,000
Environmental Monitoring Cost (for flyover and intersection in Thaketa Township) - Air quality monitoring (SO2, NO2, PM10, PM2.5) 1 point - Noise monitoring 1 point	Times	1	1,900	2,000
and Total			-	7,000

Source: JICA Study Team

9.3 SOCIAL CONSIDERATIONS

Construction of the Bago River Bridge and improvement of intersections are planned to use public land such as land owned by MOC or Myanma Railways (MR) in order to minimize social impact to be caused by land acquisition. However, there are some households occupying land inside the project area for living and/or for running a shop. The number of households required physical displacement has less than 200 people. Thus, preparation of Abbreviated Resettlement Action Plan (A-RAP) is requested according to the JICA Guidelines for Environmental and Social Considerations issued in April 2010 (the JICA Guidelines) and the World Bank (WB) Operational Policy (OP) 4.12.

At the time of F/S and Supplemental F/S, the draft A-RAP was prepared although the results of Detailed Measurement Survey (DMS), i.e., census, socioeconomic survey, and inventory of asset, and the public consultation meetings were not included since contacting possible Project Affected Households (PAHs) before approval of the Project by the parliament was regarded as not appropriate. Since the Project was approved by the parliament in December 2016, A-RAP prepared in F/S and Supplemental F/S were updated in this B/D and D/D by conducting DMS and holding public consultation meeting.

9.3.1 Review of A-RAP

The draft A-RAP was prepared to the design of F/S in 2014 and Supplemental F/S in 2016 in accordance with the JICA Guidelines and WB OP 4.12. Although all items needed to be covered were mentioned in the draft A-RAP, the contents of the compensation policy and the monitoring were overmuch considering the possible scale of relocation impact and number of PAHs. Thus, the items considered as overmuch such as compensation policies and monitoring were modified referring to good practices in the neighboring countries.

9.3.2 Regulations related to Relocation and Gap Analysis

There is no update of regulations related to relocation in Myanmar from the time of F/S and Supplemental F/S. Accordingly, there is no modification of gap between regulations on relocation in Myanmar and JICA Guidelines.

9.3.3 Procedure of Updating A-RAP and Relocation

The draft A-RAP was updated and finalized based on the results of DMS and the additional consultation meeting held on December 17, 2016. The final A-RAP was submitted to MOC, and MOC requested Compensation Committee (the Committee) to approve it. The committee was established with approval from the Yangon Region Government (YRG) in May 2017 to implement relocation caused by construction of the Bago River Bridge. The Committee was chaired by YRG, and was composed of members from various authorities.

Figure 9.3.1 shows the procedure of updating A-RAP and implementing relocation in accordance with A-RAP. The JICA Study Team supported MOC to implement items listed in Table 9.3.1.

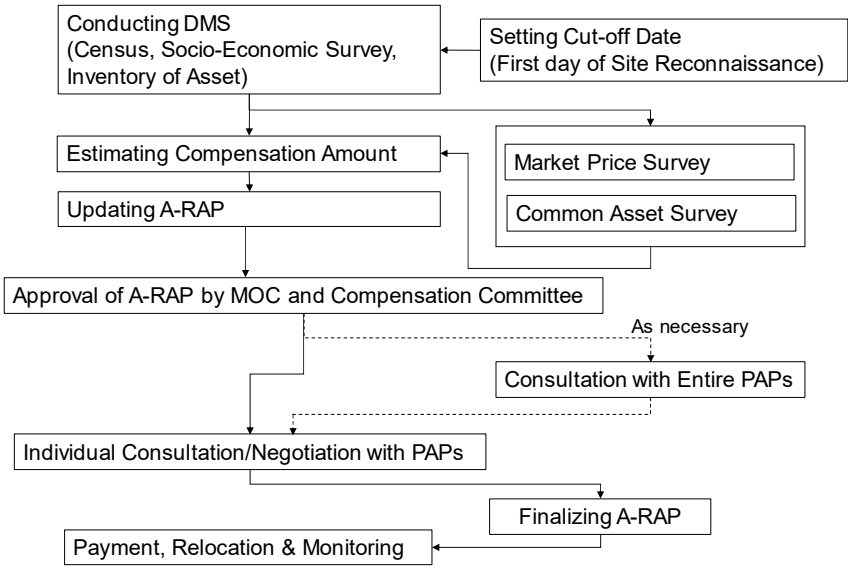


Figure 9.3.1 Location of Necessary Land Acquisition in Thaketa Township

Source: JICA Study Team

Table 9.3.1 Work Items Assisted by the JICA Study Team

Work Items	Contents of Assistance
Set the Cut-off Date (COD)	- Examined the most appropriate COD
ConductedDetailed Measurement Survey (DMS)	- Examined survey target households, survey items, and methods - Facilitate with governemntal authorities to conduct DMS
Conducted Common Asset Survey and Market Price Survey	- Conducted common asset survey in the project area - Conducted market price survey in and around the project area
Estimated Compensation Amount	- Estimated compensation amount based on the results of DMS and market price survey
Held Supplemental Consultation Meeting	- Confirmed target households - Prepared necessary materials to be explained - Logistic arrangement (venue, reception) - Prepared minutes of meeting
Updated A-RAP	- Updated A-RAP based on the results of DMS, market price survey, common asset survey, and supplemental consultation meeting

Source: JICA Study Team

9.3.4 Updating A-RAP

(1) Setting Cut-off Date and Eligibility

The Cut-off Date (COD) is the day to determine eligibility for entitlement of compensation due to relocation caused by the Project. Persons (or households) living or doing income generation activities inside a project area on the COD are eligible for compensation and persons (or households) who occupy the project area after the COD are not eligible for relocation assistance.

The COD is normally the day that the census begins according to WB OP 4.12. In some neighboring countries, the COD is also set as the date of issuing official documents (i.e., notice or decree) on land acquisition for a project. In the case of the Project, either the census or official documents on land acquisition as well as relocation was not conducted or issued although initial site reconnaissance was conducted in February and March 2016 in the Supplemental F/S.

Under this situation, the MOC and JICA Study Team examined the most appropriate COD for the Project, and concluded to set March 1, 2016, the first day of site reconnaissance for confirming the number and location of structures in the project area during Supplemental F/S, as the COD for the Project. People who lived in or used land in the project area at the COD are eligible for compensation in this Project. It was explained to the public and stakeholders at the time of stakeholder meeting on November 12, 2016; and PAHs at public consultation meeting on December 17, 2016, and no objection was obtained.

(2) Detailed Measurement Survey (DMS)

1) DMS Target Area and Survey Methodology

The Detailed Measurement Survey (DMS) is composed of: i) census, ii) socio-economic confirmation, and iii) inventory of asset loss, and its result is to be used for assessing impact on land acquisition and relocation. It is conducted to potential PAPs who use or occupy a project area.

DMS for the Project was conducted for the areas of: i) the width of planning road and drainage improvement (No. 1 in Figure 9.3.2), ii) the width of planning bridge, its approach road, and candidate construction yard (Nos. 6 and 8 in Figures 9.3.2 and 9.3.3), iii) approach road to the existing Thalyin No. 1 Bridge (No. 5 in Figure 9.3.1), and iv) candidate sites of construction yards (Nos. 3, 4, 7, and 9 in Figures 9.3.2 and 9.3.3).

The width of planning road was not equal throughout the road alignment, but it differed due to conditions of adjoining areas. Under this condition, dimension of 16 m from the edge of the existing Thanlyin Chin Kat Road was regarded as the general construction area for the purpose of conducting DMS. DMS was conducted to households and stalls existed in the construction area at the time of COD.

The DMS target households (i.e., households existed at the time of COD) were identified by using information of structure location confirmed in March 2016, and DMS was conducted jointly (i.e., PAPs, representative from authorities and the survey team sub-contracted by the JICA Study Team) using a questionnaire form.

Table 9.3.2 Contents of DMS

Items	Contents
Survey Period	February 23, 24, and 27, 2017, April 5 and 6, 2017, May 8, 2017, and June 9, 2017
Survey Area	Project Area in the Bridge Portion and Intersection Portion
Survey Methodology	Conducted by the household head, Township representatives, MOC representatives and the Survey Team subcontracted by the JICA Study Team jointly (Four Parties Measurement)
Survey Contents	

Items	Contents
(1) Census	- Confirmed family members, gender, and age, education level, literacy rate, major occupation, etc., of PAHs
(2) Inventory of Asset Loss	- Confirmed exact location of households and other structures of PAHs and cultivation areas with coordinates - Listed and measured the affected properties of PAHs on the ground - Confirmed types of structures (e.g., living structure, hut) - Confirmed paddy size, agriculture products, and production of PAHs on the ground - Confirmed and listed movable assets such as livestock cow/buffalo and agricultural machine
(3) Socio-Economic Survey	- Confirmed socio-economic information of PAHs including monthly or annual incomes and income sources, monthly or annual expenditures

Source: JICA Study Team

Note: Nos. 1 to 10 are the necessary areas in Thaketa Township to be acquired.
Source: JICA Study Team

Figure 9.3.2 Location of Necessary Land Acquisition in Thaketa Township

Note: Nos. 11 and 12 are the necessary areas in Thanlyin Township to be acquired.
Source: JICA Study Team

Figure 9.3.3 Location of Necessary Land Acquisition in Thanlyin Township

Table 9.3.3 Summary of Land Acquisition and Relocation Impact

Area No.	Land Owner	Acquisition Type	Land Acquisition (m^2)	No. of Structures (Unit: No.)		
				House	Living People[1]	Stall
1	YCDC	Permanent	374	0	0	0
2	MOC & YCDC	Permanent	494	36[2]	165[1]	32[3]
3	MOC	Permanent	1,001			
4	MR	Permanent	2,904			
5	YESC	Permanent	663	0	0	0
6	MR	Temporary	8,200	0	0	0
7	MOC	Temporary	5,500	0	0	0
8	MR & YCDC	Permanent	1,900	0	0	1[4]
9	MR	Permanent	67,300	0	0	0
10	MR	Temporary	19,000	0	0	0
11	MR	Permanent	111,000	0	0	0
12	MPA	Temporary	34,500	0	0	0

Note:
1. Number of living people is counted based on the condition at the time of Cut-off Date which was confirmed during DMS.
2. There is one empty house located in No. 3 area. Nobody lived in this house, and the owner of this house was not available during DMS. Thus, this household was not included in this figure.
3. This is the total number of stalls located on both sides of Thanlyin Chin Kat Road. Two shops (one shop with permanent structure and one shop with temporary structure) were used as a shop and house, and they were classified as houses in this table.
4. In the No. 8 area, there were four stalls in total. Among the four stalls, only one stall was available at the time of DMS. Three stalls with no conduct of DMS were not included in this figure.

Source: JICA Study Team

(3) Results of DMS

1) Household Profile

The profiles of Project Affected Households (PAHs) identified by DMS are shown below.

a) Ethnic Groups

The ethnic groups of PAHs living in the project area are summarized in Table 9.3.4.

Table 9.3.4 Outline of Ethnic Groups

(Unit: No.)

Ethnic Group	Living PAHs
Burmese	36
Muslim	-
Total	36

Source: JICA Study Team

b) Number of Family Members

The number of family members at each household living in the project area at the time of COD is summarized in Table 9.3.5.

Table 9.3.5 Scale of Households

No. of Family Members per Household	Applicable PAHs (No.)	Percentage (%)
1 person	1	2.8
2 persons	6	16.7
3 persons	7	19.4
4 persons	8	22.2
5 persons	2	5.5
6 persons	6	16.7
7 persons	3	8.3
8 persons	0	0
9 persons	1	2.8
10 persons	1	2.8
11 persons	1	2.8
Total	36	100

Source: JICA Study Team

c) Types of Household-Heads

The types of household-heads living in the project area are summarized in Table 9.3.6.

Table 9.3.6 Types of Household-Heads

(Unit: No.)

Headed by Male	Headed by Female	Headed by Elderly	Total
27	7	2	36

Source: JICA Study Team

d) Literacy of Household-Heads

DMS results indicated that almost all household-heads living in the project area were good in speaking, reading, and writing in Myanmar language as only one household-head was found as illiterate.

e) Religion

DMS results showed that almost all PAHs living in the project area were Buddhist while one household was Christian.

2) Socio-economic Information

The socio-economic information of PAHs identified through DMS are shown below.

a) Income Source of Household-Heads

The income source of household-heads living in the project area is summarized in Table 9.3.7.

Table 9.3.7 Number of Households

(Unit: No.)

Self-Employed (shop owner)	Self-Employed (others)	Odd Job	Government Staff	No Job*	Company/Shop Staff	Total
8	10	5	5	5	3	36

Note*: "No job" category includes a retired person.
Source: JICA Study Team

b) Expenditure of Households

The ratio of expenditure of items in PAHs living in the project area is summarized in Table 9.3.8.

Table 9.3.8 Expenditure of PAHs

(Unit: %)

Food	Education	Health	Public Service	Transpiration	Others	Total
57.5	15.1	11.8	4.2	9.4	2.0	100

Source: JICA Study Team

c) Drinking Water

Table 9.3.9 shows the type of drinking water in PAHs living in the project area used.

Table 9.3.9 Expenditure of Households

(Unit: No.)

Purified Water	Tube Well	Monastery	Total
34	1	1	36

Source: JICA Study Team

d) Poverty

The Asian Development Bank (ADB) issued the Basic Statistic 2016 in April 2016 and this statistic book mentioned the national poverty line in 2010 in Myanmar[2]. Thus, this RAP referred the same concept and applied MMK 376,151 as the line for poverty.

Total expenditure at each household was confirmed by DMS and was divided by the number of family members. Then, total expenditure per person per year of households living in the project area was compared with the national poverty line (i.e., MMK 376,151). It was found that six households among 36 living households are below the national poverty line.

[2] MMK 376,151 per year per person defined in the report, Integrated Household Living Condition Survey in Myanmar (2009-2010) issued by Ministry of National Planning and Economic Development, UNDP, UNICEF, and CIDA.

3) Stalls and Shops

There were a total of 35 shop and stalls[3] (i.e., 3 shops and 32 stalls). Among them, two shops (i.e., one shop with permanent structure and one shop with temporary structure) were used as shop and house in the project area. These two shops used as shop and house in the project area are included in the result of socio-economic information of affected shops/ stalls.

a) Types of Business

The types of business of stalls and shops including two stalls used as houses confirmed by DMS were shown in Table 9.3.10.

Table 9.3.10 Types of Business

(Unit: No.)

Beer Shop	Betel Shop	Bicycle Repair Shop	Chip Shop	Cold Drink Shop	Gas and Oil Shop
1	15	2	1	2	1
Grocery Shop	Hair Salon	Rice and Curry Shop	Tea Shop	-	Total
3	1	7	2	-	35

Source: JICA Study Team

b) Number of Employees

Only 4 out of 35 stalls and shops had employees. DMS indicated that stalls and shops hired 1 employee counting 1 shop, 2 employees counting 1 stall, 3 employees counting 1 shop, and 8 employees counting 1 shop.

c) Business Registration

According to the interview with the Thanlyin Township Development Committee, a part of YCDC organization, there was no registration system for stalls on street while shops need to register to YCDC. It was found that only two shops had registered their businesses to YCDC.

d) Operation of Stalls and Shops

It was found that most of the stalls and shops operated more than six days a week or more than 350 days a year.

(4) Common Asset Survey and Market Price Survey

a) Common Asset Survey

Assets commonly used by local residents (i.e., residents living in and around the project area) such as wells, cemetery, or school and located in the project area were confirmed from February 23, 24, and 27, 2017 along with the conduct of DMS. From common asset survey, two small-sized praying facilities were found in No. 11 area on the Thanlyin side. There were no people living in No. 11 area, and therefore, they were not used by local people although these were maintained by the private company.

[3]A shop in this A-RAP is defined as a store fixed its structure on the ground. A stall is defined as a vendor with movable structure.

b) Market Price Survey

Market price survey was conducted for collecting the unit price of immovable properties confirmed in the project area as referential information for estimating compensation amount. In DMS, a house, annex of house, and tree were identified as immovable assets. Thus, unit price of house/annex construction materials and trees was collected from the area, namely; No. 9 Quarter and No. 10 Quarter in February 2017 since local people around the project area bought construction materials at these areas.

Table 9.3.11 Outline of Survey

Survey Items	Survey Area	Survey Period
House/ Annex Construction Materials	No. 9 Ward and No. 10 Ward in Thaketa Township	March 22, 2017
Tree	Ditto	Ditto

Source: JICA Study Team

[redacted]

(5) Supplemental Consultation Meeting

A total of two stakeholder meetings were organized for the Bago River Bridge Construction Project at the time of F/S and Supplemental F/S. In these stakeholder meetings, project description and possible environmental and social impacts were explained to the stakeholders including people living in and around the project area. However, the policy to compensate loss to be caused by land acquisition and relocation was not explained to possible PAHs since the project was not officially approved by the parliament at that time.

Explaining and exchanging opinions about the compensation policy with PAHs and reflecting those opinions and comments to the A-RAP is essentially required action based on the JICA Guidelines. Therefore, MOC made an explanation on the compensation policy to PAHs by organizing the

additional consultation meeting on December 17, 2016.

PAHs were classified into five groups based on the current structure conditions and features of possible impacts: 1) MR's Staff Apartment 2) Structures on Government Land, 3) Private fence, tea shop, hair salon, and beer shop, 4) Movable stall Group-1 and 5) movable stall Group 2. The additional consultation meeting was organized separately for each group.

For organizing the additional consultation meeting, firstly, the JICA Study Team supported MOC to confirm the location of households listed in the draft A-RAP since they were the targets of the additional consultation meeting but there was no personal information to identify them. Thus, ground confirmation was done on December 12 and 13, 2016 based on coordinate information and photos of affected structures available in the draft A-RAP. On December 16, 2016, the JICA Study Team and a hundred households heads[4]in the affected communities visited each household found in the ground confirmation to announce the additional consultation meeting (i.e., the purpose, date and time, and venue) verbally. In addition, the note showed the time of the meeting was provided to each household. Table 9.3.13 shows the number of invited and participated households, while Table 9.3.14 summarizes questions and answers raised during the additional consultation meeting. Detailed minutes of the meeting and materials used for the additional consultation meeting are enclosed in Appendix.

Table 9.3.13 Number of Invited and Participated Households

	Category	No. of Invited Household	No. of Participated Household
1	MR Staff Apartment	14[1]	13
2	Structures on Government Land	21[2]	18[6]
3	Private Fence, Tea Shop, Hair Salon, Beer Shop	4[3]	4
4	Stall Group (1)	18[4]	18
5	Stall Group (2)	21[5]	19
	Total	78	72

Note:

1 & 2: This category is same as "resident" in "land acquisition and facilities" in the draft A-RAP. Four households in the bridge portion were outside of the project area, and were excluded from announcement. At the time of ground confirmation on December 12 and 13, 2016, a total of 21 structures were found in the recorded place of the intersection portion although 19 structures were recorded in this place in the draft A-RAP. Since identification of recorded 19 structures was impossible due to lack of information, 21 structures were announced.

3: This category is same as "non-resident" in "land acquisition and facilities" in the intersection portion in the draft A-RAP. One household, namely, the monastery to be affected its fence and one household, namely, YCDC were excluded from announcement since the fence of monastery would be excluded from the project area, and YCDC would be discussed separately later. Thus, a total of three households and one household from the stall group (i.e., beer shop) were announced.

4 & 5: This category is the same as "non-resident" in "only facilities" in the draft A-RAP. One household of religious facility in the bridge portion in Thaketa Township was not found on December 12 and 13, 2016, and was excluded from the announcement. Two households of religious facility in the bridge portion in Thanlyin Township were owned by a private company, and would be discussed separately later. One household of stall was redundantly counted in the bridge portion and in the intersection portion. In this case, invited household was counted as one household. Eleven structures in the intersection portion were not found in the recorded place on December 12 and 13, 2016, and they were excluded from the announcement. Three structures in the intersection portion were found but users were not found (i.e., no users but just structures located in the recorded place), and they were excluded from the announcement. One household considered as stall (i.e., beer shop) was included in the "private fence tea shop, hair salon, beer shop" due to its structure condition. A total of 39 households of stalls were found on December 12 and 13, 2016, and were

[4] A ward administrator is the person officially appointed by the General Administration Department based on the voting result of respective local community. Under the Ward Administrator, there are a hundred-household head, a ten-household head, etc., who are elected by a local community and work as the leader of the community. In other words, a hundred-household head is also regarded as a coordinator between a ward administrator and a local community.

announced.

6: One household is classified into "Structure on Government Land" participated in the meeting for "MR Staff Apartment due to the convenience since he lived inside the compound of MR staff apartment.

Source: JICA Study Team

Table 9.3.14 Summary of Questions and Answers

Date and Time	Venue and Session	Questions and Answers
December 17, 2016 9:40 – 10:10	MOC Office in Thaketa Township Session 1 MR's staff apartment	Q1:Would like to know the date for relocation in order to apply for a new apartment from MR. A1: It is not sure at this moment. MOC will inform the moving date when the date is sure. MOC will discuss with MR Officers for the MR's staff apartments that are included in the project area for the convenience of people living in the MR staff apartment. Q2: I am willing to move from the apartment if necessary. Request to inform relocation beforehand. A2: When the time is fixed, MOC will inform in advance. Q3: Is there any consideration for renters? A3: The apartment owners should solve it by themselves.
December 17, 2016 10:20 – 10:45	MOC Office in Thaketa Township Session 2 Structures on Government Land	Q1: It is convenient if the relocation place is available. In addition, it is also convenient if the moving cost is supported. A1: Due to difficulties in arranging a relocation site, MOC cannot promise to provide the relocation place. MOC will provide the compensation for the structures and other assets by following JICA Guidelines and the decision making by the compensation committee and instruction of YRG.
December 17, 2016 11:00 – 11:40	MOC Office in Thaketa Township Session 3 Private Fence, Tea Shop, Hair Salon and Beer Shop	Q1: Up to which area or distance, the shop needs to move in order to avoid affecting the project activities. A1: At this moment, MOC cannot answer exactly, but MOC will inform when it is fixed. Q2: It is preferable if the relocation place is near from the current business place. A2: The structure is located within the road ROW area owned by the government. MOC will provide the compensation based on the type of structures.
December 17, 2016 02:10 – 02:20	MOC Office in Thaketa Township Session 4 Movable Stall Group 1	No one raised questions in this section.
December 17, 2016 03:05– 03:20	MOC Office in Thaketa Township Session 5 Movable Stall Group 2	Q1: Permanent structures will be affected or not. A1: As the zero level of flyover will stop before arriving to the 108 Yard Pagoda, it can be assumed that the permanent living structure will not be affected due to the project. Q2: Requesting recommendation letter for betel shop to apply new place in YCDC. A2: The project will provide the requested recommendation letter.

Source: JICA Study Team

(6) Compensation Contents

1) Compensation Policy

There is no comprehensive law and regulation which stipulates relocation related issues in the current legal framework in Myanmar. Thus, Land Acquisition Act (1894) is used as the fundamental regulation for land acquisition in Myanmar.

As for the Project, there is no acquisition of private land since all land to be used for the Project is confirmed as governed by the national authorities although some households occupied land in the project area without holding proper legal land title.

A project funded by the Japanese government needs to satisfy the requirements of environmental and social considerations including relocation stipulated in the JICA Guidelines. The key principles on relocation issues in the JICA Guidelines are summarized below.

- Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. If population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.
- People who must be resettled involuntary and people whose measures of livelihood will be hindered or losses must be sufficiently compensated and supported in a timely manner. Compensation must be provided as full replacement cost as much as possible, and compensation and other kinds of assistance must be provided prior to displacement. So that they can improve or at least restore their standard of living, income opportunities, and production levels to pre-project levels
- Appropriate participation and accessible grievance mechanisms must be established for the affected people and their communities.

Accordingly, the Project established key principles on relocation for aiming the objectives of this A-RAP:

- Involuntary resettlement and loss of means of livelihood are to be avoided or minimized as much as possible by exploring all viable alternatives.
- People to be relocated will be provided sufficient compensation for loss of their own fixed property and income. Since land to be used by the Project belongs to the government or national authorities. Land compensation is not provided to people using land in the project area.
- Compensation is provided in full replacement cost in timely manner by holding consultation with people in the project area.

2) Entitlement Matrix

Based on the compensation policies described in 1) above, previous experience in MOC projects and custom on relocation in Myanmar, the entitlement and contents of compensation for the Project are summarized in Table 9.3.15.

Table 9.3.14 Entitlement Matrix

Type of Losses/ Category of Assistance	[redacted]	[redacted]	Concerned portion of the Project	Application	Entitled Person	Assistance Policy	[redacted]
1) Assets and Structures							
i) 23 m² MR staff's apartments	[redacted]	[redacted]	Improvement at intersections	Located within ROW of widening of Thanlyin Chin Kat Road in Thaketa Township for improvement at intersections project	People living in those apartments at the time of Cut-off Date	▪ Provide substitute living structure ▪ Cash assistance for moving	[redacted]
ii) Houses made of bamboo and wood on government land	[redacted]	[redacted]	Improvement at intersections	Located within ROW of widening of Thanlyin Chin Kat Road in Thaketa Township for improvement at intersections project	People living in those houses at the time of Cut-off Date	▪ Compensation loss of assets, structures, and facilities based on replacement cost[3]	▪ [redacted]
iii) Small praying religious facilities	[redacted]	[redacted]	Bridge portion	Located within ROW of construction of an approach road for Bago River Bridge	Owner of each facility	▪ Cash assistance for moving	
vi) Fences and structures such as tea shop, hair salon, beer shop, sundry shop (i.e. coffee shop in the Myanmar term)	[redacted]	[redacted]	Improvement at intersections	Located within ROW of construction of widening of roads in Thaketa Township	Legal owners of respective structure	▪ Reconstruction of fence and structures at necessary setback distance if land for setback is available	▪ [redacted]
vii) Compensation for temporary stop of business for tea shop and hair salon in vi) under 1) assets and structures	[redacted]	[redacted]	Improvement at intersections	Located within ROW of construction of widening of roads in Thaketa Township	Owners of these shops in vi	▪ Compensation for those days when business is closed during destruction and reconstruction of their	▪ [redacted]

Type of Losses/ Category of Assistance	[redacted]	[redacted]	Concerned portion of the Project	Application	Entitled Person	Assistance Policy	[redacted]
						shops	[redacted]
2) Stalls							
i) Stalls which are easily reassemble	[redacted]	[redacted]	Improvement at intersections	Located within ROW of widening of roads in Thaketa Township	Owner of the stalls	▪ Cash assistance for moving	

Note:

[redacted]

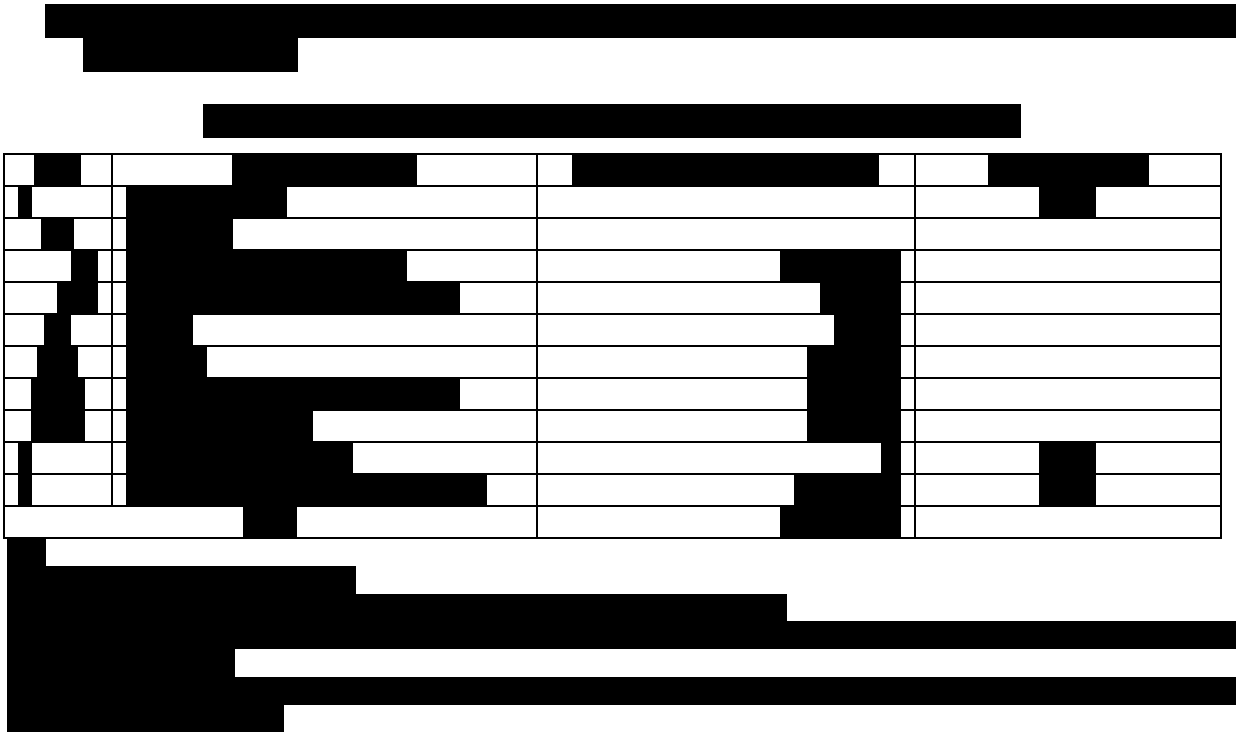
3. With regard to land and structures, "replacement cost" is defined as follows according to World Bank: For agricultural land, it is the pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes. In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account, nor is the value of benefits to be derived from the project deducted from the valuation of an affected asset. Where domestic law does not meet the standard of compensation at full replacement cost, compensation under domestic law is supplemented by additional measures so as to meet the replacement cost standard. Such additional assistance is distinct from resettlement measures to be provided under other clauses in OP 4.12, para. 6.

Source: JICA Study Team

3) Draft Compensation Amount

Compensation is provided for eligible persons and households in accordance with the policy stipulated in the entitlement matrix in Table 9.3.15. The compensation amount is finalized by consultation between the committee and eligible persons/ households referring to the draft compensation amount estimated in this detailed design (D/D). The draft compensation amount was estimated with the conditions listed below, and is summarized in Table 9.3.16.

- Compensation for living structures was estimated based on the house condition confirmed by DMS (i.e., the condition in the dry season) although some households in this area repaired their houses after DMS to prepare for the rainy season.
- Compensation for loss of income from business is calculated for business owners whose establishments were fixed on ground in the project area. Business owners of movable or easily reassembled establishments were not entitled for compensation for loss of income from business referring to WB OP4.12.
- Allowance for moving includes moving of households living in houses at the Yadanar Intersection areas and households living in MR staff apartment.



(7) Institutional Structure for Implementing Relocation

According to the general relocation practice in MOC, relocation issues are handled by a compensation committee which is established for a project with the approval of a regional government such as YRG in the case of Yangon. For the Project, the Compensation Committee (the Committee) chaired by the Minister of Ministry of Electric, Technical, and Transportation in YRG was established with the approval letter from YRG in May 2017. The Committee is composed of several authorities: MOC, MR, YCDC, Ministry of Agriculture, Livestock and Irrigation, MPA, YESC, Myanmar Post, and Telecommunication and District Administrators.

Institutional structure for implementing the relocation of the Project is set by nexus of the Committee and other authorities as shown in their responsibility presented in Table 9.3.17.

Table 9.3.17 Responsibilities of Relevant Organizations for Implementing Relocation

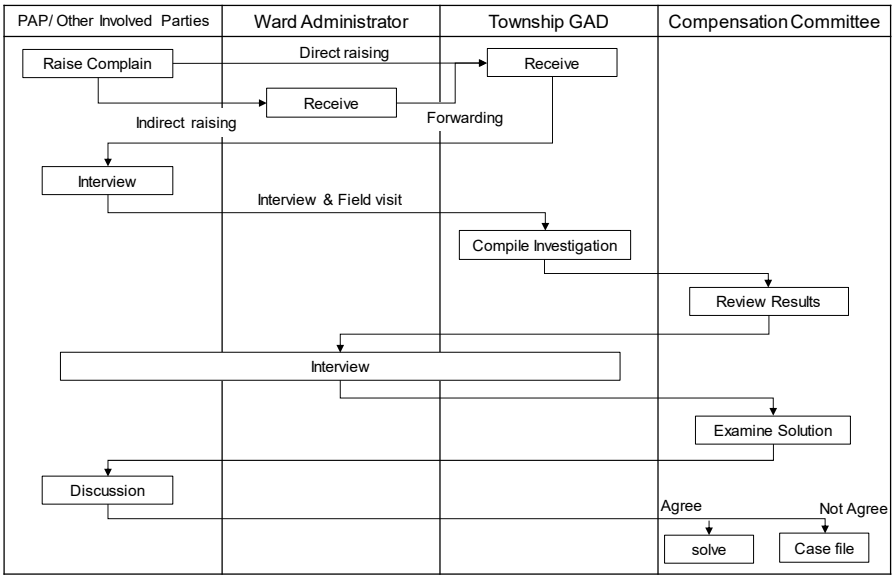
Organization	Responsibilities
Compensation Committee	1) Confirm the ownership of affected assets and eligibility of compensation 2) Examine compensation amount 3) Conduct individual consultation and negotiation with PAPs based on the instruction from YRG and in accordance with the JICA Guidelines/A-RAP 4) Examine the approach to solve the raised grievance based on the result of initial investigation by GAD 5) Support PMU for conducting internal monitoring
Township General Administration Department (GAD)	1) Contact window of grievance from PAPs and conduct initial investigation of raised grievance
Ward Administrator	1) Contact window of grievance from PAPs and support Township GAD on initial investigation of raised grievance
Environmental and Social Staff in the Project Management Unit (PMU) of MOC	1) Conduct internal monitoring based on A-RAP with the Compensation Committee 2) Support the Compensation Committee and Township GAD on solving raised grievance

Source: JICA Study Team

(8) Grievance Redress Mechanism

The grievance redress mechanism for land acquisition is stipulated in Land Acquisition Act 1894 and Farmland Rules 2012 although, there is no description of relocation not requiring land acquisition. Accordingly, MOC and the JICA Study Team examined the grievance redress mechanism applicable for the project referring to general practices in Myanmar to ensure: i) easy access of PAPs and other parties involved into relocation activities to appeal issues on relocation issues, ii) all complaints related to relocation are appropriately dealt with, and iii) taking adequate measures to solve the raised issues.

If PAPs or parties who are involved into the relocation activities of the project have an issue on relocation activities, they are able to raise it to GAD in the concerned township directly or through their respective ward administrators. Concerned township GAD confirms the status by conducting a field visit and holding an interview with a person who raised an issue and informs the result of an interview to the Compensation Committee. The Compensation Committee reviews the confirmation results to be submitted by the concerned township GAD, and conducts an interview with the concerned person and authority. As necessary, attendance of a third party such as a local community leader or a local monk will be considered. The Compensation Committee considers an approach to solve the raised issue, which will be informed and discussed with the person and township GAD concerned. When a raised issue is not solved, it will be filed in court. The expected period for grievance redress is considered as one month after complaints are submitted to the concerned township GAD. The procedure of each grievance will be recorded by the concerned township GAD.



Source: JICA Study Team

Figure 9.3.4 Provisional Grievance Redress Mechanism

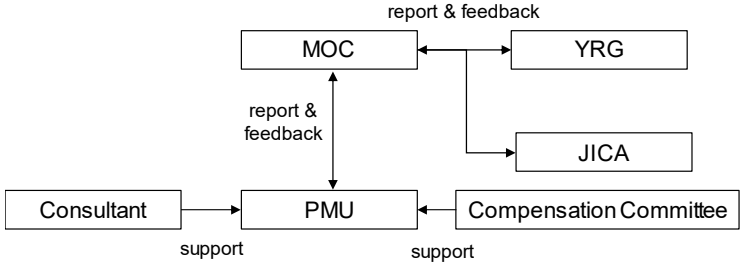
(9) Monitoring

A project proponent is generally requested to implement internal monitoring (i.e., monitoring by a project proponent and other authorities to be included into relocation and compensation process) in the case of relocation scale less than 200 people. The Project will require relocation of less than 200 people, and therefore, internal monitoring is needed.

The purposes of internal monitoring are: i) to monitor progress and contents of relocation, ii) to identify problems which were not identified during A-RAP preparation, and iii) to assess compensation contents are sufficient. Monitoring items include the following elements:

- Timely and complete disbursement of compensation to each PAH in accordance with agreed conditions;
- Participation of PAPs into preparation and implementation of relocation;
- Information disclosure and consultation procedures;
- Effectiveness of grievance mechanism and raised issues; and
- Unforeseeable issues or additional measures to be taken.

Internal monitoring will be periodically conducted by PMU from the time of compensation payment until completion of relocation. Results of internal monitoring will be periodically reported from PMU (or MOC) to YRG and JICA as shown in the reporting flow in Figure 9.3.5.



Source: JICA Study Team

Figure 9.3.5 Structure of Implementing Internal Monitoring

CHAPTER 10. HIV/AIDS PREVENTION PROGRAM

10.1 INTRODUCTION

In most of Asia, especially in developing countries like Myanmar, the human immunodeficiency virus (HIV) and acquire immune deficiency syndrome (AIDS) are still concentrated. While infrastructure development projects will contribute to economic development of the developing countries, the construction work involved in the implementation will increase the movement of mobile workers who has the potential of high risk of HIV/AIDS infection around the project site. International aid agencies regarded the construction sector as the priority place for HIV/AIDS transmission. Therefore, in August 2006, the Japan International Cooperation Agency (JICA) signed a joint initiative together with five other donor agencies to incorporate HIV/AIDS prevention programs for workers engaged in construction work. According to the abovementioned facts, HIV/AIDS prevention program is cooperated in the Project.

The primary objective of HIV/AIDS prevention program in the Project is to spread the appropriate knowledge for preventing HIV/AIDS infection among construction workers and in the neighboring communities. Therefore, the HIV/AIDS prevention program of the Project has been organized with three components: Component 1) the education/awareness program for the construction workers and the surrounding local communities, Component 2) peer education program for the construction workers, and Component 3) voluntary counseling and testing to the construction workers.

10.2 SITUATION IN MYANMAR

10.2.1 Laws Related to HIV/AIDS Epidemic Diseases in Myanmar

Even though there is no regulation which deals specifically with HIV/AIDS, the Law for the Prevention and Control of Communicable Diseases (hereinafter called "the Law") enacted on January 27, 2011 is concerned with HIV/AIDS epidemic diseases. The facts related to HIV/AIDS in the Law are summarized below.

- Under the Law, HIV/AIDS are classified as "principal epidemic diseases."
- In order to prevent the outbreak, the Department of Health shall implement the following:
- Immunization of those who have attained majority, by injection or orally, when necessary.
- Carrying out health education activities relating to communicable diseases.
- When a principal epidemic diseases or noticable diseases occur, immunization or other necessary measures shall be undertaken by the Department of Health in order to control the spread thereof.

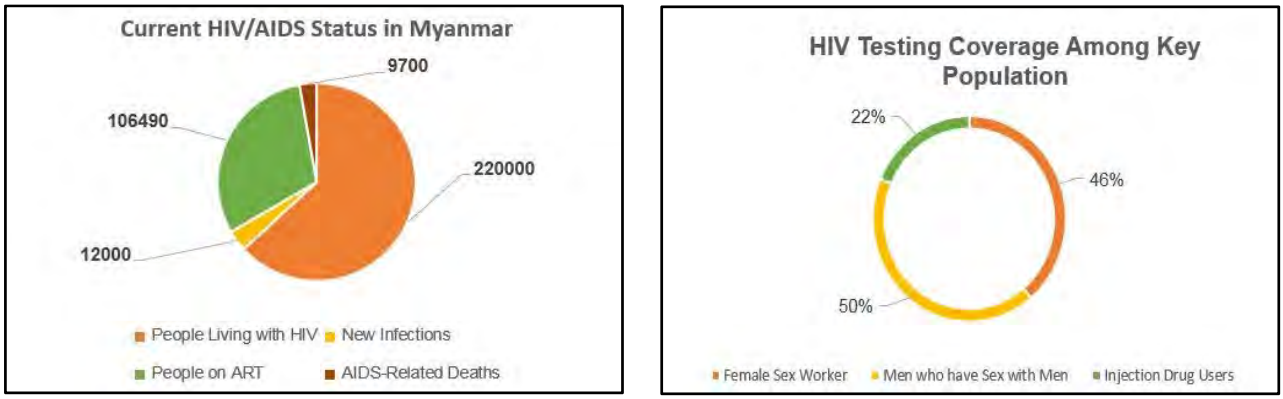
10.2.2 Approach in Myanmar

Myanmar has a diverse population where 70% of whom resides in rural areas. The first HIV-infected individual was identified in 1988 and the first AIDS case was reported in 1991. The national response to the HIV epidemic commenced in mid-1980. A multi-sectoral National AIDS Committee chaired by the Minister of Health and Sports (previously known as the "Ministry of Health") was established in 1989 and a short-term plan for the prevention of HIV transmission was launched in that year. In 1991, the Sexually Transmitted Infections Prevention and Control Programme and the HIV/AIDS Prevention and Control Programme were incorporated into one programme – the National AIDS Programme (NAP). The general objective of the NAP is to increase the awareness and perception of HIV/AIDS in the community by promoting access to information and education leading to behaviorial change and adoption of a healthy lifestyle.

HIV/AIDS prevention activities in Myanmar are mainly focused on the general population: injection drug users (IDUs), female sex workers (FSWs), and men who have sex with men (MSM). The first National

Strategic Plan (NSP I) covered 2006-2010. Following the review of its achievements and experiences, the National Strategic Plan 2011-2015 (NSP II) was prepared. In the current national health plan of Myanmar, the top three priority diseases in ranked order are AIDS, malaria, and tuberculosis (TB). In Myanmar, AIDS, TB, and sexually transmitted infectious (STI) contributed 4.3%, 1.6%, and 0.8%, respectively, for a total of 6.7% of overall disease burden expressed by Disability Adjusted Life Years. Expressed by deaths, the overall disease burden for AIDS, TB, and STD is 4.0%, 1.8%, and 0.4%, respectively, of all deaths in the country combining to a total of 6.3% according to the Myanmar National Strategic Plan on HIV and AIDS Report (2011-2015).

According to HIV and AIDS DATA HUB for Asia-Pacific, the number of people who are living with HIV is 220,000, among them, 47% of people (i.e., 106,490 people) received antiretroviral therapy (ART) and 9,700 people are dead with AIDS-related deaths. People living with HIV receives free treatment at the General Hospital and Special Infectious Hospital. The current condition and HIV testing coverage among key population in Myanmar are shown in Figure 10.2.1. Starting from 2017, NAP extends the targeted population to mobile workers (migrants) and prisoners.



Source: Compiled by the JICA Study Team based on HIV and AIDS DATA HUB for Asia-Pacific (http://www.aidsdatahub.org/Country-Profiles/Myanmar)

Figure 10.2.1 Current Status of HIV/AIDS Condition and HIV Testing Coverage among Key Population in Myanmar

10.2.3 Responsible Agencies

In Myanmar, the National Aid Committee, established in 1989 by the Ministry of Health and Sports (previously known as the "Ministry of Health"), is the leading organization in fighting HIV/AIDS. The National AIDS Committee has organized AIDS/STD Prevention and Control Team in each state and division. In Yangon Division, there are eight AIDS/STD Prevention and Control Teams under the NAP of Yangon Division to increase the awareness and perception of HIV/AIDS in the community by promoting access to information and education leading to behaviorial change and adoption of a healthy lifestyle. Those teams have the responsibility to be successful by implementing the objective of NAP in relevant districts and townships. There are other non-governmental organizations (NGOs)/international non-governmental organizations (INGOs) which are carrying out HIV/AIDS related activities based on their fund availabilities.

10.2.4 Donor Policy

As mentioned in Section 10.1, JICA incorporates fighting HIV/AIDS through Infrastructure Project after Joint Initiative Launched on the Eve of the XVI International AIDS Conference in August 2006. The Japan Bank for International Cooperation (ex-JBIC; Governor: Kyosuke Shinozawa) joined the World Bank (WB), Asian Development Bank (ADB), African Development Bank (AfDB), United Kingdom Department for International Development (DFID), and KfW Entwicklungsbank (KfW Development Bank) and launched the Joint Initiative by Developing Agencies for the Infrastructure Sectors to Mitigate the Spread of

HIV/AIDS on August 11, 2006. The Joint Initiative was prepared and agreed to in time for the XVI International AIDS Conference held in Toronto from August 13 to 18, 2006.

In the Joint Initiative, the development agencies have agreed to take the following actions:

- Strengthen the framework for sharing good practices in planning, implementation, and scaling up HIV/AIDS interventions in infrastructure programs;
- Ensure that interventions are consistent with each partner country's national strategy for combating HIV/AIDS;
- Strengthen cooperation and partnership between communities, local governments, and other authorities, related donors, NGOs, and private enterprises and their employees;
- Carry out joint assessment of key HIV/AIDS programs in infrastructure projects in terms of their impact, sustainability, and cost-effectiveness; and
- Seek to encourage the partner country governments to scale up HIV/AIDS programs in their infrastructure projects.

10.2.5 Issues of HIV/AIDS Prevention Program at the Construction Sector in Myanmar

In Myanmar, HIV/AIDS prevention activities are mainly focused on the general population such as IDUs, FSWs, and MSM. Although HIV/AIDS prevention program is being incorporated in some of foreign loan construction projects for the construction workers and surrounding communities, the number of projects is very few. Moreover, only NGO/INGO who targeted mobile workers and migrants were able to implement the HIV/AIDS prevention program in construction sites due to the work scope limitation. Based on the experiences of one INGO in construction sectors, the issues found in HIV/AIDS prevention program of construction sector are as follows:

- Contractor could not give enough time to the workers to attend to the HIV/AIDS education program.
- Attention of workers to the education program is less.
- People from surrounding communities are not keen to attend to the HIV/AIDS education program due to disturbance in their works even though transportation, incentive, and refreshment are arranged.

10.3 SITUATION IN THE PROJECT SITE

The current HIV/AIDS situation of Thanlyin and Tharketa townships are mentioned as below.

10.3.1 HIV/AIDS Situation in Thanlyin Township

In Thanlyin Township, the project area is located in Myoe Hyaung (west) Ward. There are two residences, Star City and Mya Han Thar, which are close to the project area and there are small shops near the project area. Those shops are targeted as the main stakeholders of HIV/AIDS prevention program of the Project for the local communities rather than in Star City and Mya Han Thar residence due to their expected education level. There is no specialized infectious disease hospital for HIV/AIDS in Thanlyin Township. Those who are suffering from HIV/AIDS epidemic diseases would be referred to relevant hospitals. Referring to the general information of yearly statistical data of Thanlyin Township, the prevalence of HIV/AIDS condition in Thanlyin Township from 2013 to 2017 is shown in Table 10.3.1.

Table 10.3.1 Prevalence of HIV/AIDS in Thanlyin Township

Sr.	2013-2014		2014-2015		2015-2016		2016-2017	
	Incidence	Death	Incidence	Death	Incidence	Death	Incidence	Death
1	35	2	33	2	308	5	130	12

Source: General Information of Thanlyin Township Yearly Statistical Book

10.3.2 HIV/AIDS Situation in Thaketa Township

The project area is located in 10th Ward South and 10th Ward North of Thaketa Township. The surrounding people living in these two wards are the main stakeholders of the Project. The surrounding communities' condition in the project area where squatters' structures, government apartments, religious facilities, and private structure. Based on the observation of the surrounding communities, it is assumed that the level of knowledge of health for HIV/AIDS prevention might be low, although there are two access centers for HIV/AIDS diseases, called National AIDS Programme (NAP) Hospital owned by the Government and Médecins Sans Frontières (MSF) established by an INGO. Referring to the general information of yearly statistical data of Thaketa Township, the prevalence of HIV/AIDS condition in Thaketa Township from 2013 to 2016 is shown in Table 10.3.2.

Table 10.3.2 Prevalence of HIV/AIDS in Thaketa Township

Sr.	2013-2014		2014-2015		2015-2016		2016-2017	
	Incidence	Death	Incidence	Death	Incidence	Death	Incidence	Death
1	2446	481	128	45	2210	172	1092	175

Source: Source: General Information of Thaketa Township Yearly Statistical Book

10.4 SCOPE AND IMPLEMENTATION STRATEGY

10.4.1 Objective

The main objective of the HIV/AIDS prevention program is to reduce potential negative social impacts associated with the implementation and operation of the Project. In order to achieve the main objective, the HIV/AIDS prevention program mitigates HIV risks and vulnerability to HIV/AIDS at the construction sites and surrounding communities by the following outputs:

- Reducing the risk of transfer of HIV between and among construction workers, their families, and the local community by raising awareness about HIV/AIDS.
- Ensuring that construction workers have access to condoms.
- Providing peer education program among the construction workers to be more effective in voluntary consulting about HIV/AIDS matters, more comfortable in receiving condoms from peer educators, and expected behavior changes.
- Providing HIV voluntary counseling and referring to NAP or INGO if necessary.
- Monitoring and evaluation of the program outcomes.

10.4.2 Components of HIV/AIDS Prevention Program of the Project

The HIV/AIDS prevention program of the Project will be implemented with three components mentioned as follows. These three components are commonly implemented for Packages 1, 2, and 3.

Component 1- HIV/AIDS education program to the construction workers and surrounding communities

In HIV/AIDS education program, the service providers (i.e., an entity approved to provide HIV/AIDS Prevention Program) will provide information about HIV/AIDS and STI risks and prevention, introducing behavior change, and promoting safe behavior to the construction workers and surrounding communities. The aim of the HIV/AIDS Awareness Program is to empower and increase the awareness of participants on HIV/AIDS, its impact, management, and availability of support systems. Furthermore, it is intended to encourage early testing and lifestyle changes that will thereby reduce and prevent further infection. For the effective implementation of the program, the participant is better not to be more than 50 persons in each session. Due to the instability of the workers' nature in the construction site, the program will be arranged every month throughout the construction period to cover all workers at least once. For the surrounding communities, the education program is tentatively arranged to organize once for every three months in each ward.

Component 2- Peer education program among construction workers

Peer education program is based on the idea that individuals are most likely to change their behavior if people they know and trust persuade them to do so. It helps to break down barriers by allowing people to discuss sensitive matters without fear. Team leaders or key persons respected in the team will be selected as peer educators and they will have an education level of high school and have an interest in helping others and good communication skills. Peer educators can disseminate information and supplies, organize skill-building sessions, and make referrals to other HIV/AIDS services. The service provider will design the content of peer education program. Tentatively, the peer education program will be organized four times per construction period including refresher courses. The peer educators will be supported by daily wages and additional necessary allowances.

Component 3- HIV voluntary counseling and testing for construction workers

The purpose of this component is to secure access to health services including HIV voluntary counseling and testing in cooperation with NAP, other INGO in relevant township, and linking with other components in the HIV/AIDS prevention program for the Project with trust and confidentially. If a person with positive findings is found, that person will be suggested to be put to care at NAP or other INGO in relevant township without discrimination due to any reasons.

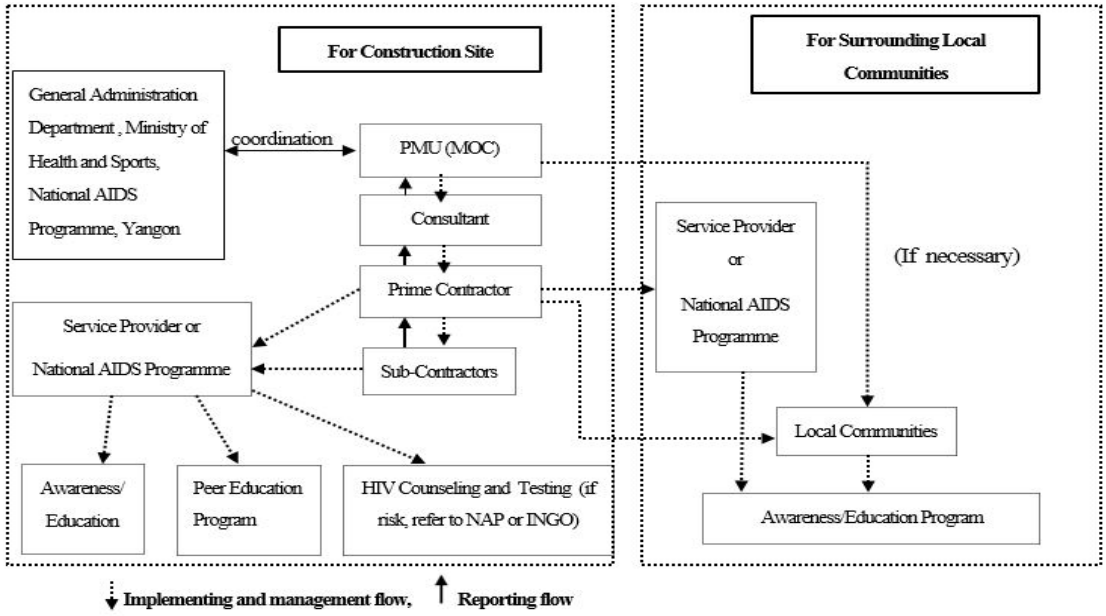
10.4.3 Implementation Structure

Before starting the construction work, the project management unit (PMU) of the Ministry of Construction (MOC) needs to coordinate with NAP of the Yangon Region and the General Administration Department of the respective township to get the co-operation in the implementation of the program.

The program implementation will be controlled by the PMU of MOC as part of construction. The PMU will assign the project consultant to control the quality of the program through participating in the preparation of HIV clause for the contracts, monitoring, and evaluation of the program. Based on the contract between a prime contractor and service provider, the service provider will operate the program on site. Therefore, service providers will be the responsible persons from NAP or other related NGO/INGO.

For the construction site, if the prime contractor divides and transfers the work to the sub-contractors, the sub-contractors need to follow the HIV/AIDS prevention program of the prime contractor and need to submit separate report to the prime contractor. The prime contractor needs to review and organize the reports of sub-contractors and submit the report to the consultant in accordance with the contract on a timely manner. After receiving the report from the prime contractor, the consultant will submit the report to the PMU of MOC.

The prime contractor has the main responsibility to implement the HIV/AIDS awareness and education program within the surrounding local communities. The prime contractor can request the consultant when the co-operation from the government ministries is necessary. The PMU has the responsibility to deal with the relevant ministries and government departments when the consultant is requested to get cooperation from the other relevant ministries and government departments. The implementation strategy of HIV/AIDS prevention program is shown in Figure 10.4.1 and the responsibilities of each organization are mentioned in Table 10.4.1.



Source: JICA Study Team

Figure 10.4.1 Implementation Strategy of HIV/ AIDS Prevention Program

Table 10.4.1 Responsibilities of Relevant Organization for Implementing HIV/AIDS Prevention Program

Organization	Responsibilities
PMU of MOC	1) Communicate with the relevant General Administrative Department and National Aid Program. 2) Monitor the implementation and effectiveness of the HIV/AIDS prevention program at the construction site and the surrounding local communities.
GAD	1) Responsible for co-operation of HIV/AIDS prevention program, especially in engagement with the surrounding local communities of the project.
Ministry of Health and Sports, National AIDS Program or Service Provider	1) Organize the HIV/AIDS awareness and education program both at the construction site and the surrounding communities. 2) Conduct the Peer Education Program for the construction workers. 3) HIV voluntary counseling and testing to the construction workers and referring to the relevant hospitals (if necessary).
Consultant	1) Monitor the implementation program of HIV/AIDS prevention program of the prime contractor. 2) Report the HIV/AIDS prevention program to the PMU. 3) Modify the implementing approach of HIV/AIDS prevention program, if necessary.

Organization	Responsibilities
Prime Contractor	1) Conduct the HIV/AIDS prevention program of the project both at the construction site and the surrounding local communities as per contract. 2) Monitoring the implementing status of HIV/AIDS prevention program of the sub-contractors. 3) Submit the report of HIV/AIDS prevention program in timely as per contract to the consultant.
Sub-contractor	1) Conduct the HIV/AIDS prevention program of the project both at the construction site and the surrounding local communities as per contract. 2) Monitoring the implementing status of HIV/AIDS prevention program as per contract. 3) Submit the report of HIV/AIDS prevention program in a timely manner as per contract to the prime contractor.

Source: JICA Study Team

10.4.4 Implementation Schedule

The tentative implementation schedule of the HIV/AIDS program throughout the project period for all packages are mentioned in Table 1.4.1.

Table 10.4.2 Implementation Schedule for All Packages

Sr.	Component	Target Group	Package 1	Package 2	Package 3	Implemented Organization	Responsible Organization	Supervised Organization
1	Education/Awareness Program	Construction workers	Every month (~ 28 times per construction period)	Every month (~ 28 times per construction period)	Every month (~ 28 times per construction period)	National AIDS Programme or Service Provider	Contractor	Consultant/ PMU (MOC)
		Local Communities	2 times per year (~ 4 times per construction period)	Not necessary due to implementation in Package 1 and Package 3.	4 times per year in each ward and continue throughout the construction period. (Total- 8 times for 2 wards per year) (~ 16 times per construction period)			
2	Peer Education Program	Construction workers	2 times per throughout the construction period	2 times per throughout the construction period	2 times per year, and continue throughout the construction period (~ 4 times per construction period)	National AIDS Programme or Service Provider	Contractor	Consultant/ PMU (MOC)
3	HIV Voluntary Counseling and Testing	Construction workers	One time throughout the construction period	One time throughout the construction period	One time throughout the construction period	National AIDS Programme or Service Provider	Contractor	Consultant/ PMU (MOC)

**HIV/AIDS prevention program should be arranged within the working hours.*
Source: JICA Study Team

10.5 COST ESTIMATION

The total cost estimation of the HIV/ AIDS prevention program for all packages is USD 65,574.17: (Package 1 - USD 16,782.68, Package 2 - USD 14,227.61, and Package 3 - USD 34,563.88). The cost is estimated based on the estimated workers -700 persons, surrounding communities – 200 persons and peer educators – 10 persons for each package. The details of the estimation are described in Tables 10.5.1 to 10.5.3.

Table 10.5.1 Summary for the Cost Estimation of HIV/AIDS Prevention Program of Package 1

Sr. No.	Component	Items	Total Cost/ Construction Period (MMK)	Total Cost/ Construction Period (USD)
1	Education/ Awareness Program	i) Construction site ii) Surrounding communities iii) Poster (on site) iv) Condom distribution (on site)	12,748,000.00	9,359.77
2	Peer Education Program	- All training throughout the construction period	4510,000.00	3,311.31
3	HIV Voluntary Counseling and Testing	- Voluntary counseling and testing	5,600,000.00	4,111.60
Total			**22,858,000.00**	**16,782.68**

Note: USD 1 = MMK 1,362 as of March 13, 2017 (Central Bank)
Source: JICA Study Team

Table 10.5.2 Summary for the Cost Estimation of HIV/AIDS Prevention Program of Package 2

Sr. No.	Component	Items	Total Cost/ Construction Period (MMK)	Total Cost/ Construction Period (USD)
1	Education/ Awareness Program	i) Construction site ii) Surrounding communities iii) Poster (on site) iv) Condom distribution (on site)	9,268,000.00	6,804.70
2	Peer Education Program	- All trainings throughout the construction period	4,510,000.00	3,311.31
3	HIV Voluntary Counseling and Testing	- Voluntary counseling and testing	5,600,000.00	4,111.60
Total			**19,378,000.00**	**14,227.61**

Note: USD 1 = MMK 1,362 as of March 13, 2017 (Central Bank)
Source: JICA Study Team

Table 10.5.3 Summary for the Cost Estimation of HIV/AIDS Prevention Program of Package 3

Sr. No.	Component	Items	Total Cost/ Construction Period (MMK)	Total Cost/ Construction Period (USD)
1	Education/ Awareness Program	i) Construction site ii) Surrounding communities iii) Poster (on site) iv) Condom distribution (on site)	9,268,000.00	23,829.66
2	Peer Education Program	- All trainings throughout the construction period	4,510,000.00	6,622.61
3	HIV Voluntary Counseling and Testing	- Voluntary counseling and testing	5,600,000.00	4,111.60
Total			**47,076,000.00**	**34,563.88**

Note: USD 1 = MMK 1,362 as of March 13, 2017 (Central Bank)
Source: JICA Study Team

CHAPTER 11. OPERATION AND MAINTENANCE

11.1 INTRODUCTION

The Ministry of Construction (MOC) has an intention to collect tolls from vehicles using the bridge with the aim of covering the maintenance cost of the Project.

This chapter will discuss plans of toll collection, traffic management, and maintenance for Operation and Maintenance (O&M) planning.

11.2 TOLL COLLECTION PLAN

MOC determines rating to charge fees for access of toll bridges according to vehicle class by weight/ number of axes, etc., and also imposes penalty on overweight vehicles for extra weight. Thus, it is general to collect the toll fee and penalty mentioned above in the same tollgate.

Consequently, the collection of both toll fee and penalty also in the Bago River bridge should be in accordance with the regulation of MOC and make distinction between regular vehicles (non-large vehicle) and large vehicles like trucks, which needs to be weighed.

Given these facts, the following shows recommended toll collection system for the Project:

11.2.1 Toll Type

Flat Toll; Uniform tolls by vehicle class per entry, regardless of traveled distance on the toll road.

11.2.2 Toll Collection Method

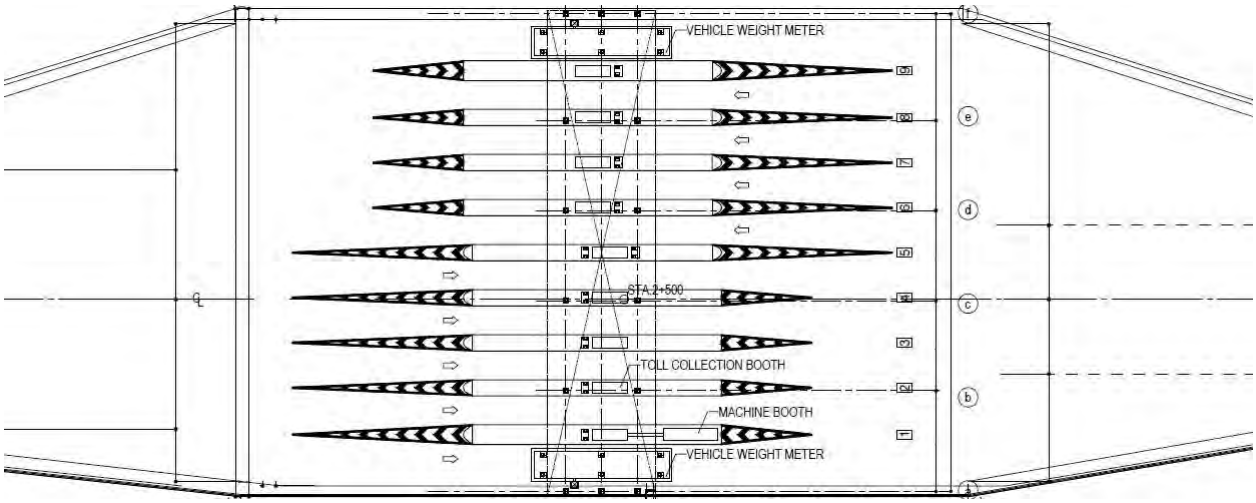
Entry/Exit Collection; in consideration of one-time payment at integrated tollgate.

11.2.3 Extent of Toll Charging

Tolls are charged to all users. The toll roads should be physically designed not to let any users escape from paying the toll, and also to let large vehicles go through only exclusive lanes, equipped with truck scale.

11.2.4 Tollgate Allocation

As shown in Figure 11.2.1, toll booths will be allocated according to the future traffic demand in order to prevent congestion at the tollgate.



Source: JICA Study Team

Figure 11.2.1 Tollgate Allocation

11.2.5 Organization for Toll Collection

In general, the implementation body of toll collection is entrusted to the private sector entity, with toll collecting operations by MOC. Considering the fact, this section shows a recommended implementation structure:

- 8-hour shift, with three groups in turn
- Setup of personnel in one group:
  - 1 supervisor
  - 10 collectors (1 collector per lane)
  - 2 standby persons
- On-site staffs for administrative office along with tollgate
  - 1 responsible person/ 1 accountant/ IT engineer/ security guards and others

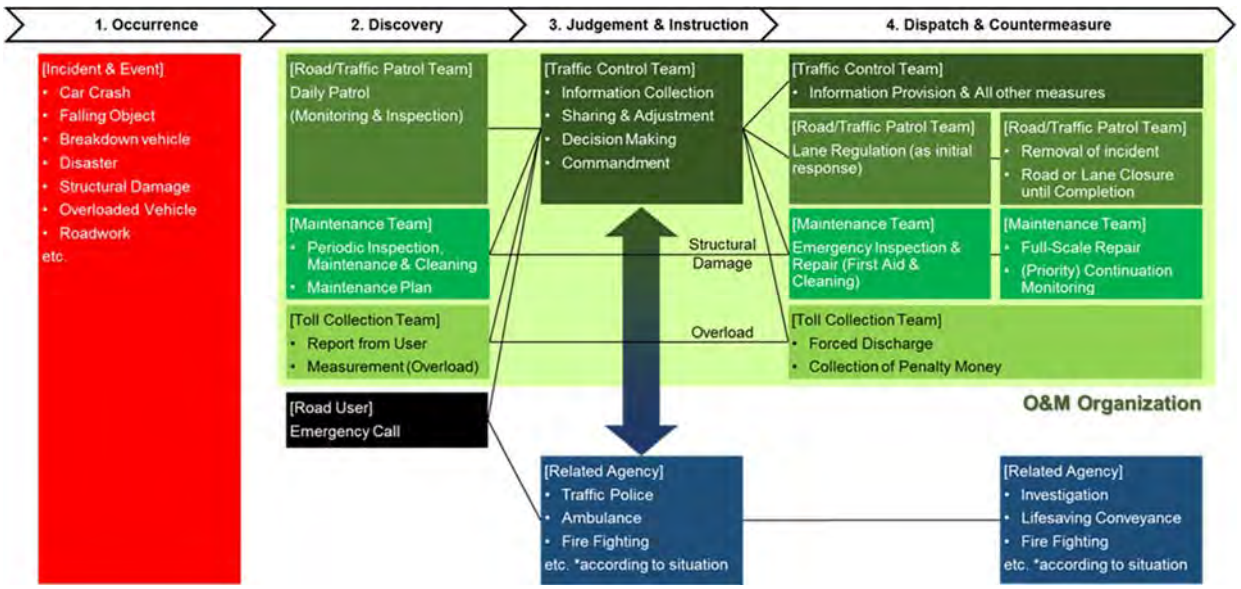
11.3 TRAFFIC MANAGEMENT PLAN

Traffic management is implemented in order to secure safe, smooth, and comfortable road traffic.

One of its important tasks is the traffic patrol to observe throughout the road traffic space, which detects not only sudden and unexpected accidents and fallen objects, but also minor differences (damages) in road structures.

Another important task is the traffic control, which directs and executes quickly and precisely the most appropriate measures, e.g., traffic regulation, contacts with parties concerned, and provision of information as occasion may demand, according to the ever-changing traffic conditions. To this end, cooperation with the teams related to O&M is also required.

Figure 11.3.1 shows the concept image of the abovementioned.



Source: JICA Study Team

Figure 11.3.1 Traffic Management Flow (in case of incident occurrence)

In the Project, traffic management plan shall conform to the existing general practices of traffic management in Myanmar. To be specific, the model to realize safe and smooth road traffic will not establish a control department to integrate contractors of toll collection, maintenance, and enforcement, but entrust actions required in each task among contractors.

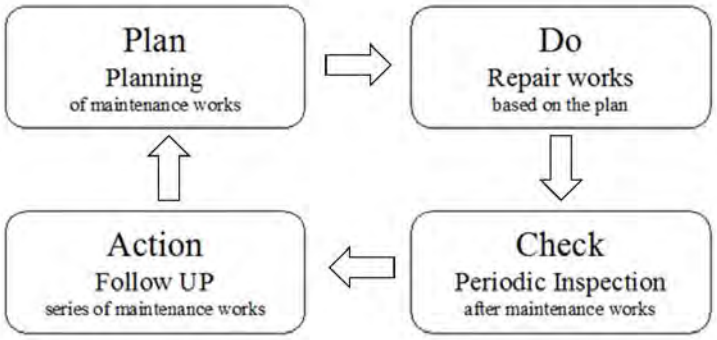
Besides, the Intelligent Transport Systems (ITS) technology (e.g., data collection, information provision, etc.) for efficient traffic management or its equivalent is appropriate to introduce when rising momentum for efficient road network because the independent introduction in the Project will provide limited effect.

11.4 MAINTENANCE PLAN

The following shows the recommended maintenance plan in the Project:

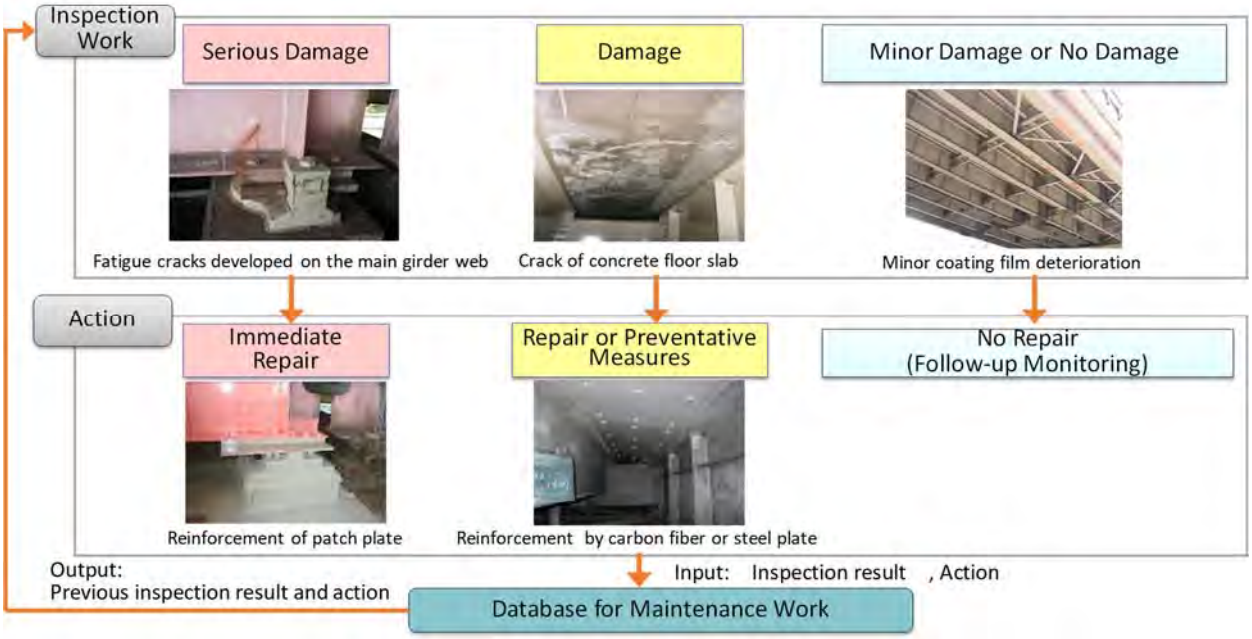
11.4.1 Basic Concept

With the aim of road safety, proper maintenance works are important to secure functions required for structures during their service life. A series of operations: plan, inspection, and repair should be implemented repeatedly during the maintenance period to maintain the structures in a proper state. Figure 11.4.1 and Figure 11.4.2 show the Operation Cycle and General Maintenance Flow, respectively. Engineers should always conform to plan-do-action cycle (PDCA) for the proper maintenance works, taking into account life cycle cost (LCC) of road structures.



Source: JICA Study Team

Figure 11.4.1 Maintenance Cycle



Source: JICA Study Team

Figure 11.4.2 General Maintenance Flow of Structures

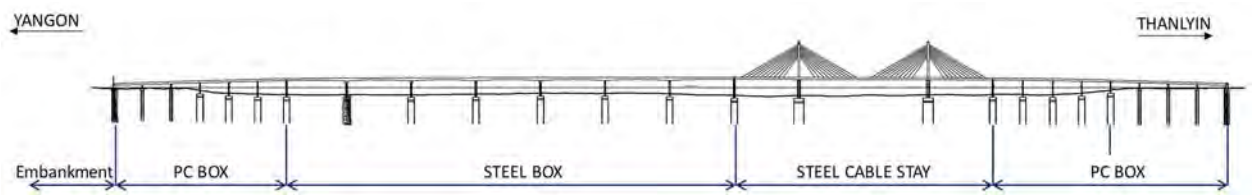
In the maintenance works, engineers should make clear their tasks to carry out. For example, in case of detection of serious damage to traffic safety, it is necessary to establish implementation system beforehand to judge the necessity of traffic regulations such as road blocking and emergency repair works, and to take measures required.

Establishment of database to store all information from design to construction and repair of structures is essential. It is important to store drawings, specifications, and initial inspection records as reference of initial state of road structures, but also to record even cases of minor damages observed in regular inspections.

Repair works of the structures require to define cause of damage, to make corresponding repair and to fix repair period considering progress of damages. To select repair methods, consideration of life cycle cost (LCC) will be important.

11.4.2 Considerations in Maintenance Works

The Bago River Bridge has several bridge types showed in Figure 11.4.3 Maintenance works require to understand their component parts, purposes, and functions of members.



Source: JICA Study Team

Figure 11.4.3 Bridge Types in the Bago River Bridge

11.4.2.1 Cable-stayed Bridge

Different from general bridges as it consists of particular parts such as main tower, cables, and it requires sensitive maintenance with understanding on their structural functions.

11.4.2.2 PC Bridge

As for corrosion, fracture and impaired tone of PC steel can reduce the safety of the structure and it requires maintenance to detect damages early in inspections and to maintain PC steel in good condition.

11.4.2.3 Steel Bridge

As the use of the steel bridge progressed, damages in steel materials such as fatigue crack, corrosion, and loss of bolts can reduce safety of the structure, it requires maintenance to detect damages early in the inspections and to maintain PC steel in good condition.

11.4.2.4 Substructure (foundation/ pier/ abutment)

It requires maintenance monitoring progress of damages in inspections, in light of ground stability, e.g., existence of scour at foundation, and attributes of RC structure, although it permits minor cracks, e.g., existence of earth pressure or excess load from superstructure.

11.4.2.5 Appurtenance

(1) Expansion Device

It requires maintenance to detect damages early in inspections and to maintain it in good condition; in order to keep functions to absorb expansion caused by changes in temperature and earthquake and consequently not to hinder passage of vehicles and humans.

(2) Bearing

It requires maintenance to detect damages early in inspections and to maintain it in good condition; in order to keep functions to transmit load of superstructure to substructure and absorb thermal contraction caused by temperature and earthquake.

Additionally, as cable-stayed bridge employs rocking bearing because of negative reaction force generated at the end of piers, it is necessary to understand its required performances sufficiently.

11.4.3 Inspections

11.4.3.1 Purpose

The purpose of inspections is to figure out accurately the existence of damages such as deformations in structures and breakdowns in order to maintain all the structures in a sound and safe state.

11.4.3.2 Types of inspections

Inspections can be classified into three types i.e., Daily, Periodic, and Emergency as shown in Table 11.4.1:.

Table 11.4.1 Types of Inspections

Type	Purpose and Designation
Daily Inspection	Executed on a daily basis to secure safe and smooth traffic.
Periodic Inspection	Executed at regular intervals to detect all damages occurred in structures.
Emergency Inspection	Executed when abnormalities such as major earthquakes, storms, and accidents.

Source: JICA Study Team

11.4.3.3 Daily Inspection

In this inspection, visual inspections from patrol vehicles on roads and walking inspections around are executed to check if there are serious damages threatening road safety or broken parts in the facilities caused by accidents. Table 11.4.2 shows items and cycle of this inspection.

Table 11.4.2 Items and Cycle of Daily Inspection

Inspection Type	Target Structure	Time of Implementation	Inspection Item
Daily Inspection	On road	Once a day	Visual inspection from patrol car pavement, expansion joint, railing, drainage, accessories, etc.

Source: JICA Study Team

11.4.3.4 Periodic Inspection

In this inspection, approaching structures is monitored as closely as possible for detection and to keep a record of damages, which can affect performances of structures. Table 11.4.3 shows items and cycle of this inspection.

Table 11.4.3 Items and Cycle of Periodic Inspection

Inspection Type	Target Structure	Time of Implementation	Inspection Item
Periodic Inspection	Cable Stay	Before service 1 year after service After 5 years interval	Visual inspection of appearance, vertical alignment, inclination of pylon, fluctuation of substructure of pylon, measurement of cable tension, measurement of movement of bearing and joint *Monitoring with inclinometer for inclination of pylon is carried out separately.
	Others	Before service 1 year after service After 5 years interval	Visual inspection of appearance, hammering test, etc. *Monitoring with inclinometer for inclination of abutments is carried out separately.

Source: JICA Study Team

(1) General Inspection Method

To figure out the condition of structures/ damages on a regular basis and checks by seeing and touching are carried out approaching closely to the structures. Also, non-destructive inspections like hammering test will be employed where necessary. It is advisable to keep records of damages like materials/ parts detected, size, etc.

As for as inspections of inaccessible parts like cables in cable-stayed bridges and narrow places, inspections with binoculars and fiberscopes and others as needed are recommended.

1) Concrete Structure

- As the hammering test is effective to detect damages caused by rusting in steel rods such as spalling of concrete, visual inspection and hammering by inspector are basic.

- Cracks are measured in length and width in order to observe their progress. In addition, recording with sketch and photograph after marking with chalk is recommended.
- Table 11.4.4 shows common major parts in concrete structures.

Table 11.4.4 Common Major Parts in Concrete Structures

Member	Major Part
Concrete girder	Medium and 1/4 points of span length, ends of girder, placing joint, notched part, anchorage zone of PC
Concrete floor slab	Overhanging section, haunch part, drain board, ends of girder (if PC slab: anchorage zone of PC, placing joint, block joint)
Concrete pier	Corner, root of hanging section, surrounding part of bearing shoe, placing joint

Source: JICA Study Team

2) Steel Structures

- Visual inspection and hammering by inspector is basic. If corrosions are observed, their range and depth should be measured.
- If detected cracks of coating in welding parts, which could have been caused by fatigue crack, non-destructive inspections like magnet particle test will be conducted.
- High-strength bolts are inspected visually at first; then, 10% of total bolts are tested by hammering.
- Table 11.4.5 shows common major parts in steel structure.

Table 11.4.5 Common Major Parts in Steel Structures

Member	Major Part
Steel girder	Overhanging section of steel slab, medium point of span length, ends of girder, surrounding part of bearing, notched part, crossing part of members, splicing part
Steel pier	Corner, surrounding part of bearing shoe, splicing part, pillar base

Source: JICA Study Team

(2) Inspections in Bago River Bridge

1) Major Inspection Items

In addition to the common inspection methods mentioned above, Table 11.4.6 shows major inspection items in the Bago River Bridge.

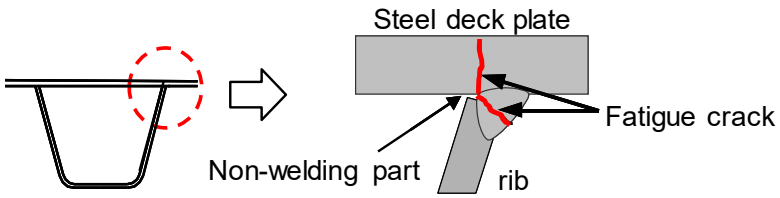
Table 11.4.6 Major Inspection Items in the Bago River Bridge

Classification	Major Inspection Items
Cable-stayed Bridge	Inspections for special bridge: cable tension, damage in anchorage zone examined by the entire behavior of the bridge: vertical alignment, inclination of main tower, etc.
PC Bridge	Damages in concrete like cracks, gaps between blocks, damages in PC steel and its anchorage zone
Steel Bridge	Fatigue crack in steel slab deck plate, welding part of U-rib and others, deterioration of coating, lack of welding bolts
Substructure: foundation/ pier/ abutment	Scour at foundation, deformation, and damages such as crack in concrete

Appurtenance	Joint	Constraint of movement, difference in level, deformation, deterioration *Check designed movement range before inspection
	Bearing	Constraint of movement and rotation, deformation, deterioration, corrosion, Cracks in concrete base, water leakage from joint *Check designed movement range before inspection

Source: JICA Study Team

Steel deck plates, even though designed against fatigue with sufficient consideration of repeated loads, have non-welded parts due to the structure of U-rib, which can induce fatigue cracks as shown in Figure 11.4.4 depending on their quality at production time. Therefore, the inspection team wants checking if there are any cracks of this kind.



Source: JICA Study Team

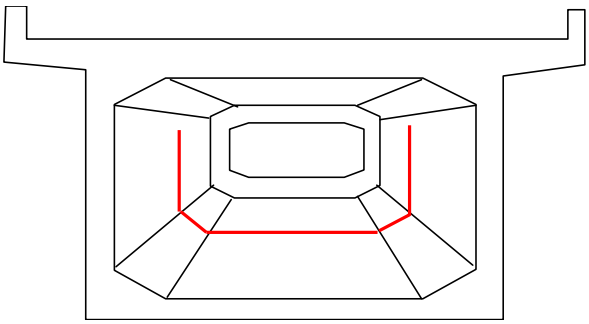
Figure 11.4.4 Fatigue Cracks at U-rib in Steel Slab

Cable-stayed bridges want checking if there are any pulled-out cables or worn-out ones in anchorage zones.

Source: JICA Study Team

Figure 11.4.5 Pulled-out/ Worn-out Cables

On the other hand, PC box girder bridges, which could have gaps at the joint part of blocks as shown in Figure 11.4.6 require close attention.



Source: JICA Study Team

Figure 11.4.6 Gap at Joint Part of Blocks in PC Box Girder Bridge

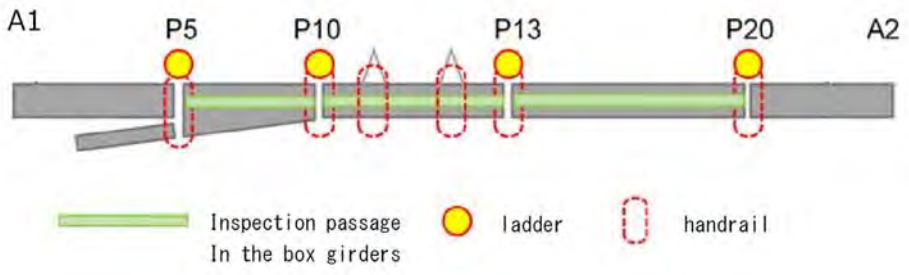
2) Access methods

Exterior parts of girder, pier, bearing, and others are inspected with inspection vehicles for bridge as shown in Figure 11.4.7.

Source: JICA Study Team

Figure 11.4.7 Example of Inspection Vehicle

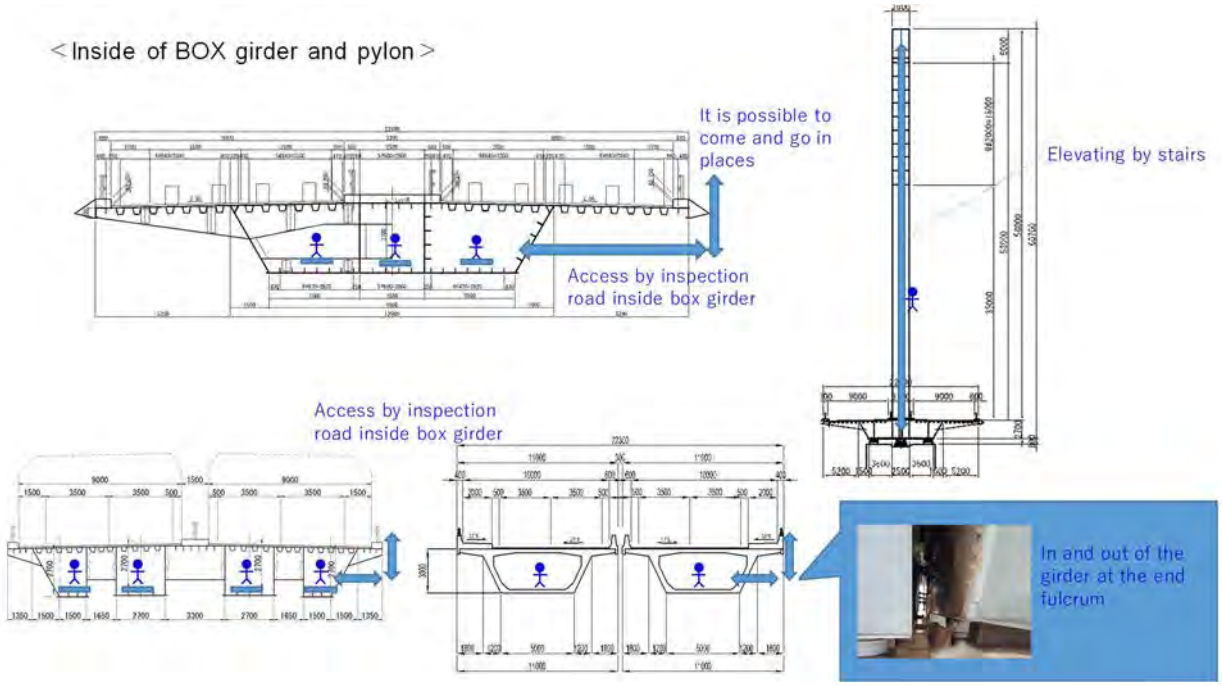
Interior parts of box girder and main tower are inspected using maintenance facilities as shown in Figure 11.4.8. As switching points of bridging at P5/ P10/ P13/ P20 have ladder equipped from the road surface to the top of the bridge pier as they allow inspectors to access into girders. Furthermore, the box girders at P5/ P10/ P13/ P20 are equipped with inspection passage within them in order to secure space for walking.



Source: JICA Study Team

Figure 11.4.8 Maintenance Facilities

Figure 11.4.9 shows the concept images of access to interior of box girder and main tower.



Source: JICA Study Team

Figure 11.4.9 Access Methods

11.4.3.5 Emergency Inspection

Table 11.4.7 shows the proposal of inspection items at the occurrence of incidents such as major earthquake, storm, and accidents that can damage the facilities.

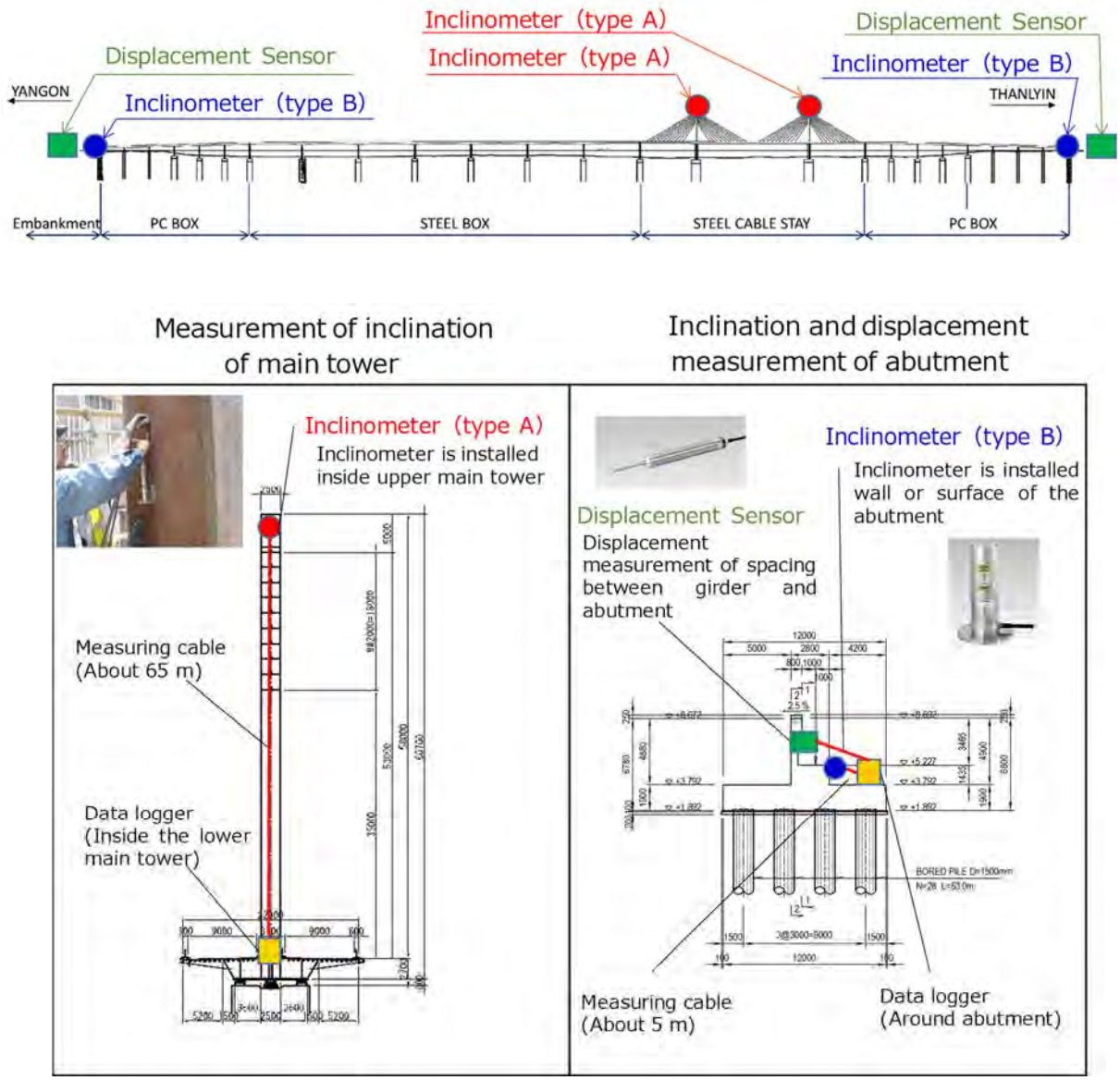
Table 11.4.7 Items and Cycle of Emergency Inspection

Inspection Type	Target Structure	Time of Implementation	Inspection Item
Emergency Inspection	All structures	Earthquake On storm Other	Visual inspection of distant range Approach when abnormality is confirmed, visual inspection of appearance, hammering test, other measurements, etc.

Source: JICA Study Team

11.4.4 Simplified Monitoring

Since largely deformed bridges due to defective work and ground deformation are observed in Myanmar, this Study proposes to execute simplified monitoring in order to obtain historical data of deformation from the early stage of construction. Figure 11.4.10 shows arrangement planning of measuring devices.

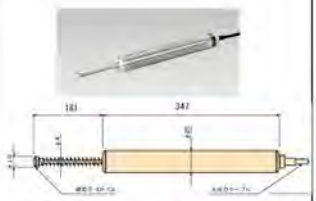


Source: JICA Study Team

Figure 11.4.10 Arrangement Planning of Measuring Devices in Simplified Monitoring

Table 11.4.8 and Table 11.4.9 show the specification of measuring devices and guide of measurement, respectively.

Table 11.4.8 Reference Specification of Measuring Devices

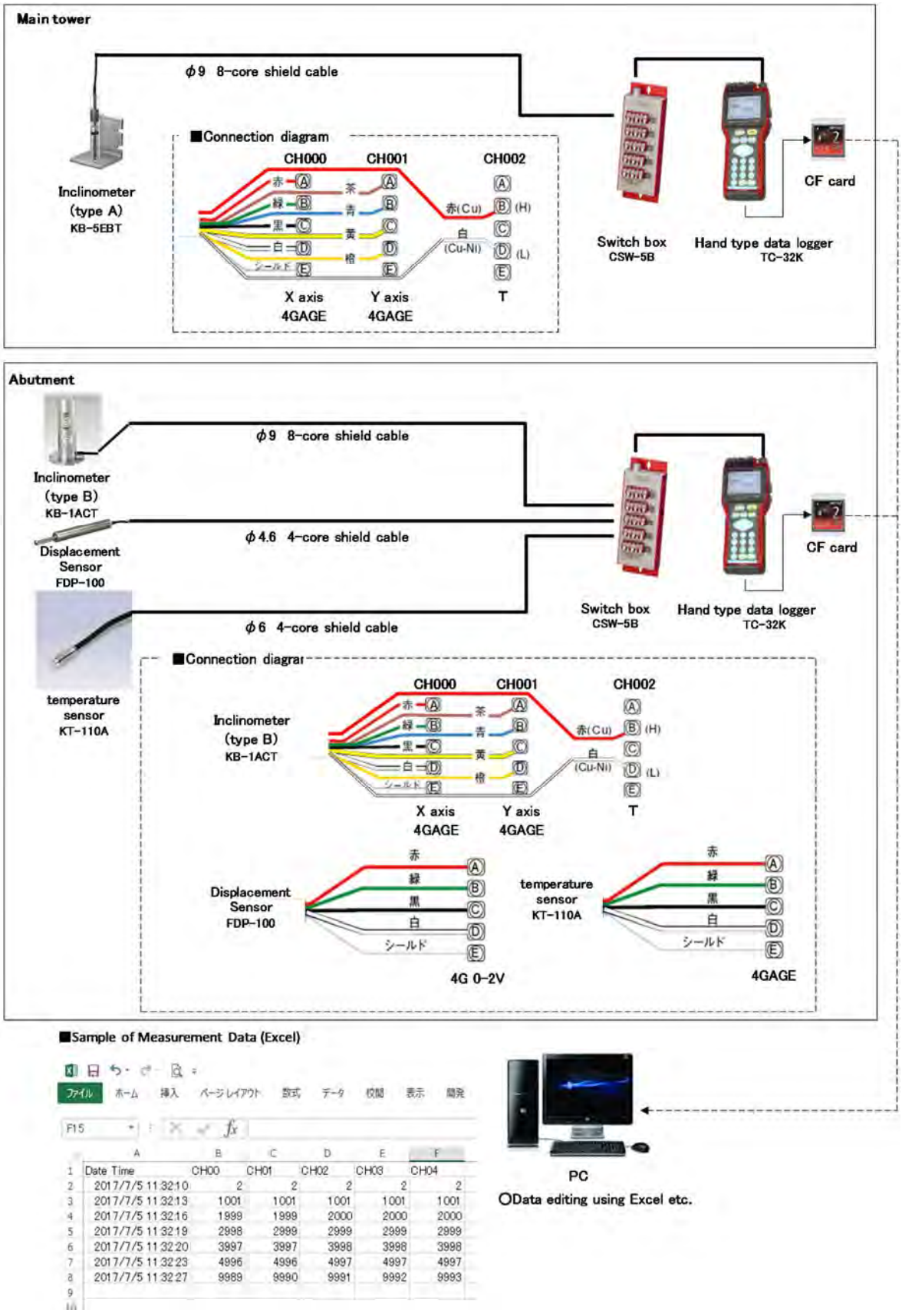
Item		Inclinometer (type A)	Inclinometer (type B)	Displacement Sensor
Installation place		Main tower 2 locations	Abutment 2 locations	
Device	Range	±5°	±1°	100mm
	Direction	2 directions(xy axis)	2 directions(xy axis)	1 direction(x axis)
	Accurucy	0.025°	0.005°	0.5mm
	Others	With temperature sensor	With temperature sensor	Optional temperature sensor is required
	Reference diagram	 KB-5EBT (Tokyo Sokki Kenkyujo)	 KB-1ACT (Tokyo Sokki Kenkyujo)	 FDP-100A (Tokyo Sokki Kenkyujo)
Data Logger	Specification	2 data recorders ※Standard Output 1×10^{-6} ε	2 data recorders ※Standard Output 1×10^{-6} ε	
	Reference diagram	 Switch box CSW-5B Hand type data logger TC-32K (Tokyo Sokki Kenkyujo)	 Switch box CSW-5B Hand type data logger TC-32K (Tokyo Sokki Kenkyujo)	

Source: JICA Study Team

Table 11.4.9 Guide of Measurement

Item	Designation
Measurement Contents	Main tower : Inclination measurement Abutment part : Inclination measurement and displacement measurement
Measurement Period	From completion of construction/ 1 year after service commencement *As deformations due to defective works and ground deformation tends to occur within 1 year, decision to continue measurement will be made one year later after service commencement.
Measurement Cycle	Every 1 hour
Data Collection Cycle	Approximately once a month（manually to collect data）

Source: JICA Study Team



Source: JICA Study Team

Figure 11.4.11 Diagram of Entire Measuring System

Aginst abnormal states of cable-stayed bridges: deficiency of cables and yielding of girder/ main tower, Table 11.4.10 shows summary of guidance values of tilt angle of main tower and countermeasures elicited from the structural analysis of each state.

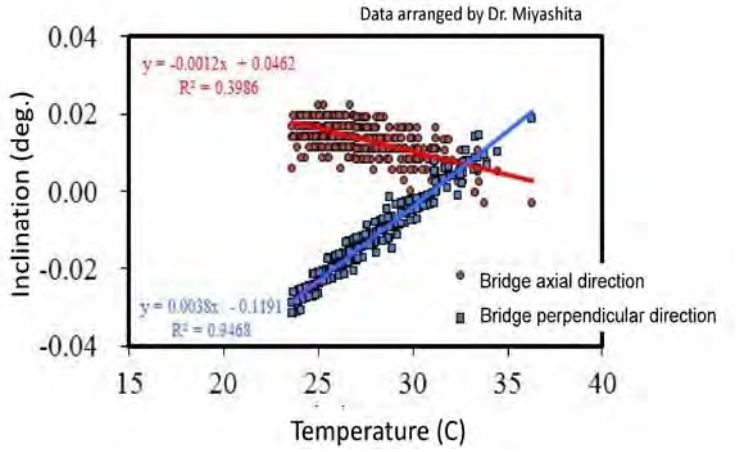
However, as mesasuring devices themselves have influence of ambient temperature, shown in Figure 11.4.12, in order to determine significant change or not, it is necessary to consider correlation between temperature and changes.

Additionally, it is required to give thought to possibility of outlier: abnormal value measured due to failuars of devices.

Table 11.4.10 Guidance Value for Tilt Measurement of Main Tower

Tilt Angle θ	State of Structure	Countermeasure
θ＜0.2°	Sound state or No problem in safety of entire structure	—
0.2°≦θ＜0.5	Possible state with intial yield in main tower/ part of girders, or deficiency of cables	<Caution Required> ・On-site check by emergency inspection ・Contact with JICA experts and others
0.5°≦θ	Possible state with ultimet yield in main tower/ part of girders	<Emergency> ・Lane closure ・On-site check by emergency inspection

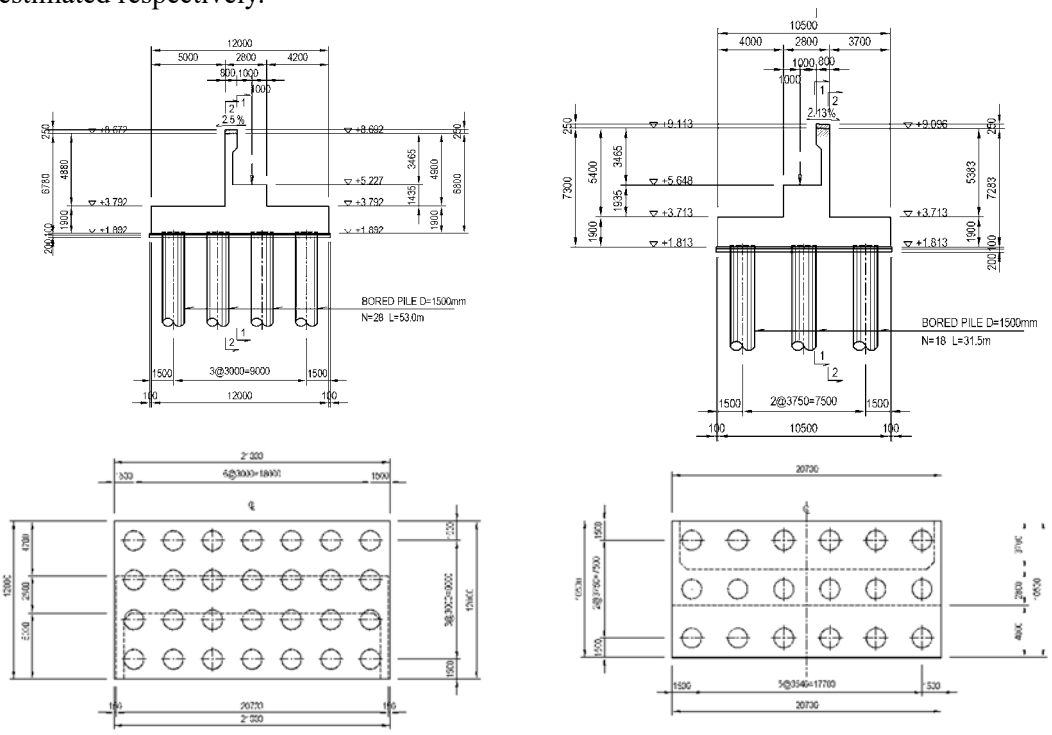
Source: JICA Study Team



Source: JICA Study Team

Figure 11.4.12 Temperature Characterictic of Measuring Devices

Next, Table 11.4.11 shows summary of guidance values of tilt angle of abutment A1/ A2 and countermeasures. Since abutments A1 and A2 have different number of foundation piles due to the different ground conditions such as thickness of weak stratum, as shown in Figure 11.4.13, their guidedance values are estimated respectively.



Abutment A1 Abutment A2

Source: JICA Study Team

Figure 11.4.13 Component Drawing of Abutments A1 and A2

Table 11.4.11 Guidance Value for Tilt Measurement of Abutments A1 and A2

Tilt Angle θ		State of Structure	Countermeasure
Abutment A1	Abutment A2		
θ＜0.017°	θ＜0.034°	Sound state or No problem in safety of base of abutments	－
0.017°≦θ＜0.024°	0.034°≦θ＜0.038°	Possible state with intial yield in some parts of pile foundation	<Caution Required> ・On-site check by emergency inspection ・Contact with JICA experts and others
0.024°≦θ	0.038°≦θ	Possible state with intial yield in many parts of pile foundation	<Emergency> ・Lane closure ・On-site check by emergency inspection

Source: JICA Study Team

Since guidande values are small, in order to dermine significant change or not, with consideration of correlation between temperature and changes as wel as tilt measurement of maint tower, displacement measurement will be used in combination desirably.

However, in displacement measurement, i.e., measuring expansion gap between girder and abutment, not only expansion and contruction resulting from temperature changes, but also drying shrinkage of girder at early stage of construction shoud be taken into consideration.

11.4.5 Measurement with Laser Profiler

In order to figure out the entire behavior of cable-stayed bridge in periodic inspections, this Study proposes measurement with laser profiler shown in Figure 11.4.14.

Source: JICA Study Team

Figure 11.4.14 Measurement by Laser Profiler

11.4.6 Repair and Reinforcement Works

In these, it is required to identify cause of damage and to execute the corresponding repair. Moreover, it is important to decide repair timing considering progress of damages. The following shows example cases of repair works:

Source: JICA Study Team

Figure 11.4.15 Example Cases of Repair Works

11.4.7 Personnel Organization for Implementation

Basically, it has the same implementation system as the one in the maintenance and management of other structures in Myanmar.

For reference, the standard personnel organization for implementation in Japan is shown in Table 11.4.12.

Table 11.4.12 Personnel Organization for Implementation in Japan (Reference)

Role		Number	Task
Station	Supervisor	1 person	Management of all tasks related to maintenance
	Engineer	1 person	Supervising inspections and repair works/ data collection of simplified monitoring
At inspection	Responsible person	1 person	Responsible person for inspection
	Inspectors	2 persons	Workers who carry out visual inspection and hammering test
	Driver	1 person	Driver for bridge inspection vehicle
At repair work	Organize structure according to designations and amount of repair works		

Source: JICA Study Team

11.5 PROPOSED O&M STRUCTURE

Given the actual condition of O&M in Myanmar, and based on the hearings and consultations, the responsibility and assignment are summarized as follows:

Since in Myanmar, toll collection, entrusted through bidding, has been operated already under build-operate-transfer (BOT) and tender scheme, and there are several companies which have experiences in toll collection business. Appropriate toll collection services for the Project can be provided by experienced companies mentioned above through bidding procurement. Also, taking into account the requirements mentioned in development of toll road, at least, a general office shall be provided for the entrusted company.

On the other hand, although private business operators have experience in improvement and maintenance of roads on ground under BOT, the maintenance for large-scale bridges, like the Project, has been executed directly by MOC in practical terms. Therefore, it is realistic that MOC shall also take the initiative in the maintenance of the Project.

For reference, Table 11.5.1 shows a proposed O&M structure based on a typical structure.

Table 11.5.1 Proposed Organization for O&M

	Operation & Maintenance			Reference *Construction
Agency	Maintenance *Inspection & Repair	Toll Management	Traffic Management	
MOC	Bridge & Road *including accessories			Bridge & Road *including accessories Toll Plaza & Booth *except equipment
Private Sector *Operator	Toll Plaza & Booth *except equipment Equipment for Toll Management	Toll Collection & Track Scale		Equipment for Toll Management
Traffic Police			Control & Patrol	

Source: JICA Study Team

CHAPTER 12. COST ESTIMATE AND PROCUREMENT

12.1 POLICY OF COST ESTIMATE

12.1.1 Guidelines

The construction cost was estimated in accordance with the Japanese guideline and standard (specifically as shown Table 12.1.1), because there is no cost estimate standard for bridge work in Myanmar. New standards have a priority to be used. Some work items refer to conventional standards.

Table 12.1.1 Applied Standard and Manual for Cost Estimate

Japan International Cooperation Agency (JICA)
- Preparatory Survey for Grant Aid / Design and Cost Estimate Manual (Civil Engineering), 2016 - Preparatory Survey for Grant Aid / Design and Cost Estimate Manual (Equipment Procurement), 2016 - Preliminary Project Cost Estimate Guideline, 2008
Construction Research Institute
- Cost Estimate Standard for Civil Works (MLIT), 2016, 2013, 2012, 2011 - Cost Estimate Standard for Civil Works (MOC), 2000, 1999, 1993, 1992 - Cost Estimate Standard for Port Civil Works (MLIT), 2016 - Standard Specification of Cost Estimate for Civil Works (MLIT), 2016 - Construction Material Cost, April, 2017
Japan Construction Machinery and Construction Association
- Construction Equipment Depreciation Calculation, 2016 - Bridge Erection Works Cost Estimation, 2016

Source: JICA Study Team

12.1.2 Cost Estimate Base Time

This project cost estimation was executed in May 2017.

12.1.3 Currency Exchange Rate

Applied currencies are Myanmar Kyat (MMK) as local portion, Japanese Yen (JPY) as main currency, US Dollar (USD) as foreign portion from other countries except from Japan. According to the JICA guideline, exchange rate from USD to JPY was calculated based on TTS exchange rate of "The Bank of Tokyo-Mitsubishi UFJ Ltd" and exchange rate from USD to MMK was applied based on "The Central Bank of Myanmar". The applied exchange rates for this cost estimate were calculated the last three months average rate from February 1 to April 30, 2017 as shown in Table 12.1.2.

Table 12.1.2 Applied Exchange Rates

Currency	Exchange Rate
US Dollar (USD)	USD 1 = JPY 113.11 USD 1 =MMK 1358
Local Currency: Myanmar Kyat (MMK)	MMK 1 = JPY 0.0832

Source: JICA Study Team

12.1.4 Direct Construction Cost Factor

12.1.4.1 Labor Cost

Labor cost was collected in Myanmar through inquiry to contractors. Main laborers are assumed Myanmar citizens. The costs of organizers and specialists from other countries were estimated as indirect cost of "site management cost".

12.1.4.2 Lease Cost of Construction Equipment

Every ordinal construction equipment cost is collected in Myanmar through inquiry to machine lease companies.

Heavy equipment cost was applied based on "Construction Equipment Depreciation Calculation, 2016". For heavy equipment from other countries, shipping cost was estimated by inquiring freight company.

12.1.4.3 Material Cost

Every material cost was collected in Myanmar by inquiring of suppliers. Special material and products, hardly to be procured in the local market, unit rates were estimated based on inquiry and "Construction Material Cost, April 2017".

[redacted]

[redacted]

[redacted]

12.1.5 Construction Schedule Conditions

12.1.5.1 Rainy Season and Workable Period

Myanmar has a tropical monsoon climate. As winter ends, warm and moist air from the Indian Ocean is carried by southwest wind promoting a large amount of rain during the rainy season. During the dry season, there is clear weather for several days until the end of April. For schedule purposes, the rainy season was set up from June to August.

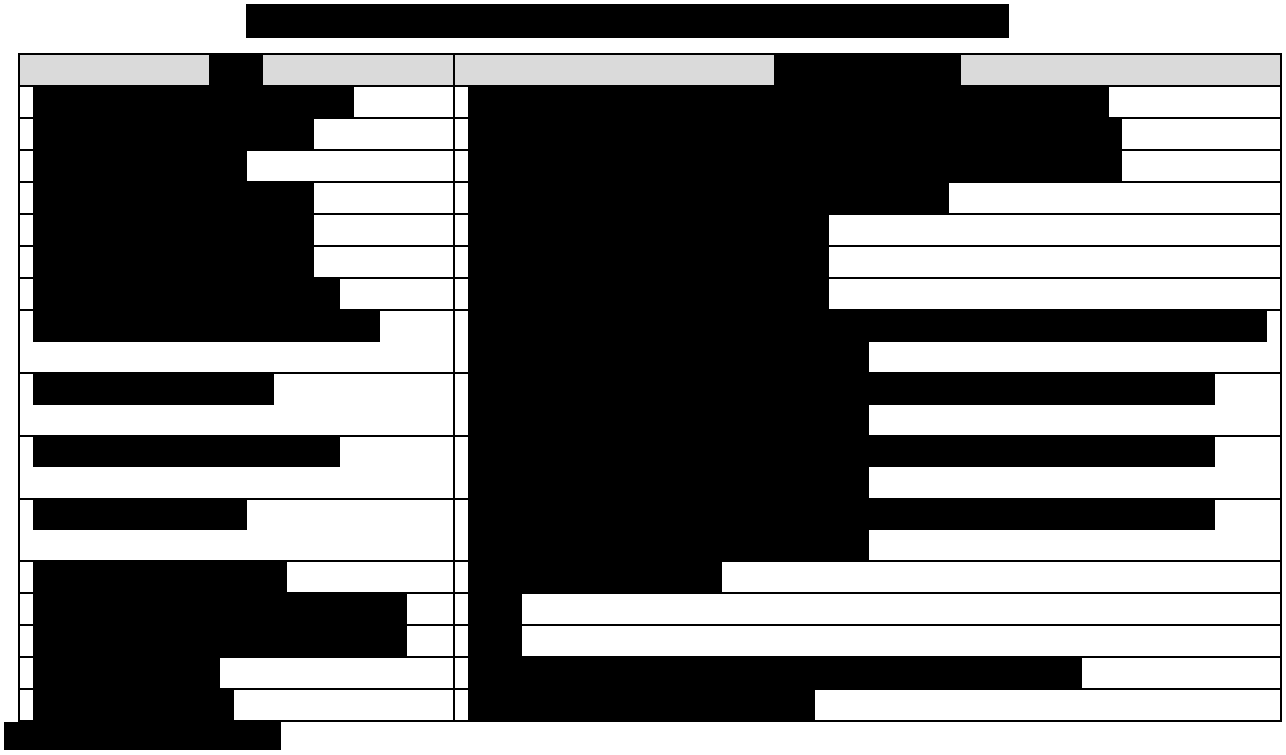
[redacted]

12.1.6 Indirect Construction Cost Factor

Mainly indirect construction cost is classified into three parts, i.e., site expenses (site management cost), general temporary work cost, and overhead cost. Those indirect construction costs were estimated according to the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) standard and JICA guidelines.

12.1.6.1 Site Expenses (Site Management Cost)

Site expenses (site management cost) was estimated with summation method classified as 16 items as shown in [redacted].



12.1.7 Price Escalation

Price escalation ratio for every currency was estimated in accordance with the "Preparatory Survey for Grant Aid / Design and Cost Estimate Manual (Civil Engineering)". Base data are from the "International Monetary Fund". Applied ratio is shown in Table 12.1.5 (for Packages 1 and 2), Table 12.1.6 (for Package 3).

For Packages 1 and 2, the ratio considered the duration from cost estimate base date (May2017) to construction midpoint (November 2019).

For Package 3, the ratio considered the duration from cost estimate base date (May2017) to construction midpoint (July 2019).

Table 12.1.3 Estimated Price Escalation Ratio (Packages 1 and 2)

Currency	Ratio
Foreign Currency: US Dollar (USD)	6.412%
Local Currency: Myanmar Kyat (MMK)	14.524%
Main Currency: Japanese Yen (JPY)	3.434%

Source: JICA Study Team (based on IMF data)

Table 12.1.4 Estimated Price Escalation Ratio (Package3)

Currency	Ratio
Foreign Currency: US Dollar (USD)	-
Local Currency: Myanmar Kyat (MMK)	14.435%
Main Currency: Japanese Yen (JPY)	3.438%

Source: JICA Study Team (based on IMF data)

12.1.8 Physical Contingency

[redacted]

Table 12.1.5 Physical Contingency Amount

Currency	Amount(mil.)
Foreign Currency: US Dollar(USD)	[redacted]
Local Currency: Myanmar Kyat(MMK)	
Main Currency: Japanese Yen(JPY)	
Total (Converted to JPY)	

Source: JICA Study Team

12.1.9 Consultant Service

[redacted]

Table 12.1.6 Consultant Service Amount

Currency	Amount(mil.)
Foreign Currency: US Dollar (USD)	[redacted]
Local Currency: Myanmar Kyat (MMK)	
Main Currency: Japanese Yen (JPY)	
Total (Converted to JPY)	

Source: JICA Study Team

12.1.10 Dispute Board Cost (Eligible and Non-Eligible Portion)

Dispute board shall be set for every package. The cost is mainly going to be separated into Eligible (50%) and Non-eligible portion (50%) except for local portion. Applied "Dispute Board Cost" is shown in Table 12.1.9

Table 12.1.7 Dispute Board Cost

Currency	Amount			Total
	Package 1	Package 2	Package 3	
Total (Converted to JPY)	[redacted]			
Eligible Portion (Converted to JPY)				

Source: JICA Study Team

12.1.11 Tax (Non-eligible Portion)

Taxation is owned by the government (Non-eligible portion). Mainly "Commercial tax: 5% for total project cost" and "Import tax: 5% for foreign portion"

12.1.12 Interest During Construction (Non-eligible Portion)

The ratio is applied as same as the feasibility study.

- 0.01% for construction
- 0.01% for consultant

12.2 UPDATE OF PROJECT COST

The total project cost is shown in Table 12.2.1. Eligible portion amount was estimated [redacted] The details of "a base cost for eligible portion" is explained in the following sections:

Table 12.2.1 Updated Project Cost

[redacted]

Source: JICA Study Team

12.3 ANNUAL FUND REQUIREMENT

Expected annual fund requirement schedule, based on Loan Agreement amount, is shown in Table 12.3.1.

Table 12.3.1 Annual Fund Requirement (Not include Contingencies and Commercial Tax)

[redacted]

Source: JICA Study Team

12.4 UPDATE OF CONSTRUCTION COST

A total construction cost, including direct and indirect construction costs, of every package is shown in Table 12.4.1. Furthermore, a breakdown of the construction cost is shown in following sections in every package.

Table 12.4.1 Summary of Total Construction Cost

Source: JICA Study Team

12.4.1 River Bridge Section (Packages 1 and 2)

A breakdown of construction cost in packages 1 and 2 (river portion) is shown in this subsection and explained comparing to F/S amount.

12.4.1.1 Update of Construction Cost (Packages 1 and 2)

(1) Package1

1) Summary

Table 12.4.2 Summary of Civil Works Construction Cost (Package1)

Source: JICA Study Team

2) Design Change Portion (3 spans Steel Box Girder)

The design change was executed due to the change of span arrangement for additional navigation in the approach bridge section. In an original design, a bridge type was “PC box girder” having a span with approx. 50m. On the other hand, in a changed design, the bridge type has been changed to “Steel box girder type” with maximum span of approx. 104m.

Regarding this change of superstructure type, a foundation type has also been changed from “Cast in bored pile” to “SPSP” for Pier Six. In addition, one pier has been omitted for longer span. Therefore, a total number of piers were reduced from three to two, and all of foundation type has been changed to SPSP.

Moreover, with this change of superstructure type, an asphalt pavement material type has been changed too for a steel deck.

From those design changes, a cost composition in each case “Original Design Portion” and “Changed Design Portion” is shown in Table 12.4.3 respectfully.

Table 12.4.3 Cost Composition of “Original Design Portion” and “Changed Design Portion”

[redacted]

Source: JICA Study Team

A cost comparison between “Original Design” and “Changed Design” is shown in the following Table 12.4.4.

Table 12.4.4 Cost Comparison of Approach Bridge between PC box girder and Steel Box Girder

[redacted]

Source: JICA Study Team

[redacted]

(2) Package2

1) Summary

Table 12.4.5 Summary of Civil Works Construction Cost (Package 2)

Source: JICA Study Team

12.4.1.2 Comparison of Construction Cost with F/S Amount (Packages 1 and 2)

A comparison of estimated costs between D/D and F/S is shown in Table 12.4.6 and Table 12.4.7 respectfully in each package.

For the difference based on comparison between D/D and F/S, description of reason due to cost change are listed in Table 12.4.6 and Table 12.4.7 too.

Table 12.4.6 Comparison of Construction Cost with F/S Amount (Package 1)

Source: JICA Study Team

Table 12.4.7 Comparison of Construction Cost with F/S Amount (Package 2)

Source: JICA Study Team

12.4.2 Flyover Section (Package 3)

12.4.2.1 Update of Construction Cost (Package 3)

Table 12.4.8 Summary of Civil Works Construction Cost (Package 3 / Yen Loan Portion)

Source: JICA Study Team

Table 12.4.9 Summary of Civil Works Construction Cost (Package 3 / MOC Portion)

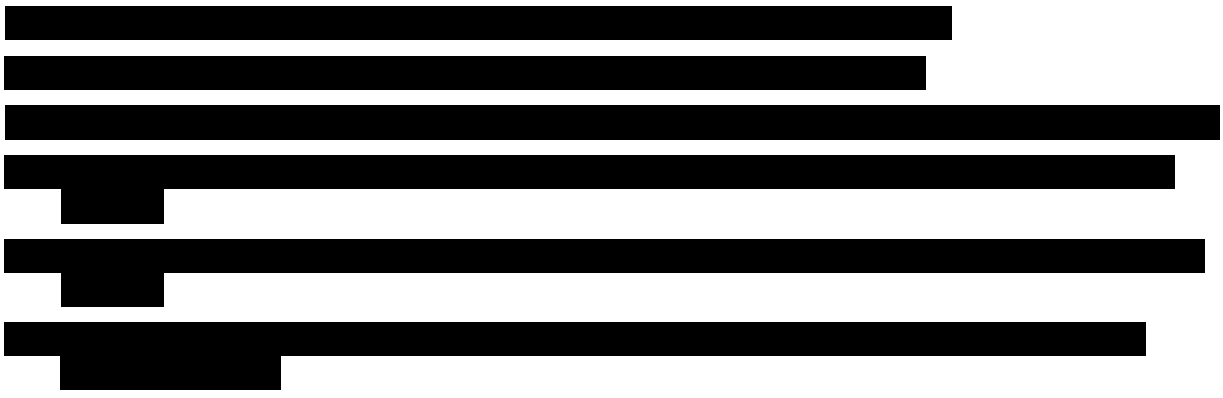
Source: JICA Study Team

12.4.2.2 Comparison of Construction Cost with F/S (Package 3)

Table 12.4.10 Comparison of Construction Cost with F/S (Package 3)

Source: JICA Study Team

12.4.2.3 Description of Changed Cost from F/S (Package 3)



12.5 PROCUREMENT PLAN

The procurement plan is described in “Chapter 7 Construction Planning”, and furthermore, information is in “Cost Estimate Report” as appendix.

CHAPTER 13. CONSTRUCTION TECHNOLOGY TRANSFER

13.1 CONSTRUCTION OF RIVER BRIDGES IN MYANMAR

In this chapter, the Japan International Cooperation Agency (JICA) Study Team's proposal on construction technology transfer in the Project is introduced by reviewing the current situation of construction organizations for river bridge construction in Myanmar.

13.1.1 Construction Records of River Bridges

There are bridge construction companies in Myanmar which have experiences in bridge construction as shown in Table 13.1.1. As shown in the table, these experiences are mainly on flyovers.

Table 13.1.1 Bridge Construction by Private Companies

No	Construction Company	Example of Bridge Construction
1	Shwe Taung Development Co., Ltd.	Hledan Flyover
		Twenwa Flyover
		Nyaung Tone Bridge (subcontracted from MOC)
		Sin Kah Bridge (subcontracted from MOC)
		Yadanar Theinga Bridge (subcontracted from MOC)
		Pakakuu Bridge (subcontracted from MOC)
		Tarmwe Flyover (subcontracted from MOC)
		New Thaketa Bridge (subcontracted from Tokyu)
2	Capital Construction Ltd.	Shwe Gone Daing Flyover
		Myaeni Gone Flyover
		Kokk Kaing Flyover
3	Myanmar V-Pile Groupe of Companies	Bayint Naung 2 Layered Flyover
4	Crown Advanced Construction Co., Ltd.	8 Mile Flyover

Source: JICA Study Team

On the other hand, in the history of bridge construction in Myanmar, the Ministry of Construction (MOC) has implemented bridge construction over major rivers by its own construction units, such as the rivers of Ayeyarwady, Thanlwin, Sittaung, and Chindwin as shown in Table 13.1.2.

Although there are few private construction companies, such as Shwe Taung Development Co. Ltd., have experience in bridge construction over some major rivers, these private companies participated in the works as a subcontractor for foundation construction only. Therefore, it can be said that MOC is the only organization which has an experience as main construction unit in bridge construction over major rivers.

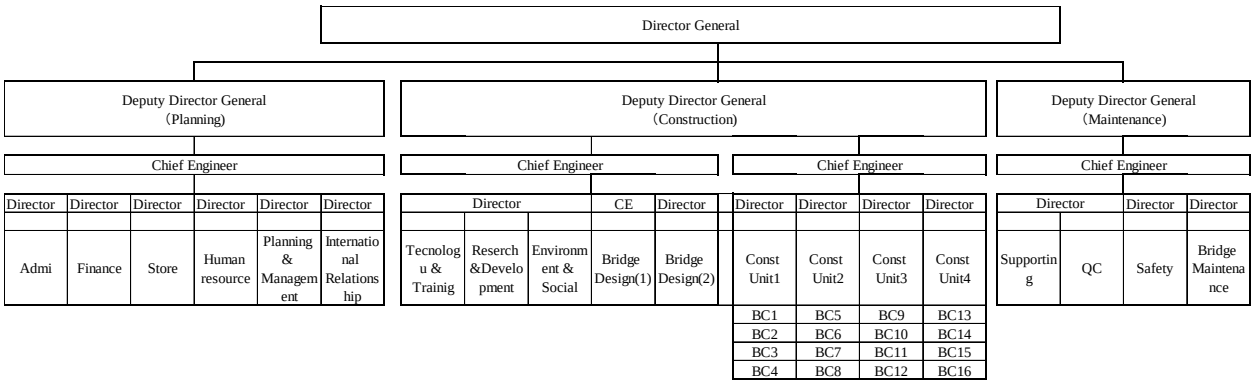
Table 13.1.2 Bridge Construction by MOC Construction Units

No.	Bridge Name	Bridge length (ft)	Bridge length(m)	Steel Truss Span(m)	Bridge types	Type of Bridge	Location	year opened
River Ayeyarwady								
1	Innwa Bridge (Sagaing)	3,960	1,207	9 x 350 ft +1 x 250 ft + 6 x 60 ft	Rail-cum-Road	Steel Truss + steel plate	Sagaing(Sagaing Region)	1943
2	Nawaday Bridge	4,183	1,275	96 + 9 x 120 + 96	Road	Steel Truss	Pyay(Bago Region)	18.9.97
3	Maubin Bridge	2,362	720	4 x 30 + 4 x 120 + 4x 30	Road	Steel Truss + RCC	MaUBin(Ayeyawaddy Region)	10.2.98
4	Bala Min Htin Bridge	2,688	819	84 + 6 x 108 + 84	Road	Steel Truss	MyitKyiNar(Kachin State)	14.11.98
5	Bo Myat Htun Bridge	8,544	2,604	15 x 18.33 + 96 + 14 x 120 + 96 + 15 x 18.33	Road	Steel Truss + RCC	NyaungDone (Ayeyawaddy Region)	15.11.99
6	Anawrahtar Bridge	5,192	1,582	96 + 9 x 120 + 96 + 10x 30.51	Road	Steel Truss + RCC	Chauk(Magway Region)	4.4.2001
7	Ayeyarwaddy Bridge (Magway)	8,989	2,740	8x19.81+30.48+10.67+30.48+27.43+30.48+97.5+16 x120+97.5+3x30.48+32+3x15.24+8x19.81	Road	Steel Truss+ PC+RCC	MaGway(Magway Region)	24.11.2002
8	Dadaye Bridge	4,088	1,246	20 x 19.811 + 96 +2 x 120 + 96 + 21 x 19.81	Road	Steel Truss+ RC	DayDaYe'(Yangon Region)	23.3.2003
9	Ayeyarwaddy Bridge (Yadanarpon)	5,641	1,719	19.81x10 + 30.48 + 19.81 x 6 + 2 x 112 + 3 x 224 + 2 x 112 + 19.81 x 12		Steel Truss + RC	Sagaing(Mandalay-Sagaing Region)	11.4.2008
10	Ayeyarwaddy Bridge (Nyaungdone)	7,402	2,256	60 x 2 + (100 + 2 x 120) x 2 + (120 x 3) x 4		Steel Truss	NyaungDone(Ayeyawaddy Region)	27.11.2011
11	Ayeyarwaddy Bridge (Pakokku)	11,431	3,484	100 + 19 x 120 + 5 x 100 + 4 x 120 + 100		Steel Truss	Pakhokku(Magway Region)	31.12.2011
12	Ayeyarwaddy Bridge (Sinkhan)	3,215	980	(96 + 2 x 112) + (3 x 120) + (2 x 120 + 96)		Steel Truss+ PC+RCC	BaMaw(Kachin State)	4.2.2012
13	Ayeyarwaddy Bridge (Malun)	3,215	980			Steel Truss	Malun(Magway Region)	11.5.2013
14	Ayeyarwaddy Bridge (Yadanartheinga)	2,480	756	19.81 x 3 + 112 x 6 + 19.81		Steel Truss	ThaBeikKyin(Mandalay-Sagaing Region)	24.7.2013
15	Ayeyarwady Bridge(Htee Gyaint)	7,730	2,356	27.43 x 10 + 120 x 15 + 27.43 x 10		Steel Truss	Htee Gyaint(Sagaing Region)	
River Sittaung								
16	Sittaung Bridge (Theinzayat)	2,320	707			Steel Truss	TheinZaYet(Mon State)	1963
17	Sittaung Bridge (Taungngu-Mawchi-Loik	680	207			CH Steel Girder		1985
18	Sittaung Bridge (Shwe Kyin-Madauk)	1,500	457			PC+RCC	MaDauk(Bago Region)	11.2.2003
19	Sittaung Bridge (Mokepalin)	2,393	729	10 x 18.29 + 2 x 27.43 + 4 x 104 + 2 x 27.43 + 18.29		Steel Truss+ Plate	Mokepalin(Mon State)	12.7.2008
20	Sittaung Bridge (Natthankwin)	720	219			Steel Truss	KyaukTagar(Bago Region)	29.9.2012
River Thanlwin								
21	Kwan Lon Bridge	789	240.4755	16.8 + 23.45 + 160 + 23.45 + 16.8		Steel Suspension	Kwan Lon(Shan State)	1966
22	Tar Kaw Bridge	780	237.7324			Steel Truss	LwanLin(Shan State)	1974
23	Thanlwin Bridge (Hpa An)	2,252	686.3761	5 x 18.29 + 85.5 + 3 x 123 + 85.5 + 3 x 18.29		Steel Truss	PhaAn(KaYin State)	3.8.1997
24	Thanlwin Bridge (Tarsan)	900	274.3066	274.3066		Suspension	MinePan(Shan State)	20.2.1999
25	Thanlwin Bridge (Mawlamyine)	11,575	3527.888	19x18.33 + 26.52 + 17x18.33 + 19 x 112 +22 x 18.33 + 9.16 + 18.33 + 9.16 +3x18.33		Steel Truss+ PC+	MawLaMyaing(Mon State)	5.2.2005
26	Thanlwin Bridge (Tarpar)	600	182.8711	182.87		Steel Suspension	KyutKhaing(Shan State)	21.5.2005
27	Thanlwin Bridge (Tarkaw At)	600	182.8711	182.87		Bailey Suspension	TantYan(Shan State)	12.2.1997
28	Thanlwin Bridge (Tarsuitpha)	1,200	365.74			Steel Truss	(Shan State)	
29	Thanlwin Bridge (Pharsaung)	1,800	548.61			Steel Truss	Pharsaung(KaYar State)	
River Chindwin								
30	Shinphyushin Bridge	4,957	1510.82	80 + 12 x 112 + 80		Steel Truss	ChaungOo-YaeSaKyo(Sagaing /Magweregion)	18.9.1999
31	Chindwin Bridge (Monywa)	4,730	1441.634	28 x 18.33 + 8 x 104 + 5 x 18.33		Steel Truss	MonYwa(Sagaing Region)	7.4.2003
32	Chindwin Bridge(Khan Thee)	2,650	807.6806			Steel Truss	Khan Thee(Sagaing Reigon)	
33	Chindwin Bridge(Home Ma Linn)	2,897	882.9625			Steel Truss	Home Ma Linn(Sagaing region)	
34	Chindwin Bridge(Ka Lay Wa)	2,805	854.8796			Steel Truss	KaLayWa(Sagaing Region)	
Other River								
35	Aungzeya Bridge	3,786	1153.999	14 x 18.514 x 140 + 300 + 140 + 17 x 18.514		Cable Stayed + R C	Yangon(Yangon region)	
36	Bayint Naung Bridge-1	1,201	366	65.6+2x123+65.6		Steel Truss	Yangon(Yangon region)	
37	Bayint Naung Bridge-2	5690	1734.227	3 x 122 +2 x 30.8		Steel Truss + steel plate	Yangon(Yangon region)	
38	ShwePyiThar	3415	1040.841	14 x 18.33 + 84 + 3 x 120 + 84 + 14 x 18.33		Steel Truss + RC	Yangon(Yangon region)	
39	Yangon-ThanLyin(China)	6959.985	2121.3	3x80 + 104+ 2x112 +2x3x112 + 2x112 +104 + 3x80		Steel Truss + steel plate	Yangon(Yangon region)	31.7.1993
40	DaGone Bridge	4540	1383.724				Yangon(Yangon region)	

Source: Department of Bridge, MOC

13.1.2 Organization of MOC's Construction Units

In the Department of Bridge (DOB) in MOC, there are four construction units which are organized under the Deputy Director General (Construction), Chief Engineer, and Directors as shown in Figure 13.1.1. Each construction unit has four bridge construction teams (BC) depending on the state/division and township as shown in Table 13.1.3



Source: Department of Bridge, MOC

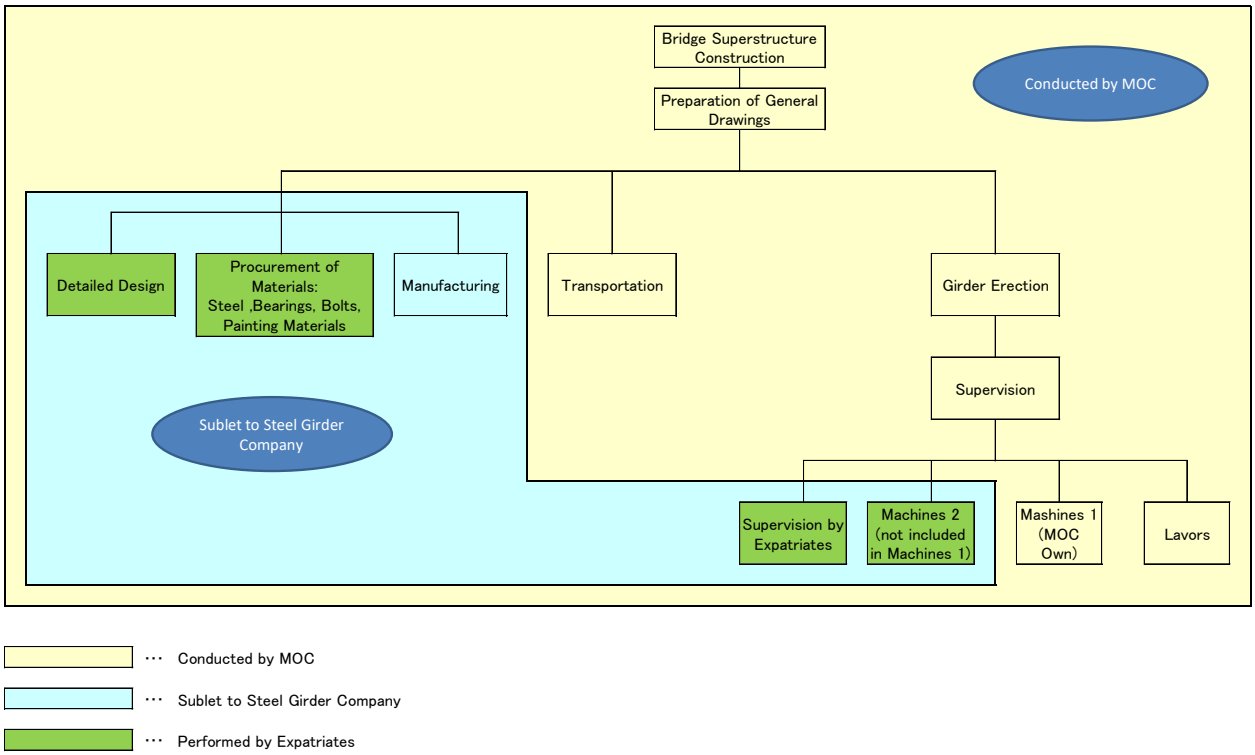
Figure 13.1.1 Organization of Department of Bridge (DOB)

Table 13.1.3 Bridge Construction Teams under Construction Unit

Name	Township	State/Division
Construction Unit 1	**Mandalay**	**Mandalay Division**
1. Bridge construction (1)	Myitkyina	Kachin state
2. Bridge construction (2)	Monywa	Sagaing division
3. Bridge construction (3)	Pakokku	Magwe division
4. Bridge construction (4)	Mandalay	Mandalay Division
Construction Unit 2	**Nyaung Oo**	**Mandalay Division**
1. Bridge construction (5)	Seikphyu	Magwe division
2. Bridge construction (6)	Naypyitaw	Mandalay Division
3. Bridge construction (7)	Kyauktaw	Rakhine state
4. Bridge construction (8)	Minpyar	Rakhine state
Construction Unit 3	**Yangon**	**Yangon Division**
1. Bridge construction (9)	Bago	Bago division
2. Bridge construction (10)	Hlegu	Bago division
3. Bridge construction (11)	Yangon	Yangon Division
4. Bridge construction (12)	loilem	Shan state
Construction Unit 4	**Yangon**	**Yangon Division**
1. Bridge construction (13)	Myeik	Tanintharyi division
2. Bridge construction (14)	Mawlamyine	Mon state
3. Bridge construction (15)	Pyapon	Ayeyarwaddy division
4. Bridge construction (16)	Bokalay	Ayeyarwaddy division

Source: Department of Bridge, MOC

For the construction, which needs supervision and/or involvement by expatriates, such as erection of steel truss girder of Chaung Sone Bridge, an example of demarcation of works is shown in Figure 13.1.3.



Source: JICA Study Team

Figure 13.1.2 Work Demarcation between MOC and Steel Girder Company

13.2 PROPOSAL ON CONSTRUCTION TECHNOLOGY TRANSFER

13.2.1 Participation of MOC Construction Unit

13.2.1.1 Contractual Role of MOC Construction Unit

It was notified that MOC is willing to let its Construction Unit (hereunder referred to as "the Unit") to participate in the construction works for its dignity and construction technology transfer. Since the Unit is the only organization that built more than 40 major bridges crossing big rivers, and similar situations will continue in the near future, it is desirable to transfer construction technology to the Unit.

Again, since the Unit is the only organization which has the experience in construction of major river bridge, it is necessary for the bidders to give opportunity for Unit's participation as partner for securing fair competition.

Therefore, it was agreed between MOC and JICA to let the Unit participate in the construction as Nominated Subcontractor (hereunder, "NSC").

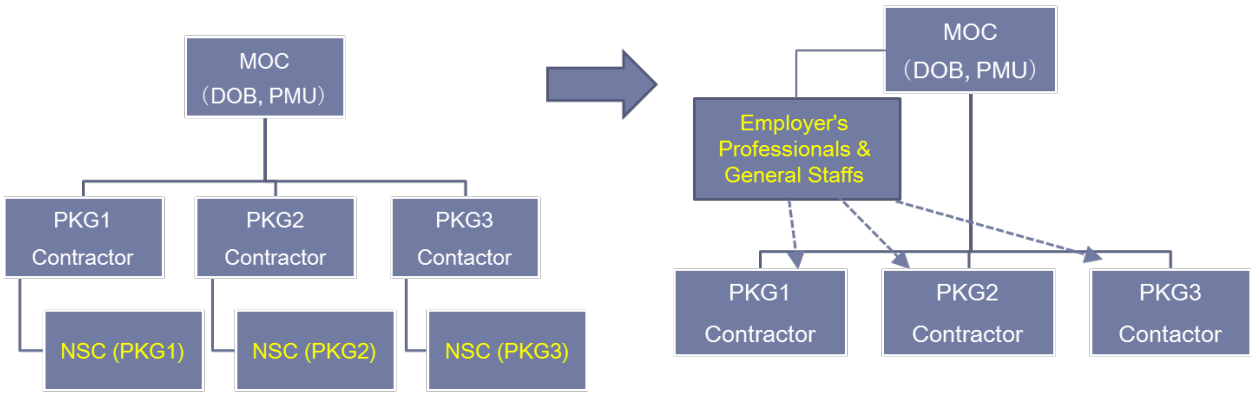
For MOC's participation as NSC, the following are to be considered:

- Need for a subcontract agreement between the Contractor and NSC.

- Define the responsibilities of NSC.

- Monitor work demarcation between the Contractor and NSC during construction.

It was also notified that the Unit will dispatch their engineers, supervisors, and labors, but not machines nor equipment. Other than the participation of NSC, there is another option of participation to the works as "Employer's Professionals and General Staffs (Option (b)) as shown in Figure 13.2.1 which is similar concept as "Employer's Equipment and Free Issue of Materials" in accordance with Sub-clause 4.20 in General Condition of Contract in FIDIC MDB.



(a) as "Nominated Subcontractor" (b) as "Employer's Professionals and Staffs

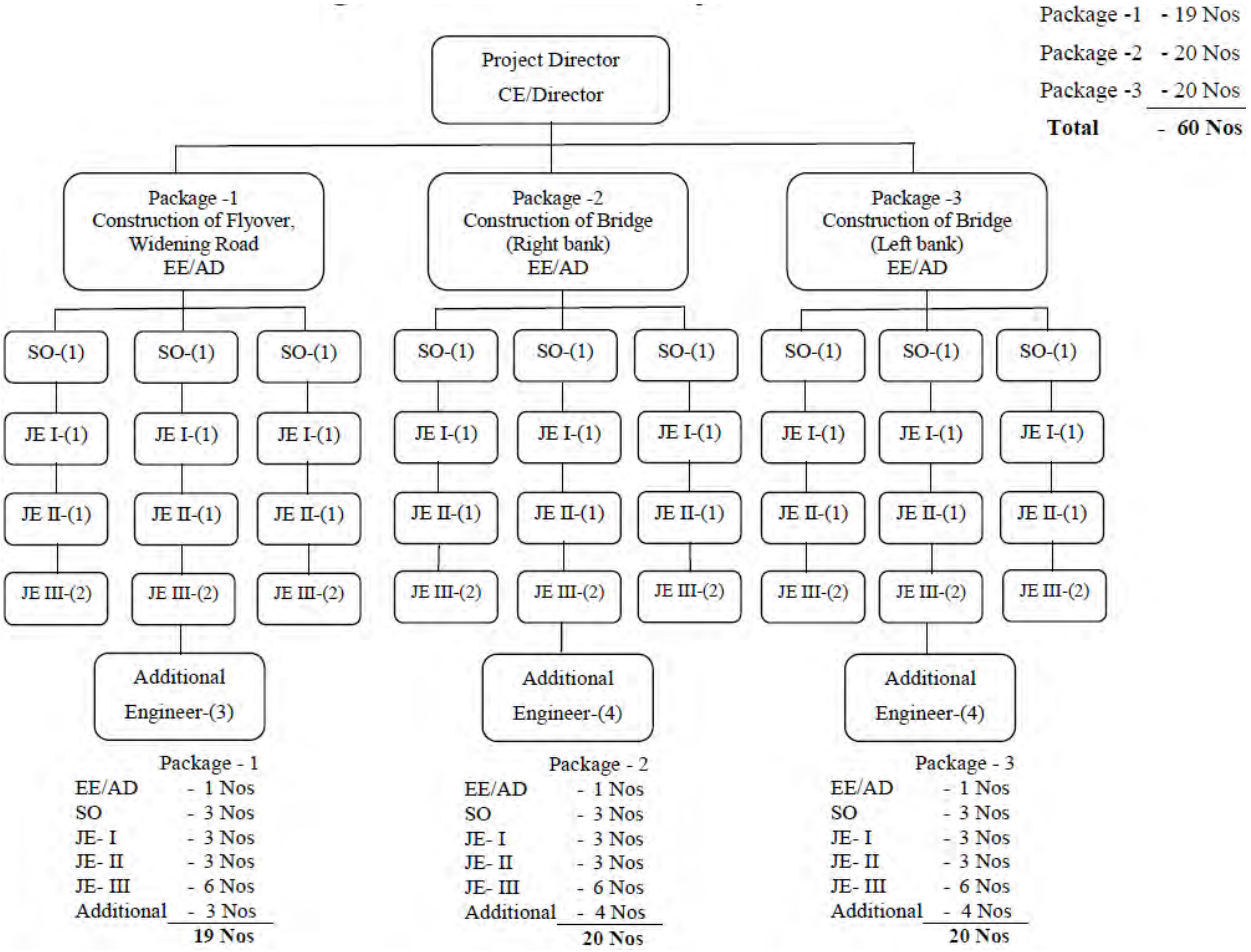
Source: JICA Study Team

Figure 13.2.1 Options for Participation of MOC's Construction Unit to the Works

MOC's participation as "Employer's Professionals and General Staffs" is more appropriate for construction technology transfer since MOC wishes to participate as practical on-the-job trainees for new construction technology and as physical workers for other comventional bridge construction works, while generally NSC takes limited and specific works. Therefore, Option (b) is recommended and MOC agreed on the definition of MOC Construction Unit as Employer's Professinals and General Staffs on May 25, 2017.

13.2.1.2 Organization of MOC Construction Unit in the Construction of Bago River Bridge

It was notified by MOC by MOC's letter, bridge/DDG/P2/2017-2018/015 dated May 15, 2017 that the engineers of MOC Construction Unit in the construction of Bago River Bridge will be about 20 in each package as shown in Figure 13.2.2. Junior engineers will play a role as foreman who leads skilled, semi-skilled, and unskilled labors.



Source: Department of Bridge, MOC Note: EE/AD: Assistant Director, SO: Staff Officer, JE: Junior Engineer

Figure 13.2.2 Organization of MOC's Construction Units in the Construction of Bago River Bridge

13.2.2 Issues on Participation of MOC in Construction

Below are the following issues on participation of MOC in the construction of Bago River Bridge:

- Conflict of interest
- Fairness in bidding process
- Responsibility of MOC on MOC's Construction Unit's errors
- Quality control

13.2.2.1 Conflict of Interest

For avoiding the risk of conflict of interest, the following measures will be taken:

- No salary for MOC's general staffs will be paid to avoid double payment
- No profit for MOC will be included in payment to MOC's Construction Units

13.2.2.2 Fairness in the Bidding Process

For securing fairness in the bidding process, the following measures will be taken:

- Detailed information on MOC's Construction Units, such as specialization and experiences of engineers, organization of engineers, and specialization and number of labors, is included in the bidding documents.
- Payment to MOC Construction Units will be categorized into provisional sum so that the cost is out of the price competition.

13.2.2.3 Responsibility of MOC on MOC's Construction Unit's Errors

When MOC's Construction Unit commits errors which cause loss or damage, MOC will be required to:

- Indemnify the contractor against loss or damage caused by MOC's Construction Unit;
- Grant an extension of Time for Completion without delay damages; and
- Pay the contractor additional cost incurred during extended period.

The Contractor will be entitled to:

- Request MOC to replace or reject the personnel whom the contractor judges as disqualified or inappropriate (with reasonable evidence).

The following are the samples of description in the Contract of Works:

"With due consideration of the special circumstances in the Employer's country, the Contractor shall contribute to the development of bridge construction technology in the country by means of a technology transfer programme, which includes training of the Employer's professionals and general staffs. In consideration of such services, the Employer shall indemnify and hold the Contractor harmless against and from all claims, damages, losses, and expenses (including legal fees and expenses) caused by any of the Employer's professionals and general staffs in respect of damages to or loss of any property caused by any negligence or misuse of the Contractor's Equipment, Goods, or Materials by the Employer's professionals and general staffs.

In the event that the Employer refuses to:

(i) undertake to the Contractor such obligations and liabilities as will enable the Contractor to discharge his obligations and liabilities under the Contract, and

(ii) indemnify the Contractor against and from all obligations and liabilities arising under or in connection with the Contract and from the consequences of any failure by the Employer's professionals or general staffs to perform the obligations or to fulfill the liabilities, then the Contractor shall not be under any obligation to accept such professionals or general staffs.

For avoidance of doubt, the Employer agrees to grant the Contractor, notwithstanding other provisions of the Contract, a reasonable extension of Time for Completion and additional payment for the cost incurred as the result of such an extension of Time without imposing the delay damages set out at Sub-clause 8.7, should the Employer's professionals or general staffs fail to comply with the terms of agreement.

Payment for the additional cost shall be made with immediate effect in accordance with the procedures set out in Clause 14.

Alternatively, the Contractor is entitled to remove or replace any member of the Employer's professionals or general staffs with 7-days prior notice to the Employer, should the Contractor

determines that the member is incompetent to achieve the duties entrusted. The Employer shall take necessary action following the Contractor's notice within 7 days after receiving notice."

13.2.2.4 Quality Control

For avoiding misuse of authority by personnel of the MOC's Construction Unit to give instruction to the consultant to pass over some errors in quality, the following will be included in the Technical Specifications of the Contract of Works:

The Engineer will at regular intervals inspect and test materials and completed work for compliance with the specified requirements, and where applicable, the various specified judgment plans will be applied. The testing frequencies and sample and lot sizes for routine testing shall be at the Engineer's discretion.

All sections of completed work shall be submitted to the Engineer for routine inspection and testing, and the Contractor shall not cover up or construct any work on top of sections of completed work before being advised by the Engineer of the outcome of his tests and inspection. The Contractor shall arrange the submission of work for testing in a manner as will afford the Engineer reasonable opportunity for inspecting and testing.

CHAPTER 14. PROJECT IMPLEMENTATION PLAN

14.1 LOAN AGREEMENT

The fund for the Bago River Bridge Construction Project (the Project) is financed by the Japan International Cooperation Agency (JICA) and the Government of the Republic of the Union of Myanmar (GOM).

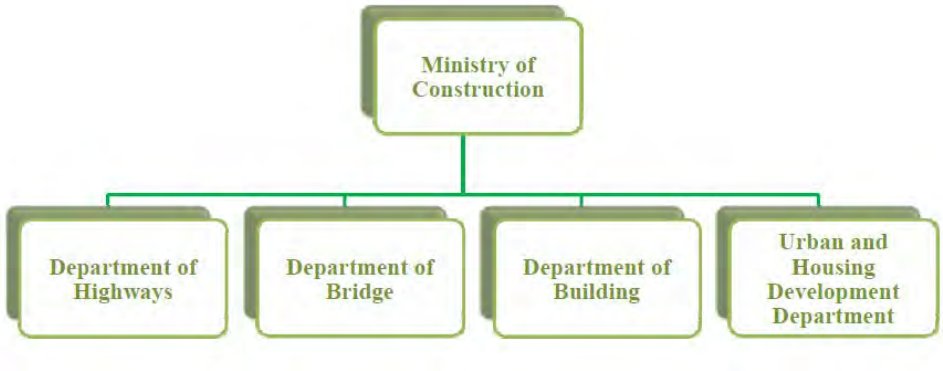
The loan agreement of JICA and GOM for the Project was signed on March 1, 2017.

14.2 IMPLEMENTATION STRUCTURE

14.2.1 Implementation Agency

The Ministry of Construction (MOC) is "the Line Agency" and concurrently "the Employer' of the Project. The Department of Bridge (hereinafter referred to as “DOB”) is "the Employer's Representative" and concurrently "the Implementation Agency" managing the total implementation of the Project.

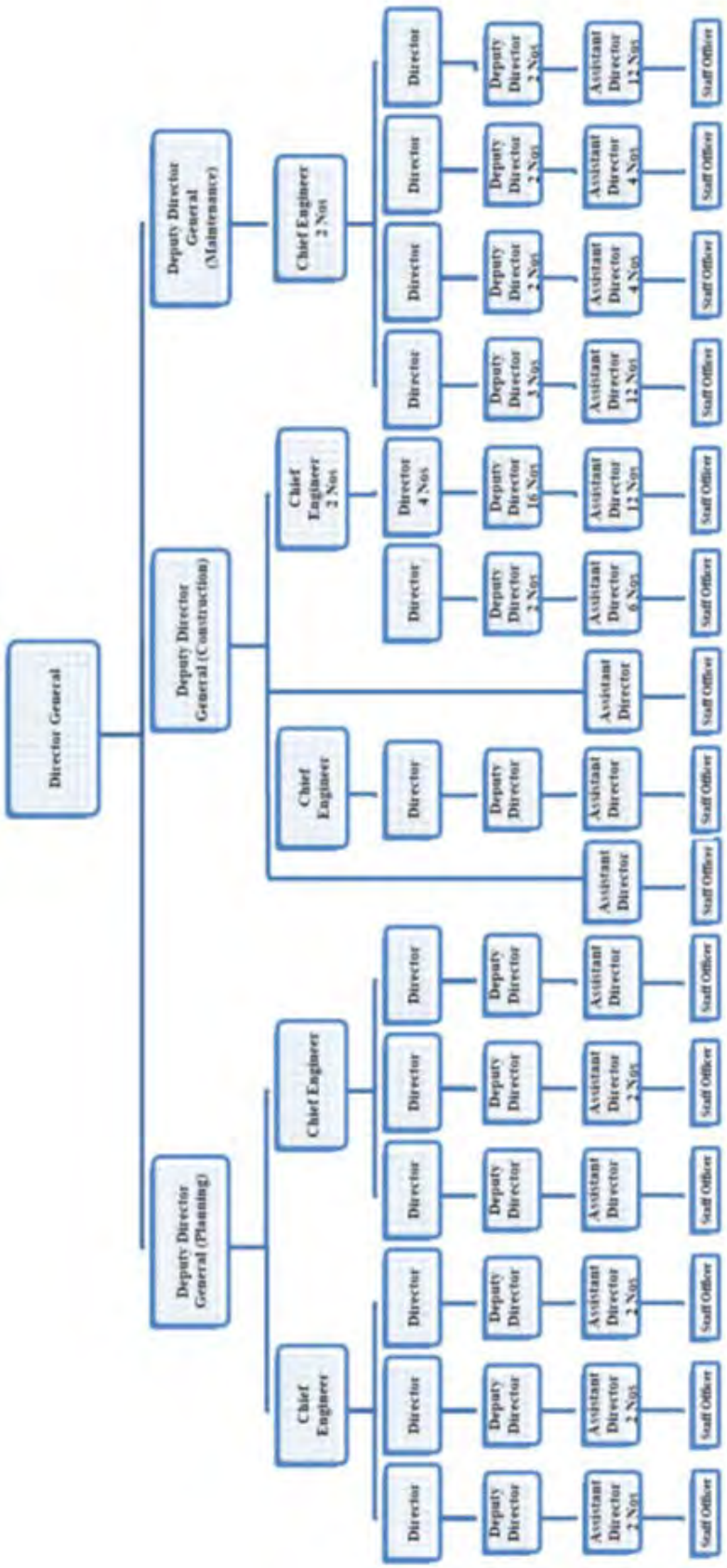
The following Figure 14.2.1 shows the organizational chart of MOC.



Source: MOC

Figure 14.2.1 Organization of MOC

As seen in the figure above, MOC consists of four departments under the ministry: Department of Bridge (DOB), Department of Highway (DOH), Department of Building, and Urban and Housing Development Department. Figure 14.2.2 shows the organizational chart of the Department of Bridge.



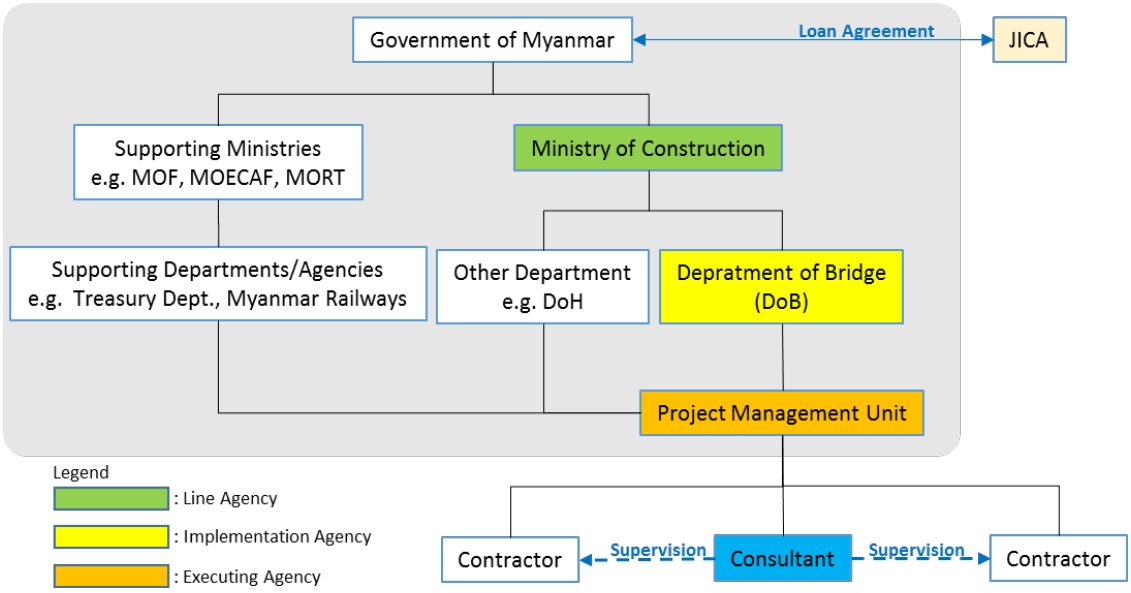
Source: MOC

Figure 14.2.2 Organization of the Department of Bridge (DOB), MOC

14.2.2 Project Management Unit

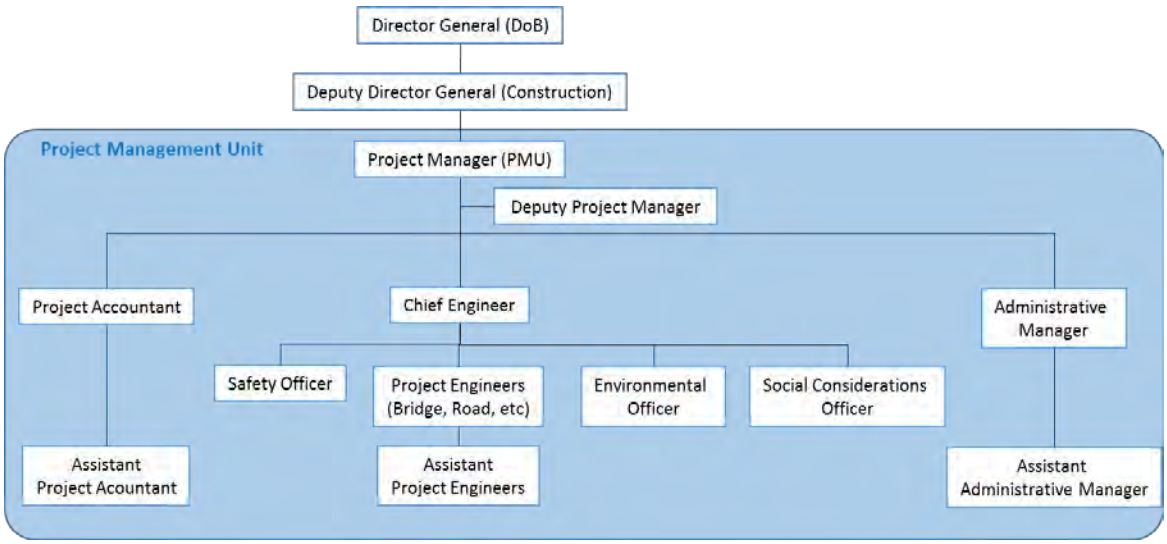
For the implementation of the construction project, the JICA Study Team recommended to DOB to establish an exclusive Project Management Unit (PMU). As recommended, PMU was established during the detailed design services and all the implementation works are being supervised by PMU consistently.

The following Figure 14.2.3 and Figure 14.2.4 show the implementation structure with PMU and a proposed organization of PMU, respectively.



Source: JICA Study Team

Figure 14.2.3 Implementation Structure



Source: JICA Study Team

Figure 14.2.4 Proposed Organization of Project Management Unit (PMU)

The Executing Agency will be the PMU under DOB and will be responsible for all project works as follows:

- Pre-construction works comprising engineering design, land acquisition, relocation/resettlement, and tender;

- Construction supervision;

- Traffic safety management during construction; and

- Operation and maintenance of civil works and equipment during defect liability period.

14.2.3 Demarcation among JICA, MOC, and YCDC

The design of the Project including river bridge, on-ramp, flyover, and Thanlyin Chin Kat Road under the flyover will be performed through a JICA grant. The construction of the Project will be financed by JICA excluding Thanlyin Chin Kat Road. After the construction, operation and maintenance of the bridge between the abutments will be conducted by DOB of MOC while the Department of Highway (DOH) of MOC or Yangon City Development Committee (YCDC) will be responsible for the approach road, the adjacent intersections, and connecting roads on Yangon side; and DOH will be responsible for the approach road, adjacent intersections and connecting roads on Thanlyin side including Thilawa Access Road. The summary of the responsible authorities is shown in Table 14.2.1, which was confirmed by MOC on October 6, 2016.

Although the demarcation of road widening works of Thanlyin Chin Kat Road had been under discussion for long time, it was concluded on July 20, 2017, that the works will be conducted by MOC on the following conditions;

(1) Scope of MOC works

The scope of MOC works would be limited to the boundary to the temporary yard for the flyover construction for no waste demolition and restoration of pavement. The final work will be done by the Contractor for the Flyover.

(2) Design

Design documents for MOC works would be provided for its reference only by JICA D/D Study Team (JST); JST would not be liable for the design documents since the design documents will not be utilized for the procurement process of the Contractor for the Flyover.

(3) Construction supervision by Loan Consultant

Since MOC will directly implement the widening work, Loan Consultant to be procured by the Project would not carry out the duties as "the Engineer" whose general definition is provided by the Standard Bidding Documents under Japanese ODA Loans (Procurement of Works) (October 2012).

(4) Schedule

MOC makes sure that reallocation of public utilities starts in October 2017 and widening work starts in April 2018 so that the Contractor for Flyover can start in November 2018. If needed, MOC would apply supplemental budget (Revised Estimate) for this purpose.

Table 14.2.1 Responsible Authorities on the Implementation of Bago River Bridge

		Land Acquisition and Compensation	**Design**	**Construction**	**Operation and Maintenance**
Bago Bridge (River Bridge Section)		-	JICA Grant	MOC (DOB) (Financed by JICA)	MOC (DOB)
Yangon Side	Approach Road of Bago Bridge	MOC (DOB) / YRG	JICA Grant	MOC (DOB) (Financed by JICA)	MOC (DOB) / YCDC
	Flyover and its Approach Road	MOC (DOB) / YRG	JICA Grant	MOC (DOB) (Financed by JICA)	MOC (DOB) / YCDC
	Connecting Roads and Intersections (Including Thanlyin Chin Kat Road under Flyover)	MOC (DOB) / YRG	JICA Grant	MOC (DOB)	MOC (DOH) / YCDC
Thanlyin Side	Approach Road	MOC (DOB) / YRG	JICA Grant	MOC (DOB) (Financed by JICA)	MOC (DOH)
	On-ramp	MOC (DOB) / YRG	JICA Grant	MOC (DOB) (Financed by JICA)	MOC (DOH)
	Connecting Road to On-ramp	-	-	-	MOC / Thanlyin Yadanar Housing Project
	Thilawa Access Road (including intersection from/to housing projects)	MOC (DOH) / YRG	MOC （DOH)	MOC (DOH)	MOC (DOH)

Source: JICA Study Team

14.3 IMPLEMENTATION PROGRAM

In this section, the implementation program of shortest scenario is introduced.

< Shortest Scenario >

The Shortest Scenario was established in the Supplemental Survey based on the following conditions:

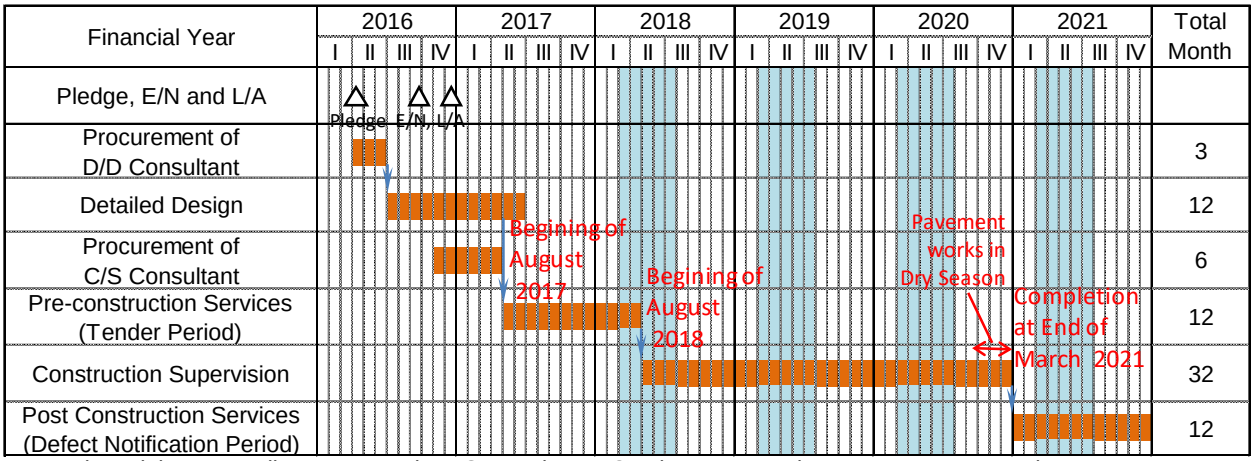
- Pledge by the Japanese government was in July 2016.
- Exchange note was signed in December 2016.
- Loan agreement was signed in March 2017.
- Scheme of Japanese official development assistance (ODA) loan is applied.
- Consultancy services of the detailed design (D/D) are conducted by the Japanese grant and started in September 2016.
- Consultancy services of construction supervision (C/S) would have started in August 2017.
- Procurement of D/D consultant was after the pledge of the Japanese government.
- Construction period will be 32 months as a consequence of commencement in August.

The implementation milestones and I/P are shown in Table 14.3.1 and Figure 14.3.1 respectively, assuming that common practice will be adopted.

Table 14.3.1 Implementation Milestones and Periods

Event/ Milestone	Period
Actions by the Governments	
Pledge by the Japanese Government	: July 2016
Exchange Note and Loan Agreement	: December 2016
Land Acquisition	: 17 months
Resettlement	: 17 months
Consultancy Services	
Procurement of D/D Consultant (by JICA)	: after Pledge
Detailed Design (by JICA)	: 12 months after Procurement
Procurement of C/S Consultant (by Myanmar)	: 9 months
Pre-construction Services (Tender Period)	: 12 monts
Construction Supervision	: 32 months
Post-construction Services (Defect Liability Period)	: 12 months
Construction	
Procurement of Contractor (by Myanmar)	: 12 months
Construction	: 32 months
Defect Liability Period	: 12 months

Source: JICA Study Team



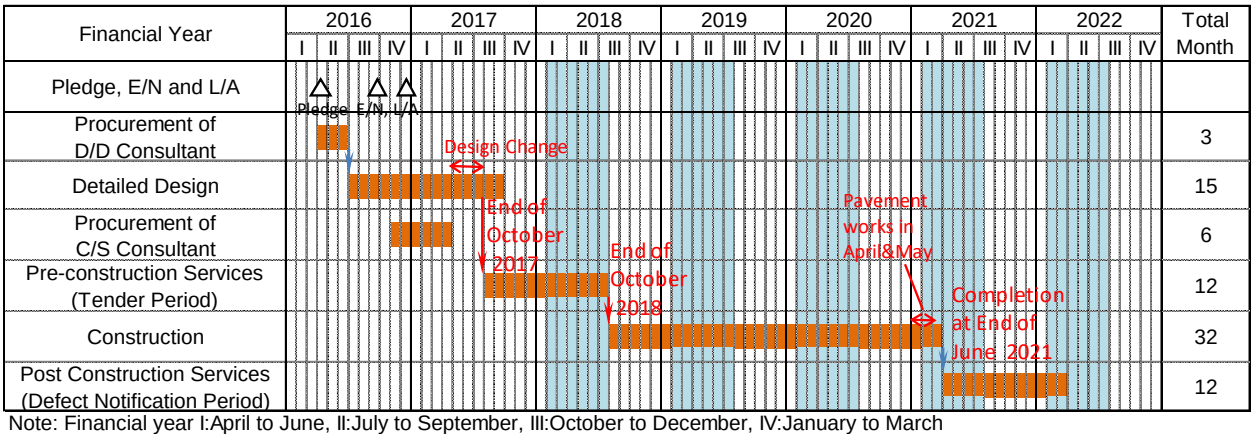
Note: Financial year I:April to June, II:July to September, III:October to December, IV:January to March

Source: JICA Study Team

Figure 14.3.1 Implementation Program with Shortest Scenario Assuming Commencement of Works: Beginning of August 2018

However, due to design change instructed by DOB in April 2017 for changing the span arrangement at the approach bridge on Thanlyin side, it is expected to be delayed for three months as shown in Figure 14.3.2 below. The detailed implementation schedule is shown in Figure 14.3.3.

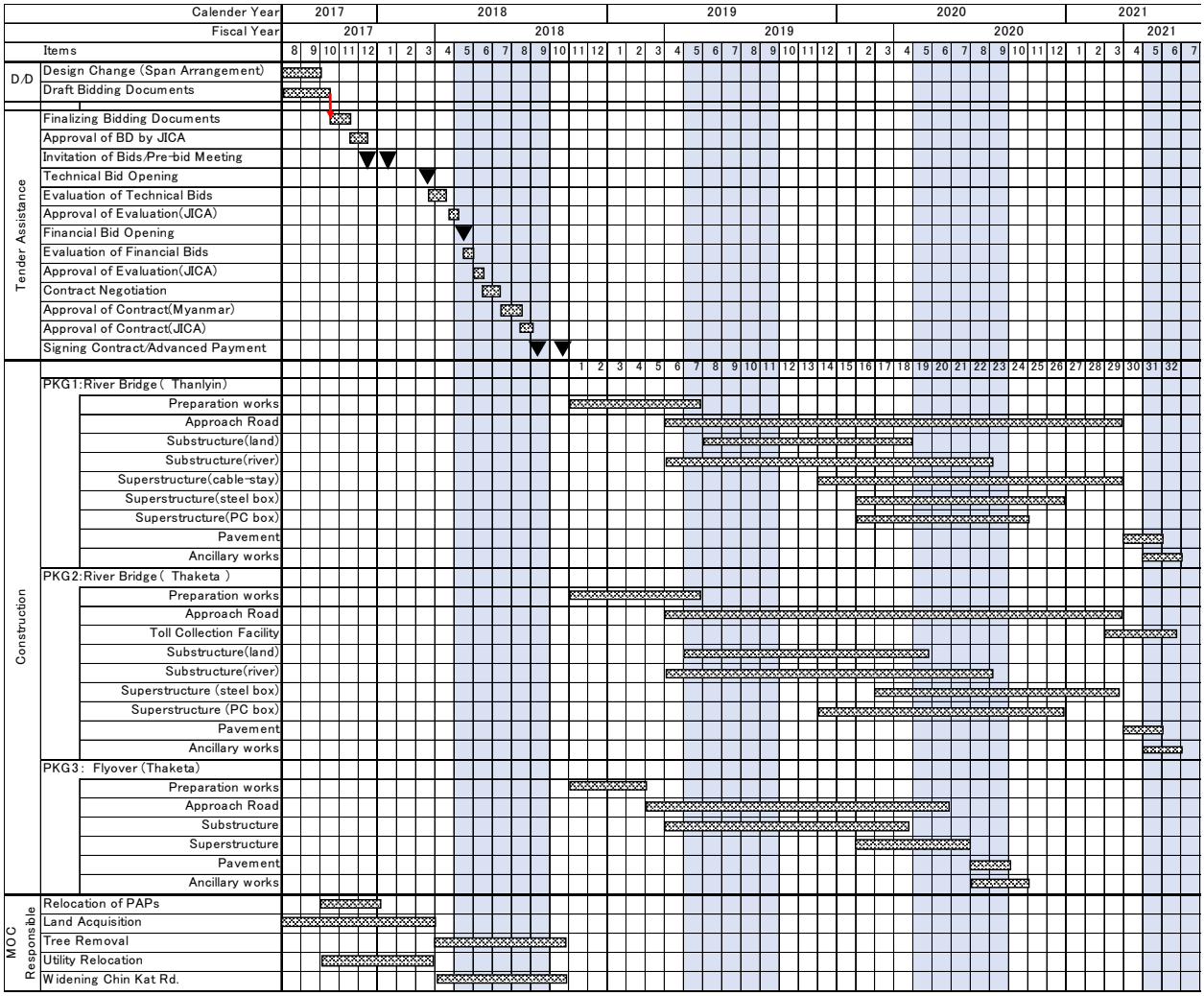
In this scenario, pavement works which cannot be implemented in the rainy season are expected to be in April and May. Therefore, it should be noted that a little more delay will result in much longer delay in waiting for the next dry season and the completion of the works might be after December 2021.



Note: Financial year I:April to June, II:July to September, III:October to December, IV:January to March

Source: JICA Study Team

Figure 14.3.2 Implementation Program Shortest Scenario Assuming Commencement of Works: End of October 2018



Source: JICA Study Team

Figure 14.3.3 Detailed Implementation Program with Shortest Scenario Assuming Commencement of Works: End of October 2018

CHAPTER 15. PROJECT PROMOTION

15.1 GENERAL

Considering the situation where the construction projects for transportation including the Project attracts a great deal of interest not only in Myanmar but also in Japan, the documents for promotion, promotion videos, perspectives and a magazine article were prepared.

15.2 PROMOTION VIDEO

A 7-minutes-long promotion video were prepared and submitted on September 14th, 2017, for explaining the objectives, components, features and effects of the Project. The video contains following stories;

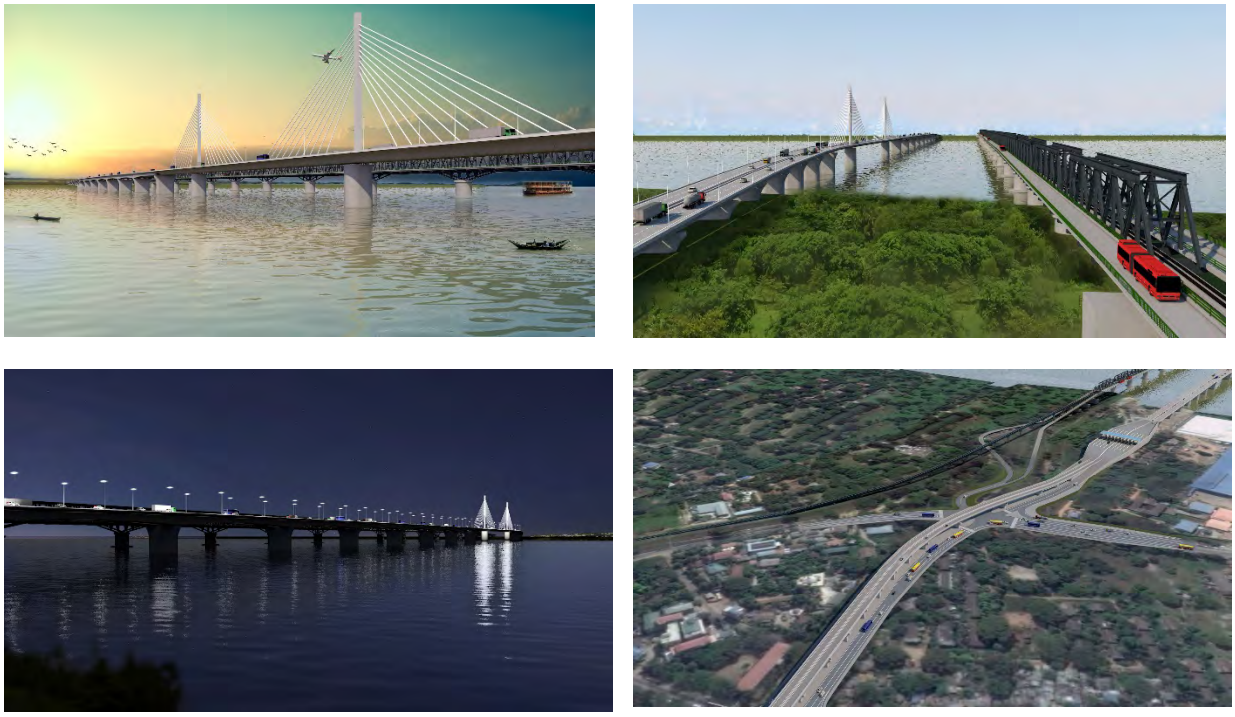
- Introduction of City of Yangon and issues on transportation network,
- Introduction of Bago River and issues on access between Yangon and Thilawa,
- Interview of a Thanlyin resident showing terrible traffic congestion for crossing Bago River at the exisiting Thanlyin Bridge,
- Interview of Vice Minister of MOC explaining necessity of a new bridge crossing Bago River
- Interview of President of MJTD (Myanmar Japan Thilawa Development Ltd) looking forward to construction of Bago River Bridge
- Major component of Bago River Bridge
- Construction technology and design features of Bago River Bridge
- CG perspectives of Bago River Bridge

The video was prepared with narration in the three languages, English, Japanese and Myanmar. The detailed storyboard in English is shown in Appendix 15.

15.3 CG PERSPECTIVES

Based on 2-D drawings of Bago River Bridge, a 3-D model were created for preparing perspectives of the completion image of the Project. For 3-D model creation, the application, Civil 3D®, was used. The application, Infraworks®, was used for finalizing the model with background image for presentation of perspectives and animation from bird-eye or driver's eye.

The samples of perspectives are shown in Figure 15.3.1



Source: JICA Study Team

Figure 15.3.1 Image Perspectives

15.4 PROMOTION PLAN

15.4.1 Promotion Plan in Myanmar

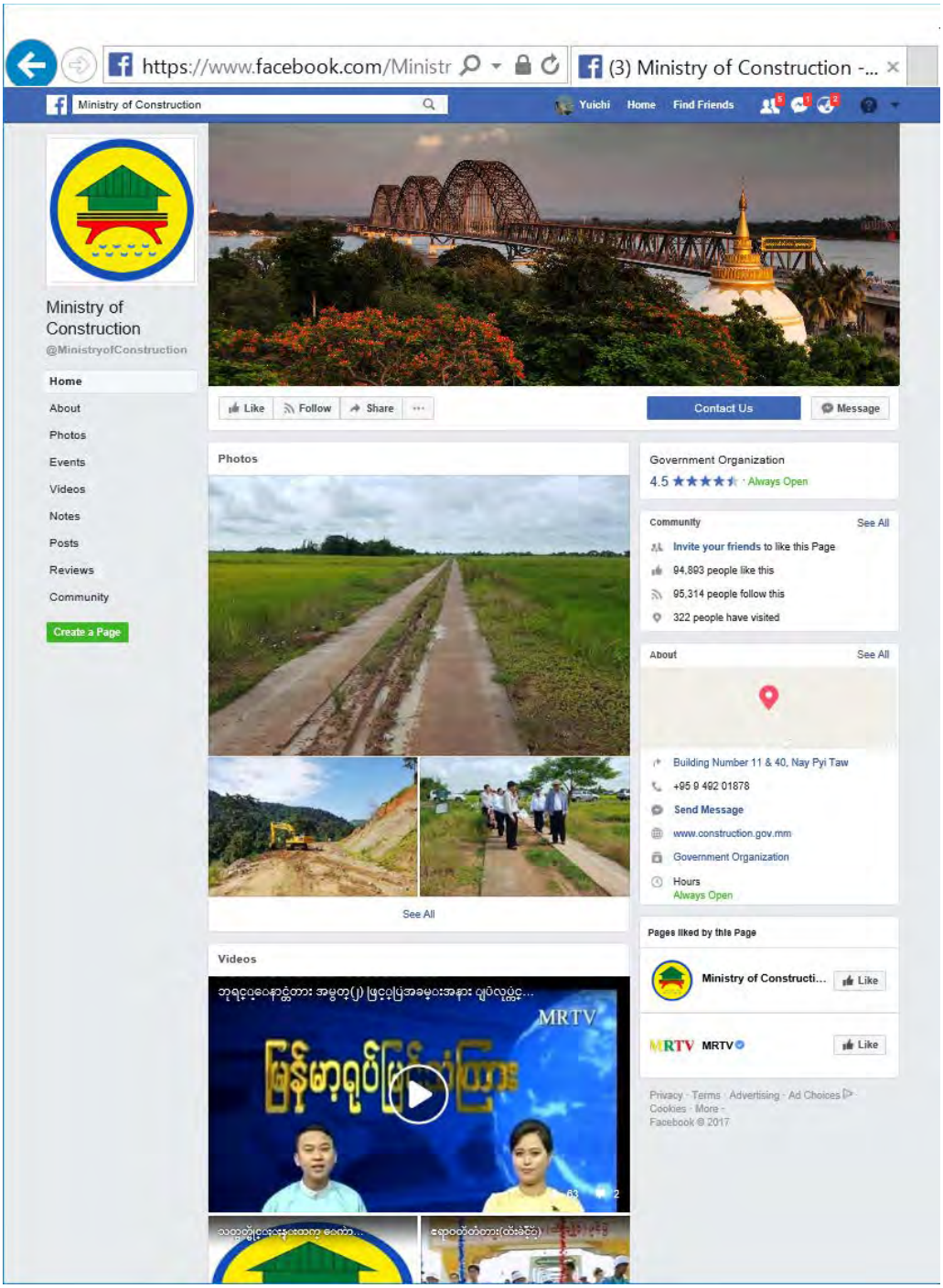
After introducing the contents of the promotion video to DOB of MOC on August 24, 2017, DOB agreed to upload the video in MOC's website, as shown in Figure 15.4.1. The video was submitted to DOB on September 21, 2017.

15.4.2 Promotion Plan in Japan

It was planned to post the promotion videos, both Japanese and English versions, in JICA's website as shown in Figure 15.4.2. The promotion video was submitted to JICA on September 14, 2017.

In addition to promotion video, it was proposed to publish an article in a periodical specialized in international cooperation, such as "International Development Journal". The article would contain followings;

- Project Background and Objectives of the Bridge Construction,
- Interview of Vice President of MOC,
- Interview of President of MJTD,
- Structural Features and Components of the Project, and
- Implementation Plan.



Source: https://facebook.com/MinistryofConstruction/

Figure 15.4.1 MOC's Web Site