CHAPTER 6 NATURAL CONDITION SURVEYS

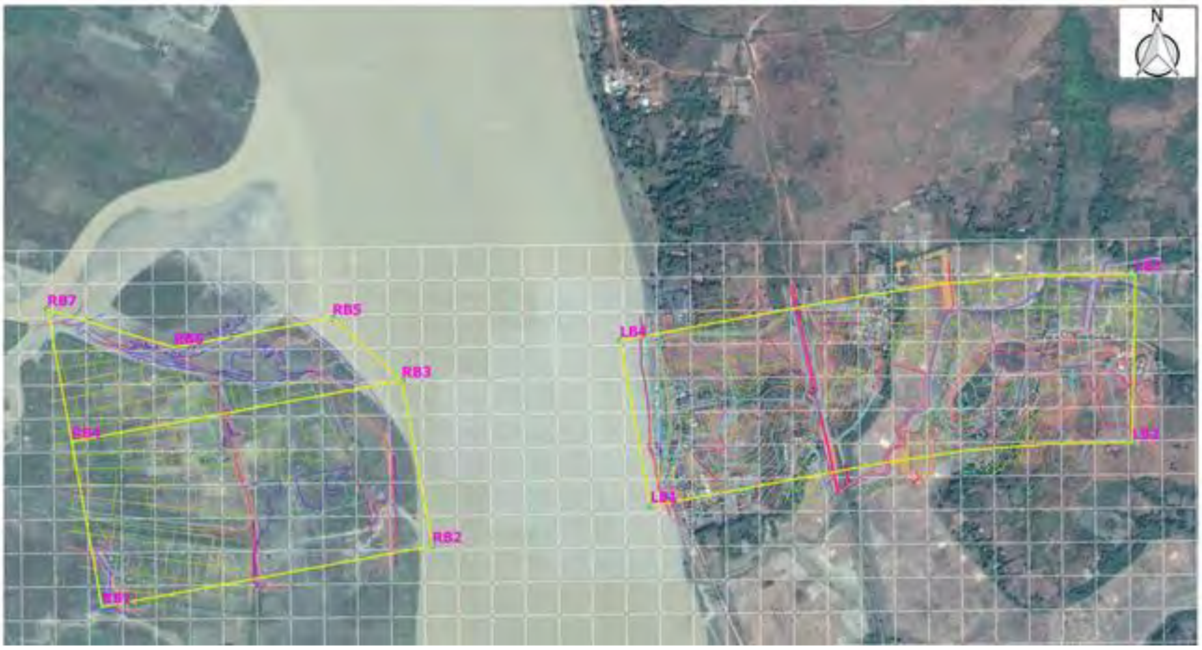
6.1 Topographic Survey

6.1.1 Survey Outline

A topographic, bathymetric, river condition survey and an interview survey were carried out to collect information on the natural conditions including the terrain information in the Project for the preliminary design of the New Sittaung Bridge. The objective of the survey is to provide preliminary data regarding the topographic formation and hydrographical change of the area along the Sittaung River.

(1) Survey Location

The location of the survey is in and around the candidate site of the New Sittaung Bridge crossing the estuary of Sittaung River. The land to be connected by the bridge designed in the Project was extracted as the area of topographic survey.



Source: JICA Study Team based on Google Satellite Map

Figure 6.1.1 Topographic Mapping Area

The twelve river survey lines for the river sectional survey are observed to understand the natural conditions of the river and to secure topographical information in wide-ranging areas of candidate sites.

Source: JICA Study Team based on Google Satellite Map

Figure 6.1.2 River Survey Location

(2) Geographic Reference System

The following coordinate system was adopted in the survey.

Table 6.1.1 Coordinate System Used in the Survey

Ellipsoid	WGS84 (World Geodetic System 1984)
Projection	Universal Transverse Mercator (UTM) Projection
UTM Zone	Zone Number N47
Origin of Central Meridian	99 degree east of Meridian International
Origin of Latitude	Equator
Scale factor at the origin	0.9996
False Easting	(0,500,000) at equator

Vertical Datum	Bench mark height adopted by Myanmar Survey Department
Unit of measurement	Meter

Source: JICA Study Team

(3) Equipment

Table 6.1.2 shows the equipment used in the survey. The UAV which was used is shown in Figure 6.1.3.

Table 6.1.2 Equipment of the Survey Work

No.	Survey Instruments	Qty	Softwares
1	Spectra Precision SP80 GNSS Receiver (one base two rover)	1set	Auto CAD Civil 3D Land Desktop
2	Topcon GR5 GNSS Receiver (one base two rover)	1set	Trimble Business Center (TBC)
3	Topcon Hipper II GNSS Receiver (one base two rover)	1set	Magnet Field
4	Nikon nivo 2m Total Station	2set	Azuka
5	Nikon NPL 322	1set	Info 5.6
6	Topcon GTS 7503 Total Station	1set	Auto CAD Map 3D 2014
7	Focus DL 15 Digital Level	2set	UAS Master 6.0
8	Topcon B2 Auto Level	2set	Global Mapper
9	Garmin Aqua Map Sounder 80xS	4set	
10	Leica Digital Sprinter 150m		Sprinter Downloader

Source: JICA Study Team

Source: JICA Study Team

Figure 6.1.3 UAV Used in the Survey

6.1.2 Scope of Work

Table 6.1.3 shows the quantities of execution in the survey.

Table 6.1.3 Survey Work Discription

No.	Survey Work Item	Work Volume	Description
1	Benchmark Installation	2-Points	
2	Control Leveling Survey	112km	3-route

3	Topographic Survey acquire by UAV (Unmanned Aerial Vehicle)	1.5km^2	
4	River survey	80.8km	12-Cross Section
5	Interview Survey for Historical Maximum/Normal Levels and Flood Situations	30-Locations	Client Selected Locations
6	Measurement of Water Level	8-Days	24-hrs
7	Measurement of Water Velocity	29-Days	(m/sec)
8	Video Shooting of Tidal Bore	4-Days	(1:30hrs/day)

Source: JICA Study Team

6.1.3 Survey Results

(1) Topographic Survey Acquired by UAV

1) Aerial Photo Acquisition by UAV

The aerial photo acquisition by UAV was carried out according to the flight plan created based on the following specifications.

- Ground sampling distance : 6cm
- Number of flight line : 11 lines
- Overlap : 80%
- Sidelap : 60%
- Camera : SONY (Model – ILCE-5100)

Effect of the clouds, shadow and smoke has not been observed at the principle point of any photograph. The aerial photo of the digital topographic mapping is shown in Figure 6.1.4.

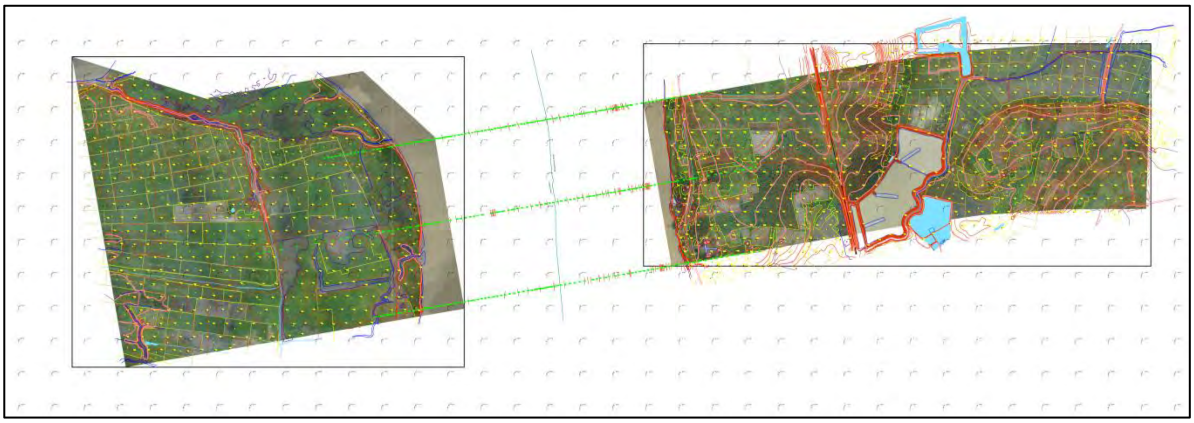
Source: JICA Study Team

Figure 6.1.4 Aerial Photo of the Digital Topographic Mapping Area

2) Production of Topographic Map by Ortho Photo

The aerial ortho photo image is obtained by converting the aerial photograph of the central projection using the Digital Terrain Model (hereinafter refer to as “DTM”), the Exterior Orientation (hereinafter refer to as “EO”) parameter and the aerial photograph. The exterior orientation of the photo center was calculated using GCP from the GPS base station. Also, all natural and artificial terrain features such as rivers, streams, forests, paddy fields, farms, plantations, roads, paths, houses, schools, public buildings, cemeteries, etc. were interpreted and plotted in the photo. Thus, a topographic map was produced with

1:1,000 scale as shown in Figure 6.1.5.



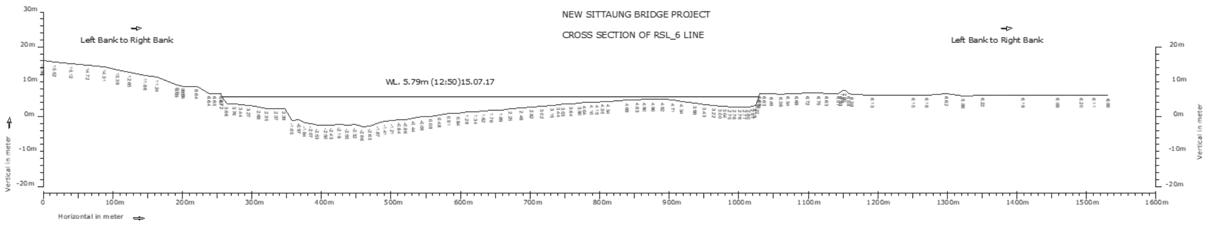
Source: JICA Study Team

Figure 6.1.5 Topographic Map

(2) River Survey

1) River Bed Height

The river bed height was determined by subtracting the depth from the water level of simultaneous observation. The river cross sectional data nearby the bridge crossing section is shown in Figure 6.1.6.



Source: JICA Study Team

Figure 6.1.6 River Cross Section at Bridge Crossing Section

2) River Water Level

Fixed point observation for the water level was carried out by recording the gauge scale. Observation intervals were performed once every other hour as shown below. A part of the results is shown in Table 6.1.4.

1. During spring tide: 24 hours, 5 days at least
2. During neap tide: 12 hours, 2 days at least
3. Other period except above periods (; half tide, midway between spring and neap tides): Daytime, 7 days at least

Table 6.1.4 Water level Measurement Result

Date	Time	W.L.(m)	Date	Time	W.L. (m)	Date	Time	W.L. (m)
25/5/2017	6:00	5.683	26/5/2017	1:00	5.203	27/5/2017	1:00	5.313
	7:00	5.378		2:00	5.158		2:00	5.233
	8:00	5.158		3:00	5.075		3:00	5.093
	9:00	5.02		4:00	4.808		4:00	5.043
	10:00	4.941		5:00	4.788		5:00	4.983

Date	Time	W.L .(m)	Date	Time	W.L. (m)	Date	Time	W.L. (m)
	11:00	4.887		5:03	5.493		5:45	5.943
	12:00	4.878		5:15	5.683		6:00	5.933
	13:00	4.74		5:30	5.803		6:15	6.023
	14:00	4.673		5:45	5.893		6:30	6.123
	15:00	4.614		6:00	5.943		6:45	6.193
	16:00	4.511		6:15	5.913		7:00	6.113
	16:15	4.517		6:30	5.903		7:15	6.093
	16:17	5.501		6:45	5.863		7:30	6.043
	16:30	5.511		7:00	5.823		7:45	5.973
	16:45	5.531		8:00	5.623		8:00	5.913
	17:00	5.945		9:00	5.413		9:00	5.713
	17:15	5.916		10:00	5.323		10:00	5.533
	17:30	5.918		11:00	5.243		11:00	5.433
	17:45	5.993		12:00	5.158		12:00	5.333
	18:00	5.998		13:00	5.013		13:00	5.243
	19:00	5.949		14:00	4.923		14:00	5.153
	20:00	5.693		15:00	4.833		15:00	5.043
	21:00	5.547		16:00	4.793		16:00	4.963
	22:00	5.378		16:50	6.013		17:00	4.933
	23:00	5.318		17:00	5.893		17:30	6.223
	24:00	5.253		17:15	6.073		17:45	6.183
				17:30	6.153		18:00	6.163
				17:45	6.093		18:15	6.423
				18:00	6.253		18:30	6.353
				18:15	6.433		18:45	6.513
				18:30	6.373		19:00	6.513
				18:45	6.273		19:15	6.413
				19:00	6.273		19:30	6.413
				20:00	6.053		19:45	6.363
				21:00	5.853		20:00	6.323
				22:00	5.733		21:00	6.023
				23:00	5.613		22:00	5.823
				24:00	5.473		23:00	5.683
							24:00	5.553

Source: JICA Study Team

3) Water Flow Velocity

The methodology used in the survey and the results are shown in Table 6.1.5 and Table 6.1.6 .

Table 6.1.5 Metodology of Water Flow Velocity Measurement

Item	Description
Measurement point	Fixed point observation
Measurement depth	Velocity at 1 m depth under water surface

Measurement season	From 2.6.2017 to 30.6.2017
Measurement time	24 hours
Equipment	Vale port current flow meter

Source: JICA Study Team

Table 6.1.6 Result of the Water Flow Velocity Measurement

Station - Sittaung River near Sut Pa Nu village Kyaikto Township			Station - Sittaung River near Sut Pa Nu village Kyaikto Township		
Location : - 17° 23' 52.68"N , 96° 53' 48.07"E			Location : - 17° 23' 52.68"N , 96° 53' 48.07"E		
Date : 2.6.2017			Date : 3.6.2017		
Time	Water Level	Velocity @ 1 meter depth from surface	Time	Water Level	Velocity @ 1 meter depth from surface
24 Hour	MSL (m)	(m/sec)	24 Hour	MSL (m)	(m/sec)
1:00	_	_	1:00	_	_
2:00	_	_	2:00	_	_
3:00	_	_	3:00	_	_
4:00	_	_	4:00	_	_
5:00	_	_	5:00	_	_
6:00	4.693	0.045	6:00	4.543	0.057
7:00	4.693	0.049	7:00	4.543	0.062
8:00	4.683	0.045	8:00	4.543	0.057
9:00	4.683	0.036	9:00	4.543	0.057
10:00	4.673	0.000	10:00	4.523	0.049
11:00	4.653	0.023	11:00	4.533	0.062
12:00	4.633	0.023	12:00	4.523	0.066
13:00	4.623	0.019	13:00	4.533	0.083
14:00	4.593	0.057	14:00	4.523	0.075
15:00	4.593	0.053	15:00	4.533	0.066
16:00	4.593	0.062	16:00	4.593	0.083
17:00	4.593	0.066	17:00	4.593	0.079
18:00	4.593	0.066	18:00	4.593	0.083
19:00	_	_	19:00	_	_
20:00	_	_	20:00	_	_
21:00	_	_	21:00	_	_
22:00	_	_	22:00	_	_
23:00	_	_	23:00	_	_
0:00	_	_	0:00	_	_
	Max: Velocity	0.066		Max: Velocity	0.083
	Min: Velocity	0.000		Min: Velocity	0.040

Source: JICA Study Team

6.2 Hydrological and Hydraulic Survey

6.2.1 Survey Outline

The climate of the targeted area in this Study is typically classified as a tropical monsoonal type (Am) with a lower humidity than in most parts of South East Asia, according to Köppen climate classification system. (The upper river basin of the study areas are classified as tropical wet and dry or savanna climates; Aw.)

The rainy season is typically tropical southwest monsoon, and it is cloudy, rainy, hot, and humid in the summer from June to September. On the other hand, the dry season is the northeast monsoon, and it is less cloudy, scant rainfall, mild temperatures, and lower humidity during the winter from December to April. The targeted area is one of areas of relatively higher precipitation in Myanmar as shown in Figure 6.2.7, and flooding occurs in the targeted area frequently. Also, at the lower reach to its junction with the Bago-Sittaung Canal from the river mouth of the Sittaung River, the tidal bore occurs twice per month, and therefore the bank erosion or deposition and the shifting of river course are serious.

The locations of the existing 19 meteorological, hydrological and tide stations are shown in Figure 6.2.7.

There are 5 observation stations of climatic data in and around the target area which have been operated by the Department of Meteorology and Hydrology (hereinafter called “DMH”) under MOT (Ministry of Transportation), as shown in Table 6.2.1. Also, the 11 existing gauging stations (of water level / discharge data) are managed by the DMH and the Irrigation Department (hereinafter called “ID”) under MOAI (Ministry of Agriculture and Irrigation) in and around target catchment basins as shown in Table 6.2.2. Of these stations, 6 stations of ID do not have discharge records. Also, of these hydrological stations, the stations which are located within 100km from the sea are affected by the tidal action during the dry season. However, the discharge records at these stations during the rainy season can be utilized for flood probability calculation.

Regarding the tide data, it is observed by the Myanmar Port Authority (hereinafter called “MPA”) under MOT. However, the location of tide station is far from the study area, and the nearest tide-station is located in the Moulmein (Mawlamyine) Port of Mon State, and the distance from the station to Sittaung River mouth is 104km. In this Study, the fixed-point observations (such as tide-levels, velocity, wave-height, etc.) will be conducted near the proposed bridge in order to reproduce the actual tidal motion and/or the tidal propagation between the existing tide station and bridge. Also, the hydrological data of above the existing stations, various information and useful documents, etc., has been collected.

In this section, the hydrological and hydraulic assessments of the study area, and the hydraulic design for the bridge design are presented. The river bank protection design is presented in Chapter 7.6.

Table 6.2.1 Inventory of Meteorological Stations

Meteorological Station	Code (WMO)	Coordinates		Height (m)	Period of Records						Remarks
		Latitude	Longitude		Temperature	Relative Humidity	Rainfall	Sunshine	Evaporation	Wind	
1. Kaba Aye (Yangon)	48097	16-54	96-10	20.00	1968-	1968-	1968-	1977-	1975-	1968-	
2. Bago	48093	17-20	96-30	9.00	1965-	1965-	1965-	-	-	1965-	
3. Tharrawady	48088	17-38	95-48	15.00	1965-	1965-	1965-	-	-	1965-	
4. Shwegyin (Madauk)	48089	15-55	96-52	12.00	-	-		-	-	-	
5. Bilin	-	17-11	97-17	16.15	-2013	-2013	-2013	-	-	-2013	

Source: JICA Study Team, DMH

Table 6.2.2 Inventory of Hydrological and Tide Stations

River / Gauging Station	Code	Coordinates		Catchment Area (km^2)	Height (m)	Type of Gauge	Period of Record	Water (Tide) level	Discharge	Observed by	Remarks
		Latitude	Longitude								
River Gauge Stations											
1. Sitttaung River / Taungoo	7040	18-55	96-28	14660	44.28	Pile Gauge	1965-	○	○	DMH	
2. Sitttaung River / Madauk	7060	17-55	96-51	26758	10.80	Pile Gauge/Auto-recording	1965-	○	○	DMH	
3. Bago River / Zaungutu	6220	17-38	96-14	1,927	9.80	Pile Gauge	1987-	○	○	DMH	
4. Bago River / Bago (Pegu)	48093	17-20	96-30	2,580	9.00	Pile Gauge/Auto-recording	1970-	○	○	DMH	
5. Bilin River / Belin	7210	17-49	95-41	2518	9.97	Mixed Gauge	1965-	○	○	DMH	
6. Sittaung River / Madauk	-			-	-	Manual	-	○	-	ID	
7. Sittaung River / Thuyethamein	-	17.7667	96.8833	-	-	Manual	-	○	-	ID	
8. Sittaung Tributary / Myit Kyoe	-	17.5992	96.8140	-	-	Manual	-	○	-	ID	
9. Sittaung River / Mokpalin	-	17.4396	96.8779	-	-	Manual	-	○	-	ID	
10. Sittaung-Bago Canal / Shan Gaing Gate	-	17.4190	96.8432	-	-	Manual	-	○	-	ID	
11. Sittaung-Bago Canal / Lower Se-Tee	-	17.2768	96.4935	-	-	Manual	-	○	-	ID	
Tide Stations											
1. Yangon River-mouth / Elephant Point	-	16-28	96-19	-	-	Steel Plate (Manual)	-	○	–	MPA	
2. Kayaikkami / Amherst	746(PSMSL)	16-05	97-34	-	-	Steel Plate (Manual)	1954-	○	–	Navy / MPA	
3. Mawlamyine Port / Moulmein	747(PSMSL) 141(GLOSS)	16-29	97-37	-	-	Steel Plate	1954-	○	-	Navy / MPA	

Source: JICA Study Team, DMH, ID, MPA

Source: JICA Study Team based on Google Earth

Figure 6.2.1 Location Map of Meteorological, Hydrological and Tide Stations

6.2.2 Survey Contents / Several River Surveys on Site

The survey has been conducted for the following survey items. (See Table 6.2.3.) A part of the survey items was conducted as a subcontract.

Table 6.2.3 Hydrological and Topographic Survey Items

No.	Survey Items	Surveyor	Remarks
1	Hydrological data and various information collection from authorities concerned	JICA survey team	hydrological data, irrigation / drainage / gate facilities, bathymetric survey results, etc.
2	Bibliographic survey	JICA survey team	documents, satellite images, digital elevation models, old maps, etc.
3	Field reconnaissance (situations for site, hydrology, bank erosion / deposition and tidal bore, etc.)	JICA survey team	
4	Hydrological interview survey (flood level measurements, situations for flood, tidal bore, river course change, etc.)	Subcontract / JICA survey team	
5	Benchmark installation	Subcontract	
6	Control Leveling Survey for River	Subcontract	
7	GPS Base station for UAV	Subcontract	
8	Aerial Photo Acquisition by UAV	Subcontract	
9	Orthophoto production	Subcontract	
10	Digital topographic mapping (scale 1:1000)	Subcontract	
11	Data Collection and Interview Survey	Subcontract	
12	Cross Section Survey for River	Subcontract	
13	Data Analyzing and Drawing for River	Subcontract	
14	Measuring of Water Level and Flow Speed	Subcontract	
15	Flow Speed acquisition by video camera	Subcontract	

Source: JICA Study Team

In this study, the topographic survey was conducted around the proposed bridge only, and the bathymetric survey of 12 cross-sectional survey-lines only in the river from downstream 36.1km to upstream 13.4km, was measured. Therefore, furthermore detailed topographic and bathymetric survey and water level observation should be performed in a future detailed design, for clarifying the channel / its catchment area and hydrological information (semidiurnal tidal motion, tidal bore propagation), etc.

6.2.3 Meteorological Conditions

(1) General Weather Conditions

1) **Temperature**

The temperature data at five stations shows almost a similar trend. The monthly mean temperature at the south-eastern area in the Myanmar has a range between around 24℃ and 30℃. According to the collected data in this Study, the mean monthly maximum temperature 37-40℃ (April) and the mean minimum temperature

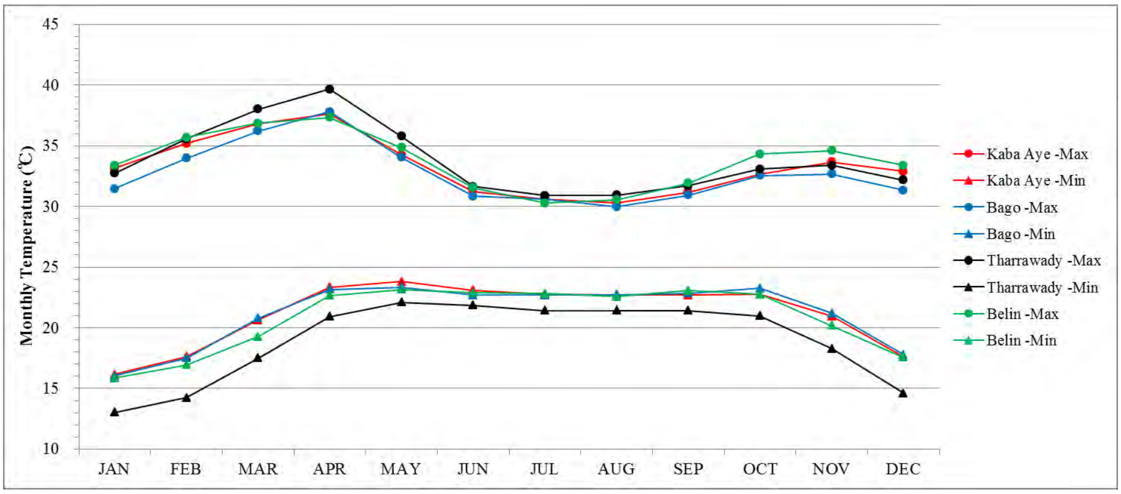
13-16℃ (January) at targeted area were recorded during the recent 10 years.

The mean monthly maximum and minimum temperature at the related 5 stations are shown in Figure 6.2.2 and Table 6.2.4.

Table 6.2.4 Monthly Mean Maximum/Minimum Temperature

Station		Item	Monthly Temperature in ℃													Remarks
			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average	
1 Kaba Aye	Kaba Aye -Max	Max	33.1	35.2	36.8	37.6	34.3	31.2	30.6	30.3	31.2	32.6	33.7	32.9	37.8	1991-2016
	Kaba Aye -Min	Min	16.2	17.6	20.6	23.4	23.8	23.1	22.8	22.7	22.7	22.7	21.0	17.6	15.9	1991-2016
2 Bago	Bago -Max	Max	31.4	34.0	36.2	37.8	34.0	30.8	30.6	30.0	30.9	32.5	32.7	31.3	38.1	1997-2016
	Bago -Min	Min	16.1	17.5	20.8	23.2	23.3	22.7	22.7	22.7	22.9	23.2	21.2	17.8	15.9	1997-2016
3 Tharrawady	Tharrawady -Max	Max	32.7	35.5	38.0	39.7	35.8	31.6	30.9	30.9	31.7	33.1	33.4	32.2	39.7	1997-2016
	Tharrawady -Min	Min	13.0	14.2	17.5	20.9	22.1	21.8	21.4	21.4	21.4	21.0	18.3	14.6	12.7	1997-2016
4 Shwegyin	Shwegyin -Max	Max	32.9	35.3	37.2	38.4	34.7	31.1	30.0	30.0	31.5	33.7	34.1	32.9	38.5	1997-2016
	Shwegyin -Min	Min	15.4	16.9	20.7	23.7	24.0	23.3	23.0	22.9	23.0	22.5	19.9	16.7	15.0	1997-2016
5 Belin	Belin -Max	Max	33.4	35.7	36.9	37.3	34.8	31.5	30.3	30.5	31.9	34.3	34.6	33.4	37.6	1997-2016
	Belin -Min	Min	15.8	17.0	19.3	22.7	23.1	22.9	22.8	22.6	23.0	22.8	20.2	17.6	15.4	1997-2016
Average			24.0	25.9	28.4	30.5	29.0	27.0	26.5	26.4	27.0	27.8	26.9	24.7	27.0	
Average Max.			32.7	35.1	37.0	38.1	34.7	31.3	30.6	30.4	31.4	33.1	33.6	32.4	33.4	
Average Min.			15.3	16.6	19.6	22.5	23.1	22.6	22.4	22.3	22.5	22.4	20.1	16.9	20.5	

Source: JICA Study Team, DMH



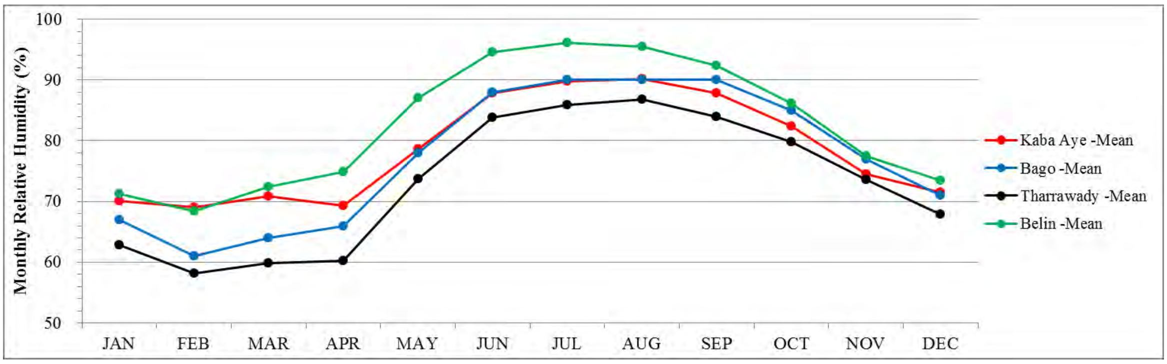
Source: JICA Study Team, DMH

Figure 6.2.2 Monthly Mean Maximum/MinimumTemperature

2) Relative Humidity

The relative humidity has been observed twice a day (at 9:30 and 18:30). Although the rainy season is hot-humid, the relative humidity during winter from December to April is low. The mean monthly relative humidity in the targeted area ranges between 64 and 91%.

The mean monthly relative humidity at the related 4 stations is shown in Figure 6.2.3.



Source: JICA Study Team, DMH

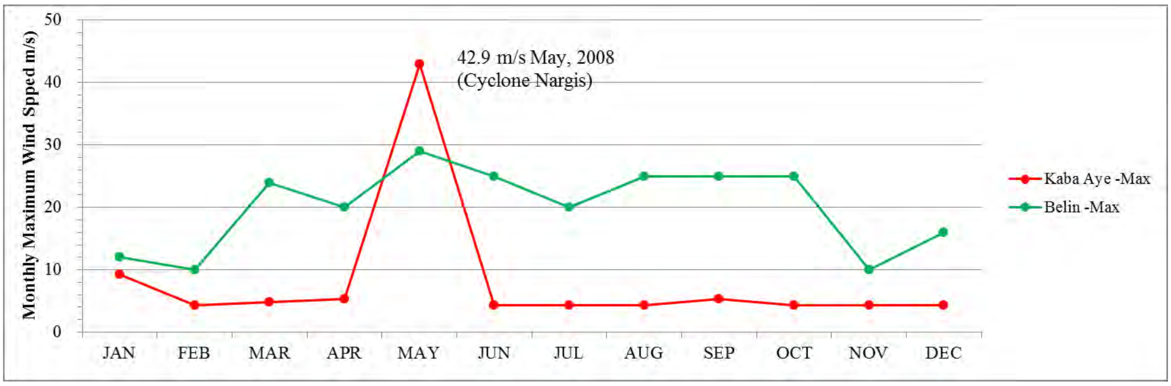
Figure 6.2.3 Monthly Mean Relative Humidity (9:30)

3) Maximum Wind Speed

The monthly maximum wind speed at each station is not stable, and is recorded at a range between 4 and 43 m/s throughout the year. The wind direction in the targeted area depends on the influence of the southwest monsoon during the rainy season and the northeast monsoon during the dry season. Most of the maximum wind speeds of the targeted area is caused by low-pressure waves (the remnants of typhoons and tropical storms of South China Sea) and cyclones.

The track of cyclones mostly passes through the upper northwestern coastal zone of the study area, while the cyclones have never hit the southern coast of the study area. However, in the case of the southward shifting of the cyclone track (e.g. the Cyclone Nargis), the cyclones hit toward Yangon and the study area with a 3.2% probability (during 1947 to 2008).

The monthly maximum wind speed at the related 2 stations is shown in Figure 6.2.4.



Source: JICA Study Team, DMH

Figure 6.2.4 Monthly Maximum Wind Speed

4) Evaporation

The evapotranspiration is observed at Yangon (Kaba Aye) only. The annual mean evapotranspiration is 1324mm, and it accounts for 48% of annual rainfall.

The monthly mean evapotranspiration at Kaba Aye station is shown in Figure 6.2.5.

Source: JICA Study Team, DMH

Figure 6.2.5 Monthly Mean Evaporation

5) **Sunshine Hours**

The sunshine hours are also observed at Kaba Aye Station only. The annual mean sunshine hours have 6.3 hours/day and 76 hours/month at Kaba Aye. The sunshine hours are shorter during the rainy season, and its pattern is shown as the opposite of monthly rainfall fluctuation.

The mean monthly sunshine hours at Kaba Aye Station are shown in Figure 6.2.6.

Source: JICA Study Team, DMH

Figure 6.2.6 Monthly Mean Sunshine Hours

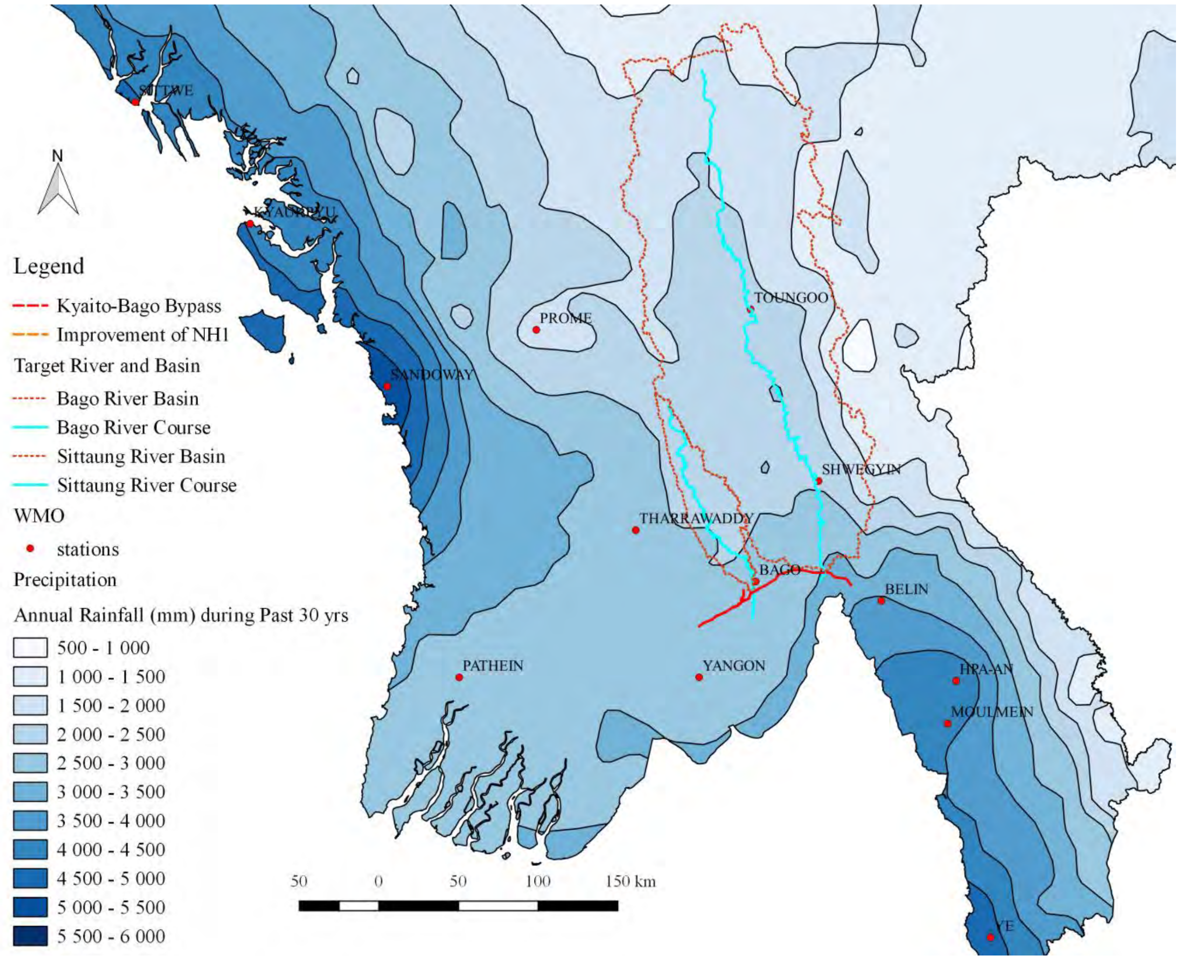
(2) Rainfall

1) **Annual Rainfall and Seasonal / Long-term Fluctuation**

The targeted area is the area with average to abundant precipitation in Myanmar. (The areal distribution of annual rainfall which is predicted based on annual rainfalls during past 10 years or more of observation stations in and around south-eastern Myanmar, is shown in Figure 6.2.7.) The annual mean rainfall ranges from 3,481mm at Shwegyin (Madauk) to 5,695mm at Belin. Also, the annual rainfall fluctuates between each station significantly. (e.g. between 2,396 and 4,633mm at Shwegyin.)

Seasonal variation of monthly mean precipitation is similar in each station. Regarding the seasonal fluctuation of rainfall, 95% or more of annual rainfall is brought by the rainy season from May to October, with the highest amount of rainfall in July or August.

The mean monthly rainfall at the 8 stations is shown in Figure 6.2.8 and Table 6.2.5.



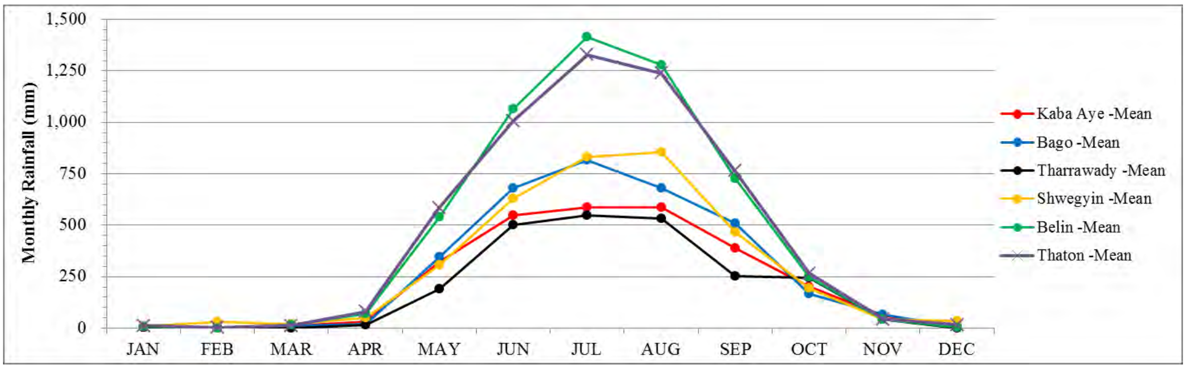
Source: JICA Study Team, Digital Agricultural Atlas (FAO, http://dwms.fao.org/atlases/myanmar/index_en.htm)

Figure 6.2.7 Areal Distribution (Isohyet) of Annual Rainfall in Southern Myanmar

Table 6.2.5 Monthly Mean Rainfall

Station			Item	Monthly Rainfall in mm													Remarks
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total	
1	Kaba Aye	Kaba Aye -Mean	Mean	4	3	13	32	321	550	587	587	390	201	62	6	2,756	1968-2008, 2013-16
2	Bago	Bago -Mean	Mean	5	5	14	22	346	681	818	679	509	167	65	8	3,318	1996-2005, 2013-16
3	Tharrawady	Tharrawady -Mean	Mean	3	1	0	15	191	501	549	534	253	246	43	1	2,335	2013-16
4	Shwegyin	Shwegyin -Mean	Mean	9	32	21	52	306	632	833	857	466	193	45	35	3,481	1996-2016
5	Belin	Belin -Mean	Mean	6	1	16	70	541	1,064	1,417	1,277	725	251	42	6	5,416	2004-2016
6	Thaton	Thaton -Mean	Mean	12	3	14	80	585	1,008	1,328	1,240	765	265	45	17	5,362	2004-2016
7	Myit Kyoe	Myit Kyoe -Mean	Mean					495	520	520	731	656	245	92		3,259	2008-2016
8	Shan Gyaing	Shan Gyaing -Mean	Mean	15	0	0	0	217	609	903	770	497	219	123	0	3,352	2014-16
Average				8	6	11	39	375	696	869	834	533	223	64	10	3,660	

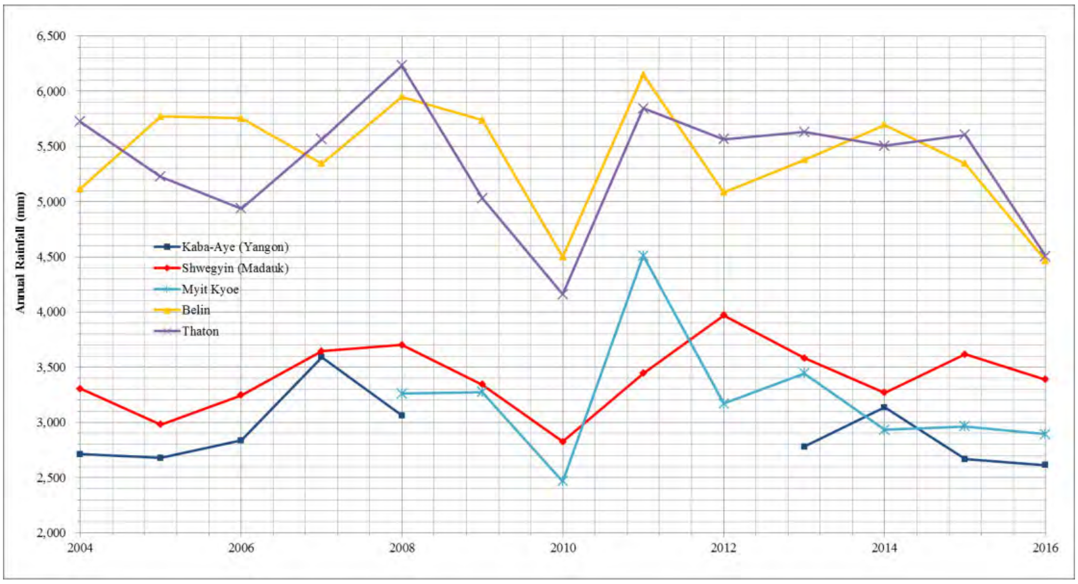
Source: JICA Study Team, DMH, ID



Source: JICA Study Team, DMH

Figure 6.2.8 Monthly Mean Rainfall

Figure 6.2.9 shows the long-term fluctuation of annual rainfall at 5 stations. Although the cycle of wet and droughty periods is not clear, the annual rainfall of 2010 was small relatively.



Source: JICA Study Team, DMH

Figure 6.2.9 Fluctuation of Annual Rainfall (2004-2016)

Also, as an indicator of the annual workable days for construction, generally, the annual total number of days with daily-rainfall more than 10mm is counted as unworkable days[1]. The annual mean rainy days with more than 10mm/day is shown in Table 6.2.6, for reference.

[1] As mentioned in Chapter 8.4, construction schedule in this study is prepared considering the unworkable days based on the rainfall observation data in the past four years (2013-2016)

Table 6.2.6 Annual Mean Rainy Days (more than 10 mm/day)

District	Yangon		Bago		Bago		Bago	
Station Name	Kaba Aye		Bago		Shwegyin (Madauk)		Myit Kyoe	
Organization	DMH		DMH		DMH		ID	
Observed Year	Rainy Days							
	>0 mm	>10 mm	>0 mm	>10 mm	>0 mm	>10 mm	>0 mm	>10 mm
1996					140	92		
1997					130	91		
1998					125	65		
1999					152	90		
2000					144	91		
2001					154	90		
2002					144	91		
2003					133	73		
2004					132	94		
2005					137	83		
2006					140	93		
2007					143	97		
2008					158	97	114	84
2009					138	78	110	85
2010					146	84	100	66
2011					153	97	137	111
2012					145	96	109	85
2013	140	87	147	92	134	89	118	95
2014	127	83	133	92	132	87	107	74
2015	127	80	124	82	126	91	110	78
2016	125	73	136	90	124	82	111	77
2017								
Average	129.75	80.75	135.00	89.00	139.52	88.14	112.89	83.89
Rate of Workable Days		77.9%		75.6%		75.9%		77.0%

Source: JICA Study Team, DMH, ID

2) Exceedance Probability and Intensity Curve of Rainfall

The annual maximum daily rainfall (extremal value) data at 5 meteorological stations is collected. The 24-hour rainfalls of 2 to 500 year probabilities are calculated by using these extreme values, as shown in Table 6.2.7.

The probability calculation adopts the Generalized Extreme Value (GEV) distribution method with the highest correlation and best fit.

There are about 1.2 times differences for probability values of the 5 stations, and the regional deviation is also big. Therefore, the maximum probability values at the proposed bridge are set by using its isohyetal map. For reference, the spatial distribution map of 10-years probability daily rainfall is plotted in Figure 6.2.10, in one instance. (The probability daily rainfalls are estimated by reading the maximum probability values at the proposed bridge on the TIN <Triangulated Irregular Network> of GIS software.)

As a next step, the correlation between the intensity of short time rainfall duration and 24-hour rainfall is estimated in reference to Mononobe's equation. The relationship of IDF (Intensity-Duration-Frequency), namely the rainfall-intensity is shown in Table 6.2.8.

Table 6.2.7 Calculation Results of Probable Daily Rainfall at 5 Stations

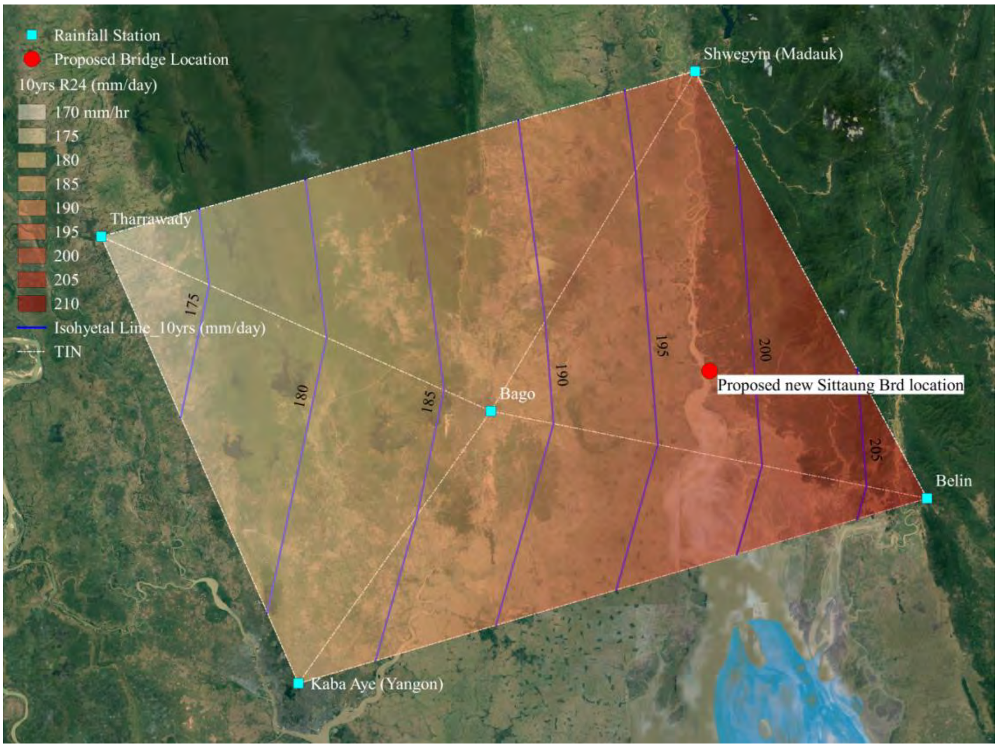
Station Name			Kaba Aye (Yangon)	Bago	Tharrawady	Shwegyin (Madauk)	Belin	Remarks
River Name			Yangon	Bago	Hlaing (Yangon)	Sittaung	Belin	
Station ID			48097	48093	48088	48089	-	
Lat. (Y)			16.8647	17.3333	17.6333	17.9167	17.1833	
Long. (X)			96.1542	96.5000	95.8000	96.8667	97.2833	
Data No. of Extreme Value			49	52	52	20	13	
Probable Rainfall (mm)	(Year)	(%)						
	1.1	90.9%	80.60	96.90	73.00	108.80	158.40	
	2	50%	112.40	127.70	107.70	150.50	178.70	
	3	33.3%	129.20	142.90	124.30	165.90	187.20	
	5	20%	150.50	161.30	143.90	181.20	196.50	
	10	10%	181.80	187.00	170.40	198.30	207.90	
	20	5%	217.50	214.60	198.00	212.70	218.70	
	25	4%	230.10	224.00	207.30	216.90	222.00	
	30	3.33%	240.90	231.80	214.90	220.10	224.80	
	50	2%	273.40	255.00	237.20	228.70	232.20	
	80	1.25%	306.80	277.90	258.70	235.80	239.00	
	100	1%	324.00	289.30	269.30	239.00	242.10	
	150	0.667%	357.40	311.10	289.20	244.40	247.80	
	200	0.5%	383.10	327.30	303.80	248.00	251.80	
	300	0.333%	422.40	351.50	325.20	252.80	257.40	
	400	0.25%	452.50	369.50	341.00	256.00	261.20	
	500	0.2%	477.30	384.00	353.60	258.30	264.20	
X-COR(99%)			0.994	0.986	0.991	0.986	0.972	
P-COR(99%)			0.996	0.993	0.992	0.991	0.987	
SLSC(99%)			0.026	0.032	0.027	0.036	0.049	

Source: JICA Study Team, DMH

Table 6.2.8 Calculation Results of IDF (Intensity-Duration-Frequency) at Proposed Bridge

Return Period (Probability) (Year, %)		Dairy Rainfall: R_{24} (mm/day)	Rainfall intensity each rainfall duration (mm/hr): It = $R_{24}/24*(24/t)^m$, m=2/3													Remarks
		24 hour	24	12	8	6	3	2	1.5	1	0.75	0.5	0.333	0.167	It= $A/t^{2/3}$	
at Bridge Location		1,440 min.	1,440	720	480	360	180	120	90	60	45	30	20	10		
1.1	90.9%	123.97	5.2	8.2	10.7	13.0	20.7	27.1	32.8	43.0	52.1	68.2	89.4	141.9	A= 42.977	
2	50%	153.02	6.4	10.1	13.3	16.1	25.5	33.4	40.5	53.0	64.3	84.2	110.3	175.2	A= 53.048	
3	33.3%	165.60	6.9	11.0	14.4	17.4	27.6	36.2	43.8	57.4	69.5	91.1	119.4	189.6	A= 57.410	Pavement /Bridge Drain
5	20%	179.70	7.5	11.9	15.6	18.9	29.9	39.2	47.5	62.3	75.5	98.9	129.6	205.7	A= 62.298	
10	10%	197.81	8.2	13.1	17.1	20.8	33.0	43.2	52.3	68.6	83.1	108.9	142.6	226.4	A= 68.577	
20	5%	215.81	9.0	14.3	18.7	22.7	36.0	47.1	57.1	74.8	90.6	118.8	155.6	247.0	A= 74.816	
25	4%	221.63	9.2	14.7	19.2	23.3	36.9	48.4	58.6	76.8	93.1	122.0	159.8	253.7	A= 76.835	
30	3.33%	226.42	9.4	15.0	19.6	23.8	37.7	49.4	59.9	78.5	95.1	124.6	163.3	259.2	A= 78.497	
50	2%	240.11	10.0	15.9	20.8	25.2	40.0	52.4	63.5	83.2	100.8	132.1	173.1	274.9	A= 83.241	
80	1.25%	253.11	10.5	16.7	21.9	26.6	42.2	55.3	67.0	87.7	106.3	139.3	182.5	289.7	A= 87.747	
100	1%	259.39	10.8	17.2	22.5	27.2	43.2	56.6	68.6	89.9	108.9	142.7	187.1	296.9	A= 89.926	

Source: JICA Study Team



Source: JICA Study Team, DMH, Google Earth

Figure 6.2.10 Probable Daily Rainfall - Isohyetal Map (10-years Return Period)

6.2.4 Hydrological / Hydraulic Conditions

(1) Rivers and River Flow Characteristics

1) Riverine System

In and around the target area, two big river basins (Bago and Sittaung River basins) exist, and there are the Sittaung-Bago Canal that connects their rivers, and many drainage/irrigation creek systems. The related drainage / irrigation network in the target area is shown in Figure 6.2.11.

➢ **Sittaung River**

The Sittaung (formerly, the Sittang or Sittoung) is a river in central-south Myanmar in the Bago Region. The Sittaung River is the fourth largest river of Myanmar with a length of about 590 km. It originates near Yamethin, and it discharges into the Gulf of Martaban of the Andaman Sea. The source of Sittaung River is at 460 m above mean sea level. The broad Sittaung River valley lies between the forested Bago Mountains on the west and the steep Shan Plateau on the east. The Sittaung River is navigable for 40km year-round and for 90km during three rain months. Transport is used to float timber, particularly teak, south for export. Its lower course is linked by canal to Bago River, which makes the basins during the wet season very inter-related. The number of dams and reservoirs are increasing, and currently, there are 17 dams and 13 reservoirs in the Sittaung River basin for multi-purpose uses, such as irrigation, flood control and hydropower generation.

➢ **Bago River**

The Bago River has its source near Thikkyi in the Bago Yoma. It flows down the east-facing slope of the Bago

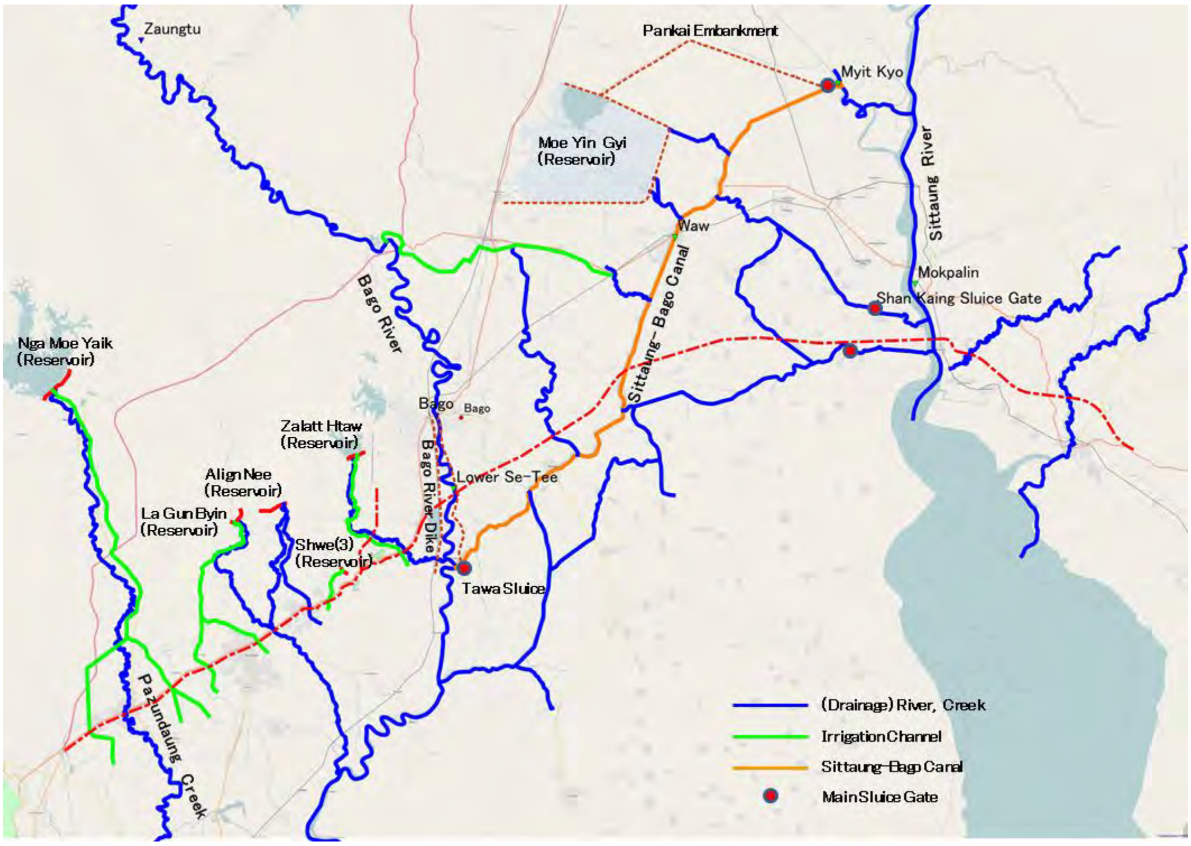
Yoma from north to south approximately parallel to the Sittaung River. When it reaches Bago, it turns to the southwest and flows into the sea as Yangon River. From the confluence point with the Hlaing River (located in Yangon), it is called the Yangon River.

Total length from its source to its mouth at the confluence of Yangon River is about 260km long. Bago River at Bago gauging station is clearly influenced by tidal level during the period of low flows. In the Bago River basin, 13 reservoirs and 1 dam are situated for multipurpose uses.

- **Sittaung-Bago Canal**

The Sittaung-Bago canal was constructed in 1878 primarily for navigational (timber transport) purposes, and it is aimed to connect Bago River with the Sittaung River to avoid the tidal bore on the lower reach of Sittaung River. The canal leaves the Bago River at Tawa and continues for 61km to enter the Sittaung River at Myit kyoe, and it provided the only route from Yangon to Taungoo. The Sittaung-Bago Canal was renovated in 2014 and now protects residents from flood occurrences and is an important water supplier for local irrigation. The canal has 1 interconnected reservoir and 6 sluices. Also, there are a large number of sluices of which most are not clearly documented, because they were constructed by local residents. Sluices regularly regulate the in- and out-flow of tributaries. A tidal effect is seen on both ends from the canal. According to the literature of Myo Lin of TU Delft (2015), it is described that 'During heavy rainfall event, the operation of reservoir and sluices is very complex due to the effect of inland flow and high tide'. This causes continuous complexity for decision making with uncertainty of the system tidal and rainfall components.

There are lock-gates at entrances of the main canal of both Bago/Sittaung River sides for water transportation, but the function is not operated for its original purpose at the present time, and it is mainly operated for irrigation / drainage. The gate of the Sittaung side is normally closed except for during the dry season, and the opening-closing timing of gate at the flooding time will be decided by relations between the inside / outside water levels of the inland area, Bago and Sittaung Rivers.



Source: JICA Study Team

Figure 6.2.11 Drainage and Irrigation Channel Network around Proposed Roads

(Lock Gate of entrance: Myit Kyoe Station) (Downstream side)

Source: JICA Study Team

Figure 6.2.12 Photo of Sittaung Bago Canal

➢ **Shan Gyaing Gate**

There is a trace of old Sittaung River before 1942 at north-eastern area at Proposed Bridge. It is just a tributary at the present time, its size is small and it functions as a dual purpose canal for irrigation and drainage. A position of confluence for a tributary is directly upstream of the proposed new bridge location, and the Shan Gyaing Gate facility was constructed in 2002 at a position upstream 6km from the confluence. Normally, the gate is closed, and it is opened when the inland area will be flooded. However, in the case of this study area, the agricultural gate facilities also have the disadvantage of inviting a large amount of sediment to the front of the gates accompanying the tidal-bore runup, while gates have the advantage of preventing the intrusion of sea water to many paddy-fields.

(Upstream side) (Downstream side: many siltations by tidal-bore)

Source: JICA Study Team

Figure 6.2.13 Photo of Shan Gyaing Gate

2) **Catchment Areas of Related Rivers**

The related rivers or creeks at the proposed bridge/road are identified by the topographic map and the hearing investigation to ID, DWIR and local peoples, and their catchment areas are measured as shown in Figure 6.2.14. The catchment basin of Sittaung River was obtained from DWIR as GIS data. The proposed bridge/road traverses across several types of terrain such as swampy, waterways, paddy field zones, low-lying and hilly areas. And, as stated above, the most of targeted area is low-lying area and paddy field area, and the drainage and irrigation channels are a mutual part of the intricate network.

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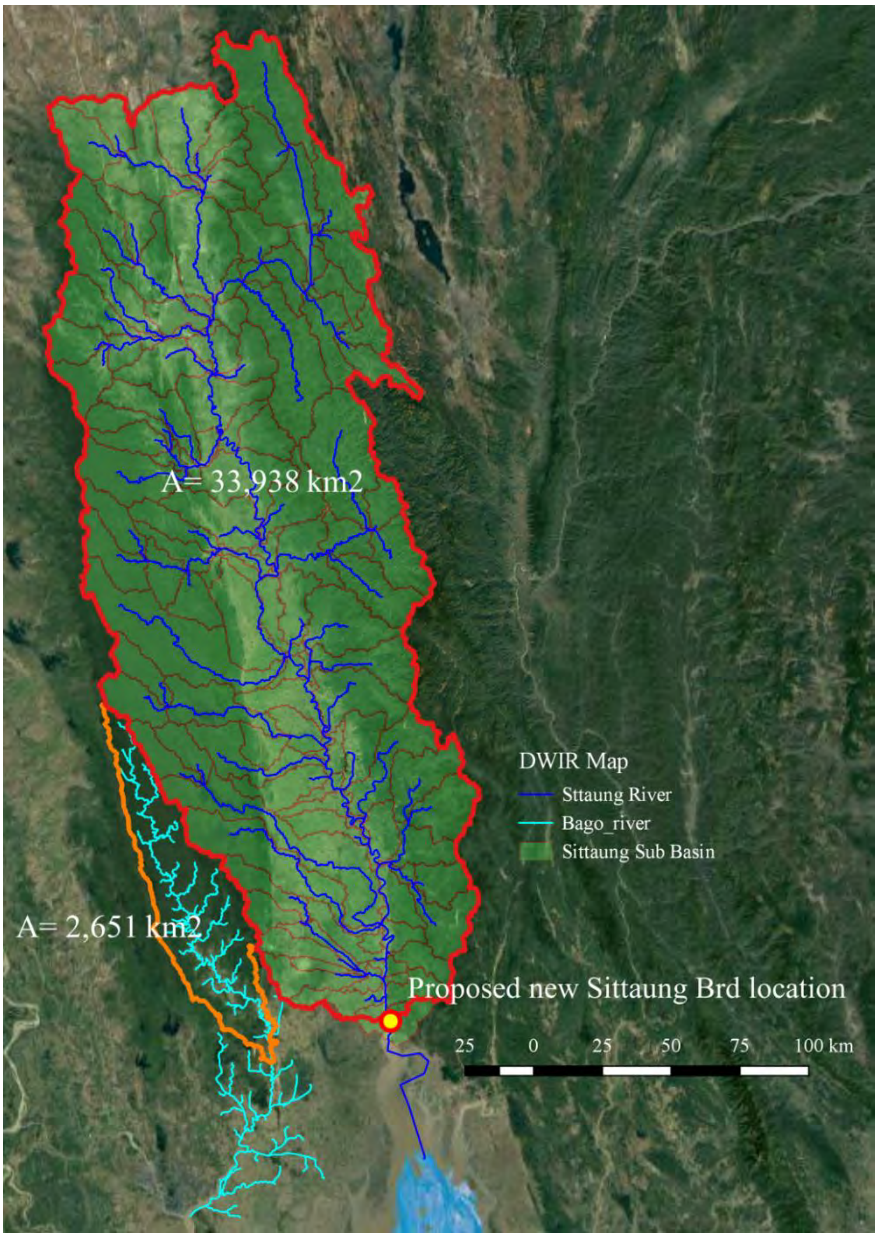


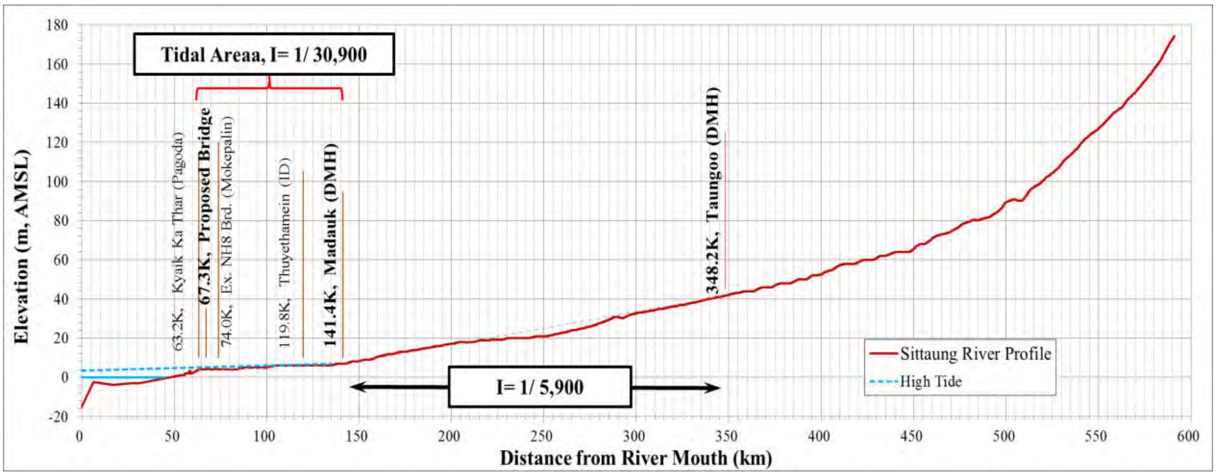
Source: JICA Study Team, DWIR based on Google Earth

Figure 6.2.14 Catchment Area Map

3) **Flow Regime of Main Rivers**

The longitudinal profile of Sittaung River is shown in Figure 6.2.15, and it was made based on DEMs (Digital Elevation Model) by the Shuttle Radar Topographic Mission (SRTM). The stream gradient gradually becomes gentle from upstream, and the gradient between Taungoo Station and Madauk Station is 1/6,000, then between Madauk and the proposed bridge is 1/31,000. (According to the Japanese classification for river course characteristics, the study area can be classified into the very gentle river of 'segment-3'.) Although the influence area changes depending on the tidal cycle, the river zone up to the downstream of Madauk Station from the estuary is a tidal river, and it has semi-diurnal tides. Therefore, the discharge data of downstream from Madauk station is not so useful to understand the river flow-regime. (The H-Q relationship between the water level (H) and discharge (Q) influences the tidal motion, so it is difficult to grasp the flow regime.)

Also, at the lower reach to its junction with the Bago-Sittaung Canal from the river mouth of the Sittaung River, the tidal bore occurs twice per month. However, unfortunately, in general there is not much knowledge about the generation mechanism and propagation characteristics of the tidal-bore. Although the phenomenon of tidal-bore by observing actual water level at near proposed bridge will be re-created / visualized to some extent in this Study, it is difficult in reality, and it cannot be reached to the academic verification and the establishment of analytical-method. Therefore, further hydrological survey/study or river morphological study will be needed for understanding the magnitude, the damage situation and the generating mechanism of the tidal bore.



Source: JICA Study Team, Figure is made based on SRTM data taken from USGS. (https://earthexplorer.usgs.gov/)

Figure 6.2.15 River Profile of Sittaung

The discharge-duration curve is examined in order to understand the potential surface water characteristics of the river through the year. The flow regime shows the annual flow condition using the daily discharge at each hydrological station, and is indicated by the daily discharge and the number of exceeded days. The annual flow regime shows as follows;

- High discharge (95th daily discharge from the greatest)
- Normal Discharge (185th daily discharge from the greatest)
- Low Discharge (275th daily discharge from the greatest)
- Drought Discharge (355th daily discharge from the greatest)

The coefficient of river regime is the ratio of the minimum flow and the maximum flow rate at optional point of the river, and shows the stability of the river flow quantitatively. The magnitude of coefficient of river regime indicates the magnitude of flow fluctuation, and if it is large, it indicates that the full year water intake is difficult to handle, and the flood damage is likely to occur. (For example, in the Europe, 18 - Basel of the Rhine River, 4 - Vienna of the Danube river, 34 - the Seine River. In Japan, 930 - the Tone River, 870 - the Kiso River, 5060 - the Yoshino River.)

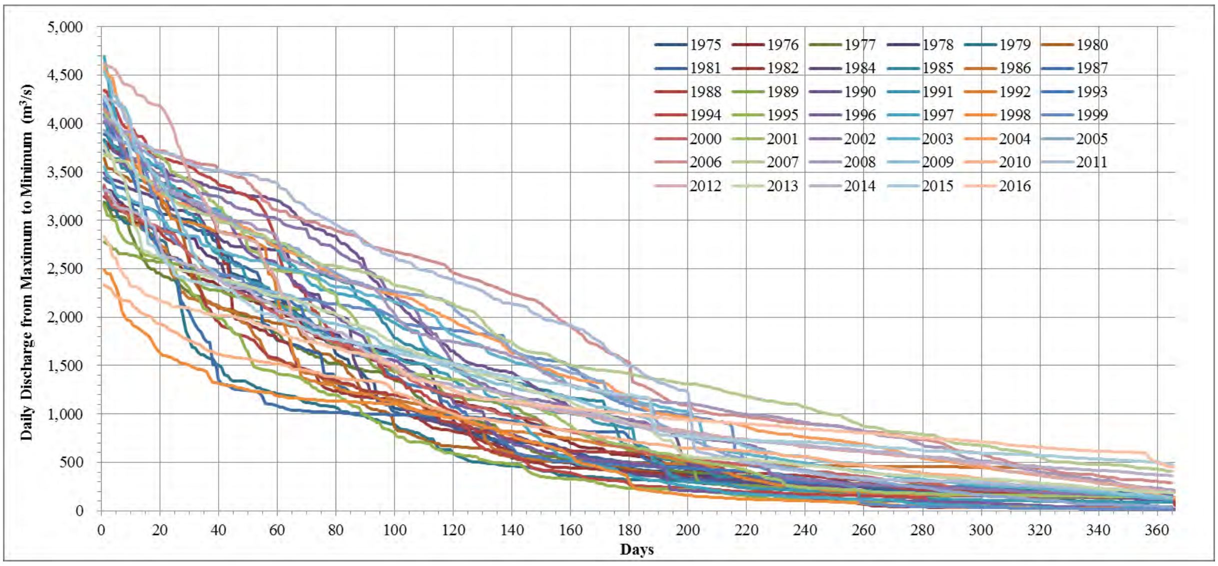
The flow regime which was calculated at the 3 stations of Madauk, Taungoo (Sittaung River) and Bago (Bago River), is summarized in Table 6.2.9 / Table 6.2.10 / Table 6.2.11 and Figure 6.2.16 / Figure 6.2.18 / Figure 6.2.19.

Although there is a certain level of flow fluctuation in the rainy season, the coefficient of the river regime of both rivers is relatively small and similar, for having the morphology of delta-specific. (The coefficient for Sittaung is small and ranges from 17 to 25, on the other hand, the coefficient for Bago is big a little more than Sittaung. Regarding the Bago Station, it is influenced by the tide to gauging-station during the dry-season, and real minimum discharge cannot be measured accurately.) The flow-rate during the dry-season is relatively stable for both rivers. What is notable is that there is a flow-rate difference in the dry-season between before 2000 and after 2000, and the increase of the flow-rate in the dry-season can be seen in 'Figure 6.2.16' and 'Figure 6.2.17 except 1986'. This can be estimated that the flow-rate increased by irrigation use during dry-season with the increase of the irrigation dams and reservoirs after 2000.

Table 6.2.9 Flow Regime (1975-2016) at Madauk Station of Sittaung River

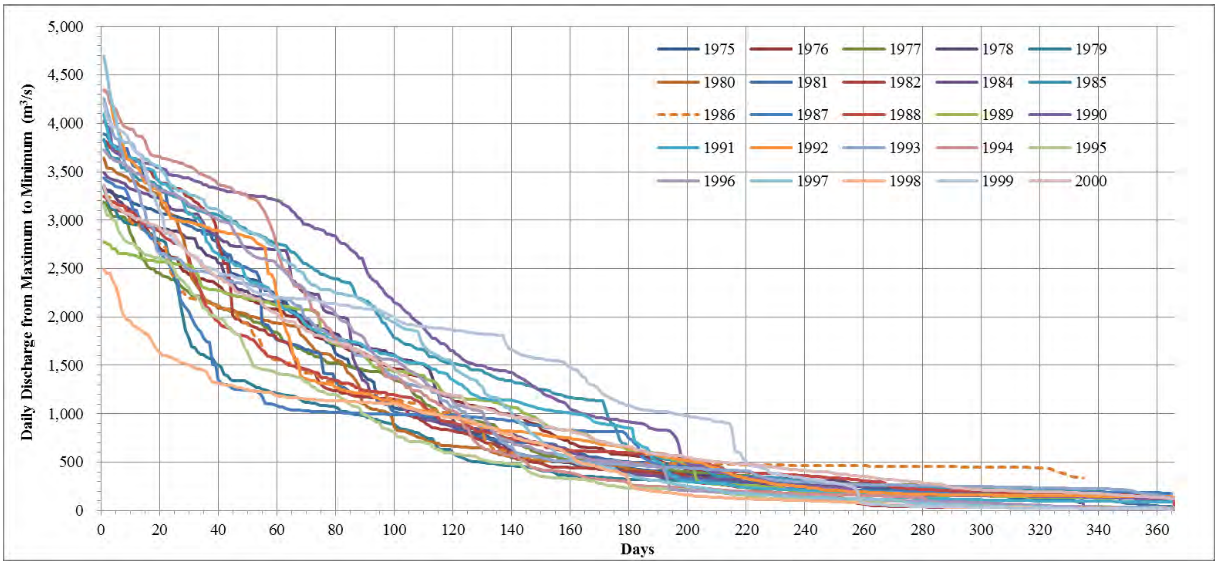
Year	Annual Maximum Discharge	Plentiful Discharge	Ordinary Discharge	Low Discharge	Drought Discharge	Annual Minimum Discharge	Coefficient of River Rregime	Remarks
	1-day	95-day	185-day	275-day	355-day	365-day	Max/Min	
Average	3672.0	1619.0	695.4	309.2	171.3	149.7	24.5	1975-2016
Maximum	4697.0	2709.0	1404.0	805.0	599.0	483.0	-	
Minimum	1674.0	448.0	213.0	42.0	16.0	12.0	-	

Source: JICA Study Team, DMH



Source: JICA Study Team, DMH

Figure 6.2.16 Discharge-Duration Curve (1975-2016) at Madauk of Sittaung River



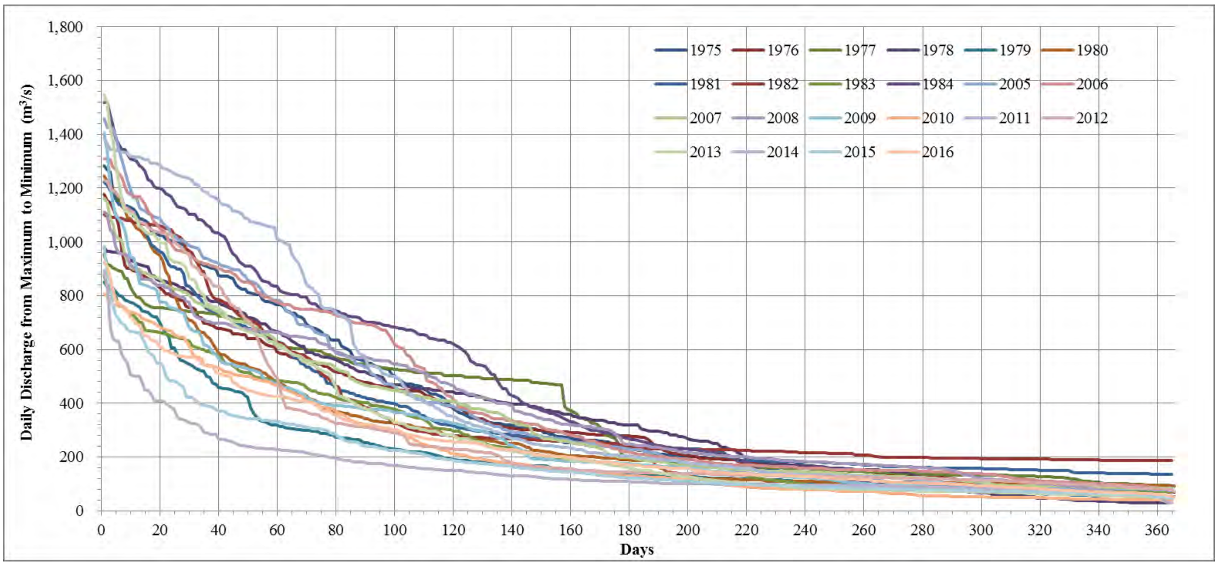
Source: JICA Study Team, DMH

Figure 6.2.17 Discharge-Duration Curve (1975-2000) at Madauk of Sittaung River

Table 6.2.10 Flow Regime (1975-2016) at Taungoo Station of Sittaung River

Year	Annual Maximum Discharge	Plentiful Discharge	Ordinary Discharge	Low Discharge	Drought Discharge	Annual Minimum Discharge	Coefficient of River Rregime	Remarks
	1-day	95-day	185-day	275-day	355-day	365-day	Max/Min	
Average	1155.7	419.8	192.9	115.1	75.1	68.8	16.8	1975-2016
Maximum	1548.0	697.0	302.0	199.0	186.0	186.0	-	
Minimum	807.0	177.0	107.0	60.0	29.0	28.0	-	

Source: JICA Study Team, DMH



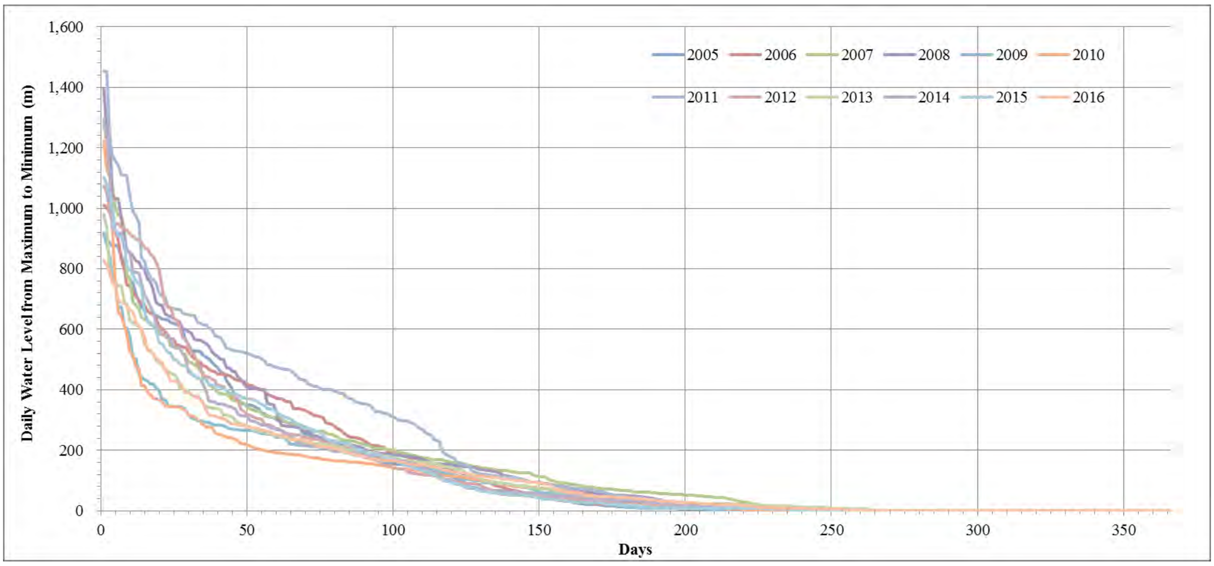
Source: JICA Study Team, DMH

Figure 6.2.18 Discharge-Duration Curve (1975-2016) at Taungoo of Sittaung River

Table 6.2.11 Flow Regime (2005-2016) at Bago Station of Bago River

Year	Annual Maximum Discharge	Plentiful Discharge	Ordinary Discharge	Low Discharge	Drought Discharge	Annual Minimum Discharge	Coefficient of River Rregime	Remarks
	1-day	95-day	185-day	275-day	355-day	365-day	Max/Min	
Average	1123.0	192.8	28.8	-	-	-	∞	2005-2016
Maximum	1455.0	327.0	62.0	-	-	-	-	
Minimum	829.0	150.0	9.0	-	-	-	-	

Source: JICA Study Team, DMH



Source: JICA Study Team, DMH

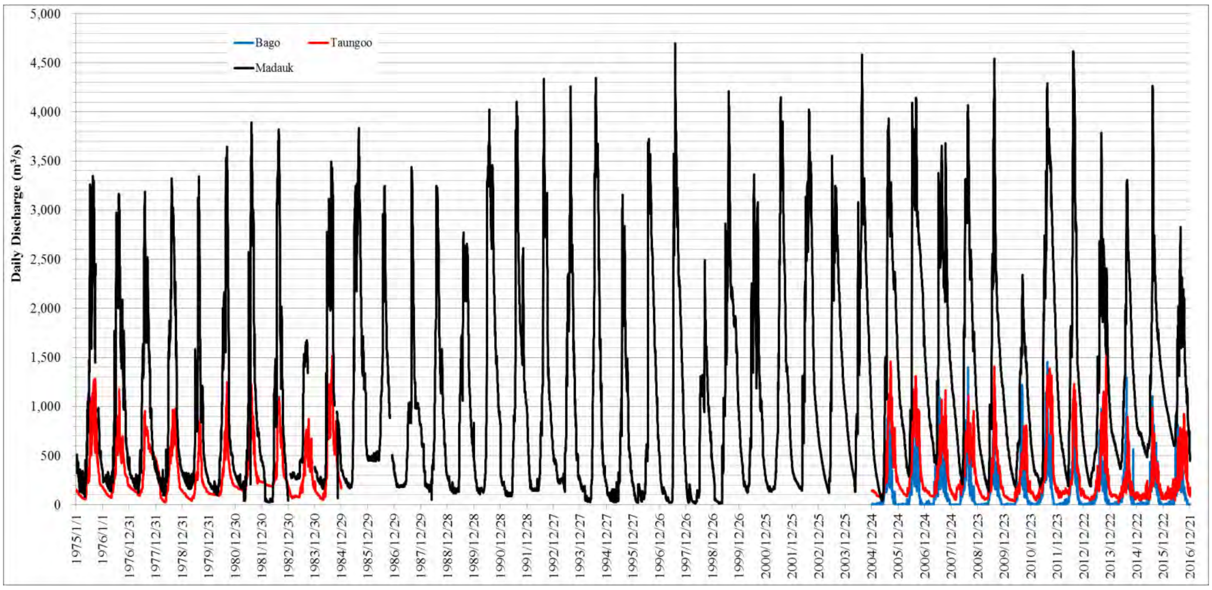
Figure 6.2.19 Discharge-Duration Curve (2005-2016) at Bago of Bago River

4) **Yearly, Monthly and Daily Flow Pattern**

The mean daily flow patterns from the data collected at the 2 rivers' 3 gauging stations are shown in Figure 6.2.20. Also, the monthly mean flow patterns and specific discharge (unit discharge per drainage area) from them are shown in Figure 6.2.21. The peak discharge occurs in around August. The unit discharge per drainage area increases in the order of Bago>Madauk>Taungoo, and they are related to its rainfall distribution and river topographic shape.

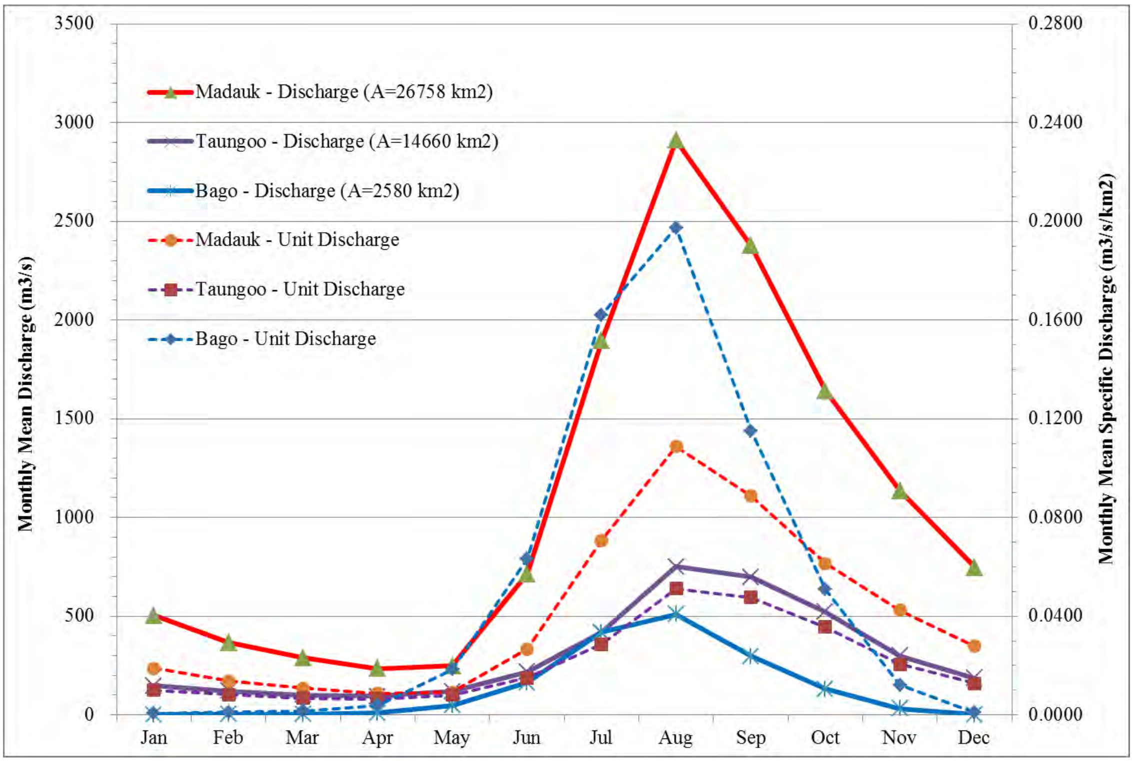
Figure 6.2.22 shows the fluctuation of annual maximum discharge at 3 stations during past 42 (47) years. The historical maximum discharge occurred in 2011 at Bago, in 2013 at Taungoo and in 1997 at Madauk. The monthly mean discharge in dry-season (Jan-Apr) at Madauk trends toward an increase in recent years, as shown in Figure 6.2.23.

Figure 6.2.24 shows the monthly mean sediment discharge. The sediment discharge, namely, the erosion amount from the watershed is related to runoff size. And Figure 6.2.25 shows an increase trend as with the discharge in recent years, and it signals that the land degradation is progressed by the land development.



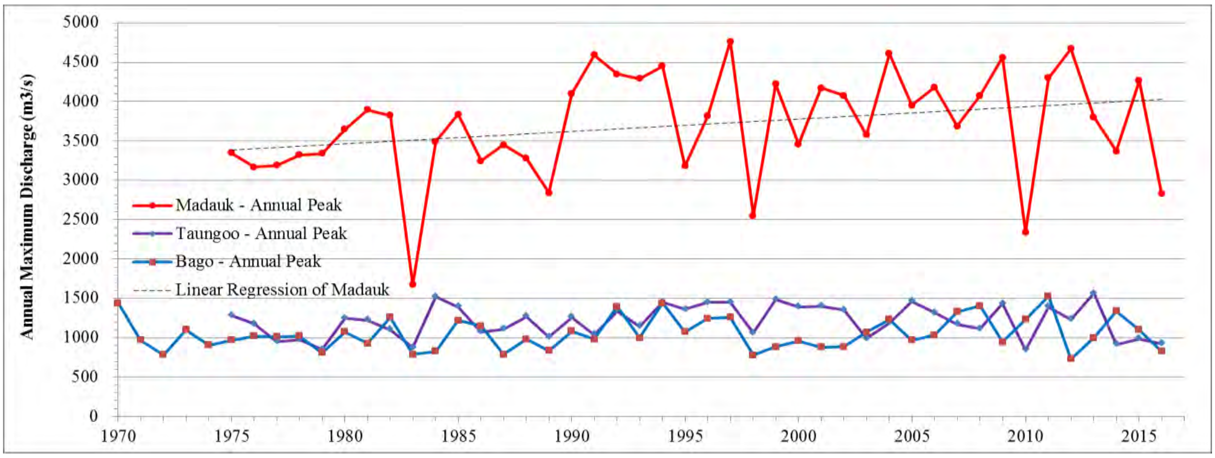
Source: JICA Study Team, DMH

Figure 6.2.20 Daily Flow Pattern at 2 Rivers (Madauk, Taungoo, Bago)



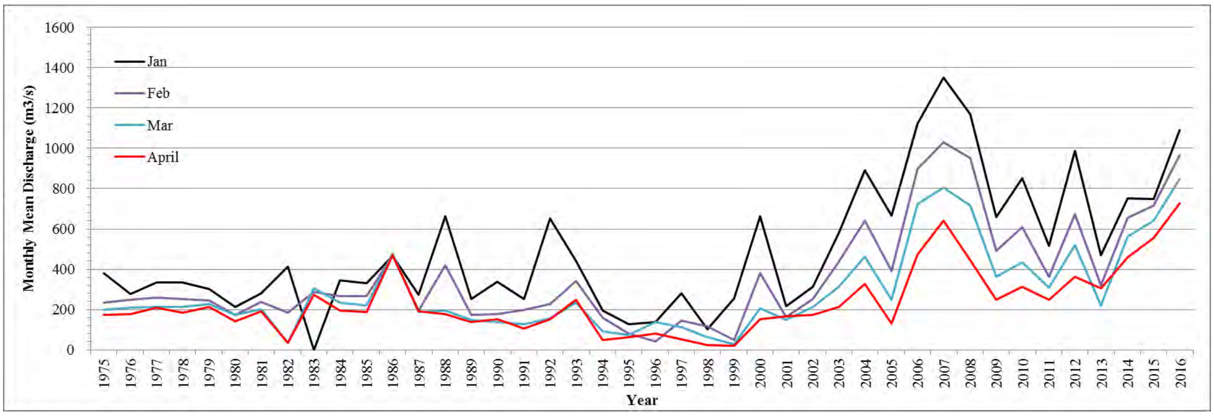
Source: JICA Study Team, DMH

Figure 6.2.21 Monthly Mean Flow and Specific Discharge Pattern at 2 Rivers (Madauk, Taungoo, Bago)



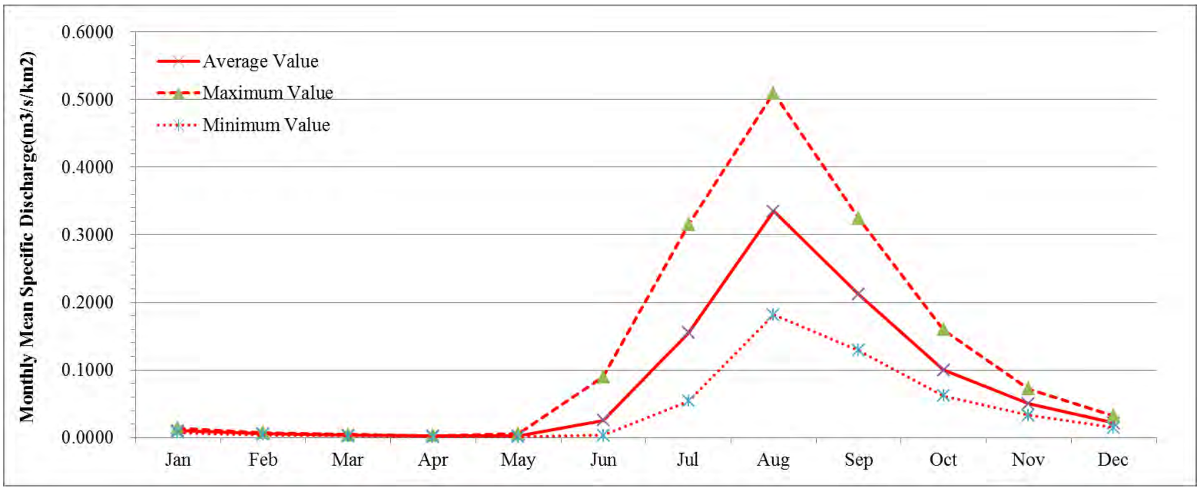
Source: JICA Study Team, DMH

Figure 6.2.22 Fluctuation of Annual Maximum Discharge at 2 Rivers (Madauk, Taungoo, Bago)



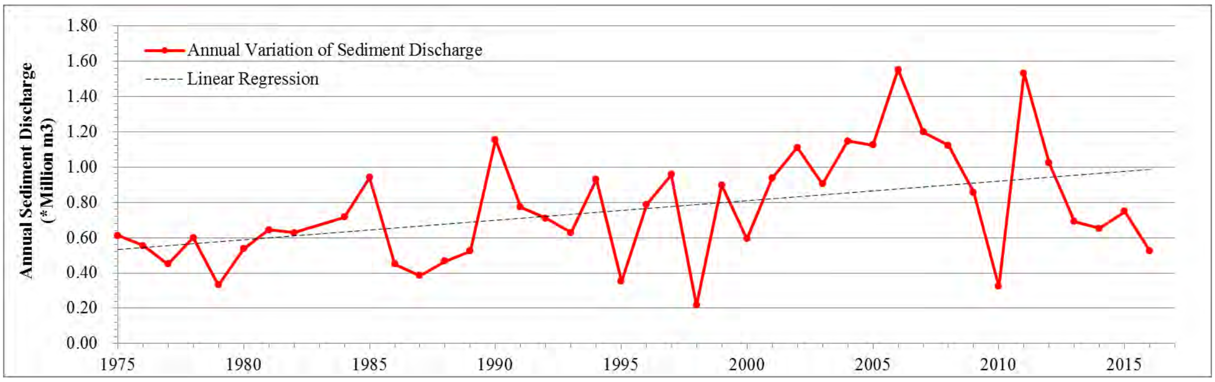
Source: JICA Study Team, DMH

Figure 6.2.23 Annual Variation of Flow-Rate in Dry Season at Madauk Station



Source: JICA Study Team, DMH

Figure 6.2.24 Monthly Mean Sediment Discharge at Madauk Station



Source: JICA Study Team, DMH

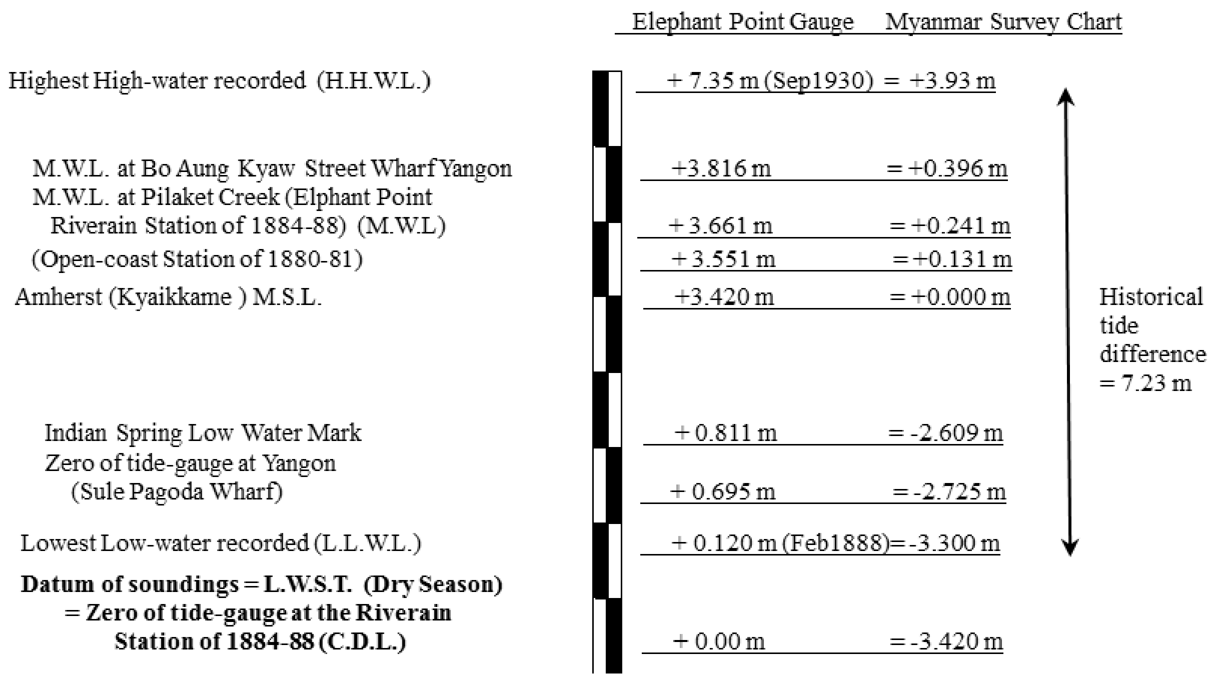
Figure 6.2.25 Fluctuation of Annual Sediment Discharge at Madauk Station

(2) River and Tidal Levels

1) Tide, Storm Surge

The nearest tide-gauge station of the study area is the Mawlamyine (formerly, Moulmein) Port (located near the Andaman Sea). However, its tide chart diagram is difficult to obtain, therefore, the chart diagram at the Elephant Point as same tidal station, is shown in Figure 6.2.26. From this, the difference between historical highest and lowest tide levels is observed as 7.23m.

And, zero of Myanmar Survey Datum, namely, zero meter of topographic survey is measured based on M.W.L. (Mean Water Level) at Amherst (Kyaikkhame) tidal station. Hence, historical high-tide at Elephant Point becomes +3.93m of Myanmar Survey Datum from this Figure.



Source: MPA

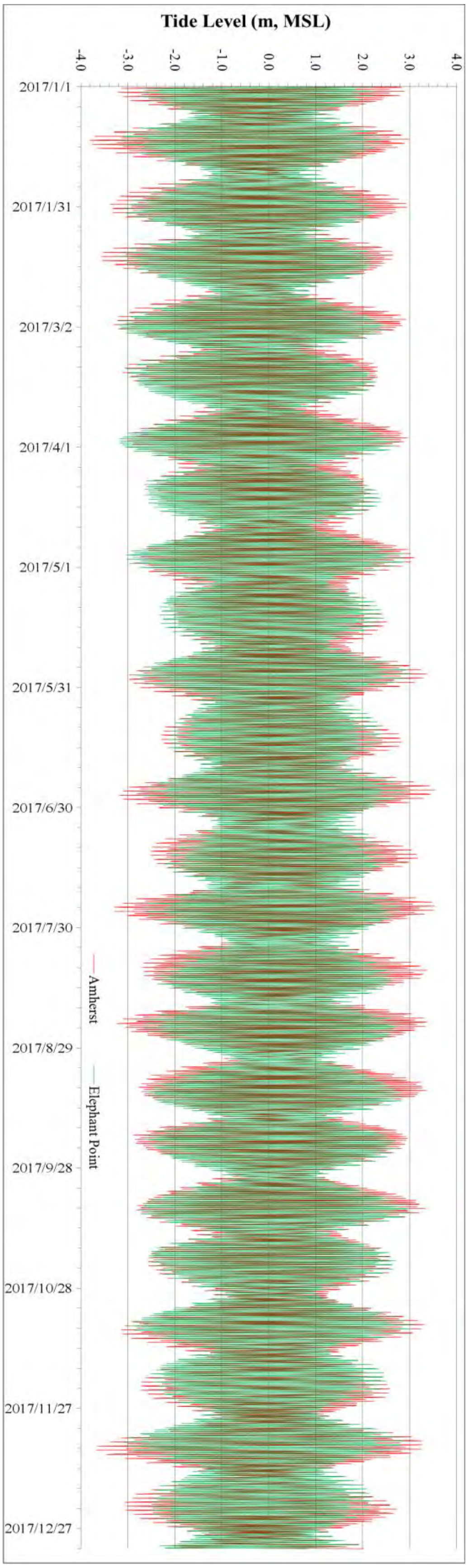
Figure 6.2.26 Tide Level of Elephant Point (Chart Diagram)

The astronomical tide levels at Amherst and Elephant-Point during 2017 are shown in Figure 6.2.27. (Elephant point is located in a very shallow region inside the Yangon River. Amherst is located in a further deeper point, and its tide amplitude is bigger.) The season of highest tide as seen in this Figure is in the rainy season. In addition to this seasonal difference, it is shown in the literature that the tide in estuary is amplified from its funnel-like estuary shape and becomes larger. Also, in reality, since the rising of water-level by the discharge from the river and the cyclone's barometric fluctuations are added to this astronomical tide, the actual water level during the rainy season is higher further as 'storm surge'. In addition, at the river-mouth of Sittaung River, the sudden increase in the water level will be additionally appeared by the influence of tidal bore.

2) **Tide Prediction**

According to the description of formal tide-table (published by MPA), the astronomical tide predictions are based on 'Harmonic Analysis' of observation data, and the predictions have been made by computer at Debra Dun (of Survey of India; SOI). However, constants of harmonic analysis are not given to the general public. Therefore, constants of Amherst and Elephant Point of past documents published on the Internet are used. The harmonic constants of 23 tidal components at both stations by SOI are shown in Figure 6.2.27. The astronomical tides at future year of 2017 and other years are calculated and predicted, by using these 23 constants. These results are useful for the work plan by ships at construction time and the downstream boundary condition for hydraulic analyses.

Location	Amherst			Elephant Point		
Latitude	16 °	5'	16.08333	16 °	29'	16.48333
Longitude	97 °	34'	97.56667	96 °	18'	96.30000
Z0	306.6 cm	3.066 m		366.1 cm	3.661 m	
code	Amplitude: H		Lag: g	Amplitude: H		Lag: g
記号	(cm)	(ft)	(degrees)	(cm)	(ft)	(degrees)
Sa	**23.1**	0.758	**130.0**	**25.7**	0.842	**140.0**
Ssa	**4.5**	0.149	**112.0**	**3.9**	0.129	**150.0**
Mm	**0.0**			**0.0**		
MSf	**0.0**			**0.0**		
Mf	**0.0**			**0.0**		
2Q1	0.0			0.0		
σ1	0.0			0.0		
Q1	**1.2**	0.039	**332.0**	**0.8**	0.026	**342.0**
ρ1	**0.0**			**0.0**		
O1	**9.8**	0.323	**336.0**	**9.8**	0.323	**0.0**
MP1	**0.0**			**0.0**		
M1	**0.0**			**0.0**		
χ1	0.0			0.0		
π1	**0.0**			**0.0**		
P1	**5.8**	0.191	**352.0**	**5.9**	0.193	**31.0**
S1	**5.4**	0.176	**133.0**	**0.2**	0.006	**115.0**
K1	**21.6**	0.709	**4.0**	**22.7**	0.746	**20.0**
ψ1	**0.0**			**0.0**		
φ1	**0.0**			**0.0**		
θ1	0.0			0.0		
J1	**1.6**	0.053	**45.0**	**0.9**	0.030	**92.0**
SO1	**0.0**			**0.0**		
OO1	**0.0**			**0.0**		
OQ2	0.0			0.0		
MNS2	0.0			0.0		
2N2	**7.5**	0.245	**20.0**	**5.4**	0.178	**48.0**
μ2	**8.7**	0.285	**285.0**	**10.9**	0.358	**281.0**
N2	**39.1**	1.284	**42.0**	**33.9**	1.111	**80.0**
ν2	**10.3**	0.339	**40.0**	**8.2**	0.269	**88.0**
OP2	**0.0**			**0.0**		
M2	**192.6**	6.320	**60.0**	**179.9**	5.902	**99.0**
MKS2	0.0			0.0		
λ2	**0.0**			**0.0**		
L2	**9.8**	0.321	**94.0**	**12.0**	0.395	**126.0**
T2	**12.9**	0.422	**169.0**	**7.0**	0.230	**141.0**
S2	**82.5**	2.708	**102.0**	**72.6**	2.381	**142.0**
R2	**0.0**			**0.0**		
K2	**30.1**	0.987	**6.0**	**22.9**	0.752	**140.0**
MSN2	0.0			0.0		
KJ2	0.0			0.0		
2SM2	**5.0**	0.164	**10.0**	**4.1**	0.136	**47.0**
MO3	**1.6**	0.051	**301.0**	**2.0**	0.064	**343.0**
M3	**0.0**			**0.0**		
SO3	0.0			0.0		
MK3	**2.8**	0.091	**328.0**	**2.8**	0.092	**24.0**
SK3	**0.0**			**0.0**		
MN4	6.5	0.214	193.0	5.8	0.191	54.0
M4	**9.9**	0.324	**30.0**	**8.6**	0.281	**80.0**
SN4	0.0			0.0		
MS4	**9.7**	0.318	**68.0**	**8.9**	0.291	**125.0**
MK4	0.0			0.0		
S4	0.0			0.0		
SK4	0.0			0.0		
2MN6	0.0			0.0		
M6	**0.0**			**0.0**		
MSN6	0.0			0.0		
2MS6	**0.0**			**0.0**		
2MK6	0.0			0.0		
2SM6	0.0			0.0		
MSK6	0.0			0.0		



Source: JICA Study Team, "Technical Report Part 3 Geodetic Work (1952), Survey of India"

Figure 6.2.27 Harmonic Constants and Astronomical Tide Forecast at 2017

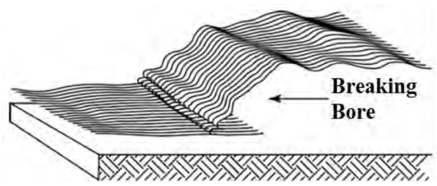
3) **Tidal Bore**

A tidal bore is a tidal phenomenon in which the leading edge of the rising-tide forms waves of water that travels up a river or narrow bay against the direction of the river or bay's tidal-current.

The tidal bore occurs usually in areas with a large tidal range (typically more than 6m between high and low water), and it occurs in where flood-tides are funneled into a shallow, narrowing river via a broad bay. The funnel-like shape not only increases the tidal range, but it can also decrease the duration of the flood-tide, down to the point where the flood appears as a sudden increase in the water level. A tidal bore takes place during the flood-tide and it never occurs during the ebb-tide. According to the interview survey to residents at the existing Sittaung Bridge (at Mokepalin), the tidal bore occurs twice per month, and the past maximum wave-height of the tidal bore has been witnessed as the height of around 2m.

A tidal bore may be defined generally as 2 forms, and they are called the “Breaking bore" and the “Undular bore". A breaking bore occurs when the Froude number is larger than 1.7-1.8, while an undular bore occurs for smaller Froude numbers. The breaking bore has a single breaking wave-front with a roller – somewhat like a hydraulic jump. The undular bore comprises a smooth wave-front followed by a train of secondary waves. The most important factors for the formation of a tidal bore are the tidal range, freshwater discharge, estuary geometry and the channel bathymetry. According to the literature, the tidal bore starts near Zawtika Village and then propagates to near Kyaik Ka Thar Village as the breaking bore, and it never passes through the Kyaik Ka Thar upstream. After that, a tidal bore as undular bore propagates to the upstream beyond the existing Mokepalin Bridge. (Quoted from “The Tidal Bore in the Sittaung River - A Sensitivity of the propagation”, M.P. de Ridder, 2017, TU Delft, Netherlands.)

According to the interview to local peoples, the water energy of the tidal-bore around proposed bridge location is dissipated in recent years together with major-scale riverbank erosion expand at estuary area and a large amount of sedimentation to river-bed at downstream area of Kyaik Ka Thar village. And it is estimated that a magnitude of tidal-bore diminished in size a little.



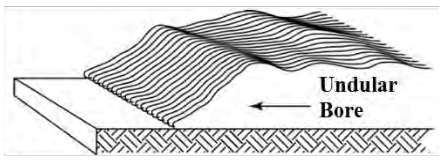
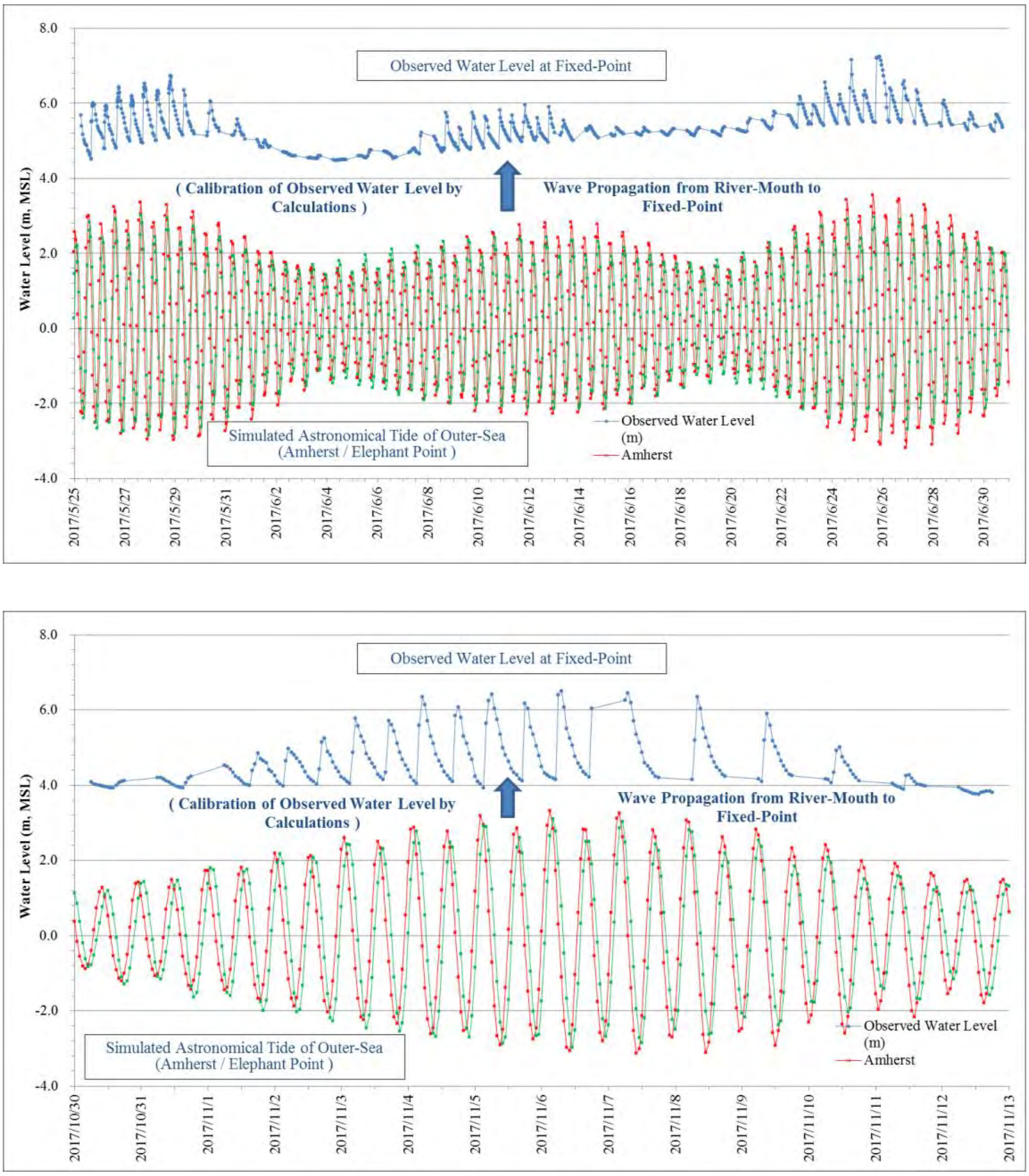


Figure 6.2.28 Types of Tidal Bore

The water level and flow velocity for a fixed period at a fixed point near the proposed bridge are observed, and performed by fixed point observation, with the aim of calibrating the tidal amplitude of the outer sea and the observed water levels, by the hydraulic analysis. Observation intervals was once every other hour among 24 hours during the spring tide period and 12 hours during the neap tide period. Total observation period is 25 May to 30 June and 30 October to 12 November. Observation results for water levels and velocities at fixed-point are shown in Figure 6.2.29 and Figure 6.2.30. In the duration of the spring tide among a tidal cycle, the tidal bore instantly arrives and the water level rise to the peak, after the water level declined due to the falling tide. After that, it continues to decline until the next tidal bore. (In the observation record, the maximum water level rise rate was

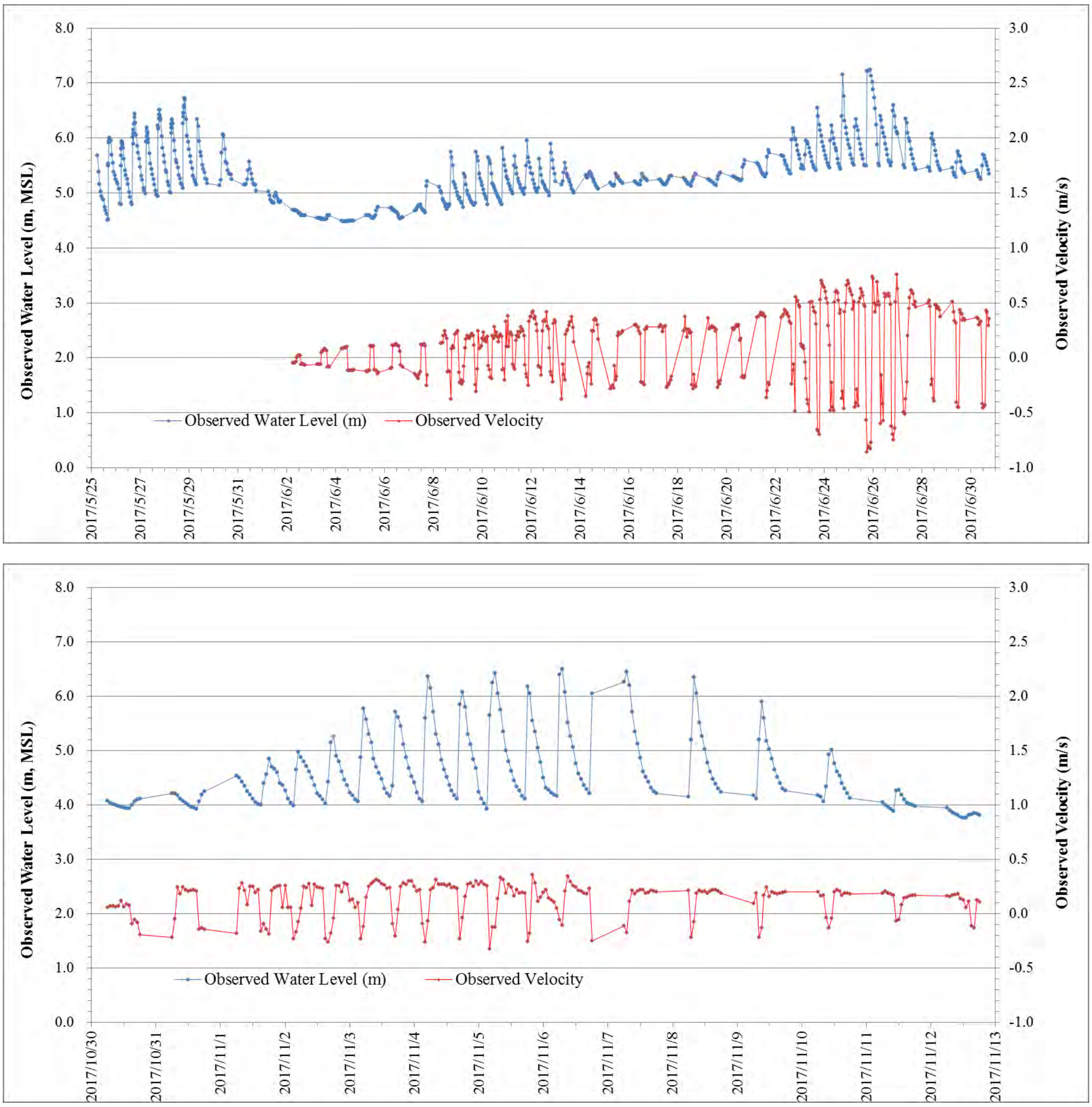
29.02 m/hour, which means that there was a water level rise of 1m in roughly 2 minutes.) In the duration of the neap-tide, the significant water-level fluctuation as above mentioned does not occur. Also, since the location at velocity observation is nearly the river bank side, it is a small value, and although it is not representative of the mean velocity for the overall river cross section, it can assess trends in time-series change of velocity.

In addition, the video pictures of tidal bore shoots for verifying actual phenomena at several points on site. Also, past video pictures are collected from ID and local peoples, etc. The shooting spots are 8 locations including past video shooting spots, as shown in Figure 6.2.31. The run-up speed of the tidal bore obtained from the bore observation at several points on sites is shown in Table 6.2.12. The actual run-up speed of tidal bore approximates the theoretical run-up speed of the tsunami with having water depth of 2-3m.



Source: JICA Study Team

Figure 6.2.29 Water Levels at Fixed-Point Observation Point and Astronomical Tides



Source: JICA Study Team, Fixed point is at near left bank, the velocity is slower than deepest portion of the river.

Figure 6.2.30 Water Levels and Velocities at Fixed-Point Observation Point

Source: JICA Study Team, except for photos of “Existing Bridge of 2016/4/10", "Shan Gyaing at 2016/10/20" and "Breaking Bore at unknown location (from YouTube)".

Figure 6.2.31 Video Shooting Locations of Tidal Bore

Table 6.2.12 Runup Speed (Propagation Velocity) from Video Shooting Results

< Observed Propagation Velocity >

Bore Event		Reach	v (m/s)	Reach	v (m/s)	Reach	v (m/s)
2017/5/25	evening Bore	A to C	4.88	C to E	4.64		
2017/5/26	evening Bore	B to C	5.00	C to D	4.21	D to F	5.04
2017/5/27	evening Bore	D to F	5.36				

< Tsunamic Propagation ; theoretical formula >

Water Depth (m)	0.5	1	2	3	4	5	10	Remarks
Propagation Velocity (m/s)	2.21	3.13	4.43	5.42	6.26	7.00	9.90	
Propagation Velocity (km/hr)	8	11	16	20	23	25	36	

$$= \sqrt{g \times (h + a)}$$

where, C: Propagation Velocity
g: Acceleration of gravity
h: Depth
a: Wave height

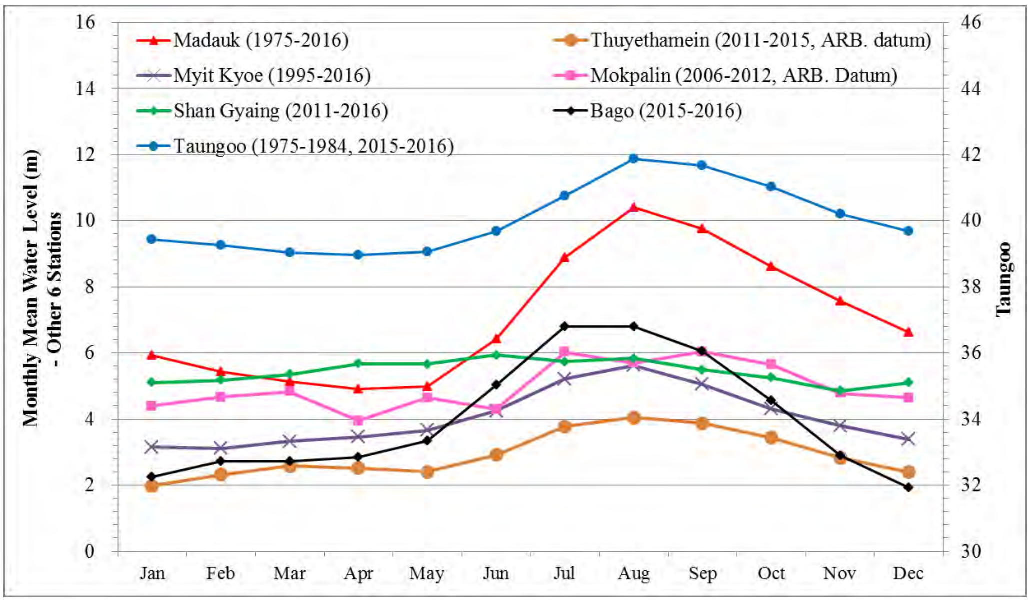
Source: JICA Study Team

4) **Water Levels of Related Rivers**

The monthly mean water levels at DMH's 3 gauging stations and ID's 4 stations are shown in Figure 6.2.32[2].

And Figure 6.2.33 shows the fluctuation of annual maximum water levels at 4 stations among of them. Also, the daily maximum water levels during 2-5 years at 4 gauging stations of ID are shown in Figure 6.2.34.

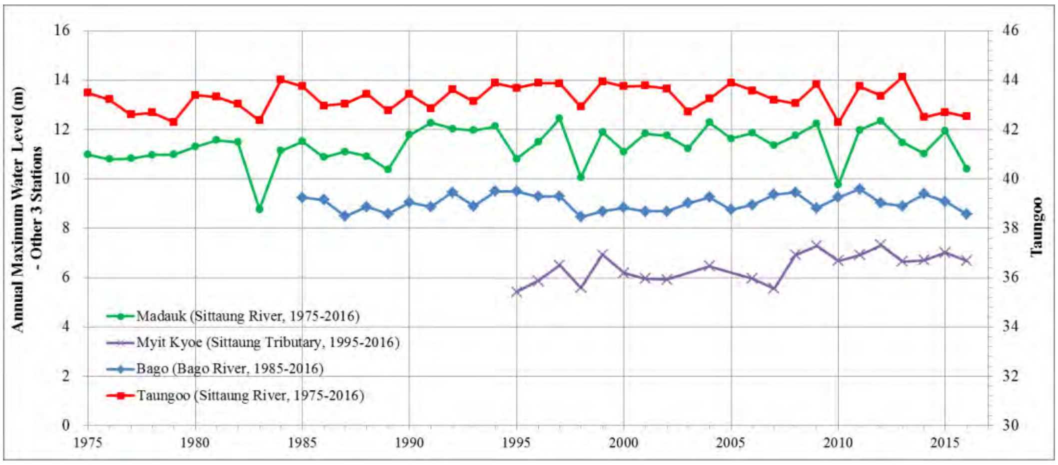
Although the daily and monthly pattern shows almost same trend as the discharge pattern, the stations closer to the estuary is affected by the tide. These fluctuations of water levels causes by the tidal cycle between the spring- and neap-tides. At any rate, the water levels of these stations are measured every day on-time, and the instantaneous rise in water level cannot grasp.



Source: JICA Study Team, DMH, ID

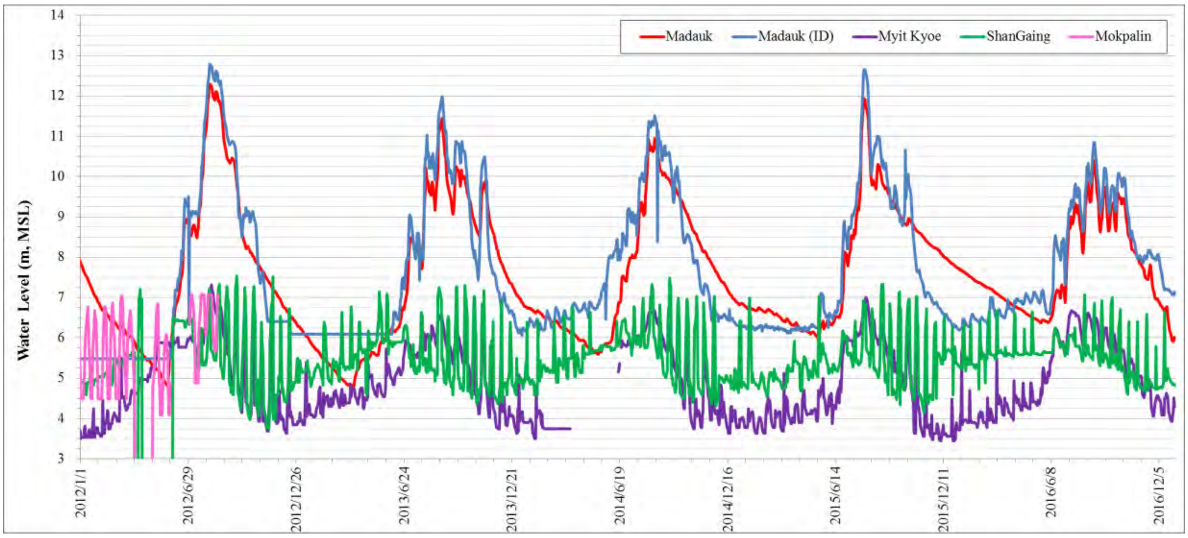
Figure 6.2.32 Monthly Mean Water Level at Related Rivers (Madauk, Taungoo, Bago)

[2] The datum of Thuyethamein and Mokepalin Stations of ID is arbitrary datum, the elevation value is just used as reference. The fundamental bench mark of Myit Kyoe and Shan Gyaing Stations of ID was re-measured as Myanmar MSL datum in this survey. Since there is a large volume of sediment in front of Shan Gyaing Gate station, the low-water level becomes high and the difference in water level is small.



Source: JICA Study Team, DMH, ID

Figure 6.2.33 Fluctuation of Annual Maximum Water Level at Related Rivers



Source: JICA Study Team, DMH, ID

Figure 6.2.34 Daily Water Levels at Related Rivers (2012-2016)

5) **Flood Conditions**

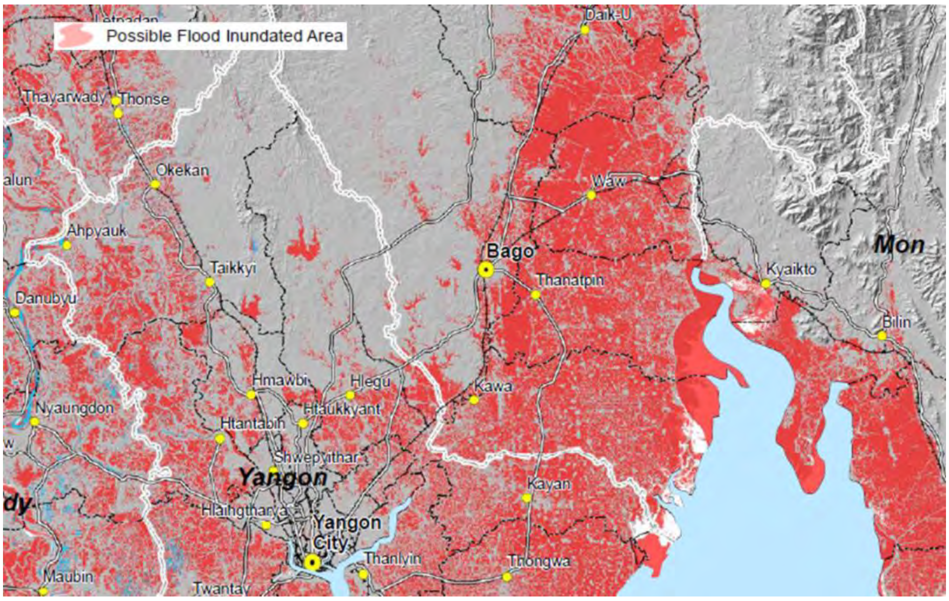
According to "Hazard Profile of Myanmar, 2009", flooding has always been one of the major hazards in Myanmar, accounting for 11% of all disasters, second only to fire. Floods around the targeted area can be classified into three types:

- Riverine floods in the river delta or the lowland;
- Localized floods in urban area due to a combination of factors, such as cloudburst, saturated soil, poor infiltration rates and inadequate or poorly built infrastructure (such as blocked drains);
- Flooding due to storm surge in the coastal areas.

In Sittaung riverine systems, floods are caused by rainfall associated with low-pressure waves (the remnants of typhoons and tropical storms of South China Sea) moving from east to west. Riverine floods are most common among all, and they happen when the monsoon troughs or low-pressure waves or storm-surges superimposes on the general monsoon pattern resulting in intense rainfall over lowlands of the river catchment areas. "Cyclone

Nargis" of 2008 was caused serious damage to this area.

According to DMH reference, the flood frequency during 1966-2009 along the Sittaung River is 88 events in 44 years at Madauk of Sittaung River. Figure 6.2.35 shows the flood hazard map by MIMU, it is suggested that the most of the target area is a flood-prone area.



Source: MIMU (Myanmar Information Management Unit)

Figure 6.2.35 Hazard Map around Sittaung River Estuary

6.2.5 Riverbank Stability at Proposed Bridge Site

(1) Methodology

River bank erosion and deposition is generally caused by factors such as river channel morphology, river-bank /-bed constituent material, riverbank topography, vegetation type / condition, seepage flow condition, flow rate fluctuation, sediment supply, etc., and it has been changing in a sudden or short term, or in a long term in case of meandering motion. On the other hand, the formation of the natural flow channel also has a great influence by artificial flood control facilities (structures).

In this section, historical satellite images have been utilized to evaluate the characteristic features of channel shifting, and the river bank erosion estimates by tracing the history of past installations of flood control structures and past changes of river-course. As satellite images at different times are available for the study reach, and the analysis of the stability of the study river reach using satellite images and past topographic maps is presented.

The description of following clauses is same as Chapter 5.

(2) Past River Channel Shifting

1) Comparison of the Corridor A to C

Firstly, as for the alignments of New Sittaung Bridge, three alternatives were considered as the Corridor A, B and C (See Figure 6.2.36.) as described in Chapter 5.

The planform analysis of the proposed bridge was conducted using Landsat Thematic Mapper (TM) images, Goggle Earth images and old topographic maps. Thirteen (13) images of the years 1973, 1980, 1989, 1996, 2000, 2004, 2006, 2010, 2011, 2012, 2013, 2014 and 2016 were used for the analysis. The change in planform over the 44 year period is shown in Figure 6.2.36, and a zoomed view around Corridor B site is shown in Figure 6.2.37. Also, the past river course of 1942 are shown in Figure 6.2.38 from topographic maps of the SOI (Survey of India). It can be seen in Figure 6.2.39 that the river reach has experienced significant erosion or deposition over the last 44 years.

Table 6.2.13 shows the general comparison for hydrological issues at Corridor A to C. From this, locations near Corridor A and B are recommendable as new bridge location. (The riverbank of Corridor B is stable even without existing guide bank.)

Table 6.2.13 Comparison of Hydrological Issues at Corridor A to C

Items	Corridor A	Corridor B	Corridor C
Existing Condition	- Guide bank built in 1907. - It is old, the renovation will be desirable.	Natural bank	Natural bank
Distance from River-mouth	73.3 (km)	66.5 (km)	59.2 (km)
Type of Tidal Bore	Undular Bore	Undular Bore	Breaking Bore
Magnitude of Wave Power	Slightly large	Slightly large more than Corridor A	Very large
Riverbank Stability / Influence for erosion	- Relatively Stable, due to recent sedimentation, - It recognized a few erosion in the past.	- Relatively Stable, due to recent sedimentation, - It recognized a few erosion in the past.	- Unstable, - It experienced large scale erosion in the past.
Evaluation	- Recommendable, - Renovation of exiting guide bank will need.	- Recommendable, - New guide bank will need.	- Not Recommendable for the future.

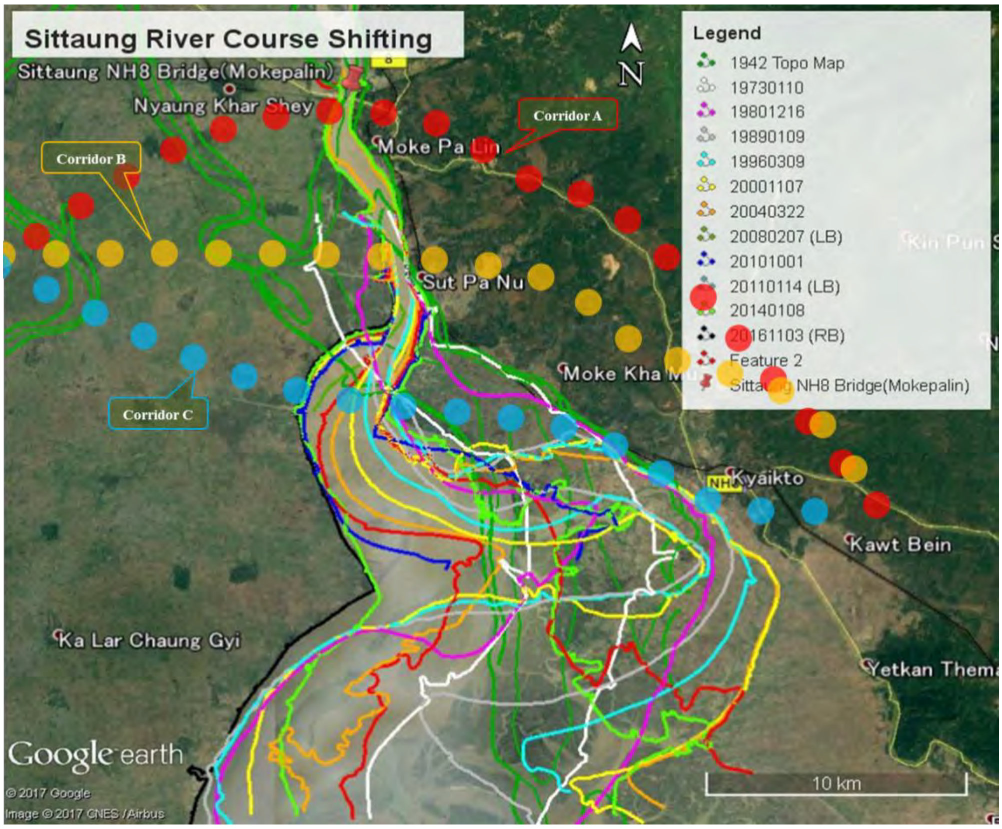
Source: JICA Study Team

2) **Comparison of the Alignment A to D within the Corridor B**

Secondly, within certain range of the Corridor B, four alternatives were considered as the A to D. (See Figure 6.2.37.)

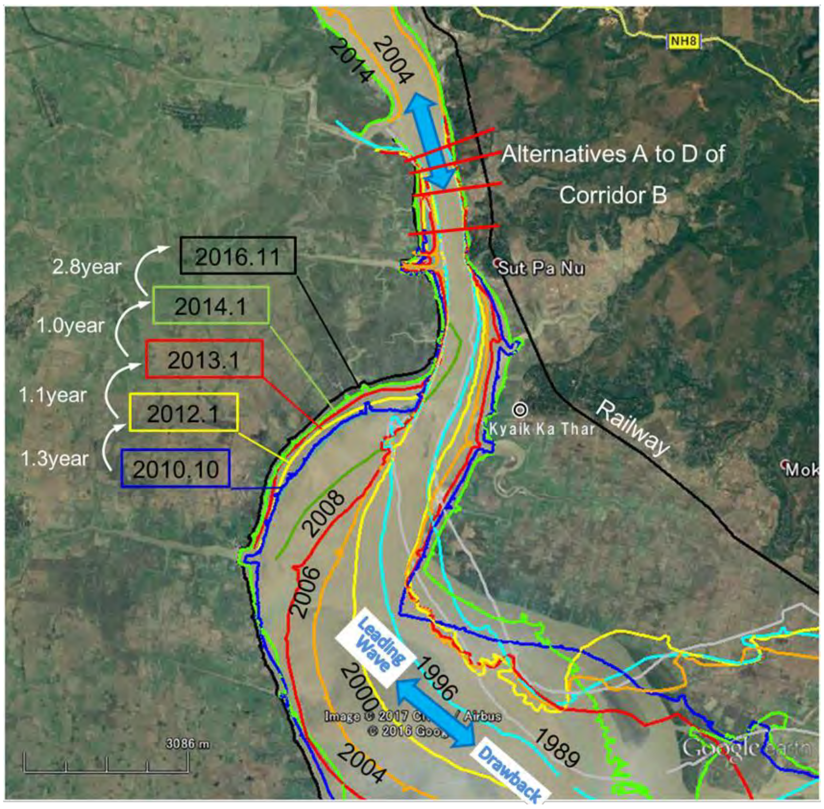
From Figure 6.2.37, the slightly large changes can be seen in the right bank side at the alignment of Alternative C and D. Alternative A and B is relatively stable. And the left riverbank sides at all Alternatives of the Corridor B are also stable.

On the other hand, the bank erosion has progressed from 1989 to 2016 at the right bank of the Corridor B downstream 1.8-3.4km. However, the erosion speed becomes somewhat dull in recent years, and it is not foreseen to develop into a serious problem in the future since the type of tidal bore will be changed from the breaking bore to the undular bore. In the literature of TU Delft (2017), it is mentioned that the tidal bore will change to the undular bore from the breaking bore at around Kyaik Ka Thar Village.



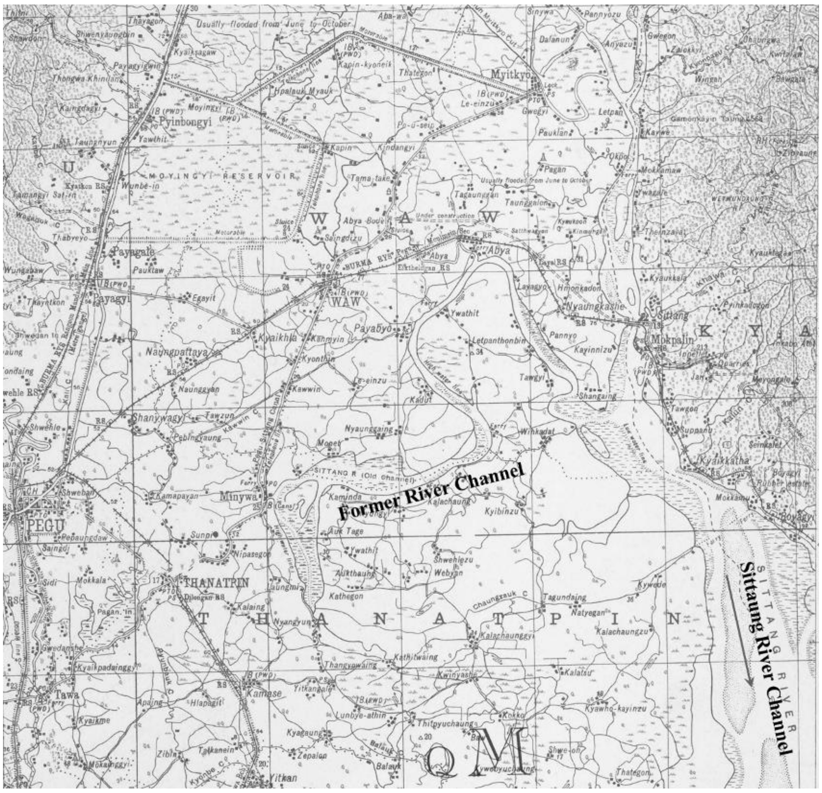
Source: JICA Study Team based on Google Earth and NASA (Landsat TM)

Figure 6.2.36 Shifting of Bank Lines around the Proposed Bridges during Past 44 years



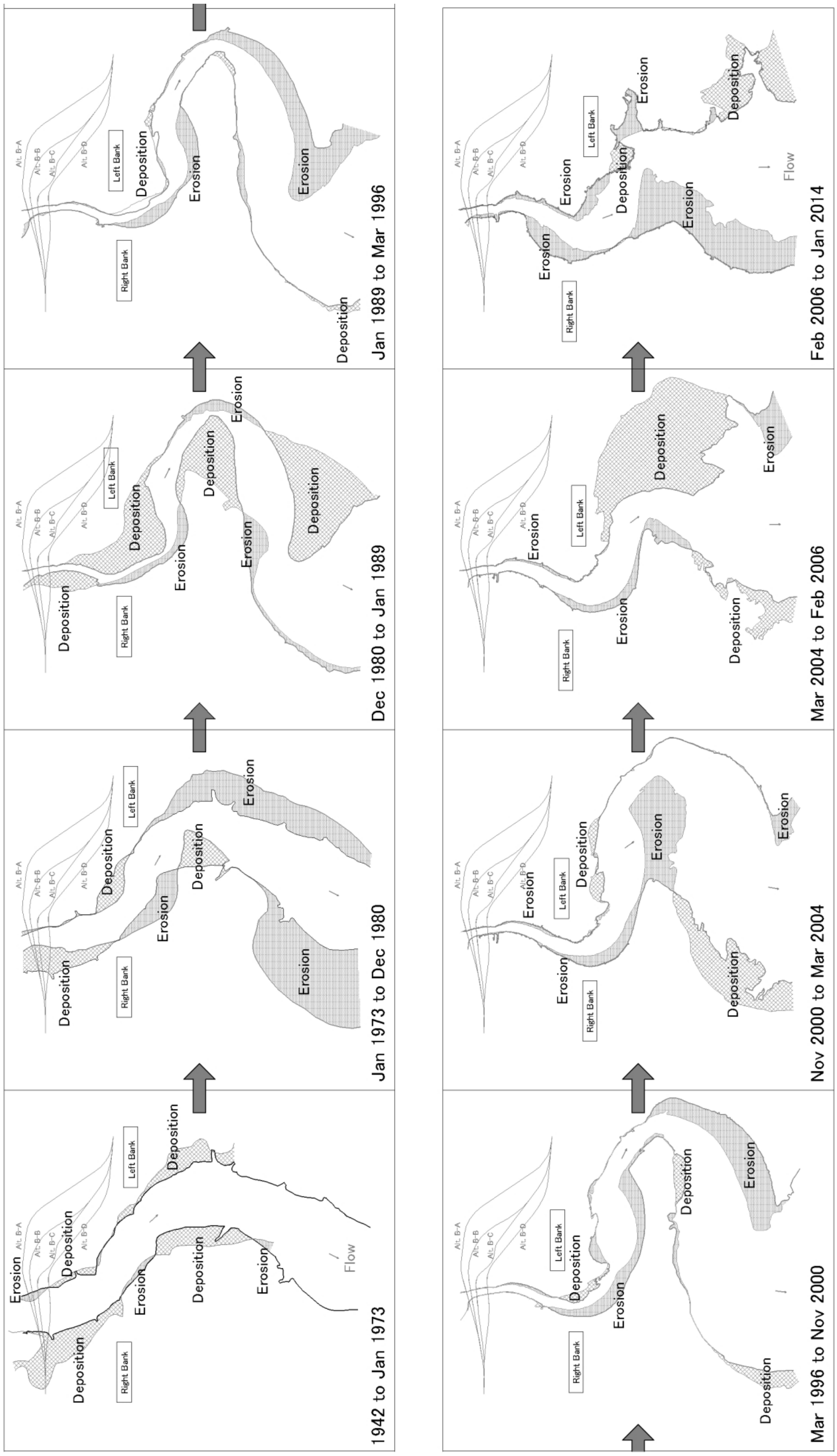
Source: JICA Study Team based on Google Earth and NASA (Landsat TM)

Figure 6.2.37 Shifting of Bank Lines around the Proposed Bridges (Corridor B)



Source: Survey of India, 1942

Figure 6.2.38 Topographic Map at 1942 (Survey of India) around Proposed Bridge



Source: JICA Study Team

Figure 6.2.39 Past Erosions and Depositions of Bank Lines around Proposed Bridge

(3) History of Past Installations of Flood Control Structures

The history of past representative flood control facilities installations in and around related basins are as shown in Table 6.2.14 and Figure 6.2.40. The construction of the main water structures on the right bank side of the Sittaung River in Corridor A and B is very old, 140 years have passed. The main land on the right bank side has been dried up over 100 years, and the vestige of old Sittaung River course have gone presently. For this instance, the construction of the above main facilities and the improvement of irrigation facilities are greatly related. The chronological changes for these main water facilities and river morphology are shown in Table 6.2.15, the inventory of present water infrastructures is shown in Table 6.2.16, and the trend of reservoir and dam is shown in Figure 6.2.41.

On the right bank side and/or upstream area of Sittaung River, many dams, reservoirs and dikes have been constructed since the 1990s, and the flood protection function is enhanced by leaps and bounds in recent years. Also, many sluice gates have been constructed for preventing the salinity intrusion to main farmland, and then, drainage channels have been dried up during dry season and sediments tends to accumulate to the channel bottom.

(4) Recommendation from Hydrological / Hydraulic Point of View

Considering the fact of which the current riverbank of Corridor-B has not moved much over the last 30 years and the abovementioned history of water structures, it is estimated that the erosion of right bank side like before 1980 will not progress so significantly. Therefore, alignments of Corridor A and B are recommended.

However, notwithstanding above the recommendation, the long-term prediction of erosion and deposition may be difficult realistically. (Although the key factor of erosion/deposition can estimate as day-to-day active tidal-flow and semimonthly tidal bore, the numerical analysis or modeling of tidal bore will have difficulty.) Hence, the protection works to the river bank erosion by the tidal-bore and tidal-motion, should be installed as safeguard facilities. This is proved from the fact that the erosion nearby the existing Sittaung Bridge has been controlled over 110 years by the guide bank even if it is not so robust.

For the selection of eligible alignment within Corridor-B, the alternative A and B should be recommended from the point of view of hydrological assessment.

Table 6.2.14 History of Representative Flood Control Facilities

Facilities		Construction Year	Renovation Year	Purpose
1	Sittaung-Bago Canal	1878	2014	Water traffic, Irrigation / Flood Control
2	Moe Yin Gyi Reservoir		2006	Irrigation
3	Pankai Embankment		1978, 2011	Flood Control
4	Bago River Embankment	1878	-	Flood Control
5	(Railway from Rangoon to Toungoo)	1884	-	(Railway Embankment)
6	(Railway from Pegu to Moulmein)	1907	-	(Railway Embankment)
7	Sittaung River Railway Bridge Guide Bank	1907	-	Protection for Riverbank

Source: JICA Study Team

Table 6.2.15 Chronological Change of Water Facilities and River

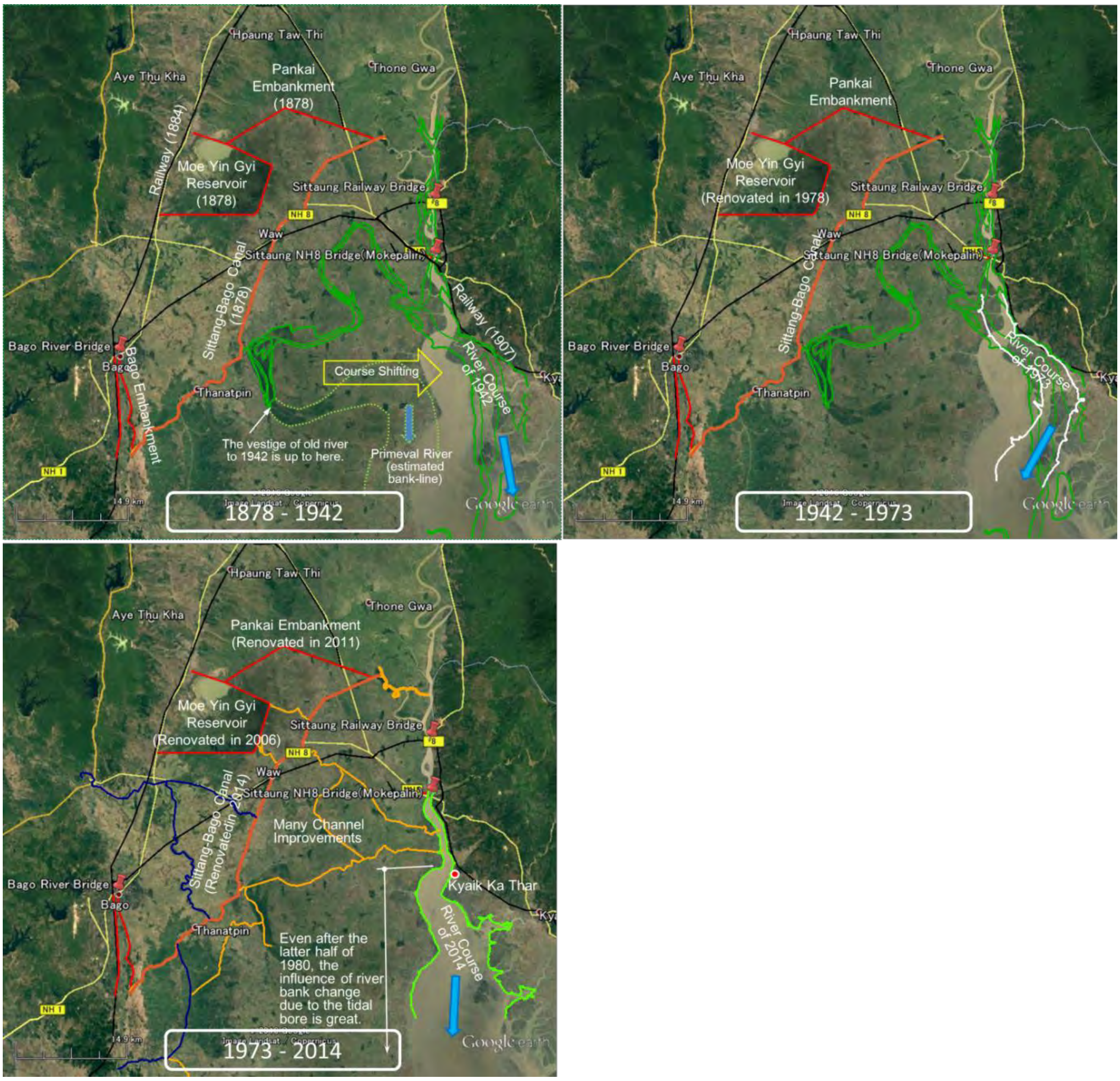
<table>
<tr><th>Time</th><th>1840</th><th>1860</th><th>1880</th><th>1900</th><th>1920</th><th>1940</th><th>1960</th><th>1980</th><th>2000</th><th>2020</th></tr>
<tr><td>Infrastructures</td><td></td><td>1878
Sittaung-Bago
Canal / Dike /
Reservoir ----------------------------------</td><td></td><td>1907
Railway Bridge
Guide Bank</td><td></td><td></td><td>1976
Yezin Dam (1) --------------> (18 dams)
---> (26 reservoirs)
13 reservoirs and 1 dam is situated in the Bago River,
13 reservoirs and 17 dams in Sittaung River.</td><td></td><td></td><td></td></tr>
<tr><td>Change in Upstream Area and Floodplain</td><td>Primitivism
(Flood-plain)</td><td>|--></td><td>Flood Reduction
from Bago /
Sittaung</td><td>-- (Right Bank landed gradually.) --></td><td></td><td></td><td>Irrigation/Drainage Channel
Improvement
Gate / Tide-Embankment Improvement</td><td></td><td></td><td></td></tr>
<tr><td>Flow Regime</td><td>Frequent
Occurrence of
Flood</td><td>|--></td><td></td><td></td><td></td><td></td><td>To Leveling of Annual Maximum Flood</td><td></td><td></td><td></td></tr>
<tr><td>Sediment Runoff</td><td></td><td>|--></td><td></td><td></td><td></td><td></td><td>Coarse Particle Size decreases, and the
Fine Sand becomes dominant.</td><td></td><td></td><td></td></tr>
<tr><td>River Channel Alignment</td><td>Free Meander</td><td>---------- (Tendency to stabilize with straight line.) ----------></td><td></td><td></td><td></td><td></td><td>Right bank stabilized.</td><td></td><td></td><td></td></tr>
<tr><td>Stability of Corridor-A</td><td>At the time it was
low.</td><td>|---></td><td></td><td></td><td></td><td></td><td>High, but the guide bank is aging</td><td></td><td></td><td></td></tr>
<tr><td>Stability of Corridor-B</td><td>At the time it was
low.</td><td>|-------(It was landed gradually with infrastructure development.) ----></td><td></td><td></td><td></td><td></td><td></td><td>Presently, High.
It is a natural river bank, but the
amount of erosion is small.</td><td></td><td></td></tr>
</table>

Source: JICA Study Team

Table 6.2.16 Present Water Infrastructures in Related Basins

Infrastructures	Sittaung River	Bago River
Dam	17	1
Dam (Proposed)	1	-
Reservoir	13	13
Gate	13	-
Gate (Proposed)	10	-
Main Channel (Irrigation / Drainage) (km)	300 or more	-
Embankment (km)	90 or more	14.0
Embankment (Proposed) (km)	(Proposed for Tide)	-

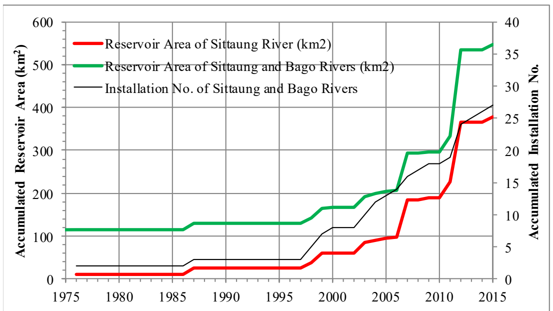
Source: JICA Study Team, Bago-Sittaung river basin analysis (https://sites.google.com/site/bagosittaungriverbasinanalysis/)

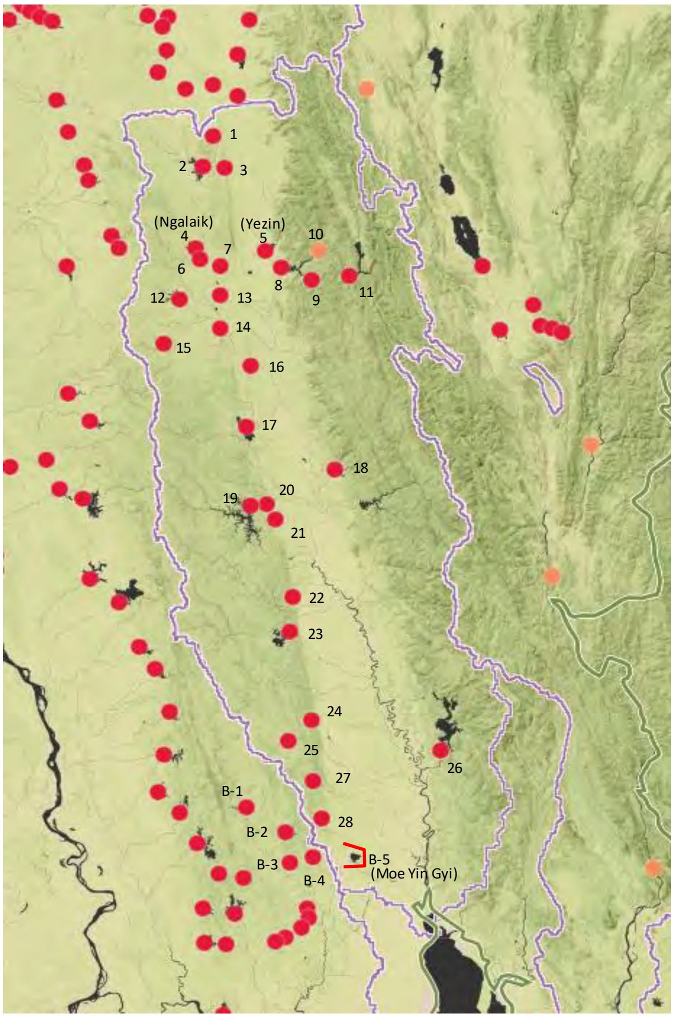


Source: JICA Study Team

Figure 6.2.40 History of Representative Flood Control Facilities and River Courses

ID		Name	Year Commissioned	Reservoir Area (km^2)	Function
Sittaung	1	Myo Hla (Tat Kon)	2006	1.88	Irrigation
	2	Sinthe	1999	16.00	Irrigation
	3	Unknown 12	(Unknown)	(Unknown)	Irrigation
	4	Ngalaik	1987	15.58	Irrigation
	5	Yezin	1976	11.25	Irrigation
	6	Unknown 11	(Unknown)	(Unknown)	Irrigation
	7	Chaungma Gyi	2003	6.00	Irrigation
	8	Lower Paungluang	2005	5.27	Multi-purpose
	9	Nancho	2014	(Unknown)	Hydropower
	10	Middle Paungluang (Planned)	Planned	(Unknown)	Hydropower
	11	Upper Paungluang	2015	12.62	Hydropower
	12	Chaungma Nge	2007	12.74	Irrigation
	13	Yan Aung Myin	2004	3.36	Irrigation
	14	Unknown 8	(Unknown)	(Unknown)	Irrigation
	15	Madan	2009	4.50	Irrigation
	16	Phyu	2012	59.00	Irrigation
	17	Thailand Mo	2004	2.34	Irrigation
	18	Thailandukyegat II	2013	(Unknown)	Hydropower
	19	Kabaung	2008	(Unknown)	Hydropower
	20	Unknown 4	(Unknown)	(Unknown)	Irrigation
	21	Yetho	1998	5.67	(Unknown)
	22	Nganwe	1998	6.28	Irrigation
	23	Kun	2012	80.00	Hydropower
	24	Yenwe	2007	74.00	Hydropower
	25	Baing Dar	(Unknown)	62.00	Irrigation
	26	Shwegyn	2011	36.78	Hydropower
	27	Kawliya	2003	18.50	Irrigation
	28	Bawni	1999	5.67	Irrigation
Bago	1	Zaung Tu	2000	4.07	Irrigation+Hydropower
	2	Kodukwe	2012	27.00	Irrigation
	3	Shwe Laung	2012	16.00	Irrigation
	4	Salu	2012	19.00	Irrigation
	5	Moe Yin Gyi	1878, (2006)	104.00	Irrigation





Source: JICA Study Team, Dam Maps (https://wle-mekong.cgiar.org/maps/)

Figure 6.2.41 Trend of Dam (Reservoir) Construction in Sittaung and Bago River Basins

6.2.6 Hydrological Analyses

(1) Probability Floods at Gauging Stations

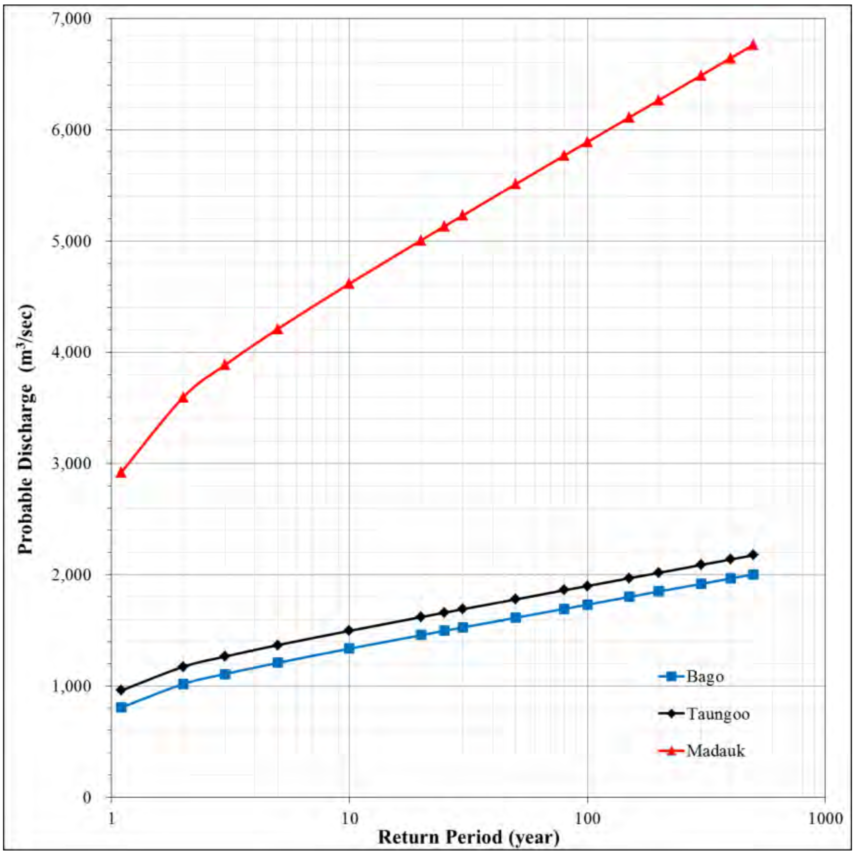
Past annual maximum discharges (extremal values) of 3 stations (Madauk, Taungoo, Bago) for the design discharge are collected. Although the Bago gauging stations are influenced by the tide, it is considered that the accuracy against flow rate in rainy season is no problem, since the flow of rainy season is only one-way from upstream to downstream. Calculation return periods are 1.1, 2, 3, 5, 10, 20, 25, 30, 50, 80, 100, 150, 200, 300, 400 and 500 years.

The results of probable discharge at 3 discharge stations are shown in Table 6.2.17 and Figure 6.2.42. Probabilistic distributed model is adopted the Gumbel distribution model.

Table 6.2.17 Probability Flood Calculation at Madauk, Taungoo, Bago Stations

Observation Organization			DMH			Remarks
Station Name			Bago	Taungoo	Madauk	
River Name			Bago (Yangon)	Sittaung	Sittaung	
Station ID			48093	7040	7060	
Long. (X)			17.3337	18.9167	17.9167	
Lat. (Y)			96.4801	96.4667	96.8500	
Catchment Area (km2)			2,580	14,660	26,758	
Data No. of Extreme Value			47	42	42	
Probable Discharge (m^3/s)	(Year)	(%)				
	1.1	90.9%	808.0	960.0	2922.0	
	2	50%	1018.0	1173.0	3595.0	
	3	33.3%	1108.0	1265.0	3885.0	
	5	20%	1209.0	1368.0	4209.0	
	10	10%	1336.0	1496.0	4616.0	
	20	5%	1457.0	1620.0	5006.0	
	25	4%	1496.0	1659.0	5130.0	
	30	3.33%	1527.0	1691.0	5230.0	
	50	2%	1614.0	1779.0	5511.0	
	80	1.25%	1694.0	1861.0	5768.0	
	100	1%	1732.0	1899.0	5889.0	
	150	0.667%	1801.0	1969.0	6110.0	
	200	0.5%	1850.0	2018.0	6266.0	
	300	0.333%	1918.0	2088.0	6487.0	
	400	0.25%	1967.0	2138.0	6643.0	
	500	0.2%	2004.0	2176.0	6764.0	

Source: JICA Study Team, DMH



Source: JICA Study Team, DMH

Figure 6.2.42 Probability Flood Calculation at Madauk, Taungoo, Bago Stations

(2) Probability Water Levels at Gauging Stations

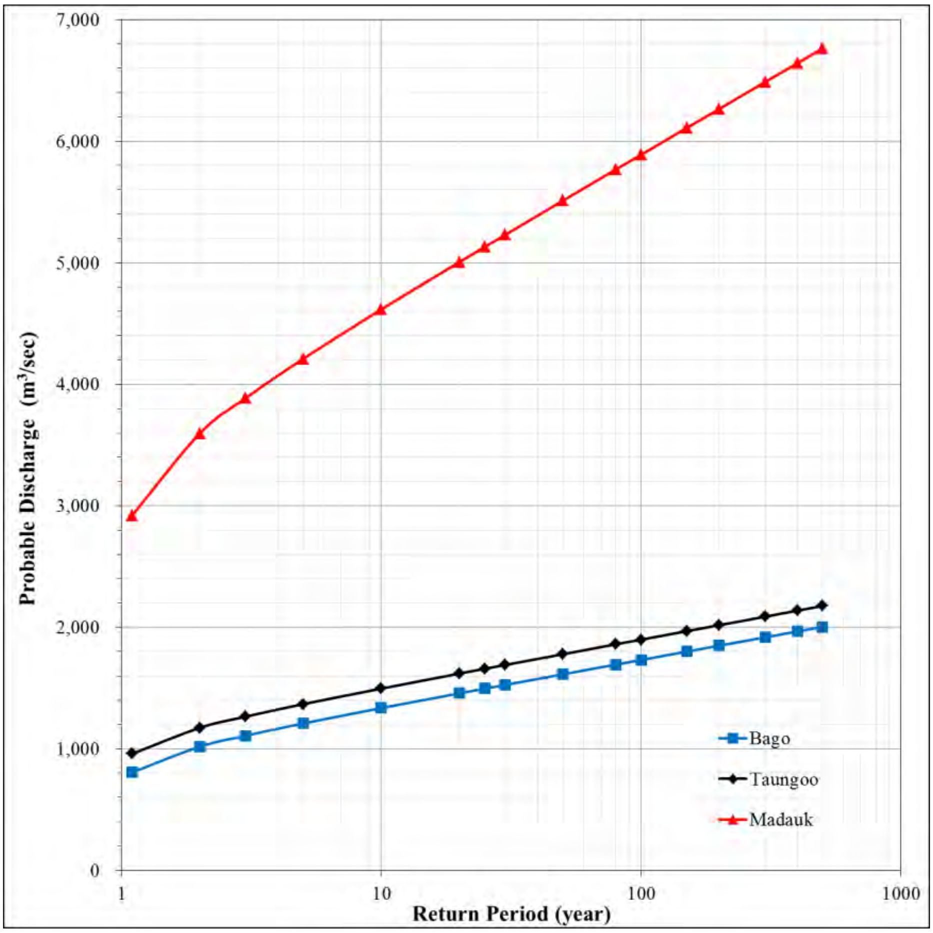
In a similar way, the probability water-level at gauging stations is calculated just for reference. In the calculation Myit Kyoe Station of ID is added, in addition to 3 stations of DMH. (Regarding the observed water levels of other stations of ID, the observed-year is sparse, and it is not used for the probability calculation.)

The results of probability water-level at above 4 stations are shown in Table 6.2.18 and Figure 6.2.43. The probabilistic distributed model is adopted the Generalized extreme value distribution (GEV) model, and all results have good correlation.

Table 6.2.18 Probability Water Level Calculation at 4 Stations

Observation Organization			DMH			Irrigation Departmrnt	Remarks
Station Name			Bago	Taungoo	Madauk	Myit Kyoe	
River Name			Bago (Yangon)	Sittaung	Sittaung	Sittaung	
Station ID			48093	7040	7060	- (ID)	
Long. (X)			17.3337	18.9167	17.9167	17.5988	
Lat. (Y)			96.4801	96.4667	96.8500	96.8141	
Catchment Area (km2)			2,580	14,660	26,758	-	
Data No. of Extreme Value			32	42	42	20	
Probable Water Level (m)	(Year)	(%)					
	1.1	90.9%	8.58	42.51	10.26	5.91	
	2	50%	9.03	43.32	11.44	6.77	
	3	33.3%	9.18	43.56	11.72	7.04	
	5	20%	9.32	43.76	11.95	7.28	
	10	10%	9.47	43.95	12.13	7.51	
	20	5%	9.58	44.08	12.24	7.68	
	25	4%	9.62	44.11	12.27	7.73	
	30	3.33%	9.64	44.13	12.29	7.76	
	50	2%	9.70	44.19	12.33	7.84	
	80	1.25%	9.75	44.24	12.36	7.91	
	100	1%	9.77	44.25	12.37	7.93	
	150	0.667%	9.81	44.28	12.39	7.98	
	200	0.5%	9.83	44.30	12.40	8.00	
	300	0.333%	9.86	44.32	12.41	8.04	
	400	0.25%	9.87	44.33	12.41	8.06	
	500	0.2%	9.89	44.34	12.42	8.07	

Source: JICA Study Team, DMH



Source: JICA Study Team, DMH

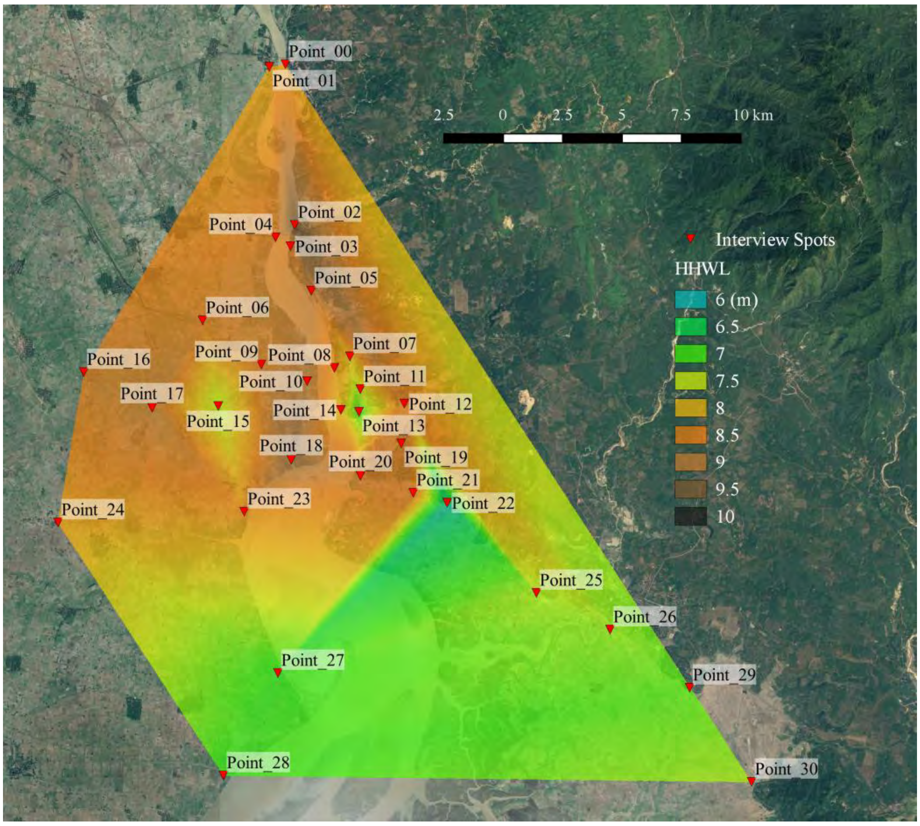
Figure 6.2.43 Probability Water Level Calculation at 4 Stations

(3) Interview Survey

In order to analogize the correlation between the flood-level around proposed bridge site, the probability values at the gauging stations, and calculated water-levels by hydraulic analyses, the interview survey for actual flood levels to inhabitants was conducted. Interviewed water levels are measured as Myanmar datum (MSL) by survey device (total station).

Locations of the interviews with local residents and the distribution of interviewed historical high flood levels are shown in Figure 6.2.44. The result is shown in Table 6.2.19.

Interviewed Historical high water Level (HHWL) at Point-10 closer to the proposed bridge is 9.01m from results, and annual mean highest water level is 7.68m.



Source: JICA Study Team

Figure 6.2.44 Interviewed Water Level Distribution and Locations of Interview Spots

Table 6.2.19 Interview Survey Results

Interview Point No.	Location	X	Y	Annual Mean Maximun Flood: AFL (m)	AFL Flood Depth above Ground	Historical Flood: HFL (m)	HFL Flood Depth above Ground	Occurrence Year	Tidal Bore Wave Height / Flood Depth above Ground	Ground Level (m)	Remarks
Point_00	Sat Can Thar	274593.564	1937956.955	7.42	0.38	8.26	1.23	July, 1996	1.5 m, 0.4 m above ground	7.034	
Point_01	Kyauk Nyart	273917.105	1937856.192	7.83	0.27	8.16	0.60	July, 1996	(unk) , 0.3 m above ground	7.556	
Point_02	Mya Thi Da	274911.392	1931205.788	8.91	0.53	9.57	1.19	July, 1996	0.5 m, 0.5 m above ground	8.373	
Point_03	Aye Thi Da	274718.993	1930319.153	8.19	0.14	8.66	0.60	May, 2008	No Occurrence	8.053	
Point_04	Kan Kyi Sate	274100.265	1930698.518	8.01	0.07	8.62	0.69	July, 1996	1.5 m, 0.7 m above ground	7.937	
Point_05	Koke Ko Tan	275577.819	1928435.473	8.15	0.43	8.92	1.20	May, 2008	No Occurrence	7.721	
Point_06	Shan Kine	270991.859	1927240.184	-	-	8.62	1.00	July, 1996	No Occurrence	7.622	
Point_07	Taw Kone	277171.258	1925659.558	7.68	0.10	7.96	0.38	May, 2008	No Occurrence	7.575	
Point_08	Taw Kone	276512.924	1925184.588	-	-	-	-	-	No Occurrence	8.891	
Point_09	Shan Kine	273438.971	1925359.64	7.51	0.32	8.69	1.51	1996	No Occurrence	7.186	
Point_10	Shan Kine Thaung	275357.132	1924640.491	7.68	0.22	9.01	1.54	May, 2008	No Occurrence	7.466	
Point_11	Swa Pa Lue	277593.825	1924276.153	-	-	-	-	-	No Occurrence	10.419	
Point_12	Kalon	279434.632	1923652.274	8.13	1.02	8.63	1.52	May, 2008	(unk) , 1.3 m above ground	7.108	
Point_13	Kyauk Yae Kan	277525.561	1923328.547	6.54	0.27	6.98	0.71	May, 2008	No Occurrence	6.267	
Point_14	Sut Pa Nue	276764.556	1923415.285	7.65	0.67	7.95	0.97	2004, 2005	No Occurrence	6.974	
Point_15	Pauk Pan Phyu	271606.71	1923633.134	6.97	0.59	7.41	1.03	May, 2008	No Occurrence	6.379	
Point_16	Ze Phyu Kone	265969.445	1925125.271	7.10	0.24	8.70	1.85	July, 1994	No Occurrence	6.854	
Point_17	WinKaTat	268826.391	1923594.271	7.67	0.54	8.90	1.77	July, 1994	1.0 m, 0.5 m above ground	7.129	
Point_18	Kyu Taw Thaung	274653.353	1921342.958	8.79	0.88	9.32	1.41	May, 2008	1.0 m, (unk)	7.912	
Point_19	Ma Lock Kyaung	279287.934	1921980.103	-	-	-	-	-	No Occurrence	10.013	
Point_20	Kyaik Ka Tha	277556.604	1920639.596	8.07	0.57	8.68	1.19	May, 2008	(unk) , 0.5 m above ground	7.495	
Point_21	Kyaik Ka Tha	279769.458	1919902.679	7.92	0.73	8.64	1.45	July, 1996	No Occurrence	7.193	
Point_22	Ma Lock Kyaung	281192.663	1919469.57	5.89	0.24	6.16	0.51	May, 2008	No Occurrence	5.649	
Point_23	Tha Nat Ten	272653.109	1919186.097	7.83	0.84	8.33	1.34	July, 1996	0.5 m, 1.0 m above ground	6.987	
Point_24	Upper Kyung Pa	264816.925	1918821.608	6.96	1.20	8.16	2.40	1996	0.5 m, 1.0 m above ground	5.758	
Point_25	Kauk Htin	284908.805	1915639.553	6.00	0.81	7.35	2.17	May, 2008	2.0 m, 0.8 m above ground	5.186	4.676
Point_26	Kyauk Hto (North)	287988.43	1914065.328	7.31	1.16	7.26	1.11	May, 2008	No Occurrence	6.153	
Point_27	Kywe Te	273994.73	1912391.67	6.02	0.41	6.93	1.32	1996	1.8 m, 0.4 m above ground	5.606	
Point_28	Nat Yae Kan	271653.431	1908110.333	6.55	1.01	6.92	1.38	May, 2008	1.0 m, 1.0 m above ground	5.535	
Point_29	Thein Gu	291311.781	1911590.803	6.86	0.39	7.05	0.58	May, 2008	0.3 m, 0.3 m above ground	6.469	
Point_30	Yat Kan Tha Ma	293879.793	1907607.372	7.08	0.33	7.37	0.62	May, 2008	2.0 m, 0.3 m above ground	6.746	

Source: JICA Study Team

6.2.7 Hydraulic Analyses

(1) General

The hydraulic phenomena (rising tide, falling tide, tidal bore, etc. in addition to the river own flood) at the tidal compartment of the river are necessary to simulate all temporal motions, as the tide level changes from moment to moment. Therefore, the range of numerical calculation shall be all of the tidal area from river mouth to Madauk of the non-tidal area. In the boundary of downstream, the tidal curves are necessary for hydraulic calculation, and the boundary line assumed the line between the Elephant Point (river-mouth of Yangon River) and Amherst (Kyaikkhame) which have tide table.

Also, since the river surveying range in this study is conducted within a limited area, some channel topography is supplemented by using the following data and GIS software.

- ✓ DEM data of GEBCO (General Bathymetric Chart of the Oceans) of International Hydrographic Organization for the seabed topography,
- ✓ Cross-section data of past survey documents by TU Delft for the riverbed topography, etc.

The river length and river plane shape is measured from the river route on the topographic map and Google Earth map. The length to upstream boundary from river-mouth is 145km and the length to river-mouth from downstream boundary of Amherst / Elephant-Point is 104km, and the total analysis length is 249km.

(2) Hydraulic Design Criteria of Bridge

In order to design the opening of the bridge waterway, the following design criteria for hydraulics are required.

- ✓ The backwater does not significantly increase the flood damage to properties upstream of the bridge.
- ✓ The velocity through the bridge does not damage the road facility or increase the damages to downstream properties.
- ✓ The existing flow distribution is maintained to the extent practicable.
- ✓ The pier and abutment are designed to minimize the flow disruption.
- ✓ Potential local scour is within acceptable limits.
- ✓ Clearance at the structure is adequately designed to pass safety any anticipated debris. (The elevation of bottom of bridge girder is higher than "Highest high water level + Navigation channel height".)

The design return period, the clearance from the bridge girder to high water level shall be compliant with authorized standards by the organizations concerned.

In this study, the design return period is adopted as a 100-year return period. And the clearance from the bridge girder to high water level is applied with the Japanese standard1 because the practicable standard is not established in Myanmar. Also, other design standard is based on the HEC series of FHWA2 as well-used international standards.

Table 6.2.20 Freeboard for the Levee

Item	Design flood discharge	Value to be added to design high water level
1	Less than 200 m^3/s	0.6m
2	200 and over, and less than 500 m^3/s	0.8m
3	500 and over, and less than 2,000 m^3/s	1.0m
4	2,000 and over, and less than 5,000 m^3/s	1.2m
5	5,000 and over, and less than 10,000 m^3/s	1.5m
6	10,000 m^3/s and over	2.0m

Source: Government ordinance for structural standards for river administration facilities, Japan

(3) Analysis Software

Hydraulic analysis was carried out to simulate the tidal and flood phenomena at the Sittaung River using HEC-RAS (Hydrologic Engineering Center - River Analysis System) developed by US Army Corps of Engineers, USA.

HEC-RAS has the capability to compute one- and two-dimensional water surface profiles for both steady and unsteady flow. Sub-critical, supercritical and mix flow regime profiles can be calculated.

Water surface profiles are computed from one cross section to the next by solving the energy equation using standard-step method. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion coefficients. HEC-RAS requires inputs for boundary conditions of upstream discharge and either downstream water level or known energy gradient.

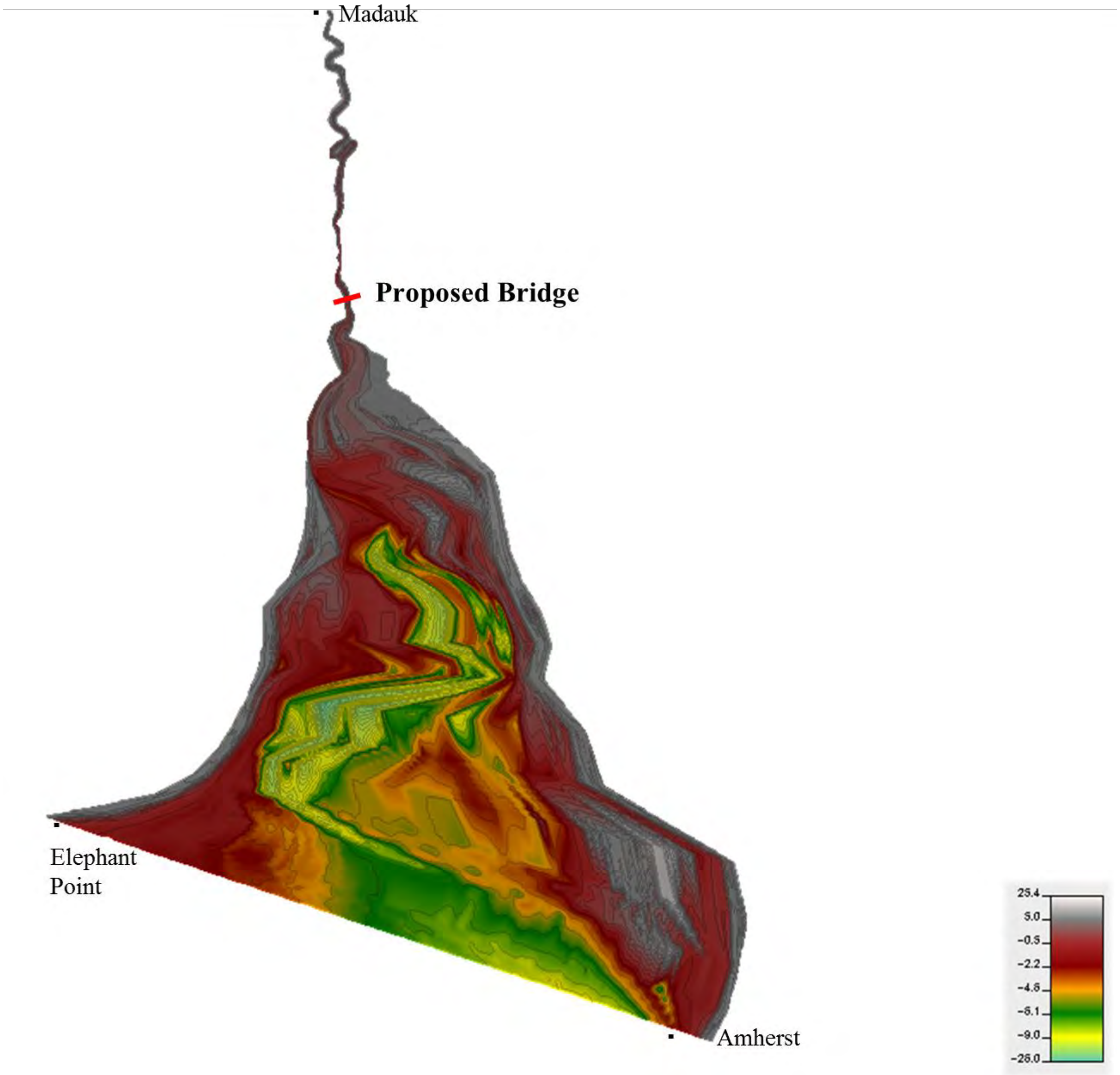
(4) Hydraulic Analyses and Precondition

The hydraulic analyses are conducted by the following procedure;

- ✓ To estimate the roughness coefficient of the river channel by simulating from the calculated astronomical tide levels at Amherst and observation water level at fixed-point observation location during the observation period. The water level at a fixed point observation location upstream can be calculated from the astronomical tide for Amherst (/ Elephant-Point) of the downstream boundary by the hydraulic calculation, if the water level from the downstream is hydraulically continuous (influence of backwater). Concretely, the calculated water level is approximated / calibrated at the tide waveform at the fixed-point observation location by changing the roughness-coefficient of each tidal-reach. The astronomical tide at Amherst is given in 6.2.4(2).
- ✓ Calculation is conducted under the mixed flow regime, since the flow regime show a mixture of sub-critical and super-critical flow by the run-up for tidal-bore and flood / ebb tide.
- ✓ To conduct the calculation case at the time of flood (of each return period) by using the above roughness coefficient calculated from real tide level.
- ✓ As an additional case, the rising value of static water level by barometric depression at the time of "Cyclone Nargis" (2008) is added to downstream boundary condition.

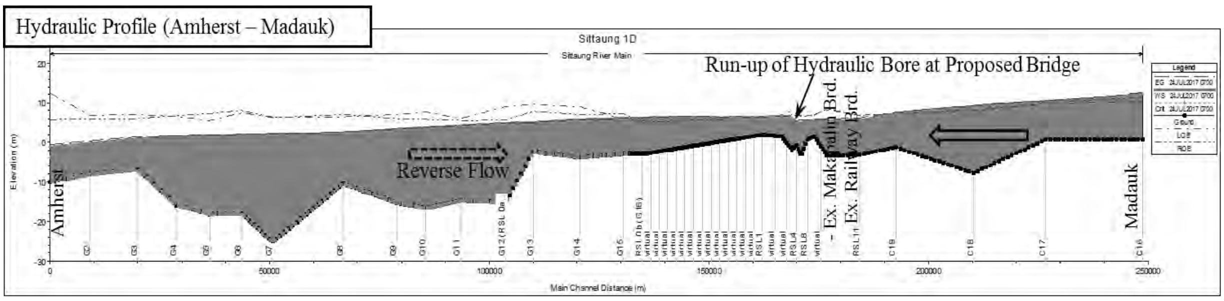
The preconditions of the calculation case are followings.

- ✓ The cross-sections for hydraulic calculation are given by using the bathymetry survey results in this study and other data (GEBCO's DEM and TU Delft result, etc.). The generated terrain model by GIS software is shown in Figure 6.2.45. And the river longitudinal profile for analysis is shown in Figure 6.2.46, and the total number of hydraulic cross sections is 454 cross sections as shown in Figure 6.2.47.
- ✓ The downstream boundary for hydraulic calculation of observation period is given the tide levels (at Amherst / Elephant-Point) which vary from hour to hour. (Hence, the flow becomes the unsteady flow.) The upstream boundary is given the monthly mean runoff as the steady flow.
- ✓ The downstream boundary for hydraulic calculation of the rainy season, is given the tide level (from 25 May to 10 November 2017, spring tide) at the Amherst. The upstream boundary of the rainy season is given by the 100-year flood flow, etc., as the steady flow.
- ✓ The flood discharge to the upstream end is given as proportional distribution between catchment area at the upstream end and total area, flow rate of remaining catchment area is given as "the uniform lateral inflow" against the stream length.



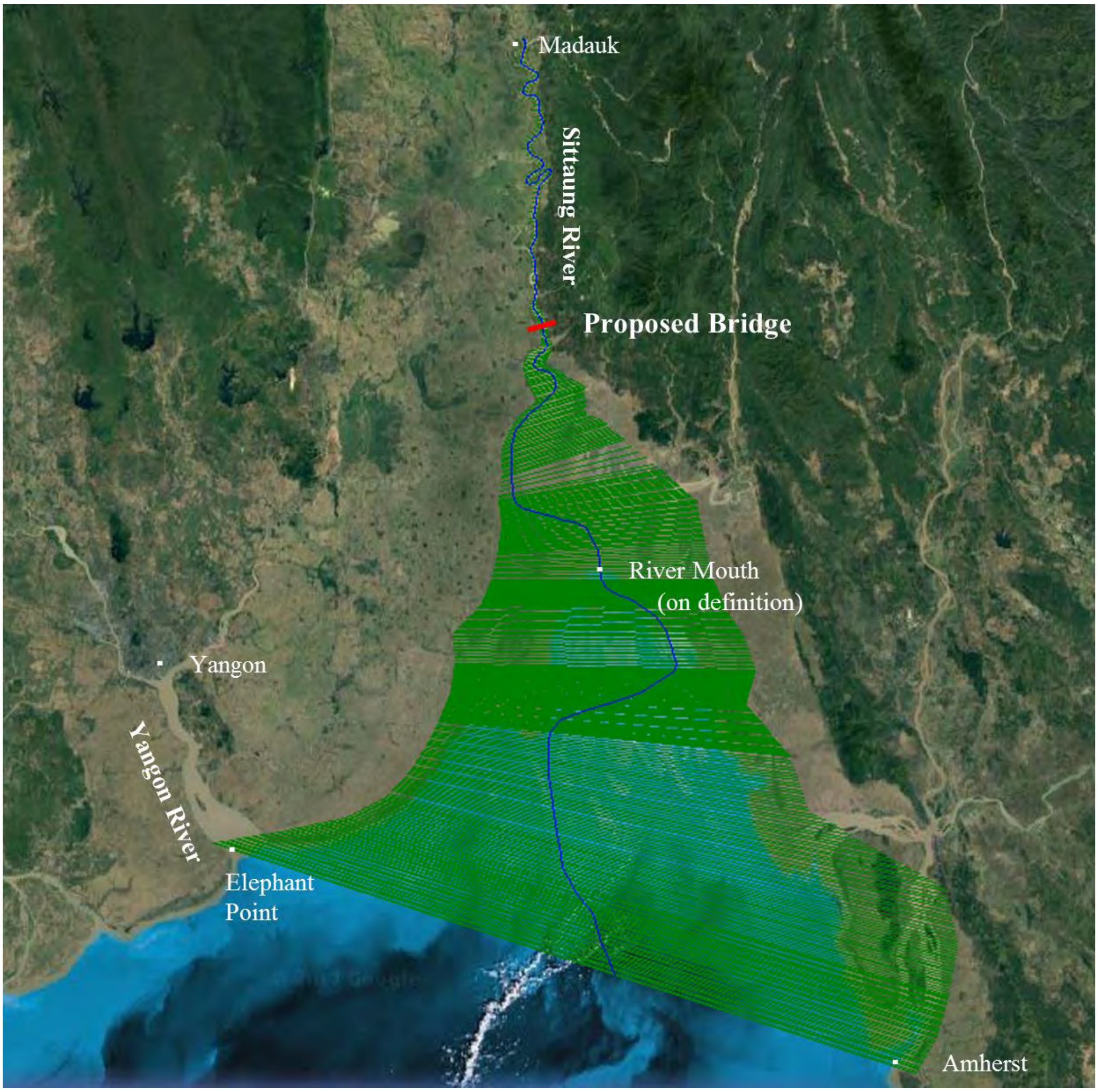
Source: JICA Study Team

Figure 6.2.45 Terrain Model for Hydraulic Analysis



Source: JICA Study Team

Figure 6.2.46 River Longitudinal Profile for Hydraulic Analysis



Source: JICA Study Team

Figure 6.2.47 Hydraulic Cross Sections Location for Analysis

The hydraulic parameters for input conditions are shown in Table 6.2.2

- ✓ The design flood discharge refers the result of 6.2.6(1). However, the observation interval for discharge on site is once a day, and it may not catch a real maximum. In this Study, it is adjusted of the daily values to 24 hours maximum values by applying a correction factor to the daily extremes, by considering the uncertainty of H-Q curve transforming or the measurement error at field measurement. (A correction factor for the estimation of 24-hour events from daily data will be applied 1.12 from past literatures, in reference to the coefficient in case of daily rainfall.)
- ✓ This river slope is very gentle and the classification for river course is 'segment-3' as shown in 6.2.4(1). In Japanese standard, the roughness coefficient of river channel is generally recommended as approximately

0.015 for the river of 'segment-3' with having very small grain size of river bed material. However, the tidal motion of the Sittaung estuary is very big, and the tidal-bore wave has been transiently and dynamically propagated. The analysis is performed under the mixed flow condition which is mixed with the sub-critical and super-critical flows, and the roughness coefficient was calibrated and evaluated to approximate the real water-level value which is obtained from the fixed-point observation.

- ✓ For the influence of storm surges such as "Cyclone Nargis", it made an allowance for the elevation of water surface due to a decrease in atmospheric pressure by cyclone. (The increment by waves is not considered in this Study.) The elevation of water surface due to a decrease in atmospheric pressure is estimated by following equation.

  - Rising value of static water level by barometric depression

η_{PS}=0.991・(1013 - p) = 0.991・(1013 - 962) = 50.54 cm = 0.505 m

where; η_{PS}: Rising value of static water level by barometric depression (hPa)

p: Atmospheric pressure value which is decreased due to cyclone (hPa)

(2008 Cyclone Nargis: 962 hPa)

Table 6.2.21 Design Flood Discharge (only Upland Flow)

Items	Normal Discharge (Upland flow by rainfall) at Madauk : Q1	Normal Discharge (Upland flow by rainfall) at Proposed Bridge: Q2	ΔQ (Q2- Q1)	Remarks
Catchment Area (km^2)	26758	33938		
Pribable Flood (year)	(m^3/s)	(m^3/s)	(m^3/s)	
1.1	3300	4200	900	
2	4100	5200	1100	
5	4800	6000	1200	
10	5200	6600	1400	
25	5800	7300	1500	
50	6200	7900	1700	
100	6600	8400	1800	
500	7600	9700	2100	
Monthly Mean Discharge				
Jan	504	640	135	
Feb	366	465	98	
Mar	289	366	78	
Apr	234	297	63	
May	248	314	67	
Jun	713	905	191	
Jul	1894	2403	508	
Aug	2910	3691	781	
Sep	2375	3012	637	
Oct	1641	2081	440	
Nov	1135	1439	304	
Dec	746	947	200	

Note: 1. Discharge at Madauk is multiplied the value of "Table. 6.1.17" by 1.12.

2. Discharge at proposed bridge is multiplied the value at Madauk by catchment area ratio. (by concept of 'Specific discharge'.)

3. ΔQ will be distributed as "the uniform lateral inflow" against the stream length between Madauk and proposed bridge.

Source: JICA Study Team

Table 6.2.22 Hydraulic Parameters for Input

No.	Item		Unit	Parameters	Remarks
1	Location			Proposed Bridge Alignment	
2	Bridge Length	L	m	2000	
3	Catchment Area	A	km^2	33938	
4	Design Return Period	F	years	100 years	
	Design Flood Discharge				
5	Steady flow (Upland flow)	Q	m^3/s	8400	
6	Flood including Ebb Tide	Qmax	m^3/s	16600	from Hydraulic analysis
7	Flood including Flood Tide	Qmin	m^3/s	-11300	from Hydraulic analysis
8	High Water Level (Design Flood Level)	DFL	m	9.10	from Hydraulic analysis
9	Freeboard for Bridge	Fb1	m	2.0	Table 6.1.20
10	Freeboard for Guide Bank	Fb2	m	1.0	
11	Normal Water Level (NWL)	NWL	m	3.93	

Source: JICA Study Team

(5) Hydraulic Analyses and the Results

1) 1-dimensional Hydraulic Analysis

1-dimensional hydraulic analysis was performed for the calibration of hydraulic parameter. Both of the observed and calculated water levels are compared and evaluated, although the flow discharge at fixed-point observation location is not measured and other input conditions are uncertainly. Table 6.2.23 shows the calibration results against observed maximum water level, and it is estimated that the roughness coefficient is between approximately 0.006 and 0.007. In this study, to approximate the value to observed level which is considered as the most basic objective, the parameter which was estimated by these average values is adopted as the design parameter value. The calculated water levels result for each return period by using these average values is shown in Table 6.2.24. Although the return period equivalent to 'Cyclone Nargis' is unknown, the average value for '100 years return period with storm surge event' is nearly same as historical maximum high water level '9.01 m (Point-10 of Table 6.2.19)'. (This value was resulted from ‘Cyclone Nargis’ and interviewed from local peoples.) From this Table, the design values are 9.10m for the water level of 100-year return period, 16600 m^3/s for the maximum flood discharge including ebb-tide, and -11300 m^3/s for the maximum flood reverse-discharge including flood-tide. As results under unsteady flow condition of 1-dimensional analysis are shown in Figure 6.2.48 for water level distribution and Figure 6.2.49 for velocity distribution. Also, as results under steady flow condition are shown in Figure 6.2.50 for hydraulic cross section and Table 6.2.25 for hydraulic quantities at proposed bridge.

Table 6.2.23 Calibration Results to Water Level at Fixed-Point Observation

Discharge		Manning's roughness coefficient; n										Remarks
	Q (m^3/s)	n=0.005	n=0.006	n=0.007	n=0.008	n=0.009	n=0.010	n=0.015	n=0.020	n=0.025	n=0.030	
May Mean Discharge	314	8.71	7.69	6.41	5.24	4.38	3.81	3.17				Input Tide is 25 May-30 June
June Mean Discharge	905		7.78	6.56	5.52	4.73	4.25	3.79				
July Mean Discharge	2403		7.96	6.87	5.98	5.29	4.81	4.61	4.92	5.20	5.44	
August Mean Discharge	3691		8.12	7.06	6.24	5.53	5.08	5.08				

Note: Maximum value of observed water levels at fixed point near proposed bridge location is measured as **7.24 m** during 25 May to 30 June.

Source: JICA Study Team

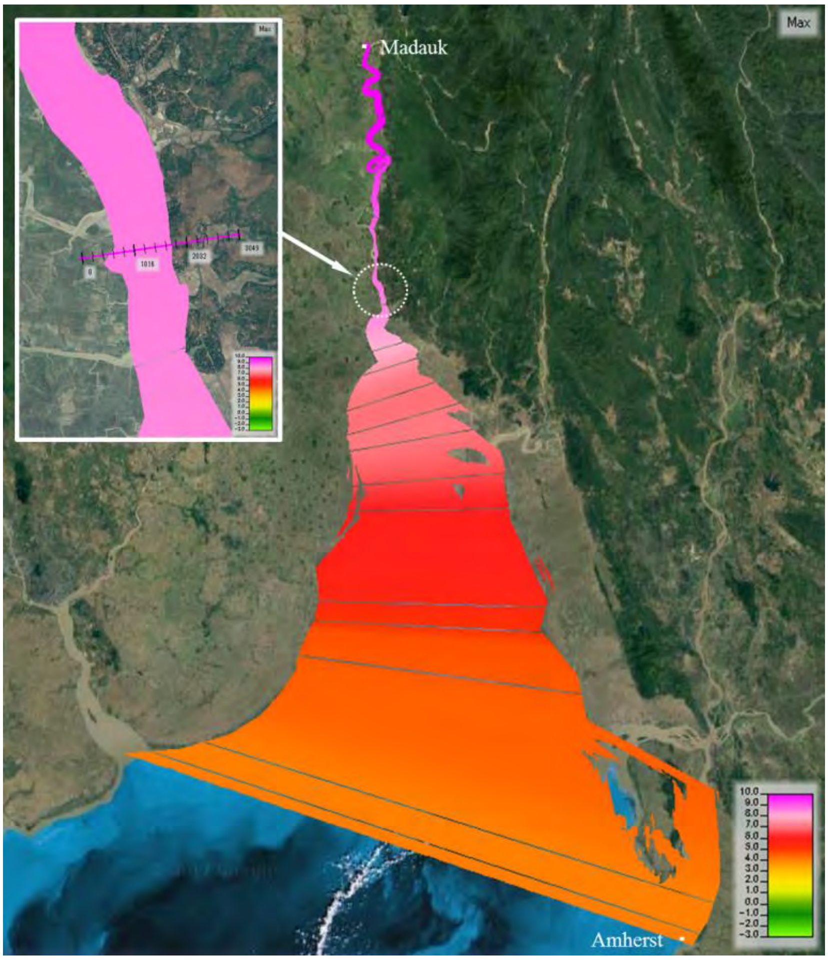
Table 6.2.24 Design Values for Flood Discharges (Qmax/Qmin) and Flood Levels at Proposed Bridge

Discharge		Water Level: WL		Discharge: Qmax / Qmin				Design Value			Remarks
	Q (m^3/s)	n=0.006	n=0.007	n=0.006		n=0.007		WL	Qmax	Qmin	
5yrs flood	6000	8.45	7.45	11448	-10417	9341	-4282	7.95	10400	-7300	Input Tide is 25 May-10 Nov
5yrs flood + Storm Surge	6000	9.42	8.40	15204	-19032	11985	-9987	8.90	13600	-14500	
10yrs flood	6600	8.51	7.50	13617	-11124	10381	-4087	8.00	12000	-7600	
10yrs flood + Storm Surge	6600	9.46	8.45	16026	-18217	12766	-9074	9.00	14400	-13600	
100yrs flood	8400	8.62	7.63	15666	-8458	11880	-950	8.10	13800	-4700	
100yrs flood + Storm Surge	8400	9.57	8.59	18652	-16054	14501	-6459	9.10	16600	-11300	Design Value

Input Upland Flow: 8400 m^3/s

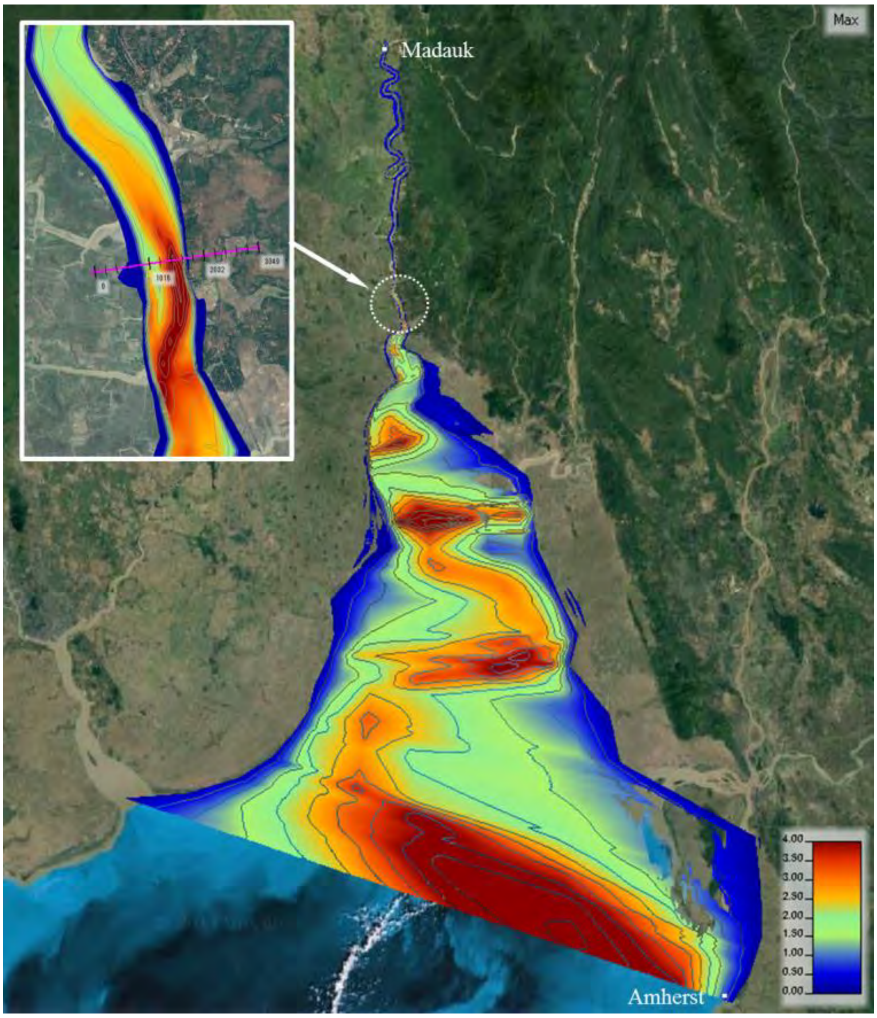
Interviewed Water Level near Bridge: 9.008 m (Point 10, Right bank side)

Source: JICA Study Team



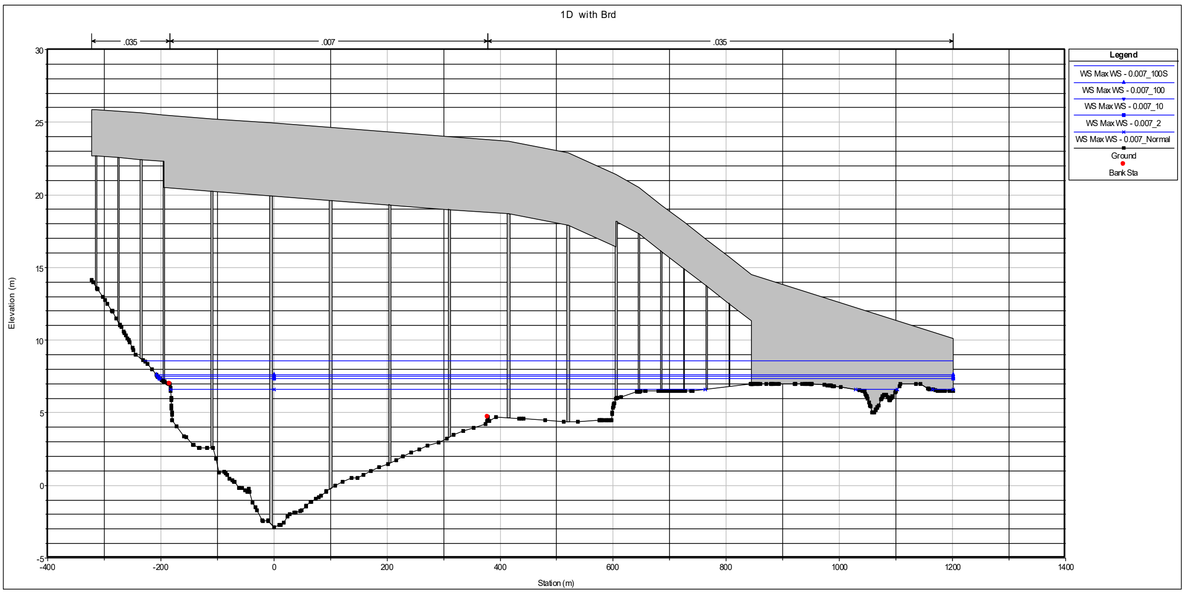
Source: JICA Study Team

Figure 6.2.48 Water Level Distribution of 1-Dimensional Hydraulic Analysis (100-yrs)



Source: JICA Study Team

Figure 6.2.49 Velocity Distribution of 1-Dimensional Hydraulic Analysis (100-yrs)



Source: JICA Study Team

Figure 6.2.50 Hydraulic Cross-sectional Profile at Proposed Bridge

Table 6.2.25 Hydraulic Output Table at Proposed Bridge (100-yrs)

Plan: SteadyF_P1 Sittaung River Main RS: 67.381 BR D Profile: 100yrs_StormS					
E.G. Elev (m)	9.21	Element	Left OB	Channel	Right OB
Vel Head (m)	0.13	Wt. n-Val.	0.035	0.007	
W.S. Elev (m)	9.08	Reach Len. (m)	1	1	1
Crit W.S. (m)	3.93	Flow Area (m2)	63.8	5271.93	
E.G. Slope (m/m)	0.000011	Area (m2)	63.8	5271.93	526.03
Q Total (m3/s)	8400	Flow (m3/s)	6.92	8393.08	
Top Width (m)	1027.08	Top Width (m)	56.59	755.74	214.76
Vel Total (m/s)	1.57	Avg. Vel. (m/s)	0.11	1.59	
Max Chl Dpth (m)	11.94	Hydr. Depth (m)	1.13	6.98	
Conv. Total (m3/s)	2526043	Conv. (m3/s)	2081.2	2523961	
Length Wtd. (m)	1	Wetted Per. (m)	61.19	859.32	
Min Ch El (m)	-2.86	Shear (N/m2)	0.11	0.67	
Alpha	1.02	Stream Power (N/m s)	0.01	1.06	
Frctn Loss (m)	0	Cum Volume (1000 m3)	1369344	122517600	1186540
C & E Loss (m)	0	Cum SA (1000 m2)	543088.6	9763182	423151.7

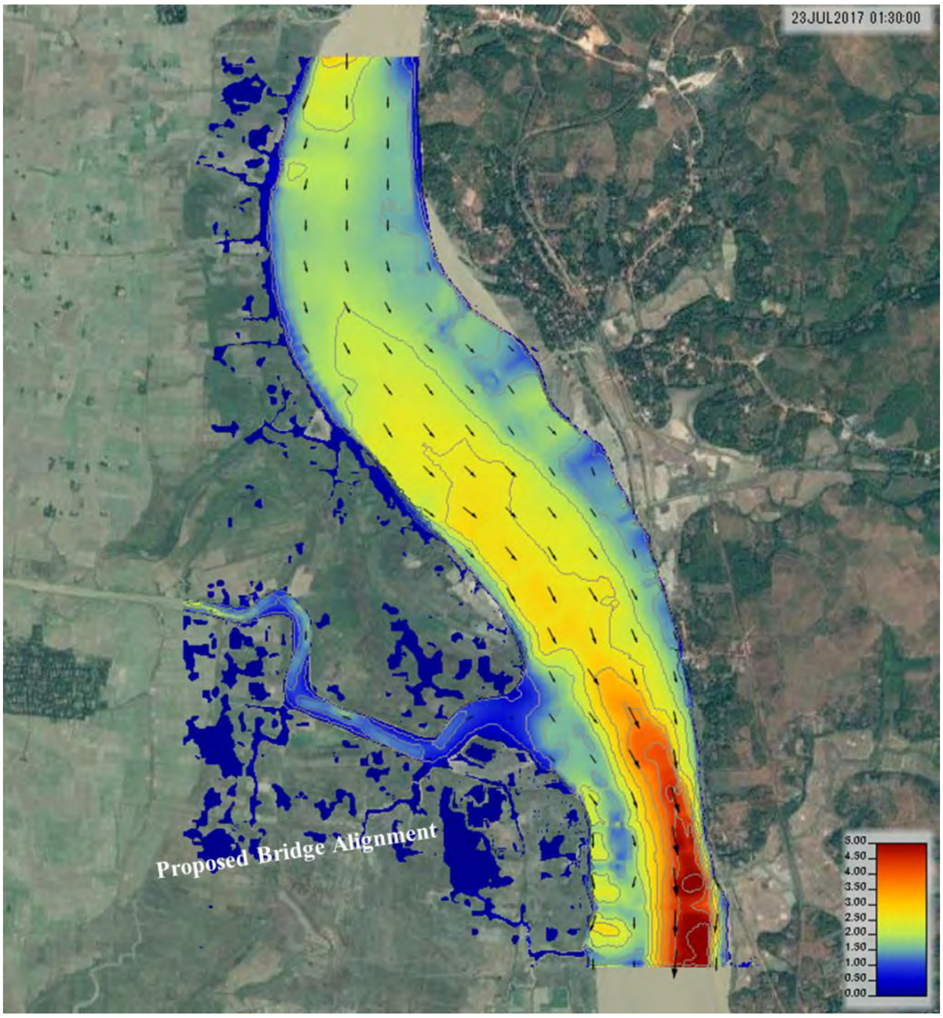
Source: JICA Study Team

2) **2-dimensional Hydraulic Analysis**

2-dimensional analysis was performed since the velocity vector at each riverbed point is not obtained from 1-dimensional analysis. The calculation case is one case only, and the calculation condition is under the steady flow of design discharge (100 year with storm surge). In calculation, the bathymetric survey result in this study is used and interpolated for the river topography of 2-dimensional analysis, and the topographic survey result of this study is used for the surrounding area at proposed bridge. Also, SRTM DEM is used for the land portion of upstream area[3].

Figure 6.2.51 shows the velocity vector distribution map. From this Figure, several issues are indicated as shown in Chapter 7.6.1.

[3] The elevation of SRTM DEM at upstream area is relatively lower compared with survey result in this study, and it is estimated that the accuracy of DEM is not so high. Therefore, the topographic survey at the land portion between existing Mokepalin and proposed bridges shall be recommended to be conducted at detailed design stage, in order to reproduce the upland flow overflowed from upstream right bank.



Source: JICA Study Team

Figure 6.2.51 Velocity Vector Distribution Map by 2-Dimensional Analysis (100-yrs)

6.2.8 Hydrological Assessments

From the above hydrological and hydraulic studies, several challenges and conclusions have been extracted. As for the hydraulic issues of the proposed bridge, the following respects are left as future challenges.

- ✓ Since the hydraulic analysis area is a huge area, the necessary and sufficient topographic, bathymetric and hydrological surveys are not conducted in this study. In order to clarify the river morphology/characteristics, tidal motions (flood-/ebb tide) and the unique hydraulic phenomenon (tidal bore), these detailed surveys should be conducted.
- ✓ Further fixed-point observations for the water level / flow discharge including other points shall be performed, and the more detailed hydraulic analyses shall be performed by special hydraulic software. And detailed hydraulic studies will be needed furthermore, in order to reproduce the special / un-usual hydraulic phenomena.

6.3 Geotechnical Survey

6.3.1 Survey Outline

In order to conduct the preliminary design of the New Sittaung Bridge, a geotechnical survey was conducted. The survey components are as follows:

- Boring at 2 points in the river and 2 points in land
- Standard Penetration Test (SPT) : every 1m
- Laboratory tests
  - Unit weight for undistributed sample : 2 samples
  - Natural moisture contents :26 samples
  - Atterberg limits (Liquid Limit/ Plastic Limit) for cohesive soil : 2 samples
  - Grain size analysis (sieve + hydrometer) : 26 samples
  - Specific gravity : 26 samples
  - Unconfined compression test : 2 samples
  - Consolidation test : 2 samples

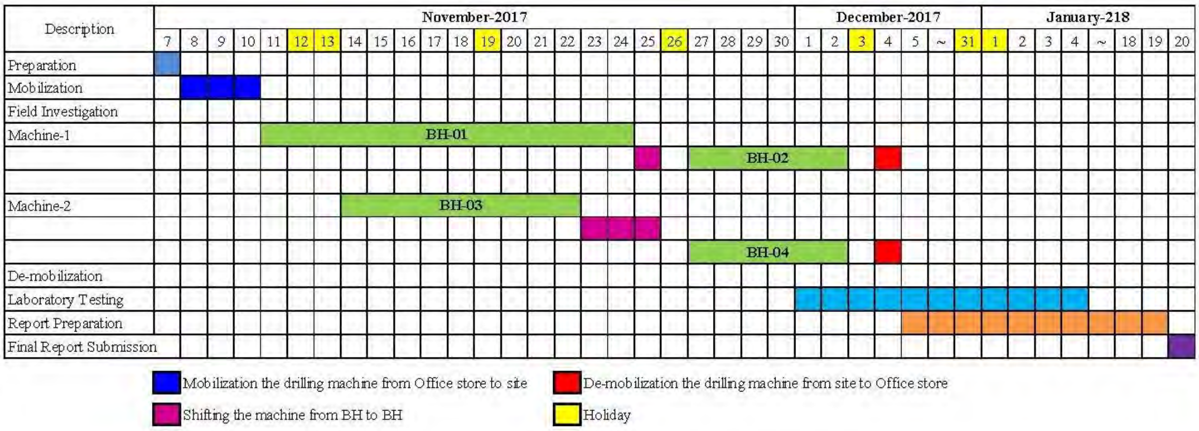
Source: JICA Study Team based on Google Satellite Map

Figure 6.3.1 Location of Borehole Investigation

6.3.2 Survey Schedule and Progress

Table 6.3.1 shows the implementing schedule of the geotechnical survey. Since the rainy season basically continues until October, the work was started from the beginning of November 2017.

Table 6.3.1 Implementing Schedule of Geotechnical Survey



Source: JICA Study Team

6.3.3 Borehole Investigation Results

Table 6.3.2 shows the survey quantities or borehole investigation. Original target depth of boring was to confirm 5.0 m of N-value of more than 50. However, only BH-3 was confirmed 5 continuous times of N-value ≥ 50 from the depth of 60 m.

Table 6.3.2 Survey Quantities of Boring Works

Boring No.	Soil Drilling (m)			SPT (Nos)	Undisturbed Sampling (Nos)
	ϕ 112 mm	Φ 64 mm	Total		
BH-01	20.0	45.0	65.0	65	0
BH-02	9.0	56. 0	65.0	65	0
BH-03	5.0	59.0	64.0	64	0
BH-04	2.0	59.0	61.0	59	2
Total :	**36.0**	**219.0**	**255.0**	**253**	**2**

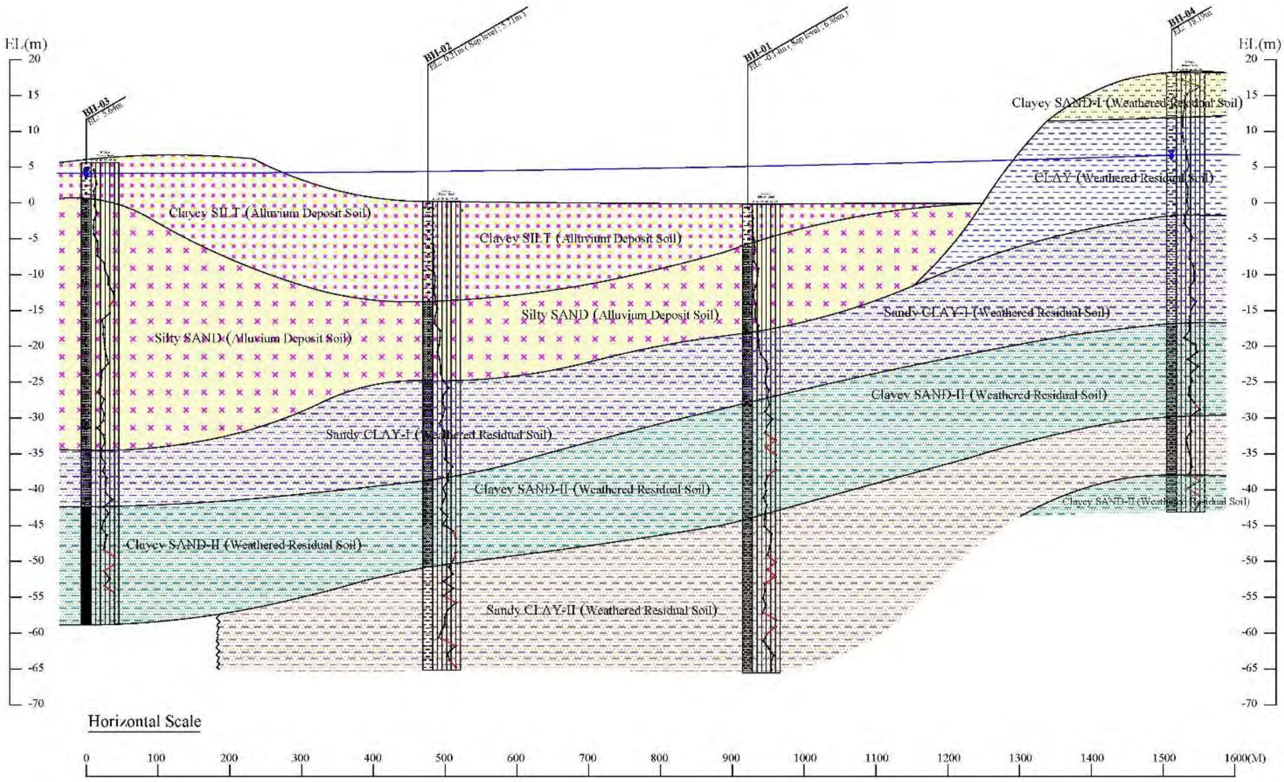
Source: JICA Study Team

In the project area, it is reasonable to assume that the transported soil is dominated rather than residual soil at the top layer. The transported soils are mostly derived from flood plain deposits of clay, silt and sand. According to the investigation results, the top soil layer is cohesive soil layer and the thickness is 5.0m in minimum and 14.0m in maximum below ground level. The very soft to stiff, gray, SILT and CLAY deposit is mainly composed as top soil layer. And then, granular soil layer are well observed in this area. However, the granular soil layer is different in relative density and their physical properties. According to the investigation results, cohesive and granular soils alternative in this project area.

Based on the results from 4 borehole investigation, soil profile for the alignment of new bridge can be formulated as shown in Figure 6.3.2. The soil layers are divided in 2 layers depending on soil produced condition, Alluvium deposit soil layer and Weathered residual soil layer, and a total of 7 different layers have been recognized. The soil layers are classified in accordance with their physical properties and/or their relative density. The 7 different layers observed in the Project Area are described from top to bottom as follows.

The area from BH-01 to BH-03 is covered by transported soils which are derived from flood plain deposits, Silt and Sand (Alluvium deposit soil). Under the Alluvium soil layer, Residual soil layer are confirmed as cohesive and granular alternatively (Weathered residual soil). For only BH-04, the residual soil layer is confirmed from the surface ground. Soil character of each layer are summarized in Table 6.3.3**.**

i. Clayey SAND-I (Weathered Residual Soil)
ii. CLAY (Weathered Residual Soil)
iii. Clayey SILT (Alluvium Deposit Soil)
iv. Silty SAND (Alluvium Deposit Soil)
v. Sandy CLAY-I (Weathered Residual Soil)
vi. Clayey SAND-II (Weathered Residual Soil)
vii. Sandy CLAY-II (Weathered Residual Soil)



Source: JICA Study Team

Figure 6.3.2 Soil Profile based on 4 Borehole Investigation

Table 6.3.3 Major Charactor of Soil Layers

No.	Soil Layer	Description
1	Clayey SAND-I	• According to the investigation results, the upper most layer is Clayey SAND-I layer. • Color of this layer is mottled gray and reddish brown. The plasticity of this layer is low to medium plasticity and the water content is moist. • Gained size of sand is fine grained. • It can be described as medium dense to very dense in relative density.
2	CLAY	• Color of it is mottled gray and yellowish brown, and the water content is moist. • Plasticity of this layer is low to medium plasticity and trace of silt and fine-grained sand included.

		• Consistency of this layer is stiff to very stiff.
3	Clayey SILT	• Color of this layer is gray and water content is moist. • Plasticity of this layer is low to medium plasticity and the water content is moist. • It can be described as very soft to stiff in consistency.
4	Silty SAND	• Color of gray to dark gray, and water content is moist. • Gained size of sand is fine to medium grained. • It can be described as very loose to dense in relative density.
5	Sandy CLAY-I	• Color of this layer is reddish brown and water content is moist. • Grained size of sand is fine-grained and the plasticity of clay is low to medium plasticity. Trace of fine lateritic gravel including. • Consistency of it is stiff to hard.
6	Clayey SAND-II	• Color of this layer is reddish brown and water content is moist. • Grained size of sand is fine-grained and the plasticity of clay is low to medium plasticity. Trace of fine to medium gravel including. • Relative density of this layer is medium dense to very dense.
7	Sandy CLAY-II	• Color of this layer is mottled gray and reddish brown and water content is moist. • Grained size of sand is fine-grained and the plasticity of clay is low to medium plasticity. Trace of fine lateritic gravel including. • Consistency of it is soft to stiff.

Source: JICA Study Team

6.3.4 Laboratory Test Results

From disturbed samples by SPT and undisturbed samples with Denison Sampler, the laboratory soil test as shown in Table 6.3.4 were conducted. Results of soil physical property tests and soil engineering tests are summarized in Table 6.3.5 and Table 6.3.6 respectively.

Table 6.3.4 Quantities of Laboratory Soil Tests

BH No.	Physical Property Test						Engineering Test	
	Water Content	Specific Gravity	Grain Size Distribution	Atterberg Limits		Unit Weight	Unconfined Compression	One Dimensional Consolidation
				Liquid Limit	Plastic Limit			
BH-01	6	6	6	-	-	-	-	-
BH-02	6	6	6	-	-	-	-	-
BH-03	6	6	6	-	-	-	-	-
BH-04	8	8	8	2	2	2	2	2
Total:	**26**	**26**	**26**	**2**	**2**	**2**	**2**	**2**

Source: JICA Study Team

Table 6.3.5 Results of Soil Physical Property Tests

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution (%)			
		GL (m)	EL (m)		W (%)	Gs	Gravel	Sand	Silt	Clay
BH-01	P-5	5.00	-5.14	F	29.30	2.699	-	27.74	64.26	8.00
	P-14	14.00	-14.14	SM (or) SC	18.43	2.702	3.35	55.34	14.11	27.20
	P-18	18.00	-18.14	F	28.43	2.699	-	26.43	17.68	55.90

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution (%)			
		GL (m)	EL (m)		W (%)	Gs	Gravel	Sand	Silt	Clay
	P-30	30.00	-30.14	SM (or) SC	20.35	2.712	2.09	48.62	20.28	29.00
	P-43	43.00	-43.14	SM (or) SC	16.76	2.642	1.22	84.36	7.12	7.30
	P-54	54.00	-54.14	F	25.64	2.672	0.87	37.46	22.97	38.70
BH-02	P-7	7.00	-6.79	F	36.16	2.692	-	1.22	85.78	13.00
	P-20	20.00	-19.79	SM (or) SC	29.11	2.681	-	81.60	11.60	6.80
	P-28	28.00	-27.79	F	25.74	2.843	0.47	39.79	23.13	36.60
	P-39	39.00	-38.79	SM (or) SC	15.73	2.648	5.29	67.54	7.07	20.10
	P-52	52.00	-51.79	F	19.49	2.694	-	0.65	56.75	42.60
	P-60	60.00	-59.79	F	17.81	2.647	-	30.23	28.58	41.20
BH-03	P-10	10.00	-4.36	SM (or) SC	25.88	2.708	-	82.60	14.70	2.70
	P-20	20.00	-14.36	SM (or) SC	20.68	2.692	-	80.32	17.58	2.10
	P-32	32.00	-26.36	SM (or) SC	16.69	2.671	3.23	68.80	7.97	20.00
	P-38	38.00	-32.36	SP-SM (or) SP-SC	10.45	2.653	1.49	89.49	5.62	3.40
	P-45	45.00	-39.36	F	25.11	2.722	-	22.33	27.58	50.10
	P-56	56.00	-50.36	SM (or) SC	15.64	2.712	15.02	54.93	9.85	20.20
BH-04	P-5	5.00	+13.19	SM (or) SC	19.71	2.705	8.48	58.20	13.31	20.00
	D-1	8.00	+10.19	MH	41.22	2.624	-	13.40	34.70	51.90
	D-2	10.00	+8.19	MH	37.15	2.685	2.27	30.38	42.75	24.60
	P-18	20.00	-1.81	F	33.75	2.712	-	17.22	31.78	51.00
	P-36	38.00	-19.81	SM (or) SC	13.60	2.705	19.14	56.55	10.61	13.70
	P-43	45.00	-26.81	SP-SM (or) SP-SC	16.56	2.701	30.66	60.74	3.60	5.00
	P-51	53.00	-34.81	F	26.50	2.643	-	17.96	41.94	40.10
	P-57	59.00	-40.81	SM (or) SC	14.55	2.664	4.13	64.59	14.68	16.60

BH No.	Sample No.	Depth		Atterberg Limits			Bulk Density σt (g/cm^3)
		GL (m)	EL(m)	LL(%)	PL(%)	PI(%)	
BH-04	D-1	8.00	+ 10.19	93.65	41.37	52.28	1.737
	D-2	10.00	+8.19	84.40	37.86	46.54	1.766

Source: JICA Study Team

Table 6.3.6 Results of Soil Engineering Tests

BH No.	Sample No.	Depth		Consolidation			Unconfined Compression	
		GL (m)	EL(m)	e_0	Py (kN/m^2)	Cc	q_u (kN/m^2)	E_{50} (kN/m^2)
BH-04	D-1	8.00	+ 10.19	1.070	516.7	0.262	143.4	6,452.5
	D-2	10.00	+8.19	1.110	299.7	0.271	118.8	3,561.9

Source: JICA Study Team

CHAPTER 7 PRELIMINARY DESIGN ON NEW SITTAUNG BRIDGE

7.1 Introduction

The New Sittaung Bridge as a part of the East - West Economic Corridor Highway (New Bago – Kyaikto Section) will be developed as Primary Road Classification, considering future possible extension, which is the road classification for an access-controlled expressway in ASEAN Highway Standards. The outline of the preliminary design for the New Sittaung Bridge is described in this chapter.

7.2 Design Standards and Codes

Prior to the execution of the preliminary design, each design criteria was established for the design of the New Sittaung Bridge. In the 2nd Technical Committee held on 24th October 2017, each design criteria and condition was approved.

7.2.1 Design Standards and Codes for Road Design

The principle design standard for the road design of the New Sittaung Bridge is:

- ASEAN Highway Standards (Oct 9, 2012)

The following design standards are complementally applied for the road design of the New Sittaung Bridge.

- Road Design Criteria in Myanmar, Department of Highways, Ministry of Construction, 2015
- Japanese Expressway Design Criteria

7.2.2 Design Standards and Codes for Bridge Design

The principle design standards for the bridge design of the New Sittaung Bridge are:

- Specification for Highway Bridges (Japan Road Association, 2012) (hereunder “JSHB2012”)
- AASHTO LRFD Bridge Design Specifications (2010, 5th edition)

The bridge design shall be conducted based on the above design standards. It is noted that live loading is applied in accordance with AASHTO guidelines, and other design loads such as earthquake, temperature, wind, etc., are applied in accordance with the JRA specifications considering local conditions.

7.2.3 Geometric Design Condition

Geometric design criteria in ASEAN Highway Standards and MOC's Road Design Criteria, and the adopted value for the design of the New Sittaung Bridge are shown in Table 7.2.1.

Table 7.2.1 Geometric Design Criteria and Adopted Value

	Road Design Criteria (MOC)	ASEAN Highway Standards	Adopted Value	Remark
Design Speed	120 km/h	120 km/h	120 km/h	
Classification	Expressway	Primary	Primary	
Area	Rural	-	Rural	
Terrain	Level	Level	Level	
Vertical Clearance	5.0m	4.5m	5.5m	• Request from MOC
Min Horizontal Curve Radius	600m	390m	Straight	• No horizontal curve in bridge section
Min Horizontal Curve Length	140m	-	-	• No horizontal curve in bridge section
Min Transition Curve Length	70m	-	-	• No horizontal curve in bridge section
Max Superelevation	10%	7% (Rural) 6% (Urban)	-	• No superelevation in bridge section
Stopping Sight Distance	250m	-	250m	• Apply MOC Criteria
Max Vertical Grade	3%	4%	3%	• Considering heavy vehicles
Min Vertical K Value (Crest)	95	-	95	• Apply MOC Criteria
Min Vertical K Value (Sag)	63	-	166	• Apply MOC Criteria

Source: ASEAN Highway Standards, MOC Road Design Criteria

7.2.4 River Conditions

Based on the results of bathymetric survey and hydraulic assessment described in Chapter 6, the following river conditions were established. As for the necessary free board for the New Sittaung Bridge, the equivalent free board to the existing Sittaung Bridge (Mokepalin) is secured for the Main Bridge, and then the free board for approach bridge is determined by design peak flow rate (=16,600 m3/sec) in accordance with Government Ordinance for Structural Standards for River Administration Facilities (Japan River 2000).

Table 7.2.2 Comparison table for Preliminary Bridge Type Selection of Main Bridge

Item		Applied Condition	Remark
H.W.L	100yrs return period	9.1m (M.S.L)	Both bridge and road embankment
Required Free broad	Main Bridge	6.1m	Refer to the free board of existing Sittaung Bridge (Mokepalin)
	Approach Bridge	2.0m	According to Table 7.2.3
River Width		Approx. 840m	

Source: JICA Study Team

Table 7.2.3 Required Free Board Under Bridge Girder (Reference)

Item	1	2	3	4	5	6
Design Peak Flow Rate Q (m3/sec)	＜200	200≦Q<500	500≦Q<2,000	2,000≦Q<5,000	5,000≦Q<10,000	10,000＜
Free Board	0.6m	0.8m	1.0m	1.2m	1.5m	2.0m

Source: Prepared by JICA Study Team based on Government Ordinance for Structural Standards for River Administration Facilities (Japan River 2000)

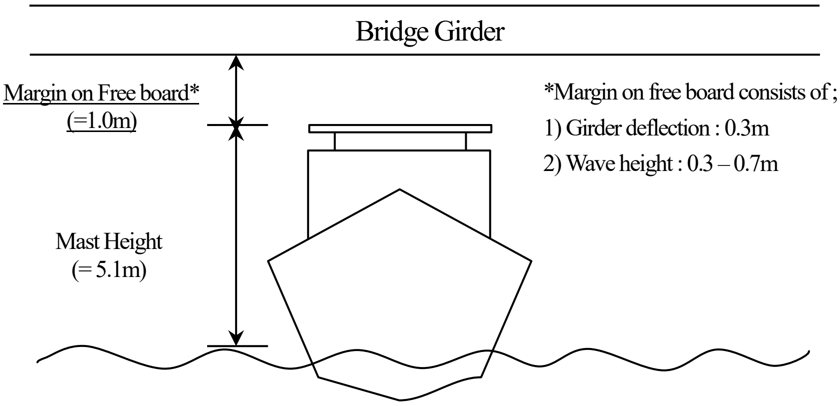
< Verification of Free Board in the Sittaung River >

The free board for main bridge(=6.1m) has been verified in the following survey conducted by the JICA Study Team. Three types of vessels were identified along the Sittaung River and the mast height of vessels is summarized in Table 7.2.4. It is verified that the free board of 6.1m is reasonable as shown in Figure 7.2.1.

Table 7.2.4 Required Free Board Under Bridge Girder (Reference)

Type of Vessel	Cargo Ship	Ferry Boat	Sand Suction Ship
Picture			
Mast Height	3.1m	4.6m	5.1m

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2.1 Free Board for Main Bridge

7.2.5 Vertical Clearance for Crossing Railway

The existing railway to Mawlamyine crosses the New Sittaung Bridge alignment as shown in Figure 7.2.2. Vertical clearance for the railway crossing is 19 feet 6 inches (approximately 6m) from the top surface of the railway which was directed by the Myanmar Railways (MR) through an official letter dated on 10th Oct 2017 (See Appendix1.5).

Source: JICA Study Team (Left) / Prepared by JICA Study Team based on Google Earth (Right)

Figure 7.2.2 Locations of Existing Railway and Proposed Vertical Clearance

7.2.6 Design Loads

(1) Dead Load

Dead loads including the weight of all components of the structure and facilities are calculated based on those prescribed in JSHB 2012 as shown in Table 7.2.5.

Table 7.2.5 Unit Weights for Dead Load Calculation

Material	Unit Weight (kN/m^3)
Steel	77.0
Plain Concrete	23.0
Reinforced Concrete	24.5
Prestressed Concrete	24.5
Asphalt Pavement	22.5

Source: Prepared by JICA Study Team based on JSHB 2012

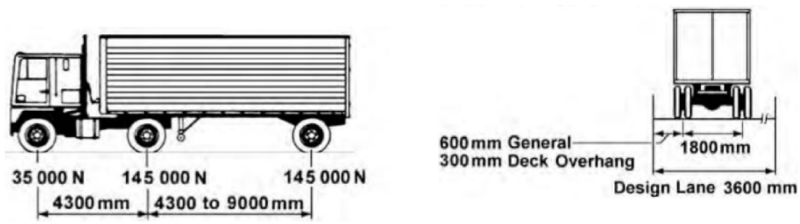
(2) Live Load

According to ASSHTO LRFD and direction by MOC, the following live loads shall be considered for bridge design:

① **HL-93** (Combination of the Design Truck (HS20-44) or Design Tandem, and Design Lane Load)

a) Design Truck

The loading combination for spacing of wheels and axles of the design vehicle specified in AASHTO LRFD is the layout given in Figure 7.2.3.



Source: AASHTO LRFD

Figure 7.2.3 Design Truck (HS20-44) by AASHTO LRFD

b) Design Lane Load

The design lane load is a uniform linear load of 9.3 kN/m in longitudinal direction. Transversely, the design lane load shall be assumed to be uniformly distributed over a 3.0m width.

② **HS 25** (Only truck load)

HS25 with a gross vehicle weight of 40.8 ton (≒900,000 lb), which is 25% greater than the truck load of HS20-44 (720,000 lb), shall be considered for design by MOC's direction . The load is not combined with the lane load.

(3) Wind Load

The design wind speed is determined in conformity with Myanmar National Building Code (2016) (hereunder MNBC 2016). Among the basic wind speeds for Bago, Hpa-An and Mawlamyine nearby the project site, the maximum basic wind speed, 40m/s (90mph) for Mawlamyine, is employed as the design wind speed of New Sittaung Bridge.

Sr	City/Town	Basic Wind Speed (mph)
1	Bago	80
2	Bhamo	70
3	Bogalay	100
4	Chauk	70
5	Dawei	90
6	Falam	70
7	Hakha	90
8	Henzada	90
9	Homalin	50
10	Hpa-An	70
11	Kale	70
12	Kawthaung	90
13	Kengtung	70
14	Kyaukpyu	130
15	Lashio	70
16	Loikaw	70
17	Magwe	70
18	Mandalay	80
19	Mawlamyine	90
20	Meiktila	70
21	Monywa	70
22	Muse	70
23	Myeik	90
24	Myitkyina	70
25	Nansam	70
26	Naypyitaw	70
27	Pakokku	70
28	Pathein	100
29	Putao	70
30	Pyay	70
31	Sittwe	130
32	Taungyi	70
33	Thandwe	130
34	Yangon	100
35	Ye	90
36	Yenangyaung	70

Note: For cities note included in the table, wind speed of the nearest city in the list shall be used.

Source: Myanmar National Building Code 2016

Figure 7.2.4 Basic Wind Speed

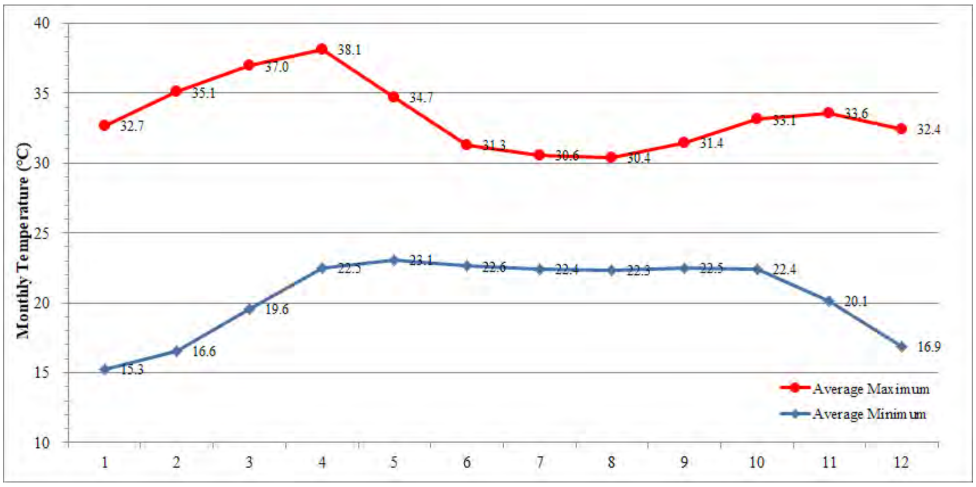
(4) Temperature

The design temperature was determined by the monthly average temperature in the past 20-26 years at 5 stations (Kaba Aye/Bago/Tharrawady/Shwegyin/Belin), which is 15.3 degrees Celsius to 38.1 degrees Celsius as shown in Figure 7.2.5. The temperature range to be used in design is shown in Table 7.2.6.

Table 7.2.6 Design Temperature for New Sittaung Bridge

Item		Description	Remark
Mean Temperature		25℃	
Main Structure	PC, RC	+15℃ to +40℃ Relative difference between members : 5℃	Based on the past observed temperature
	Steel	+5℃ to +50℃ Relative difference between members : 15℃	±10℃ to PC, RC
Bearing and Exp.	PC, RC	+10℃ to +45℃	Main structure±5℃ (refer to JSHB)
	Steel	+5℃ to +50℃	Same as main structure (refer to JSHB)

Source: JICA Study Team



Source: JICA Study Team

Figure 7.2.5 Average Maximum and Minimum Temperature

7.2.7 Seismic Design and Force

Seismic design of New Sittaung Bridge shall be conducted in accordance with JSHB 2012.

The design maximum earthquake with 1000 years of return period[1] is employed as "Level 2 earthquake" which is equivalent to the "Level 2 earthquake" in JSHB. Thus, the following multiple design earthquake and seismic performance are defined for the Project in conformity with JSHB 2012 as shown in Table 7.2.7. It is noted that the design earthquake for Level1 (earthquake which may occur once or twice during the service period) is determined by JHSB 2012

Table 7.2.7 Design Earthquake and Seismic Performance for New Sittaung Bridge

Design Earthquake		Seismic Performance	
Level1	by JSHB 2012	Level1	Bridge is expected to be No Damage by possible maximum earthquake during the service period.
Level2	1000 years return period	Level2	Limited Damage is allowed by considered maximum earthquake (Limited plastic deformation is allowed only for the selected structural members where easy (urgent) recovery can be secured)

Source: JICA Study Team

7.2.8 Rainfall Intensity for Drainage Design

190 mm/hour (10 minutes intensity in 3 years return period) is employed for design rainfall intensity according to

[1] It is linearly assumed from the maximum considered earthquakes specified by both of MNBC2016 (2500 yrs return period) and MNBC2012(475yrs return period)

the Intensity-Duration-Frequency (IDF) estimated based on the observed data in the past 13-52 years as shown in Table 6.2.8.

7.2.9 Soil Conditions

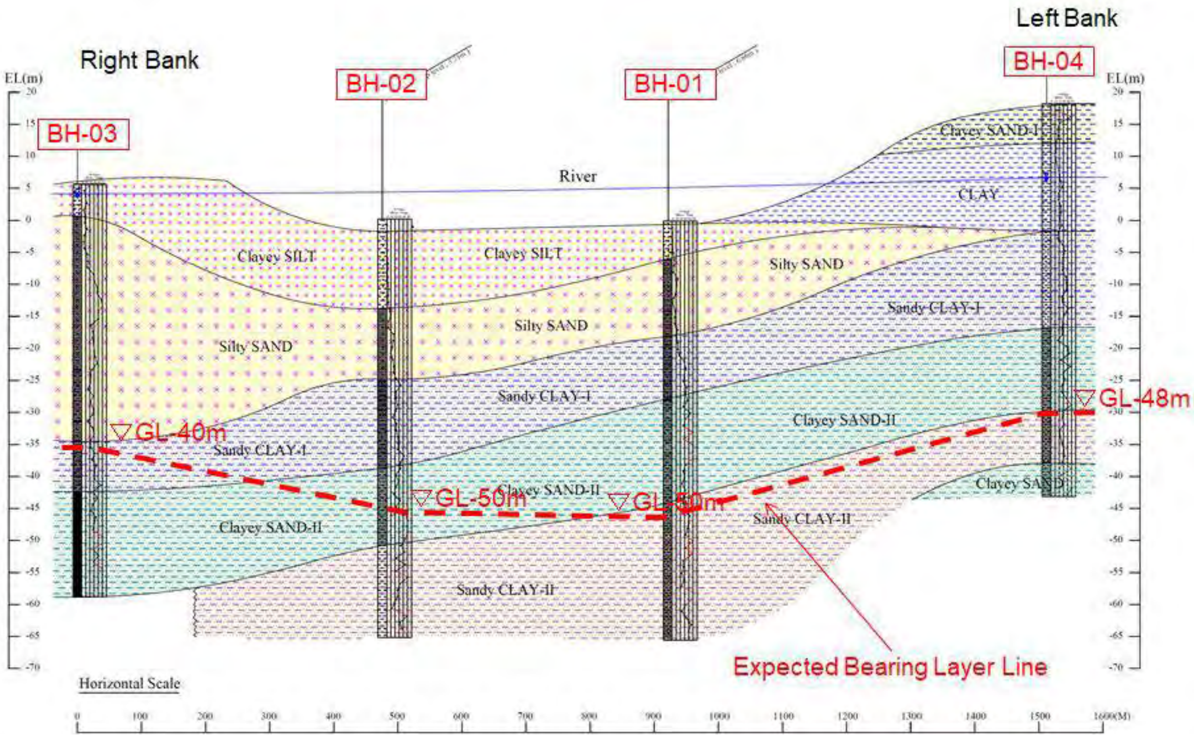
Based on the soil investigation survey carried out in this Study, the following soil conditions for preliminary design were developed.

(1) Bearing Layer

According to the JSHB2012, the bearing layer should satisfy the following conditions:

- For the cohesive layer, N value is 20 or more and unconfined compression strength is 0.4 N/mm2 or more
- For sand and/or gravel layer, N value is 30 or more

Considering the above conditions, it is expected that the bearing layer spreads at 40m to 50m under the ground surface as shown in Figure 7.2.6.



Source: JICA Study Team

Figure 7.2.6 Expected Bearing Layer

(2) Design Soil Property

Based on the results of standard penetration tests and laboratory tests, the design soil property was established as shown in Table 7.2.8 to Table 7.2.11.

Table 7.2.8 Design Soil Property for Approach Bridge on the Right Bank (A1 to PR5)

Soil Layer	Thickness	N Value (Mean)	Unit weight	Adhesion	Internal friction angle	Deformation Coefficient
	m		kN/m3	kN/m2		kN/m2
Clayey silt	5.0	8	18.0	48	―	22,400
Silty sand	35.0	24	18.0	―	30	67,200
Sandy clay-I	8.0	30	18.0	180	―	84,000
Clayey sand II	16.42	39	20.0	―	30	109.,200

Source: JICA Study Team

Table 7.2.9 Design Soil Property for P1 to P5 of Main Bridge

Soil Layer	Thickness	N Value (Mean)	Unit weight	Adhesion	Internal friction angle	Deformation Coefficient
	m		kN/m3	kN/m2		kN/m2
Clayey silt	14.0	2	16.0	12	―	5,600
Silty sand	11.0	12	17.0	―	30	33,600
Sandy clay-I	14.0	26	18.0	156	―	72,800
Clayey sand II	12.0	35	20.0	―	30	98.,000
Sandy Clay II	14.37	34	18.0	204	―	95,200

Source: JICA Study Team

Table 7.2.10 Design Soil Property for P6 to P9 of Main Bridge

Soil Layer	Thickness	N Value (Mean)	Unit weight	Adhesion	Internal friction angle	Deformation Coefficient
	m		kN/m3	kN/m2		kN/m2
Clayey silt	6.0	1	14.0	6	―	2,800
Silty sand	12.0	7	17.0	―	30	19,600
Sandy clay-I	10.0	24	18.0	140	―	67,200
Clayey sand II	17.0	5	20.0	―	30	98.,000
Sandy Clay II	20.45	36	18.0	210	―	100,800

Source: JICA Study Team

Table 7.2.11 Design Soil Property for Approach Bridge on the Left Bank (PL1 to A2)

Soil Layer	Thickness	N Value (Mean)	Unit weight	Adhesion	Internal friction angle	Deformation Coefficient
	m		kN/m3	kN/m2		kN/m2
Clayey sand-I	6.0	17	18.0	―	35	47,600
Clay	14.0	20	17.0	65	―	20,000
Silty clay-I	15.0	30	18.0	180	―	84,000
Clayey sand II	13.0	32	19.0	―	30	89,600
Sandy clay-II	8.0	28	18.0	168	―	78,400
Clayey Sand	5.3	40	20.0	―	30	112,000

Source: JICA Study Team

7.3 Bridge Planning for New Sittaung Bridge

7.3.1 Policy of Bridge Planning

As shown in Figure 7.3.1, the New Sittaung Bridge can be divided into 3 sections as follows:

- Main Bridge Section: Span length will be more than 100m.
- Approach Bridge (Right bank side): Span length will be about 30~50m.
- Approach Bridge (Left bank side): Span length will be about 30~50m.

Source: JICA Study Team

Figure 7.3.1 Component of New Sittaung Bridge

Since the required span lengths are different in both the Main Bridge and Approach Bridges (Right bank and Left bank), bridge planning shall be carried out for both the Main Bridge and Approach Bridges.

7.3.2 Bridge Planning for Main Bridge

(1) Basic Policy

Bridge type study for Main Bridge was carried out by the following two steps:

- Step 1: Preliminary Bridge Type Selection:

  Based on general characteristics and experiences, candidate bridge types (more than 3 types) shall be preliminarily extracted from possible bridge types.

- Step 2: Secondary Bridge Type Selection:

  Bridge type shall be finally selected based on the detailed comparative study for the candidate bridge types selected in the preliminary bridge type selection.

(2) Span Arrangement in the River

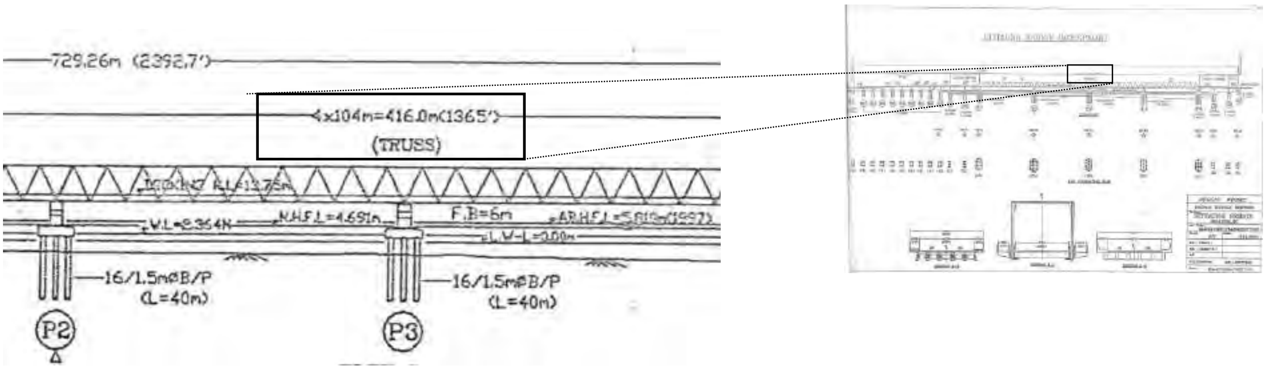
Specific necessary navigation clearance is not defined for the Sittaung River, the suitable span length in the river is proposed to be 105m to 110m by the following reasons:

➢ Since the Sittaung River is not used as a water way, there is no specification of navigation clearance, thus, the minimum span length is desirable to follow the existing Sittaung Bridge

(Mokepalin), which is 104m as shown in Figure 7.3.2.

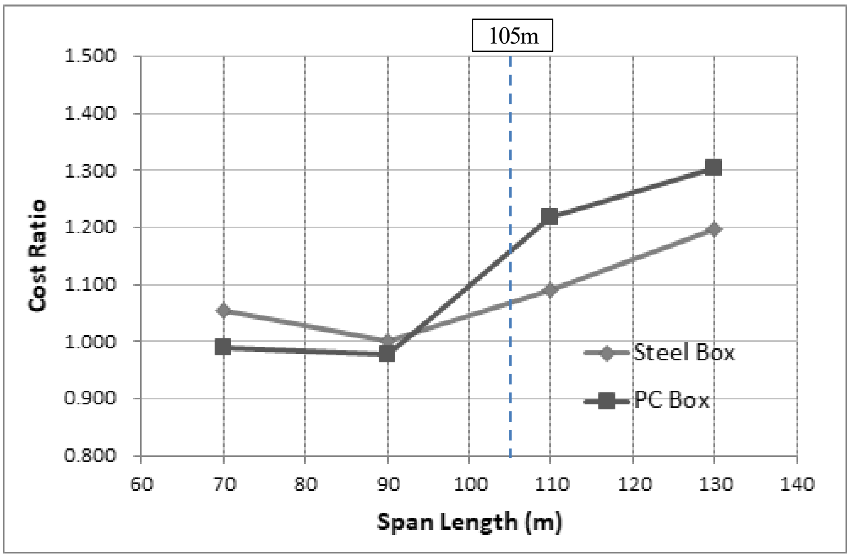
- As the result of the case study shown in Figure 7.3.3, 105 to 110m span is an economically reasonable option
- The proposed span length is desirable in order to effectively mitigate river flow block by piers

In addition, the proposed minimum span length (=104m) has been approved in the official letter issued on 17 October 2017 by DWIR (See Appendix 1.3).



Source: JICA Study Team

Figure 7.3.2 Span Length of Existing Sittaung Bridge (Mokepalin)



Source: JICA Study Team

Figure 7.3.3 Study on Economical Span Length of New Sittaung Bridge

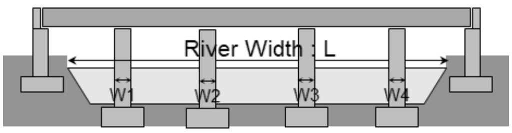
(Reference) Japanese Regulation for Bridge Piers in River

In order to effectively mitigate river flow block by piers, no. of piers is regulated in Japan by the concept of "Ratio of Total Pier Width against River Width". Essentially, the ratio should be 5% or less, which is calculated by the following formula.

Ratio of Total Pier Width against River Width = $\Sigma W \div L$

Where, L : River width (m) (=855m)

ΣW : Total width of piers in river



In case of 90 meters span, the total pier width is 43.6 meters so that the ratio is approximately 5.1 % (> 5.0%)

In case of 105 meters span, the total pier width is 38.2 meters so that the ratio is approximately 4.5% (< 5.0%)

(3) Preliminary Bridge Type Selection for Main Bridge

As described in the previous section, the span length of the New Sittaung Bridge is planned to be between 105m and 110m in order to secure the span length of the existing Sittaung Bridge (Mokepalin) and to effectively mitigate river flow blockage by piers in the river as well as to be economically eligible. The bridge type selection was conducted by narrowing down from the applicable bridge types (Preliminary Bridge Type Selection) for the proposed span length to the optimum bridge type selection (Secondary Bridge Type Selection). At this stage, 2 to 3 possible alternatives were extracted for each concrete and steel bridge.

The comparison table for the preliminary bridge type selection for the main bridge is shown in Table 7.3.1.

First, alternatives 4 and 5 was excluded since they are considered to be economically unreasonable compared to alternative 1[2].

As for alternative 8, girder erection is usually executed by the cable erection method or bulk erection method using floating cranes. The former erection method is quite economically unreasonable if applied to the site and the latter method is inapplicable at the site because a sufficient towing route / draft for floating cranes cannot be secured.

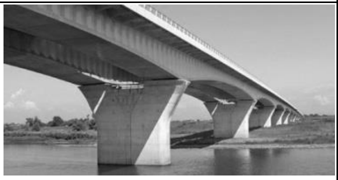
In addition, alternative 2 would be a technically challenging application at the site since there are only two practices even in Japan where the necessary span length is more than 100m and no practice in the shore area where salt damage is a concern.

As a result, the following bridge types were extracted for the Secondary Bridge Type Selection.

- PC Box Girder
- PC Box Girder with Steel Web (Corrugated Steel Web)
- Steel Narrow Box Girder with Composite Deck Slab
- Steel Box Girder with Steel Deck Slab
- Steel Truss with Composite Deck Slab

[2] According to the past practices in Japan, construction cost for alternatives 4 and 5 is 1.67 times and 1.91 times higher than that of alternative 1 in the bridge span range between 105m and 110m.

Table 7.3.1 Preliminary Bridge Type Selection of Main Bridge

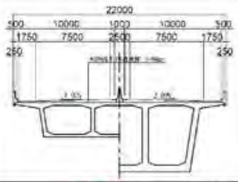
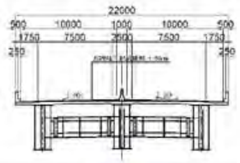
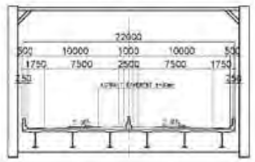
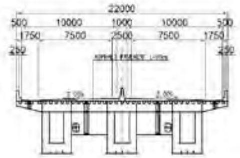
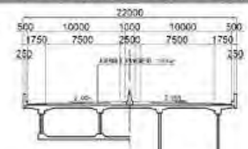
No.	Bridge Type	Schematic View	Applicable Span Length	Evaluation
1	PC Box Girder		50~170m (Balanced cantilever method)	**Selected**
2	PC Box Girder with Steel Truss Web		50~110m (Balanced cantilever method)	Not Selected (No past application the shore area)
3	PC Box Girder with Corrugated Steel Web		50~150m (Balanced cantilever method)	**Selected**
4	PC Extra-dosed Bridge		100~200m (Balanced cantilever method)	Not selected (uneconomical option)
5	PC Cable Stayed Bridge		100~250m (Balanced cantilever method)	Not selected (uneconomical option)
6	Steel Narrow Box Girder with Composite Deck Slab		80~110m (Launching girder method)	**Selected**
7	Steel Box Girder with Steel Deck Slab		40~150m (Launching girder method)	**Selected**
8	Steel Arch		60~200m (Cable crane method)	Not selected (difficulty in erection)
9	Steel Truss with Composite Deck Slab		60~120m (Traveler crane method)	**Selected**

Source: JICA Study Team

(4) Secondary Bridge Type Selection for Main Bridge

A comparison table for the secondary bridge type selection for the main bridge is shown in Table 7.3.2. As shown in Table 7.3.2, the "Steel Narrow Box Girder with Composite Deck Slab" structure type was selected since this type is the most economical, has the shortest construction period, and new technology can be introduced to Myanmar. The bridge type was approved in the 2nd T/C on 24th October 2017.

Table 7.3.2 Secondary Bridge Type Selection of Main Bridge

Evaluation Item	Alternative-1 PC Box Girder Bridge		Alternative-2 Steel Narrow Box Girder with Composite Deck Slab		Alternative-3 Steel Truss with Composite Deck Slab		Alternative-4 Steel Box Girder with Steel Deck Slab		Alternative-5 PC Box Girder with Steel Web (Corrugated Steel Web)	
View										
Construction Cost	1.15	△	1.00	◎	1.06	○	1.07	○	1.01	◎
Construction Period	4.5 years	△	3.5 years	◎	4.0 years	○	3.5 years	◎	4.2 years	△
Structural Aspect	- High durability (PC girder, PC slab and by application of epoxy-coated re-bars)	◎	- Durability can be greatly enhanced by Heavy Anticorrosion Coating - Composite Slab has higher durability than conventional RC deck slab.	○	- Durability can be greatly enhanced by Heavy Anticorrosion Coating. - Composite Slab has higher durability than conventional RC deck slab	○	- Durability can be greatly enhanced by Heavy Anticorrosion Coating. - Careful consideration is necessary for pavement on steel deck slab	○	- High durability (PC girder, PC slab and by application of epoxy-coated re-bars) - No practical application on the sea side where heavy salt damage is a concern.	△
Maintenance	- Replacement of bearings and expansion joints are necessary as well as daily maintenance.	○	- Repainting is necessary as well as replacement of bridge accessories and daily maintenance.	△	- Repainting is necessary as well as replacement of bridge accessories and daily maintenance.	△	- Repainting and careful maintenance of pavement are necessary as well as replacement of bridge accessories and daily maintenance.	△	- Repainting is necessary and careful maintenance of the connection of slab and web are necessary as well as replacement of bridge accessories	△
New Technology	- N/A	△	- Narrow steel box girder - Composite steel deck slab	◎	- Composite steel deck slab	○	- N/A	△	- PC Box Girder with Corrugated Steel Web	○
Evaluation	Less recommended		**Recommended**		Less recommended		Less recommended		Less recommended	

◎ : Excellent ○ : Good △ : Moderate ✕ : Not good or Inapplicable

Note) For bridge type selection, separate 2-lane bridge is assumed. Blue colored description is "advantage" Red colored description is "disadvantage"

Source: JICA Study Team

(5) Study on Bridge Cross Section

Based on the bridge type study result for the main bridge, details of the bridge cross section (Integrated Section or Separated Section) was studied.

Since the location of the New Sittaung Bridge is at an open space where high velocity wind occurs and the span length of main bridge is 105m, resistance to wind should be studied carefully.

For this study, resistance to wind was studied in accordance with “Design Specification for Wind Resistance for Road Bridge” issued by the Japan Road Association at December 2007. According to this specification, the types of phenomena to be studied shall be different based on the types of bridges as shown in Table 7.3.3. Since the bridge type of the main bridge is “Steel Narrow Box Girder with Composite Deck Slab”, Divergence Vibration for flection (Galloping) and Vortex-induced Vibration for Deflection were studied.

Table 7.3.3 Phenomena to be studied based on Bridge Type

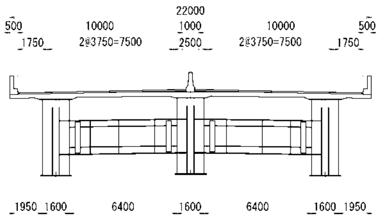
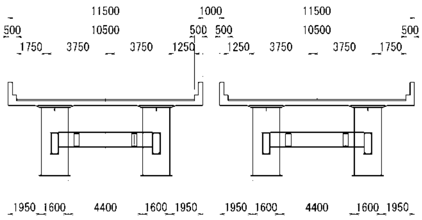
Bridge Type \ Phenomena			Divergence Vibration		Vortex Excitation-induced	
			Deflection	Torsion	Deflection	Torsion
Suspension Bridge / Cable Stayed Bridge	Truss		N/A	A	N/A	N/A
	Box Girder	Steel	A	A	A	A
		Concrete	N/A	A	A	A
Steel Girder	Box		A	N/A	A	N/A
	I-Shape		A	A	A	A

Note: A: Applied N/A: Not Applied

Source: Design Specification for Wind Resistance for Road Bridge (Japan Road Association, December 2007)

Based on the study result shown in Table 7.3.4, the integrated type shall be applied for the Main Bridge since the separated type cannot satisfy the required wind resistance.

Table 7.3.4 Study Result and Comparison Table for Bridge Cross Section for Main Bridge

Item	Integrated Type		Separated Type	
Cross Section				
Superstructure Weight	1.00	◎	1.07	○
Wind Resistance Performance	■ **Galloping: U_{cg} > Urg OK** U_{cg}: Wind velocity of galloping – induced 131 m/s U_{rg}: Criterion wind velocity 52.3 m/s ■ **Vortex Excitation: U_{cvh} > U_{rvh} OK, hc < ha OK** U_{cvh}: Wind velocity of vortex excitation-induced 49.3 m/s U_{rvh}: Design wind velocity 43.6 m/s hc: Amplitude of vortex excitation-induced 0.030 ha: Allowable amplitude 0.036	○	■ **Galloping: U_{cg} > Urg OK** U_{cg}: Wind velocity of galloping – induced 117 m/s U_{rg}: Criterion wind velocity 59.6 m/s ■ **Vortex Excitation: U_{cvh} < U_{rvh} NG, hc >ha** OK U_{cvh}: Wind velocity of vortex excitation-induced 23.0 m/s U_{rvh}: Design wind velocity 49.7 m/s hc: Amplitude of vortex excitation-induced 0.039 ha: Allowable amplitude 0.040	×
Evaluation	**Recommended (Applicable)**		Inapplicable	

◎ : Excellent ○ : Good △ : Moderate × : Not good or Inapplicable

Source: JICA Study Team

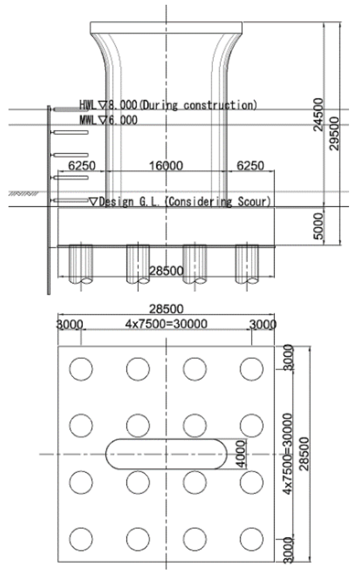
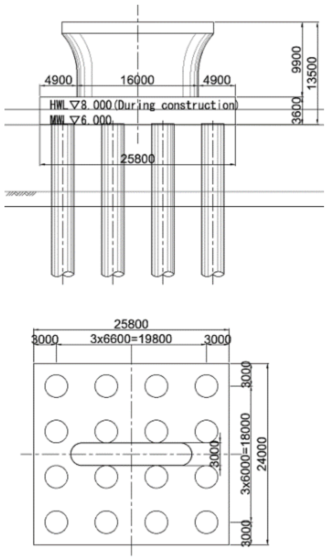
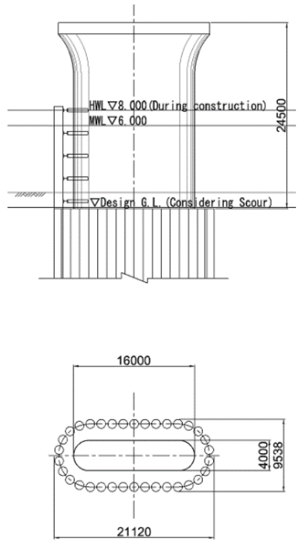
(6) Foundation Type of Main Bridge

Since the main bridge is located inside the river area and a large bearing capacity is required because of the large span length of more than 100m, the applicable foundation types are 1) Cast-in-place Concrete Pile (Diameter=3.0 m) and 2) Steel Pipe Sheet Pile. In addition, pile bent type foundation, which is very common in Myanmar and can avoid cofferdam installation and excavation inside rivers, is added.

According to the results of soil investigation surveys, good-quality bearing layer (N value is more than 50) cannot be found. Moreover, the mean N value of each layer at all four bore holes is not uniform. Therefore, the expected bearing layer is decided based on the observed N values distribution in each bore holes, not by soil layer as shown in Figure 7.2.6.

Considering the above conditions, a comparative study was carried out. As a result of the study, the "Steel Pipe Sheet Pile" type is recommended to be applied as foundation type for Main Bridge since it is most economical option.

Table 7.3.5 Comparative Study of Foundation Type for Main Bridge

	Alt-1 Cast-in-Place Concrete Pile (Diameter=3.0 m)		Alt-2 Multiple-pile Foundation (Diameter=3.0 m)		Alt-3 Steel Pipe Sheet Pile (Diameter=1.2m)	
View						
Construction Cost	1.56	△	1.17	△	1.00	◎
Construction Period	15 months	△	11 months	○	13 months	○
Evaluation	Not Recommended (Expensive option)		Not Recommended (Expensive option)		**Recommended** **(Most economical)**	

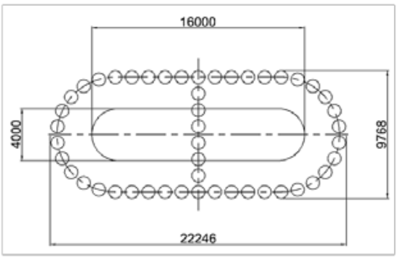
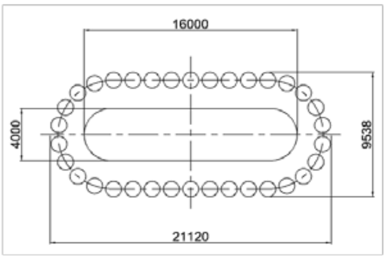
◎ : Excellent ○ : Good △ : Moderate × : Not good or Inapplicable

Source: JICA Study Team

(7) Study on Pile Diameter for Steel Pipe Sheet Pile

In order to select the most economical and shortest construction period, a comparative study on the pile diameter for steel pipe sheet pile was carried out as shown in Table 7.3.6. As a result of the study, a diameter of 1200mm is recommended since this type is most economical and the shortest construction period.

Table 7.3.6 Comparison of Pile Diameter for Steel Pipe Sheet Pile

Evaluation Item		Alternative 1			Alternative 2		
		Dia 1000mm SKY490 , L=55.0m			Dia 1200mm SKY490 , L=55.0m		
Schematic View		 Outer part : n=42 , Bulkhead part : n=6			 Outer part : n=34 , Bulkhead part : n=0		
Calculation Result	Longitudinal direction	Pnmax<Ra (kN)	3125 < 3427	91%	Pnmax<Ra (kN)	3473 < 3929	88%
		δfx<δa (mm)	19.93 < 50.00	40%	δfx<δa (mm)	17.91 < 50.00	36%
		σs<σsa (N/mm2)	181.65 < 277.50	65%	σs<σsa (N/mm2)	191.72 < 277.50	69%
	Transverse Direction	Pnmax<Ra (kN)	3125 < 3427	91%	Pnmax<Ra (kN)	3473 < 3929	88%
		δfx<δa (mm)	14.03 < 50.00	28%	δfx<δa (mm)	15.43 < 50.00	31%
		σs<σsa (N/mm2)	210.07 < 277.50	76%	σs<σsa (N/mm2)	228.87 < 277.50	82%
Construction Cost*		Ratio = 1.15		○	Ratio = 1.00		◎
Construction Period*		- Construction period: 15month		○	- Construction period: 13month		◎
Evaluation		Not Recommended			**Recommended**		

◎: Excellent, ○Good, △Moderate, × Not Good
*Icluding Pier Column

Source: JICA Study Team

7.3.3 Bridge Planning for Approach Bridge

(1) Preliminary Bridge Type Selection for Approach Bridge

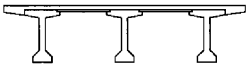
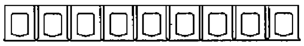
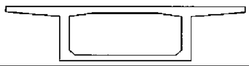
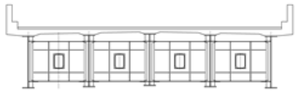
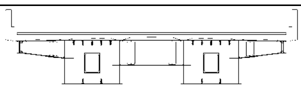
Since there is no large size of crossing structure, 30 to 50m span length of bridge is economically reasonable for Approach Bridge. At first, 3 alternatives, which are the PC pre-casted girder, the PC cast-in-situ girder and the steel girder, for the secondary bridge type selection, were extracted among the possible bridge types as shown in Table 7.3.7.

At the preliminary bridge type selection, alternative 2 was excluded since it is inferior to alternative 1 in regard to construction cost due to the heavier weight of the superstructure which may result in a larger configuration of substructure and foundation[3]. For the same reason, alternative 5 was excluded among the candidates for the steel girders[4]. As a result of the preliminary bridge type selection, the following bridge types were extracted for the secondary bridge type selection.

- PC-I Girder Bridge
- PC Box Girder Bridge
- Steel-I Girder Bridge

[3] Construction cost of alternative 2 is 1.11 times higher than that of alternative 1.
[4] Superstructure weight of alternative 5 is 1.55 times heavier than that of alternative 4.

Table 7.3.7 Comparative Study of Bridge Type of Approach Bridge

No.	Bridge Type	Schematic View	Applicable Span Length	Evaluation
1	PC-I Girder (Pre-casted)		20 – 40m	**Selected**
2	PC Hollow Slab Girder (Pre-casted)		25 – 40m	Not selected (Uneconomical against No.1)
3	PC Box Girder (Cast-in-situ)		30 – 60m	**Selected**
4	Steel-I Girder		30 – 60m	**Selected**
5	Steel Box Girder		40 – 80m	Not selected (Uneconomical against No.4)

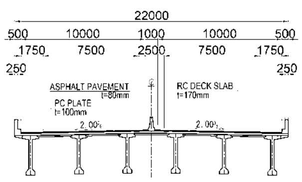
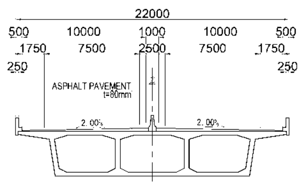
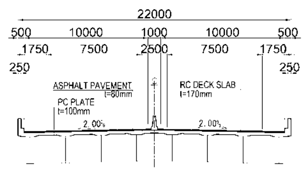
Source: JICA Study Team

(2) Secondary Bridge Type Selection for Approach Bridge

The comparison table for the secondary bridge type selection for approach bridge is shown in Table 7.3.8.

"PC-I Girder Bridge" was selected since this type is the most economical option. The bridge type was approved in the 2nd T/C on 24th October 2017.

Table 7.3.8 Comparison table for Superstructure Type Selection of Approach Bridge

Evaluation Item	PC-I Girder Bridge (Span : 40m)		PC Box Girder Bridge (Span : 50m)		Steel-I Girder Bridge (Span : 40m)	
View						
Construction Cost	1.00	◎	1.28	△	1.16	△
Construction Period	2.0 years	◎	2.5 years	○	2.0 years	◎
Structural Aspect	-Applicable span length: 20~40m -Moderate weight -High durability (PC girder, PC composite)	○	-Applicable span length: 30~60m -Heavy weight -High durability (PC girder, PC slab)	○	-Applicable span length: 30~60m -Light weight -Durability can be much enhanced by Heavy Anticorrosion Coating.	◎
Maintenance	-Replacement of bearings and expansion joints are necessary as well as daily maintenance.	○	-Replacement of bearings and expansion joints are necessary as well as daily maintenance.	○	Repainting is necessary as well as replacement of bridge accessories and daily maintenance.	△
Evaluation	**Recommended**		Not recommended		Not recommended	

◎ : Excellent ○ : Good △ : Moderate ✕ : Not good or Inapplicable

Note) Blue colored description is "advantage" Red colored description is "disadvantage"

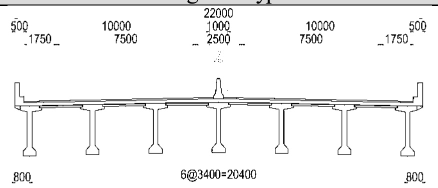
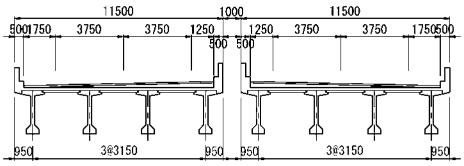
Source: JICA Study Team

(3) Study on Bridge Cross Section

Based on the result of the bridge type study for the approach bridge, detail of bridge cross section (Integrated Section or Separated Section) was studied. "Integrated Type" is recommended by the following aspects:

- Difference of dead load in both alternatives is quite small (only 3%) so that the effect on the configuration of substructures and foundations is negligible.
- "Alt-1 Integrated structure" can provide sufficient width for special vehicles which needs to meander when passing on the road.

Table 7.3.9 Study Result and Comparison Table for Bridge Cross Section for Approach Bridge

Item	Integrated Type	Separated Type
Cross Section		
Superstructure Weight	390 kN/m (1.00)	402 kN/m (1.03)

Source: JICA Study Team

(4) Foundation Type of Approach Bridge

The following condition should be taken into account for the extraction of alternatives;

- <u>Loading Level</u> : Normal (PC-I Girder/Max. span 40 m)
- <u>Depth of Supporting Layer</u> : G.L -26 m to 34 m (Soil investigation survey results at Pre-F/S)
- <u>Soil Condition of Supporting Layer</u> : Clay ($20 \leq N$)
- <u>Water Level on Land</u> : Water level is nearly ground level

According to Table 7.3.10, all the foundations can be applied as the foundation type of approach bridge. However, the Diaphragm Wall Foundation, Steel Pipe Sheet Pile and Concrete Caisson could be more economical than the other pile foundation types, only if the restricting condition must be considered, for example, the foundation configuration is controlled by adjacent structures, a large-scale cofferdam in the river is necessary or the loading level is quite large, etc. Since there is no such conditions at the approach bridge location, these foundation types are excluded from the alternatives. Also, the foundation types and Steel Pipe Pile are less economical than Cast-in-place RC pile and PHC Pile, because the equipment and materials necessary must be imported from overseas while those for the Cast-in-place RC pile and PHC Pile can be procured from the local market. Hence, the two alternatives below are nominated for the comparative study on foundation type of approach bridge.

Alternative 1 : Cast-in-place RC Pile

Alternative 2 : PHC Pile

Table 7.3.10 Possible Foundation Type for Approach Bridge

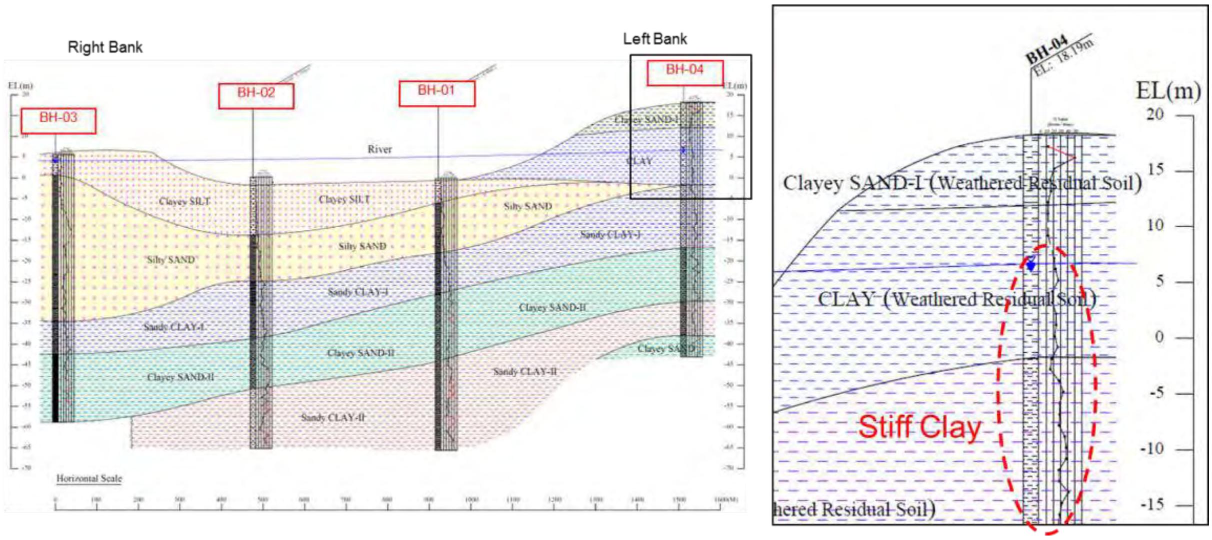
Criteria		Applicable Foundation Type	Cast- in-place RC Pile	PHC Pile	Steel Pipe Pile	Diaphragm wall	Steel pipe sheet pile	Concrete Caisson
Condition of Construction	Construction on River/Sea	Water Depth < 5 m	×	△	△	×	○	△
		Water Depth > 5 m	×	△	△	×	○	△
	Construction Yard	Narrow/Limited	△	△	△	△	×	△
	Environment	Vibration, Noise	○	△	△	○	×	○
		Impact on Adjacent Structure	○	△	△	○	△	△
		Harmful Gas	○	○	○	○	○	○
	Loading Level	Small (Span < 20 m)	○	○	○	×	×	○
		Normal (20 m ≦ Span < 50 m)	○	○	○	○	○	○
		Large (50 m < Span)	○	△	○	○	○	○
		Vertical Load > Sway Load	○	○	○	△	△	△
		Vertical Load < Sway Load	○	○	○	○	○	○
Ground Condition	Depth of Supporting Layer from Ground Level	< 5 m	△	×	×	×	×	×
		5 ~ 15 m	○	○	○	△	△	○
		15 ~ 25 m	○	○	○	○	○	○
		25 ~ 40 m	○	○	○	○	○	○
		40 ~ 60 m	○	△	○	○	○	○
		≥ 60 m	△	×	×	△	△	△
	Water Level on Land	W.L is nearly G.L	△	○	○	△	○	○
	Liquefaction		○	○	○	○	○	○
	Soil Type of Supporting Layer	Clay (20 ≤ N)	○	○	○	○	○	○
		Sand/Gravel (30 ≤ N)	○	○	○	○	○	△
		Soft Rock/Hard soil	○	○	○	○	○	○
		Hard Rock	△	×	×	△	×	×

Legend :○ Highly applicable △ Applicable × Inapplicable

Source: JICA Study Team based on JSHB (2012), Japan Road Association

Regarding to PHC Pile installation, according to soil investigation result, it is confirmed that there is a stiff clay layer where conventional drilling by a pile hammer is inapplicable in the middle layer on the right bank as shown in Figure 7.3.4. If the design pile length is above the stiff clay layer, resistance against the pull out force cannot be secured. Therefore, "Supplemental Drilling Method" is required to be applied.

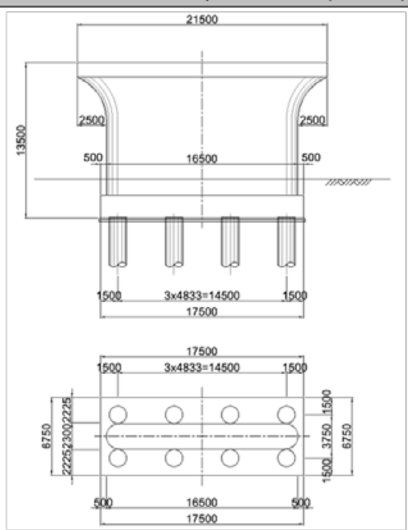
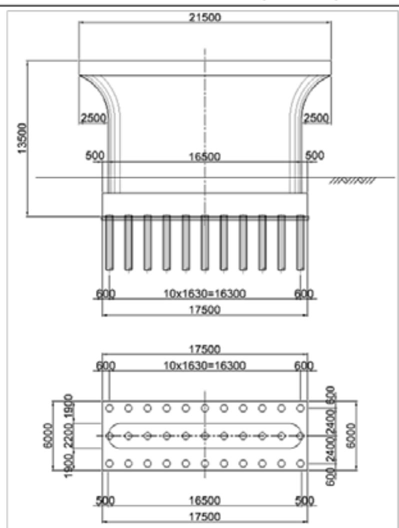
Based on the above consideration, a comparative study on foundation type for the approach bridge was carried out as given in Table 7.3.11. Since there is an advantage for the construction cost in the Cast-in Place Concrete Pile, thus, the Cast-in Place Concrete Pile type is recommended.



Source: JICA Study Team

Figure 7.3.4 Soil Investigation Result in the Middle Layer at Right Bank

Table 7.3.11 Comparative Study of Foundation Type for Approach Bridge

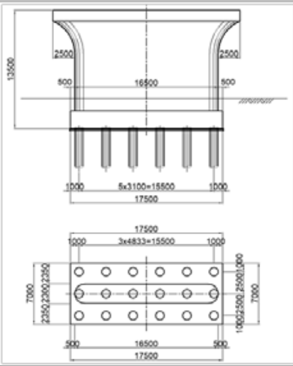
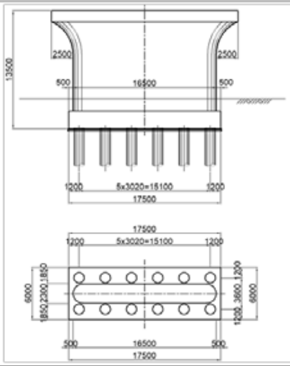
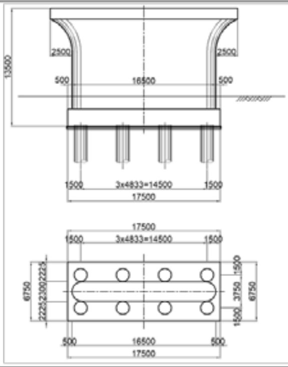
Evaluation Item		Alternative-1: Cast-in-place RC Pile (D=1.5m)					Alternative-2: PHC Pile (D=0.6m)				
Schematic View											
		4x2=8 Nos, L=40.00m					11x3=33 Nos, L=40.00m				
Calculation Result	Level 1	Pnmax<Ra (kN)	8,785.5	<	11,994.0	73%	Pnmax<Ra (kN)	2,421.4	<	3,617.0	67%
		δfx<δa (mm)	12.5	<	15.0	83%	δfx<δa (mm)	7.7	<	15.0	51%
		σs<σsa (N/mm2)	205.0	<	300.0	68%	σc<σca (N/mm2)	37.78	<	40.00	94%
	Level 2	Mmax<My(kN· m)	3,175.0	<	4,822.0	66%	Mmax<My(kN· m)	402.6	<	594.7	68%
		S<Ps (kN)	14,176	<	21,729	65%	S<Ps (kN)	422.8	<	523.1	81%
Construction Cost		Ratio = 1.00				◎	Ratio = 1.12				○
Construction Period				24	days	○			22	days	○
Evaluation		**Recommended**					Not Recommended				

◎: Excellent, ○Good, △Moderate, × Not Good
Source: JICA Study Team

(5) Study on Pile Diameter for Cast-in-Place Concrete Pile

In order to select the most economical and shortest construction period, the pile diameter for the above selected foundation type was studied. A comparison table is shown in Table 7.3.12. As a result of the study, a diameter of 1500mm is recommended since this type is the most economical and gives shortest construction period.

Table 7.3.12 Comparison of Pile Diameter for Cast-in-Place Concrete Pile

Evaluation Item		Alternative 1: D=1000mm					Alternative 2: D=1200mm					Alternative 3: D=1500mm				
Schematic View																
		6x3=18 Nos, L=39.50m					6x2=12 Nos, L=39.50m					4x2=8 Nos, L=40.00m				
Calculation Result	Level 1	Pnmax<Ra (kN)	4,375.1	<	7,966.0	55%	Pnmax<Ra (kN)	5,265.9	<	9,520.0	55%	Pnmax<Ra (kN)	8,785.5	<	11,994.0	73%
		δfx<δa (mm)	7.8	<	15.0	52%	δfx<δa (mm)	7.9	<	15.0	53%	δfx<δa (mm)	12.5	<	15.0	83%
		σs<σsa (N/mm2)	236.4	<	300.0	79%	σs<σsa (N/mm2)	195.8	<	300.0	65%	σs<σsa (N/mm2)	205.0	<	300.0	68%
	Level 2	Mmax<My(kN· m)	1,390.2	<	1,848.5	75%	Mmax<My(kN· m)	2,220.4	<	2,313.7	96%	Mmax<My(kN· m)	3,175.0	<	4,822.0	66%
		S<Ps (kN)	29,354	<	47,783	61%	S<Ps (kN)	29,760	<	36,291	82%	S<Ps (kN)	14,176	<	21,729	65%
Construction Cost		Ratio = 1.52				△	Ratio = 1.28				△	Ratio = 1.00				◎
Construction Period				38	days	△			33	days	△			24	days	◎
Evaluation		Not Recommended					Not Recommended					**Recommended**				

◎: Excellent, ○Good, △Moderate, ×Not Good

Source: JICA Study Team

7.4 Preliminary Road Design for New Sittaung Bridge

7.4.1 Geometric Design

(1) Horizontal Alignment

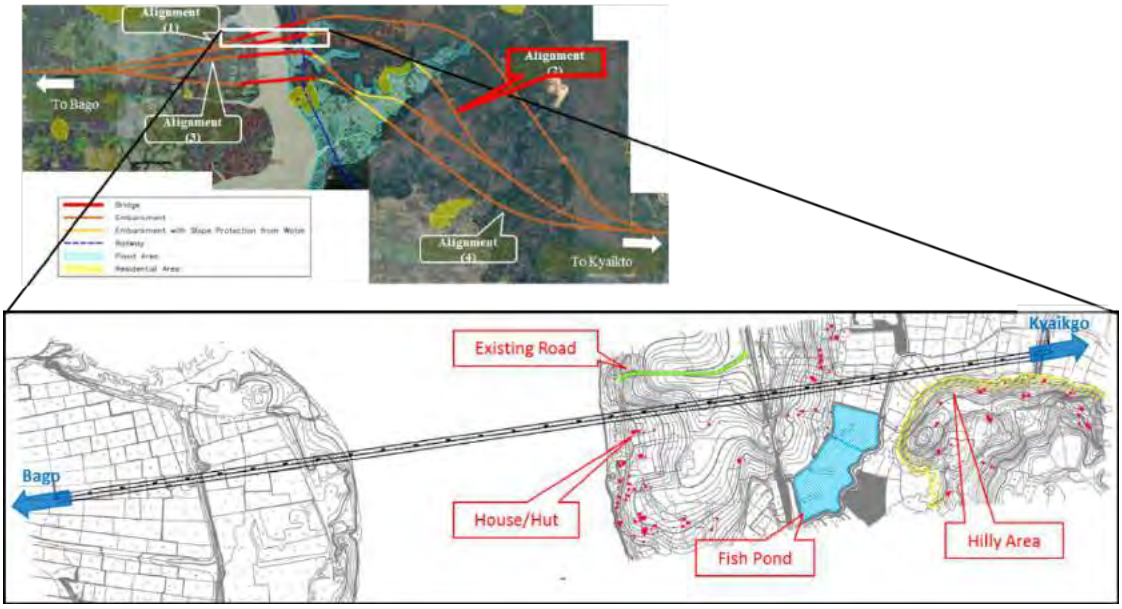
In "5.3 Selection of Eligible Alignment", Alignment (2) was selected as the most eligible alignment of the New Sittaung Bridge based on the satellite image.

In the preliminary road design, the detailed alignment was studied for the Sittaung River crossing area, i.e. JICA portion of the project area, based on the topographic map as well as the detailed site survey results.

Horizontal alignment around the Sittaung River crossing was determined taking into account the following conditions:

- ➢ Existing structures, such as houses and huts, are avoided.
- ➢ Existing important facilities for the residents, such as fish ponds, are avoided.
- ➢ Existing roads parallel with the Project Road are avoided to secure the existing local access.
- ➢ Hilly area is avoided to avoid large cuts.

Horizontal alignment around the Sittaung River crossing is shown in Figure 7.4.1.



Source: JICA Study Team

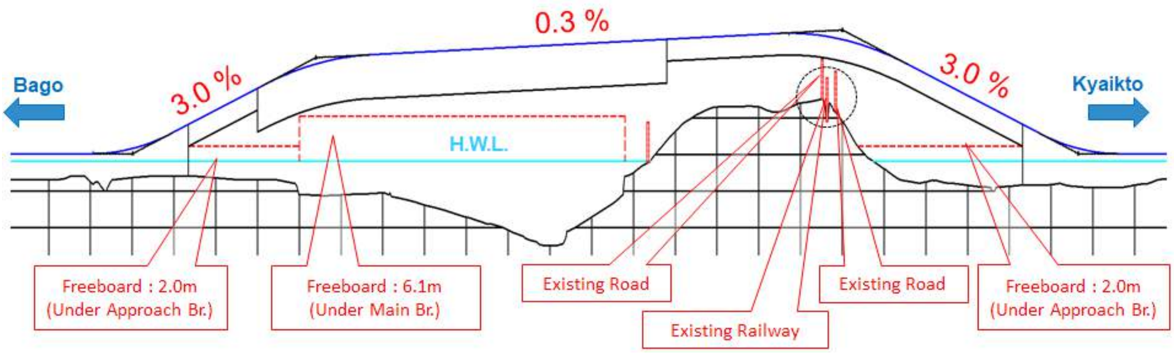
Figure 7.4.1 Horizontal Alignment of the New Sittaung Bridge

(2) Vertical Alignment

Vertical alignment around the Sittaung River crossing was determined taking into account the following conditions.

- Maximum grade is 3.0 % to secure the smooth drive for all types of vehicles including heavy vehicle.
- Minimum grade is 0.3 % to secure the smooth discharge of rainwater from the road surface.
- Freeboard under the main bridge in river is 6.1m.
- Freeboard under the approach bridge on land is 2.0m.
- Vertical clearance of the existing road is 5.5m.
- Vertical clearance of the existing railway is 6.0m.

Vertical alignment around the Sittaung River crossing is shown in Figure 7.4.2.

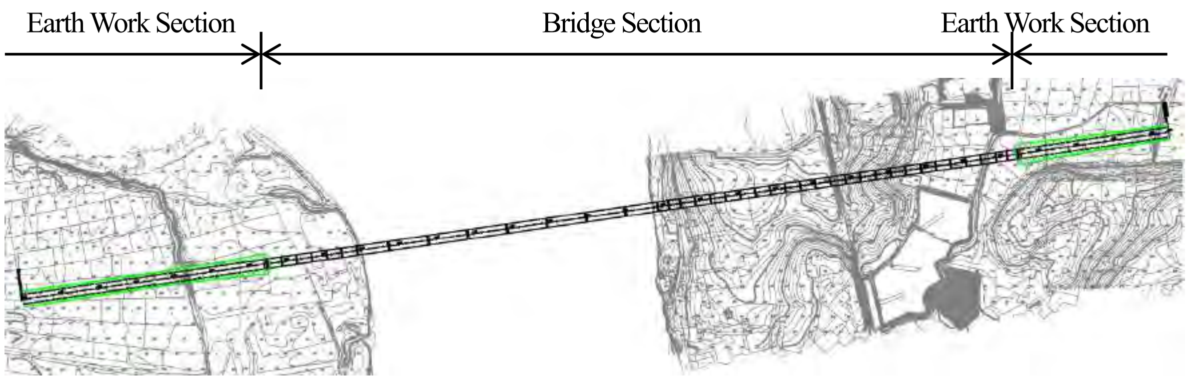


Source: JICA Study Team

Figure 7.4.2 Vertical Alignment of the New Sittaung Bridge

7.4.2 Earth Work Design

Embankment is constructed in the earth work section as shown in Figure 7.4.3. As the earthwork section is located in a flood area, slope protection should be provided on the embankment.

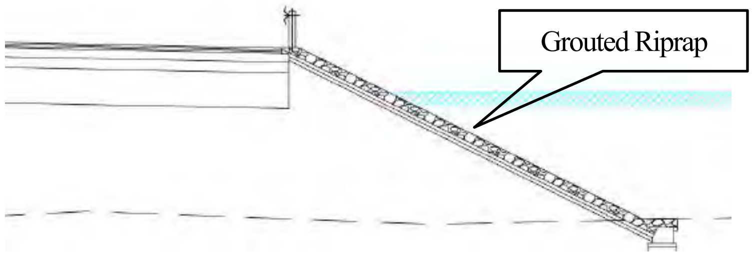


Source: JICA Study Team

Figure 7.4.3 Embankment Construction in Earth Work Section

It is proposed that grouted riprap is installed on the embankment to protect the embankment slope in the flood area.

However, as the earth work section will be constructed by the fund from ADB, the type of slope protection shall be determined in the detailed design stage after the feasibility study for earth work section is completed by ADB.



Source: JICA Study Team

Figure 7.4.4 Slope Protection on the Embankment

7.4.3 Pavement Design

(1) Introduction

Pavement design was conducted based on the "AASHTO Guide for Design of Pavement Structures (hereinafter called AASHTO Pavement Guide)"

In AASHTO Pavement Guide, the pavement layer thickness is determined so that it provides the load-carrying capacity corresponding to the design structural number (SN).

The design structural number (SN) is calculated by the following formula.

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

where;

W18: Predicted number of 18-kip equivalent single axle load applications

ZR: Standard normal deviate

S0: Combined standard error of the traffic prediction and performance prediction

ΔPSI: Difference between the initial design serviceability index, P0, and the design terminal serviceability index, Pt

MR: Resilient modulus (psi)

SN: Design structural number

(2) Design Condition

1) Predicted Number of 18-kip Equivalent Single Axle Load Applications (W18)

Predicted number of 18-kip equivalent single axle load applications (W18) is calculated based on the traffic volume for 10 years (2025 - 2035) as the design period.

Axle load equivalency factor for the Project is shown in Table 7.4.1.

Table 7.4.1 Axle Load Equivalency Factor

Vehicle Type	Total Weight (ton)	Axle-1				Axle-2				Axle-3				Axle-4				**Axle Load Equivalency Factor for Vehicle**
		Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	Type	Weight (ton)	Weight (kips)	Axle Load Equivalency Factor per a Axle	
Passenger Car	2.0	Sin	1.0	2.2	0.0004	Sin	1.0	2.2	0.0004									**0.0008**
2 Axle Truck	10.0	Sin	2.0	4.4	0.0036	Sin	8.0	17.6	0.9246									**0.9282**
3 Axle Truck	20.0	Sin	4.0	8.8	0.0556	Sin	8.0	17.6	0.9246	Sin	8.0	17.6	0.9246					**1.9048**
4 Axle Truck	20.0	Sin	3.0	6.6	0.0172	Sin	3.0	6.6	0.0172	Sin	7.0	15.4	0.5441	Sin	7.0	15.4	0.5441	**1.1226**
Trailer	25.0	Sin	5.0	11.0	0.1385	Tan	10.0	22.0	2.1800	Tan	10.0	22.0	2.1800					**4.4985**
Bus	10.0	Sin	5.0	11.0	0.1385	Sin	5.0	11.0	0.1385									**0.2770**

Source: JICA Study Team

Predicted number of 18-kip equivalent single axle load applications (W18) for the Project is shown in Table 7.4.2.

Table 7.4.2 Predicted Number of 18-kip Equivalent Single Axle Load Applications (W18)

Vehicle Type	Design Traffic (2025-2034)	ESAL Factor	Design ESAL	**18-kip ESAL Traffic in Design Lane**
Passenger Car	63,692,500	0.0008	50,954	22,929
2 Axle Truck	328,500	0.9282	304,914	137,211
3 Axle Truck	4,270,500	1.9048	8,134,448	3,660,502
4 Axle Truck	10,055,750	1.1226	11,288,585	5,079,863
Trailer	1,642,500	4.4985	7,388,786	3,324,954
Bus	3,631,750	0.2770	1,005,995	452,698
Total				**12,678,157**

Source: JICA Study Team

2) Standard Normal Deviate (ZR)

Standard normal deviate (ZR) for the Project is shown in Table 7.4.3

Table 7.4.3 Standard Normal Deviate (ZR)

Reliability, R (%)	90
Standard Normal Deviate, ZR	**-1.282**

Source: AASHTO Pavement Guide

3) Combined Standard Error of the Traffic Prediction and Performance Prediction (S0)

Combined standard error of the traffic prediction and performance prediction (S0) for asphalt pavement is “0.45”.

4) Difference between the Initial Design Serviceability Index, P0, and the Design Terminal Serviceability Index, Pt (ΔPSI)

Difference between the initial design serviceability index, P0, and the design terminal serviceability index, Pt (ΔPSI) for the Project is shown in Table 7.4.4.

Table 7.4.4 Difference between the Initial Design Serviceability Index, P0, and the Design Terminal Serviceability Index, Pt (ΔPSI)

P_o	4.2
P_t	2.5
ΔPSI	**1.7**

Source: AASHTO Pavement Guide

5) Resilient Modulus (psi) (MR)

Resilient modulus (psi) (MR) is calculated by the following formula. CBR value of the roadbed soil in the Project is set as “6”.

Resilient Modulus (psi) (MR) = 1500 x CBR

= 1500 x 6 = 9000

6) Design Structural Number (SN)

Design structural Number (SN) for the Project is calculated as “4.83”, based on the SN calculation formula with above stated design conditions.

(3) Pavement Layer Thickness

Pavement layer thickness is calculated by the following formula.

$$SN = a1D1+a2D2m2+a3D3m3$$

where

a1, a2, a3: Layer coefficients representative of surface, base, and subbase courses, respectively

D1, D2, D3: Actual thicknesses of surface, base, and subbase courses, respectively

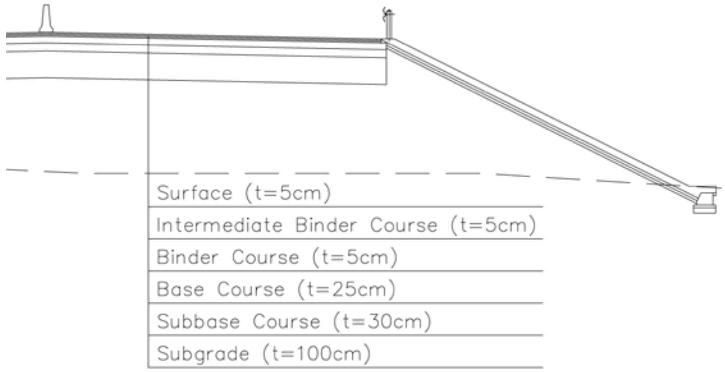
m2, m3: Drainage coefficients for base and subbase layers, respectively

Pavement layer thickness for the Project is shown in Table 7.4.5 and Figure 7.4.5.

Table 7.4.5 Pavement Layer Thickness

Layer	Material	a	m	D		SN		
				cm	inch			
Surface	Asphalt Concrete	0.42		5	1.969			
Binder Course	Asphalt Concrete	0.42		5	1.969			
Binder Course	Asphalt Concrete	0.42		5	1.969	5.02		
Base Course	Granular base	0.14	0.95	25	9.843		>	4.83
Subbase Course	Granular Subbase	0.11	0.95	30	11.811			**OK**

Source: JICA Study Team



Source: JICA Study Team

Figure 7.4.5 Pavement Structure

7.4.4 Drainage Design

(1) Introduction

Rainwater must be removed from the road surface as soon as possible, since the surface water has a negative impact on road performance.

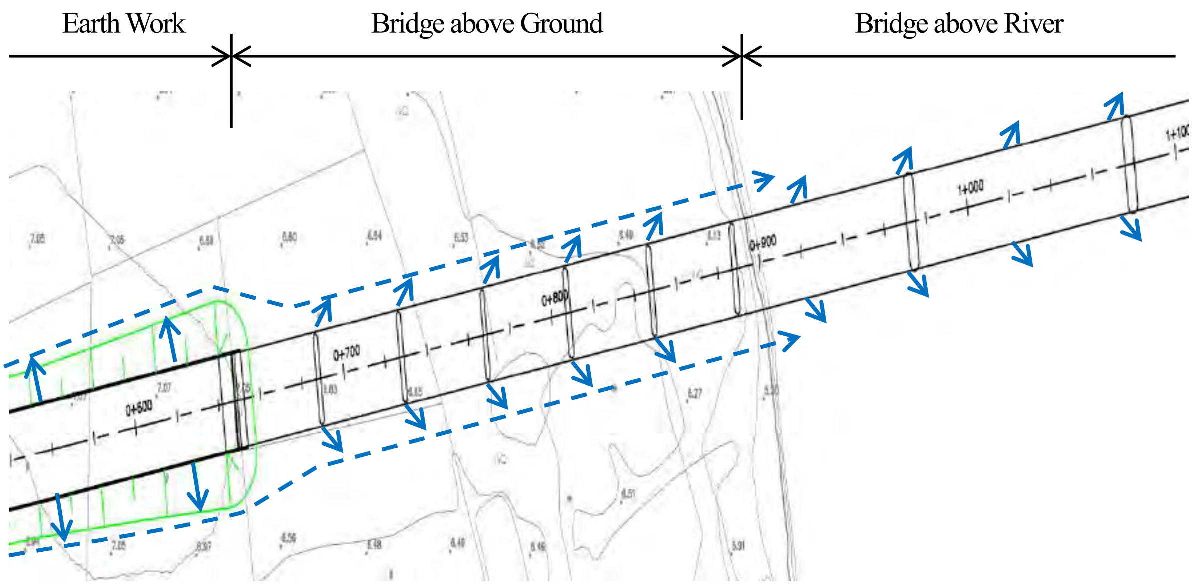
- Rainwater reduces the effectiveness of tire grip on the carriageway, which increases stopping distance.
- Spray from rainwater being thrown up by car tire reduces visibility.

In addition, if rainwater penetrates into the pavement structure, the pavement as well as embankment is damaged.

Rainwater is removed from road surface through the drainage facilities such as curb, ditch, culvert, pipe and catch basin, and then discharged to existing river or stream.

(2) Road Surface Drainage

Drainage plan for road surface rainwater is shown in Figure 7.4.6.



Source: JICA Study Team

Figure 7.4.6 Drainage Plan

1) Drainage Plan for Bridge Section (Above River)

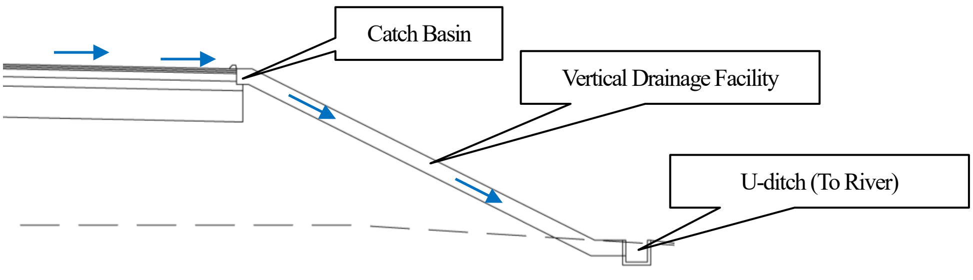
Rainwater on the bridge surface above the river is discharged into the river directly through catch basins installed at the edge of shoulders.

2) Drainage Plan for Bridge Section (Above Ground)

Rainwater on the bridge surface above the ground is collected with catch basins installed at the edge of the shoulders. Rainwater collected with catch basins is drained to the drainage facilities installed on the ground such as u-ditch and pipe drainage through the bridge drainage pipes installed at pier/abutment locations. Rainwater is finally discharged into the river through drainage facilities.

3) Drainage Plan for Earth Work Section

Rainwater on the road surface in the earth work section is collected with catch basins installed at the edge of the shoulders. Rainwater collected with catch basins is drained to the drainage facilities installed on the ground such as u-ditch and pipe drainage through the vertical drainage facilities installed on the embankment slope. Rainwater is finally discharged into the river through drainage facilities.



Source: JICA Study Team

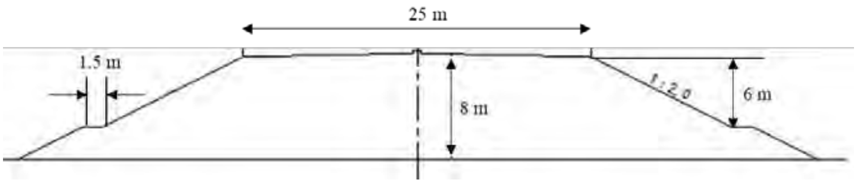
Figure 7.4.7 Drainage Plan for Earth Work Section

7.4.5 Assessment on Necessity of Soft Soil Treatment

(1) Residual Settlement

The embankment height for the approach road of the New Sittaung Bridge is approximately 8m which is considered as high embankment. It is necessary to check the slope stability and residual settlement in order to guarantee safety during construction and post-construction for the approach road.

The dimension of the embankment is shown in Figure 7.4.8.



Source: JICA Study Team

Figure 7.4.8 Design Dimension of Approach Road

1) Design Criteria

For slope stability, the following criteria are adopted for evaluation design:

Table 7.4.6 Factor of Safety of Slope Stability

Criteria		Factor of Safety (FS)
Slope stability	Static condition	FS ≥ 1.2
	Earthquake	FS ≥ 1.1

Source: JICA Study Team

For residual settlement, it is required that the maximum residual settlement at a location on the approach road must be less than 10cm.

2) Input Soil Properties

Two boreholes BH3 and BH4 were conducted on each side of the riverbank to investigate subsoil conditions. Soil properties for design input are directly derived from a Standard Penetration Test and the laboratory test results of respective BH3 and BH4. Those data along with properties of embankment filling are tabulated in Table 7.4.7.

Table 7.4.7 Input Properties

Input Data	Filling material	BH3	BH4
Soil type	Sand	Loose to dense silty sand	Stiff Silt
Average N value	-	22.5	19
Unit weight (kN/m3)	18	17.5	19
Internal friction angle (^{o})	30	35	-
Cohesion (kPa)	-	-	120

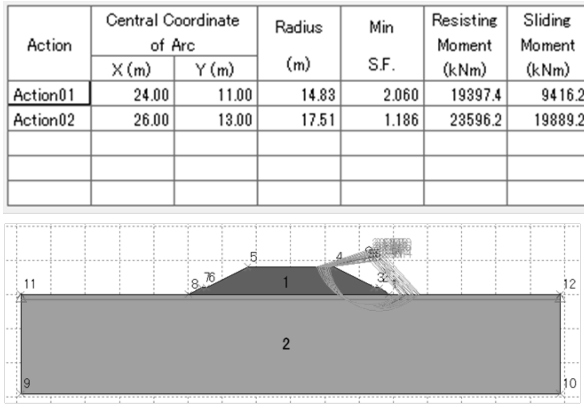
Source: JICA Study Team

3) Calculation Results

In the slope stability checking, the failure surface is considered to be circular calculated by the Bishop Method. The minimum FS (Safety Factor) for the most dangerous surface is calculated. Results for both approach roads are shown in Table 7.4.8.

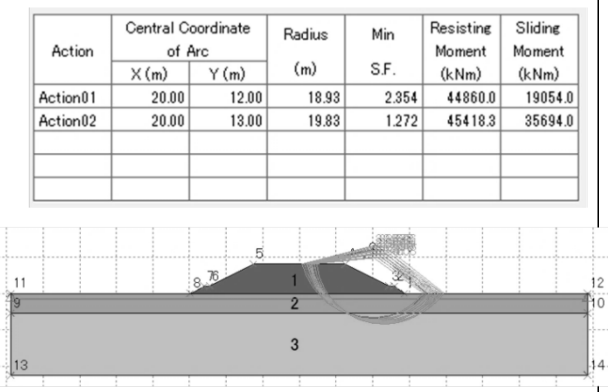
Table 7.4.8 Calculation Results

Min FS	BH3	BH4	Judgement
Static Condition	2.1	2.4	OK
Earthquake	1.2	1.3	OK



Action	Central Coordinate of Arc X (m)	Central Coordinate of Arc Y (m)	Radius (m)	Min S.F.	Resisting Moment (kNm)	Sliding Moment (kNm)
Action01	24.00	11.00	14.83	2.060	19397.4	9416.2
Action02	26.00	13.00	17.51	1.186	23596.2	19889.2

At BH3



Action	Central Coordinate of Arc X (m)	Central Coordinate of Arc Y (m)	Radius (m)	Min S.F.	Resisting Moment (kNm)	Sliding Moment (kNm)
Action01	20.00	12.00	18.93	2.354	44860.0	19054.0
Action02	20.00	13.00	19.83	1.272	45418.3	35694.0

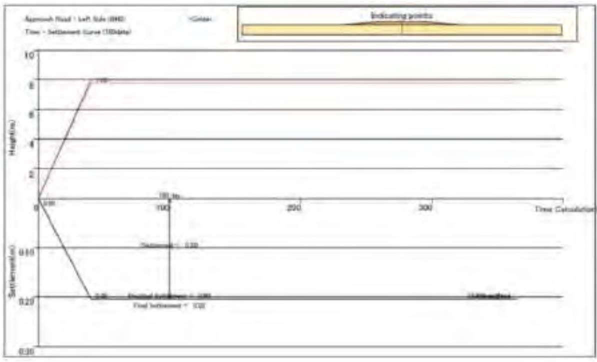
At BH4

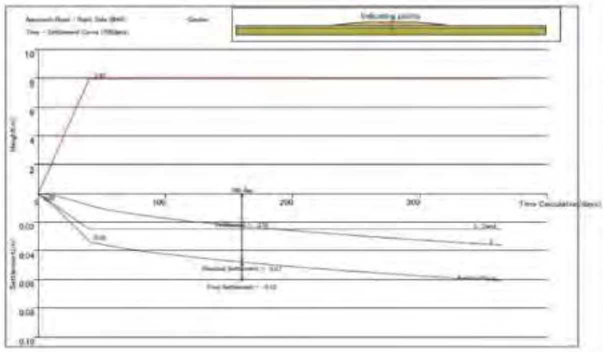
Source: JICA Study Team

Residual settlement at each location BH3 and BH4 was calculated. The results show very small settlement at both locations, which is easily explained due to the present of mainly medium dense sand to stiff clay in BH3 and stiff clay in BH4. Summary of outputs is given in Table 7.4.9.

Table 7.4.9 Residual Settlement at each Boring Location

Borehole	Residual Settlement (cm)	Judgement
BH3	0	OK
BH4	5	OK





Source: JICA Study Team

(2) Liquefaction

1) Possibility of Liquefaction

The project area is piled up loose sandy soil at the shallow portion, and the sandy soil layer is saturated by groundwater. In the case of an earthquake, the project area has a risk of damage by liquefaction phenomena. Although the number of soil physical property tests is not sufficient for the study of liquefaction due to the limitation of survey budget, liquefaction judgement by FL-value in accordance with Japanese Specifications for Highway Bridges was conducted by using the limited test results.

Table 7.4.10 shows the results of liquefaction judgement at BH-01, BH-02 and BH -03. Earthquake force is considered Level-I Earthquake (0.18) and Level-II Earthquake (0.40 or 0.60). Where FL-value of the soil layer is less than 1.0, the said layer has risk of damage of liquefaction. Three locations have been judged to result in liquefaction even in a Level-I Earthquake.

Table 7.4.10 Results for Liquefaction Judgement by Japanese Specifications for Highway Bridges

No.	Depth	Layer name	N-value	σv	σ'v	Fc	γt	γsat	Design horizontal seismic intensity								
									Level I			Level II					
												Type I			Type II		
									0.18			0.40			0.60		
	(m)			(kN/m2)	(kN/m2)	(%)	(kN/m3)	(kN/m3)	R	L	FL	R	L	FL	R	L	FL
1	1.000	Clayey SILT	0.0	15.00	5.00	—	14.0	15.0	0.126	0.532	—	0.126	1.182	—	0.137	1.773	—
2	2.000	Clayey SILT	1.0	30.00	10.00	—	14.0	15.0	0.203	0.524	—	0.203	1.164	—	0.272	1.746	—
3	3.000	Clayey SILT	1.0	45.00	15.00	—	14.0	15.0	0.199	0.516	—	0.199	1.146	—	0.265	1.719	—
4	4.000	Clayey SILT	1.0	60.00	20.00	72.3	14.0	15.0	0.196	0.508	0.39	0.196	1.128	0.17	0.258	1.692	0.15
5	5.000	Clayey SILT	3.0	75.00	25.00	72.3	14.0	15.0	0.283	0.500	0.57	0.283	1.110	0.25	0.455	1.665	0.27
6	6.000	Clayey SILT	5.0	90.00	30.00	72.3	14.0	15.0	0.445	0.491	0.91	0.445	1.092	0.41	0.890	1.638	0.54
7	7.000	Silty SAND	4.0	108.00	38.00	41.3	17.0	18.0	0.234	0.458	0.51	0.234	1.017	0.23	0.338	1.526	0.22
8	8.000	Silty SAND	3.0	126.00	46.00	41.3	17.0	18.0	0.202	0.434	0.47	0.202	0.964	0.21	0.269	1.446	0.19
9	9.000	Silty SAND	13.0	144.00	54.00	41.3	17.0	18.0	0.886	0.415	2.13	0.886	0.923	0.96	1.772	1.384	1.28
10	10.000	Silty SAND	11.0	162.00	62.00	41.3	17.0	18.0	0.407	0.400	1.02	0.407	0.888	0.46	0.815	1.333	0.61
11	11.000	Silty SAND	10.0	180.00	70.00	41.3	17.0	18.0	0.327	0.386	0.85	0.327	0.859	0.38	0.573	1.288	0.44
12	12.000	Silty SAND	4.0	198.00	78.00	41.3	17.0	18.0	0.205	0.375	0.55	0.205	0.833	0.25	0.277	1.249	0.22
13	13.000	Silty SAND	2.0	216.00	86.00	41.3	17.0	18.0	0.155	0.364	0.43	0.155	0.809	0.19	0.184	1.213	0.15
14	14.000	Silty SAND	7.0	234.00	94.00	41.3	17.0	18.0	0.249	0.354	0.70	0.249	0.787	0.32	0.371	1.180	0.31
15	15.000	Sandy CLAY-I	6.0	252.00	102.00	73.6	18.0	19.0	0.301	0.345	0.87	0.301	0.766	0.39	0.502	1.149	0.44
16	16.000	Sandy CLAY-I	6.0	270.00	110.00	73.6	18.0	19.0	0.294	0.336	0.88	0.294	0.746	0.39	0.483	1.119	0.43
17	17.000	Sandy CLAY-I	13.0	288.00	118.00	73.6	18.0	19.0	1.838	0.327	5.62	1.838	0.727	2.53	3.676	1.091	3.37
18	18.000	Sandy CLAY-I	11.0	306.00	126.00	73.6	18.0	19.0	0.688	0.319	2.16	0.688	0.709	0.97	1.377	1.064	1.29
19	19.000	Sandy CLAY-I	14.0	325.00	135.00	73.6	18.0	19.0	1.720	0.310	5.55	1.720	0.689	2.50	3.439	1.033	3.33
20	20.000	Sandy CLAY-I	14.0	344.00	144.00	73.6	18.0	19.0	1.375	0.301	4.57	1.375	0.669	2.06	2.750	1.003	2.74

No.	Depth	Layer name	N-value	σv	σ'v	Fc	γt	γsat	Design horizontal seismic intensity								
									Level I			Level II					
												Type I			Type II		
									0.18			0.40			0.60		
	(m)			(kN/m2)	(kN/m2)	(%)	(kN/m3)	(kN/m3)	R	L	FL	R	L	FL	R	L	FL
1	1.000	Clayey SILT	1.0	17.00	7.00	98.8	16.0	17.0	0.250	0.431	0.58	0.250	0.957	0.26	0.373	1.435	0.26
2	2.000	Clayey SILT	1.0	34.00	14.00	98.8	16.0	17.0	0.243	0.424	0.57	0.243	0.942	0.26	0.358	1.413	0.25
3	3.000	Clayey SILT	1.0	51.00	21.00	98.8	16.0	17.0	0.237	0.417	0.57	0.237	0.928	0.26	0.345	1.390	0.25
4	4.000	Clayey SILT	1.0	68.00	28.00	98.8	16.0	17.0	0.232	0.411	0.56	0.232	0.913	0.25	0.333	1.370	0.24
5	5.000	Clayey SILT	1.0	85.00	35.00	98.8	16.0	17.0	0.228	0.404	0.56	0.228	0.899	0.25	0.323	1.348	0.24
6	6.000	Clayey SILT	1.0	102.00	42.00	98.8	16.0	17.0	0.223	0.398	0.56	0.223	0.884	0.25	0.315	1.326	0.24
7	7.000	Clayey SILT	3.0	119.00	49.00	98.8	16.0	17.0	0.333	0.391	0.85	0.333	0.869	0.38	0.588	1.304	0.45
8	8.000	Clayey SILT	2.0	136.00	56.00	98.8	16.0	17.0	0.267	0.385	0.69	0.267	0.855	0.31	0.414	1.282	0.32
9	9.000	Clayey SILT	2.0	153.00	63.00	98.8	16.0	17.0	0.262	0.378	0.69	0.262	0.840	0.31	0.402	1.260	0.32
10	10.000	Clayey SILT	3.0	170.00	70.00	98.8	16.0	17.0	0.300	0.372	0.81	0.300	0.826	0.36	0.498	1.239	0.40
11	11.000	Clayey SILT	5.0	187.00	77.00	98.8	16.0	17.0	0.566	0.365	1.55	0.566	0.811	0.70	1.132	1.217	0.93
12	12.000	Clayey SILT	3.0	204.00	84.00	98.8	16.0	17.0	0.288	0.358	0.80	0.288	0.797	0.36	0.466	1.195	0.39
13	13.000	Clayey SILT	4.0	221.00	91.00	98.8	16.0	17.0	0.329	0.352	0.93	0.329	0.782	0.42	0.577	1.173	0.49
14	14.000	Clayey SILT	6.0	238.00	98.00	98.8	16.0	17.0	0.664	0.345	1.92	0.664	0.767	0.87	1.327	1.151	1.15
15	15.000	Silty SAND	10.0	256.00	106.00	18.4	17.0	18.0	0.232	0.337	0.69	0.232	0.749	0.31	0.333	1.123	0.30
16	16.000	Silty SAND	5.0	274.00	114.00	18.4	17.0	18.0	0.164	0.329	0.50	0.164	0.731	0.22	0.198	1.096	0.18
17	17.000	Silty SAND	4.0	292.00	122.00	18.4	17.0	18.0	0.145	0.321	0.45	0.145	0.713	0.20	0.167	1.070	0.16
18	18.000	Silty SAND	16.0	310.00	130.00	18.4	17.0	18.0	0.274	0.313	0.88	0.274	0.696	0.39	0.430	1.044	0.41
19	19.000	Silty SAND	16.0	328.00	138.00	18.4	17.0	18.0	0.268	0.306	0.88	0.268	0.680	0.39	0.418	1.020	0.41
20	20.000	Silty SAND	14.0	346.00	146.00	18.4	17.0	18.0	0.247	0.299	0.83	0.247	0.664	0.37	0.367	0.995	0.37

No.	Depth	Layer name	N-value	σv	σ'v	Fc	γt	γsat	Design horizontal seismic intensity								
									Level I			Level II					
												Type I			Type II		
									0.18			0.40			0.60		
	(m)			(kN/m2)	(kN/m2)	(%)	(kN/m3)	(kN/m3)	R	L	FL	R	L	FL	R	L	FL
1	1.000	Clayey SILT	6.0	—	—	—	18.0	19.0	—	—	—	—	—	—	—	—	—
2	2.000	Clayey SILT	9.0	36.50	31.50	17.4	18.0	19.0	0.285	0.202	1.41	0.285	0.450	0.63	0.46	0.674	0.68
3	3.000	Clayey SILT	12.0	55.50	40.50	17.4	18.0	19.0	0.329	0.236	1.39	0.329	0.523	0.63	0.578	0.785	0.74
4	4.000	Clayey SILT	5.0	74.50	49.50	17.4	18.0	19.0	0.198	0.255	0.78	0.198	0.566	0.35	0.262	0.849	0.31
5	5.000	Clayey SILT	8.0	93.50	58.50	17.4	18.0	19.0	0.240	0.266	0.90	0.240	0.591	0.41	0.350	0.887	0.39
6	6.000	Silty SAND	7.0	112.50	67.50	17.4	19.0	20.0	0.218	0.273	0.80	0.218	0.607	0.36	0.302	0.910	0.33
7	7.000	Silty SAND	13.0	131.50	76.50	17.4	19.0	20.0	0.285	0.277	1.03	0.285	0.615	0.46	0.460	0.923	0.50
8	8.000	Silty SAND	6.0	150.50	85.50	17.4	19.0	20.0	0.191	0.279	0.68	0.191	0.620	0.31	0.248	0.929	0.27
9	9.000	Silty SAND	5.0	169.50	94.50	17.4	19.0	20.0	0.170	0.279	0.61	0.170	0.621	0.27	0.210	0.931	0.23
10	10.000	Silty SAND	6.0	188.50	103.50	17.4	19.0	20.0	0.181	0.279	0.65	0.181	0.619	0.29	0.229	0.929	0.25
11	11.000	Silty SAND	14.0	207.50	112.50	19.7	19.0	20.0	0.272	0.277	0.98	0.272	0.616	0.44	0.425	0.924	0.46
12	12.000	Silty SAND	14.0	226.50	121.50	19.7	19.0	20.0	0.265	0.275	0.96	0.265	0.611	0.43	0.410	0.917	0.45
13	13.000	Silty SAND	14.0	245.50	130.50	19.7	19.0	20.0	0.259	0.273	0.95	0.259	0.606	0.43	0.396	0.909	0.44
14	14.000	Silty SAND	28.0	264.50	139.50	19.7	19.0	20.0	0.562	0.270	2.08	0.562	0.599	0.94	1.124	0.899	1.25
15	15.000	Silty SAND	30.0	283.50	148.50	19.7	19.0	20.0	0.622	0.266	2.34	0.622	0.592	1.05	1.245	0.888	1.40
16	16.000	Silty SAND	37.0	302.50	157.50	19.7	19.0	20.0	1.426	0.263	5.42	1.426	0.584	2.44	2.851	0.876	3.25
17	17.000	Silty SAND	37.0	321.50	166.50	19.7	19.0	20.0	1.151	0.259	4.44	1.151	0.575	2.00	2.302	0.863	2.67
18	18.000	Silty SAND	47.0	340.50	175.50	19.7	19.0	20.0	3.780	0.255	14.82	3.780	0.567	6.67	7.560	0.850	8.89
19	19.000	Silty SAND	50.0	359.50	184.50	19.7	19.0	20.0	4.435	0.251	17.67	4.435	0.557	7.96	8.870	0.836	10.61
20	20.000	Silty SAND	40.0	378.50	193.50	19.7	19.0	20.0	0.983	0.246	4.00	0.983	0.548	1.79	1.966	0.822	2.39

Source: JICA Study Team

2) Countermeasures for Liquefaction

As indicated in the above, the project area has risk of liquefaction when earthquake occurs. In this study, the following countermeasures are applied;

For Bridge Structure

Necessary number of foundation piles is designed to ensure the required bearing capacity against liquefaction.

For Embankment Structure

"Without countermeasures" is employed for the embankment of approach road of the New Sittaung Bridge. Since there is soft soil treatment under the embankment, such as the installation of a U-shape retaining wall with pile foundation or soil cement by deep mixing method, additional high initial cost would be needed, although urgent repairs might be necessary on the heavy damaged portion after a large earthquake.

7.5 Preliminary Bridge Design for the New Sittaung Bridge

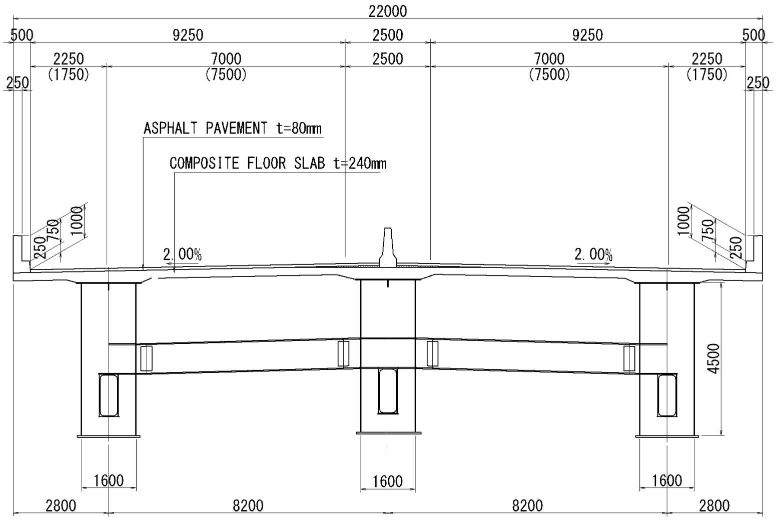
7.5.1 General

According to the bridge planning and design conditions, the preliminary design of the New Sittaung Bridge was carried out. The outline of the design is described in the following sections.

7.5.2 Design of Superstructure

(1) Main Bridge

The superstructure of the main bridge consists of a steel narrow box girder and steel-concrete composite deck slab. Considering the total width of 22.0m, three main girders are arranged as shown in Figure 7.5.1. In order to simplify the girder erection by a launching nose girder, the constant girder height (4.5m) is employed. The maximum outrigger length, which is usually around 0.4 times of slab spacing, is applied so that the thickness of the composite slab can be minimized.



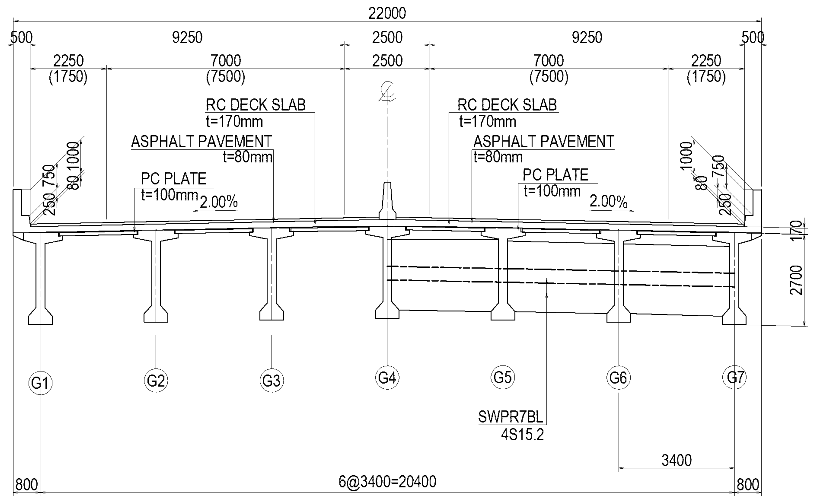
Note : ( ) shows the configuration for future operation stage

Source: JICA Study Team

Figure 7.5.1 Typical Cross Section of Main Bridge

(2) Approach Bridge

According to the Japanese guideline for the design of a PC composite girder, the cantilever length of slab is usually 1.0m or less (minimum : 0.1m) and spacing of slab is generally 2.6 m to 3.8m. Considering this, the superstructure of the approach bridge consists of 6 main girders (height : 2.7m) and composite deck slab (t=270mm) as shown in Figure 7.5.2.



Note : (　　) shows the configuration for future operation stage

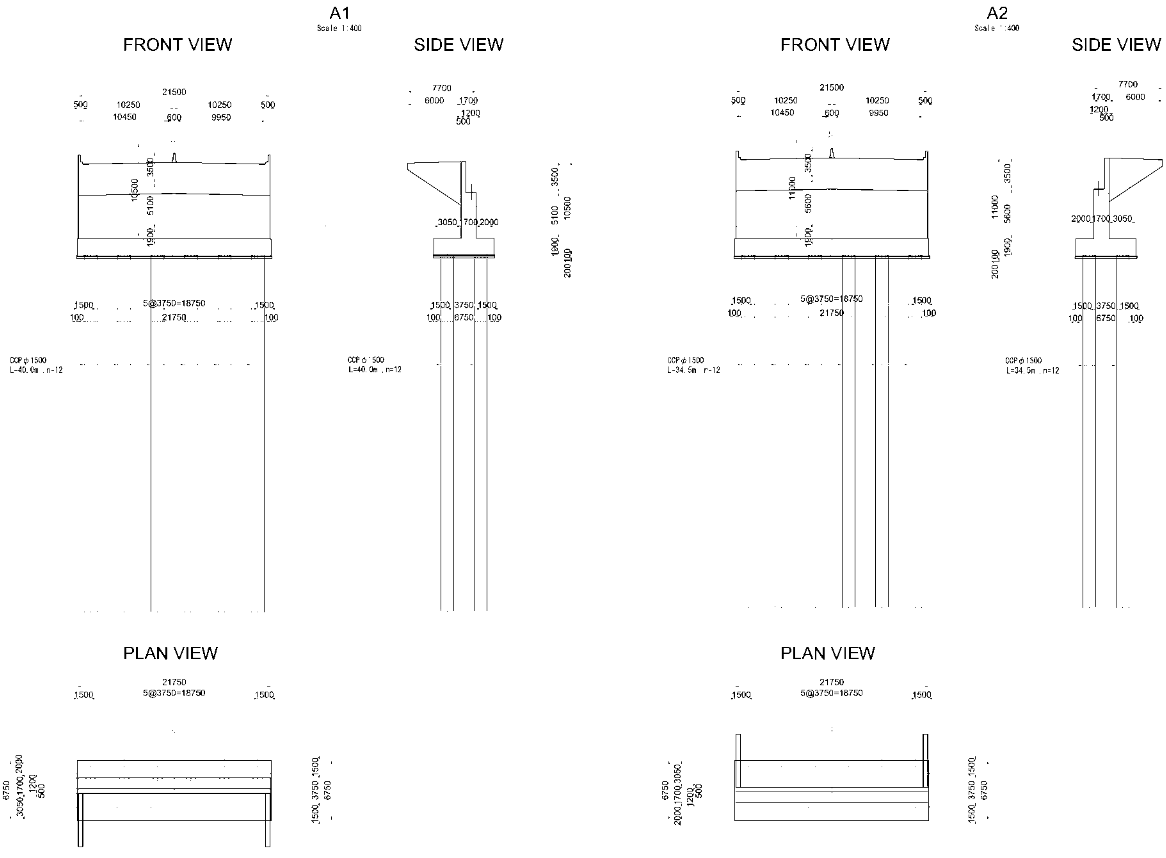
Source: JICA Study Team

Figure 7.5.2 Typical Cross Section of Approach Bridge

7.5.3 Design of Substructure and Foundation

(1) Abutment

Inversed T-shape RC abutment shall be arranged at both ends of the approach bridges. The height of abutment is 10.5 m for A1 and 11.0 m for A2. The abutment is supported by 12 cast-in-place RC piles with a diameter of 1.5m. The general view of abutment is shown in Figure 7.5.3.



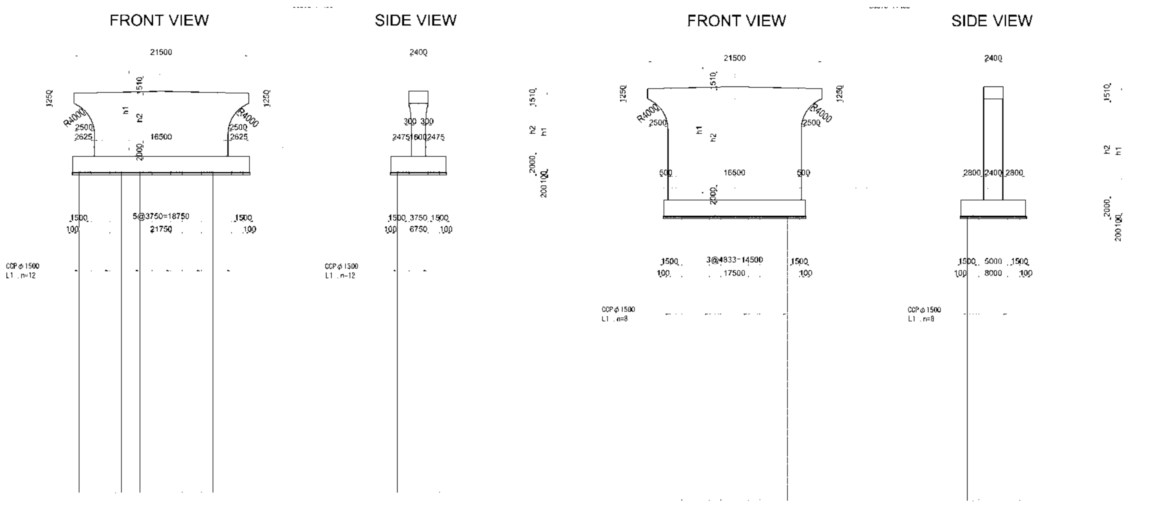
Source: JICA Study Team

Figure 7.5.3 General View of Abutment

(2) Piers on Land

Orval shape RC piers, which is favorable to the scouring mitigation, shall be employed for the piers on land since piers even on land might be subjected by overflows during flooding. The piers on the right bank side are supported by 12 cast-in-place RC piles with a diameter of 1.5m as shown in Figure 7.5.4 (left). The piers on the left bank side are supported by 8 cast-in-place RC piles with a diameter of 1.5m as shown in Figure 7.5.4 (right).

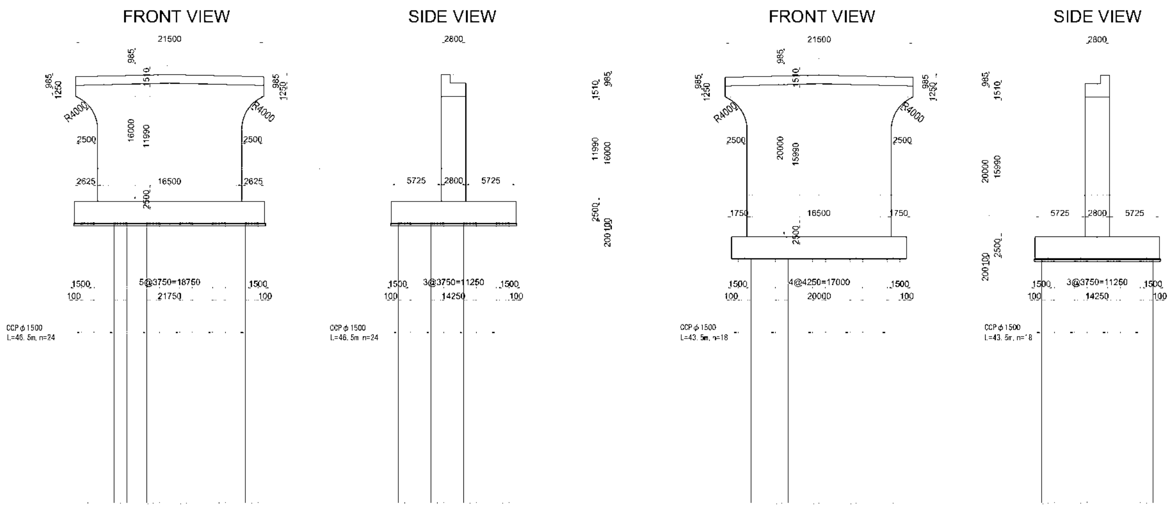
The piers located at both ends of main bridge are also oval shape RC piers and supported by 24 cast-in-place RC piles with a diameter of 1.5m as shown in Figure 7.5.5.



Right bank side (PR1 to PR5) Left bank side (PL1 to PL24)

Source: JICA Study Team

Figure 7.5.4 General View of Piers on Land

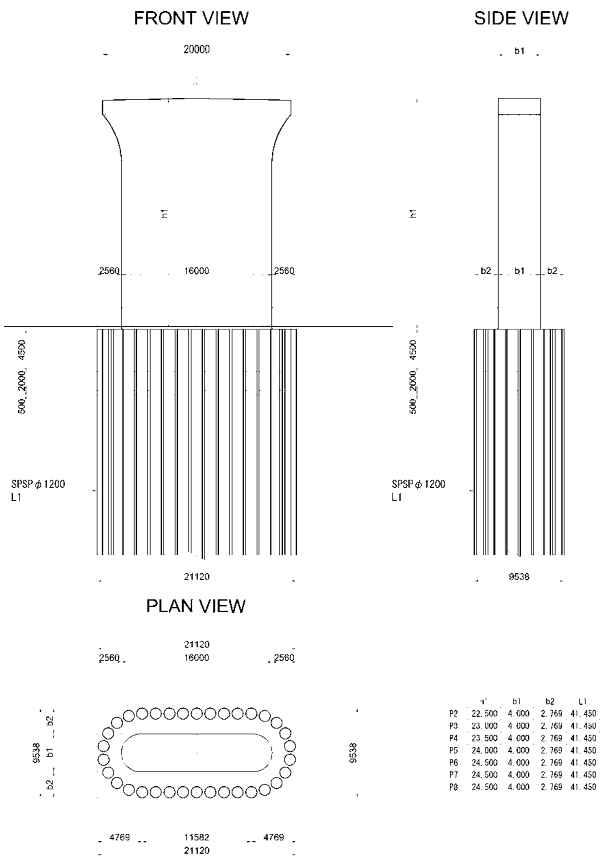


Source: JICA Study Team

Figure 7.5.5 General View of End Piers

(3) Piers in River

Oval shape RC piers, which is favorable to the scouring mitigation, shall be employed for the piers in river. As shown in Figure 7.5.6, the piers are supported by steel pipe sheet pile foundation which consists of 34 steel pipe piles with a diameter of 1.2m.



	h1	b1	b2	L1
P2	22.500	4.000	2.769	41.450
P3	23.000	4.000	2.769	41.450
P4	23.500	4.000	2.769	41.450
P5	24.000	4.000	2.769	41.450
P6	24.500	4.000	2.769	41.450
P7	24.500	4.000	2.769	41.450
P8	24.500	4.000	2.769	41.450

Source: JICA Study Team

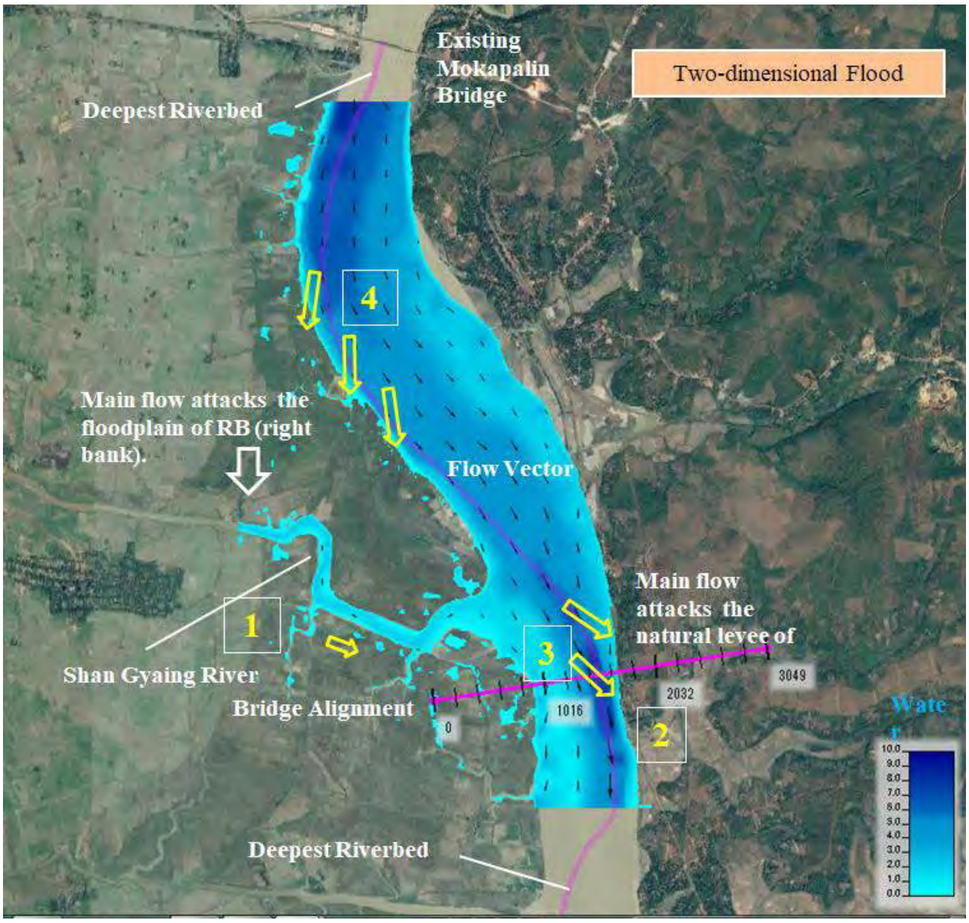
Figure 7.5.6 General View of Piers in River

7.6 Preliminary Design for Bank Protection and Scour Protection

7.6.1 General

The new bridge is proposed to be constructed where the river bank is the most stable along the river line downstream of the existing Sittaung (Mokepalin) Bridge. However, the following issues are concerned;

- ✓ Overflow from a tributary inflow of the Shan Gyaing River located and the main flow upstream from the proposed bridge may cause critical scouring of pier foundations in the future. Therefore, it is necessary to smoothly guide the overflow / inflow water into the main river even when flood events. - 1 in Figure 7.6.1.
- ✓ River bank erosion nearby the new bridge location might be caused by the main river flow even though the left river bank is likely a natural levee with sufficient height and resistance, thus, the revetment should be installed. - 2 in Figure 7.6.1.
- ✓ Bridge foundation scour is a concern due to tide water and tidal bore. - 3 in Figure 7.6.1.
- ✓ River bend portion on the right bank upstream has a risk of bank erosion and channel change (as experienced before 2006). - 4 in Figure 7.6.1.



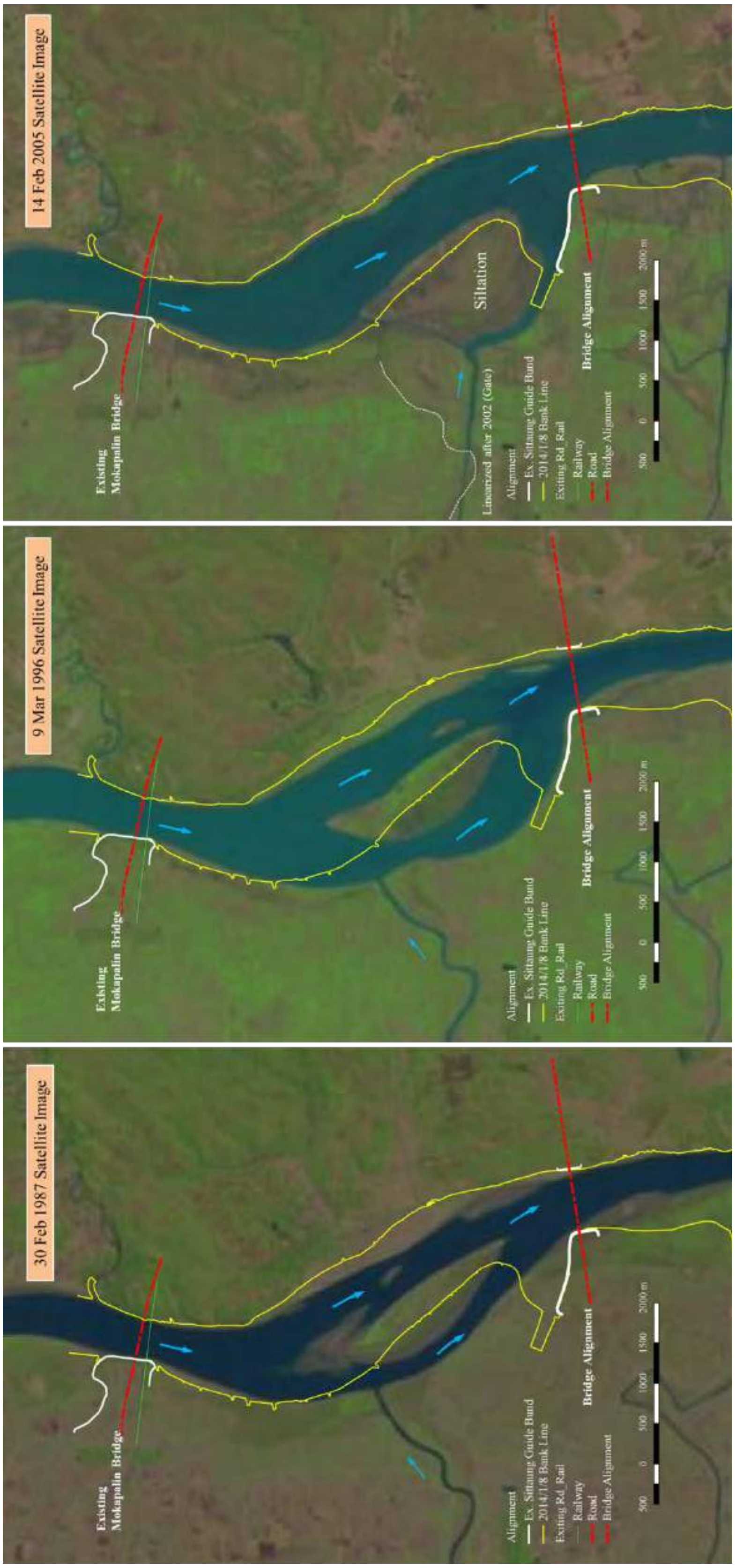
Source: JICA Study Team based on Google Earth Map

Figure 7.6.1 Hydraulic Challenges around Proposed Bridge (2D Hydraulic Analysis)

7.6.2 Necessity of River Bank Protection and Scour Protection

The past satellite images between the existing Sittaung (Mokepalin) and the proposed new bridges at 1987, 1996 and 2005 are shown in Figure 7.6.2. It is recognized that there were two clear waterways before 2000 and then the two waterways have gradually combined and shifted to the current river alignment.

Moreover, it is inferred that sedimentation has progressed on the land area downstream of the Shan Gyaing River since 2002. It is also considered that the sedimentation was caused by the change of tributary flow route of the Shan Gyaing River, the occurrence of several major floods and the leveling of flow discharge by many developments of water infrastructures. Then, a large-scale river course change has not been observed since 2004, and the flood channel has been filled with silted deposit and changed to the flood plain of low land. However, it is reasonable to predict that the river evolution is still active on the upstream side of the proposed bridge and the evolution may progress due to natural events such as floods / storm-surge / tidal-bores / regular semi-diurnal tides. Therefore, it is recommended that river bank protection is adopted in order to mitigate the partial erosion at the existing natural bank (left bank side) and further erosion to the bridge construction site by major river course change (right bank side). Also, the protection for scour around bridge piers and abutments is necessary.



Source: JICA Study Team, Landsat Image by NASA

Note: Yellow lines of above Figure shows riverbank lines at 8 Jan 2014. White lines shows the bank protection for proposed bridge and existing guide bank for Mokepalin Bridge

Figure 7.6.2 Historical Channel Evolution between Existing Mokepalin and Proposed Bridges

7.6.3 Preliminary Design for Bank Protection

(1) Design Concept

To address the issues mentioned above, the following design concepts are developed:

- The land area and riverbank nearby the New Sittaung Bridge shall be protected from future critical erosion and/or scouring by the installation of protection structures, and;
- The progress of river bank erosion/channel evolution or the other portion beyond the range of the New Sittaung Bridge shall be monitored and necessary countermeasures shall be taken when necessary, for instance as mentioned in 7.6.5.

(2) Countermeasures for Future Erosion and Scour at the Right Bank

To avoid the critical land erosion and scouring on the right bank side of the proposed bridge, the below two alternatives were considred.

Alternative 1 : Guide bank

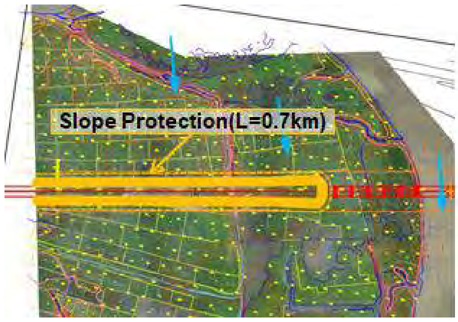
Alternative 2 : Slope Protection

Alternative 1 is to install a guide bank along the Shan Gyaing River in order to smoothly guide the backwater and/or overflow water from the upstream into the main river channel and protects the land area within the guide bank and the New Sittaung Bridge from erosion and scour.

Alternative 2 is to apply slope protection to the road embankment and protects the embankment from scour due to overflow water.

A comparative study result is shown in Table 7.6.1. Alternative 2 is more economical but has a risk for erosion at the riverbank and serious scour at the piers. On the other hand, Alternative 1 is economically reasonable if considering that the erosion at the riverbank can be controlled and it is the best way to ensure stability of river morphology in the future.

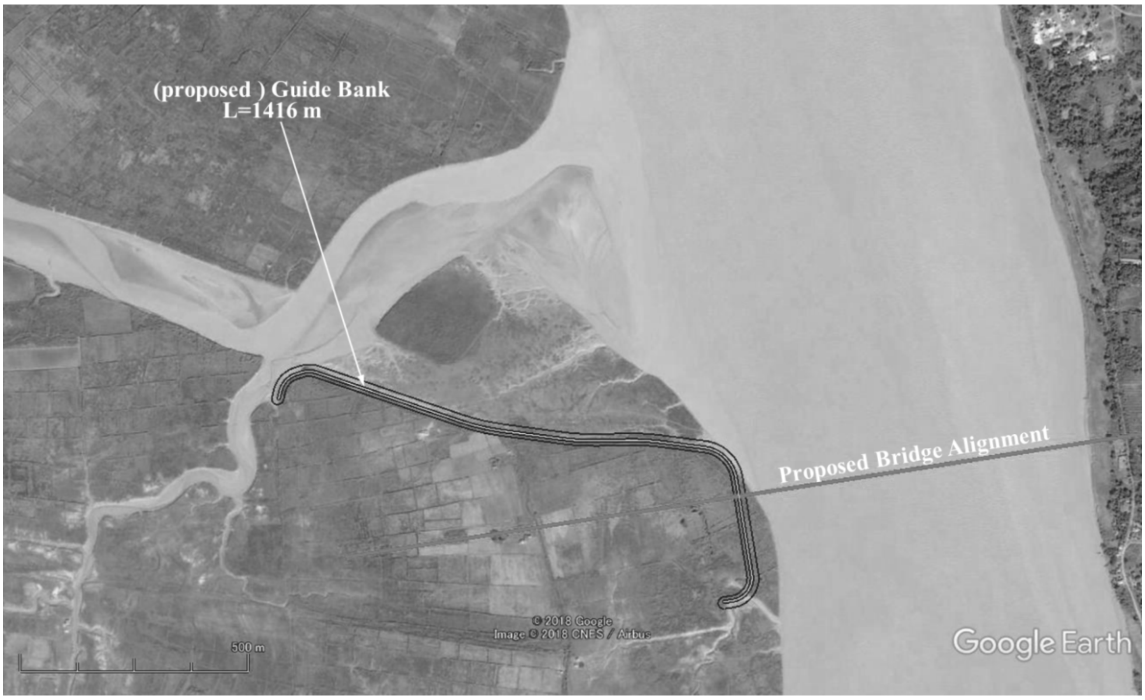
Table 7.6.1 Bank Protection Comparison Table for Right Bank

Evaluation Item	Alt-1 Guide Bank		Alt-2 Slope Protection	
Schematic View				
Basic Concept	River bank erosion and scour on land are not allowed in the bridge design		River bank erosion and scour are allowed in the bridge design	
Effectiveness	The existing river channel and bridge	○	Erosion/scour of the existing river channel	△

Against Erosion	foundations can be protected from the erosion/scour by the guide bank		and bridge foundations on land are concerned (Max. scour depth : 3- 6m)	
Social & Environmental Impact	- Improvement of flood control on site - Effective land use within the bank - Additional land acquisition is necessary	○	- No improvement of flood control - Additional land acquisition by the project is unnecessary, however more severe loss of the current agricultural land by erosion during/after tidal bore and flood events is highly concerned"	△
Construction Cost	1.18	△	1.00	○
Evaluation	**Recommended**		Not recommended	

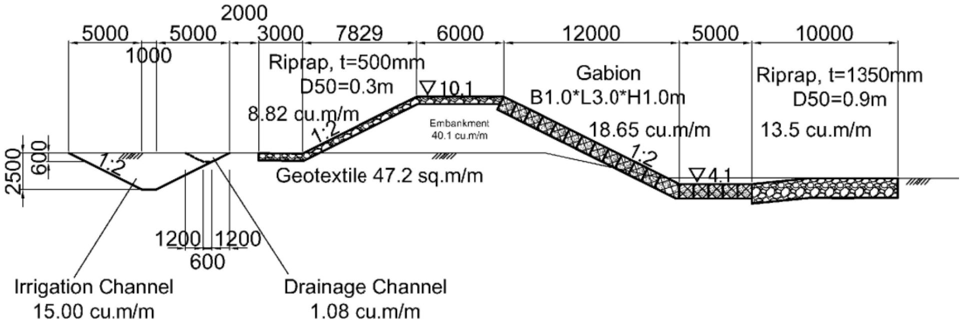
Source: JICA Study Team

The plan view and typical cross section are given in Figure 7.6.3 and Figure 7.6.4 respectively. The guide bank with approximately 1.42km is installed to cover the range of the New Sittaung Bridge including its approach road.



Source: Prepared by JICA Study Team based on Google Earth Map

Figure 7.6.3 Proposed Guide Bank at Right Bank



Source: JICA Study Team

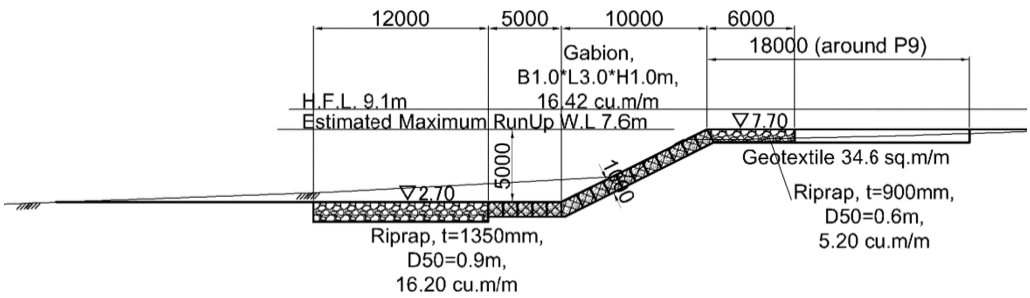
Figure 7.6.4 Typical Cross Section of Guide Bank for Right Bank

(3) Countermeasure for Riverbank Erosion of the Left Bank

As shown in Figure 7.6.1, the main river flow attacks the left bank nearby the proposed bridge. Although the left bank side is a natural levee with sufficient height and stability, the revetment is desirable to be applied to avoid the further river bank erosion. The revetment with approximately 330 meter in length is proposed to be installed along the current river bank line as shown in Figure 7.6.5.

Source: Prepared by JICA Study Team based on Google Earth Map

Figure 7.6.5 Proposed Guide Bank at Left Bank



Source: JICA Study Team

Figure 7.6.6 Typical Section of Revetment for Left Bank

7.6.4 Preliminary Design for Scour Protection

(1) Scour Estimation

1) Methodology of Scour Computation

For the design of bridge substructures, it is very important to evaluate the scour potential at piers and abutments, carefully studying site-specific subsurface information. Total scour is comprised of three components as listed below:

1. Long-term aggradation or degradation
2. Contraction scour
3. Local scour

a. Aggradation and Degradation

Aggradation and degradation are changes of streambed elevation over the long-term due to natural or man-induced causes which can affect the streambed. Aggradation involves the deposition of material eroded from the stream or watershed upstream of the bridge and degradation involves the lowering of the streambed due to the lack of sediment supply from upstream. Basically, it is to be evaluated independently of the hydraulic model. Generally, streams are considered to have stable and balanced sediment transport if the configuration is not changed over the long-term. (In this study, the river bed/course fluctuation analysis is not conducted. At the stage of detailed design, it shall be conducted, and their results will be studied after surveying current and past topographic data of rivers.)

b. Contraction Scour

Contraction scour at a bridge crossing involves the removal of material from the streambed and banks across the channel width, as a result from a contraction of the flow area and an increase in discharge at the bridge.

In the case of new bridge construction, common causes for contraction of flows are constriction (encroachment) of road embankment onto the floodplain and/or into the main channel or piers blocking a portion of flow. As a result, the flow area decreases which causes an increase in velocity and bed shear stress.

Hence, more bed material is removed from the contracted reach than transported into the reach. As bed elevation is lowered, the flow area increases, velocity reduces, and a situation of relative equilibrium is reached.

c. Local scour

Local scour at piers or abutments is due to the removal of bed material as a result of the formation of vortices known as the horseshoe vortex and wake vortex at their base. The horseshoe vortex results from the pileup of water on the upstream surface of the obstruction and subsequent acceleration of the flow around the nose of the pier or abutment. The action of the vortex removes bed material around the base of the obstruction. In addition to the horseshoe vortex around the base of a pier, there are vertical vortices downstream of the pier called the wake vortex. Both the horseshoe and wake vortices remove material from the pier base region. The intensity of wake vortices diminishes rapidly as the distance downstream of the pier increases. As a result, immediately downstream of a long pier there is often deposition of material.

Factors which affect the magnitude of local scour depth at piers and abutments are;

① Velocity of the approach flow,

② Depth of flow,

③ Width of the pier,

④ Discharge intercepted by the abutment and returned to the main channel at the abutment,

⑤ Length of the pier if skewed to flow,

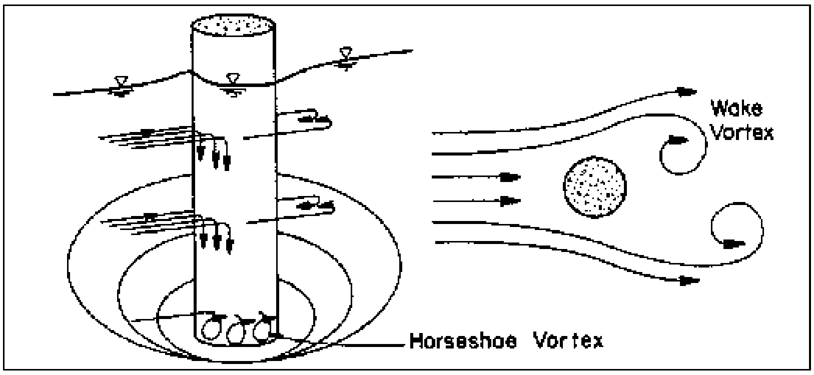
⑥ Size and gradation of bed material,

⑦ Angle of attack of the approach flow to a pier or abutment,

⑧ Shape of a pier or abutment,

⑨ Bed configuration, and

⑩ Ice formation or jams and debris.



Source: Evaluating Scour at Bridges (2012 Fifth edition), Hydraulic Engineering Circular No. 18 (HEC 18), FHWA, USA

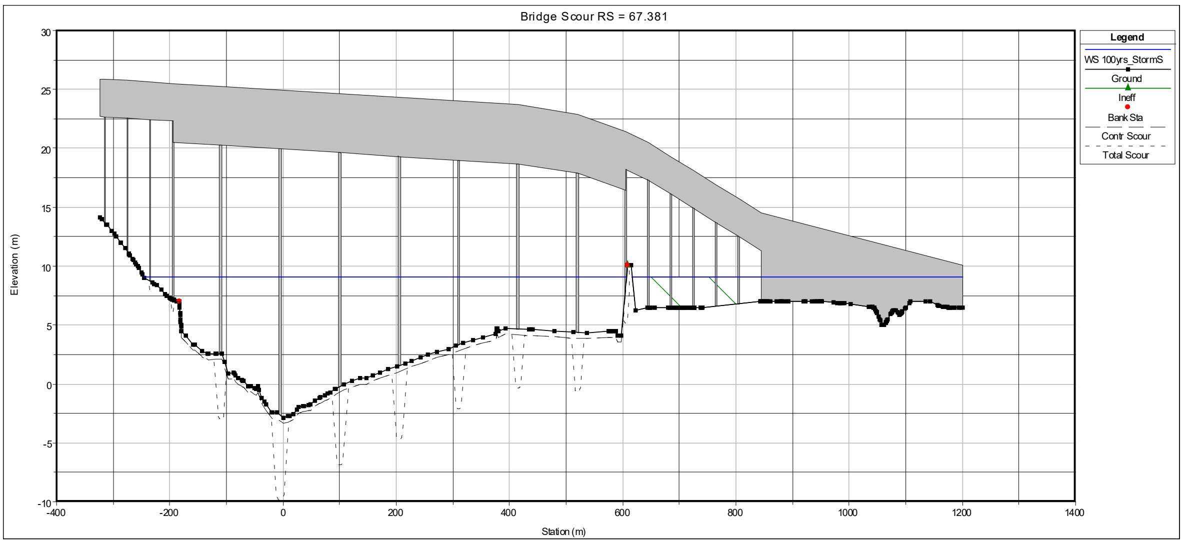
Figure 7.6.7 Schematic Representation of Scour at a Cylindrical Pier

2) Scour Estimation

All major stream reaches intercepted by the proposed bridge alignment were modeled by HEC-RAS model developed by Hydraulic Engineering Center, USA. These models were simulated for a 100-year return period discharging under the existing condition (without bridge) and incorporating the bridge. In Geometric Data, all of the bridge data including deck/roadway and piers are given.

Scour estimation by steady flow analysis of HEC-RAS is conducted, based on Hydraulic Engineering Circular No. 18 (HEC 18) of Federal Highway Administration (FHWA), USA by using the value of probable maximum discharge and probable high water level. And the schematic diagram of the scour depth of the proposed bridge is shown in Figure 7.6.8.

The results of scour estimation are as shown in Figure 7.6.8. The set design scour depth of 7.6m is taken into account in the foundation design of the main bridge.



Source: JICA Study Team

Figure 7.6.8 Schematic Diagram of Scour at Proposed Sittaung Bridge (100 yrs)

Table 7.6.2 Result for Scour Estimation (100 yrs)

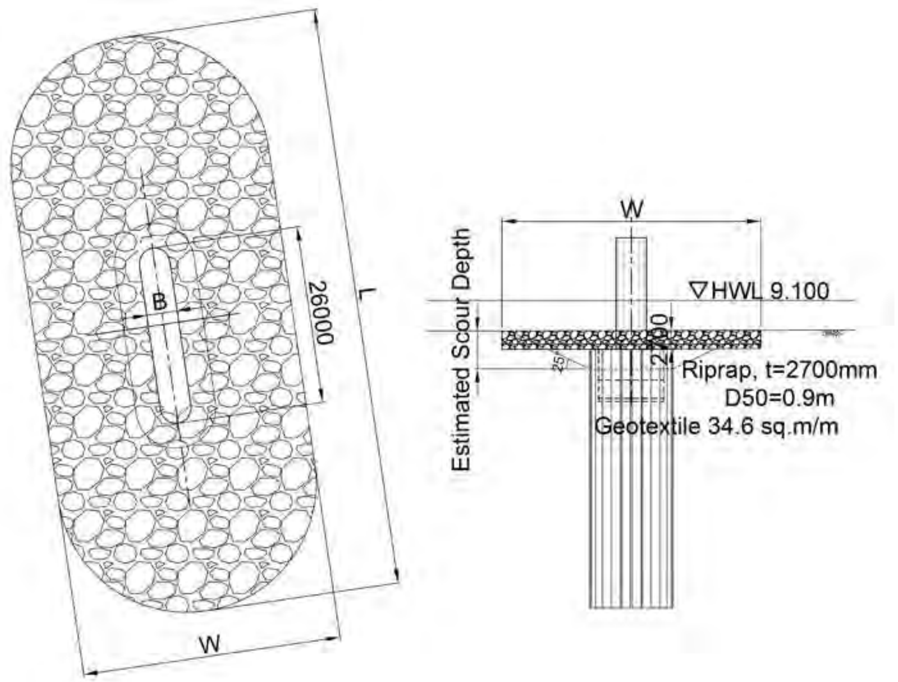
No.	Pier No.	100yrs Flood			100yrs Flood&Storm Surge		
		Contraction	Local	Total	Contraction	Local	Total
1	LP3	-	-	-	-	-	-
2	LP2	-	-	-	-	-	-
3	LP1	-	-	-	-	0.70	0.70
4	P9	-	0.95	0.95	-	1.14	1.14
5	P8	0.45	5.25	5.70	0.50	5.11	5.62
6	P7	0.45	7.16	7.60	0.50	6.71	7.22
7	P6	0.45	6.54	6.98	0.50	6.18	6.69
8	P5	0.45	6.00	6.45	0.50	5.74	6.24
9	P4	0.45	5.03	5.48	0.50	4.94	5.44
10	P3	0.45	4.49	4.93	0.50	4.51	5.01
11	P2	0.45	4.59	5.04	0.50	4.59	5.09
12	P1	-	0.00	0.00	0.50	2.70	3.20
13	RP5	-	0.00	0.00	-	0.00	0.00
14	RP4	-	0.00	0.00	-	0.00	0.00
15	RP3	-	0.00	0.00	-	0.00	0.00
16	RP2	-	0.00	0.00	-	0.00	0.00
17	RP1	-	0.00	0.00	-	0.00	0.00

Source: JICA Study Team

(2) Scour Protection for Bridge Pier

In this river area, the special phenomena (tidal bore, storm surge, etc.) occurs in the estuary of the Sittaung River, and the possibility for flow channel geometry's change by unforeseeable hydraulic events and/or channel evolution at other areas of the proposed bridge, cannot be denied. Therefore, it is effective to apply scour protection around piers in the river.

The typical plan and cross-section is shown in Figure 7.6.9. The riprap is to be installed within the zone of influence of each pier scour, and the minimum thickness is three times of the median riprap size (3xD50). The zone of influence of each pier scour is estimated by the angle of repose of riverbed materials (25°) in the water. The protection range at each pier is shown in Table 7.6.3. The mean diameter of riprap is calculated as 0.9 m by the rearranged Isbash equation.



Source: JICA Study Team

Figure 7.6.9 Typical Plan / Section of Bridge Pier Protection for Scouring

Table 7.6.3 Extent of Bridge Pier Protection

Pier No.	Protection Width (m)	Protection Length (m)	Protection Area (m^2)	Remarks
P8	39.00	86.00	2914.94	
P7	47.00	94.00	3831.29	
P6	44.00	91.00	3475.88	
P5	42.00	89.00	3246.79	
P4	38.00	85.00	2807.46	
P3	36.00	83.00	2597.22	
P2	36.00	83.00	2597.22	

Source: JICA Study Team

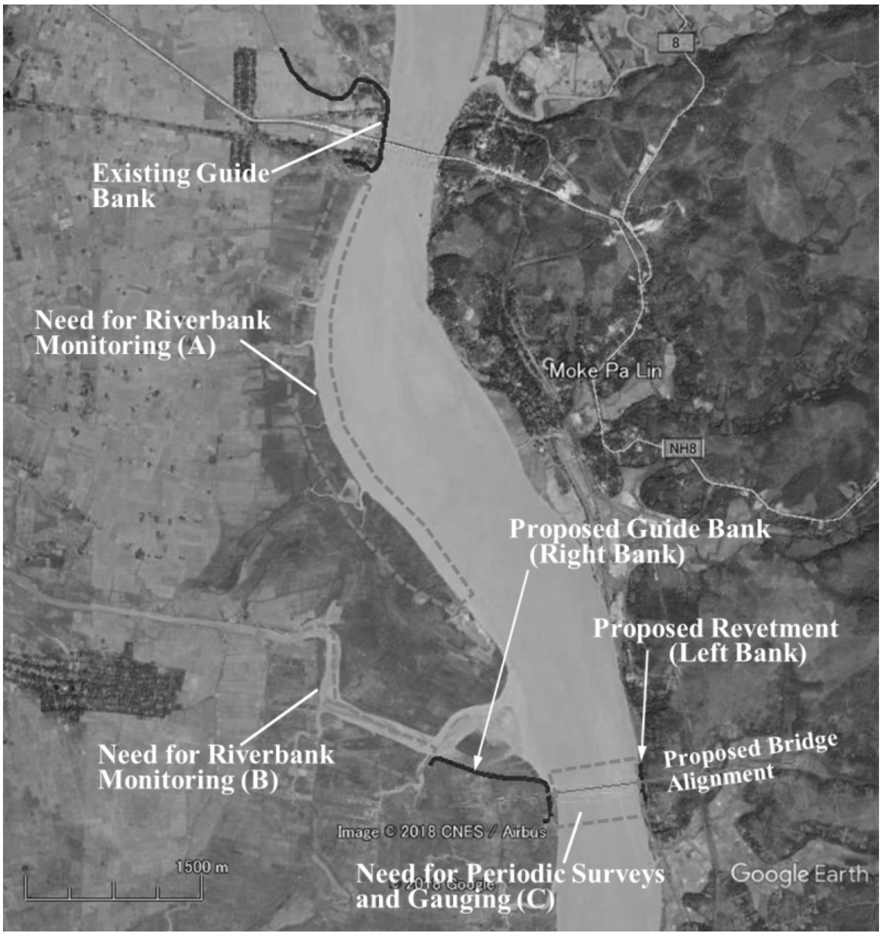
7.6.5 Further Consideration for Bank Protection

In a view from hydraulics, even if the above proposed countermeasures for both bank sides are installed, a risk of erosion and scour may remain due to unforeseen natural events (flood, storm surge by cyclone, etc.). Hence, the following monitoring should be periodically performed by the execution agency to take necessary further actions.

- ✓ Need for river bed monitoring around bridge section in order to check the further degradation (settlement) of the river-bed and the soundness of rip-rap protection works,
- ✓ Need for river bank monitoring at the river bend portion at the main river upstream (A), and right bank of tributary (B),

- ✓ Need for periodic bathymetric surveys at bridge cross-section, and water-level gauging (C).

It might be a concern that the river bank erosion on the bend portion of the right bank as shown in Figure 7.6.10. If progress of erosion is recognized by periodic monitoring, the following countermeasures should be taken.



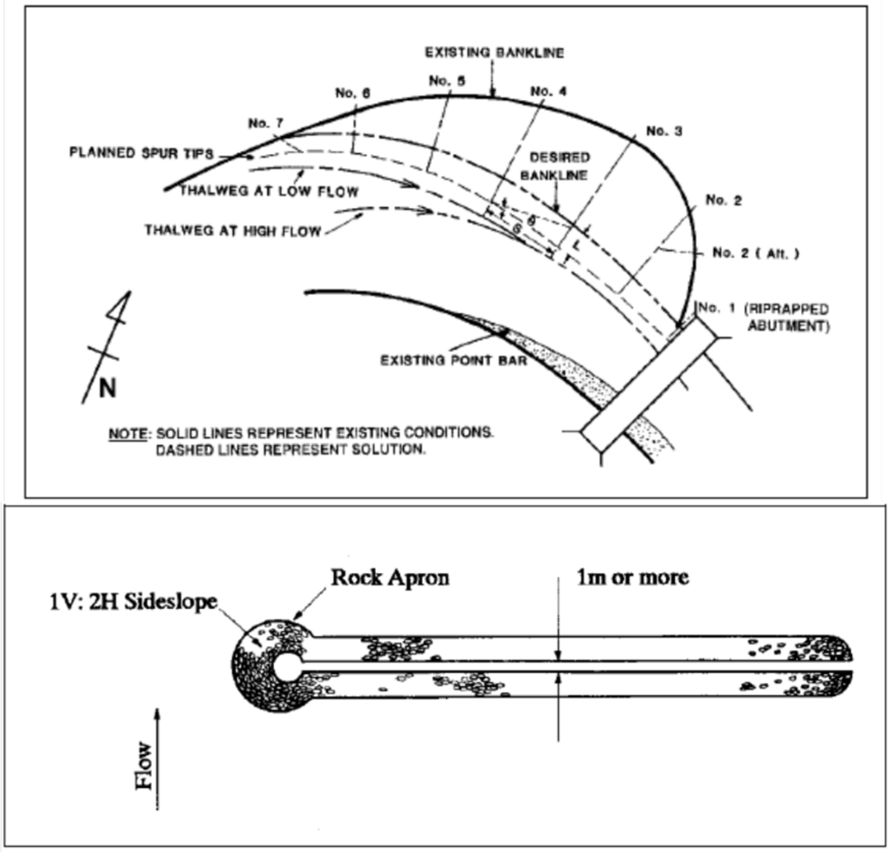
Source: JICA Study Team based on Google Earth Map

Figure 7.6.10 Need for Monitoring / Surveying / Gauging

(1) Countermeasures for the River Bend Portion at Right Bank Upstream

One of the possible countermeasures for extensive river bank erosion for the river bend portion on the right bank is to install spurs.

The spacing of spur dikes in a meander bend and the typical shape is shown in Figure 7.6.11. The calculation result for the spacing and length of each spur is shown in Table 7.6.4. As a result of conceptual design, 7 spur dikes with 2.4 km in total length are necessary as shown in Figure 7.6.12.



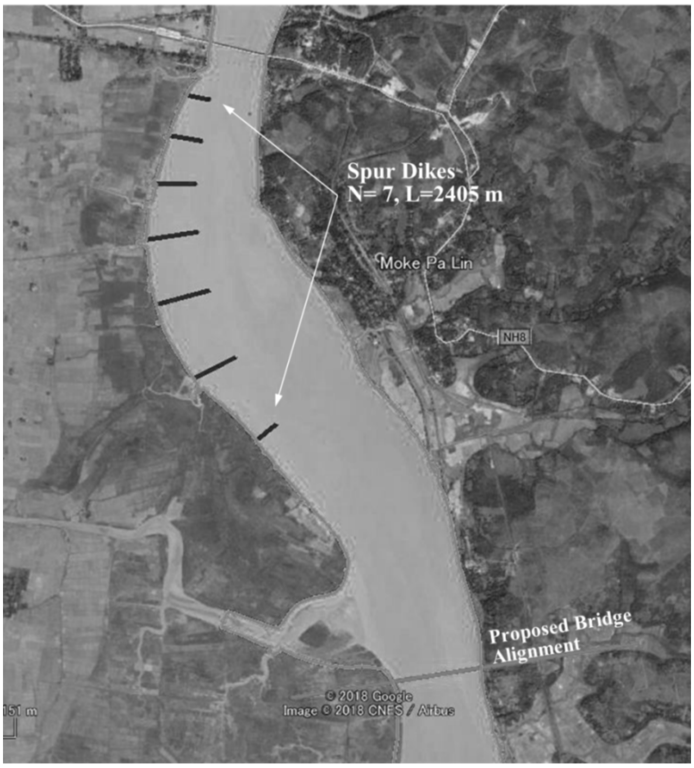
Source: JICA Study Team, Google Earth Map

Figure 7.6.11 Spur Dikes for the Bend Portion 1 on the Right Bank Upstream

Table 7.6.4 Spacing and Length of Each Spur for the Bend Portion 1

No.	Total Existing River Width: W2	Desirable River Width: W	Width between existing and desired banklines: W1	Total Spur Length: L1	Desired bankline to the spur tips: L	Span for spurs: S	Remarks
				L1= L+ W1	L= 0.2*W	S = L cot θ	
From Upstream							
1	649.3	556.8	92.5	203.9	111.4	364.2	
2	768.0	602.8	165.2	285.7	120.6	394.4	
3	882.5	670.3	212.2	346.3	134.1	438.5	
4	1106.3	816.4	289.9	453.2	163.3	534.1	
5	1290.4	1013.8	276.7	479.4	202.8	663.2	
6	1340.5	1161.8	178.8	411.1	232.4	760.0	
7	1119.8	1118.2	1.6	225.2	223.6	731.5	
			Total	2404.8			

Source: JICA Study Team



Source: JICA Study Team, Google Earth Map

Figure 7.6.12 Layout Map for Spur Dikes for the Bend Portion 1

CHAPTER 8 CONSTRUCTION PLANNING OF NEW SITTAUNG BRIDGE

8.1 Construction Outline

The construction of the New Sittaung Bridge consists of a main bridge (L=800m), both approach bridges (L=240m on the right bank side and L=960m on the left bank side) and approach roads.

The major components for civil works are summarized in Table 8.1.1.

Table 8.1.1 Summary of Major Civil Works

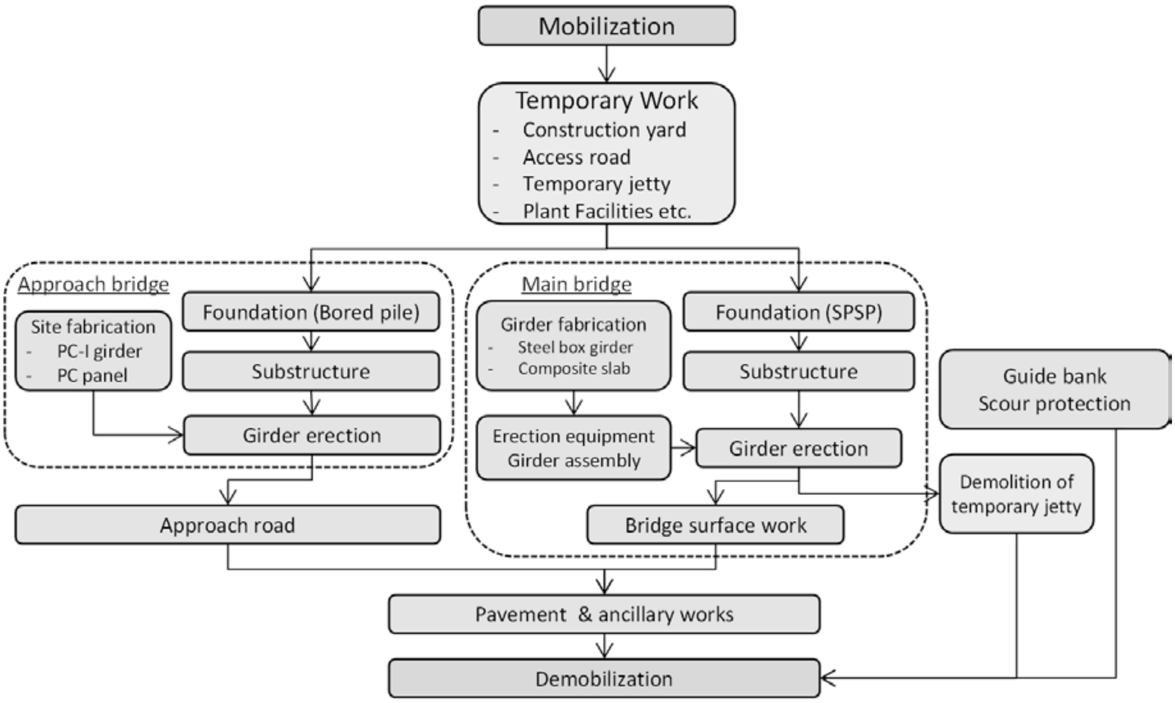
Work Item			Description
Main Bridge	Super structure	Bridge Type	8 span continuous steel narrow box girder, L=800m
		Width	W=22.0m
		Deck	Steel composite slab
	Substructure	Pier	Orval shape RC pier x 9 Nos (on land: 2 , in river :7)
	Foundation	In river	Steel Pipe Sheet Pile (SPSP), D=1200mm x 238 Nos
		On land	Cast-in-place RC Pile, D=1500mm x 42 Nos
Approach Bridge	Super structure	Bridge Type	PC-I composite girder, L=240m (right), L=960m (left)
		Width	W=22.0m
		Deck	PC composite slab
	Substructure	Abutment	Inversed-T shape RC abutment x 2 Nos
		Pier	Orval shape RC pier x 5 Nos (right), 24 Nos (left)
	Foundation	On land	Cast-in-situ Pile, D=1500mm x 276 Nos
Approach Road	Embankment	Width	W = 23.5m
		Length*	L = 248m (right), L = 252m (left)
Bank and Scour Protection		Guide bank	L= approx. 1.5km (right bank)
		Revetment	L= approx. 0.3 km (left bank)
		Scour protection	Riprap (t=2.7m) x 7 Nos

*Construction limit between JICA portion and ADB portion should be adjusted during detailed design
Source: JICA Study Team

8.2 Construction Methodology

8.2.1 Overall Construction Sequence

The major construction sequence for the construction of the New Sittaung Bridge is shown in Figure 8.2.1. The key points of the construction methodologies for specific works in this project are introduced in the following sections, excluding general civil works such as earth works, pavement works, etc.



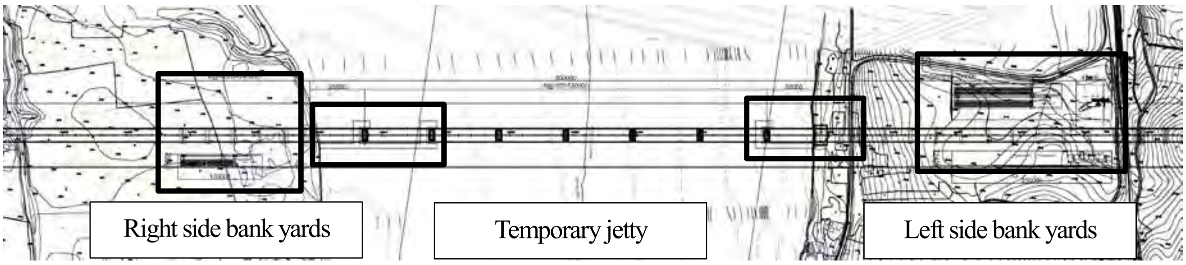
Source: JICA Study Team

Figure 8.2.1 Overall Construction Sequence

8.2.2 Temporary Works

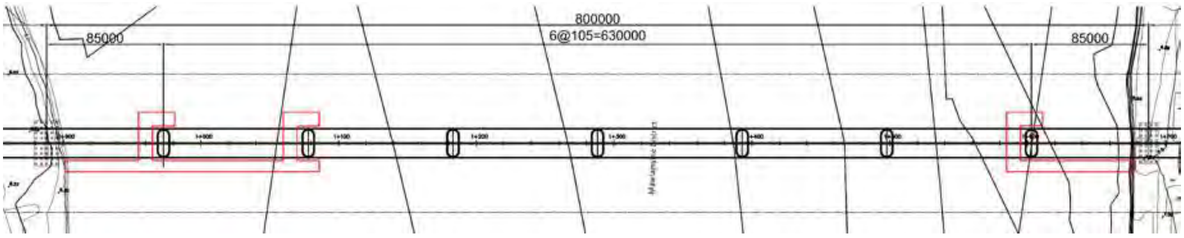
(1) Construction Yards and Temporary Jetty

The plan of the construction yards for the main and approach bridges is shown in Figure 8.2.2. The construction yards will be set up within the ROW except for the left bank north side construction yard. The land for a part of the left bank north side construction yard should be leased. As mentioned in Figure 8.2.3, a temporary jetty shall be installed in the shallow area of the river for construction in river section.



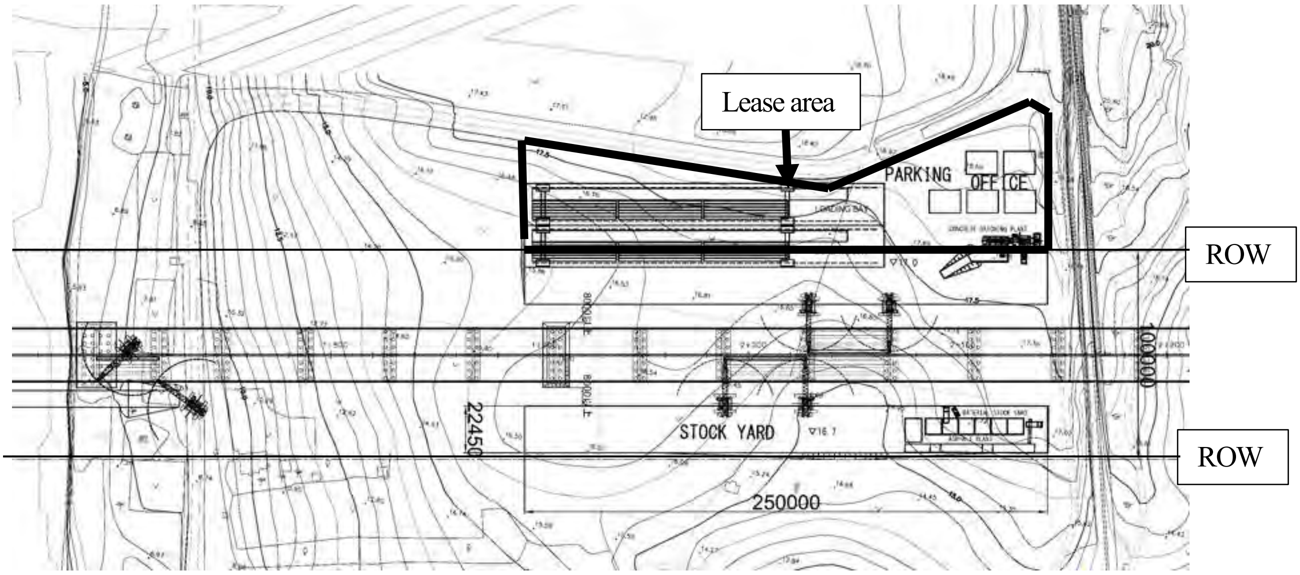
Source: JICA Study Team

Figure 8.2.2 Layout of Construction Yards for New Sittaung Bridge (Reference only)



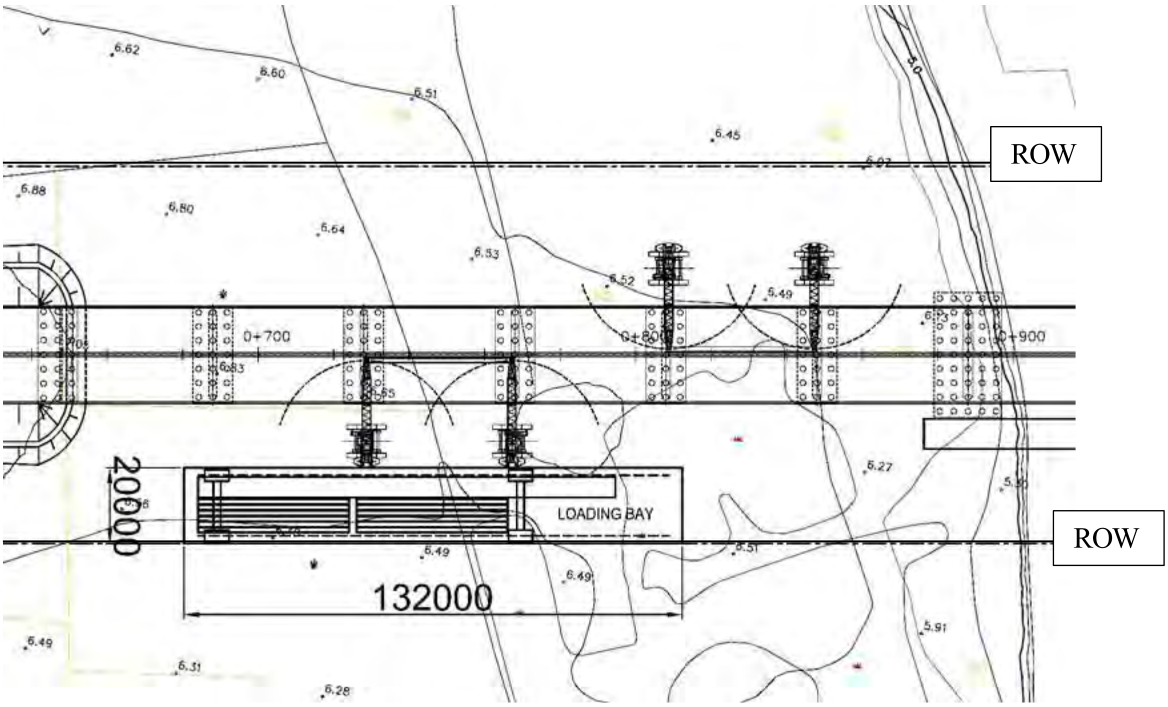
Source: JICA Study Team

Figure 8.2.3 Enlarged View of Temporary Jetty (Reference only)



Source: JICA Study Team

Figure 8.2.4 Enlarged View of Left Bank Side Construction Yards (Reference only)



Source: JICA Study Team

Figure 8.2.5 Enlarged View of Right Bank Side Construction Yards (Reference only)

(2) Access Roads

To enable the efficient construction works on both bank sides and shorten the construction period, access roads are necessary for both sides. The plan of the temporary access road for construction is shown in Figure 8.2.6. The existing "A" and/or "B" route has sufficient width, four meters, for a construction access road and is expected to be utilized as a construction road on the left bank. The widening and installation of a lay-by for construction vehicles are necessary on some portions along the route. On the right bank side, the existing route doesn't connect to the construction site and passes through the residential area (village). Thus, half of the route should be newly developed, bypassing the residential area, and the other section should be widened and raised up.

Source: Prepared by JICA Study Team based on Google Earth

Figure 8.2.6 Location and Plan of Temporary Access Road

8.2.3 Bridge Foundation Works

(1) Steel Pipe Sheet Pile (SPSP)

1) Construction yard for SPSP

Considering the river condition, foundation works shall be conducted on a "temporary jetty" in the shallow area, on the other hand, in the deep area it shall be conducted by "barge" as shown in Figure 8.2.7.

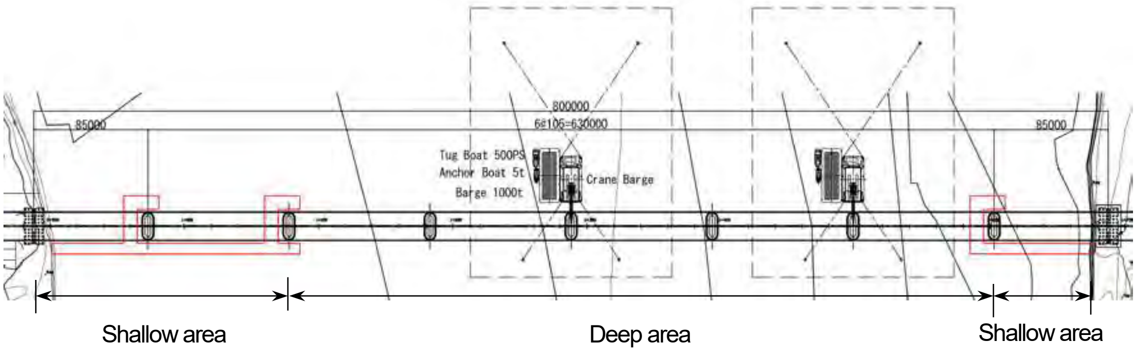
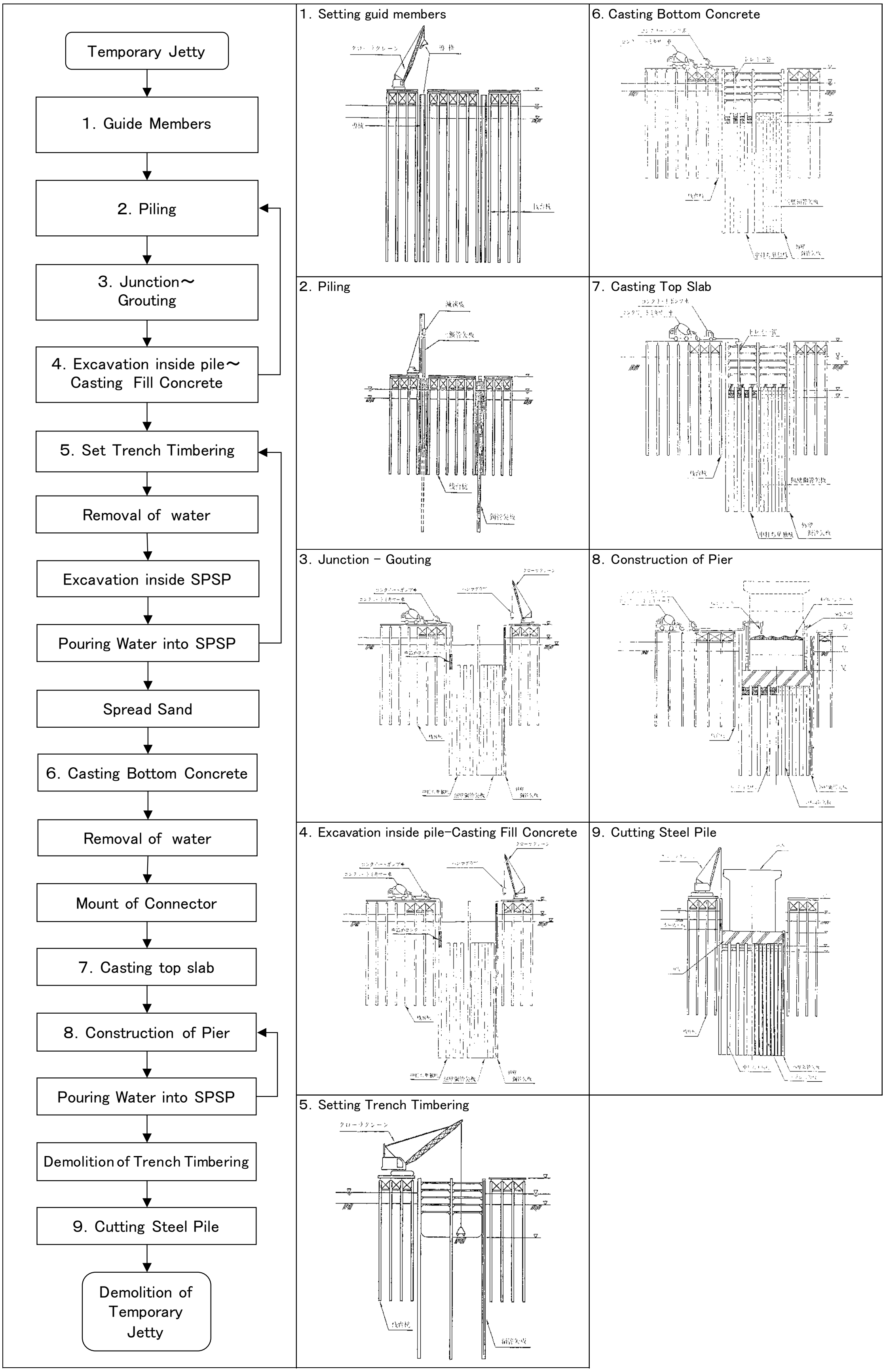


Figure 8.2.7 Typical Layout of Temporary Jetty and Barges during SPSP Construction

2) Construction Method

The SPSP shall be piled by a hydraulic vibro-hammer in consideration of the soil properties at the site. The work procedure for the installation of SPSP is shown in Figure 8.2.8.



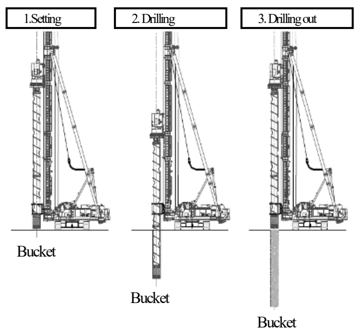
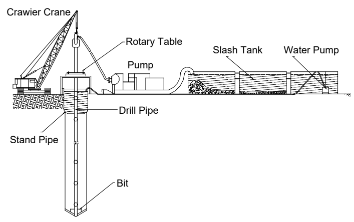
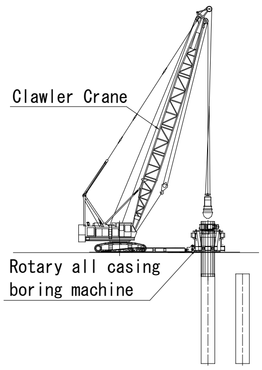
Source: JICA Study Team

Figure 8.2.8 Construction Steps for Steel Pipe Sheet Pile

(2) Cast-in-place RC Pile

Cast in-place RC pile construction methods are introduced in Table 8.2.1. Considering the applicable pile length as well as economically efficiency, the Reverse Circulation Drilling Method is recommended.

Table 8.2.1 Comparison of Piling Method for Cast-in-place RC Pile

Work method	Earth Drill Method	Reverse Circulation Drilling Method	All Casing Method (Rotary all casing boring system)
Schematic View			
Applicable Diameter	0.8m–3.0m	0.8m–3.0m	1.0m–3.0m
Standard applicable depth	to 40m	More than 60m	to 60m
Underground water	Applicable	Applicable	Applicable
Very soft surface layer	Applicable	Applicable	Not applicable
Gravel layer in mid layer	Difficult	Not applicable	Applicable all soil conditions
Direct cost	Reasonable	Tolerable	Higher
Evaluation	Not recommended	**Recommended**	Not recommended

Source: JICA Study Team

8.2.4 Substructure Works

(1) Piers in River

Concrete work including scaffolding, form work and reinforcement for pier column in river shall be carried out under a dry-up condition since the SPSP can work as a temporary cofferdam by waterproofing the joints of the steel pipes. The materials and construction machineries can be hauled through the temporary jetty or by barges.

(2) Substructures on Land

Structural excavations for the construction of piers/abutments on land are 3m to 4m deep, and hence can be directly excavated by a backhoe. The water level is high so countermeasures against water inflow – i.e., sump excavation and drainage pump installation – might be necessary.

The main substructure elements are divided into the footing, column, and pier head. 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 the 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.

8.2.5 Superstructure Works

(1) Erection Method of Steel Narrow Box Girder

1) Alternatives

Two alternatives can be extracted based on the below table.

Alternative 1 : Launching girder erection method (Erection nose girder)

Alternative 2 : Truck crane with bent method

Table 8.2.2 Applicable Erection Method for Steel Bridge

Erection Method / Bridge Type	with Bent (temporary pier)					Cable erection		Launching girder				Cantilever				Large-block erection			
	Truck Crane	Cable Crane	Traveler Crane	Portal-frame Crane	Floating Crane	Straight hanging	Oblique hanging	Erection nose girder	Barge + movable bent	Erection girder: Straight alignment	Erection girder: Curve alignment	Truck crane	Cable crane	Traveler crane	Floating crane	Truck crane	Floating crane	Barge	Winch
Simple girder	◎	○	△	○		△		◎	○							◎	○	○	
Continuous girder	◎	○	○	○	○	△		◎		○		○	○	○	○	△	○	○	△
Steel girder (at curve section)	◎	○	○		○						◎	○				△			
Simple truss	○	○	○		○	◎											○	○	
Continuous truss	○	△	◎		○	△						○	○	◎	○		○		△
Steel Arch	△	○				○	◎		○	○	○							○	
Rigid-frame bridge	○	△																	
Cable-stayed	△	○	◎		◎							○	○	◎	○	◎			

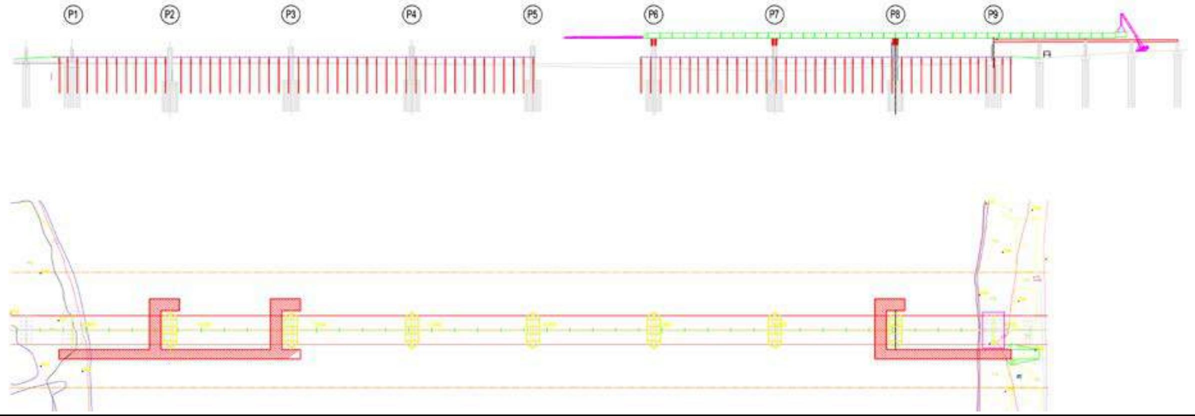
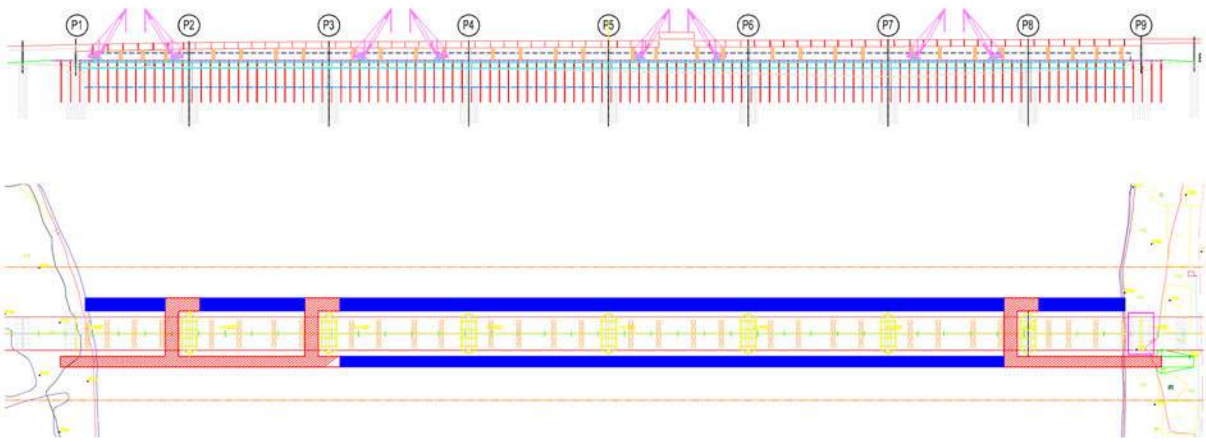
Note) ◎ : Often applied ○: Occasionally applied △ can be applied

Source: Prepared by JICA Study Team based on "Guide line for cost estimation of bridge erection (2018), Japan Construction Machinery and Construction Association

2) Evaluation

The comparison table is shown in Table 8.2.3. Alternative-1 is selected for the erection method of a steel narrow box girder bridge since alternative-2 needs higher construction cost and longer construction period due to the additional temporary bridge/jetty which is necessary for girder erection by truck cranes. The construction sequence and schedule for each alternative is shown in Table 8.2.4 and Table 8.2.5, respectively.

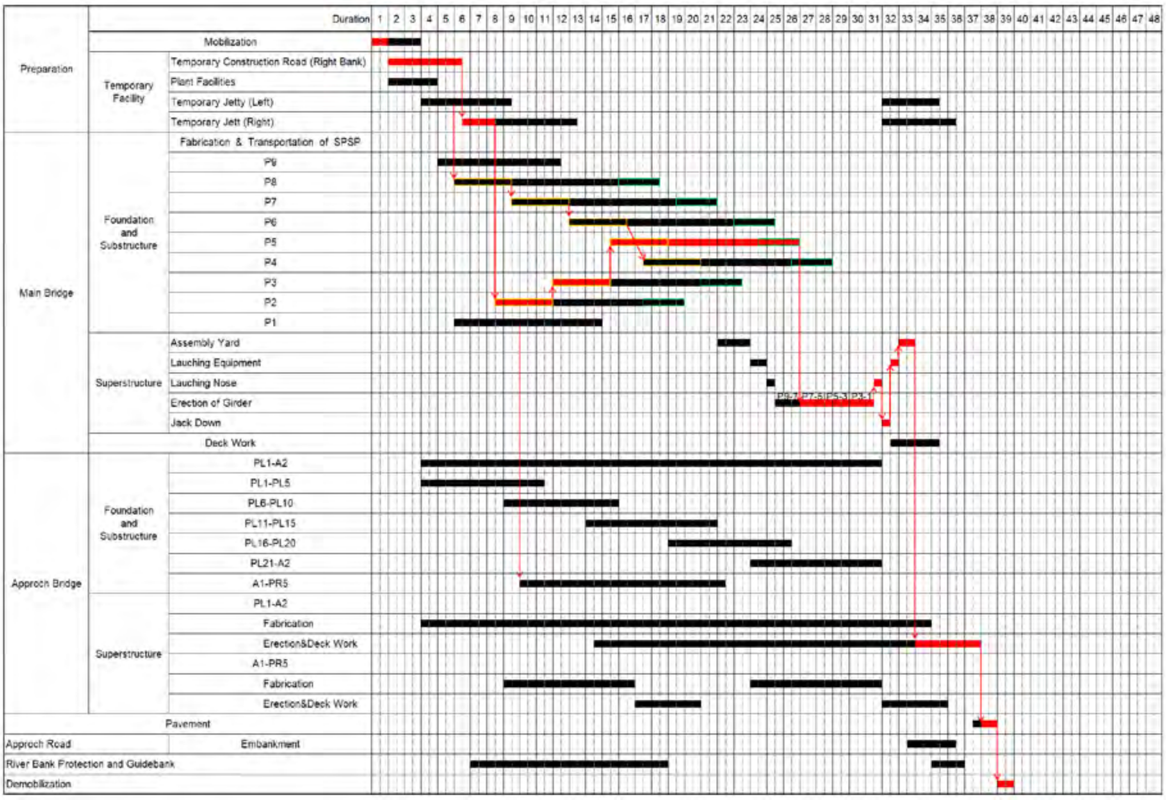
Table 8.2.3 Comparative Study on Erection Method for Steel Narrow Box Girder Bridge

<table>
<tr><td colspan="5">Alternative-1 : Launching girder erection method (Erection nose girder)</td></tr>
<tr><td colspan="5">
</td></tr>
<tr><td colspan="2">Erection Cost</td><td colspan="2">Construction Period*</td><td>Evaluation</td></tr>
<tr><td>1.00</td><td>◎</td><td>39 months (1.00)</td><td>◎</td><td>Recommended</td></tr>
<tr><td colspan="5">Alternative-2 : Truck crane with bent method</td></tr>
<tr><td colspan="5">

Additional temporary bridge / jetty</td></tr>
<tr><td colspan="2">Erection Cost</td><td colspan="2">Construction Period*</td><td>Evaluation</td></tr>
<tr><td>1.13</td><td>○</td><td>44 months (1.13)</td><td>△</td><td>Not Recommended</td></tr>
</table>

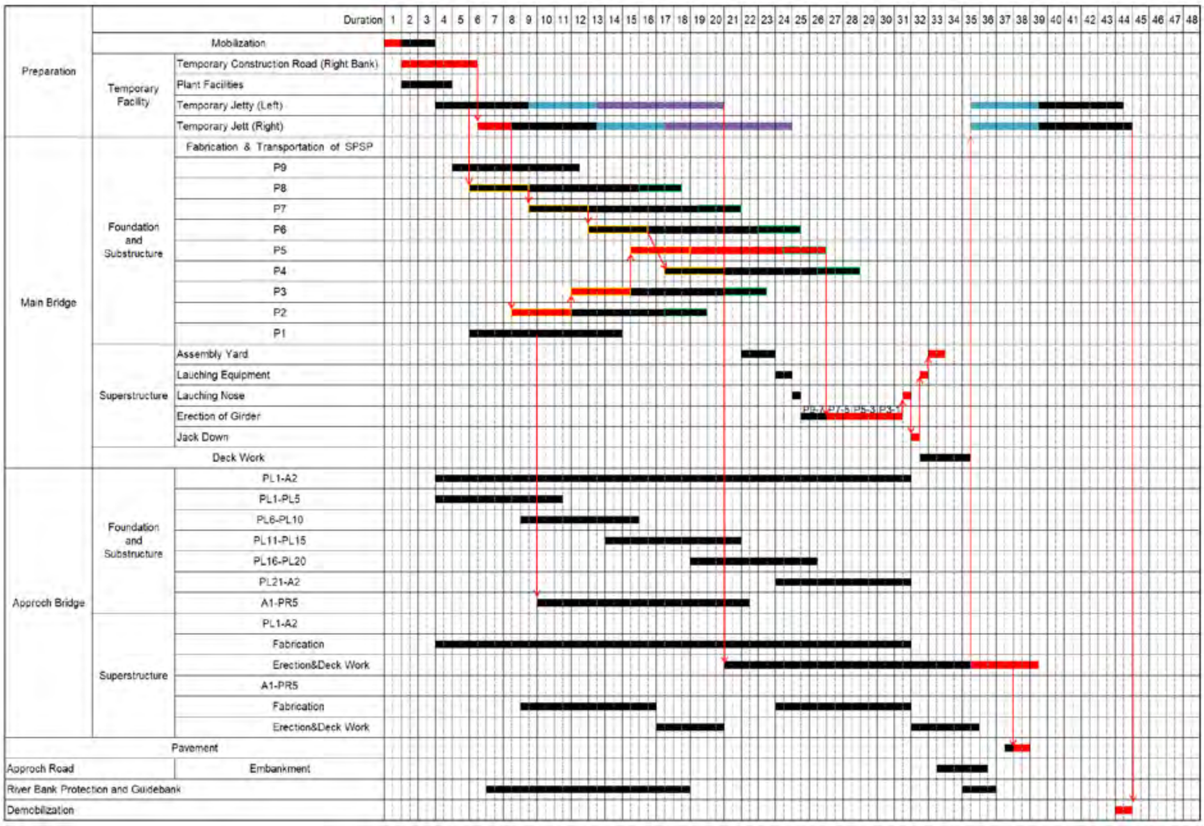
◎ : Excellent ○ : Good △ : Not good
* Construction period in case that work efficiency is 0.83.
Source: JICA Study Team

Table 8.2.4 Comparative Schedule for Alternative 1 (As reference)



Source: JICA Study Team

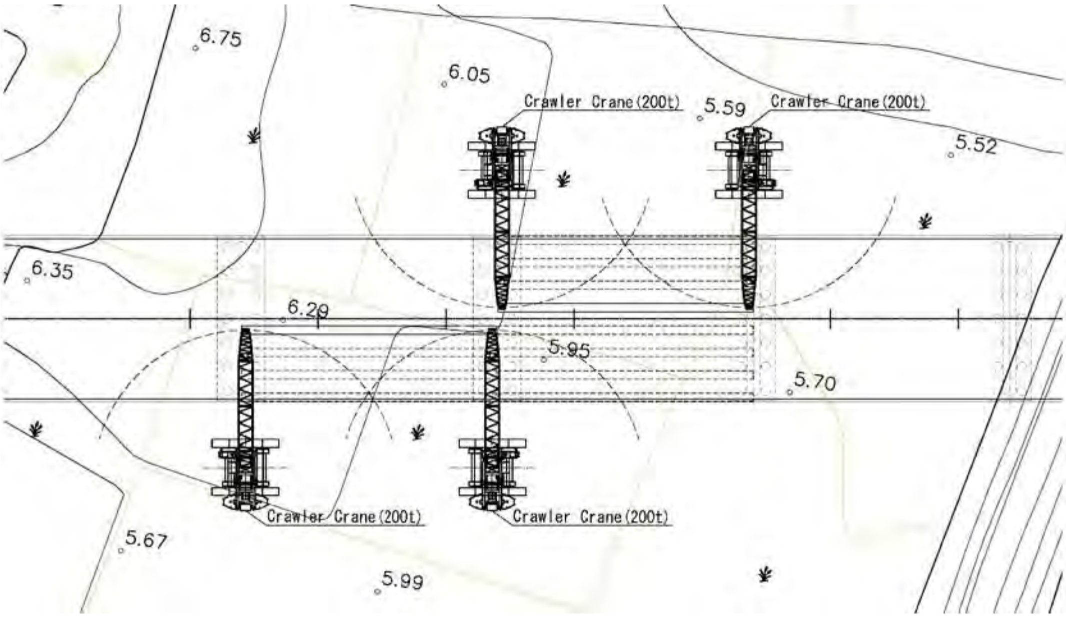
Table 8.2.5 Comparative Schedule for Alternative 2 (As reference)



Source: JICA Study Team

(2) PC-I Composite Girder

PC-I girder and PC slab panels are fabricated in a factory and hauled to/stored in a temporary yard. Since each girder weighs approximately 120 tons, it is necessary to use two 200 ton crawler cranes as illustrated in Figure 8.2.9. To shorten the construction period, the slab construction is carried out in parallel with the girder erection and the precast panels are set in position using a truck crane.



Source: JICA Study Team

Figure 8.2.9 Erection of PC-I Girder

8.3 Procurement Plan

8.3.1 Procurement Plan for Major Materials and Source of Materials

Cement, aggregate, PC-I girders and PC panels and temporary jetty can be procured domestically in Myanmar. Factory produced steel box-girder and steel deck slab for main bridge, and bearing and expansion joint will be procured from Japan or 3rd countries. Main materials for the construction of the bridges and road, and expected those sources are shown in Table 8.3.1.

Table 8.3.1 Procurement Plan for Main Materials

Material	Country to be Procured	Remarks
Gasoline	Local	
Diesel	Local	
Natural Gravel	Local	
Asphalt Prime Coat	Local	Imported bitumen products
Asphalt Tack Coat	Local	Imported bitumen products
Asphalt Concrete	Local	Imported bitumen products
Cement	Local	
Steel Pipe Sheet Pile	Japan or 3rd Country	
H-Shaped Steel	Local	Imported steel products
Other Shaped Steel	Local	Imported steel products
Reinforcement Bar	Local	Imported steel products
Steel Box Girder	Japan or 3rd Country	
Steel Deck Slab	Japan or 3rd Country	

PC-I Girder	Local	Imported PC cable products
PC Board	Local	Imported PC cable products
Bearing	Japan or 3rd Country	
Expansion Joint	Japan or 3rd Country	

Source: JICA Study Team

8.3.2 Procurement Plan for Major Equipment

The construction of the main bridge on the river is planned by an unconventional construction method in Myanmar which is the push-out method for steel box-girder erection and the steel pipe sheet pile method for foundation. Therefore, equipment for the push-out method and the pile driver for the steel pipe sheet pile will be procured from Japan.

The other equipment for the construction of bridges and road is available in Myanmar. The main equipment for construction of the bridge and road are shown in Table 8.3.2.

Table 8.3.2 Procurement Plan for Main Equipment

Equipment	Specification	Country to be Procured
Dump Truck	10t	Local
Dump Truck	2t	Local
Track Crane	4.9t	Local
Track Crane	16t	Local
Track Crane	200t	Local
Rough Terrain Crane	16t	Local
Rough Terrain Crane	25t	Local
Rough Terrain Crane	50t	Local
Crawler Crane	40~45t	Local
Crawler Crane	50~55t	Local
Crawler Crane	60~65t	Local
Crawler Crane	100t	Local
Clamshell	Bucket Struck Capacity 0.8m^3	Local
Back Hoe	Bucket heaped Capacity 0.8m^3	Local
Back Hoe	Bucket heaped Capacity 0.45m^3	Local
Bulldozer	21t	Local
Bulldozer	15t	Local
Motor Grader	Blade Length 3.1m	Local
Road Roller	10~12t	Local
Tire Roller	8~20t	Local
Vibration Roller	8~10t	Local
Vibration Roller	Combined Type 3~4t	Local
Tamper	60~80kg	Local
Asphalt Finisher	1.7~3.1m	Local
Concrete Pumping Truck	90~110m^3/h	Local
Vibratory Hammer	60kW	Local or Foreign
Push-out Devices		Japan
Bent		Local or Foreign
Crawler Pile Driver		Japan
Generator	250kVA, 300kVA	Local

Source: JICA Study Team

8.4 Construction Schedule

8.4.1 Introduction

In order to establish an eligible construction schedule, two alternatives were nominated in consideration of the following conditions:

- In principle[1], construction work at night shall not be carried out, in order to mitigate negative impact to birds and ecology around the project area, designated as IBA/KBA
- Basic working condition : 5days / week, 9 hours (8:00 – 17:00)

Table 8.4.1 Alternatives for Comparative Study on Construction Schedule

Item	Alternative-1 : Normal Construction Period	Alternative-2 : Shortened Construction Period
Work Hour	5days / week 9 hours / day (8:00 – 17:00)	6days / week 10 hours / day (8:00 – 18:00)
Workable Days	207days / year (57%)	285days /year (78%)

Source: JICA Study Team

8.4.2 Result

A comparison table is shown in Table 8.4.2. Considering a request by MOC that the completion date of civil works should be as early as possible, "Alternative-2" is a recommended option although the option requires bid higher construction cost (approx. +3%) due to additional cost for labor's overtime works. The construction schedule for each alternative is shown in Figure 8.4.1 and Figure 8.4.2.

Table 8.4.2 Comparative Study on Construction Schedule

Item	Alt-1 Normal Construction Period		Alt-2 Shortened Construction Period	
Condition	- 5 days / week - 9 hours / day (8:00 – 17:00)		- 6days / week - 10 hours / day (8:00 – 18:00)	
Workable Days	207days / year (57%)		285days /year (78%)	
Construction Period	44 months	○	36 months	◎
Project Cost Ratio	1.00	◎	1.03	○

Source: JICA Study Team

Table 8.4.3 Calculation of Workable Days (As Reference)

Alternative-1

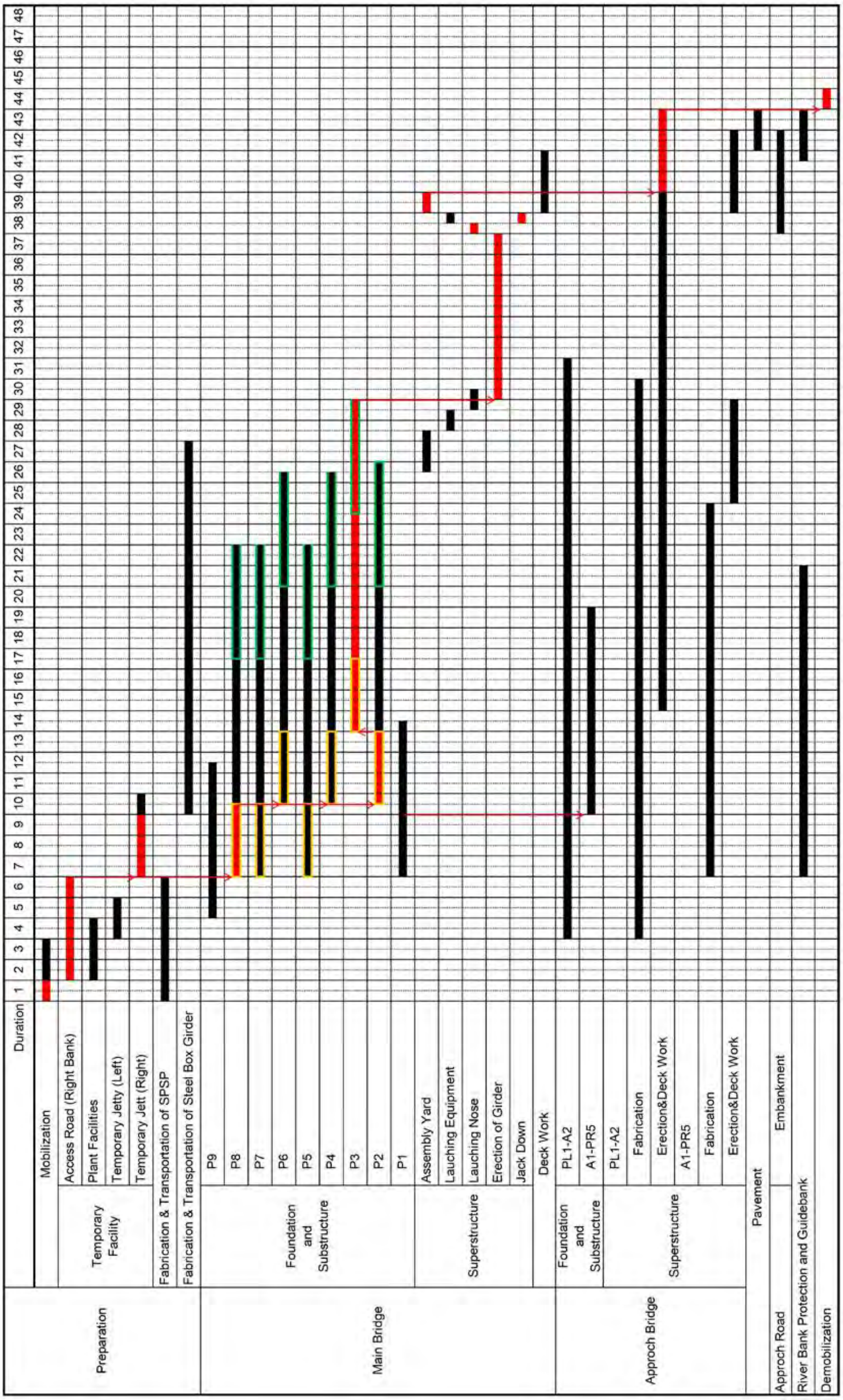
Item	Unit	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Unworkable day due to heavy rains*	Day	0.25	0.00	0.00	0.25	5.00	12.50	15.25	12.75	9.00	5.25	1.75	0.00	62.0
Weekend	Day	6	6	6.5	4.5	6	6.5	7	6	7.5	6	6	7.5	75.5
Public holidays	Day	2	1	3	6	1	0	2	0	0	3	2	1	21.0
Calendar days	Day	31	28	31	30	31	30	31	31	30	31	30	31	365.0
Unworkable days	Day	8.25	7.00	9.50	10.75	12.00	19.00	24.25	18.75	16.50	14.25	9.75	8.50	158.5
Workable days	Day	22.75	21.00	21.50	19.25	19.00	11.00	6.75	12.25	13.50	16.75	20.25	22.50	206.5
Work efficiency		0.73	0.75	0.69	0.64	0.61	0.37	0.22	0.40	0.45	0.54	0.68	0.73	0.57

Alternative-2

Item	Unit	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Unworkable day due to heavy rains*	Day	0.25	0.00	0.00	0.25	5.00	12.50	15.25	12.75	9.00	5.25	1.75	0.00	62.00
Weekend (Sunday)	Day	4	4	4	3	4	4	5	4	5	4	4	5	50.0
Public holidays	Day													0.0
Calendar days	Day	31	28	31	30	31	30	31	31	30	31	30	31	365.0
Unworkable days	Day	4.25	4	4	3.25	9	16.5	20.25	16.75	14	9.25	5.75	5	112.0
Workable days	Day	26.75	24.00	27.00	26.75	22.00	13.50	10.75	14.25	16.00	21.75	24.25	26.00	253.0
Adjustment factor for work efficiency	Day	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.13	
Adjustedd work efficiency		0.98	0.97	0.98	1.01	0.80	0.51	0.39	0.52	0.60	0.79	0.91	0.95	0.78

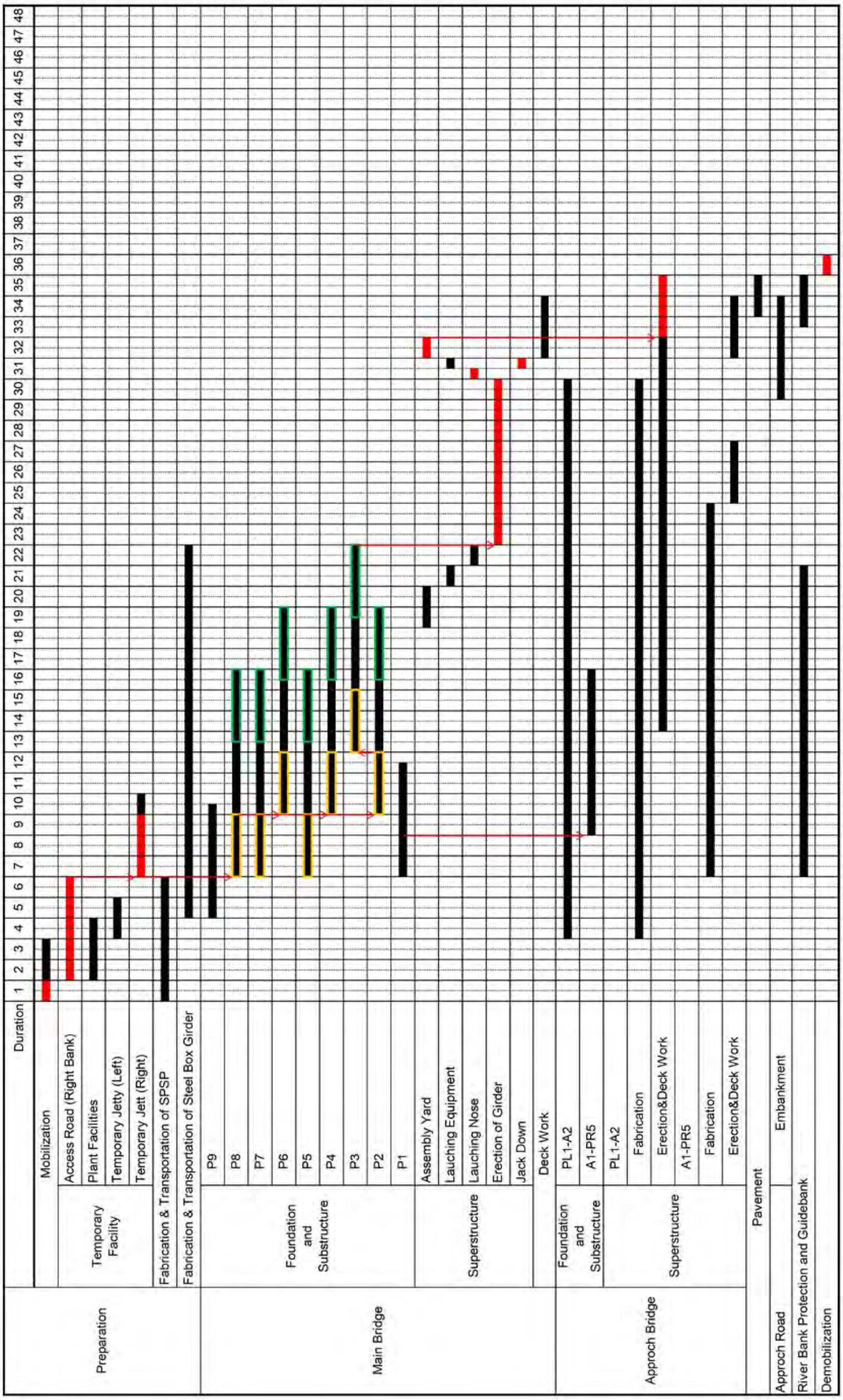
Source: JICA Study Team

[1] For instance, concrete works are necessary to be carried out during night time for quality assurance.



Source: JICA Study Team

Figure 8.4.1 Construction Schedule for Alternative-1



Source: JICA Study Team

Figure 8.4.2 Construction Schedule for Alternative-2

CHAPTER 9 OPERATION AND MAINTENANCE PLAN

9.1 Introduction

The planning and design, construction, as well as operation and maintenance of major roads including union highways in Myanmar are under the control of MOC. Likewise, MOC is the executing agency for this Project, therefore the operation and maintenance of the project expressway will be responsible by MOC.

In this Chapter, the existing implementation structure and capacity of MOC are confirmed at first. Second, an effective operation and maintenance plan for the project expressway is prepared in consideration of the ADB plan.

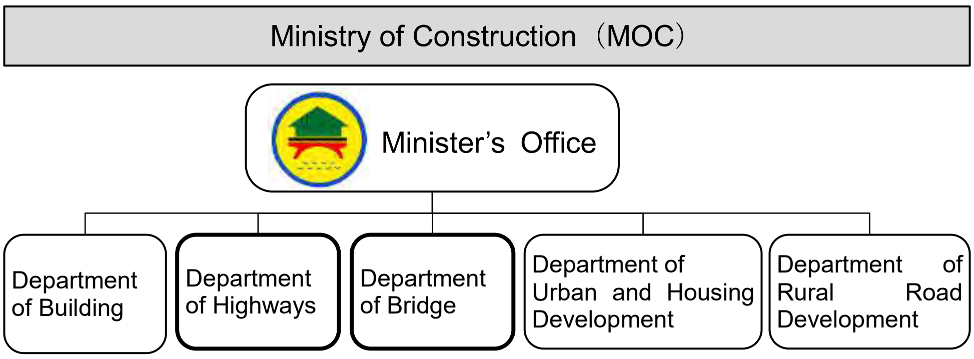
9.2 Organization and Capacity of Agency Responsible for Road and Bridge Operation and Maintenance

9.2.1 The Organization and Responsibilities of MOC

MOC is mainly responsible for the planning, design and construction as well as operation and maintenance of the road and bridge sector in Myanmar, and it consists of 5 departments as shown in Table 9.2.1

The construction and maintenance of bridges with more than 50 feet in length (approx. 15 meters) is conventionally undertaken by the special units under DOB, while with 50 feet or less in length is undertaken by the special units or the local offices under DOH. In this Project, the road section assisted by ADB is under DOH, the bridge section assisted by JICA is under DOB.

Around 13% of the national roads out of whole length of the roads (42,100 km) undertaken by MOC are operated and maintained under Build–Operate–Transfer (BOT) by private companies.

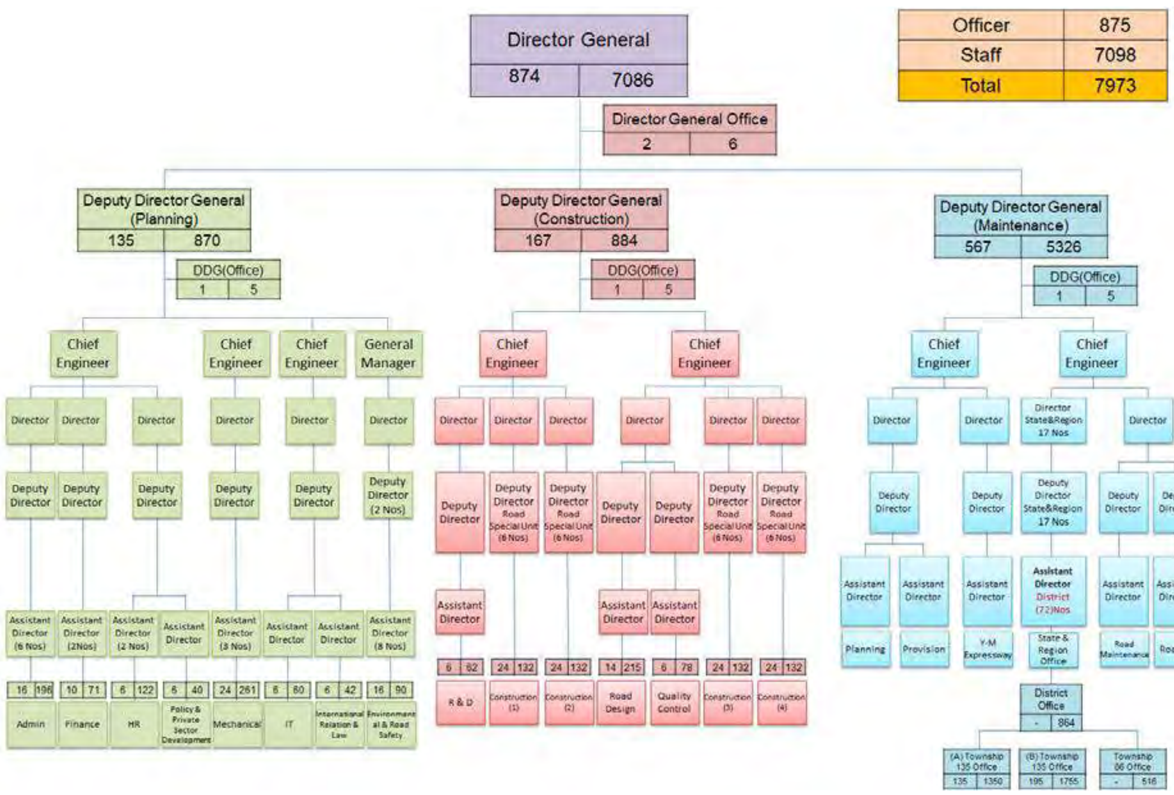


Source: MOC

Figure 9.2.1 MOC's Organization Chart

(1) Department of Highways (DOH)

DOH is the largest department in MOC. The division of planning, the division of construction and the division of maintenance are organized under the Director General as shown in Figure 9.2.2. In collaboration with the 24 special units and the local branch offices throughout the country, the maintenance division under the head office of DOH in Nay Pyi Taw manages road maintenance works. The Yangon-Mandalay Expressway (the Y-M Expressway), which is the sole expressway in Myanmar, is under direct management by the maintenance division.

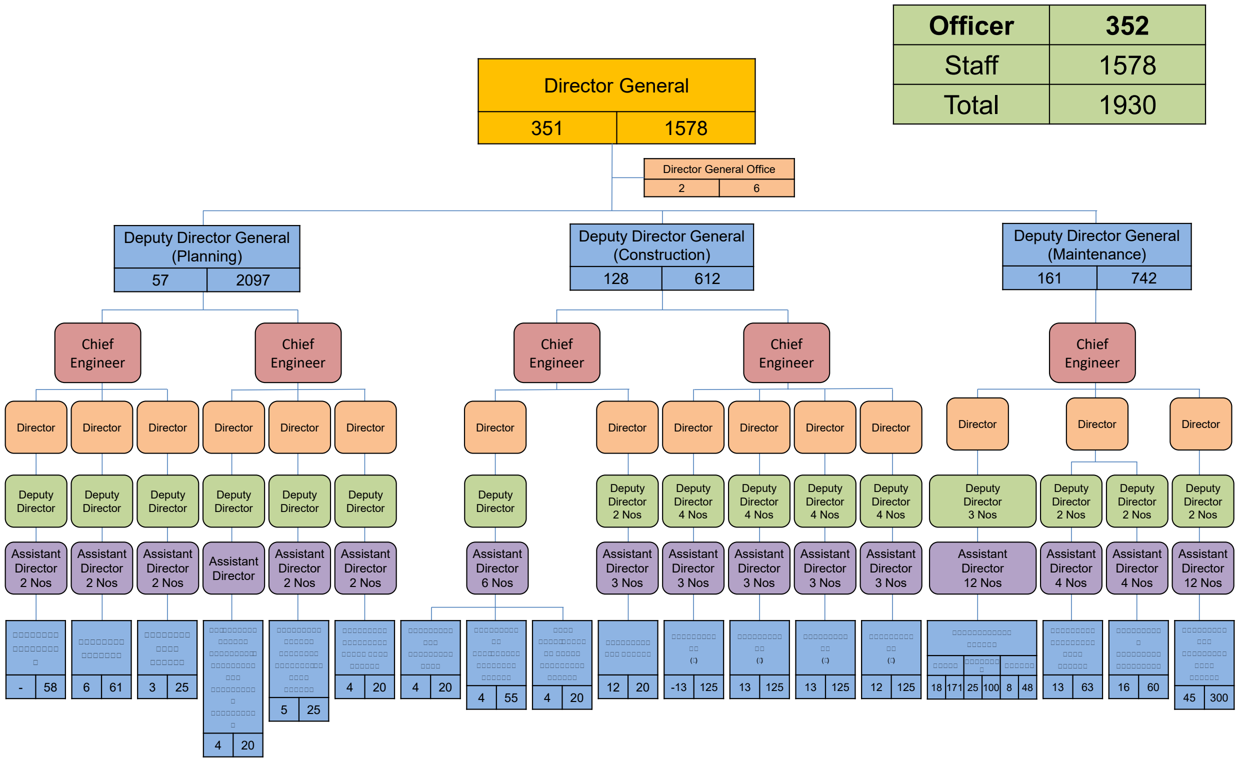


Source: MOC

Figure 9.2.2 DOH's Organization Chart

(2) Department of Bridge (DOB)

Likewise DOH, the division of planning, the division of construction and the division of maintenance are organized under the Director General which are responsible for planning, design and construction as well as operation and maintenance, respectively (see Figure 9.2.3). The maintenance division under the head office of DOB in Nay Pyi Taw is responsible for management of bridge maintenance works and the 16 special units are in charge of site work such as inspection and repairing work.



Source: MOC

Figure 9.2.3 DOB's Organization Chart

9.2.2 Finance and Budget of MOC

Table 9.2.1 and Table 9.2.2 show the recent budget status of DOH and DOB respectively. The budget of DOH is basically divided into the capital budget for construction cost, and the current budget for maintenance cost. Except for the annual budget for 2015/2016 fiscal year which was reorganized from the former Public Works (PW) and those in 2018 when the fiscal year was changed from April/March to October/September, the annual budget of DOH has been between 250 to 270 billion kyats. The annual budget for maintenance work has been approximately 50 billion kyats.

Regarding the total annual budget of DOB, it has been between 50 to 120 billion kyats. According to the interviews with DOB, 17 billion kyats has been generally allocated as the annual budget for maintenance works and it is enough for maintenance cost. In addition, extraordinary budgets can be allocated from the union account in case of emergencies such as a bridge collapse due to natural disaster.

Table 9.2.3 shows the comparison on the budgetary situation for road maintenance with other countries. Although there are some fundamental differences such as price level and road specifications among the countries, it is found that the annual budget for the road maintenance per kilometer in Myanmar is much lower than those of Thailand.

Table 9.2.1 Actual Budget of DOH (Million Kyat)

Type of Budget	2015/2016	2016/2017	2017/2018	2018 (6 months)	2018/2019
Union Capital Budget					
Capital Budget	281,590	196,006	183,462	43,326	246,811
Supplementary Budget	1,263	16,490	11,668	-	-
Reserved Fund	16,225	5,000	11,688	-	-
SUBTOTAL	299,078	217,496	206,818	43,326	246,811
Proportion	84.9%	80.8%	80.3%	86.6%	97.5%
Union Road Maintenance Budget					
Routine Maintenance	5,066	5,053	5,309	2,701	6,278
Special Maintenance (Periodic, Preventive)	34,243	28,946	36,145	989	-
Emergency Maintenance (Repair for Rainy Damages)	11,618	8,620	6,136	2,217	-
Special Maintenance for Yangon – Mandalay Expressway	2,421	8,972	3,206	798	-
Supplementary Budget	-	29	-	-	-
SUBTOTAL	53,348	51,620	50,796	6,705	6,278
Proportion	15.1%	19.2%	19.7%	13.4%	2.5%
GROUND TOTAL	352,426	269,116	257,614	50,031	253,089

Source: MOC

Table 9.2.2 Actual Budget of DOB (Million Kyat)

Type of Budget	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018
Bridge Construction Budget	56,183	87,118	121,757	83,476	59,575

Source: DOB, MOC

Table 9.2.3 Comparison of Budget for Road Maintenance with Other Countries

Responsible Authority	Country	Total Length [km]	Maintenance Cost [JPY/Year]	Unit Maintenance Cost [JPY/Year/km]
MOC	Myanmar	41,400	52.3billion	1.6million
Expressway Company	Thailand	22	1.7billion	77.3million
HIROSHIMA Pref. Road Public Corporation	Japan	25	5.5billion	220.0million
Metropolitan Expressway Company Limited	Japan	319	76.8billion	240.8million

Source: JICA Study Team

9.2.3 Current Situation and Issues of Operation and Maintenance for Road and Bridge

(1) The Yangon-Mandalay Expressway

By reviewing the current status on the Y-M Expressway, the current situation and issues of road/bridge operation and maintenance in Myanmar is studied.

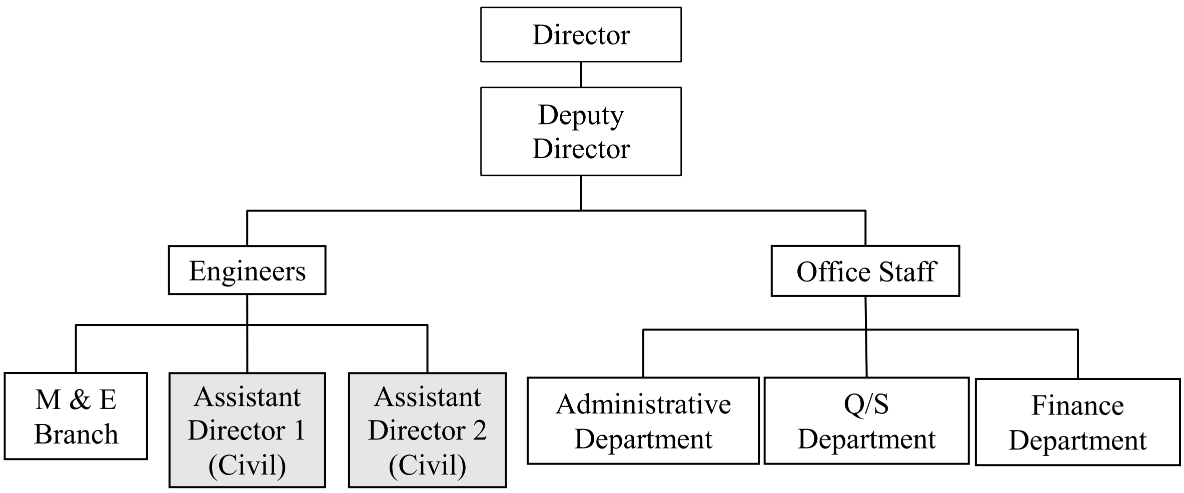
1) The Overview of The Yangon-Mandalay Expressway

The Y-M Expressway opened in 2011 and is the sole expressway in Myanmar having 586 km in total length. The expressway is under direct management by DOH, including toll collection.

2) The Organization Structure for Operation and Maintenance of the Y-M Expressway

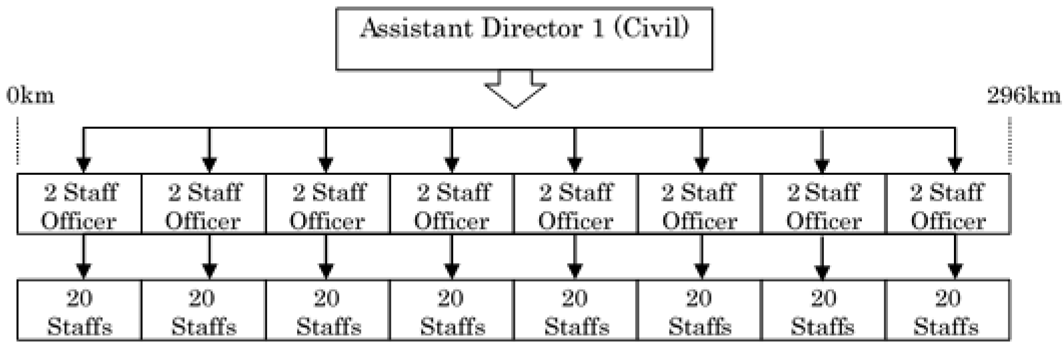
Figure 9.2.4 to Figure 9.2.6 show the organization structure for operation and maintenance of the Yangon-Mandalay Expressway. Headed by the Director, the maintenance unit is organized under the head office of DOH (Nay Pyi Taw). According to the interviews with DOH, about 70 personnel work under this unit.

There are two site management offices along the Y-M expressway; one is in charge of the section from Yangon to Naypyidaw with a length of 296km and the other is in charge of the section from Naypyidaw to Mandalay which is 290km. In addition, there are a total of 16 site branch offices, and 8 site branch offices in each section, having 2 engineers and 20 staff for each. In collaboration with the site management offices, the staffs engage in site operation and maintenance work such as communication and response in case of traffic accidents.



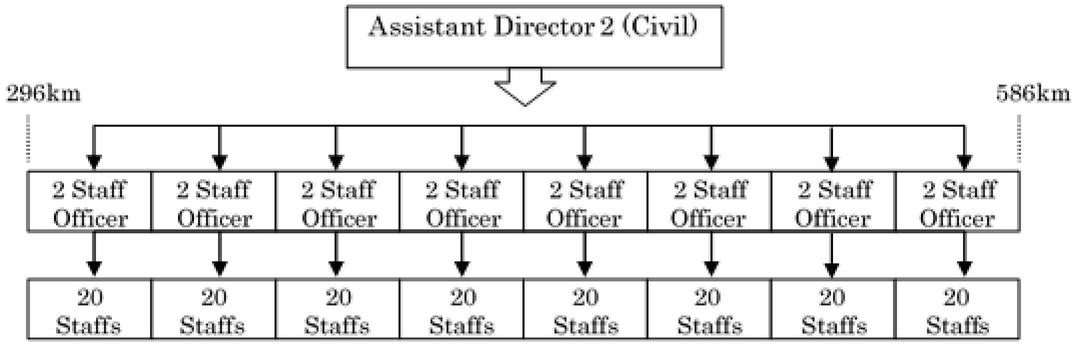
Source: JICA Study Team based on the Information from MOC

Figure 9.2.4 Organization Chart of the Y-M Expressway Management Unit



Source: MOC

Figure 9.2.5 Organization Chat of the Y-M Expressway Site Branch Office-1



Source: MOC

Figure 9.2.6 Organization Chat of the Y-M Expressway Site Branch Office-2

3) Annual Toll Revenue and Maintenance Cost of the Yangon-Mandalay Expressway

Table 9.2.4 shows the past annual toll revenue and maintenance cost of the Yangon-Mandalay Expressway. The amount of toll revenue is higher than the maintenance cost in every year except the 2014-2015 fiscal year when the large-scale rehabilitation of asphalt pavement was carried out. According to DOH, the accounting of the Y-M Expressway is not ring-fenced since the annual toll revenue goes to the union account and the required annual budget for the Y-M Expressway is allocated from the union budget.

Table 9.2.4 Toll Revenue and Maintenance Budget of the Y-M Expressway (Million Kyat)

Fiscal Year	Revenue by Toll Fee	Maintenance Cost
2014-2015	12,500	22,000
2015-2016	16,000	14,000
2016-2017	19,000	18,000
2017-2018	21,000	7,600
Apr 2018-Sep2018	15,000	1,300
Oct 2018-May 2019	16,000	8,300

Source: JICA Study Team

4) Maintenance Manuals

According to DOH, although there are manuals and standards for road geometric design and pavement design, there are no manuals and standards for road maintenance. Therefore, the quality of inspection works and appropriateness of diagnosis depend on the inspector’s experience.

5) Maintenance and Service Level

Even though most sections of the Y-M Expressway are paved with rigid (concrete) pavement (some sections are already overlaid with asphalt pavement), it is difficult to evaluate them as “good condition” because significant damage and deterioration such as deep cracks on pavement, big potholes and heavily damaged drainage were observed as seen in Figure 9.2.7.

Crack

Pothole

Damaged Drainage

Source: JICA Study Team

Figure 9.2.7 Road Deterioration of the Y-M Expressway

Traffic safety facilities such as guardrails, guide lights and road lights are not sufficiently installed. Moreover, as shown in Figure 9.2.8, there are some pedestrians and livestock along/across the expressway due to no wall fences for access-control, and it is a very dangerous situation for road users.

Pedestrian along the Side Road

Ignoring Traffic Rules

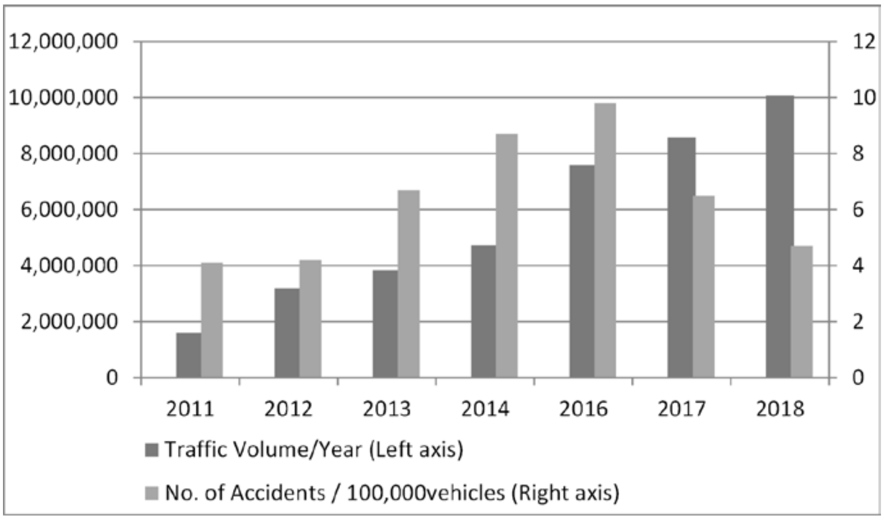
The Livestock Mobility

Source: JICA Study Team

Figure 9.2.8 The Current Situation of the Y-M Expressway

Figure 9.2.9 shows the traffic volume and the number of traffic accidents on the Yangon-Mandalay Expressway in the past 7 years. Since fully opening in 2011, traffic volume has risen sharply, and it recorded about 10 million vehicles per year in 2018. On the other hand, the ratio of traffic accidents per 100,000 vehicles has been decreasing since 2016. This is probably due to the installation of safety facilities such as guardrails and safety signs in places where traffic accidents frequently occurred in recent years, and the large-scale pavement rehabilitation in 2015/2016.

However, the government may open the expressway to use by heavy vehicles, which are presently prohibited from using the expressway, and the traffic condition is predicted to be worsen due to this policy transition.



Source: JICA Study Team based on DOH Data

Figure 9.2.9 Amount of Traffic Volume and Accidents

(2) Bridge Maintenance

According to the interviews with DOB which manages approximately 5,000 bridges in Myanmar, bridge inspection is normally conducted 2 times per year (before and after the rainy season), and every inspection result is reported to the head office of DOB in Nay Pyi Taw. Bridge inspection is conducted in accordance with 5 check lists in which 15 to 40 sheets are available covering each structure element (see Table 9.2.5), and predicted damages and deteriorations are described. Then inspection results are evaluated by the 10 ratings as shown in Table 9.2.6.

According to the reported inspection results, the head office of DOB selects priority bridges subject to maintenance work in each fiscal year, then requests a maintenance budget for the next fiscal year. Moreover, DOB has established the bridge inventory system for recording and sharing bridge properties and results of bridge inspections as shown in Figure 9.2.10, with assistance by JICA through “Project for Capacity Development of Road and Bridge Technology” from 2016 to 2019. Therefore, it could be said that the fundamental capacity/mind to determine priorities and implement effective and efficient bridge maintenance work has been developed even under such limited budgets.

On the other hand, as observed in the collapse of Myaungmya Bridge due to corrosion and fractured anchorages for the suspension cables in April 2018, there is still room for improvement of the technical capacity in bridge inspection and maintenance.

Technical capacity development, especially on the maintenance of large-scale bridges, is one of the urgent tasks for DOB because the number of bridges is expected to increase rapidly due to remarkable economic growth and assistance by international organizations.

Table 9.2.5 Type of Check List for Bridge Inspection

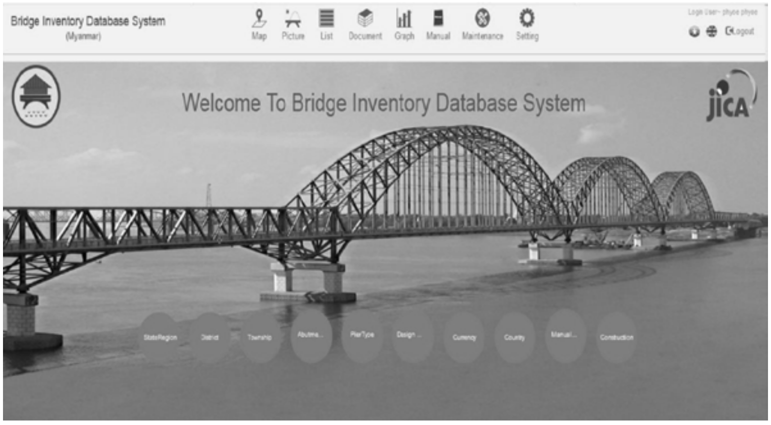
Type	Elements
Bailey	1) Bored pile, 2) Pier caps, 3) Pier shaft & cross beam, approach bridge, 4) Pier shaft & cross beam, approach bridge, 5) Bailey panels, 6) Main bridge transom, 7) Main bridge sub-transom, 8) Chord reinforcements (upper & lower), 9) Bracing frame, 10) Sway brace, 11) Clamps, 12) Panel pin, 13) Bracing bolts & nuts and chord bolts & nuts, 14) End post of male & female, 15) Bearing seat, 16) Decking beams, 17) Toe wall, river bank, retaining wall, platforms, 18) Wearing course
Cable Suspension	1) Bored pile, 2) Pier caps, 3) Pier shaft & cross beam, 4) Tower cap, shaft & cross beam, 5) Anchor block, 6) Steel tower & transom, 7) Main cable, 8) Bailey panels, 9) Main bridge transom, 10) Main bridge sub-transom, 11) Chord reinforcements (upper & lower), 12) Bracing frame, 13) Sway brace, 14) Clamps, 15) Suspenders, 16) Pannel pin, 17) Bracing bolts & nutes and chord bolts & nuts, 18) End post of male & female, 19) Bearing on T_1 & T_2, 20) Expansion joints on T_1 & T_2, 21) Decking beams, 22) Walkway (main bridge), 23) Hand rail (main bridge), 24) RCC girders, 25) Precast slab, 26) Overlay slab, 27) Deflector, walkway & handrail, 28) Toe wall, river bank, retaining wall, platforms, 29) Wearing course
RC Portion	1) Pile, 2) Footing, 3) Backwall, 4) Wings, 5) Caps, 6) Columns, 7) Footing, 8) Shaft, 9) Pier cross beam, 10) RCC girder, 11) Diaphragms, 12) Precast slab, 13) Overlay slab, 14) Concrte deck, wearing surface, expansion joint, 15) Curbs, median, sidewalks, parapet, railing, paint, drain, lighting, utilities
Steel Bridge	1) Pile, 2) Footing, 3) Back wall, 4) Wings, 5) Piles, 6) Footing, 7) Caps, 8) Shaft, 9) Bearing, 10) Beams & girders, 11) Flanges, 12) Bolts & rivet heads, 13) Gusset, 14) Diaphrams, 15) Bracing, 16) Hangers, 17) Pin connections, 18) Stiffeners, 19) Welds, 20) Floor beams, 21) Stringers, 22) Flanges, 23) Interior member, 24) Welds, 25) Rivets or bolts, 26) Chord members, 27) Flanges, 28) End posts, 29) Webs, 30) Cover & gusset plates, 31) Rivets & bolts, 32) Eye bar members, 33) Diaphrams, 34) Pints, 35) Lateral bracings, 36) Cross & sway frames, 37) Concrete deck, wearing surface, expansion joint, 38) Curbs, median, sidewalks, parapet, railing, paint, drain, lighting, utilities
Underwater	Record damages on footing（Details are unreadable）

Source: MOC Bridge Inspection Form

Table 9.2.6 Rating for Bridge Condition

Rating	Condition
9	New Condition
8	Good Condition
7	Minor items in needed of repairs by maintenance forces
6	Major items in needed of repairs by maintenance forces
5	Major repair by special unit forces
4	Minimum adequacy to tolerate present traffic-immediately rehabilitation necessary
3	Inadequacy to tolerate present heavy load – warrants closing bridge to all traffic
2	Inadequacy to tolerate any live load – warrants closing bridge to all traffic
1	Bridge repairable, if desirable to reopen to traffic
0	Bridge condition beyond repair – danger of immediate collapse

Source: MOC Bridge Inspection Form



Source: Bridge Inventory Database System (2019) MOC

Figure 9.2.10 Bridge Inventory System

9.2.4 Capacity of Agency Responsible for Operation and Maintenance of the Project

DOB has experienced a lot of large-scale bridge projects and major international projects are shown below. DOH also has experience in the operation and maintenance of the Y-M Expressway and other toll roads operated under BOT, therefore it is considered that DOB and DOH has a certain capacity to implement this project. However, as aforementioned, the present level of road operation and maintenance is not sufficient and a preferable maintenance plan is proposed in the next section.

1) The East-West Economic Corridor Improvement Project (Phase 1)

The project is to replace 3 bridges which are presently the bottlenecks of the section connecting Mawlamyine and the border with Thailand along the GMS East-West Economic Corridor. The project has been implemented by Japanese ODA loan assistance. The total project cost is approximately 33.9 billion Yen.

2) Bago River Bridge Construction Project

The project is to construct a new bridge across the Bago River in order to respond to drastically increased traffic volume due to the development of the Thilawa SEZ and remarkable economic growth in Myanmar. The Bago River Bridge is approximately 2km in length and is similar scale to the New Shittaung Bridge. This project is being implemented by Japanese ODA loan with approximately 31.0 billion Yen.

3) Dala Bridge Construction Project

The Dala Bridge is a long bridge with a length of approximately 1.9km across the Yangon River. The project is being implemented by KOICA. The total project cost is approximately 18.2 billion Yen.

9.3 Operation and Maintenance Plan for the Project

9.3.1 Major Operation and Maintenance Duty by the Executing Agency

In general, the O/M of a toll road including this Project which allows vehicles to drive at a high speed is divided into 4 major tasks; 1) inspection, 2) maintenance, 3) toll collection, and 4) traffic management, in addition to overall management.

The following table summarizes the outline of each task.

Table 9.3.1 Overview of Road Operation and Maintenance

Item	Present Condition and Issues
1) General Supervision	- Preparation of an overall business plan and a budgetary management plan - Supervision of budget allocation and work execution - Preparation of required standards and manuals - Supervision of Contract on maintenance work - Coordination with related organizations - Supervision and monitoring of the execution of inspection, toll maintenance and traffic management
2) Inspection	- Preparation of inspection plan - Execution of the inspection work - Compilation of the results of inspection and evaluation of structural soundness - Prioritizing of the need for repair of damage - Preparation of medium- to long-term maintenance plans - Monitoring and evaluation of completed repair and improvement work
3) Maintenance	- Preparation of the maintenance plan - Execution of the maintenance work - Emergency work - Execution of improvement and maintenance work - Monitoring and evaluation of completed repair and improvement work
4) Toll Collection	- Preparation of the plan required for toll collection including the number of lanes (toll booths) at the tollgate, assignment and work shift of toll collectors, toll collection methods and toll collection facilities. - Toll Collection - Counting, verification , storing and depositing of collected tolls - Responses to inquiries from road users
5) Traffic Management	- Collection of traffic information from related organizations and road users - Regular and emergency patrols - Collection of traffic information and road information from road patrols and roadside equipment (CCTV, emergency telephone, etc.) - Provision of road information and traffic information through information media (radio, Internet, information board, etc.) - Initial response to events (accidents, falling objects, breakdowns, etc.) (Implementation of traffic regulations, contact with traffic police and fire department, etc.) - Warning and enforcement of violating vehicles in cooperation with traffic police

Source: JICA Study Team

9.3.2 Operation and Maintenance Plan

(1) Inspection Plan

The project road is expected to be an access-controlled expressway and a major international logistic route connecting the Yangon area and the southeast part of Myanmar including the border with

Thailand. In order to maintain the project expressway in the condition which ensures safe and comfortable driving for a long term, damage to the structures shall have to be detected at an early stage with regular inspection and repaired.

In general, inspection work is divided into 4 types; 1) Initial inspection, 2) Regular inspection, 3) Routine inspection (normal and detailed), and 4) Emergency inspection.

The outline of each inspection is summarized in the following and the types and frequency of the inspection work are given in Table 9.3.2.

Table 9.3.2 Types and Frequency of Inspection Works

Type		Frequency	Object	Method
Initial inspection		After completion of the construction and/or before opening	All facilities	Short range visual
Regular inspection		2 times / day（morning, evening）	Road surface	On board visual
Routine inspection	Normal	1 time / year	All structures	Distance visual
	Detailed	1 time / 5 year	All structures	Short range visual
Emergency inspection		As necessary	Required points	Short range visual

Source: JICA Study Team

1) Initial Inspection

Initial Inspection is the inspection by short range visual such as hammering to grasp the initial situation after the completion of the construction. The inspection is conducted before commencing services. The records such as defects, disasters and repairs under construction are gathered and it is necessary to arrange basic data about the initial situation of the structure to utilize it for later maintenance.

2) Regular Inspection

Regular Inspection is to detect the conditions of the structure on a daily basis to secure safe road traffic, and to prevent damage to third parties. Moreover in order to detect damage and changes in the conditions at an early stage and to maintain roads in ordinary sound conditions, it is decided whether appropriate measures against the damages and changes should be taken or not by this inspection.

The inspection is conducted in the range capable of confirmation from carriage way mainly by looking from the car and the feeling while driving, and as necessary the condition is identified by direct visual inspection.

3) Routine Inspection

In general, Routine Inspection is divided into two types; 1) Routine normal inspection and 2) Routine detailed inspection.

The Routine Normal Inspection is to examine the general conditions of structures in the entire section on a regular basis, including the inspection of intersections and road sides where damage to third parties is concerned. In principle the inspection is conducted yearly in the entire section mainly by distant visual observation from the outside of the carriage way and the short-range visual method where necessary.

On the other hand, in principle, the Routine Detailed Inspection is to examine each structure every 5 years in detail on a regular basis, and evaluate the condition of structures, in order to grasp structural soundness, to ensure safe road traffic and to prevent damage to third parties. The inspection is conducted basically by short range visual observation with palpation, hammering and non-destructive inspection as necessary.

Table 9.3.3 Summary of Type of Defects

Structure Element to Inspect		Inspection Item（Type of Damage/Deterioration）
Bridge Surface	Pavement	- Flatness of pavement - Defects on pavement (Potholes etc.) - Obstruction by soil
	Median Concrete barrier	- Cracks - Peeling of cover concrete / Reinforcement exposure - Leak of water / Free lime - Discoloration / Deterioration - Deformation / Partial loss of section
	Bridge lights	- Corrosion - Fracture - Slack or Loss of bolts - Painting deterioration - Discoloration / Deterioration - Deformation / Loss of parts
Steel Superstructure	Main girder Cross beam Stringer Steel-concrete composite slab（Steel part）	- Corrosion - Fracture - Slack or Loss of bolts - Fracture - Painting deterioration - Leak of water / Undrained water - Occurrence of abnormal sound / vibration - Abnormal deformation - Deformation / Loss of parts
	Steel-concrete composite slab（Concrete part）	- Cracks - Peeling of cover concrete / Reinforcement exposure - Leak of water / Free lime - Discoloration / Deterioration - Leak of water / Undrained water - Occurrence of abnormal sound / vibration - Abnormal deformation - Deformation / Defects
PC Superstructure	Main girder Cross beam Deck slab	- Cracks - Peeling of cover concrete / Reinforcement exposure - Leak of water / Free lime - Discoloration / Deterioration - Leak of water / Undrained water - Occurrence of abnormal sound / vibration - Abnormal deformation - Deformation / Defects

Substructure	Column Pier head Pile cap Top slab of SPSP *	- Cracks - Peeling of cover concrete / Reinforcement exposure - Leak of water / Free lime - Abnormal Deformation / Partial loss of section
	Cast-in-situ RC pile*	- Cracks - Peeling of cover concrete / Reinforcement exposure - Settlement / Movement / Declination - Scouring
	SPSP*	- Corrosion - Fracture - Settlement / Movement / Declination - Scouring
Bridge Accessories	Bearing	- Corrosion - Fracture - Slack or Loss of bolts - Painting deterioration - Functional defects such as abnormal gas at girder ends - Leak of water / Undrained water - Occurrence of abnormal sound / vibration - Deformation / Defects - Obstruction by soil - Settlement / Movement / Declination - Cracks / Deterioration on base concrete and base mortar
	Expansion joints	- Corrosion - Fracture - Abnormal gap at girder ends - Leak of water / Undrained water - Occurrence of abnormal sound / vibration - Deformation / Defects （Settlement behind abutment）
	Drainage pit Drainage pipe	- Corrosion - Painting deterioration - Slack / Defects of bolts - Discoloration / Deterioration - Leak of water / Undrained water - Obstruction by soil

Source: JICA Study Team

4) Emergency Inspection

The Emergency Inspection is conducted when the need for the inspection arises, e.g. when a problem which cannot be solved with the regular inspection has been detected, when severe damage has been detected on a structure, at the time of extreme weather conditions or a traffic accident or a natural disaster.

(2) Maintenance Plan

In accordance with the result of the inspection, various maintenance works should be conducted. Required performance for road maintenance is shown in Table 9.3.4 as reference.

Table 9.3.4 Required Performance for Road Maintenance (Reference)

Type of defects		Required performance
Carriage way and Shoulder	Closure due to traffic accidents and natural disasters	-Temporary restoration of traffic within 24 hours -Permanent restoration

		within15 days
	Potholes	Within 48 hours
	Raveling / Stripping of bitumen surface exceeding $10m^2$	Within 15 days
	Removal of debris	Quickly every observation
Road side facilities (including pavement markings and signs)	Damage to shape or position; poor visibility or less of retro-reflectivity	Within 48 hours
Road lights Telecoms	Any major failure of the system	Within 24 hours
	Minor failures	Within 8 hours
Trees and plantations	Obstruction in a minimum head-room of 5.5m above carriage way or obstruction in visibility of road sings	Within 24 hours
	Removal of vegetation affecting sight line and road structures	Within 15 days
Rest areas	Cleaning of toilets	Every 4 hours
	Defects in electrical, water and sanitary installations	Within 24 hours
Toll plaza(s)	Failure of toll collection equipment or lighting	Within 8 hours
	Damage on toll plaza	Within 7 days

Source: JICA Study Team

The maintenance plan for the New Shittung Bridge is given in Table 9.3.5. The bridge maintenance work is divided into 2 types: 1) Routine Maintenance, which is required to keep comfortable driving and service level of safety 2) Periodic Maintenance, which is required for longer life of structures.

Since the New Shittung Bridge is a part of important expressways in Myanmar and requires extensive expenditure for large-scale rehabilitation recovering from serious damage, it basically requires the implementation of preventive maintenance before the condition results in the rating of 5 out of 10 in Table 9.2.6

Table 9.3.5 Major Maintenance Required Items of New Shittung Bridge

Work Item		Required Performance (Frequency etc.)
Routine Maintenance	Cleaning the road surface	1time / day
	Pavement rehabilitation（Potholes etc.）	Within 48 hours
	Raveling/ Stripping of bitumen surface exceeding $10m^2$	Within 15 days
	Removal of debris	Quickly every observation
Periodic Maintenance	Pavement rehabilitation（Overlay etc.）	1time / year
	Replacement of pavement	1time /10years
	Rehabilitation of water proof on bridge slab	1time /10years
	Repairing of cracks（Minor）	1time / year
	Repairing of cracks（Major）	1time /10years
	Replacement of bridge drainage	1time /50years
	Replacement of expansion joints (Concrete bridge)	1time /10years
	Replacement of expansion joints (Steel bridge)	1time /30years
	Repaint of steel main girder	1time /30years
	Rehabilitation of PC girder	1time /20years
	Rehabilitation of scouring protection（Replacement of revetment）	1time /10years

Source: JICA Study Team

9.3.3 Expressway Facility Plan for Operation and Management

This section summarizes the highway incidental facility plan including traffic management and toll collection facilities necessary for the operation of the expressway. In this section, by reviewing the basic incidental facility plan by the ADB TA, the necessary improvement measures are proposed for more effective and efficient expressway operation and maintenance.

(1) Target Management Level

The facilities and the operation structures required for the operation of the expressway depend on the target management level for the entire expressway. Hence, the following two scenarios are considered: 1) the management level equivalent to the existing toll roads and the basic plan by ADB (Scenario 1), and 2) the management level proposed by the JICA Study Team (Scenario 2). Table 9.3.6 shows the outline for each target management level.

Table 9.3.6 Outline of Target Management Level

Item	Scenario 1 Management Level Equivalent to the Existing Toll Roads and Basic Plan by ADB	Scenario 2 Management Level Proposed by JST
Management Level	− Focus on Low Charges − Minimize incidental facilities and make the toll level as low as possible. − Passive response to road incidents.	− Focus on Safety and Comfort − Collect extensive traffic information with incidental facilities, and can respond quickly and accurately − Users can use the road comfortably − Extensive and autonomous response to road incidents
Traffic Information Collection	− Minimal Traffic Information Collection	− High-frequency full-line patrol and CCTV at high risk of accidents enable road operator to quickly grasp the extensive traffic information and respond quickly and accurately
Traffic Information Provision	− No Information is provided	− Road operator can quickly provide the traffic information with VMS at the entrance and SNS to users, which contributes to prevention of secondary accident damage and promotion of road use
Ensuring Safety of Toll Plaza Staff	− Operation of Lane Crossing	− Installation of safety stairs so that the toll collection staff can escape in emergencies.

Source: JICA Study Team

9.3.4 Review on Toll System

(1) Toll System

ADB's TA report describes the entry fee system (flat rate toll system) like the existing concession roads in Myanmar and the entry charge / exit receipt confirmation system (distance-based toll system) like the Yangon-Mandalay Expressway.

In case of a distance-based toll system, two types can be considered such as “Entry charge / Exit receipt confirmation system” described in the ADB’s TA report and “Entry ticket / Exit charge system”, as shown in Table 9.3.7.

The entry ticket / exit charge system has simpler cash management than the entry charge / exit receipt confirmation system, and it is thought that stable throughput can be ensured.

Table 9.3.7 Toll Collection System for Distance-Based Toll System

Item	Entry Charge / Exit Receipt Confirmation System	Entry Ticket / Exit Charge System
Overview	− At the entrance toll plaza, a user will be charged according to the vehicle class and the user’s use section declaration, and a receipt will be issued according to the use section. − At the exit toll plaza, the issued receipt is confirmed by toll collection staff, and if it is different from the use section declared at the entrance toll plaza, the difference is collected.	− At the entrance toll plaza, a user receive a ticket that shows the vehicle classification. − At the exit toll plaza, the ticket is checked by toll collection staff, and the user will be charged the toll according to the used section.
Example of Facilities Required for Toll Collection	Entrance Toll Plaza − Toll Collection Terminal − Receipt Issuing Machine Exit Toll Plaza − Receipt Reader − Toll Collection Terminal − Receipt Issuing Machine	Entrance Toll Plaza − Ticket Issuing Machine Exit Toll Plaza − Ticket Reader − Toll Collection Terminal − Receipt Issuing Machine
Vehicle Classification	Vehicle classification and charge according to vehicle class at the entrance toll plaza.	Vehicle classification and record the vehicle class on the ticket.
Vehicle Weight Measurement	Only large vehicles are measured with WIM at the entrance toll plaza. Vehicles that are suspected of being overloaded should be directed to the Weigh-Station to measure static loads.	Only large vehicles are measured with WIM at the entrance toll plaza. Vehicles that are suspected of being overloaded should be directed to the Weigh-Station to measure static loads.
Throughput	Entrance Toll Plaza − Ordinary Car : 260 Vehicles per hour − Large Vehicle : 130 Vehicles per hour Exit Toll Plaza (Assuming 10% difference collection) − Ordinary Car : 431Vehicles per hour − Large Vehicle : 216 Vehicles per hour	Entrance Toll Plaza − Ordinary Car : 600 Vehicles per hour − Large Vehicle : 300 Vehicles per hour Exit Toll Plaza − Ordinary Car : 260 Vehicles per hour − Large Vehicle : 130 Vehicles per hour
Evaluation	Not Recommended Cash management is complicated because cash handling is required at both the entrance toll plaza and the exit toll plaza. In addition, the throughput deteriorates when the percentage of difference collection at the exit toll plaza.	**Recommended** Cash management is simple because cash is handled only at the exit toll plaza. In addition, stable throughput can be ensured.

Source: JICA Study Team

(2) Vehicle Classification

As recommended by the ADB TA, it is preferable that the vehicle classification for tolls is classified into 6 types (ordinary cars, buses, 2-axle trucks, 3-alxe trucks, 4 axle-trucks and connected trailer trucks). At the toll plaza, the truck shall pass through the large vehicle lane. The vehicle classification is identified at the entrance of toll plaza. The WIMs shall be installed in all large vehicle lanes at the entrance toll plaza in order to measure the vehicle weight and the number of axles. The vehicle classification is determined automatically or by the toll collection staff based on the vehicle shape and the number of axles. The vehicle classification shall be recorded on the ticket. At the exit toll plaza, the charge amount is calculated based on the vehicle class recorded in the ticket.

(3) Settlement Means

For the time being only cash settlement is accepted. Although cash management costs can be reduced by introducing cashless payment, a few percent of sales will be charged, and if the percentage of users is small, the toll collection process will be complicated. It is recommended that introduction of the cashless payment system is not necessary in the initial operation stage and the necessity and the timing can be judged looking at the actual trends and growth of the system in Myanmar's market.

(4) ETC (Electric Toll Collection)

In the ADB plan, introduction of the ETC is not mentioned. In Myanmar, the ETC with active DSRC was introduced in July 2018 on the Yangon-Mandalay Expressway. In the BOT section managed by Max Highway Co., Ltd. such as the Yangon-Bago Road, the ETC has not yet been introduced, but the introduction of the ETC with RFID is being considered.

The introduction of the ETC needs a large initial cost for road operators, but there are advantages such as reduction of traffic congestion around toll plazas by improving throughput, enhancing the efficiency of toll management by cashless settlement and reduction of personnel costs of toll collection staff. On the other hand, the effect of the ETC appears only after the ETC is widely spread so that countermeasures such as campaigns should be considered to increase the utilization rate of ETC.

Considering the above, the introduction of the ETC from the initial operation stage is too early for this Project, but it is desirable to coordinate with other road operators and introduce a unified ETC system.

9.3.5 Review on Toll Collection Facilities

(1) Configuration of Toll Plaza

The ADB plan shows "Toll Gate" and "Office Toll Plaza". Based on the review results in the previous section, the configuration of toll plaza is reviewed.

1) Toll Gate

At the toll gate, the facilities necessary to collect tolls by toll collection staff shall be installed. The number of lanes required for the toll gate is calculated by the peak hour traffic volume. The right lane is for large vehicles, and it should ensure a sufficient width for the large vehicles.

2) Management Center

The management center will be located within the toll gate premises with easy access to the toll gate. The management center has a toll management room, a monitoring room, a server room, an electrical room, etc., and access restrictions are set so that only personnel related to the work can enter.

3) Weigh-Station

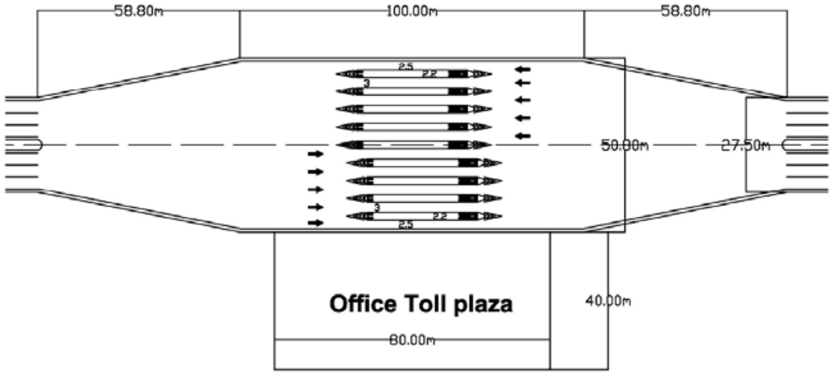
The weigh-station is installed for measuring the static load of large vehicles and discharging overloaded vehicles.

4) Housing for Staff

The housing for staff will have the same number of units as the staff engaged in toll plaza and facilities necessary for living will be installed.

(2) Scale of Toll Plaza

In the ADB plan, the scale of the toll plaza is shown in Figure 9.3.1. For the purpose of estimating the project cost, the scale of toll plaza such as the number of lanes and management center building is roughly studied in the following.



Source：Excerpted from Feasibility Study Bago-Kyaikto Expressway Volume I : Main Report (TA-9314 MYA), July 2019

Figure 9.3.1 Scale of Toll Plaza by ADB Plan

1) Number of Lanes

When calculating the number of lanes at each toll plaza, the following points should be considered.

- Traffic Volume at the Peak Hour

The number of lanes is calculated by the traffic volume at the peak hour. In case that the traffic volume at the peak hour is difficult to estimate, the required number of lanes shall be calculated by assuming 10% of the daily traffic volume.

- Correspondence to Maintenance

In case that the required number of lanes is just one lane, another lane (1 lane) shall be installed for periodic maintenance works or failures/emergencies.

- Ordinary Car and Large Vehicle Mixed Lanes

In order to increase the use efficiency of lanes, the throughput of large vehicle lanes shall be utilized when ordinary cars and large vehicles are mixed in the large vehicle lanes.

Table 9.3.8 shows the traffic volume at the peak hour, and Table 9.3.9 shows the number of lanes at each toll plaza calculated by the traffic volume at the peak hour. It is noted that the traffic volume at Waw toll plaza is assumed to be same as those at Thanapin toll plaza since no traffic data on the peak hour traffic is available at Waw Toll Plaza.

Table 9.3.8 Traffic Volume at the Time of Peak Hour at Each Toll Plaza

Unit: Number of vehicles per hour per lane

Toll Plaza	Entrance		Exit	
	Ordinary Car	Large Vehicle	Ordinary Car	Large Vehicle
Bago	1,240	300	1,100	450
Thanatpin	660	160	1,530	200
Waw	No Data	No Data	No Data	No Data
Kyaikto	1,450	500	710	320

Source: JICA Study Team

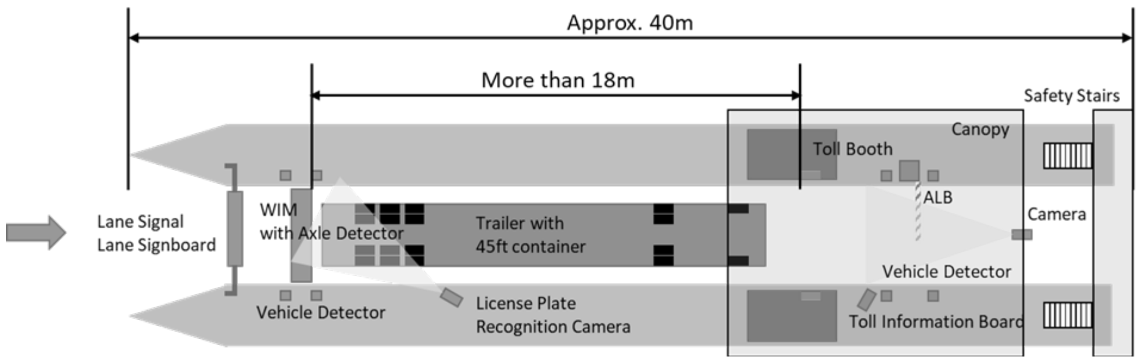
Table 9.3.9 Number of Lanes at Each Toll Plaza

Toll Plaza	Entrance			Exit		
	Ordinary Car Lane	Large Vehicle Lane	Total	Ordinary Car Lane	Large Vehicle Lane	Total
Bago	3	2	5	5	4	9
Thanatpin	2	2	4	6	2	8
Waw	2	2	4	6	2	8
Kyaikto	3	2	5	3	3	6

Source: JICA Study Team

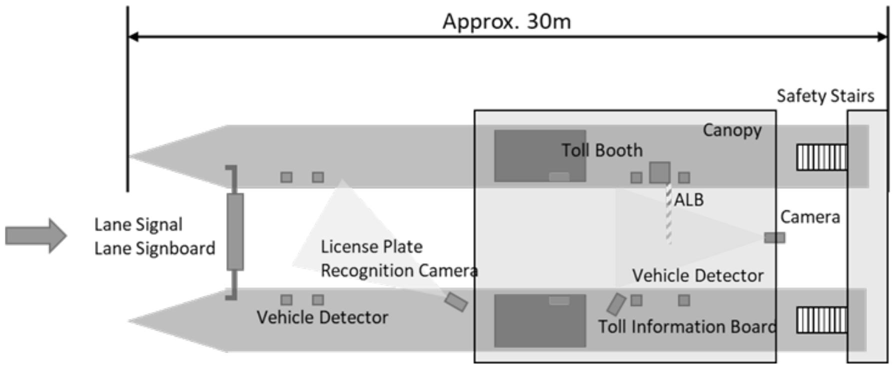
2) Length of Lanes

The length of the lanes should be 40m or more at the entrance toll plaza so that the WIM can accurately measure the weight and the number of axles in large vehicle lanes, and 30m or more at the exit toll plaza. The image of the length of the lanes at the entrance/exist is shown in Figure 9.3.2 and Figure 9.3.3 respectively.



Source: JICA Study Team

Figure 9.3.2 Image of the Length of the Lane (Entrance Toll Plaza)



Source: JICA Study Team

Figure 9.3.3 Image of the Length of the Lane (Exit Toll Plaza)

3) Toll Plaza Building

Table 9.3.10 shows the functions and scale necessary for the toll plaza building.

Table 9.3.10 Functions and Scale of Toll Plaza Building

Toll Plaza	Functions of Toll Plaza Building	Total Floor Area (m²)
Bago	Toll Gate (14 lanes at the entrance and exit) Canopy, Safety Stairs Management Center Toll Management Room, Monitoring Room, Traffic Management Room, Maintenance Management Room, Resting Room, Server Room, Electrical Room, Toilet, Bathroom	350 850
Thanatpin	Toll Gate (12 lanes at the entrance and exit) Canopy, Safety Stairs Management Center Toll Management Room, Monitoring Room, Traffic Management Room, Resting Room, Server Room, Electrical Room, Toilet, Bathroom	300 750
Waw	Toll Gate (12 lanes at the entrance and exit) Canopy, Safety Stairs Management Center Toll Management Room, Monitoring Room, Traffic Management Room, Resting Room, Server Room, Electrical Room, Toilet, Bathroom	300 750
Kyaikto	Toll Gate (11 lanes at the entrance and exit)	275

	Canopy, Safety Stairs Management Center Toll Management Room, Monitoring Room, Traffic Management Room, Maintenance Management Room, Resting Room, Server Room, Electrical Room, Toilet, Bathroom	850

Source: JICA Study Team

4) Weigh-Station

Weigh-Station building is a reinforced concrete structure. The weight management server and the weight management terminal will be installed inside the building. In consideration of the staff's room and server installation space, about 30 square meters should be secured. Outside the building, a weight measurement bridge, a loudspeaker, an automatic lane barrier, a weight display device, a surveillance camera are installed. Space for the weight measurement bridge is expected to be about 4m×15m. The scale of the weigh-station is shown in Table 9.3.11. In addition, the discharge path for the overload vehicles to the street will be installed.

Table 9.3.11 Scale of Weigh-Station

Toll Plaza	Number of Weigh-Stations	Floor Area per Place (㎡)	Total Floor Area (㎡)	Total Area (㎡)
Bago	1	30	30	90
Thanatpin	1	30	30	90
Waw	1	30	30	90
Kyaikto	1	30	30	90

Source: JICA Study Team

5) Housing for Staff

The housing facilities for staff are reinforced concrete structures and there should be a sufficient number of units for each staff member working around the toll plaza. Floor space of 25 square meters or more per unit should be secured, and facilities necessary for daily life such as a toilet, kitchen, parking lot (about 2.5m×6m) should be provided. As for land for access roads, the total area is expected to be about twice of the total floor area. The scale of housing for staff is shown in Table 9.3.12.

Table 9.3.12 Scale of Housing for Staff

Toll Plaza	Number of Staff	Floor Area per Place(㎡) (Including Parking Lot)	Total Floor Area(㎡)	Total Area(㎡)
Bago	102	40	4,080	8,160
Thanatpin	66	40	2,640	5,280
Waw	66	40	2,640	5,280
Kyaikto	93	40	3,720	7,440

Source: JICA Study Team

(3) Handling of Large Vehicles

Overloaded vehicles will cause heavy damage to road structures and pavements if allowed to run, so the weight of large vehicles should be managed. Large vehicles exceeding the weight limit should be strictly managed to prevent entry to toll roads. On the other hand, if the static weight of all large vehicles is measured, it takes time to process which in turn causes traffic congestion around the toll plazas, so it is necessary to devise the processing.

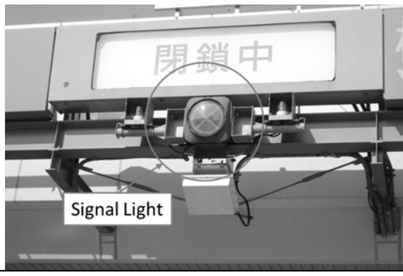
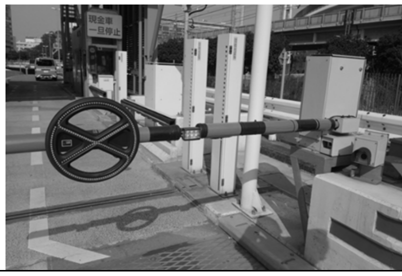
The ADB plan describes only weight measurement by WIM. The WIM shows excellent performance in number of large vehicles processed per hour, but the accuracy is not so reliable. Therefore, it is desirable to first sort the vehicles which might be overloaded by the WIM, then to guide these vehicles to the weigh-station, and make a final judgment by measuring static weight.

(4) Facilities on Lanes

Although there is no detailed description of the facilities on the lane in the ADB plan, general facilities required on the lane is proposed. Table 9.3.13 shows examples and outlines of facilities to be installed in the lane in this project.

Table 9.3.13 Examples of Facilities in Lanes

No.	Facility	Outline
1	Toll Booth	A toll booth is installed on the toll island and used by the toll collection staff to perform toll collection. It should have sufficient strength in anticipation of vehicle collision. 
2	Toll Collection Terminal	A toll collection terminal is installed in the toll booth and has the vehicle information input function and receipt issue function. 
3	Extension Telephone	An extension telephone is installed in the toll booth so that the toll collection staff can make phone calls with other toll booths and monitoring centers.

4	Signal Light	A signal light is installed in front of the canopy and indicates whether it is possible to enter the lane. It is controlled by the toll collection staff in the toll booth. 
5	Lane Barrier	A lane barrier is installed in front of the toll island to prevent vehicles from entering the lane. Lane blocking operation shall be performed manually and shall have sufficient strength in anticipation of vehicle collision. 
6	Vehicle Detector	A vehicle detector is installed on the toll island to detect the entry and exit of vehicles into the lane. It is also used as an auxiliary facility for measuring the number of passing vehicles and for WIM and license plate recognition device. 
7	Automatic Lane Barrier	An automatic lane barrier is installed behind the toll island to suppress the start of vehicles that have not received toll collection with the bar. 
8	License Plate Recognition Device	A license plate recognition device is installed on the toll island for recognizing license plates from the photographed image in front of the vehicle. The recognized license plate information is used for vehicle class discrimination support and recording on the ticket.

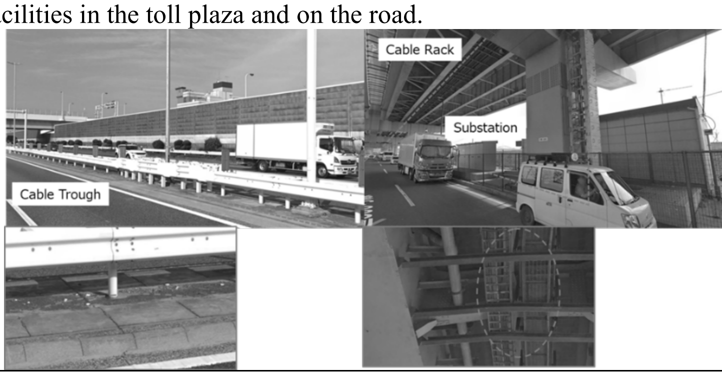
9	Lane Surveillance Camera	A lane surveillance camera is installed on the toll island to monitor the toll collection status and fraud in the lane. 
10	Toll Display Device	A toll display device is installed behind the toll booth on the toll island and displays the applicable vehicle class, billing amount, and whether allow the car to pass through. 
11	Loudspeaker	A loudspeaker is installed behind the toll booth on the toll island and to expand the voice of oral guidance by the toll collection staff and transmitting it to the users. 
12	Weigh-in-Motion (WIM)	WIM is installed in front of the large vehicle lane at the entrance toll plaza and measures the axle load of vehicles traveling at low speed. By combining with the vehicle detector, the approximate value of the total vehicle weight can be measured.
13	Safety Stairs	Safety stairs are installed behind the toll booth and used by the toll collection staff and maintenance staff to access each lane of the toll plaza. 

Source: JICA Study Team

(5) Other Facilities

Table 9.3.14 shows examples and outline of the other general facilities considered necessary for toll plaza operation in this project.

Table 9.3.14 Example of the Other Facilities

No.	Facility	Outline
1	Electric Power Distribution Facility	An electric power distribution facility is to receive electric power within the management center and distributing electric power to facilities installed at the toll plaza site.
2	Uninterruptible Power System (UPS)	UPS is installed in the management center and to prepare for momentary power outages and short-time power outages. The load target of the UPS is selected mainly for servers and communication network devices.
3	Communication Network Device	A communication network device is to communicate between CCTVs, extension telephones, and servers.  
4	Wiring	Low-voltage cable and a communication cable is to connect the facilities in the toll plaza and on the road. 

Source: JICA Study Team

9.3.6 Review on ITS Facilities

(1) ITS Facilities

Although there is no detailed description regarding ITS facilities other than road lighting in the ADB plan, the general ITS facilities are proposed for this Project. Table 9.3.15 shows examples and outlines of ITS facilities that should be provided in this project.

Table 9.3.15 Example of ITS Facilities

No.	Facility	Outline
1	CCTV	CCTV is installed to monitor road traffic conditions at junctions and bridge sections where there is a high risk of traffic accidents and abnormal events. With the introduction of PTZ camera, the wide range monitoring is possible. CCTV images are monitored in the monitoring room of the management center.
2	Radar Type Vehicle Detector	A radar type vehicle detector is installed to collect traffic volume and speed. By installing the vehicle detector on the main line at regular intervals, detailed traffic situation can be grasped.

<table>
<tr><td>3</td><td>Emergency Telephone</td><td>An emergency telephone is for users to make emergency calls to the monitoring room. It will be not installed in this project due to related laws and mobile phone diffusion in Myanmar.</td></tr>
<tr><td>4</td><td>Weather Observation Device</td><td>A weather observation device is to collect wind direction and wind speed data, and installed in places that are considered to be affected by strong winds such as long bridges. It is desirable to install a weather information display board in front of the measurement point to provide information to users.</td></tr>
<tr><td>5</td><td>Variable Message Signboard
(VMS)</td><td>VMS is to provide users with traffic conditions such as closed roads, accidents, and traffic jams, and is installed with the gantry in front of the road entrances, interchanges and junctions.

</td></tr>
<tr><td>6</td><td>Road Lighting</td><td>Road lighting is installed in areas with high risk of accidents such as around toll plazas and junctions. Details will be described later.</td></tr>
<tr><td>7</td><td>Electric Power Distribution Facility</td><td>An electric power distribution facility is to receive electric power within the management center and distributing electric power to facilities installed on the road.</td></tr>
<tr><td>8</td><td>Uninterruptible Power System
(UPS)</td><td>UPS is installed in the management center and to prepare for momentary power outages and short-time power outages. The load target of the UPS is selected mainly for servers and communication network devices.</td></tr>
<tr><td>9</td><td>Communication Network Device</td><td>A communication network device is to communicate between CCTVs, extension telephones, and servers.</td></tr>
<tr><td>10</td><td>Wiring</td><td>Low-voltage cable and a communication cable is to connect facilities in the toll plaza and on the road.</td></tr>
<tr><td>11</td><td>Vehicle for Traffic Management
Vehicle for Maintenance Management</td><td>Traffic management patrol cars and tow vehicles will be arranged for traffic management.
Maintenance patrol cars, sign vehicles, and high elevation work vehicles will be arranged for maintenance.</td></tr>
</table>

Source: JICA Study Team

(2) Road Lighting

1) Specification

According to the ADB plan, the road lighting is LED with solar panels, and its detailed specifications are available. However, if the road lighting is installed in accordance with this specification, the uniformity will be particularly low, and it might result in low driving safety. In this review, the basic specifications of road lighting are proposed as shown in Table 9.3.16.

Table 9.3.16 Basic Specifications of Road Lighting (Proposal)

Item	Specification of ADB Plan	Proposal for This Review
Lighting Height	4m	1 or 2 Lanes: 10m More than 3 Lanes：12m
Installation Interval	Unknown (14m?)	1 or 2 Lanes Section: 35m More than 3 Lanes Section: 42m
Lamp Output	7.2W or More LED Lamp	100W or 120W LED Lamp
Power Supply	Solar Panels and Built-In Battery	Power Supply by Electric Cable

Source: JICA Study Team

HID lamps such as metal halide lamps and high-pressure sodium lamps are scheduled to be discontinued by manufacturers due to the present marketing demand. When selecting the light source for road lighting, it is necessary to pay attention to the trends of the marketing as well as related laws and regulations.

2) Lighting Range around Toll Plaza

The risk of accidents increases near the toll plazas due to road alignment shifting and traffic mixture, thus careful road light planning is required. As shown in Figure 9.3.4, it is desirable that the lighting range covers the road widening section.

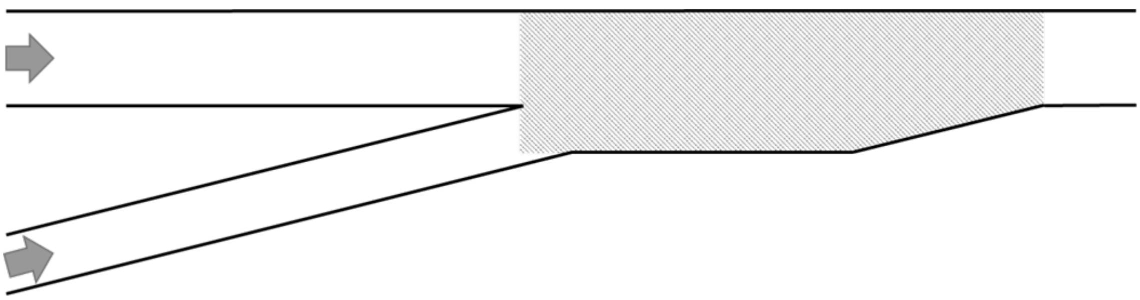
Source: JICA Study Team

Figure 9.3.4 Lighting Range around Toll Plaza

In addition, lighting shall be installed under the canopy of the toll plaza. It is desirable to install illumination with white light source so that bills can be clearly visible during toll collection. In addition, if necessary, a spotlight that irradiates the receiving port shall be installed. The average illuminance of 20 lx should be secured around the toll plaza.

3) Lighting Range on Main Line

Similar to the toll plaza, it is desirable that the lighting range covers the road widening section.



Source: JICA Study Team

Figure 9.3.5 Lighting Range of Merging Section

In addition, in the Sittaung River crossing bridge section, it is necessary to reduce the risk of secondary accidents as much as possible when an accident occurs, thus careful consideration is necessary for the road lighting plan. On the main line, the average road surface brightness of 1.0 cd / m^2 should be secured, and it is desirable to ensure a uniformity of 0.7 or higher.

In addition, installation of road lighting may affect the surrounding residents, transportation such as ships and airplanes, agricultural products, and the natural environment. In such cases, it is necessary to take countermeasures such as adopting low position lighting or installing louvers.

9.3.7 Review on Management Center

In the ADB plan, although there is the notation like "Office Toll Plaza" in Figure 9.3.1, there is no specific description. In this section, the general facilities necessary for the management center are proposed.

(1) Management Center Configuration

The management center is located within the toll plaza area and should be easily accessible to each lane of the toll gate. The management center should have a toll management room, a monitoring room, a traffic management room, a maintenance management room, a resting room, a server room, an electrical room, etc., and it should be access-controlled so that only personnel related to work can enter the room. In addition, parking lots for traffic management vehicles and maintenance management vehicles should be provided on the site of the management center.

(2) Facilities in Management Center

Table 9.3.17 shows the examples and outlines of facilities necessary for the management center in this project.

Table 9.3.17 Example of Facilities in Management Center

No.	Facility	Outline
1	Video Server Video Monitoring Terminal	A video server collects CCTV video, controls the display, and stores video, and is installed in the server room. The video monitoring terminal selects the CCTV video to be displayed and displays it on the screen, and is installed in a monitoring room. The display video is shared on a large monitor if necessary. 

2	Facility Monitoring Server Facility Monitoring Terminal	A facility monitoring server performs alarm control and accumulation of operation logs when the toll plaza facilities or ITS facilities are abnormal and is installed in a server room. The facility monitoring terminal displays the state of the toll plaza facility and the ITS facility on the screen and is installed in the monitoring room. The display of the status is shared on a large monitor if necessary. 
3	Toll Management Server Toll Management Terminal	A toll management server manages the billing data transmitted from the toll collection terminal in the toll booth and auditing tolls and is installed in the server room. Toll management terminal displays various data transmitted to the toll management server and is installed in the toll management room.
4	Extension Telephone for Toll Booths	The extension telephone for toll booths connects with the toll collection staff in the toll booth and is installed in the toll management room or the monitoring room.
5	Traffic Information Display Monitor	A traffic information display monitor displays data collected from the radar type vehicle detectors and information input by the monitoring staff and is installed in the monitoring room and traffic management room.
6	Report Receiving Device	A report receiving device is to receive telephone calls from users regarding accidents and breakdowns and is installed in the monitoring room. It is desirable to be able to record the contents of the call.

Source: JICA Study Team

9.3.8 Review on Rest Area

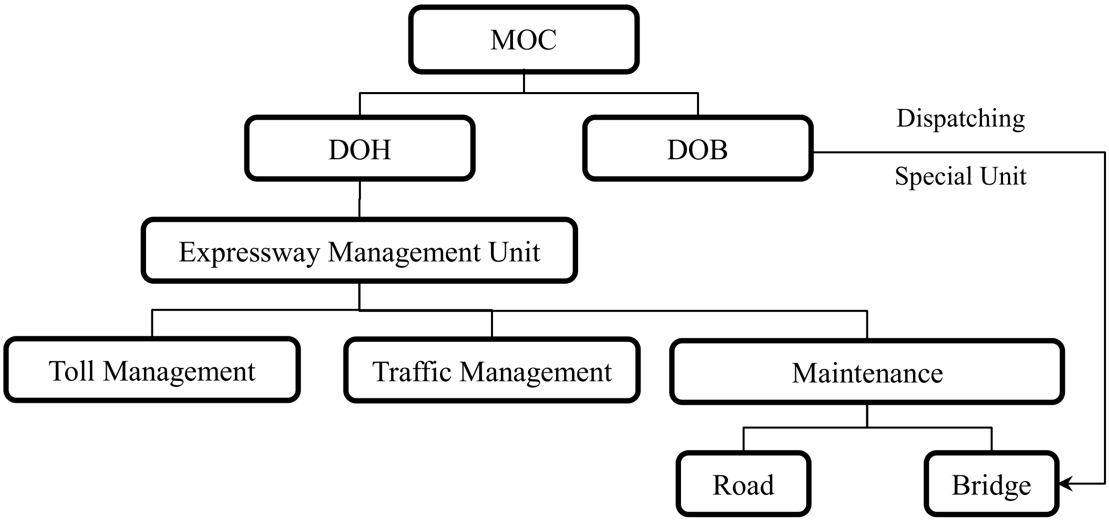
In the ADB plan, the rest area is described as “Rest Camp”, and the necessary facilities are generally reasonable.

In Japan, road operators manage the minimum facilities required for breaks (parking lots and toilets), but additional facilities such as restaurants, shops, and gas stations are typically entrusted to private businesses. In the future, it is necessary to discuss what kind of scheme should be adopted for the establishment, operation and maintenance of rest facilities.

9.4 Operation and Maintenance Structure

9.4.1 Overall Organizational Structure

Figure 9.4.1 shows the overall operation and organizational structure proposed for this project road. As described later, there is the possibility of operation management by the organization that manages the entire expressway network in the future. However, it is planned that the management unit will be established and operated and maintained immediately under the executing agency of this project during the period from the opening of the project.



Source: JICA Study Team

Figure 9.4.1 Overall Organizational Structure for Operation and Maintenance (Draft)

(1) Structure of Toll Collection Management Work

1) Toll Plaza Operation Work

Toll plaza operation work is performed by toll collection staff 24 hours a day, 365 days a year. The toll collection staff will be responsible for toll collection and will have 3 shifts of 9 hours working, including business transfer. Toll collection staff shall be assigned to each lane at each toll plaza. The required number of toll collection staff at each toll plaza is shown in Table 9.4.1.

Table 9.4.1 Number of Toll Collection Staff (Reference)

Toll Plaza	Number of Lanes	Number of Toll Collection Staff
Bago	14	42
Thanatpin	12	36
Waw	12	36
Kyaikto	11	33

Source: JICA Study Team

2) Toll Management Work

Toll Management work is performed by toll management staff 24 hours a day, 365 days a year.

The toll management staff will have 3 shifts of 9 hours working, including business transfer. The toll management staff will be responsible for the management of sales, management of the toll collection staff, etc., and two staff members will be assigned to the toll management room in the management center of each toll plaza. The required number of toll management staff at each toll plaza is shown in Table 9.4.2.

Table 9.4.2 Number of Toll Management Staff (Reference)

Toll Plaza	Number of Toll Management Staff
Bago	6
Thanatpin	6
Waw	6
Kyaikto	6

Source: JICA Study Team

3) Weight Measurement Work

Weight measurement work is performed by weight measurement staff 24 hours a day, 365 days a year. The weight measurement staff will have 3 shifts of 9 hours, including work transfer. The weight measurement staff will be responsible for measuring the weight of large vehicles at the weight measuring station, and two staff members will be assigned to the weight measuring station at each toll plaza. The required number of weight measurement staff at each toll plaza is shown in Table 9.4.3.

Table 9.4.3 Number of Weight Measurement Staff (Reference)

Toll Plaza	Number of Weight Measurement Staff
Bago	6
Thanatpin	6
Waw	6
Kyaikto	6

Source: JICA Study Team

(2) Structure of Traffic Management Work

1) Monitoring Work

Monitoring work is performed by monitoring staff 24 hours a day, 365 days a year. The monitoring staff will have 3 shifts of 9 hours, including work transfer. The monitoring staff will be responsible for monitoring around the toll plaza and on the main line using CCTV monitors, monitoring facility malfunctions, coordinating communication in the abnormal event, sending out SNS of traffic conditions, etc. and two staff members will be assigned to the monitoring room at each toll plaza. The required number of monitoring staff at each toll plaza is shown in Table 9.4.4.

Table 9.4.4 Number of Monitoring Staff (Reference)

Toll Plaza	Number of Monitoring Staff
Bago	6
Thanatpin	6
Waw	6
Kyaikto	6

Source: JICA Study Team

2) Traffic Management Work

Traffic management work is performed by traffic management staff 24 hours a day, 365 days a year. The traffic management staff will have 3 shifts of 9 hours, including work transfer. The traffic management staff will be responsible for traffic patrols, response to accidents, inspection of traffic management patrol cars, etc., and two staff members will be assigned to each traffic management vehicle placed at the management center of each toll plaza. The required number of traffic management staff at each toll plaza is shown in Table 9.4.5.

Table 9.4.5 Number of Traffic Management Staff (Reference)

Toll Plaza	Number of Traffic Management Vehicles	Number of Traffic Management Staff
Bago	Patrol Car-2 Tow Truck-1	18
Thanatpin	Patrol Car-2	12
Waw	Patrol Car-2	12
Kyaikto	Patrol Car-2 Tow Truck-1	18

Source: JICA Study Team

(3) Structure of Maintenance Management Work

1) Daily Maintenance Work (Road Maintenance)

Daily maintenance work is performed by inspection and maintenance staff, 24 hours a day, 365 days a year. The inspection and maintenance staff will have 3 shifts of 9 hours, including work transfer. The inspection and maintenance staff will be responsible for the maintenance patrol, the primary response in the event of an abnormality on the main line, inspection of the maintenance patrol car, etc. Two inspection and maintenance staff members will be assigned to each maintenance management vehicle placed at the management center of the two tollgates. The required number of inspection and maintenance staff at each toll plaza is shown in Table 9.4.6.

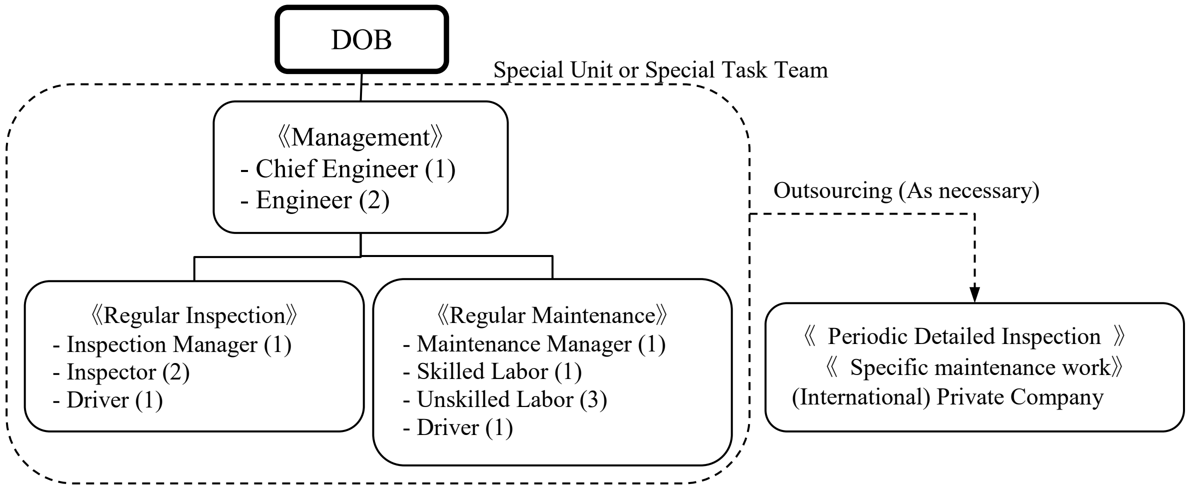
Table 9.4.6 Number of Inspection and Maintenance Staff (Draft)

Toll Plaza	Number of Maintenance Vehicles	Number of Inspection and Maintenance Staff
Bago	Patrol Car-2 Sign Vehicle-1 High Elevation Work Vehicle-1	24
Thanatpin	-	-
Waw	-	-
Kyaikto	Patrol Car-2 Sign Vehicle-1 High Elevation Work Vehicle-1	24

Source: JICA Study Team

2) Periodic Maintenance Work (Bridge Inspection and Maintenance Work)

Figure 9.4.2 shows the implementation structure for bridge inspection and maintenance work. Basically, members of the special unit in charge of DOB carry out periodic inspections every year, and if necessary, detailed inspection works will be commissioned to experienced external experts. Under the chief engineer, 2 engineers, an inspection team and a maintenance team will be organized.



Source: JICA Study Team

Figure 9.4.2 Implementation Structure for Bridge Inspection and Maintenance (Reference)

9.5 Operation and Maintenance Cost

The approximate operation and maintenance cost required for the project road is calculated based on the estimation by the ADB TA and the contents of the operation and maintenance management plan proposed in 9.3 and the operation and maintenance structure proposed in 9.4.

9.5.1 Review on Initial Construction Costs of Expressway Incidental Facilities

Table 9.5.1 shows the review results on the initial construction cost of expressway incidental facilities.

Table 9.5.1 Review Results on Initial Construction Cost of Expressway Incidental Facilities (Change Point Only)

Item		ADB Plan	Review Result
Interchanges & Toll Plazas	Interchange Toll Plaza & Building	1,716,000	2,459,600
	Interchange Lighting Pole	1,188,000	4,103,000
	Residences for Staff	0	4,676,100
	Weigh-in-motion Scales Truck Lanes	1,408,000	4,012,000
	Interchange Toll Facilities	704,000	11,875,000
	Patrol & Tow Truck of Expressway	0	1,760,000

Source: JICA Study Team

The main differences between the ADB plan and the review results are as follows.

(1) Interchange Lighting Pole

The ADB plan expects 4m poles and solar panel road lighting, but it is considered that the specifications are insufficient in brightness and uniformity. In this review, 10m or 12m poles in the main line and high poles floodlight around the toll plaza are set and it is considered that it can fully function as road lighting. It is considered that there are differences in the cost calculation results due to the differences in these specifications.

(2) Residences for Staff Members

There is no specific description of housing for staff in the ADB plan. Housing for staff members should be secured in order to avoid the risk of operation suspension due to the absence of working staff. As long as the existing toll roads in Myanmar, such as the Yangon Mandalay Expressway and Max Highway, were surveyed, housing for all staff were secured, and this was followed in this review.

Even if housing for staff is not secured, it may be possible to commute to the Bago Toll Plaza and Kyaikto Toll Plaza because the villages are close. However, since other toll plazas are far from the village, there is risk of operational suspension due to the inability to commute.

(3) Weigh-in-motion Scales Truck Lanes

Although the ADB plan only describes measurements by WIM, it is considered to be inadequate to control overloaded vehicles. In this review, after sorting by WIM, the detailed measurement of static load is performed at the weigh-station. In the case of this configuration, it is considered that weight measurement processing can be performed more efficiently while ensuring accuracy, and the risk of tollgate congestion can be reduced. It is considered that there are differences in the cost calculation results due to the differences in these configurations.

(4) Interchange Toll Facilities

Since the ADB plan does not have specific descriptions of the breakdown included in this section, it is unclear whether installation costs for electric power distribution facilities and communication network devices are expected. In this review, in addition to facilities on the toll lane, electric power distribution facilities, UPS, communication network and other infrastructure devices, servers for management and monitoring, wiring between each facilities and wiring paths are expected. It is considered that there are differences in the cost calculation results due to the differences in these calculation ranges.

(5) Patrol & Tow Truck of Expressway

Although the ADB plan is likely to anticipate a lease contract, it may be difficult to lease because it involves specialized vehicles. This review assumes that these will be initially purchased and renewed every 5 years.

9.5.2 Review on Operation and Maintenance Costs

Table 9.5.2 shows the operation and maintenance costs required for 20 years from the completion of this project, including daily operation and maintenance.

According to this, the total amount is 237 million dollars (about 25.6 billion yen), and the annual average is about 12 million dollars (about 1.3 billion yen). Looking at the annual average per km, approximately 0.2 million dollars (approximately 20 million yen) is required, which is almost one third of that in Thailand compared to the level of maintenance costs in other countries shown in Table 12.2.3. On the other hand, the annual maintenance cost budget for DOH and DOB is 67.0 billion kyat (about 5.2 billion yen), and the operation and maintenance cost of this project road is about 25%. Although the national budget can be expected to expand due to economic growth, it is suggested that the current budget level will be insufficient. In addition, it is necessary to promote road policies aimed at securing financial resources, such as securing toll-specific financial resources by revising toll road fees and introducing gasoline taxes.

The part shown in red in the table is updated by the review of the JICA Study Team. The main differences from the ADB plan are summarized below.

(1) Toll System - Cost of Staff

The ADB plan does not specifically describe the breakdown included in this section, but expects 750 staff. In this review, 327 people are expected with the breakdown as described above. It is considered that there are differences in the cost calculation results due to the differences in the number of staff.

(2) Toll System - Patrol & Tow Truck of Expressway

ADB's plan is considered to have recorded costs assuming lease contract. In this review, purchase is assumed as described above, and renewal costs are recorded every 5 years. It is considered that there are differences in the results of cost production from these differences.

(3) Toll System - System & Maintenance Management 10%

The ADB plan does not have specific descriptions regarding this section, but this review assumes that operations such as preparation of inspection plans, management of inspection results, and facilities update management are necessary.

(4) Periodic Maintenance - Toll System

As mentioned above, the ADB plan does not have specific descriptions of the breakdown included in this section, so it is unclear whether renewal costs for electric power distribution facilities and communication network devices are expected. In this review, in addition to the facilities on the toll lane, the electric power distribution facilities, UPS, communication network and other infrastructure devices, management and monitoring servers are expected to be updated. It is considered that there are differences in the cost calculation results due to the differences in these calculation ranges.

Table 9.5.2 Operation and Maintenance Costs for This Project Road (20 Years)

Description			Original (ADB Plan)	Review by JICA
ADB Section	Routine Maintenance	Patch Bituminous Pavement	$2,318,718	$2,318,718
		Repair & Patch Concrete Pavement	$96,138	$96,138
		Repair & Replace Guardrail	$2,541,668	$2,541,668
		Repair & Replace anti-glare barrier	$20,885	$20,885
		Repair & Replace ROW Fences	$7,868,502	$7,868,502
		Replace Light Luminaires	$337,960	$337,960
		Repair or Replace Light Standards	$1,448,402	$1,448,402
		General Roadway Maintenance	$1,328,340	$1,328,340
		Clean Ditches	$2,656,680	$2,656,680
		Clean & Repair Pipe Culverts	$1,463,006	$1,463,006
		Clean Box Culverts & Underapsses	$1,553,197	$1,553,197
		Repair Culverts	$974,797	$974,797
		Special Bridge Inspection Truck	$1,226,160	$1,226,160
		Inspect Bridge	$922,685	$922,685
		Repair Bridge	$12,627,023	$12,627,023
		Repaint Lines	$7,828,521	$7,828,521
		Repair Signs	$6,238,298	$6,238,298
		Control Vegetation	$3,347,417	$3,347,417
		Pickup Litter	$7,531,688	$7,531,688
		Miscellaneous Maintenance	$597,753	$597,753
		Maintenance Management 10%	$6,292,784	$6,292,784
		Routine Maintenance Road	$69,220,621	$69,220,621
	Toll System	Electricity Fee	$4,221,882	$2,772,000
		Cost of Staff	$48,280,050	$20,601,000
		Running Offices & Toll Booths	$1,287,720	$709,800
		Fire Truck & Station	$1,544,962	$1,544,962
		Inspection of Expressway	$1,544,962	$1,476,670
		Patrol and Tow Truck of Expressway	$2,059,949	$8,750,160
		Maintaining Toll System	$1,287,468	$694,650
		System & Maintenance Management 10%	—	$3,377,724
		Total Toll System	$60,226,992	$39,926,966
	Periodic Maintenance	Pavement Overlay 5 cm	$26,566,800	$26,566,800
		Pavement Overlay 7.5 cm	$39,850,200	$39,850,200
		Bridges Periodic Maintenance	$415,055	$415,055
		Bridges Expansion Joint Replacement	$4,291,560	$4,291,560
		Bridges Bearing Pad Replacement	$5,579,028	$5,579,028
		Toll System	$9,196,200	$24,606,000
		Lighting	$2,010,902	$2,748,000
		Periodic Maintenance Per Year	$87,909,746	$104,056,643
JICA Section		Routine Maintenance	$3,483,145	$3,624,492
		Electricity Fee	—	$924,000
		Periodic Maintenance	$18,176,596	$19,058,800
		Total JICA Maintenance	$21,659,740	$23,607,292
Total Road & Bridge Operations Cost			**$239,017,099**	**$236,811,522**
Mean Annual O&M Cost			**$11,950,855/Year**	**$11,840,576/Year**
Mean Annual O&M Cost / km			**$187,024/Year・km**	**$185,299/Year・km**

Source: JICA Study Team

9.6 Future Implementation Body for Expressway Operation

9.6.1 Introduction

As aforementioned, at the initial operation of the project expressway, it is planned that DOH will be in charge of road section (by ADB finance) and DOB will be in charge of the New Sittaung Bridge (by JICA finance). Considering the fact that the Yangon Inner Ring Road (YIRR) would be implemented under PPP scheme and the Yangon Outer Ring Road (YORR) is expected to be constructed by Japanese ODA Loan, it is assumed that the expressway network will elongate rapidly as well as other class roads. Under such circumstances, it will be the capacity limitation for direct operation by MOC.

In general, expressways need higher service level than other class roads, and it is a part of most important logistic ways and emergency transport routes. Hence, higher technical and institutional capacity is required for the implementation agency of expressways.

In this section, future institutional options are studied and the preferable option is proposed.

9.6.2 Recommended Operation Scheme

For future expressway operational model in Myanmar, the following 4 options can be considered. These are i) Expressway Enterprise (SOE) model, ii) Private Sector model, iii) Lease model, and iv) Direction Operation by MOC model.

Table 9.6.1 provides role allocation of each operation model. In the Expressway Enterprise model, a new public authority for expressway operation will be established, and the public authority is responsible for planning, construction, operation and maintenance of expressways. In this option, toll revenue can be the ring-fenced and it goes to repayment of the government's finance.

In the Private Sector model, all of the implementation processes (from construction to maintenance) are implemented by private finance. Whereas, in the Lease option, construction of expressway is implemented by public finance and this option is similar to the existing BOT scheme in Myanmar.

As the existing scheme, MOC will implement construction, operation and maintenance under the Direct Operation by MOC option.

Table 9.6.1 Role Allocation of Each Operation Model

Option	Budgeting	Construction	O&M	Toll Income	Asset Owner
Expressway Enterprise	Public (Agency)	Public (Agency)	Public (Agency)	Public (Agency)	Public (Agency)
Private sector	Private	Private	Private	Private	Public
Lease	Public	Public	Private	Private	Public
Direct Operation by MOC	Public	Public	Public	-	Public

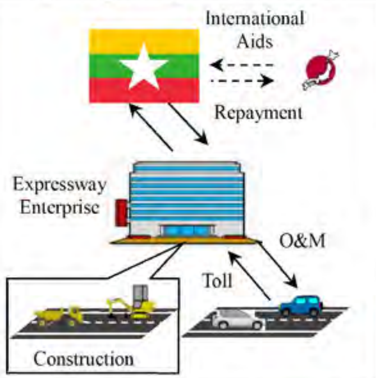
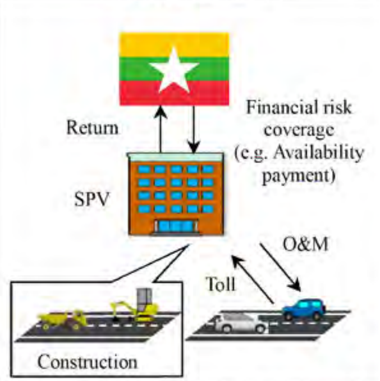
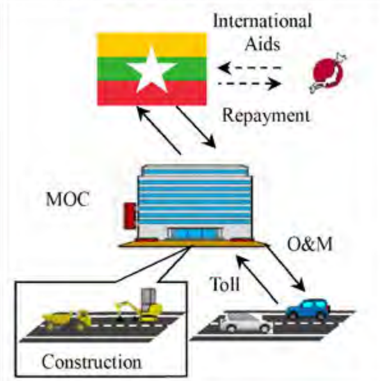
Source: JICA Study Team

Table 9.6.2 shows a comparative study on future expressway operational model. Alternative-1 : Expressway Enterprise model is recommended for the time being in the following reasons.

- Unprofitable but necessary expressway networks in the suburban area or the provincial area could be fairly developed since the public authority is financially reliable and stable.
- Institutional independence and the ring-fenced finance could theoretically build an effective and quick decision making mechanism so that quick response to emergencies and unified and high quality of services to road users can be provided.
- The option has high operational flexibility to the privatization of profitable expressways later on

According to interviews with MOC, for the aim of reorganizing the construction units as a different organization, establishment of a State-Own Enterprise is currently under discussion in Myanmar. The details such as its role and responsibility are not disclosed yet but it is assumed that the establishment of a new enterprise could be promptly realized since it follows the existing SOE law in principle. Having said that, the future operation method of expressways needs to be discussed with MOC considering the trend of the SOE establishment.

Table 9.6.2 Comparative Study on Expressway Operation Option

Item	Alt-1 Expressway Enterprise (SOE)	Alt-2 Private Sector	Alt-3 Lease	Alt-4 Direct Operation by MOC
Schematic Diagram				
Advantages	- Stable public finance enable balanced and sustainable expressway development. - Quality of construction and O&M can be highly unified. - High operational flexibility to possible involvement of private sector later on. - Toll revenue will be ring-fenced so that quick decision-making mechanism could be build and quick action such as emergency response is easier.	- Low lifecycle cost could be achieved if know-how in the private sector is sufficiently developed. - Lowest risk for union account.	- Low O&M cost could be achieved if know-how in the private sector is sufficiently developed. - Low risk for union account.	- Low financial cost. - Existing capacity and personnel can be effectively used so that this is preferable for the initial operation stage.
Disadvantages	- A certain time is necessary to settle a stable institutional body.	- Highest financial risk for private sector since compensation for risks such as Availability Payment mechanism is not established yet in Myanmar. - Low sustainability of expressway development since private sector can participate in only profitable section. Unprofitable sections would be missing links. - Compensation mechanism should be build but it takes time for settlement. - Risk of opaque accounting	- High financial risk for private sector since compensation for risks such as Availability Payment mechanism is not established yet in Myanmar as well as PPP law. - Compensation mechanism should be introduced but it takes time for settlement. - Risk in opaque accounting.	- Difficulty in quick decision-making and action. - Risk in work overflow and low road services due to the financial and capacity limitations.

Source: JICA Study Team

9.7 Necessity of Upgrading of the Thuwunna CTC and Research Laboratories and Proposal for Technical Assistance to O&M Agency

9.7.1 Necessity of Upgrading of the Thuwunna CTC and Research Laboratories and Technical Assisitance to MOC

As aforementioned, it is planned that the initial O&M of the project expressway will be undertaken by DOH and DOB. As indicated in the previous section, it is preferable that a new implementation body is established, however in any case, since the base should be DOH and DOB, it is essential to enhance technical capacity of both departments through training programs to engineers of MOC for establishment of proper and sustainable operation and maintenance body for the project expressway which needs higher level of technical capacity.

In this context, as described in Chapter 2 of this Report, the existing Thuwunna CTC and Research Laboratories is a key facility for providing advanced training programs for engineers of MOC and quality assurance of construction/maintenance works. However the existing facilities are not well functioned for the purpose due to the significant deterioration of the existing facilities and equipment and insufficient capacity of the facilities.

Moreover MOC plans to establish a new department called “Thuwunna Research Laboratory and Training Department” which will be responsible for all research and laboratory functions, and training functions provided by the current CTC and 4 Research Laboratories under DOH, DOB, DOBi and DRRD. The name of the target facility for this project is currently under consideration in the MOC, and the new facility is tentatively named “Thuwunna Research Laboratory and Training Center (Thuwunna RLTC).”

To cope with the above issues and movement, this Project aims to strengthen the functions of the Thuwunna RLTC by reconstructing the Training Facility and Research Laboratories, Hostels and procuring the necessary training and laboratory equipment for these facilities. Thereby proper implementation body for proper and sustainable O&M of the project expressway is expected to be developed through advanced technical trainings to MOC’s engineers.

Since the outline of preliminary design for the Thuwunna RLTC is described in Chapter 10 of this Report and the details are given in Vol.2 of this Report, a technical assistance program is proposed in this section.

9.7.2 Proposed Technical Assistance Program

For adequate operation and maintenance of expressways, there are basically 5 challenges. These are i) development of manuals for operation and maintenance, ii) technical capacity development of inspection and evaluation of inspection results, iii) technical capacity development of maintenance and repair work, iv) institutional development, and v) capacity development of expressway operation.

Phased implementation of technical assistance is proposed since it needs enormous time and cost as shown in Table 9.7.1.

Table 9.7.1 Proposed Technical Assistance Program

Program	Item	Description
Phase1	Major Objective	Assistance for preparation of inspection and maintenance manuals Technical capacity development of inspection and evaluation of inspection results
	Duration	3 years
	Targeted Organization	DOH and DOB
	Framework	1) Long-term detachment of a specialist for road and bridge maintenance plan and organization 2) Short-term detachment of specialists for: - Road and bridge maintenance plan - Bridge inspection (Concrete superstructure and substructures) - Bridge inspection (Steel bridge) - Road inspection 3) Assistance in preparation of road/bridge inspection and maintenance manuals 4) Assistance in formulation of road and bridge maintenance plan (short-term, mid-term and long-term) 5) Provision of training on inspection (Class room lecture and OJT) 6) Provision of road/bridge inspection equipment 7) Overseas training
Phase2	Major Objective	Technical capacity development of road/bridge maintenance Capacity development of formulating road/bridge maintenance plan
	Duration	3 years
	Targeted Organization	DOH and DOB
	Framework	1) Long-term detachment of a specialist to the CTC as a lecturer for the training course of road/bridge inspection and its evaluation 2) Short-term detachment of specialists for: - Road/Bridge Maintenance Plan - Bridge Repairing (Concrete) - Bridge Repairing (Steel bridge) - Road repairing (Pavement) 3) Assistance in preparation of road/bridge repairing manuals 4) Assistance in updating the Road/Bridge Maintenance Plan 5) Provision of training on road/bridge maintenance works (Class room lecture and OJT) 6) Provision of road/bridge maintenance equipment 7) Overseas training
Phase3	Major Objective	Assistance in institutional development for expressway operation Technical capacity development on expressway operation
	Duration	3 years
	Targeted Organization	MOC or Authority for expressway operation
	Framework	1) Short-term detachment of specialists for: - Expressway operation plan - Traffic and toll management - ITS and toll system management - Expressway facility plan

		2) Assistance in preparation of expressway operation manuals 3) Assistance in formulation of expressway operation and maintenance plan including budgetary plan 4) Assistance in formulation of institutional development plan 5) Provision of training on expressway operation (Class room lecture and OJT) 6) Overseas training

Source: JICA Study Team

CHAPTER 10 OUTLINE OF PRELIMINARY DESIGN FOR UPGRADING OF THUWUNNA RLTC

10.1 Introduction

The preliminary design for upgrading of the Thuwunna RLTC was performed by JICA Study Team to obtain sufficient engineering information in order to estimate project cost properly. In this section, main output of the preliminary design is described. The details are given in Vol.2 of this Report.

10.2 Project Contents for Upgrading Thuwunna RLTC

The scope of works is described hereafter.

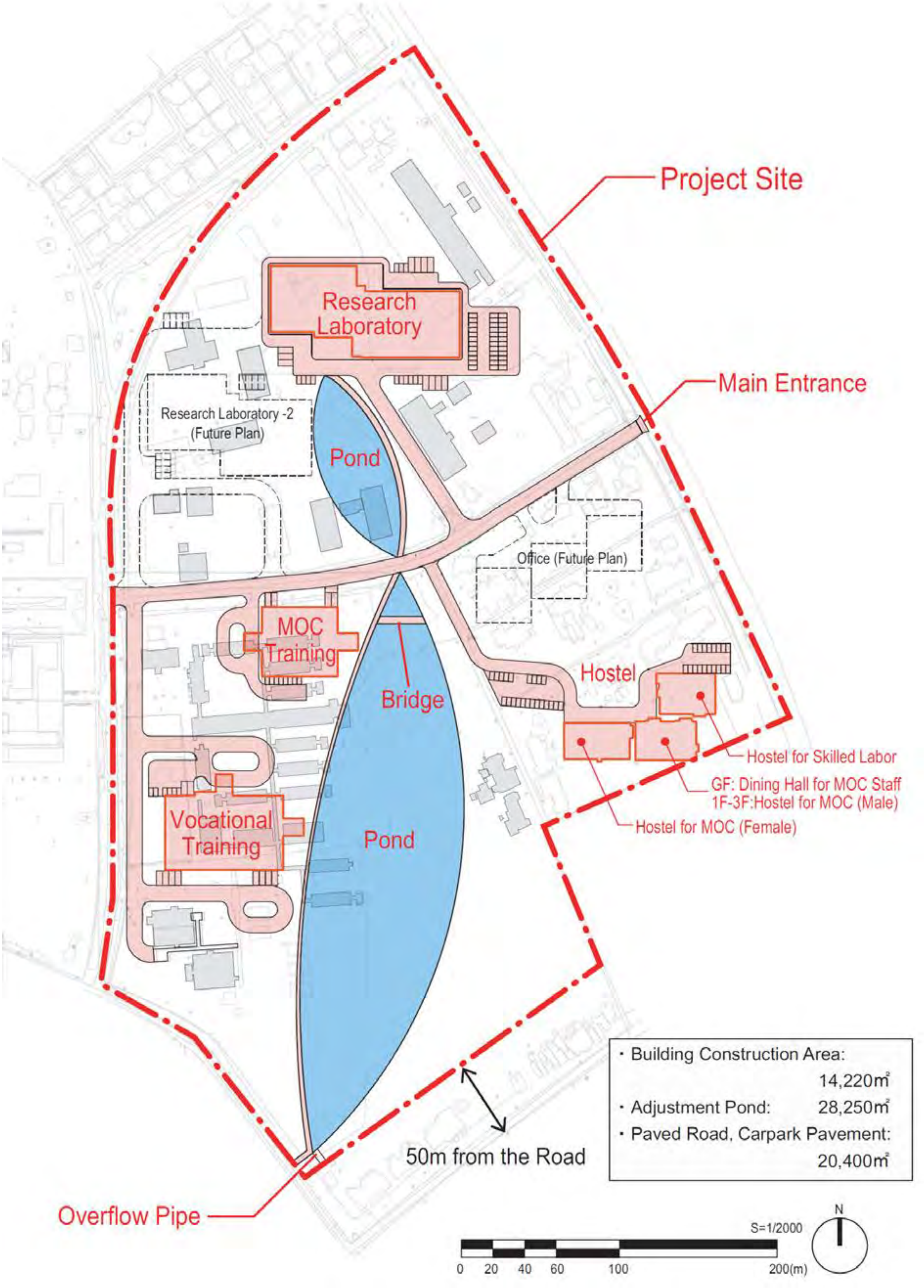
10.2.1 Building Development

The summary of work scopes for building works is shown in Table 10.2.1. The building layout plan of the Thuwunna RLTC is given in Figure 10.2.1.

Table 10.2.1 Summary of the Facilities

Block	Facilities	Story and Floor Area
MOC Training Center	Lecture room, training room, survey/quality management room, veranda, terrace/deck, exhibition space, hall/waiting room, staff meeting room, library, computer room, staff office, instructor room, maintenance staff room, support staff room, health room	3 stories, 6,100m^2
Vocational Training Center	Lecture room, training room, warehouse, veranda, terrace/deck, staff office, instructor room, reception desk	2 stories, 6,180m^2
Research Laboratory	Inspection room, warehouse, veranda, terrace, staff office, locker, support staff room	2 stories, 7,620 m^2
Hostel (3buildings)	• Hostel for MOC staff (male-only wing, with dining hall for MOC staff): 80 people • Hostel for MOC staff (female-only wing): 120 people • Hostel for skilled labors with dining hall: 100 people	3 stories, total 7,280 m^2
Outdoor Exhibition	Environmental roadway pavement field experiment, Life-size full-scale model (cross section sample of bridge, bridge pier sample and shield etc.), barrier-free experience corner	750 m^2
Road on the Premises	Paved Road, Main Gate, Sidewalk, Bridge	20,400 m^2
Adjustment Pond	Overflow Pipe, Flap Gate	28,250 m^2

Source: JICA Study Team



Source: JICA Study Team

Figure 10.2.1 Building Layout Plan of the Thuwunna RLTC

10.2.2 Procurement of Equipment

The main equipment items which are required for the Thuwunna RLTC are shown in Table 10.2.2.

Table 10.2.2 Main Equipment Items

Department	Main items of Equipment
CTC	Concrete Cutter, Total Station, Concrete Mixer, Level, Office Equipment for Text Preparation, etc.
DOB	Compressive Testing Machine, Soundness (Autoclave), Consolidation Testing Machine, Core Barrel, etc.
DOH	Los Angeles Abrasion Machine, Cement Autoclave, Automatic Digital Mortar Mixer, and Temperature and Humidity Controlled Cabinet, Pan-type Mixer, Triaxial Compression Test, Gyratory Compactor, Automatic Asphalt Extraction Apparatus, etc.
DOBi	Concrete Curing Specimen Tank, SIT (Sonic Integrity Test), Direct Shear Test Apparatus, Moist Cabinet, Universal Tensile Testing Machine, Floor-standing Optical Emission Spectrometer, etc.
DRRD	CBR Apparatus, Consolidation Test Equipment, Compressive Testing Machine, Los Angeles Abrasion Testing Machine, SIT (Sonic Integrity Testing), etc.

Source: JICA Study Team

10.3 Design Basic Policy

10.3.1 Overall Design Policy

The Thuwunna RLTC, which is planned to be built under this Project, is a center that integrates the current CTC, DOH Laboratory, DOB Laboratory, DoBi Laboratory, and DRRD Laboratory. It aims to centralize the currently scattered facilities and take the following factors into account: (1) functionality and effectiveness of the training centers and research laboratories; (2) natural and social conditions of Thuwunna; (3) construction and procurement conditions; (4) maintenance and management ability of the implementing agency; and (5) construction period; etc. The design policy shall be determined in consideration of the followings:

- As a training and laboratory facility responsible for human resource development and quality control in the field of construction in Myanmar, the facility is planned to further enhance research and human resource development.
- MOC is in the process of strengthening the organization of CTC. In this project, the minimum necessary facilities and equipment shall be designed that can be respond to the new organization.
- To establish a proper facility which contributes to construction-related technology development and quality control as well as facilitate research and development, the facility shall be designed in consideration of the possibility of building expansion in the future.
- Laboratories shall be designed to provide exhibition facilities and libraries to allow more diverse training and for easy access of trainees to acquire more knowledge.
- The Research Laboratory shall be aimed to provide quality control under the ASEAN, and facilities and provision of equipment shall be planned to adapt to ASTM standards. Since there is a possibility to restructure the laboratories in the future, flexibility of the building plan to respond to layout changes will be taken into consideration.
- In regard to the equipment, sharing and unified management of common equipment will be considered.

- In order to reduce the burden of maintenance and management in the future, the design shall be prepared in consideration of securing natural lighting and ventilation, ease of maintenance, and reduction of utility costs. In addition, the concept of green building design shall be adopted, and the facility itself shall be an example in which the trainees can learn from.
- To be a suitable environment as training center and research laboratory, the design shall be prepared the current trends (i.e. universal design, green building, etc.).

10.3.2 Facilities Location Planning

- The target facilities of this project are six buildings, namely: MOC Training Center, Vocational Training Center, Research Laboratory, MOC Staff Hostel (Male, including Dining hall for both male and female), MOC Staff Hostel (Female), and Skilled Labor Hostel. In addition, the adjustment pond, on-site access roads and entrance gates shall be included.
- These buildings are upgrades of the existing buildings, and this project targets not only space expansion, but also functional improvement including circulation, safety and efficiency. The facility as a whole shall be designed as a functional and efficient research and testing facility.
- Currently, each laboratory and the CTC have their own entrance gates, but there is no main gate for the area. The new main entrance shall be located at the T-junction on the eastern side, and access to the Research Laboratory and the Training Center will be from this center road from the east to the center road.
- The layout design shall be made in consideration of future space expansion.
- Considering the natural sunlight, the buildings shall be arranged in the east-west axis basically.
- The two existing buildings constructed by JICA shall remain and be used, new facilities will be positioned where the old ones will not be affected.
- New buildings for research laboratories will be placed away from the existing laboratory buildings so that laboratory tests will still be possible during construction of new buildings.
- Proposed laboratory building will cover only the minimum and major functions of each laboratory. Existing buildings can be continuously used as additional buildings, such as storage for drilling rigs, warehouse for unused equipment, etc.
- Each building shall be planned with internal road access for loading and unloading of materials.
- In consideration of security control, the research and testing facility is designed to have separate flow lines for insiders including researchers, and outsiders including visitors.

10.3.3 Drainage on the Premises

Currently, there is no drainage system in and around the Project site, but only a water supply system. YCDC (Yangon City Development Committee) conducted a field survey for new draining system, but there has not been any development. In this project, as measures against flooding, the ground floor level of the building is planned to be raised 1 m above the ground, storm water drainage ditches shall be constructed and storm water shall be discharged to and collected in the adjustment pond. Because the groundwater level at the site is high and the effectivity is low even if the pond is quite deep, the pond shall have a depth of 2 m or more and shall be as large as practically possible.

In addition, a flap gate will be installed on the south side of the adjustment pond in preparation for future storm water drainage system extension outside the premises. This pond is a general measure against rain during rainy seasons, and not against big floods that occur every other year. To prevent such big flood, it is necessary to have storm water drainage system for the entire town in which the target area will be expanded extremely large, so this project will not target such expanded areas.

10.4 Major Design Outputs

Based on the above design basic policies,the following design outputs were developed in this Study.

10.4.1 Architectural Plan

The floor plan was designed based on the layout plan and function or standard calculation for each necessary room. The main design policies are the following. The floor area of each building is given in Table 10.4.1 to Table 10.4.3. The building design concept diagrams are shown in Figure 10.4.1 to Figure 10.4.3.

- The layout design shall be made in consideration of future space expansion.
- Practice rooms and laboratories where much loading and unloading of materials happen are placed on the ground floor, while office rooms and lecture rooms are on the first floor.
- In order to avoid the huge burden of operation and maintenance costs, the design is made in consideration of securing natural lighting and ventilation, easy maintenance and reduction of utility costs.
- The exterior wall is made double-skinned to prevent direct sunlight from entering the building and increase the room temperature and to enable outdoor works while ensuring security.
- Veranda for outdoor works and air conditioning outdoor unit storage are placed.
- The design will provide evacuation routes properly and carry out floor plans and furniture layout plans.
- The MOC staff hostels include hostels for men and women, and hostel for skilled labors. If there are women trainees for vocational training courses, the female-only building for MOC staff will be used as hostel.
- Required functions and activity plans of CTC and laboratories will be considered when formulating the facility plans. Thus, the detailed design will be decided based on discussions with related parties.

Table 10.4.1 Area of Each Room in MOC Training Center

Room Name	Room Use	Plan			Unit Area
		Capacity	Number of Rooms	Area (m^2)	(m^2/ person)
Lecture Room	Classroom lecture	54	8	784.00	1.81
Practice Room	Concrete mixing training	-	2	196.00	-
Survey and Quality Control Room	Surveying equipment storage	-	1	49.00	-
Library	Double as study room	-	1	98.00	-
Computer Room		50	1	196.00	3.92
Exhibition Space	Exhibition to display information	-	1	94.50	-
Hall		300	1	490.00	1.63
Control Room	Preparation room	-	1	98.00	-
Executive Office		1	3	73.50	24.50
Staff Meeting Room		70	1	192.50	2.75
Staff Office	Including meeting space, personal computer room, and document storage	29	1	318.50	10.98
Lecturer's Room		11	1	98.00	8.91
Maintenance Staff Room	Waiting room for maintenance staff	21	1	96.25	4.58
Supporting Staff Room	Waiting room for security guard, cleaning service, gardener, driver, etc.	13	1	44.46	3.42
Nurse Room		-	1	49.00	-
Entrance, Corridor, Toilet, Stairways, etc. (Indoor)		-	-	1467.29	-
Veranda	Outdoor work and outdoor storage	-	-	624.20	-
Terrance and Deck	Resting space	-	-	565.74	-
Entrance, Corridor, Toilet, Stairways, etc. (Semi-outdoor)		-	-	566.80	-
Total Floor Area				**6101.74**	

Source: JICA Study Team

Table 10.4.2 Area of Each Room in Research Laboratory

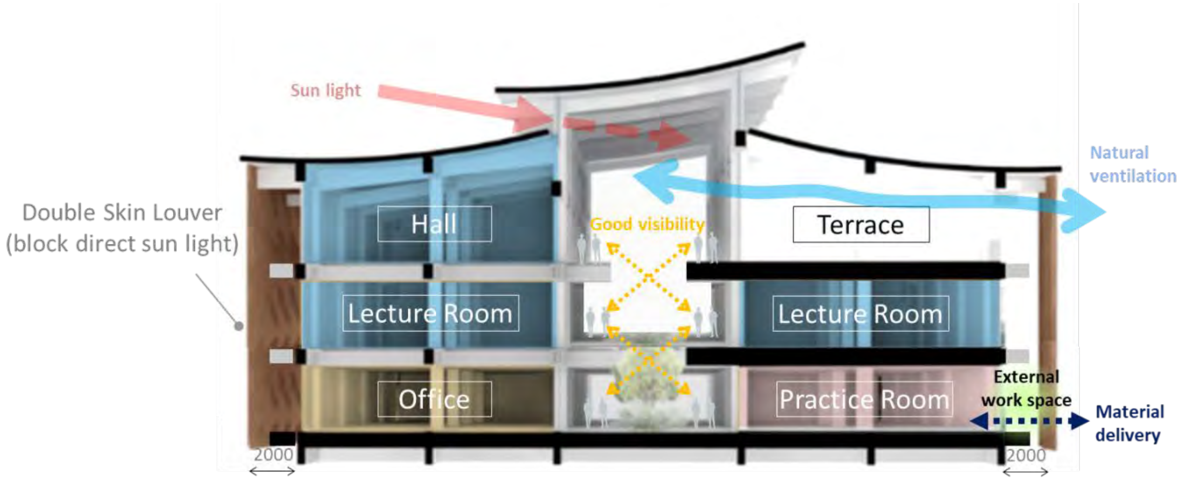
Room Name	Room Use	Plan			Unit Area
		Capacity	Number of Rooms	Area (m^2)	(m^2/ person)
Lecture Room	Classroom lecture	32	9	651.00	2.26
Practice Room		10	11	1203.00	10.94
Storage		-	17	504.00	-
Exhibition Space	Exhibition to display information	-	1	72.00	-
Executive Office		1	2	25.00	12.50
Staff Office		11	1	122.00	11.09
Lecturer's Room		13	1	75.00	8.33
Reception		10	1	72.00	7.20
Supporting Staff Room	Waiting room for security guard, cleaning service, gardener, driver, etc.	-	1	72.00	-
Entrance, Corridor, Toilet, Stairways, etc. (Indoor)		1	1	1549.00	-
Veranda	Outdoor work and outdoor storage	-	-	1130.18	-
Terrace and Deck	Resting space	-	-	282.00	-
Entrance, Corridor, Toilet, Stairways, etc. (Semi-outdoor)		-	-	417.80	-
Total Floor Area				**6174.98**	

Source: JICA Study Team

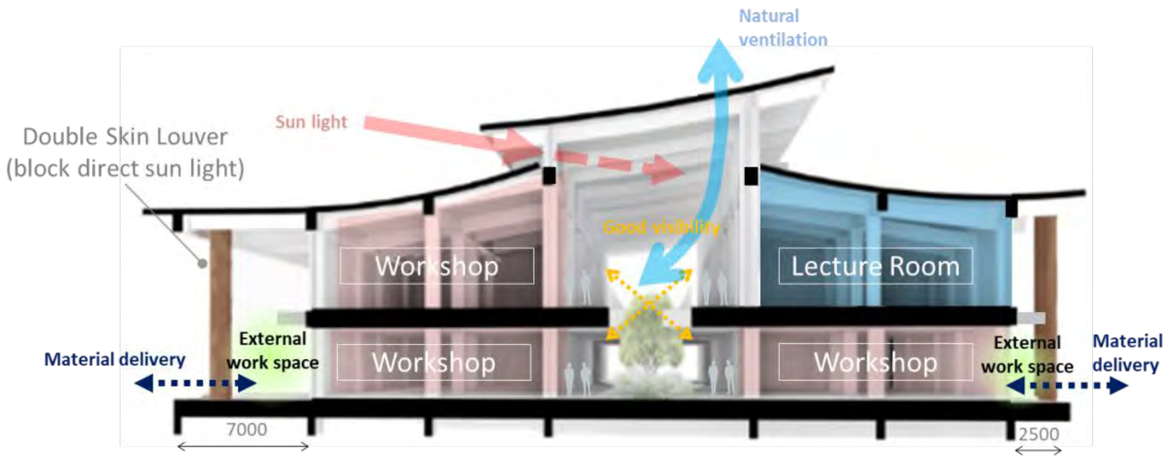
Table 10.4.3 Area of Each Room in Hostels

Room Name	Room Use	Plan			Unit Area
		Capacity	Number of Rooms	Area (m^2)	(m^2/ person)
MOC Staff Hostel (Male)					
4per. Room	Veranda excluded	4	6	252.00	10.5
8per. Room	Veranda excluded	8	7	525.00	9.38
Dining Hall	Kitchen included	200	1	499.00	2.50
Others		-	-	1393.34	
				Subtotal 2669.34	
MOC Staff Hostel (Female)					
4per. Room	Veranda excluded	4	10	420.00	10.5
8per. Room	Veranda excluded	8	10	750.00	9.38
Others		-	-	1377.04	
				Subtotal 2547.04	
Skilled Labor Hostel					
20per. Room		20	5	806.45	8.06
Cafeteria	Kitchen is shared by Dining Hall	100	1	167.22	1.67
Bath	Assuming 20 people This is twice the number of Japanese law for labor hostel, which prescribe 10% of user.	20	1	80.55	4.04
Others		-	-	1033.99	
				Subtotal 2058.21	
Total Floor Area				**7274.59**	

Source: JICA Study Team



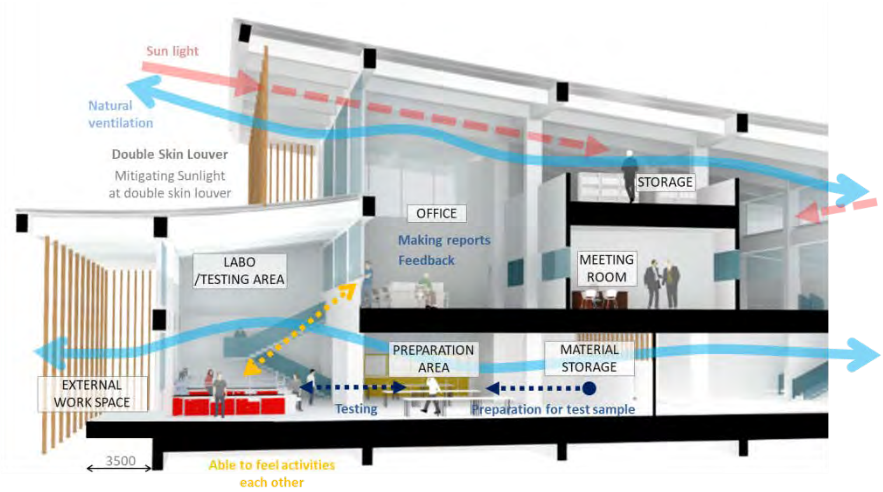
MOC Training Center



Vocational Training Center

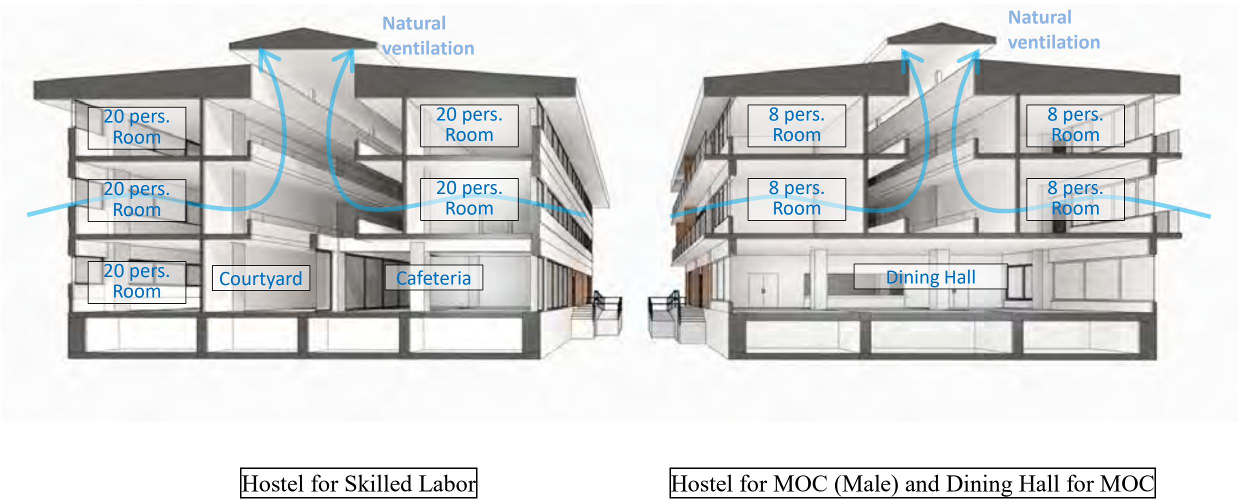
Source: JICA Study Team

Figure 10.4.1 Building Design Concept Diagram (Section) of MOC Training Center and Vocational Training Center



Source: JICA Study Team

Figure 10.4.2 Building Design Concept Diagram (Section) of Research Laboratory



Source: JICA Study Team

Figure 10.4.3 Building Design Concept Diagram (Section) of Hostels

10.4.2 MEP Plan

MEP (Mechanical, Electrical and Plumbing) plan necessary for the Thuwunna RLTC was performed in consideration of the following design policies and in accordance with the international codes and standards and technical guidelines, including those in Japan as well as in Myanmar. The list of Electrical and Mechanical Systems is shown in Table 10.4.4.

- Simple and reliable MEP (Mechanical, Electrical and Plumbing) systems
- Adoption of MEP systems which are easy to operate and maintain
- Adoption of economically rational system considering the lifecycle cost (LCC)
- Realization of an environment-friendly academic facility
- Adoption of training support system to make practices and training classes more effective.

Table 10.4.4 List of Electrical and Mechanical Systems

Electrical Systems		Vocational Training Center	MOC Training Center	Research Laboratory	Hostels 3 Buildings	Exterior
		RC 2 stories Total 6,180m^2	RC 3 stories Total 6,100m^2	RC 2 stories Total 7,620m^2	RC 3 stories Total 7,280m^2	
a.	Substation system					✓
b.	Emergency Generator system	✓	✓	✓	✓	
c.	Low Voltage Power Distribution System	✓	✓	✓	✓	
d.	Lighting and Receptacles	✓	✓	✓	✓	
e.	Telephone System	✓	✓	✓	✓	✓
f.	LAN System	✓	✓	✓	✓	✓
g.	Public Address System	✓	✓	✓	✓	
h.	Automatic Fire Detection and Alarm System	✓	✓	✓	✓	
i.	Lightning Protection System	✓	✓	✓	✓	
j.	Photovoltaic Power Generation System	✓	✓	✓		

Mechanical Systems		Vocational Training Center	MOC Training Center	Research Laboratory	Hostels 3 Buildings	Exterior
		RC 2 stories Total 6,180m^2	RC 3 stories Total 6,100m^2	RC 2 stories Total 7,620m^2	RC 3stories Total 7,280m^2	
a.	Domestic Cold Water Supply System	✓	✓	✓	✓	✓
b.	Wastewater Drainage & Vent System	✓	✓	✓	✓	✓
c.	Plumbing Fixtures	✓	✓	✓	✓	
d.	Fire Protection System	✓	✓	✓	✓	✓
e.	Liquefied Petroleum Gas Supply System			✓	✓	
f.	Wastewater Treatment Plant					✓
g.	Air-conditioning System	✓	✓	✓	✓	
h.	Mechanical Ventilation System	✓	✓	✓	✓	

Source: JICA Study Team

10.4.3 Equipment Plan

Necessary equipment items for the Thuwunna RLTC were examined in consideration of the following items, the requests by MOC including the existing CTC and laboratories, past lessons from the similar other projects and site inspection by the Study Team.

- The prioritized items which are essential to training or performing ASTM tests;
- Should meet the technical level of engineers / technicians in the target facility;
- Should be items where maintenance services provided by local agents could be secured;
- Should be items of precision and of high accuracy, or items in which quantity is too many to be procured during the annual development plan; and
- Should be supplementary items to increase the existing quantity in order to meet future usage demand.

As a result of examination by the Study Team (See Appendix-3 of Vol.2 of this Report), the following equipment listed in Table 10.4.5 is expected to be procured under this Project.

Table 10.4.5 List of the Equipment

Item No.	Description	Quantity	Use
Thuwunna CTC			
1-1	Cutting machine for brick	10	Practical Training
1-2	Bending machine for rebar	8	Practical Training
1-3	Cutting machine for rebar	8	Practical Training
1-4	Tying machine for rebar	8	Practical Training
1-5	Total station	10	Practical Training
1-6	Theodolite	10	Practical Training
1-7	Level	10	Practical Training
1-8	Concrete mixer	5	Practical Training
1-9	Los Angeles abrasion machine	1	Practical Training
1-10	Concrete compression machine	1	Practical Training
1-11	Desktop computer	10	Lecturing
1-12	Laptop computer	10	Lecturing
1-13	Printer color	10	Lecturing
1-14	Copier medium	10	Lecturing
1-15	Projector	10	Lecturing
1-16	Plate Compactor	10	Practical Training
1-17	Recessed screens	10	Practical Training
DOB (Soil Testing)			
2-1	Double Tube Core Barrel Complete Assembly	5	Quality Control
2-2	Consolidation Test Apparatus	2	Quality Control
2-3	Oven	1	Quality Control
DOB (Concrete Testing)			
2-4	Flow Table Test (Flow of hydraulic cement Mortars and cement pastes) Apparatus	1	Quality Control
2-5	Turbidimeter Test Apparatus with accessories	1	Quality Control
2-6	Soundness Test (Autoclave) Apparatus with accessories	1	Quality Control
2-7	Compressive Strength Test	1	Quality Control
DOBi (Concrete Testing)			
3-1	Mortar Mixer	3	Quality Control
3-2	Automatic Blaine Fineness Apparatus	1	Quality Control
3-3	Electronic Analytical balance	3	Quality Control
3-4	Curing Bench	1	Quality Control
3-5	Flow Tables Machine	2	Quality Control
3-6	Concrete curing specimen tank	2	Quality Control
3-7	S.I.T (Sonic Integrity Test)	1	Quality Control
3-8	Ultrasonic Pulse Velocity Tester	1	Quality Control
3-9	Pulse Echo Foundation Tester	1	Quality Control
3-10	Flat Jacks	1	Quality Control
3-11	Laboratory Ovens	1	Quality Control
3-12	Electromagnetic Sieves Shaker	1	Quality Control
3-13	Rotary Automatic scales	3	Quality Control
3-14	Water Stills	2	Quality Control
3-15	Pulse Echo Foundation Tester	1	Quality Control
3-16	Cross Hole Ultrasonic Monitor	1	Quality Control
3-17	Compression Machine 3000 KN	2	Quality Control
DOBi (Soil Testing)			
3-18	Direct Shear Test Apparatus C/W All Accessories	1	Quality Control
3-19	Horizontal Sample Ejector	1	Quality Control
3-20	Moist Cabinet	1	Quality Control

Item No.	Description	Quantity	Use
DOBi (Steel Testing)			
3-21	Universal Tensile Testing Machine (1000 kN)	1	Quality Control
3-22	Cold Bend Testing Machine	1	Quality Control
3-23	Floor-standing Optical Emission Spectrometers	1	Quality Control
DOBi (Office Equipment)			
3-24	Copier	5	Data Processing
3-25	Computer (Laptop)	11	Data Processing
3-26	Printer (A3)	5	Data Processing
3-27	Computer (desktop)w/ desk	3	Data Processing
DOH (Bitumen Testing (Lab-1))			
4-1	Gyratory Compactor	1	Quality Control
4-2	Laboratory Saw	1	Quality Control
4-3	Universal Core Drill for AC	1	Quality Control
4-4	Standard Rotational Viscometer	1	Quality Control
4-5	Oven (0-120^{o} C)	1	Quality Control
4-6	Automatic Asphalt Extraction Apparatus	1	Quality Control
4-7	Draft Chamber	3	Quality Control
4-8	Electromagnetic Sieves shaker	1	Quality Control
DOH (Fine and Coarse Aggregates Testing (Lab-2))			
4-9	Los Angeles Machine	1	Quality Control
4-10	Pilot Compact-line	1	Quality Control
4-11	Electromagnetic Sieve Shaker	1	Quality Control
DOH (Cement Testing (Lab-2))			
4-12	High Pressure Cement Autoclave	1	Quality Control
4-13	Automatic Digital mortar Mixer	1	Quality Control
4-14	Temperature and Humidity Controlled Cabinet	1	Quality Control
DOH (Concrete Testing (Lab-2))			
4-15	Pan-type Mixer with accessories	1	Quality Control
DOH (Soil Testing (Lab-3))			
4-16	Los-Angeles Abrasion Test	1	Quality Control
4-17	Triaxial Compression Test	1	Quality Control
DRRD (Soil Testing)			
5-1	CBR Apparatus	3	Quality Control
5-2	Direct Shear Test Equipment	1	Quality Control
5-3	Moisture Tester	2	Quality Control
5-4	Consolidation Test Equipment	1	Quality Control
5-5	Oven 100 Litters	1	Quality Control
DRRD (Aggregates Testing)			
5-6	Compressive Testing Machine	3	Quality Control
5-7	Los Angeles Abrasion testing machine	1	Quality Control
DRRD (Field Survey/Testing)			
5-8	Total Station	2	Survey/Testing
5-9	Level	1	Survey/Testing
5-10	SIT (Sonic Integrity Testing)	1	Survey/Testing
5-11	Theodolite	1	Survey/Testing
Furniture			
6-1	Experiment Table-1	27	Working and Testing
6-2	Experiment Table -2	19	Working and Testing
6-3	Experiment Table-3	38	Working and Testing
6-4	Experiment Table-4	32	Working and Testing
6-5	Experiment Table-5	21	Working and Testing
6-6	Lab Sink-1	42	Working and Testing
6-7	Lab Sink-2	21	Working and Testing

Source: JICA Study Team

CHAPTER 11 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

11.1 Project Description

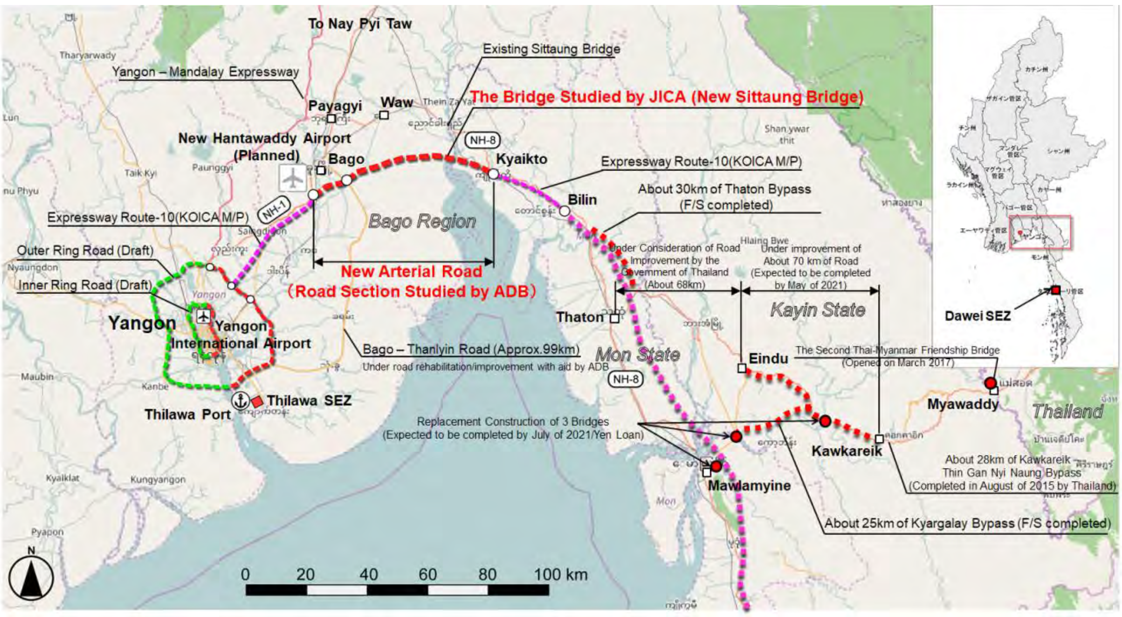
A feasibility study for construction of the New Sittaung Bridge (Approximately 2.5km including approach roads) and upgrading of the Thuwunna RLTC have been done by JICA and a feasibility study for the bypass section (Approximately 61.4km) has been done by ADB.

Table 11.1.1 Project Activities

Project Name	East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section)
Objectives	To improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to the vitalization of Myanmar's trade.
Project Summary	1.JICA Section: (1) Construction of New Sittaung Bridge (4 lanes – 2.5km), Guidebank and Revetment (2) Upgrading of Thuwunna Research Laboratory and Training Center Note) 2.ADB Section : Construction of New Expressway (4 lanes -61.4km)
Objectives of the JICA Study	Implementation of the following necessary studies for examination to be implemented as a Japanese loan project (the purpose, project cost, implementation schedule, implementation (procurement / construction) method, project implementation system, operation / maintenance system, environmental and social considerations, etc.)
Project Area	Mon State, Bago Region and Yangon Region of Myanmar
Responsible Agency	Ministry of Construction(MOC), Department of Bridge (DOB) and Department of Highways (DOH)

Note) "(2) Upgrading of Thuwunna Research Laboratory and Training Center" is classified as "Category C" in accordance with the JICA guidelines for environmental and social considerations (2010), and an environmental management plan has been prepared, since there are minimal adverse impacts on environment and society. The detailed environmental management plan is shown in Volume2 of this Report.

Source: JICA Study Team



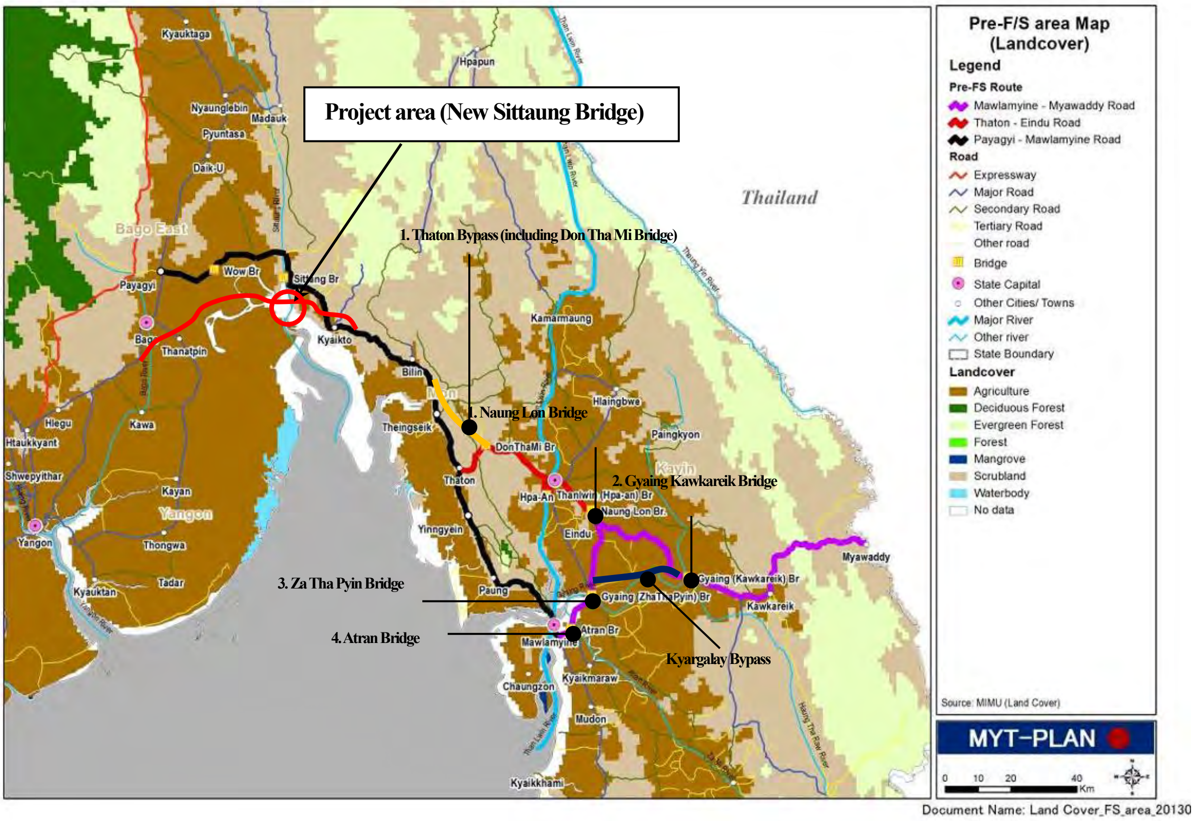
Source: JICA Study Team

Figure 11.1.1 Project Location Map

11.2 Current Natural and Social Environmental Conditions

11.2.1 Land Use

Aside from towns/villages, the bulk of land use is agricultural, such as rice fields, especially on the west bank and along the Sittaung River. A large number of rubber plantations are also developed in Kyaikto, Mon States.



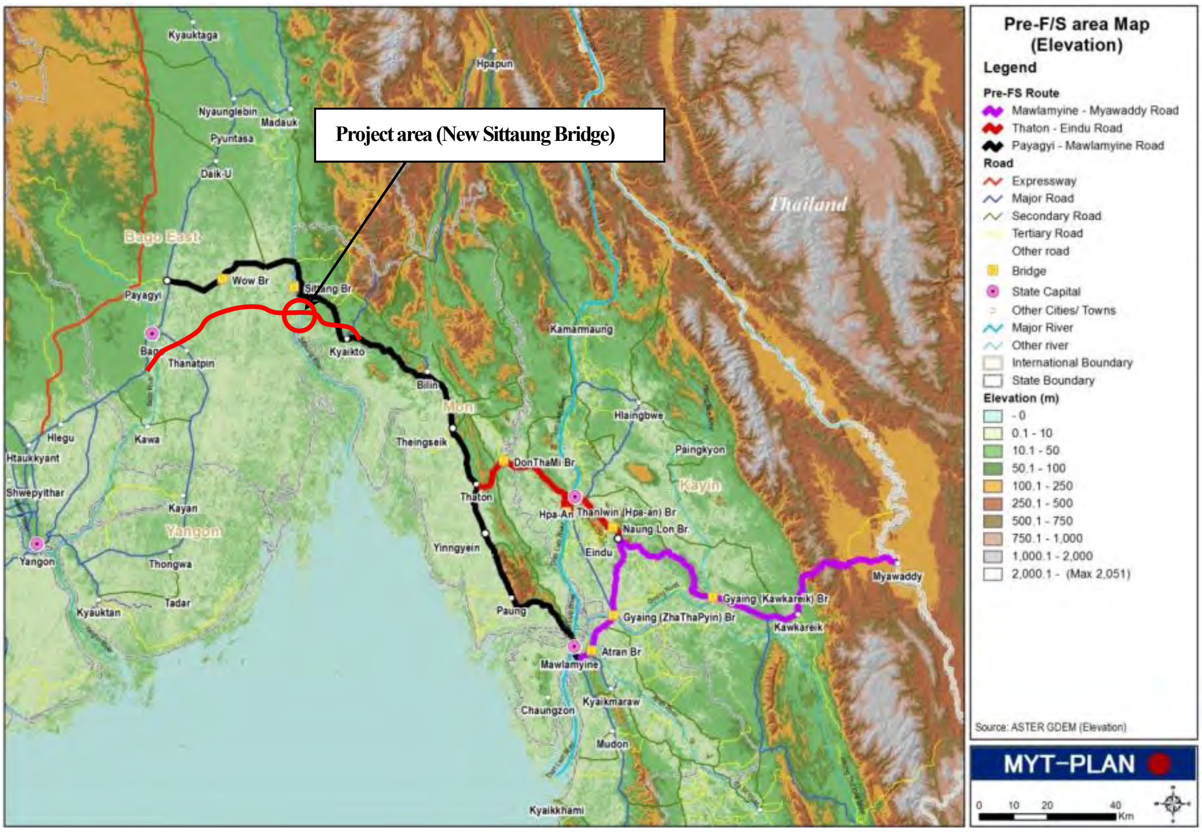
Note) ADB road section shown in red is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.

Source: MYT-Plan

Figure 11.2.1 Land Use on the East-West Economic Corridor

11.2.2 Topography and Geology

Topographical situation in the project area is shown below. The elevation in Bago Region is 0-10m and passing though only the paddy field. On the other hand, elevation varies from 0-50 m in paddy field and rubber plantation in Mon State respectively. With regard to geology in the project area, river sediment is distributed along the Sittaung River, and viscous soil and sandy soil accumulates under the river sediment.



Note) ADB road section shown in pink is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result

Figure 11.2.2 Topographical and Geological Feature in the Project Area

11.2.3 Climate

(1) Temperature

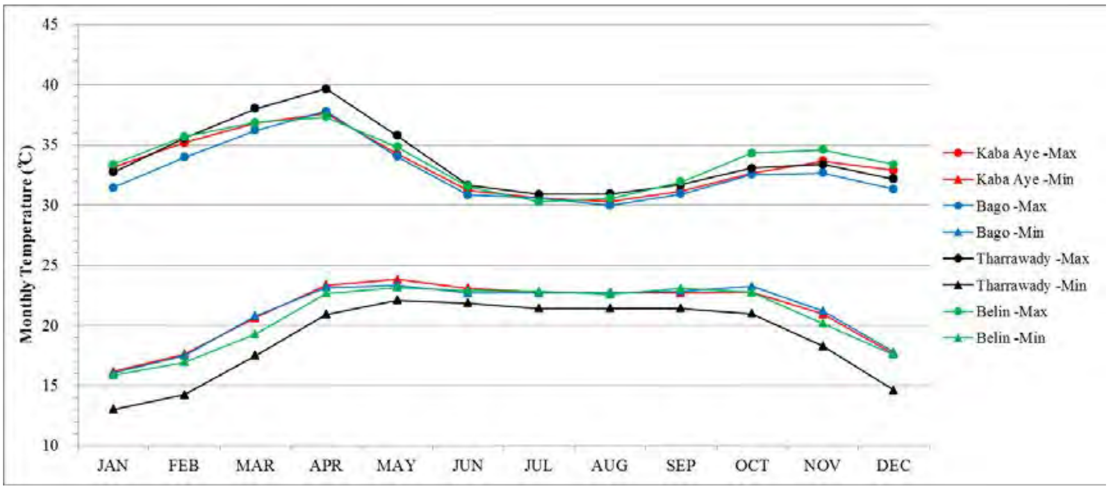
The temperature data at five stations shows almost similar trend. The monthly mean temperature at the south-eastern area in Myanmar ranges between around 24°C and 30°C. According to the collected data in this study, the mean monthly maximum temperature of 37-40°C (April) and the mean minimum temperature of 13-16°C (January) at targeted area were recorded respectively during the recent 10 years.

The mean monthly maximum and minimum temperature at related 5 stations are shown in below.

Table 11.2.1 Monthly Mean Maximum/Minimum Temperature

Station			Item	Monthly Temperature in ℃													Remarks
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average	
1	Kaba Aye	Kaba Aye -Max	Max	33.1	35.2	36.8	37.6	34.3	31.2	30.6	30.3	31.2	32.6	33.7	32.9	37.8	1991-2016
		Kaba Aye -Min	Min	16.2	17.6	20.6	23.4	23.8	23.1	22.8	22.7	22.7	22.7	21.0	17.6	15.9	1991-2016
2	Bago	Bago -Max	Max	31.4	34.0	36.2	37.8	34.0	30.8	30.6	30.0	30.9	32.5	32.7	31.3	38.1	1997-2016
		Bago -Min	Min	16.1	17.5	20.8	23.2	23.3	22.7	22.7	22.7	22.9	23.2	21.2	17.8	15.9	1997-2016
3	Tharrawady	Tharrawady -Max	Max	32.7	35.5	38.0	39.7	35.8	31.6	30.9	30.9	31.7	33.1	33.4	32.2	39.7	1997-2016
		Tharrawady -Min	Min	13.0	14.2	17.5	20.9	22.1	21.8	21.4	21.4	21.4	21.0	18.3	14.6	12.7	1997-2016
4	Shwegyin	Shwegyin -Max	Max	32.9	35.3	37.2	38.4	34.7	31.1	30.0	30.0	31.5	33.7	34.1	32.9	38.5	1997-2016
		Shwegyin -Min	Min	15.4	16.9	20.7	23.7	24.0	23.3	23.0	22.9	23.0	22.5	19.9	16.7	15.0	1997-2016
5	Belin	Belin -Max	Max	33.4	35.7	36.9	37.3	34.8	31.5	30.3	30.5	31.9	34.3	34.6	33.4	37.6	1997-2016
		Belin -Min	Min	15.8	17.0	19.3	22.7	23.1	22.9	22.8	22.6	23.0	22.8	20.2	17.6	15.4	1997-2016
Average				24.0	25.9	28.4	30.5	29.0	27.0	26.5	26.4	27.0	27.8	26.9	24.7	27.0	
Average Max.				32.7	35.1	37.0	38.1	34.7	31.3	30.6	30.4	31.4	33.1	33.6	32.4	33.4	
Average Min.				15.3	16.6	19.6	22.5	23.1	22.6	22.4	22.3	22.5	22.4	20.1	16.9	20.5	

Source: JICA Study Team, DMH (Myanmar Department of Meteorology and Hydrology)



Source: JICA Study Team, DMH (Myanmar Department of Meteorology and Hydrology)

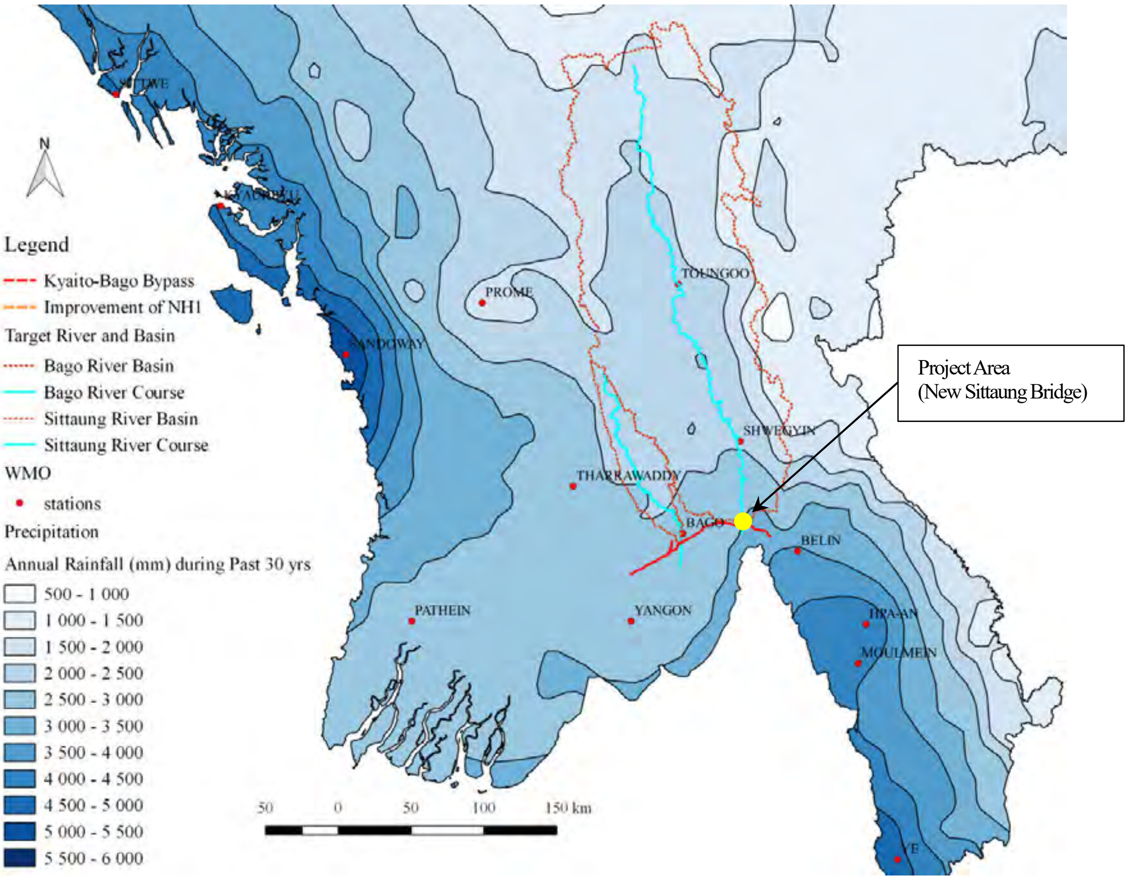
Figure 11.2.3 Monthly Mean Maximum/MinimumTemperature

(2) Rainfall

The targeted area is the area with average to abundant precipitation in Myanmar. (The areal distribution of annual rainfall which is predicted based on annual rainfalls during the past 10 year or more of observation stations in and around south-eastern Myanmar, is shown in Figure 11.2.4) The annual mean rainfall ranges from 3,481mm at Shwegyin (Madauk) to 5,695mm at Belin. Also the annual rainfall fluctuates between each station significantly. (e.g. between 2,396 and 4,633mm at Shwegyin.)

Seasonal variation of monthly mean precipitation is similar one in each station. Regarding seasonal fluctuation of rainfall, 95% or more of annual rainfall is brought by the rainy season from May to October, with the highest amount of rainfall in July or August.

The mean monthly rainfall at 8 stations is shown in Table 11.2.2 and Figure 11.2.5.



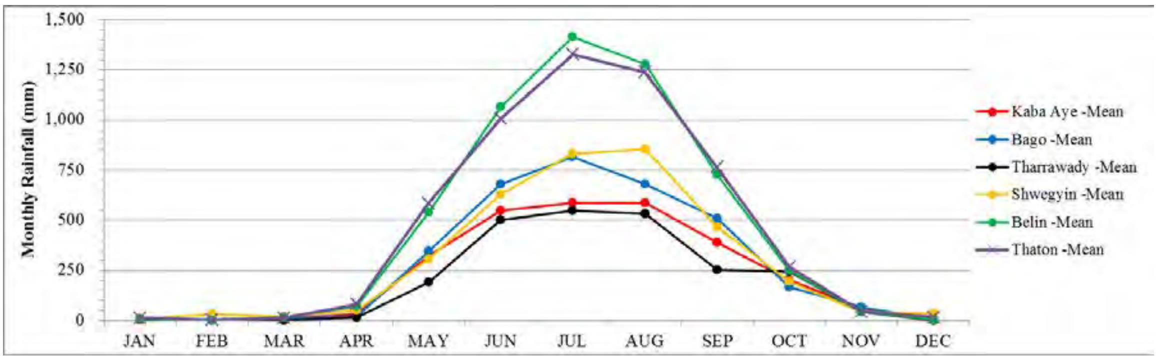
Source: JICA Study Team, Digital Agricultural Atlas (FAO, http://dwms.fao.org/atlases/myanmar/index_en.htm)

Figure 11.2.4 Areal Distribution (Isohyet) of Annual Rainfall in Southern Myanmar

Table 11.2.2 Monthly Mean Rainfall

Station			Item	Monthly Rainfall in mm													Remarks
				JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total	
1	Kaba Aye	Kaba Aye -Mean	Mean	4	3	13	32	321	550	587	587	390	201	62	6	2,756	1968-2008, 2013-16
2	Bago	Bago -Mean	Mean	5	5	14	22	346	681	818	679	509	167	65	8	3,318	1996-2005, 2013-16
3	Tharrawady	Tharrawady -Mean	Mean	3	1	0	15	191	501	549	534	253	246	43	1	2,335	2013-16
4	Shwegyin	Shwegyin -Mean	Mean	9	32	21	52	306	632	833	857	466	193	45	35	3,481	1996-2016
5	Belin	Belin -Mean	Mean	6	1	16	70	541	1,064	1,417	1,277	725	251	42	6	5,416	2004-2016
6	Thaton	Thaton -Mean	Mean	12	3	14	80	585	1,008	1,328	1,240	765	265	45	17	5,362	2004-2016
7	Myit Kyoe	Myit Kyoe -Mean	Mean					495	520	520	731	656	245	92		3,259	2008-2016
8	Shan Gyaing	Shan Gyaing -Mean	Mean	15	0	0	0	217	609	903	770	497	219	123	0	3,352	2014-16
Average				8	6	11	39	375	696	869	834	533	223	64	10	3,660	

Source: JICA Study Team, DMH, ID



Source: JICA Study Team, DMH

Figure 11.2.5 Monthly Mean Rainfall at 8 Stations

11.2.4 Air Quality

The secondary data on air quality at the nearest point in the project area is shown below. This point is similar with the project area on land use and degree of development. Air quality such as PM10, PM2.5, CO, NO2 do not exceed Myanmar Standards, IFC and Japanese Standards.

In this EIA, measured and forecasted data is compared with Myanmar Standards and/or IFC Standards in principle. However, other standards such as Japanese Standards are adopted when the standard of Myanmar and IFC does not exist for the specified item.

Table 11.2.3 Air Quality at the Nearest Point in the Project Area (Kaw Gone Village)

Item / Location	Measurement (Standards :[1]Myanmar Guideline [2]IFC Standard, [3] Japanese Standard,)				
	PM_{10} 1(50μg/m³: 24 hrs.)	$PM_{2.5}$ 1(25μg/m³: 24hrs)	CO 2(10ppm: 24hrs)	NO_2 1(200μg/m³: 1hrs)	SO_2 1(20μg/m³: 24hrs)
Kaw Gone Village	28	17	0.02	180	<100

Source: The Project for Improvement of the East – West Economic Corridor/Sub Project-1/The Project for Construction of Thaton Bypass and 3 Bridges (Don Tha Mi, Naung Lon and Gyaing Kawkareik Bridge)(2014 JICA)

Table 11.2.4 National and International Standards on Air Quality

Standard	PM_{10}	$PM_{2.5}$	CO	NO_2	SO_2
National Environmental Quality (Emission) Guidelines	50μg/m³ (24hrs)	25μg/m³ (24hrs)	-	200μg/m³ (1 hr)	20 μg/m³ (24hrs)
IFC (International Finance Corporation)	150 μg/m³ (24hrs)	75 μg/m³ (24hrs)	-	200 μg/m³ (1hr)	20 μg/m³ (24hrs)
Japanese Standards	SPM 0.10 mg/m3 (24hrs) (converted value 100 μg/m3)	-	10ppm (24hrs)	0.04-0.06ppm Converted value (75.26-110μg/m³) (24hrs)	0.04ppm Converted value (100μg/m³) (24hrs)

Source: National Environmental Quality Guidelines (Myanmar 2015), IFC Standards (Environmental, Health, and Safety (EHS) Guidelines 2007), Japanese Standards (Environmental Quality Standards in Japan - Air Quality 1973)

Source: Based on Google Earth and The Project for Improvement of the East – West Economic Corridor/Sub Project-1/The Project for Construction of Thaton Bypass and 3 Bridges (Don Tha Mi, Naung Lon and Gyaing Kawkareik Bridge)(2014 JICA)

Figure 11.2.6 Air and Water Quality Survey Point (Secondary Data in 2014)

11.2.5 Water Quality

The secondary data on water quality at the nearest point in the project area is shown below. This point is located on the branch river of the Sittaung as shown in Figure 11.2.6. Myanmar and IFC do not have any standards on river water quality. Thus, the Japanese standard for river water quality is adopted in this case. The survey results do not satisfy Japanese Standards except for the SS value.

Table 11.2.5 Water Quality at the Nearest Point in the Project Area (Kyone Eite Chaung River)

Item Location	Condition	Measured values (Standard Value : IFC Standard)				
		pH (6-9)	BOD (30 mg/l)	SS (50 mg/l)	EC (No standard)	Temp (No standard)
Kyone Eite Chaung River	River	5.47	10	7.5	25	27.8

Source: The Project for Improvement of the East – West Economic Corridor/Sub Project-1/The Project for Construction of Thaton Bypass and 3 Bridges (Don Tha Mi, Naung Lon and Gyaing Kawkareik Bridge)(2014 JICA) (Measured on 9th of September, 2014)

Table 11.2.6 National and International Standards on River Water Quality

No	Parameters	Unit	Japanese Standards (category B)
1	pH-value	pH	6.5-8.5
2	COD	-	-
3	BOD	-	3mg/l
4	Suspended Solids	mg/l	25 mg/l
5	Turbidity	NTU	-
6	Coliform	No/100ml	5,000 MPN/100ml

Source: Japanese Standards (Environmental Standard for Water, Ministry of Environment 1997)

11.2.6 Natural Protected Areas

Any law-based natural protected areas are not observed in the project area as shown in Figure 11.2.7.

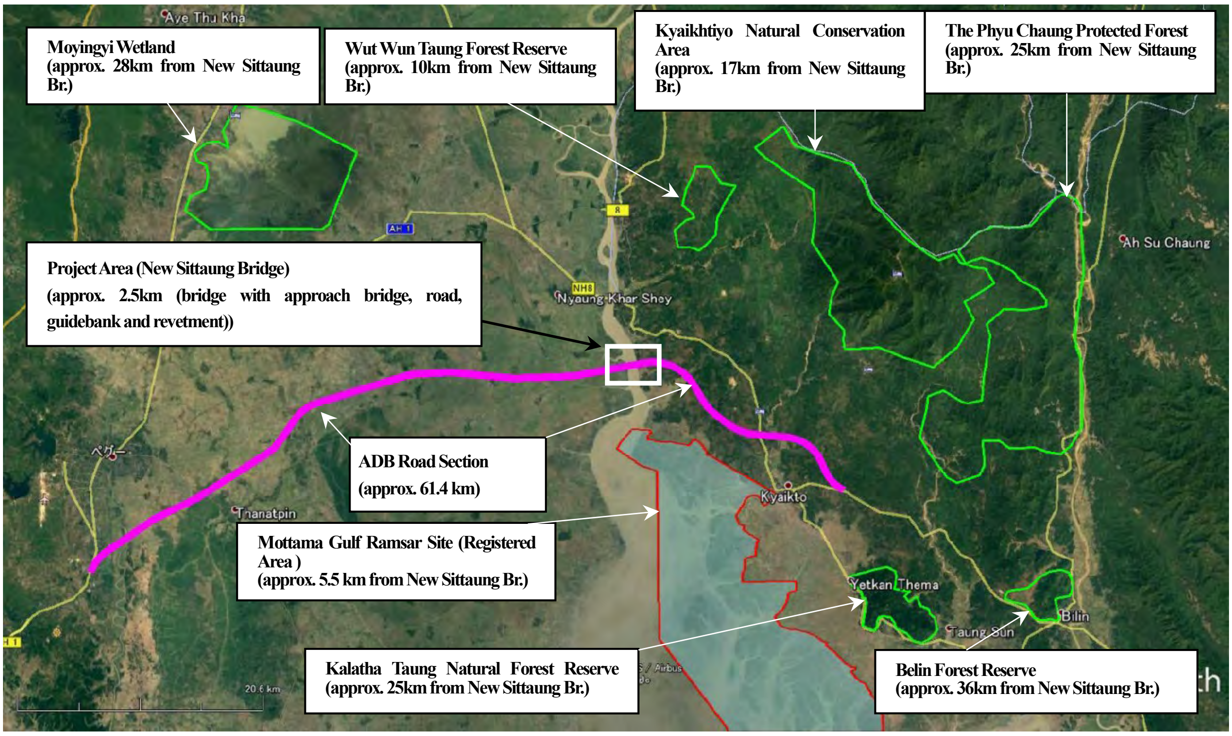
However, since the potential management area and registered Ramsar Site named Gulf of Mottama are located approximately 3.6 km and 5.5km away from planned bridge location, respectively, it is expected the project does not give serious impacts. However, the degree of adverse impacts on natural environment is analyzed based on site surveys and interview with wildlife specialists.

Table 11.2.7 Natural Protected Area and Features

Name of Protected Area (Distance from the Site to Project Area)	Basic Information	Main Purpose and Feature(Confirmed Recorded Considerable Species)
Moyingyi Wetland (approx. 28km)	Year Established : 2014 Area: 10,360 ha Relevant Law: -Forest Law (1992) -Wildlife Conservation Law (1994) -RAMSAR Convention	To protect seasonal migratory birds and conserve wetland ecosystem (migratory birds and resident bird species) Key Resources (133 bird species with a population of 1,8364 recorded which include 1 Vulnerable (VU) and 4 Near Threatened (NT): Source: BANCA (2014)
Wut Wun Taung Forest Reserve (approx. 10km)	Year Established : 1907 Area: 1,502 ha Relevant Law: Forest Law (1992) -Wildlife Conservation Law (1994)	To ensure sustainable development of forest resources for social environment and economic purposes. Conservation and management of teak and other valuable hardwood species, such as Pyinkado on a sustainable basis
Kyaikhtiyo Natural Conservation Area (approx. 17km)	Year Established : 1998 Area: 15,600 ha Relevant Law: Forest Law (1992) Wildlife Conservation Law (1994)	To protect wildlife species such as leopard, serow, red goral and tiger.
The Phyu Chaung Protected Forest (approx. 25km)	Year Established : 1884 Area: 28,617 ha Relevant Law: - Forest Law (1992) -Wildlife Conservation Law (1994)	To ensure sustainable development of forest resources for social environment and economic purposes Conservation and management of teak and other valuable hardwood species such as Pyinkado on a sustainable basis

Name of Protected Area (Distance from the Site to Project Area)	Basic Information	Main Purpose and Feature(Confirmed Recorded Considerable Species)
Kalatha Taung Natural Forest Reserve (approx. 25km)	Year Established : 1947/2016 Area: 2393 ha Relevant Law: -Forest Law (1992) -Wildlife Conservation Law (1994)	To protect wildlife species such as monkeys, wild cats, pangolin and barking deer.
Belin Forest Reserve (approx. 36km)	Year Established : 1908 Area: 208 ha Relevant Law: -Forest Law (1992) -Wildlife Conservation Law (1994)	To ensure sustainable development of forest resources for social environment and economic purposes Conservation and management of teak and other valuable hardwood species such as Pyinkado on a sustainable basis
Gulf of Mottama Ramsar Site (approx. 5.5km/ Registered area)	Year Established : 10th of May, 2017 Area: approx. 42,500 ha Relevant Law: Ramsar Convention	To protect seasonal migratory birds and conserve wetland ecosystem (resident migratory birds and resident bird species) Key Resources: (a population of 195,848 recorded which include 1 Critically Endangered (CR spoon-billed sandpiper), 1 Endangered (EN), 1 Vulnerable (VU) and 9 Near Threatened (NT) as well as Waders , Gulls and Terns and other water bird species. Source: BANCA (2017)

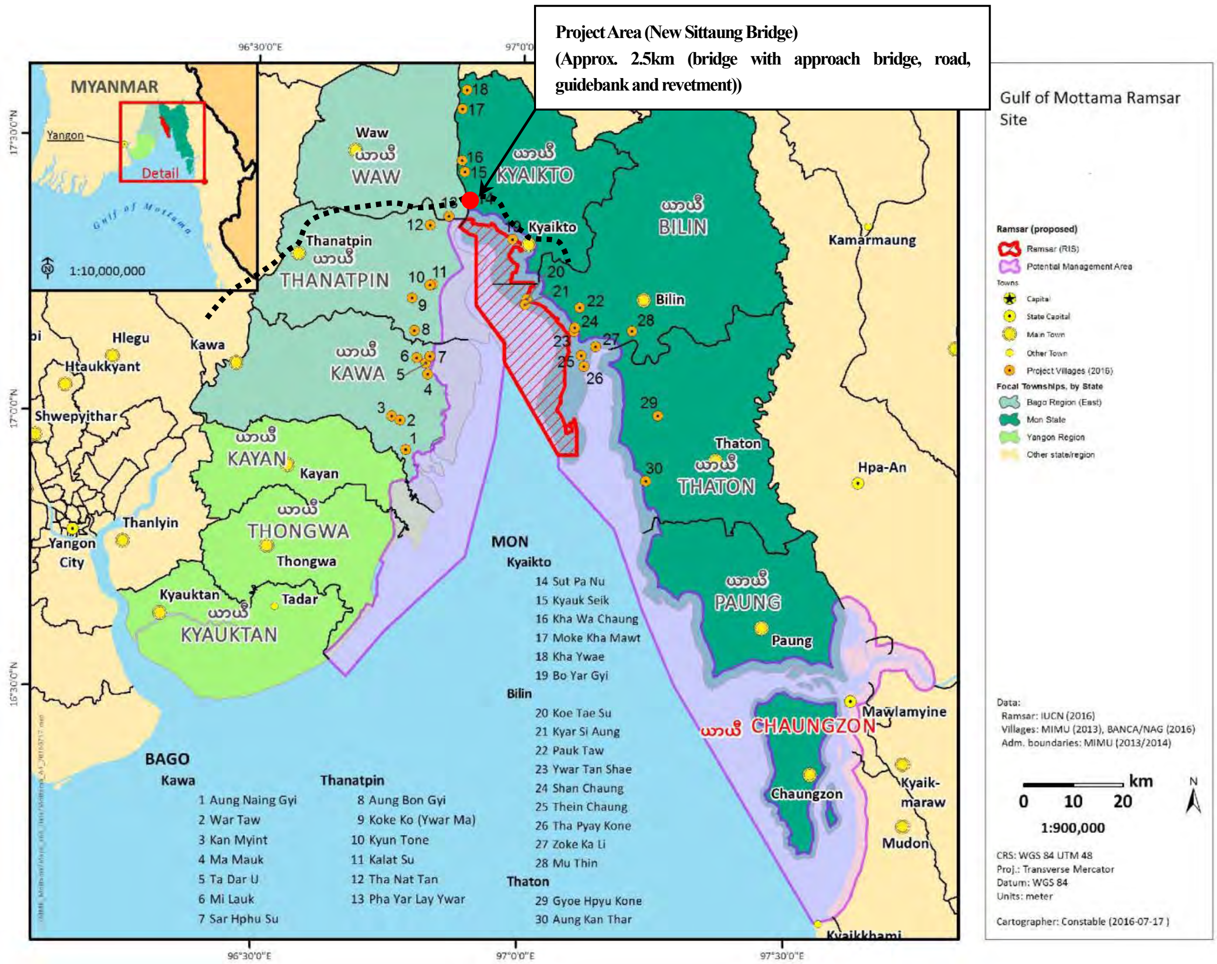
Source: JICA Study Team



Note) ADB road section shown in pink is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.

Source: JICA Study Team based on Google Earth satellite map (original source : Land Records 1944/Forest Department and. Ramsar Site (No.2299))

Figure 11.2.7 Natural Protected Area Map in the Project Area and Distance from the Project Area



Source: Myanmar Designates the Gulf of Mottama as a Ramsar Site (https://www.ramsar.org/news/myanmar-designates-the-gulf-of-mottama-as-a-ramsar-site)

Figure 11.2.8 Locations of Registered Gulf of Mottama Ramsar Site and Potential Management Area

Table 11.2.8 Major Observed Birds Species in Mottama Gulf Ramsar Site

Phylum	Scientific name	Common name	IUCN Red List	Remarks
AVES	Calidris ferruginea	Curlew Sandpiper	NT	Non-breeding
AVES	Calidris minuta	Little Stint	LC	Non-breeding
AVES	Calidris ruficollis	Red-necked Stint	NT	Non-breeding
AVES	Charadrius alexandrinus	Kentish Plover; Snowy Plover	LC	Non-breeding
AVES	Charadrius mongolus	Lesser Sand Plover; Lesser Sand-Plover	LC	Non-breeding
AVES	Chlidonias leucopterus	White-winged Tern	LC	Non-breeding
AVES	Eurynorhynchus pygmeus	Spoon-billed Sandpiper	CR	The global population estimates of the Critically Endangered Spoon-billed Sandpiper Calidris pygmaeus have been revised downwards several times, owing to the rapid decline of the species. There are now (2014) believed to be 450-500 birds remaining in the wild, including a breeding cohort of 120 pairs (Zöckler et al. 2016). The importance of the Ramsar site as a wintering area has been appreciated only in recent years, and even over this period its proportional importance and critical nature for this bird has been reassessed as even greater than originally thought. Myanmar as a whole hosts more than half of the world population at only two sites, of which the Ramsar site has the majority,
AVES	Limicola falcinellus	Broad-billed Sandpiper		Non-breeding
AVES	Limosa limosa	Black-tailed Godwit	NT	SE Asia Local migrant, breeding in region
AVES	Mycteria leucocephala	Painted Stork	NT	Non-breeding
AVES	Pluvialis fulva	Pacific GoldenPlover; Pacific Golden-Plover	LC	Non-breeding
AVES	Threskiornis melanocephalus	Black-headed Ibis	NT	Non-breeding
AVES	Tringa totanus	Common Redshank	LC	Non-breeding

Source: 3.3 - Animal species whose presence relates to the international importance of the site/ Ramsar Information Sheet, Designation date 24 January 2017, Site number 2299, Coordinates 17°08'55"N 97°00'11"E, Area 42 500,00 ha, Myanmar Gulf of Mottama, https://rsis.ramsar.org/ris/2299, Created by RSIS V.1.6 on - 7 May 2017

11.2.7 Natural Habitat Areas

The gulf of Mottama Important Bird Area (IBA) and Key Biodiversity Area (KBA) are located in the project area as shown in Figure 11.2.9. A detailed map indicating the relationship between the bridge and IBA/KBA and the feature is shown in Table 11.2.9 and Figure 11.2.10. IBA and KBA are not law-based conservation area. However, impacts on biodiversity are analyzed in this ESIA.

Table 11.2.9 Outline of Mottama Gulf IBA/KAB

Habitat Name	Basic Information	Impact	Selection Criteria for IBA/KBA
Gulf of Mottama Important Birds Area (IBA) / Key Biodiversity Area (KBA)	Year Established: 2013 Area: approx. 110,000 ha Category: A1, A4	Project area occupies approx. 25ha in IBA/KBA	Categories are indicated as follows: A1: Globally threatened species Criterion: The site is known or believed to regularly hold significant numbers of globally threatened species. A4: Congregations Criterion: The site is known or believed to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.

Source: IBA: Birdlife International Website (http://datazone.birdlife.org/site/factsheet/gulf-of-mottama-iba-myanmar)

Table 11.2.10 Trigger Species in Mottama Gulf IBA/KBA

Species	Current IUCN Red List Category	Season	Year(s) of estimate	Population estimate	IBA Criteria Triggered
Painted Stork Mycteria leucocephala	NT	resident	2008-2012	140 individuals	A4i
Black-headed Ibis Threskiornis melanocephalus	NT	resident	2008-2012	150-300 individuals	A4i
Charadrius alexandrinus	NR	non-breeding	2008-2012	10,000-20,000 individuals	A4i
Pacific Golden Plover Pluvialis fulva	LC	non-breeding	2008-2012	8,000-10,000 individuals	A4i
Lesser Sandplover Charadrius mongolus	LC	non-breeding	2008-2012	20,000-40,000 individuals	A4i
Eurasian Curlew Numenius arquata	NT	non-breeding	2008-2012	2,200-4,000 individuals	A4i
Black-tailed Godwit Limosa limosa	NT	non-breeding	2008-2012	3,500-5,000 individuals	A4i
Great Knot Calidris tenuirostris	EN	non-breeding	2009	456 individuals	A1
Broad-billed Sandpiper Calidris falcinellus	LC	non-breeding	2008-2012	4,000-5,000 individuals	A4i
Curlew Sandpiper Calidris ferruginea	NT	non-breeding	2008-2012	7,000-12,000 individuals	A4i
Spoon-billed Sandpiper Calidris pygmaea	CR	non-breeding	2010	74-180 individuals	A1, A4i
Red-necked Stint Calidris ruficollis	NT	non-breeding	2008-2012	7,000-12,000 individuals	A4i
Spotted Redshank Tringa erythropus	LC	non-breeding	2008-2012	1,400-2,000 individuals	A4i
Common Greenshank Tringa nebularia	LC	non-breeding	2008-2012	1,800-3,500 individuals	A4i
Common Redshank Tringa totanus	LC	non-breeding	2008-2012	4,500-8,000 individuals	A4i
Spotted Greenshank Tringa guttifer	EN	non-breeding	2009-2011	117 individuals	A1, A4i

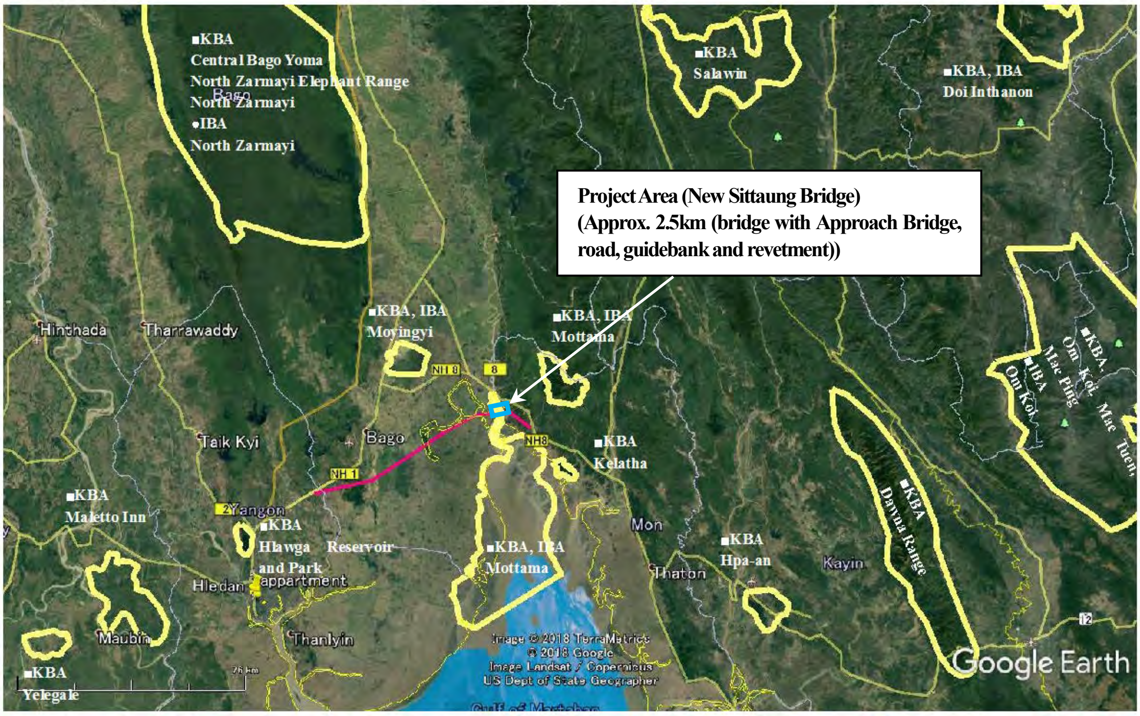
A1. Globally threatened species
Criterion: The site is known or thought regularly to hold significant numbers of a globally threatened species.
Notes: The site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable. In general, the regular presence of a Critical or Endangered species, irrespective of population size, at a site may be sufficient for a site to qualify as an IBA. For Vulnerable species, the presence of more than threshold numbers at a site is necessary to trigger selection.

A2. Restricted-range species
Criterion: The site is known or thought to hold a significant component of a group of species whose breeding distributions define an Endemic Bird Area (EBA) or Secondary Area (SA).
Notes: This category is for species of Endemic Bird Areas (EBAs). EBAs are defined as places where two or more species of restricted range, i.e. with world distributions of less than 50,000 km2, occur together. More than 70% of such species are also globally threatened. Also included here are species of Secondary Areas. A Secondary Area (SA) supports one or more restricted-range species, but does not qualify as an EBA because less than two species are entirely confined to it. Typical SAs include single restricted-range species which do not overlap in distribution with any other such species, and places where there are widely disjunct records of one or more restricted-range species, which are clearly geographically separate from any of the EBAs.

A3. Biome-restricted species
Criterion: The site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome.
Notes: This category applies to groups of species with largely shared distributions which occur mostly or wholly within all or part of a particular biome and are, therefore, of global importance. As with EBAs, it is necessary that a network of sites be chosen to protect adequately all species confined to each biome and, as necessary, in each range state in which the biome occurs. The 'significant component' term in the Criterion is intended to avoid selecting sites solely on the presence of one or more biome-restricted species that are common and adaptable within the EBA and, therefore, occur at other chosen sites. Additional sites may, however, be chosen for the presence of one or a few species which would, e.g. for reasons of particular habitat requirements, be otherwise under-represented.

A4. Congregations
Criterion: The site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.
Notes: This criterion can be applied to seasonal (breeding, wintering or migratory) congregations of any waterbird, seabird or terrestrial bird species. Sites can qualify whether thresholds are exceeded simultaneously or cumulatively, within a limited period. In this way, the criterion covers situations where a rapid turnover of birds takes place (including, for example, for migratory landbirds).

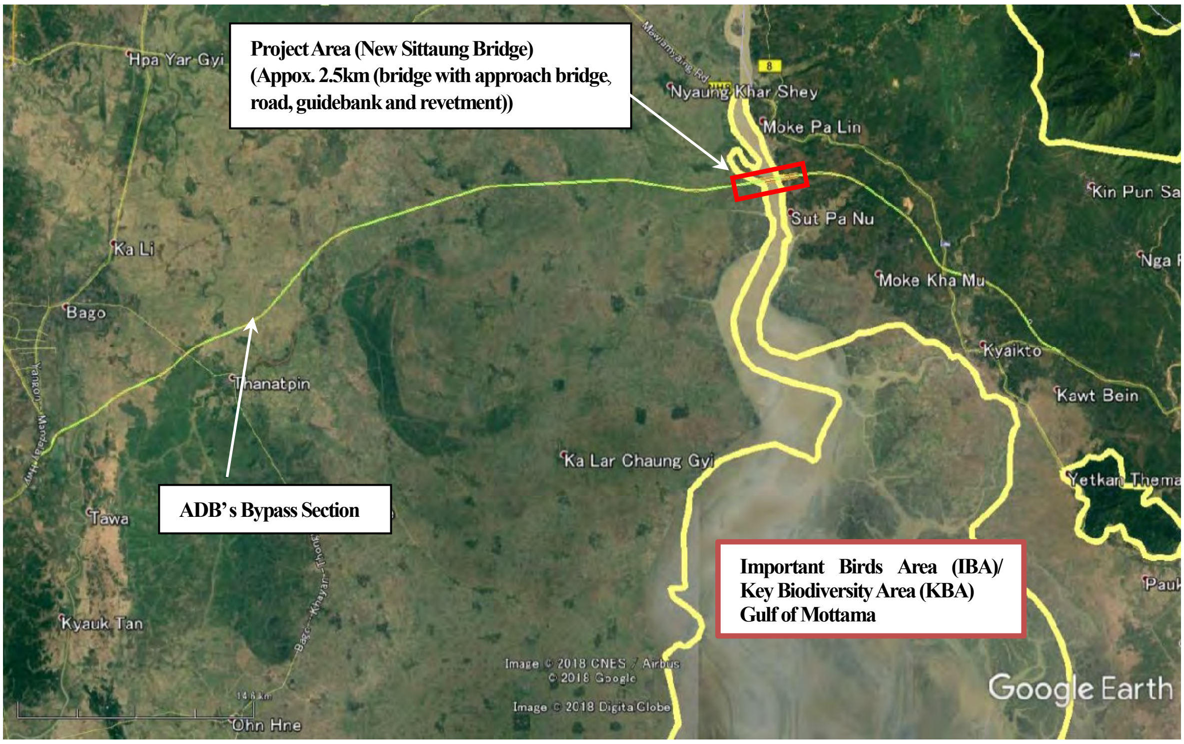
Source: IBA: Birdlife International Website (http://datazone.birdlife.org/site/factsheet/gulf-of-mottama-iba-myanmar/details)



Note) ADB road section shown in pink is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.

Source: JICA Study Team based on Google Earth satellite map (IBAT Website (https://www.ibat-alliance.org/ibat-conservation/mapviewerol213))

Figure 11.2.9 IBA and KBA Location Map near Project Area



Note) ADB road section shown in pink is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.

Source: JICA Study Team based on Google Earth satellite map
(IBAT Website (https://www.ibat-alliance.org/ibat-conservation/mapviewerol213))

Figure 11.2.10 Natural Habitat in the Project Area (IBA/KBA)

11.2.8 Cultural Heritage

No registered considerable cultural heritage sites are observed in the planned bridge location. However, a well-known ancient city named Kyaik Ka Thar is located approximately 4.5km away from the bridge location. This city is not registered on designated cultural heritage, but, the city is well known in Mon State.

Note) ADB road section shown in pink is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.

Source: JICA Study Team based on Google Earth satellite map

Figure 11.2.11 Major Cultural Heritage Site (Kyaik Ka Thar)

11.2.9 Socio Economy

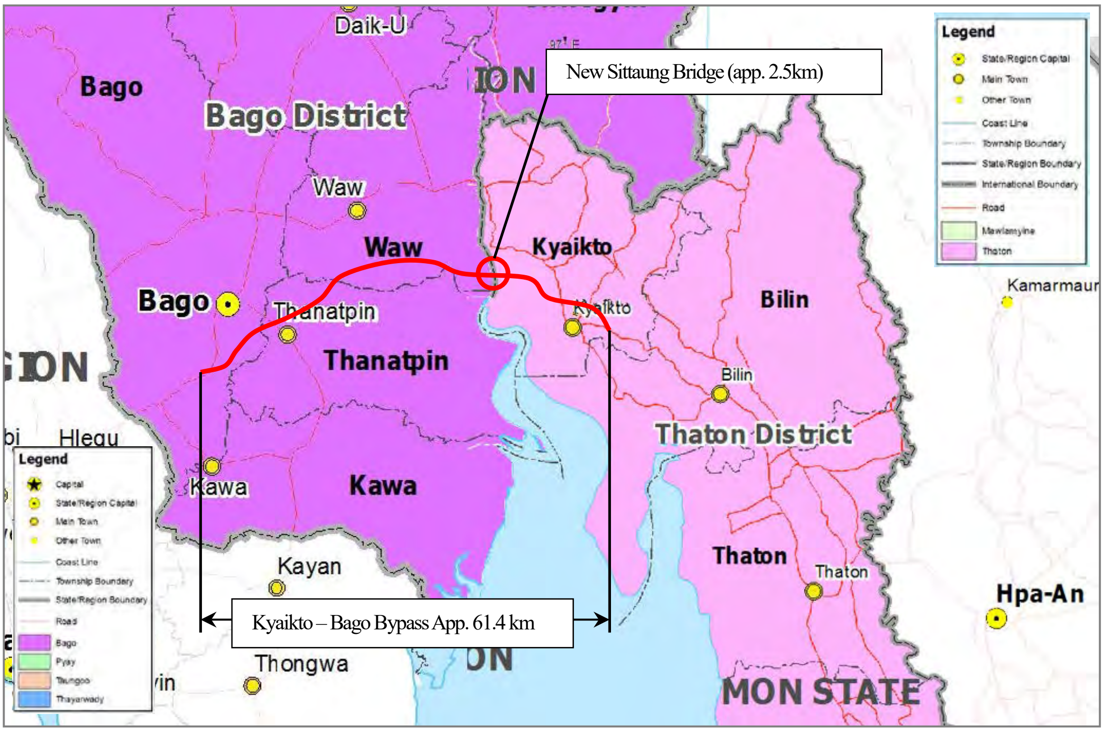
(1) Population

The socio-economic characteristics of the Project Area are shown below. The population is 2,054,000 in Mon State and 4,867,000 in Bago Region, totaling 13.4% of Myanmar's population.

Table 11.2.11 Socio-Economic Situation in the Project Area

Item	Year	State	Value	Remarks
Area (km^2)	2015	Mon State	12,297	Total in Myanmar: 676,577
		Bago Region	39,404	
Population (Persons x 1,000)	2014	Mon State	2,054	Total in Myanmar : 51,486
		Bago Region	4,867	
Population Density (Persons/km^2)	2014	Mon State	167	National Average : 76
		Bago Region	124	

Source: 2015 Myanmar Statistical Yearbook/ Central Statistical Organization, Ministry of National Planning and Economic Development



Note) ADB road section is tentative because it is under study by ADB as of August 2018. The alignment will be changed in accordance with the ADB study result.
Source: JICA Study Team based on Myanmar Information Management Unit

Figure 11.2.12 Administration Map in the Project Area

(2) Education and Literacy

The education system in Myanmar is comprised of five-year, four-year and two-year systems which are one to five grades for primary school, six to nine grades for middle school and ten to eleven grades for high school. The literacy rate of adults in Myanmar is at 92.7%. The literacy rate of women compared to men is also at high level which is 94% for women while the rate for men is set at 100%. The number of primary schools, middle schools and high schools in Bago Region and Mon State where the project area is located are shown in the table below.

Table 11.2.12 Number of Schools and Students in the Project Area

Item / Area	Number of Schools				Number of Students				Number of Student/ School			
	Primary	Middle	High	Total	Primary	Middle	High	Total	Primary	Middle	High	Total
Myanmar	38,017	2,625	1,924	42,566	5,079,135	2,736,252	840,706	8,656,093	133.6	1042.4	437.0	203.4
Bago Region	4,129	253	187	4,569	501,165	268,950	81,268	851,383	121.4	1063.0	434.6	186.3
Mon State	1,239	107	90	1,436	223,371	112,724	33,974	370,069	180.3	1053.5	377.5	257.7

Source: Myanmar Statistical Yearbook/Central Statistical Organization, Ministry of National Planning and Economic Development 2016

(3) Health and Sanitation

In Myanmar, major diseases are diarrhea, gastroenteritis, viral infection, head injury, etc., and the major cause of mortality are septicemia, disorders related to short gestation and low birth weight, human immunodeficiency virus (HIV) disease, etc.

As shown in the table below, the number of hospitals and dispensaries in each region are 33 hospitals and 20 dispensaries in Mon State and 96 hospitals and 44 dispensaries in Bago Region, respectively.

Table 11.2.13 Infectious Diseases and Cause of Deaths in the Project Area

	Infection Disease	Rate (%)	Cause of Death	Rate (%)
1	Diarrhea / gastroenteritis	6%	Sepsis	8%
2	Viral Infection	4%	Disorders related to short gestation and low birth weight	6%
3	Head Injury	4%	Human immunodeficiency virus [HIV] disease resulting in infectious and parasitic diseases	4%
4	Gastritis / Duodenitis	3%	Birth asphyxia	4%
5	Cataract	2%	Other and unspecified head injuries	3%

Source: Myanmar Statistical Yearbook/Central Statistical Organization, Ministry of National Planning and Economic Development 2016

Table 11.2.14 Number of Hospitals in the Project Area

Area	Number of Hospital	Number of Clinic※1	Number of Bed	Population per Hospital or Clinic (Person)	Population per bed (Person)
Myanmar	975	576	44,133	33,195	1,167
Mon State	33	20	1,077	38,755	1,907
Bago Region	96	44	2,706	34,764	1,799

Note) Base on survey in 2013-2014
Source: Myanmar Statistical Yearbook/Central Statistical Organization, Ministry of National Planning and Economic Development 2016

(4) Employment, Income and Poverty

The GDP per capita (2014 - 2015) in Myanmar is 1,254,582 kyat. (1 USD = 1,410 Kyat (Sep., 2018))

The average monthly household expenditure is 167,434 kyat in Myanmar, 170,223 kyat in Mon State and 160,330 kyat in Bago Region respectively.

The poverty line is 39,090 kyat per capita per month in Myanmar. On the contrary, Poverty line is 28,758 kyat in Mon State and 32,315 kyat in Bago Region.

The status of employment is shown in Table 11.2.16 below. The labor force participation rate in Mon State is 55.53% and 67.97% in Bago State. The unemployment rate is 1.1% in Mon State and 1.0% in Bago Region. Employment to population ratio is 64.2% in Mon State and 67.3% in Bago Region.

Table 11.2.15 Average Expenditure and Poverty Line in the Project Area

Item	Year	State/Region	Value	Remarks
Average Expenditure (kyat/month)	2012	Mon State	170,223	Average in Myanmar : 167,434
		Bago Region	160,330	
Poverty line Note-1) (kyat/month)	2013/ 2017	Mon State	28,758	Average in Myanmar : 39,090
		Bago Region	32,315	

Note-1) State/ Regional information is referring to "A regional perspective on poverty in Myanmar / UNDP 2013
Country information is referring to "An analysis of poverty in Myanmar / World Bank. 2017"
Note-2) 1 USD = 1,410 Kyat (September, 2018)
Source: 2015 Myanmar Statistical Yearbook/Central Statistical Organization, Ministry of National Planning and Economic Development

Table 11.2.16 Employment in the Project Area

Area	Labor force ratio (%) (16 years – 65 years)			Unemployment rate (%)			Employment rate to population (%) (16 years – 65 years)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Myanmar	64.71	80.20	51.60	0.8	0.7	0.9	64.2	79.7	51.1
Mon State	55.53	74.60	39.89	1.1	1.1	1.3	54.9	73.8	39.4
Bago Region	67.97	82.01	56.19	1.0	0.9	1.1	67.3	81.2	55.6

Source: Myanmar Statistical Yearbook/Central Statistical Organization, Ministry of National Planning and Economic Development 2016

11.3 Environmental and Social Legislation in Myanmar

11.3.1 Laws and Regulations Regarding Environmental and Social Impact Assessment

(1) Environmental Policy, Strategy and Legal Framework

A legal system with regard to the environment is established in Myanmar. The Environmental Conservation Law, a core law to protect and enhance the environmental viability in Myanmar, was issued in March 2012. The Ministry of Natural Resources and Environmental Conservation (hereinafter referred to as "MONREC") has promulgated the Environmental Conservation Rules in 2014, and Environmental Impact Assessment (EIA) Procedures and environmental quality standards were issued in 2015.

(2) Environmental Management Legislation

1) Environmental Conservation Law

The principal law governing environmental management in Myanmar is the Environmental Conservation Law, which was issued in March 2012. The law stipulates which government bodies are in charge of environmental conservation as well as their relevant roles and responsibilities. It touches on water, noise, vibration and solid waste qualities, but does not provide specific standards to be met. It also mentions both environmental and social impact assessments. In the context of project development, it is important to note that the law adopts the notion of 'polluter/beneficiary pays principle' as it implies that the project promoters are responsible for covering all environmental and social costs generated by the project. The law serves as the basis for founding the Environmental Conservation Department (ECD) under MONREC. Following the Environmental Conservation Law are two legal arrangements such as Environmental Conservation Rules; and EIA Procedures.

2) Environmental Conservation Rules

The Environmental Conservation Rules was promulgated in 2014 and provides a platform to bridge the Environmental Conservation Law with more specific and practical rules and guidelines including EIA Procedures and environmental quality standards.

3) EIA Procedures 2015

Concrete steps for undertaking EIA are stipulated in the EIA Procedures. The EIA process on the laws is as follows:

a) All development projects in Myanmar are subject to an environmental screening process through which projects will be judged to determine if they require any environmental review and, if so, at which level (i.e. IEE or EIA).

b) EIA includes an environmental management plan and a social impact assessment report.

c) Public participation is required, when deemed necessary, for the Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA), and preparation of an Environmental Management Plan (EMP).

d) The project's executing agency forms an EIA Review Committee, which gives recommendations to the Minister of MONREC from an environmental point of view on whether to approve the EIA reports or not. The Minister makes the final decision based on this recommendation. The review period is 60 days for IEE and 90 days for EIA.

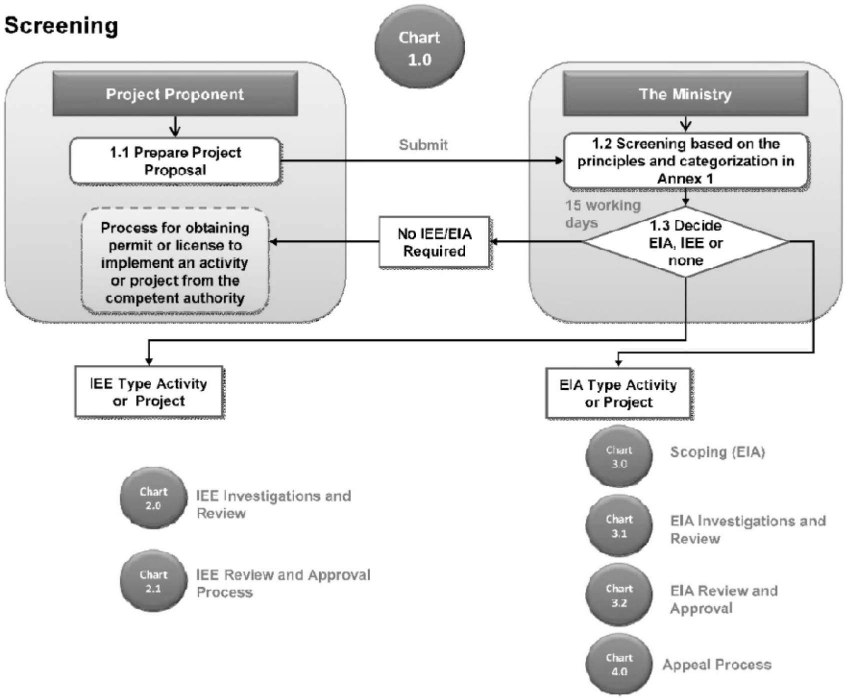
e) Members of the EIA Review Committee will be selected by the Minister of MONREC and will include persons from the industry, academia and civil society, as well as government officials.

f) Involuntary resettlement is carried out under the responsibility of respective regional governments and hence will not be included in the EIA Procedures.

g) Costs involved in conducting EIA are to be covered by the project proponent.

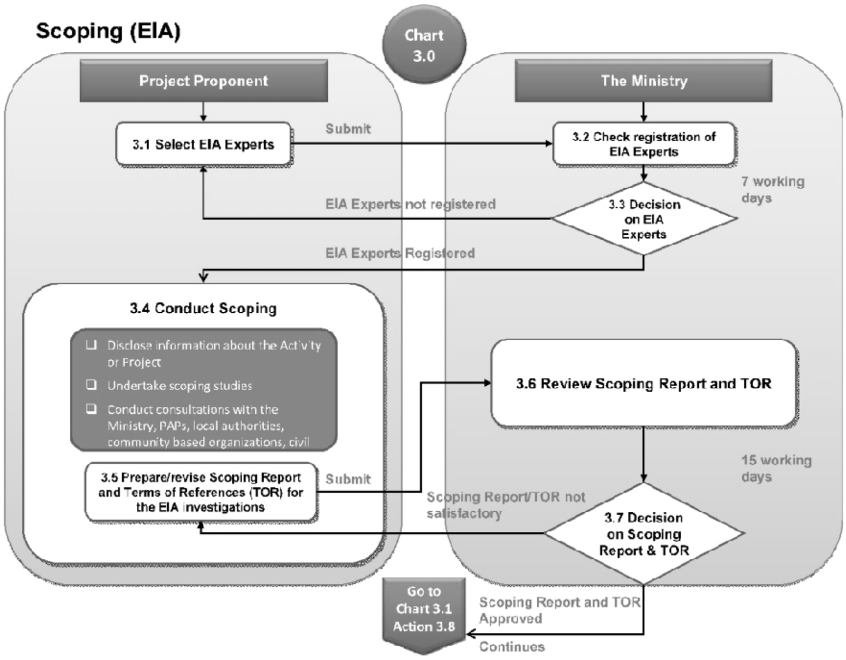
h) EIA can be carried out in Myanmar only by firms that are registered under ECD/MONREC.

The EIA approval process is shown below.



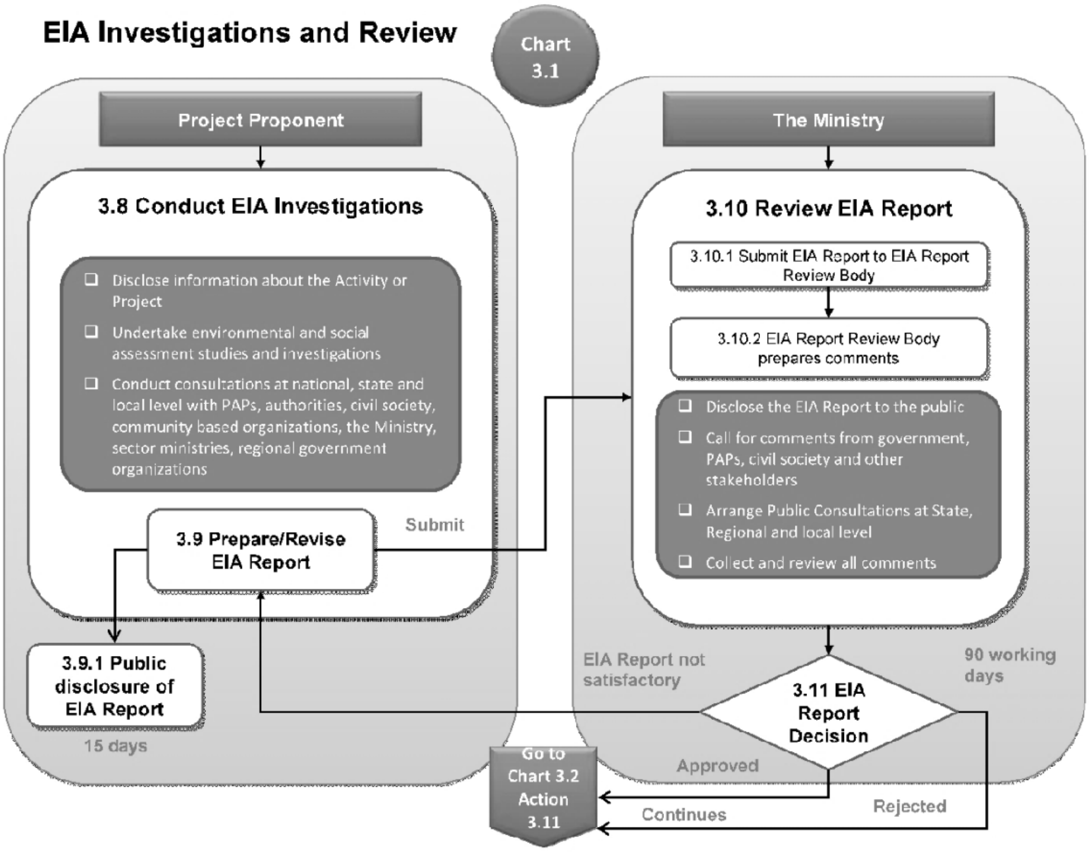
Source: EIA Procedure Law 2015 ANNEX 2 Environmental Assessment Procedure Flowchart

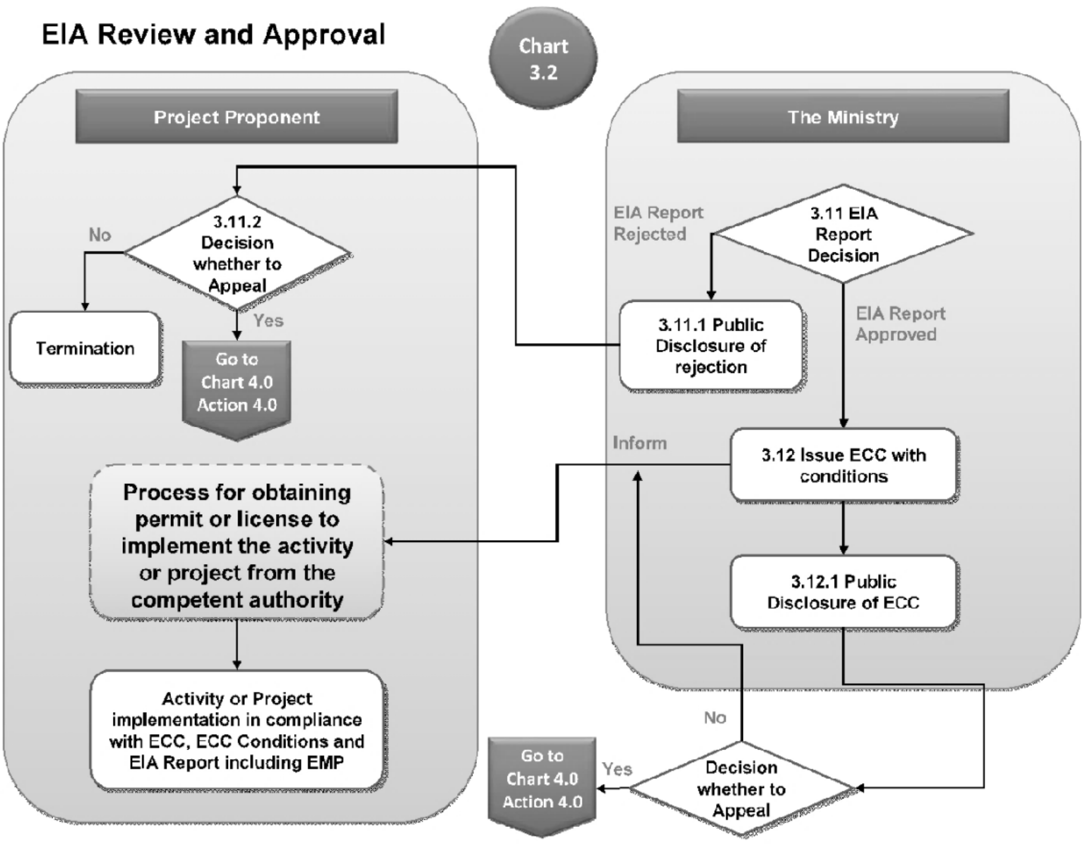
Figure 11.3.1 EIA Process-1 (screening)



Source: EIA Procedure Law 2015 ANNEX 2 Environmental Assessment Procedure Flowchart

Figure 11.3.2 EIA Process-2 (Scoping)





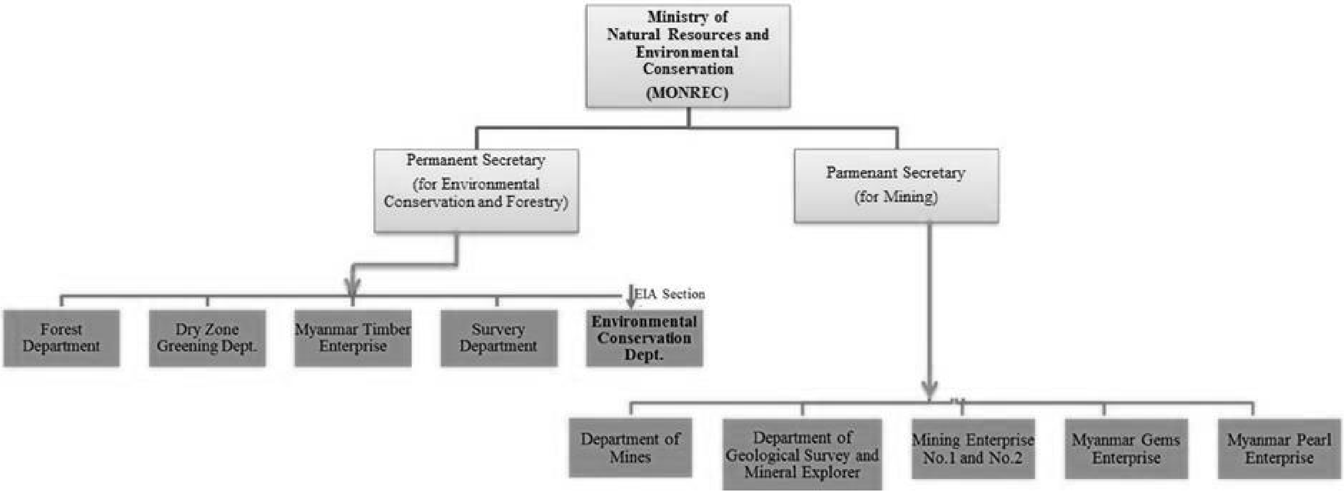
Source: EIA Procedure Law 2015 ANNEX 2 Environmental Assessment Procedure Flowchart

Figure 11.3.3 EIA Process-3 (Approval)

4) Environmental Authorizing Organization

The government body with primary responsibility for ensuring and promoting soundness of the environment in Myanmar is the Ministry of Natural Resources and Environmental Conservation (MONREC).

The Environmental Conservation Department is the department responsible for managing the EIA (Environmental Impact Assessment) process as shown in Figure 11.3.4.



Source: JICA Study Team

Figure 11.3.4 Organization Chart of MONREC

(3) Environmental Screening of the Project

1) Screening on EIA Procedure 2015

According to EIA Procedure Law 2015 as shown in Table 11.3.1, the project for the new construction of bridge longer than 2km with approach road is categorized as project requiring EIA. Additionally, the bypass section is also categorized as EIA project since road length is exceeding 50km.

As mentioned in the previous article, the EWEC project is separated into two sections such as the New Sittaung Bride and bypass section, and two feasibility studies including environmental and social studies are conducted under JICA and ADB, respectively. Thus MOC has discussed with ECD to conduct two separate EIA(s) from the view of time saving and smooth processing of loan appraisal by the two donors stated.

As the result of discussion between MOC & ECD and screening by ECD, ECD has decided to separate two (2) EIA for the New Sittaung Bridge studied by JICA and the bypass road studied by ADB, respectively in accordance with letter from ECD to MOC as of August 21st, 2017.

Table 11.3.1 IEE/EIA Project List for the Transportation Project on EIA Procedure Law 2015

Project Type	Criteria	
	IEE	EIA
126. Bridges, River Bridges and Viaducts (new construction)	**Length≥0.2km but <2km**	**Length≥2km**
127. Bridges, River Bridges and Viaducts (upgrading)	Length≥300m	All activities where the Ministry requires that the project shall undergo EIA
129. Expressways and Highways (ASEAN Highway	**Length≥2km but <50km**	**Length≥50km**

Project Type	Criteria	
	IEE	EIA
Standard; new construction or widening)		
130. Other Roads (state, region, urban; new construction or widening)	Length≥50km but <100km	Length≥100km
131. Road Improvement (upgrading from seasonal to all weather surface, widening of shoulders)	Length≥50km	All activities where the Ministry requires that the project shall undergo EIA

Source: EIA Procedure Law 2015 (ANNEX 1/Categorization of Economic Activities for Assessment Purposes)

2) Screening on JICA Guidelines

The Project is classified as "Category B" as the project does not fall under the large-scale project in the roads, railways, and bridges sector, the project is not likely to cause significant adverse impacts on the environment and society, and the project is not applicable to any of the sensitive characteristics nor located in or near sensitive areas according to the JICA Guidelines for Environment and Social Considerations (April 2010). However, the indivisible project (the ADB section of the EWEC project) is recognized as "Category A" as the large scale involuntary resettlement is expected. Therefore, the environmental and social aspects should be carefully considered to the extent considered reasonable based on the JICA Guidelines.

(4) Gaps between EIA Procedure Law 2015 in Myanmar and JICA's Guideline

The Project is categorized as Category A. Therefore, EIA activities according to EIA rules are deemed to meet JICA's Guideline Policy as shown below.

Table 11.3.2 Gaps between JICA Guidelines, ADB Safe Guard Policy and Myanmar Legislation on EIA

	JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	ADB Safeguard Policy Statement (2009) Safeguard Requirements 1: Environment	**EIA Procedure Law 2015**	**Gaps ●between ADB ■between Myanmar**	**Policy to fill up gaps in this Study**
1.	When assessment procedures already exist in host countries, and projects are subject to such procedures, project proponents etc. must officially finish those procedures and obtain the approval of the government of the host country.	No description	The project is required to prepare the EIA and obtain the environmental certificates	●Implementation of EIA is mandatory, but no description about Myanmar EIA Law ■ No gaps	Follow Myanmar Laws and JICA Guidelines (EIA approval shall be obtained in accordance with EIA Law 2015)
2.	EIA reports (which may be referred to differently in different systems) must be written in the official language or in a language widely used in the country in which the project is to be implemented. When explaining projects to local residents, written materials must be provided in a language and form understandable to them.	The borrower/client will provide relevant environmental information in a timely manner, including information from the documents in para. 17 in an accessible place and in a form and language(s) understandable to affected people and other stakeholders. For illiterate people, other suitable communication methods will be used. (para18)	The EIA rules stipulate that IEE and EIA shall be written in the local language and English.	● No gaps ■ No gaps	Not required

JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	ADB Safeguard Policy Statement (2009) Safeguard Requirements 1: Environment	**EIA Procedure Law 2015**	**Gaps ●between ADB ■between Myanmar**	**Policy to fill up gaps in this Study**
3. EIA reports are required to be made available to the local residents of the country in which the project is to be implemented. The EIA reports are required to be available at all times for perusal by project stakeholders such as local residents and copying must be permitted.	↑ Ditto (para 18) In line with ADB's Public Communications Policy, ADB is committed to working with the borrower/client to ensure that relevant information (whether positive or negative) about social and environmental safeguard issues is made available in a timely manner, in an accessible place, and in a form and language(s) understandable to affected people and to other stakeholders, including the general public, so they can provide meaningful inputs into project design and implementation. ADB will post the following safeguard documents on its website (main text para 53)	A public disclosure of EIA is required	● No description regarding right to take a copy of ESIA report ■ No description regarding right to take a copy of ESIA report	Follow JICA Guidelines (The right to copy shall be allowed by the Government of Myanmar)
4. In preparing EIA reports, consultations with stakeholders, such as local residents, must take place after sufficient information has been disclosed. Records of such consultations must be prepared.	Consultation will be carried out in a manner commensurate with the impacts on affected communities. The consultation process and its results are to be documented and reflected in the environmental assessment report. (para 19)	The prescript public consultation is held with project affected persons and other relevant agencies after sufficient announcement of the meeting(s).	● No description regarding information disclosure prior to public consultation ■ No gaps	Follow JICA Guidelines (Project information shall be informed to inhabitants prior to public consultation)
5. If necessary, consultations with relevant stakeholders, such as local residents, should take place throughout the preparation and implementation stages of a project. Holding consultations is highly desirable, especially when the items to be considered in the EIA are being selected and when the draft report is being prepared	For environment category A projects, such consultations will necessarily include consultations at the early stage of EIA field work and when the draft EIA report is available during project preparation, and before project appraisal by ADB. (para 19 footnote)	The prescript public consultation is held with project affected persons and other relevant agencies such as authorities, civil society, community based organizations, the Ministry, sector ministries, regional government organizations	● The 1st meeting is held just before EIA site survey ■ Number of meetings is not described	Follow JICA Guidelines (Meetings at scoping and draft EIA stages shall be held twice in this project)

Source: JICA Study Team (JICA Guidelines 2010 and EIA flow chart in EIA rules ECD)

(5) Other Environmental Laws

The other environment-related laws and regulations are shown below;

Table 11.3.3 Other Related Environmental Laws and Regulations

Name of the Legislation (Year Issued)	Features
(Natural Environment)	
The Protection of Wildlife and Conservation of Natural Areas Law (1994)	• Designates national parks and other protected areas to be: Scientific Reserve; National Park Marine National Park; Nature Reserve; Wildlife Sanctuary; Geo-Physically Significant Reserve; or Other Nature Reserve designated by the Minister • Specifies acts prohibited and subject to a fine
Myanmar Forest Policy (1995)	• Shows the general direction of the government for sustainably managing forest resources and carefully exploiting them for socio-economic purposes
The Forest Law (1992)	• Aims at implementing Forest Policy and Environmental Conservation Policy
(Social Environment)	
Land Acquisition Act(1894)	• Stipulates that the government holds rights to take over land provided that compensation is made to the original land owner • States that no private ownership of land is permitted and that all land must be leased from the Union State
Farmland Law (2012)	• Calls for suitable compensation and indemnity in case of repossession of farmland in the interest of the Union State
Farmland Rules (2012)	• Stipulates for farmer's right to work on the farmland • States that when farmlands are converted into different forms of land based on the interest of the Stale or Public, the State or Public needs to make compensation to the farmers without delay

Source: JICA Study Team

11.3.2 Social Consideration

(1) Land Acquisition and Resettlement Laws and Regulations in Myanmar

Currently in Myanmar, there is no law comprehensively stipulating land acquisition and resettlement. The Land Acquisition Act, enacted in 1894, is still the legal basis for land acquisition in Myanmar. The Land Nationalization Act 1953 which was repealed by the Farmland Law 2012, determines nationalization of farmlands and procedures for conversion of farmlands for other purposes (La Na 39). Resettlement-related issues are depicted in some of the existing laws and regulations. However, in most cases, details such as procedures and conditions related to resettlement issues are yet to be determined. Table 11.3.4 indicates the relevant Myanmar laws and regulations for land acquisition and resettlement which are applicable to lower Myanmar where the Project Area is located.

Table 11.3.4 Relevant Laws in Myanmar

- Farmland Law, 2012
- Farmland Rules, 2012
- Vacant, Fallow and Virgin Lands Management Law, 2012
- Vacant, Fallow and Virgin Lands Management Rules, 2012
- Special Economic Zone Law 2011
- Constitution of the Republic of the Union of Myanmar, 2008
- Forest Law, 1992
- Transfer of Immovable Property Restriction Law, 1987
- The Law Amending the Disposal of Tenancies Law, 1965
- The Lower Burma Town and Village Land Act, 1899
- Land Acquisition Act, 1894 (Amended in 1937 (Adaptation of Laws Orders), and 1940 (Burma Act 27)
- The Land and Revenue Act 1876 (Amended in 1945 (Burma Act No 12), 1946 (Burma Act No 64), and 1947 (Burma Act No 6)
- The Lower Burma Land Revenue Manual, 1876
- Development Committee Law, 1993
- Directions of Central Land Committee

Source: Prepared based on “Guidance Note on Land Issues Myanmar” UNHCR, UNHABITAT

Among these national laws, relating clauses in key laws are shown as follows:

1) Constitution of the Republic of the Union of Myanmar (2008)

37. The Union:

(a) Is the ultimate owner of all lands and all natural resources above and below the ground, above and beneath the water and in the atmosphere in the Union;

(b) Shall enact necessary law to supervise extraction and utilization of State-owned natural resources by economic forces;

(c) Shall permit citizens the right of private property, right of inheritance, right of private initiative and patent in accordance with the law.

357. The Union shall protect the privacy and security of home, property, correspondence and other communications of citizens under the law subject to the provisions of this Constitution.

2) Land Acquisition Act (1894)

- Stipulates that the Government holds rights to take over land where the State asserts that such land is needed for public purposes
- Outlines relevant procedures of land acquisition and the method of valuation of land.

3) Farm Land Law (2012)

- Calls for suitable compensation and indemnity in the case of repossession of farmland in the interest of the Union State.

4) Farm Land Rules (2012)

- Stipulates for farmer's right to work on the farmland:
- States that when farmlands are converted into different forms of land based on the interest of the State or Public, the Stare or Public needs to make compensation to the farmers without delay.

11.4 Alternative Analysis

11.4.1 Alternative Analysis

Alternative analysis regarding corridor and alignment has been conducted based on major factors such as road and river crossing length, flooding risk, construction cost and natural and social impacts. As the result of alternative analysis, Corridor B and Alignment (2) have been selected as the recommended bridge location and tentative route. The summary of analysis results, corridor and alignment is shown in Table 11.4.1 and Table 11.4.2. In the corridor and route analysis, since Important Birds Area (IBA) is located on all corridor and route, this factor is not selected as an item for evaluation. The detailed description regarding the alternative analysis is discussed in the Chapter 5.

11.4.2 Without project case

Some adverse natural and social environmental impacts are not caused during construction without project case. However acceleration of traffic congestion and increasing travel time will give negative impacts on economic activities and generate of greenhouse gases. These level of adverse negative impacts are serious than "with-project" case. In the case of with-project, temporary negative impacts are given during construction. However, since such negative impacts are minimized by appropriate mitigation measures, implementation of project is desirable.

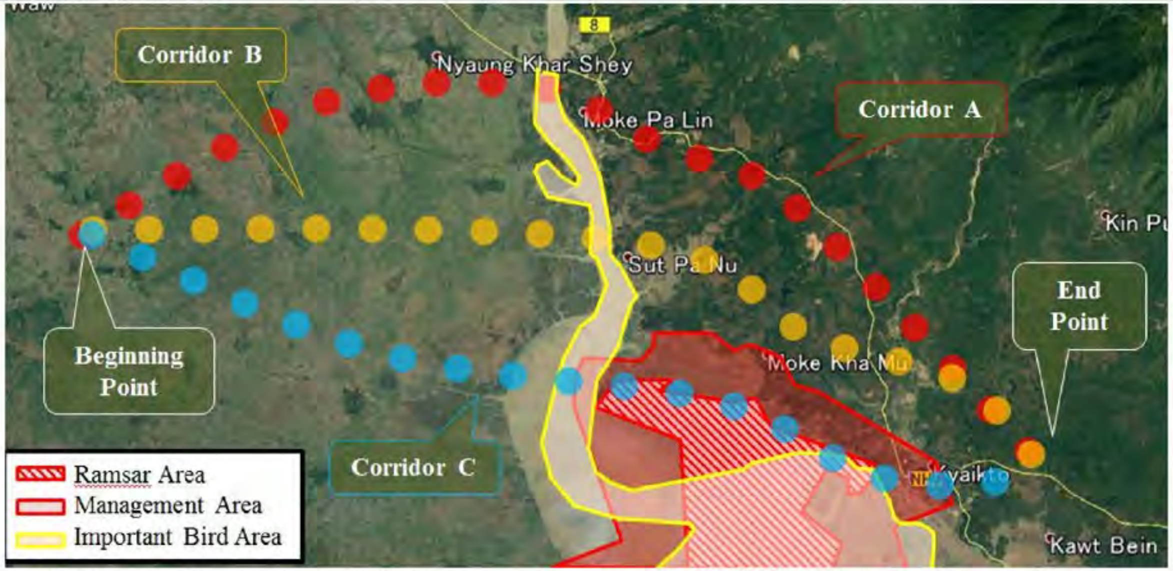
(1) Negative Impacts

- The congested situation must be accelerated due to insufficient capacity of the road and New Sittaung Bridge. This congestion and passing of large cargo trucks will give adverse impacts on pollution and traffic safety.
- The accelerated congestion requires all vehicles to decrease traveling speed, and this increases the volume of greenhouse gases from vehicles.

(2) Positive Impacts

a) Resettlement and land acquisition do not occur in the affected area

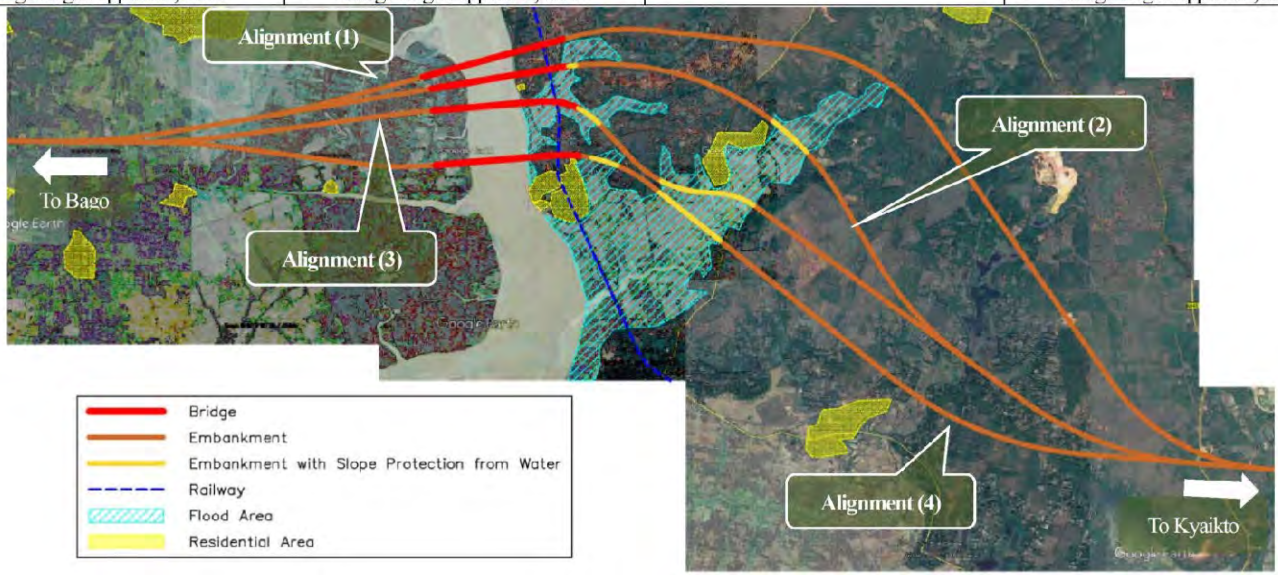
Table 11.4.1 Comparison of the Corridor for New Bago – Kyaikto Highway

Alternative	Corridor A		Corridor B		Corridor C	
Summary	✓ Along the existing highway (NH8). ✓ New bridge beside the existing Sittaung Bridge. ✓ Road length : approx. 45km ✓ Crossing river length: approx. 650m		✓ Short road length: approx. 40km. ✓ New bridge at narrow river crossing area: Crossing river length is approx. 750m		✓ Short road length: approx. 40km ✓ Long new bridge: Crossing river length approx. 2.8km	
Alternative Corridors						

Alternative	Corridor A		Corridor B		Corridor C	
Riverbank Stability / Influence of Tidal Bore	✓ "Relatively stable" but scoured by minor tidal wave	A	✓ "Relatively stable" but scored by minor tidal wave	A	✓ Unstable; scoured by tidal bore ✓ Large erosion at present	C
Construction Cost (Ratio with Lowest Cost)	✓ "Reasonable" because of shorter bridge length but longer distance of road ✓ (1.03)	A	✓ "Reasonable" because of shorter bridge length. ✓ (1.00)	A	✓ "Very High" because of longer bridge length. ✓ (1.87)	C
Environmental Impact	✓ No impact on Ramsar site, but has impact on IBA/KBA	B	✓ No impact on Ramsar site, but has impact on IBA/KBA	B	✓ Impact on Ramsar site and IBA/KBA	C
Land Acquisition and Compensation	✓ 13 residential areas in the corridor	C	✓ 5 residential areas in the corridor	B	✓ 2 residential areas in the corridor	A
Total Assessment	Score = 50/80, (Disqualified)		**Recommended** Score = 60/80		Score = 20/80 (Disqualified)	

Source: JICA Study Team

Table 11.4.2 Comparison of the Route for New Sittaung Bridge

Alternative	Alignment (1)		Alignment (2)		Alignment (3)		Alignment (4)	
Summary	✓ Avoiding flood area along the alignment ✓ Road length : approx. 22km ✓ River crossing length : approx. 880m ✓ Bridge length: approx. 2,200m		✓ Avoiding flood area at river crossing point. ✓ Road length : approx. 22km ✓ River crossing length : approx. 720m ✓ Bridge length: approx. 2,100m		✓ Pre-F/S Alignment ✓ Road length : approx. 21km ✓ River crossing length : approx. 800m ✓ Bridge length: approx. 2,200m		✓ Avoiding flood area at river crossing point. ✓ Road length : approx. 21km ✓ River crossing length : approx. 870m ✓ Bridge length: approx. 2,200m	
Sketch								
River Bank Erosion (10 years erosion ratio (m/year))	✓ Tolerably stable East (9.0m /year) West (2.1m/year)	B	✓ Relatively stable East (1.8m/year) West (4.8m/ year)	A	✓ Unstable East (0.5m/year) West (20.0m/year)	C	✓ Unstable East (0.6m/year) West (30.3 m/year)	C
Approach Road	✓ No flood area along the alignment.	A	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B
Construction Cost (Ratio)	✓ Intermediate (1.08)	B	✓ Lowest (1.00)	A	✓ Reasonable (1.03)	A	✓ Reasonable (1.06)	A
Land Acquisition and Compensation	✓ 17 households are affected.	B	✓ 26 households are affected.	B	✓ 20 households are affected.	B	✓ 29 households are affected.	B
Evaluation	Score = 50/80		**Recommended** Score = 60/80		Score = 40/80 (Disqualified)		Score = 30/80 (Disqualified)	

Source: JICA Study Team

11.5 Screening and Scoping

In this Chapter, screening in accordance with Myanmar laws and relevant guidelines and scoping for the prioritized route as a result of alternative analysis are described.

11.5.1 Screening

The Construction of New Sittaung Bridge project has been classified as EIA project by ECD as of August 21st, 2017 in accordance with EIA Procedure in 2015, Myanmar Law.

Additionally, the EWEC Project including the New Sittaung Bridge Construction Project (JICA Section) has been classified as Category A in accordance with JICA Guidelines.

11.5.2 Scoping

(1) Scoping Matrix and Reasons

Target activities and main structures to be analyzed are construction of bridge, guidebank and revetment. The impacted items, factors, degree of impacts are shown in Table 11.5.1. This matrix is called "Leopold Matrix" and indicates the relationship between the impacted item and its factor as visually understandable. Additionally, the detailed impacts and reasons are compiled in Table 11.5.2.

During construction, quarry, borrow pit, base camp, construction access road, temporary muck soil storage space and other related facilities are secured by the construction contractor.

Since these location, scale and capacity is not specified during the F/S stage, the general expected impact degree, methodology of baseline survey and forecast and draft mitigation measures will be prepared in the another chapter as "Environmental and Social Considerations for Relevant Facilities Prepared Under Decision-Making by the Construction Contractor".

Table 11.5.1 Scoping Matrix (Bridge, Guidebank and Revetment)

	No	Affected Activities / Impact Items (JICA)	Overall Rating	Pre/ During Construction Phase										Operation Phase		
				Land acquisition and loss of properties Including demolition of existing bridges	Change of land use plan, control of various activities by regulations for the construction	Reclamation of wetland, etc.	Deforestation	Alteration of the ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment and vehicles	Construction of bridges, guidebank, revetment, approach road and other related facilities	Traffic restriction in the construction area	Influx of construction workers, construction of base camp including storage	Development and operation of borrow pit and quarry*	Increase of through traffic and travelling speed	Appearance/Occupancy of roads and related building structures including tunnel and embankment	Increasing influx of settlers
Pollution	1	Air pollution	B-	—	—	—	—		B-	—	—	—	B-	B-	—	—
	2	Water pollution	B-	—	—	—	—	B-	B-	B-	—	B-	B-	C	—	—
	3	Waste	B-	—	—	—	B-	B-	—	—	—	B-	—	—	—	—
	4	Soil contamination	B-	—	—	—	—	B-	B-	B-	—	B-	B-	—	—	—
	5	Noise and vibration	B-	—	—	—	—	—	B-	—	—	—	—	B-	—	—
	6	Ground subsidence	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	7	Odor	B-	—	—	—	—	—	—	—	—	B-	—	—	—	—

	8	Sediment quality	**B-**	—	—	—	—	B-	—	B-	—	B-	B-	—	—	—
Natural Environment	9	Protected area	**C**	—	—	—	—	C	—	C	—	—	—	C	C	—
	10	Ecosystem	**B-**	—	—	—	B-	B-	—	B-	—	—	C	B-	B-	—
	11	Hydrology	**B-**	—	—	—	—	B-	—	B-	—	—	—	—	B-	—
	12	Topography and geology	**B-**	—	—	—	—	B-	—	B-	—	—	B-	—	B-	—
Social Environment	13	Involuntary resettlement	**B-**	B-	—	—	—	—	—	—	—	—	C	—	—	—
	14	The poor	**C**	C	—	—	—	—	—	—	—	—	C	—	—	—
	15	Indigenous and ethnic people	—	—	—	—	—	—	—	—	—	—	C	—	—	—
	16	Local economy such as employment and livelihood	**B-**	B-	—	—	—	—	—	—	—	—	C	B+	—	—
	17	Land use and utilization of local resources	**B-**	B-	—	—	—	—	—	—	—	—	C	—	—	—
	18	Water usage	**B-**	C	—	—	—	B-	—	B-	—	—	C	—	B-	—
	19	Existing social infrastructures and services	**B-**	C	—	—	—	B-	—	B-	B-	—	—	—	B-	—
	20	Social institutions such as local decision making institutions	**B-**	—	—	—	—	—	—	B-	B-	—	—	—	B-	—
	21	Misdistribution of benefits and damage	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Social Environment	22	Local conflict of interests	**B-**	—	—	—	—	—	—	—	—	B-	—	—	—	—
	23	Cultural heritage	**C**	C	—	—	—	—	—	—	—	—	C	—	—	—
	24	Landscape	**B-**	—	—	—	—	B-	—	B-	—	—	B-	—	B-	—
	25	Gender	**C**	—	—	—	—	—	—	—	—	C	—	—	C	—
	26	Rights of children	**C**	—	—	—	—	—	—	—	—	C	C	—	—	—
	27	Infectious diseases such as HIV/AIDS	**B-**	—	—	—	—	—	—	—	—	B-	C	—	—	B-
	28	Labor environment (including work safety)	**B-**	—	—	—	—	—	—	—	—	B-	C	—	—	—
Others	29	Accidents	**B-**	—	—	—	—	—	B-	—	B-	B-	C	B-	—	—
	30	Cross boundary impacts and climate change	**B-**	—	—	—	—	—	B-	B-	—	—	B-	C	—	—

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Degree and area of impacts are unknown (further surveys and analysis shall be done) —: Few impacts are expected. Thus baseline surveys and analysis are not necessary. +/- : Positive and Negative Impacts
* Baseline survey, forecast and evaluation for borrow pits, quarry sites, construction roads and other related facilities decided by the Construction Contractor are not target for this ESIA. Only scoping and general mitigation measures are prepared in Chapter 11.
Source: JICA Study Team

Table 11.5.2 Reasons of Scoping (Bridge, Guidebank and Revetment)

Area	No	Impacted Item on JICA Guidelines	Rating At scoping stage: Pre/During Construction	Rating At scoping stage: Operation Phase	Reasons of the Rating
Pollution	1	Air pollution	**B-**	**B-**	**Construction phase:** Temporary negative impacts are expected on air quality due to operation of construction machines and equipment. **Operation phase:** Negative impact is expected due to the increase in traffic number.
	2	Water pollution	**B-**	**C**	**Construction phase:** Turbid water may be generated by earth works and excavation in the river where bridges, guidebank and revetment are planned. Additionally, organic polluted water may be discharged from the base camp. And development and operation of borrow pits and quarries may generate turbid water. Leaking oil from construction machines may cause on soil contamination. **Operation phase:** no impacts are expected due to lack of plans regarding service area and parking along the bridge and approach road. Rain water with oil may run off from the road surface after paving the road.
	3	Waste	**B-**	—	**Construction phase:** Construction waste such as waste soil and cutting trees are expected. Additionally domestic waste and night soil may be generated from the construction base camp. **Operation phase:** No impacts are expected due to no plans regarding service area and parking along the bridge and approach road
	4	Soil contamination	**B-**	—	**Construction phase:** Excavated soil on the site may be polluted. Stored construction materials such as oil and chemicals may pollute the soil in the base camp. Leaking oil from construction machines may cause soil contamination. **Operation phase:** No impacts are expected due to lack of plan regarding soil contamination
	5	Noise and vibration	**B-**	**B-**	**Construction phase:** Noise and vibration generation is expected due to operation of construction machines and equipment. **Operation phase:** Noise and vibration generation are expected because of the increase in traffic number and traveling speed.
	6	Ground subsidence	—	—	**Construction and operation phase:** No impacts are expected since activities such as large-scale earthworks and pumping water which causes ground subsidence are not planed. Additionally soft ground which causes ground subsidence is not observed in the project area.

Area	No	Impacted Item on JICA Guidelines	Rating At scoping stage		Reasons of the Rating
			Pre/During Construction	Operation Phase	
Natural environment	7	Odor	B-	—	**Construction Phase:** Bad odor may be caused by domestic waste and construction materials in the base camp. **Operation phase:** no impacts are expected due to lack of plans regarding service and parking areas which generate solid and liquid wastes.
	8	Sediment quality	B-	—	**Construction phase:** If the excavated soil in the project site is polluted and taken out to other areas, such polluted waste soil may give impacts on the sediment quality of the nearest river. Leaking oil and chemicals from the base camps give impacts on the sediment quality of the nearest river. **Operation phase:** Road operation which causes impacts on sediment quality is not expected.
	9	Protected area	C	C	**Construction phase:** The alignment is not passing through any law-based natural protected areas. Potential management area and registered Mottama Gulf Ramsar site as law-based protected area is located downstream 3.6km and 5.5km away, respectively. Construction activities and construction noise and vibration may give impacts on some species which have feeding areas near the project area. Turbid water, which is generated from the construction area, may give impacts on the ecosystem in the Mottama Ramsar Site. However, construction activities in the river do not cause serious impacts if the methodology which does not generate significant turbidity is adopted. Furthermore, the project area is passing through Important Birds Area (IBA) and Key Biodiversity Area (KBA) which are proposed by international NGOs. Although IBA and KBA are not law-based protected areas, the project activities may give some impacts. **Operation phase:** An existence of bridge and traffic flow with noise & vibration may give adverse impacts to some species which has feeding area in the project area.
	10	Ecosystem	B-	B-	**Construction phase:** The project area is almost developed area such as paddy field and rubber trees. However construction activities with noise & vibration and generation of turbid water in the river may give some impacts to surrounding ecosystem. Additionally cutting rubber forest may give impact on its ecosystem. Development and operation of borrow pits and quarries may give impacts to surrounding ecosystem. **Operation phase:** An existence of structures such as bridge, approach road and guidebank, and traffic flow with noise and vibration may give adverse impacts on some species which have feeding areas in the project area.
	11	Hydrology	B-	B-	**Construction and Operation phase:** Construction of bridge, guidebank and revetment may change the hydrological situation of the rivers. The earthwork section and construction of structures may give impacts on small streams in agricultural land.
	12	Topography and geology	B-	B-	**Construction and operation phase:** Considerable topography and geological sites are not located in the project area. Thus, no impact is expected. However, embankment of the bridge may cause slope failure. Additionally, soil erosion and slope failure may be caused in borrow pits and quarry sites.
Social environment	13	Involuntary resettlement	B-	—	**Pre-construction phase:** Land acquisition and a few resettlements are expected on the proposed route. However, it is estimated that the number of resettles does not exceed 200 persons. **Operation phase:** No impact is expected due to no resettlement and land acquisition after construction
	14	The poor	C	—	**Pre-construction phase:** Impacts will be assessed based on the feature of the local society around the project site. **Operation phase:** No impacts are expected due to lack of resettlement and land acquisition plans after construction.
	15	Indigenous and ethnic people	—	—	**Pre-construction phase:** No indigenous and ethnic people are observed in accordance with WB OP4.10. **Operation phase:** No impact is expected due to lack of resettlement and land acquisition plan after construction
	16	Local economy such as employment and livelihood	B-	B+	**Pre-construction phase:** Livelihood of residents, farmers and fishermen may be affected by acquisition of agricultural area and traffic restriction in the river. **Operation phase:** No impact is expected due to lack of resettlement, land acquisition and traffic restriction plans after construction.
	17	Land use and utilization of local resources	B-	—	**Pre-construction phase:** Mainly agricultural areas such as paddy fields and rubber plantations will be affected by the project. **Operation phase:** No impact is expected due to lack of resettlement and land acquisition plan after construction
	18	Water usage	B-	—	**Construction phase:** Land acquisition may give impact on the irrigation system and/or drinking water resources such as wells. Earthwork section and construction of structures may give impacts on irrigation channels and small streams. Land acquisition for development of quarry and borrow pit may give impacts on wells and small irrigation channels. **Operation phase:** No impact is expected due to lack of resettlement and land acquisition plans after construction.
	19	Existing social infrastructures and services	B-	B-	**Pre-construction and construction phase:** Some schools or meeting places may be affected by land acquisition. Additionally, traffic restriction and existence of structures in the project area will give impact on commuting and fishermen in the river. **Operation phase:** Existence of structures may give impact on approaching of social infrastructures, communication between communities, access to agriculture fields and other services.

Area	No	Impacted Item on JICA Guidelines	Rating At scoping stage		Reasons of the Rating
			Pre/During Construction	Operation Phase	
	20	Social institutions such as local decision making institutions	B-	B-	**Construction and operation phase:** Restriction of the construction area and existence of embankment may cause division of the communities.
	21	Misdistribution of benefit and damage	—	—	**Construction and operation phase:** Misdistribution of benefit and damage caused by the bridge construction is not expected because benefits for construction of bridge provide fair benefits to inhabitants.
	22	Local conflict of interests	B-	—	**Construction phase:** Local inhabitants and local authorities may request to ensure fair job opportunities for construction workers. **Operation phase:** No impact is expected (same as No.21 "Misdistribution of benefit and damage")
	23	Cultural heritage	C	—	**Pre-Construction and Construction Phase:** Some religious facilities, such as pagodas and monasteries, may be affected by construction bridges, approach road, revetment and guidebank. **Operation phase:** No impact is expected due to lack of land acquisition plan after construction.
	24	Landscape	B-	C	**Construction phase:** There are not any law-based protected areas regarding landscape nearby project area. However few impacts are expected during bridge construction. In the quarry and borrow pit sites, alternation of land may give impacts on landscape. **Operation phase:** There are no law-based designated landscape areas around the project area. However, the changing of the usual landscape is expected due to construction of structures. Development of quarry sites and borrow pits may give impact on landscape.
	25	Gender	C	C	**Construction and operation phase:** According to an interview with the authority regarding gender in Myanmar, no issues on gender in infrastructure area are observed. Thus, no impacts are expected for this item.
	26	Right of children	C	—	**Construction and operation phase:** Child labor issues regarding infrastructure are not observed in the project area based on interview with Myanmar Government. However, child labor may occur in quarry site and/or borrow pits.
	27	Infectious diseases such as HIV/AIDS	B-	B-	**Construction phase:** Infectious diseases such as STDs are possible to be spread due to inflow of construction workers. Furthermore, alteration to ground by cut land and filling may trigger the formation of habitats for mosquitoes that possibly transmit malaria and dengue fever. **Operation phase:** Number of influx settlers and tourists increase after construction of the bypass and may distribute infectious diseases such as STDs.
	28	Labor environment	B-	—	**Construction phase:** Construction work environment needs to be considered in accordance with relevant laws and regulations. **Operation phase:** No impact is expected due to lack of laborers after construction.
Others	29	Accidents	B-	B-	**Construction phase:** Construction vehicles may use the existing local roads near the residential areas, thus the number of traffic accidents may increase. In addition, construction workers may have risk to be involved in the accidents caused by the tidal bore. **Operation phase:** Risks of traffic accidents on the new road is expected due to increase in traveling speed.
Others	30	Cross boundary impacts and climate change	B-	C	**Construction phase:** Operation of construction machines and construction of structures generates GHGs. **Operation phase:** The driving distance between Kyaikto and Bago will be shortened by the construction of the bypass, thus positive impacts are expected in the Project Area. However converted traffic number may generate additional GHGs.

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Degree and area of impacts are unknown (further surveys and analysis shall be done) —: Light impact is expected. Thus baseline surveys and analysis are not necessary. +/-: Positive and Negative Impacts
* Baseline survey, forecast and evaluation for borrow pits, quarry sites, construction roads and other related facilities decided by the Construction Contractor is not target for this ESIA. Only scoping and general mitigation measures are prepared in Chapter 11.
Source: JICA Study Team

11.5.3 Baseline Survey and Analysis Methodology

The expected baseline survey and analysis methodologies are shown below.

Table 11.5.3 Baseline Survey and Analysis Methodology

Category	No. (Rating)	Impacted Item on JICA Guidelines	Survey Item and Methodology	Forecast Methodology
Pollution	1 (B-/B-)	Air pollution	(1) Site measurement : 2 points (West bank and East bank) (2) Item: CO, NO2, SO2, TSP (3) Frequency: One time (in dry season, if possible) Note: Collection of Secondary data, if any	Quantitative forecast Puff Model Or refer to other examples
	2 (B-/C)	Water pollution	(1) Site measurement (2 points at each bridge (up/down stream) x 2 seasons (rainy and dry season) = 4 measurements) (2) Item: BOD, pH, SS, temperature (3) Frequency: Twice (rainy and dry season, if possible) Note: Secondary data collection, if any	Qualitative forecast Or refer to other examples
	3 (B-/—)	Waste	(1) Site survey: Registered land fill site near project site. Interview regarding construction waste management in MOC. (2) Item: Summary of the site (3) Frequency: Once Note: Secondary data collection, if any	Qualitative forecast
	4 (B-/—) 8 (B-/—)	Soil contamination Sedimentation quality	(1) Site Survey: Excavation point (2) Item: cadmium, total cyanide, organic phosphorus, lead, chromium (VI), arsenic, total mercury, alkyl mercury, PCBs, copper, dichloromethane, carbon tetrachloride, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, tetrachloroethylene, 1,3-dichloropropene, thiuram, simazine, thiobencarb, benzene and selenium. (3) Frequency: Once Note: Secondary data collection, if any	Qualitative forecast
	5 (B-/B-)	Noise and Vibration	(1) Site measurement: 2 points (West bank and East bank) (2) Item Ambient Noise: L_{Aeq}, Continuous 24hr/weekday, traffic volume and speed Ambient Vibration: 24hr/weekday (3) Frequency: Once (in dry season, if possible) Note: Secondary data collection, if any	Quantitative forecast (Traffic noise on the boundary and at sensitive receptor / L_{aeq} dB(A))
	7 (B-/—)	Odor	Baseline survey is not required	-
Natural environment	9 (C/C)	Protected area	(1)Site survey: 500m each alongside of the bridge guidebank and revetment. Bird survey area is surveyed within 1km by using a telescope. (2) Item: Fauna and flora, ecosystem, considerable species such as listed species on IUCN list Fauna: mammals, birds, reptiles, amphibians, aquatic life, insects and benthos Flora: Land plants and aquatic plant (3) Frequency: One time Note: Secondary data collection, if any. Interview with wildlife and birds specialists.	Qualitative forecast
	10 (B-/B-)	Ecosystem		
	11 (B-/B-)	Hydrology	Refer to hydrology survey by JST (Flooding record survey, Hydrologic analysis)	← Ditto
	12 (B-/B-)	Topography and geology	Refer to Topography and geology survey by JST (topographic and geological survey)	← Ditto
Social environment	13 (B-/—)	Involuntary resettlement	Refer to RAP Survey by JST (PAPs Census, Inventory of loss, socio-economic survey, replacement cost study)	Qualitative forecast
	14 (C/—)	The poverty	Refer to RAP Survey by JST (PAPs Census, socio-economic survey(income))	Qualitative forecast
	16 (B-/B+)	Local economy such as employment and livelihood	Refer to RAP Survey by JST (PAPs Census, Inventory of loss, socio-economic survey(occupation), replacement cost study)	Qualitative forecast
	17 (B-/—)	Land use and utilization of local resources	Refer to RAP Survey by JST (PAPs Census, Inventory of loss (crops, rubber trees), socio-economic survey)	Qualitative forecast
	18 (B-/—)	Water usage	(1) Site survey: 500m range along the alignment (2) Item: -River water utilization on the site	Qualitative forecast

Category	No. (Rating)	Impacted Item on JICA Guidelines	Survey Item and Methodology	Forecast Methodology
			-Underground water (pH, BOD, Total Coliform, Conductivity, Temperature and water level of well) (3) Frequency: twice (Rainy and Dry Season, if possible) Note: Secondary data collection, if any	
	19 (B-/B-)	Existing social infrastructures and services	(1) Site survey: 1,000m range along the alignment (2) Item: Distribution of hospital, school, religious place, community center and traffic number in the river (3) Frequency: Once Note: Secondary data collection, if any	Qualitative forecast
	20 (B-/B-)	Social institutions such as social infrastructure and local decision making institutions	Refer to construction plan	-
	22 (B-/−)	Local conflict of interests	Refer to local stakeholder meetings on EIA or RAP (collection of opinions regarding local conflict)	Qualitative forecast
	23 (C/−)	Cultural heritage	(1) Site survey: 300m range along the alignment (2) Item: Distribution of registered cultural heritage. (3) Frequency: Once Note: Secondary data collection, if any	Qualitative forecast
	24 (B-/C)	Landscape	(1) Site survey: Inquire major site seeing points (2) Item: Taking photograph (3) Frequency: Once (in Dry Season, if possible)	Photomontage
	25 (C/C)	Gender	(1) Site survey: Interview with relevant organizations in Myanmar	Qualitative forecast
	26 (C/C)	Right of children	(1) Site survey: Interview with MOC and visual site survey at construction sites	Qualitative forecast
	27 (B-/B-)	Infectious diseases such as HIV/AIDS	Data collection from secondary source (Interview / Statistical data)	Qualitative forecast
	28 (B-/−)	Labor environment	Confirmation of laws, regulations and IFC standards regarding labors	Qualitative forecast
Others	29 (B-/B-)	Accidents	(1) Site survey: Interview with police station and local government (2) Item: number of traffic accident and reasons (3) Frequency: Once	Qualitative forecast
	30 (B-/C)	Cross boundary impacts and climate change	Refer to traffic demand forecast done by JST, emission units by car year, car type, driving speed.	Quantitative forecast

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Degree and area of impacts are unknown (further surveys and analysis shall be done) −: Light impact expected. Thus baseline surveys and analysis are not necessary. +/-: Positive and Negative Impacts
* Baseline survey, forecast and evaluation for borrow pits, quarry sites, construction roads and other related facilities decided by the Construction Contractor are not target for this ESIA. Only scoping and general mitigation measures are prepared in Chapter 11.
Source: JICA Study Team

11.6 Summary of Baseline Survey and Impact Analysis

The summary of baseline survey, forecast and evaluation is shown below. Additionally detailed survey and quantitative forecasts regarding air, water, hydrology, noise & vibration and ecosystem are shown after summary of baseline and impact forecast.

Table 11.6.1 Summary of Baseline Survey, Forecasts and Evaluation

Area	No.	Item	Rating Scoping Stage **(After Analysis)**		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
Pollution	1	Air pollution	B- (B-)	B- (B-)	1. Survey Point No1: Bago Side No2. Mon Side 2. Result (Standard Value) No1: Bago Side NO2: 65.6 μg/m3 (200) **PM10: 74.8μg/m3 (50)** CO: 0.087 ppm (10) SO2: 9.6μg/m3(20) No2. Mon Side NO2: 69.3 μg/m3 (200) **PM10: 52.2μg/m3 (50)** CO: 0.067 ppm (10) SO2: 8.2μg/m3(20)	[During Construction] Exhaust gases including CO, NO2, SO2 and SPM are discharged from construction machines and may cause impact on the nearby residential area. However, this adverse impact is not serious due to the following reasons: · Operation time is for a limited duration and only during daytime · Most of the earthworks are limited only to excavation at pillars · Residential area is not observed the near construction area [After Construction] Forecast Result (Standard Value) No1: Bago Side NO2: 68.1 μg/m3 (200) **PM10: 74.9μg/m3 (50) +0.07%** CO: 0.077 ppm (10) SO2: 9.6μg/m3(20) No2. Mon Side NO2: 66.0 μg/m3 (200) **PM10: 74.8μg/m3 (50) +0.01%** CO: 0.068 ppm (10) SO2: 9.6μg/m3(20)	[During Const.] Exhaust gases and dusts are generated during construction, thus some adverse impacts may be caused and impacted to the nearest houses. However, the adverse impact is not serious because the residential area is far from the construction area. Furthermore, general mitigation measures such as sprinkling water and surface treatment are implemented when the dust creates impact on the nearest residential and commercial areas. [After Const.] Air quality density will increase after construction due to the existence of the road and driving of vehicles. However, air quality values on NO2, PM10, CO and SO2 will increase slightly. These forecasted values satisfy the relevant standard values except PM10. With regard to PM10, its increase is less than 1%. Thus, it is evaluated that the project does not give serious impacts on air quality.
	2	Water quality	B- (B-)	— (—)	1. Survey Point No1: Upstream of Bridge No2. Downstream of Bridge 2. Result (Standard Value) No1: Upstream of bridge [pH] Rainy: 7.4 (6.5-8.5) Dry : 7.5 (6.5-8.5) [BOD] Rainy: 12 (3) Dry : 14 (3) [SS] Rainy: 212 (25) Dry : 62(25) No2: Downstream of bridge [pH] Rainy: 7.1 (6.5-8.5) Dry : 7.6 (6.5-8.5) [BOD] Rainy: 18 (3) Dry : 20 (3) [SS] Rainy: 296 (25) Dry : 86(25)	[During Const.] a) Turbid water from unpaved area Current SS : 296 mg/l (rainy season) Forecasted SS: 298 mg/l (rainy season) (* 0.97% increase) b) Turbid water from excavation in the river at pillars: Turbid water does not come out from excavated point covered with sheet piles method (SPSP: Steel Pipe Sheet Piles), thus negative impacts on turbid water is not caused. c) Organic polluted water from base-camp Current BOD : 14 mg/l (Dry season) Forecasted BOD: 14.04 mg/l (rainy season) (* 0.26% increase) [After Construction] According to past study, effluent quality of the road surface water does not exceed standard values.	[During Const.] During construction, turbid water is caused in the construction area. The forecasted impact by the project is less than 1 % on SS and BOD. An appropriate methodology for pilling foundation work is adopted so as not to generate turbid water in the river. Thus, it supposed that such negligible impacts do not give significant impacts on mudflat in the downstream. However some general mitigation measures such as appropriate management of wastes are planned for minimization of adverse impacts [After Construction] It is confirmed that water quality from the road surface does not cause significant impacts based on previous study. (see detailes Table 11.7.6 Water Quality from the Road Surface (2010)) Additionally, a wildlife specialist in Japan has commented that significant impacts on water quality were not detected in the case of Bridge Construction Project in Man Lake

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
							Ramsar Site in Okinawa Prefecture, Japan. Therefore, it is not likely that there will be significant impacts on water quality during and after construction.
	3	Waste	B- (B-)	－ (－)	According to interview with villagers in the project area such as in Kyaikhto and Waw township, domestic waste is burned, buried or covered by soil in the form of sanitary landfill. Night soil is discharged into excavated hole and covered with soil. With regard to construction waste such as concrete and cut trees, these can be used for construction materials or sold to the village people in general. On the other hand, construction waste in Myanmar, such as waste soil, is generally disposed of into the river and sea area. Other materials such as trees and waste concrete are generally reused by villagers and/or construction companies as materials for embankment in general.	[During Const. for 4 years] Forecast of Construction Waste 1. Waste soil: 143,897 m3 2. Cut trees: 50,240 m3 3. Domestic waste from construction camp (1) Domestic solid waste: 73 ton (2) Waste water : 7,300 kl (3) Night soil : 321.2 ton [After Construction] Since offices and parking area are not planed on this project, no waste is generated after construction in general. Thus, it is not likely to give adverse impacts on waste.	[During Const.] In case of inappropriate waste management, adverse impacts are caused. However implementation of mitigation measures such as reuse and/or appropriate disposal minimize adverse impacts. Thus, it is not likely to give significant impacts on waste management. [After Construction] Although adverse impact is not expected after construction, illegal disposal should be monitored and prevented.
	4	Soil contamination and sedimentation quality	B- (B-)	－ (－)	1. Sampling site Planed pillars point on the Mon side 2. Result of Analysis All 16 items meet standard	[During const.] Estimated volume of waste soil from the project area is shown below. A total of 143,897 m^3 of waste soil is generated from the project area. However, this soil is processed and used as earthwork material during construction and embankment of ADB section. It is expected that the excavated soil does not cause pollution since the current surface soil is not polluted. On the other hand, risk such as leaking oil from construction machines may occur in the base camp site. Thus, appropriate mitigation measures are required. [After Construction] No impacts are expected due to lack of plan regarding soil contamination	[During const.] It is expected that the generated soil in the project area is not polluted based on soil analysis, thus soil contamination is not caused by the construction soil. However, construction soil is tested and confirmed after excavation during construction. Leaking oil from construction machines and waste oil storage in the base camp may give negative impact on the surrounding soil. However, appropriate management and implementation of mitigation measures minimizes such risks.

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
Pollution	5	Noise and Vibration (Ambient Noise)	B- (B-)	B- (B-)	1. Survey Point No1: Bago Side (near seasonal use house) No2. Mon Side (near Monastery) 2. Result (Standard Value) Current land use : Agriculture and residential No1: Bago Side [Noise] Daytime 7:00-22:00 45 dB(A) (55) Night time 22:00-7:00 41 dB(A) (45) [Vibration] Daytime 7:00-20:00 22 dB (65) Night time 20:00-7:00 29 dB (60) No2: Mon Side [Noise] Daytime 7:00-22:00 44 dB(A) (55) Night time 22:00-7:00 45 dB(A) (45) [Vibration] Daytime 7:00-20:00 29 dB (65) Night time 20:00-7:00 27 dB (60)	[During const.] Impacts: Construction noise & vibration Forecast Point: at Sensitive Receptor, Monastery in Supanu village, Kyaikto Township, Mon State. The forecast point is 340m away from construction area. [Construction Noise] 47 dB(A) (85) [Construction Vibration] 24 dB (75) [After Construction] Impacts: Traffic noise & vibration Forecast Point: at Sensitive Receptor, Monastery in Supanu village, Kyaikto Township, Mon State. Land use in the future: commercial and factory zone along the road All forecasted values are under standard values on commercial and industrial land use [Noise] Daytime 7:00-22:00 57 dB(A) (70) Night time 22:00-7:00 52 dB(A) (70) [Vibration] Daytime 7:00-20:00 40 dB (70) Night time 20:00-7:00 40 dB (65)	[During const.] No standard values for construction noise and vibration have been established in Myanmar at the moment. Thus it is recommended that other standard such as Japanese should be referred in this ESIA. The forecasted construction noise and vibration at sensitive receptor is within Japanese standards, thus any special mitigation measures such as setting up noise barriers are not necessary. However noise and vibration level will be higher than baseline data, thus general mitigation measures such as limitation of working time and appropriate machine maintenance for minimizing of noise and vibration are planned . [After const.] As the result of quantitative analysis with project case, all forecasted values are not exceeding present noise and vibration standard level. Thus it is not likely to give serious impacts to the project area. However some general mitigation measures for minimization of noise and vibration are planned.
	6	Odor	B- (B-)	― (―)	No baseline data	[During Const.] Putrid odor may be caused from domestic waste and night solid in the construction base-camp. Additionally smell of oil and chemicals may be generated from workshop and storage if such materials are leaking or not managed appropriately. [After Const.] No impacts are expected due to any plans regarding service area and parking which generates solid and liquid wastes.	[During Const.] In case of inappropriate management of wastes, adverse impacts are caused. However all generated construction waste and domestic waste are managed and disposed under implementation of mitigation measures, thus it is not likely to give significant impacts on bad odor.
	7	Sediment Quality (refer to (No.4 Soil Contamination))	C (B-)	― (―)	Refer to No4 Soil Contamination	Refer to No4 Soil Contamination	Refer to No4 Soil Contamination
Natural Environment	8	Ecosystem and Protected Area	B- (B-)	B- (B-)	1. Survey area Planed project area (bridge, guide bank, approach road) 2. Number of observed species (IUCN Redlist (EX, EW, EN, VU	[During Const] Following impacts are expected for the project area and Ramsar Site, however the impact level is not significant. (detailed analysis is shown in	- Project Area and IBA/KBA [During Const] The construction activities with noise and vibration may give impacts on feeding and roosting area of birds and fishes near project area, however same

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
					and NT)) a) Mammal : 0 (0) b) Birds: 51(0) c) Amphibian and Reptile: 14 (0) d) Insect : 28 (0) e) Fishes: 41 (1) f) Plankton and Benthos: 62 (0) g) Flora: 172 (5) 3. Evaluation regarding Critical Natural Habitat As a result of analysis regarding critically natural habitat, it is evaluated that the project site as a part of KBA/IBA is not categorized as critically natural habitat in accordance with JICA Guidelines.	11.7.4 Ecosystemn and Protected Area) 1.Alternation of land due to earthwork and cutting tree 2.Human Activities 3.Construction Noise and Vibration 4.Generation of Turbid water in the river and organic polluted water 5.Changing Hydrological Situation [After Const] Following impacts are expected for the project area and Ramsar Site, however the impact level is not significant. (detailed analysis is shown in 11.7.4 Ecosystemn and Protected Area) 1. Road kill 3.Traffic Noise and Vibration 4. Lightning along the bridge and road 5. Expansion of development	environment exists outside of project area, thus escaped species can find out habitats easily. [After Const] Some impacts such as road-kill, traffic noise, lightning and human activities by new development are expected, however implementation of mitigation measures minimizes theses expected adverse impacts. Thus it is not likely to give serious impacts to ecosystem in the project area and KBA/IBA. With regard to result of analysis for critically natural habitats, it is evaluated that the project area in a part of Sittaung KBA/IBA is not critically natural habitat in accordance with criteria under JICA Guidelines. - Ramsar Site According to information regarding Mottama Gulf Ramsar Site, some considerable species such as "Spoon billed Sandpiper" categorized CR on the IUCN Redlist are migrated from northern area and uses this Ramsar Site as wintering spot. Especially most of migratory aquatic birds use mad-flat as feeding and roosting during migratory season. Such critically habitats for fauna species such as potential management area and registered Ramsar site are located more than 3.6km and 5.5km away downstream respectively from the project area. Furthermore, 2 specialists have commented that the project activities do not give significant impacts to Ramsar Area.
	9	Hydrology	B- (B-)	B- (B-)	(1)River Channel and Tidal Bore Sittaung River is affected by tidal bore once a two week, thus river route has been shifting due to tidal bore and flooding. The proposed bridge location is most stable in past 30 years. Recorded highest water level by flooding and breaking bore does not reach existing village road in the East Bank, Kyaito Township. The highest flooding level is app. 9 m from mean sea level in 1996. (2) Distribution of Small Rivers around the Project area (See Figure 11.7.15). Some small streams and creeks are located in the project area.	[During and After Const] (1) Hydrological Situation of the Sittaung River The bridge crossing point is most stable location based on past flooding record and shifting of river channel in past 30 years. According to hydrological simulation by the construction of piers in the Sittaung River, it is estimated surface water level may change maximum 2-3 cm in the range of 100m downstream, however this impact does not reach more than app. 100m away downstream as shown in the next figure.(see Figure 11.7.16) Thus it is expected that existence of bridge does not give significant	[During and After Const] According to hydrological analysis, existence of bridge pillars in the Sittaung River does not give significant impacts on hydrological situation of current Sittaung River. It means changing hydrological situation does not give impact on situation of mudflat in Ramsar site. In the land area, construction of structures such as approach road and guidebank and existence cut streams and irrigation channels, however diversion channels such as alternative open irrigation channels, crossing water pipe and culvert are constructed as mitigation measures. Thus it is not like to give significant impacts on

Area	No.	Item	Rating Scoping Stage (After Analysis) Pre and During Const.	Operation	Summary of Result Baseline	Forecast	Evaluation
					On the west bank in Bago region, a couple of irrigation streams are passing at approach road and guidebank, on the other hand, only one irrigation rivers are crossing approach road on the east bank in Mon State.	impacts to hydrological situation. Furthermore a construction of guidebank and revetment keeps stabilized river channel in the project area. (2) Impacts on small stream With regard to impacts streams and irrigation channel, totally approximately 600m of streams and irrigation channels are affected by the project. Streams and irrigation channels are indispensable for agricultural field in the project area, thus mitigation measures are necessary for not to affect agricultural activities.	hydrological situation in the project area.
	10	Topography and geology	B- (B-)	B- (B-)	(1)Topography According to survey, the depth of river is between 7 to 9 m from water surface in May 2017 (2) Geology The survey was conducted at 4 points in the river and on the land. According to survey, soft ground has not been observed from survey points. Original target depth of boring was to confirm 5.0 m of N-value of more than 50.	[During and After Const] Considerable topography and geological sites are not located in the Project Area, thus no impact is expected. However embankment of the bridge may have slope failure. Embankment sections have risks of soil erosion, slope failure and landslide, thus following mitigation measures are taken in general.	[During and After Const] Implementation of appropriate designing and mitigation measures such as slope protection and periodical monitoring & maintenance will mitigate the expected impacts. Thus it is not likely to give significant impacts on stability of earthwork section.
Social Environment	11	Involuntary resettlement	B- (B-)	— (—)	A total of 20 project affected households (PAHs) on land, structures and crops/trees and 24 of displaced persons are recorded.	[During const.] A total of 20 PAHs on land, structures and crops/trees and 24 of displaced persons are recorded based on social impacts survey.	[During const.] Although 20 PAHs and 24 resettlers are caused by the project, implementation of appropriate compensation, livelihood restoration program will mitigate expected adverse impacts, thus it is not likely to give serious impacts on this item. These impacts and detailed compensation policy shall be updated during detailed design.
	12	The Poverty	C (B-)	— (—)	The poverty line is 39,090 kyat per capita per month in Myanmar. On the contrary, poverty line is 28,758 kyat in Mon State and 32,315 kyat in Bago Region. *1 USD = 1,410 kyat (Sep. 2018)	[During Const.] According to surveys regarding land acquisition, no person under poverty line has been identified. Thus, the project does not give any adverse impacts to persons under poverty line during construction.	[During Const.] No person under poverty line is observed, thus mitigation measure is not necessary. The project does not give any impacts on poverty.
	13	Local economy such as employment and livelihood	B- (B-)	B+ (B+)	1. Major Occupation Rice farming: 36.8% Orchard: 36.8% (Total 19 PAH) 2.Fishery (1) Number of Fishermen 219 / 5 villages near the project area	[During Const.] (1) Impacts on Agricultural Area Approximately 25 ha of agricultural areas such as paddy field, farming land and rubber plantation are affected by the project. In association with agricultural land, 2,625 basket on paddy, 457 basket on peas and	[During Const.] Although around approx. 25 ha of agricultural land is acquired due to the construction of bridge and approach road, appropriate compensation policy in accordance with Myanmar laws and JICA Guidelines is established and implemented by the Myanmar

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
					(2) Main Fishing Ground 9 FGs within.	beans and totally 15,439 number of variety of trees are estimated to be impacted. (2) Impacts on Fishery a) Impacts on fishes and aquatic species Turbid water is not generated because the steel pipe sheet piles method is adopted for foundation works. Fishes and aquatic species may be led to avoid the construction area temporarily within 200 m range up-downstream during construction as shown in the following figure. However, according to a study in Japan, more than 100 dB note-1) vibration gives impacts on fishes. In these construction activities, since vibrohammer with less than 80 dB vibrations is adopted, the degree of impact is not significant. b) Impacts on fishing activities and fishing area Traffic restriction in the river and setting up of prohibited fishing area from the view of safety may give impacts on fishing activities and fishing ground. However, according to an interview with the fishery department in Kyaito Township, fishermen can use other fishing grounds during construction. [After Construction] (1) Impacts on fishes and aquatic species Road surface water does not give any impacts on aquatic species because water quality does not exceed standard values under general circumstances. Fishes and aquatic species may be led to avoid the area when the bypass and bridge opens. However, such species come back under the bridge because desirable habitats are created due to setting up of riprap for the prevention of scouring at piers. (2) Impacts on fishing activities and fishing area Fishermen who are using gill net may be impacted by the existence of bridge piers after construction. However, according to interview with the fishery department in	Government. Impacts on turbid water, noise and vibration is minimized by various mitigation measures. Thus, it is not likely to give serious impacts on fishes and other aquatic species. On the other hand, establishment of restriction area within 400m range during construction gives a degree of impacts on fishermen who are using the restricted area as main fishing ground. However, such fishermen have some alternative fishing grounds, and they can shift to these fishing grounds basically, thus the project does not give significant impacts on fishermen's livelihood. [After Construction] Expected impacts by road noise and vibration are not serious. There are no restricted fishing areas after construction. Thus, the livelihood of fishermen is not impacted by the project. Furthermore, the shortening of traveling time from the project area to Yangon area gives positive impacts on trading and transportation. It will also lead to the fishermen and/or traders' better accessibility to the markets and enhance their economic activity. Thus, the project does not cause serious negative impacts and brings positive impacts on the local economy.

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
						Kyaikto Township, fishermen can avoid piers and use other fishing grounds. On the other hand, traveling time to Yangon is shortened due to commencement of new bridge and bypass, thus it will benefit the local economy. It will also lead to the fishermen and/or traders' better accessibility to the markets and enhance their economic activity.	
	14	Land use and utilization of local resources (Land use/Fisheries)	B- (B-)	－ (B-)	1. Land use in the project area (1)Swamp Area 5.9 ha/ 16.0% (2).Paddy Field 12.4 ha / 33.7% (3)Water Body 8.2 ha / 22.3% (4)Garden Land 7.7 ha / 20.9% (5)Rubber Plantation 2.6 ha / 7.1% Total 36.8 ha / 100.0%	[During Const.] During and before the construction stage, approx. 12.4 ha of paddy field, 7.7 ha of garden land and 2.6 ha of rubber tree plantation are impacted and occupied by the bridge and approach road. [After Const.] Construction of bridge and bypass improves accessibility from the project area in Kyaikto and Waw Township to Yangon area, thus it is expected that industrial area and related commercial area may be developed along the road. Since there is lack of law-based land use plan in the project area, unplanned development may occur along the bypass and bridge area. Such unplanned development leads to pollution and gives adverse impacts on natural conservation area such as KBA/IBA and Ramsar Site. Thus, adequate land use plan shall be established and managed by the government.	[During Const.] During construction, land acquisition of agricultural area is compensated appropriately in accordance with Myanmar laws and JICA Guidelines. [After Const.] Inappropriate land use may cause pollution near project area. Thus establishment of appropriate land use plan, implementation of land use management and pollution control by the local government should be done and such appropriate management can create sound development harmonized with the natural environment.
	15	Water usage	B- (B-)	－ (－)	1. Impact on wells No wells have been identified in the project-affected area. Only one well is observed located approx. 70 m away from project area. Water quality in the well Temp: 25 ℃ pH: 5.4 BOD: 10 mg/l T-Col: 10 CFU/100ml Depth: 4.5m Measured values on pH, color and turbidity are exceeding WHO guideline values. Irrigation channel and streams in the project area is shown in Figure 7.2.9. in the article "Hydrology".	[During Const] Land acquisition may give impact on irrigation system and/or drinking water resources such as wells. Earthwork section and construction of structures may give impacts on irrigation channels and small streams. Since wells are not identified in the project area, land acquisition does not give any impacts on wells. On the other hand, some irrigation channels and small stream are cut off due to occupation of bridge and approach road. A total of approximately 630m of irrigation channel and stream is impacted by the project. Thus, implementations of mitigation measures are necessary.	Drinking water source such as wells are not impacted by the project. On the other hand, construction of structures such as bridge and approach road and their existence may cut streams and irrigation channels. However, diversion channels such as alternative open irrigation channels, crossing water pipe and culvert are constructed as mitigation measures. Thus, it is not like to give significant impacts on the hydrological situation in the project area.

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
						[After Const] No impact is expected due to lack of resettlement and land acquisition plans after construction.	
	16	Existing social infrastructures and services and Social institutions such as social infrastructure and local decision making institutions	B- (B-)	B- (B-)	In the project area, meeting place and school are located outside of ROW, and community roads and agricultural road are crossing through the project area on the east bank in Mon State.	[During and After Const.] During and after construction of the bridge and approach road, the following community roads are impacted. A total of app. 460 m of 3 village roads and 100m of agricultural roads are impacted by the construction and the existence of structures. Thus, these roads should be secured during and after construction. Any other utilities such as power lines and communication cables do not exist in the project affected area. Affected streams and irrigation channels are discussed in the article "Hydrology".	[During and After Const.] Construction activities may give adverse impact on access route to public facilities and/or commuting route. Additionally, the appearance of structures on the existing road may give adverse impact on the separation of the communities and may lead to inconvenience in commuting and accessing the social infrastructures. However, the implementation of mitigation measures will minimize the impacts. Thus, they are not likely to give serious impacts on this item. A detailed construction restriction plan and detour plan shall be prepared by the construction contractor and inspected by the consultant during construction.
	17	Local conflict of interests	B- (B-)	― (―)	In general, provision of job opportunities as construction workers is a common opinion raised by local inhabitants and local authorities. In this public consultation, local people have requested for job opportunities such as construction work during construction.	[During Const.] Conflicts or disputes between communities may arise if there is imbalance in the hiring of workers. [After Const.] No adverse impacts are expected.	[During Const.] Hired workers from other areas may have conflicts with the local inhabitants. However, the implementation of mitigation measures will minimize the impacts. Thus, it is not likely to give serious impacts on this item.
	18	Cultural Heritage	C (―)	― (―)	No cultural heritage site, including law registered sites, buried cultural objects and community level pagoda, are observed in the project area. The nearest pagoda is approximately 300m away from the boundary of ROW.	[During Const] No impact is expected due absence of land acquisition after construction [After Const] No impacts on cultural heritage are expected as there are no such sites in the project affected area. Thus, mitigation measures are not necessary in this project.	The project does not give any adverse impacts on cultural heritage.
	19	Landscape	B- (B-)	C (B-)	There are no law-based protected viewpoints in the project area and its surrounding area. The project area is already a developed area as an agricultural land, and no natural parks and historical parks are located. The landscape elements from the bridge crossing point are the river and the bank of the river.	[During and After Const] According to simulated computer graphic (CG) images, the landscape elements are structure of the bridge, carriageway and relevant road structures such as embankment and guidebank. Sky landscape is reduced by construction of the structure. On the other hand, the installation of modern design structure such as bridge creates a sophisticated symbolic landscape in the project area. Although Kyaik Ka Tar Village is	A construction of bridge gives impact on landscape. For instance sky factor decreases due to the existence of bridge. However, on the other hand, a sophisticated and symbolic landscape is created. Furthermore, the color of the structure harmonizes with agricultural land. Thus, it is evaluated that the project does not give serious impacts on this item.

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
						well-known by local people as an ancient town, a considerable natural landscape is not observed in the village and it is located more than 3km away from project site. Thus a significant adverse impact is not expected in the village.	
	20	Gender	C (B-)	C (B-)	According to an interview with Women Development Division under the Ministry of Social Welfare, Relief and Resettlement, the Myanmar National Committee for Women's Affairs was established in 1996, and this organization is cooperating with the Ministry of Education and the Ministry of Health and Sports. National Strategic Plan for Advancement of Women (NSPAW) 2013-2022 was established in 2013, and it has various activities on 13 areas such as poverty, education and training, health, violence against women and etc. However, women's issues in the infrastructure sector have not been recognized until now. Thus the Women Development Division suggested there are no women's issues in the infrastructure at the moment. Although some documents such as "NPSWA 2013-2022" and " Data collection survey on Gender in Myanmar" point out the gender disparity in decision making, female participants have attended and expressed their opinions in front of others in the Public Consultations and RAP (Resettlement Action Plan) meetings, therefore females does not have significant disadvantage in the process of decision-making in the project.	[During and After const.] There are no impacts on gender in this project; however, some prevention measures such as "Equal Opportunities for Employment" should be conducted. Note) Gender equality/women's participation should be promoted under National Strategic Plan for the Advancement of Women (2013-2022), Minimum Wages in Myanmar (2013) and international recognition.	Although some reports state that women in Myanmar are not in the equal situation with men, the implementation of the project does not give adverse impact to the gender situation in the Project area. However, the implementation of the mitigation measures will enhance the gender equality and mitigate the negative situation on gender in Myanmar.
	21	Right of Children	C (B-)	C (B-)	According to information from the 2015 Labor Force Survey Report, International Labor Organization (ILO), the following are the features of child labor in Myanmar: a) 1,13 million children aged 5 to 17 years – or 9.3% of the child population- – are in child labor; b) 8.5% are girls and 10% are	[During Const] Child laborers may be hired as simple workers in the construction site and/or laborers at the quarry site. Thus appropriate rules which prohibit the hiring of child laborers under 18 years old shall be established for the project. [After Const] No impact is expected because there	In the project area, no child laborers have been observed during surveys. However, international organizations such as ILO have reported its existence in Myanmar. Thus, prevention measures shall be strictly implemented during construction. Implementation of such measures eases the risks of hiring child laborers.

Area	No.	Item	Rating Scoping Stage (After Analysis) Pre and During Const.	Operation	Summary of Result Baseline	Forecast	Evaluation
					boys; c) Over half of the child laborers – 616,815 or 5.1% of the child population – are trapped in hazardous work likely to harm their physical, mental or moral development; d) Most of the children in hazardous work are between 12-14 years old at 24.1%, and 74.6 % are between 15-17 years old. e) The 12-14 years age group tends to work very long hours. Thus, 25.8% of the 12-14 years old age group and 24.3% of the 15-17 years old age group have worked 60 hours or more; f) The key sectors where child labor occurs are agriculture (60.5%), manufacturing (12%), wholesale and retail trade, repair of motor vehicles and others (11%).	are no activities regarding child labor.	
	22	Infectious diseases such as HIV/AIDS	B- (B-)	B- (B-)	According to literature survey, major infectious diseases are lower respiratory infections, tuberculosis and STDs such as HIV/AIDS. HIV/AIDS were the leading causes of death, killing 11.4 thousand people in 2012.	[During and After Const.] Hired construction workers and skilled equipment operators who are coming from other areas and foreign countries may establish contact with inhabitants and spread infectious diseases. Additionally, puddles in the construction area and insufficient drainage will provide a habitat for dengue carrier mosquitoes.	Inflow of workers during construction may provide opportunity for spreading infection disease. Additionally insufficient and inappropriate drainage and maintenance during construction may also provide habitats of mosquito larvae. However implementation of mitigation must prevent and minimize these adverse impacts. Thus it is not likely to give serious impacts on them.
	23	Labor environment including work safety	B- (B-)	— (—)	In the 1960's , the Law Prescribing the Fundamental Rights and Duties of People's Workers (1964) had been effective as a comprehensive law regarding the rights of laborers. However, this law was abolished in 2011, and the following 14 laws are applicable in Myanmar. Labor conditions, safety of facilities and equipment are not prescribed in the following 14 laws. However, the same level shall be secured under the Factories Act 1951.	[During const.] Working without considering labor laws and regulations in the construction area may cause accident. For instance, working without using helmet and working boots increase the risks of head and foot injuries. [After Const] No impacts are expected because no related labors work in the project area.	[During const.] Relevant laws in Myanmar, IFC Standards and related conditions of FIDIC (International Federation Of Consulting Engineers) shall be applied during construction for employees. The labor environment and safety will be secured in accordance with the above laws and international standards.
Other	24	Accident	B- (B-)	B- (B-)	According to some reports, a total of 116 people died due to accident on the country's Yangon-Mandalay highway in connection with 555 traffic accident cases with 863 injured in 2017. Majority of the reasons for	[During Const.] According to construction plan, construction machines and trucks will be operated for approximately 4 years. Thus risks of traffic accident increase in the project area and surrounding connected roads, thus	[During Const.] Operation of construction machines and vehicles may increase the accident in construction area and on the road where construction machines are used, and construction vehicles may use existing local road near residential and

Area	No.	Item	Rating Scoping Stage (After Analysis)		Summary of Result		
			Pre and During Const.	Operation	Baseline	Forecast	Evaluation
					such traffic accidents are over speeding, reckless driving, defective vehicles and flat tire. On the hand, the number of fatal accident involving drivers, passengers, pedestrian and motor cyclists were 392 persons in Bago Region and 254 persons in Mon State, respectively. These accidents have been caused by over speeding and overtaking with reckless driving. Additionally insufficient road safety facilities such as traffic lights, street lights and sign boards are very limited, and such road environment accelerates the increase of traffic accidents. In addition, tidal bore is observed as natural phenomenon in the project area.	mitigation measures shall be prepared. In addition, construction workers and skilled equipment operators who are coming from other areas may not aware of the existence and risk of tidal bore in the project area. Therefore, some people may be involved in accident caused by tidal bore. [After Const.] Since bridge and approach road is designed only for vehicles, it is expected that the number of traffic accidents between vehicles and the local people will decrease. However, since the driving speed of vehicles increases from 60km/h to 100km/h due to expressway, the number of traffic accident may increase if adequate traffic safety facilities are not installed. Thus, the setting up of mitigation measures is indispensable.	commercial areas, thus number of traffic accident increase during construction. Furthermore, some construction workers coming from outside area may be involved in the accidents caused by tidal bore. [After Const.] After construction of bridge and approach road, accidents between vehicles and pedestrians may decrease. However, accidents between vehicles may increase due to over speeding. The implementation of mitigation measures during and after construction will prevent and minimize these adverse impacts. Thus, it is not likely to give serious impacts on these accidents.
	25	Cross Boundary impacts and climate change	B- (B-)	C (B+)	--	The total generated CO2 volume is analyzed for with and without project, respectively. Unit: Million CO2 t/year 1. Current Condition in 2018 With Project: 1.849 Without Project: 1.849 2. During Construction in 2023 With Project: 2.665 Without Project: 2.620 3. Operation Phase in 2025 With Project: 2.600 Without Project: 3.024 4. Operation Phase in 2040 With Project: 6.582 Without Project: 6.712 Differences of Total Accumulated CO2 volume (WoP-WP) From 2017- 2024 (4th year during const): - 0.179 Mil.CO2 t From 2017- 2025 (1st year of operation): 0.179 Mil.CO2 t	[During and After Const.] Negative impacts are forecasted during construction due to construction activities such as operation of construction machines; however, traffic in the analyzed area will be improved by easing of traffic congestion due to construction of flyover. Thus, the total generated CO2 will be improved after 2025, and the project gives positive impacts after 2025. Additionally, rise in sea level is estimated at a maximum of 83cm in accordance with MCCSAP (Myanmar Climate Change Strategy and Action Plan) in 2017. However, the bridge design with vertical clearance covers this impact of climate change. Thus, it is likely to give positive impacts on this item.

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Degree and area of impacts are unknown (further surveys and analysis shall be done) ―: Light impact is expected. Thus, baseline surveys and analysis are not necessary. +/-: Positive and Negative Impacts
* Baseline survey, forecast and evaluation for borrow pits, quarry sites, construction roads and other related facilities decided by the Construction Contractor are not target for this ESIA. Only scoping and general mitigation measures are prepared in Chapter 11.

Source: JICA Study Team

11.7 Major Baseline Data and Result of Analysis

Measured and quantitative analysis data based on the EIA is shown below.

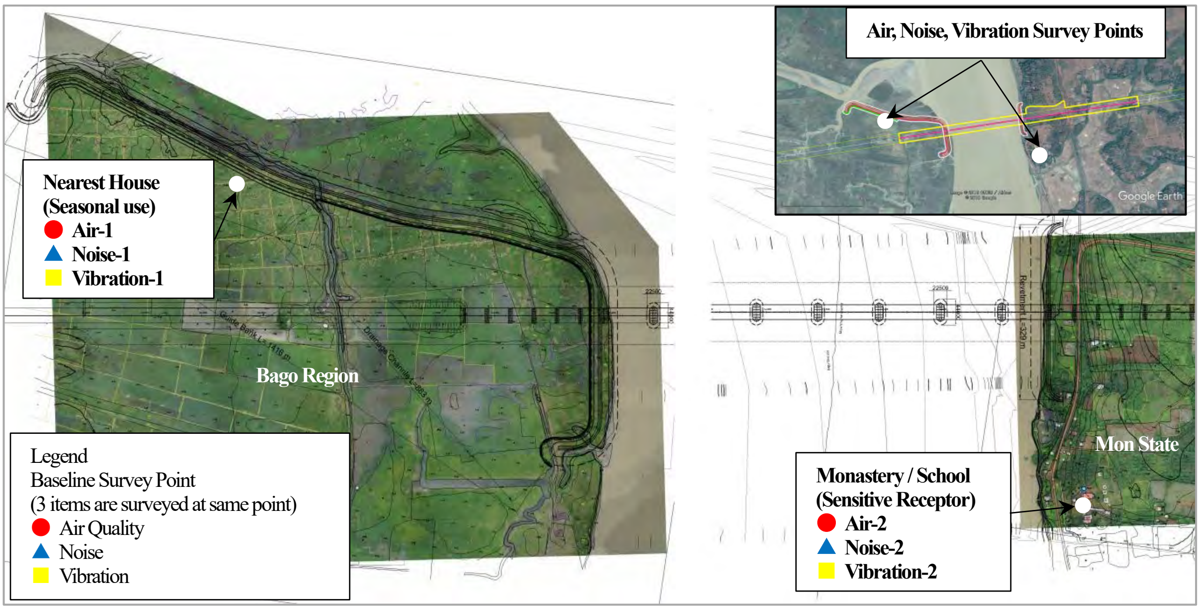
11.7.1 Air Quality

(1) Result of Baseline Survey

1) Survey Point

Measurement point for air quality, noise and vibration is shown in Figure 11.7.1.

In general, air, noise and vibration measurement is conducted along the planned bridge and approach road to grasp the current situation.



Source: JICA Study Team

Figure 11.7.1 Air and Noise and Vibration Measurement Locations

2) Result of Measurement

The measured data for air quality is shown in Table 11.7.1.

With regard to PM10 which is the indicator of dust, all points exceed Myanmar standard values due to dry season and agricultural land. Measured values on NO2, CO and SO2 satisfy Myanmar and Japanese standards.

Table 11.7.1 Monitoring Date of Air Quality (March 22nd – 23rd,2018)

Parameter / Location (measured date)		NO_2 (Nitrogen Dioxide) Average for 24hrs [μg/m^3]	PM_{10} (particulate matters 10μm) Average for 24hrs [μg/m^3]	CO (Carbon Monoxide) Average for 24hrs [ppm]	SO_2 (Sulphur Dioxide) Average for 24hrs [μg/m^3]
Air-1 (March 22nd, 2018) Bago Region, Waw Township, Shangai Village (At the nearest house (seasonal use))		65.631	**74.820** (exceeding)	0.0873	9.55
Reference ADB data (June, 2018) Bago Region (ET#11)		111.84	26.39	0.00015	3.02
Air-2 (March 23rd, 2018) Mon State, Kyaito Township, Sut Pa Nu Village (Monastery / School (Sensitive Receptor))		69.297	**52.150** (exceeding)	0.067	8.21
Reference: ADB Data (June 2018) Mon State (ET#12)		89.63	37.38	0.00000	2.63
Standard	Myanmar Standards*1	200	**50**	None	**20**
	IFC Standards *2	1year: 40 1 hour: 200	50	None	None
Reference Standard	Japanese Standards	76.53	SPM 100	**10**	106.65 (converted value)

Source: *1: National Environmental Quality (Emission) Guidelines (MONREC, Dec. 29, 2015)
*2: Environmental, Health, and Safety General Guidelines (IFC, April 30, 2007)

(2) Potential Impacts

1) During Construction

Temporary negative impacts are expected on air quality due to operation of construction machines and equipment.

2) After Construction

Negative impact is expected due to the increase in traffic number.

(3) Impact Forecast

1) During Construction

Exhaust gases, including CO, NO2, SO2 and PM, are discharged from construction machines and may cause impact on the nearby residential area. However, this adverse impact is not serious because of the following reasons:

- Operation time is for a limited duration and only during daytime
- Most of the earthworks is limited only to excavation at pillars
- Residential area is not observed near the construction area

2) After Construction

i) Location of Forecast Point and Traffic Volume

Increase of traffic volume will give a degree of adverse impacts on air quality.

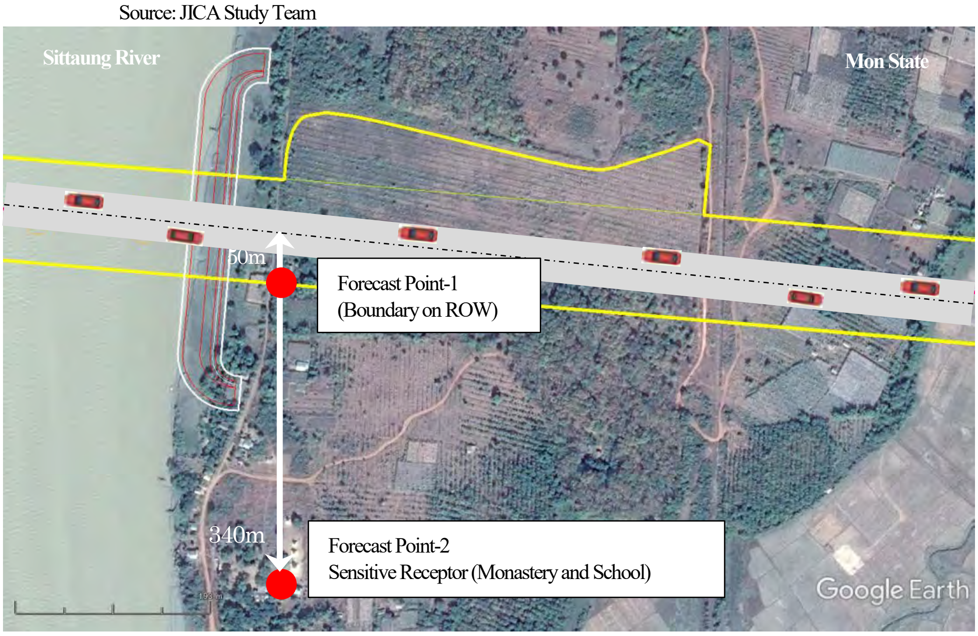
The Puff model, which is widely used in the analysis of air pollution in Japan, is adopted for quantitative analysis in this case. One point is at the boundary of ROW and another point is selected as sensitive receptor for the prediction of air pollution. The traffic volumes at each section are shown in

Table 11.7.2, and the location of forecasts shown in Figure 11.7.2 and Figure 11.7.3.

Table 11.7.2 Traffic Volume at Forecasted Points After Construction

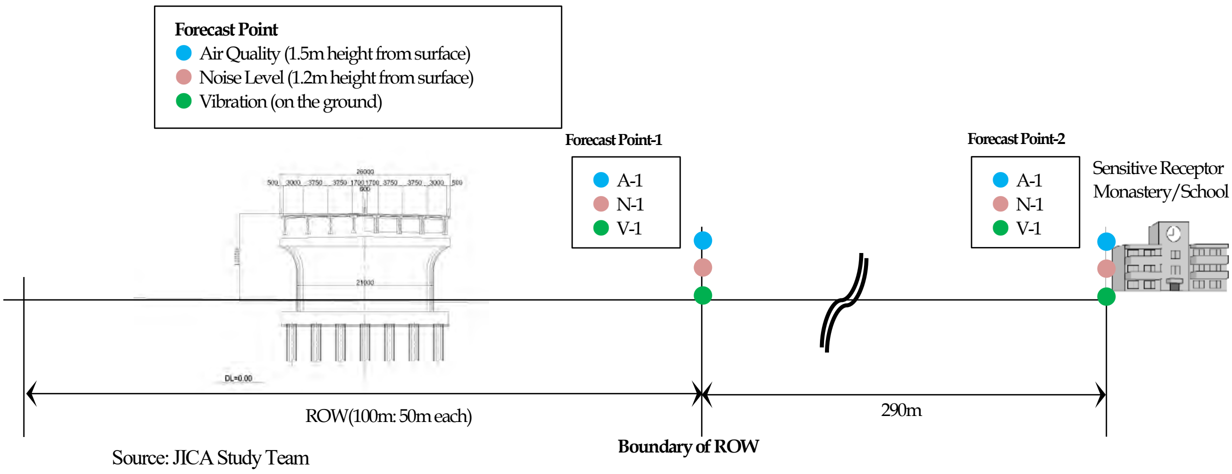
Location \ Traffic Volume	Traffic Volume/ Average Speed	Future's Traffic Volume With Project Case (2025) Number a day
Sittaung Bridge Section	Small	9,000
	Big	13,100
	Total	22,100
	Design Speed (km/h)	100 km

Source: JICA Study Team



Source: JICA Study Team based on Google Earth

Figure 11.7.2 Air and Noise and Vibration Forecast Locations (Sensitive Receptor in Sut Pa Nu Village)



Source: JICA Study Team

Figure 11.7.3 Cross Section at Forecast Points (Sensitive Receptor in Sut Pa Nu Village)

ii) Result of Forecast

The Puff Model is used to predict the road-contributed density. As the result of quantitative forecast is shown in the next table, impacts rate from the project is between 0.07 % on PM10 and 14.93% on CO. It means that background air quality concentration dominates result of air quality forecast.

The result of quantitative forecast is shown below. Forecasted values on NO2, CO and SO2 satisfy the adopted standard level. However the value of PM10 is beyond Myanmar standard value because the current monitored data is already exceeding the standard value. The increase rate is less than 0.1% in 2025, thus the project negative impacts are at negligible levels.

Table 11.7.3 Result of Quantitative Forecast on Air Quality after Construction

Point		Forecast Point-1 ROW Boundary (50m from the centerline)		Forecast Point-2 At Sensitive Receptor (Monastery/School) (340m from the centerline)		Standard (□: Adopted Standard)		
Parameter		Background (BG)	Forecasted Value with BG (increase rate)	Background (BG)	Forecasted Value with BG (increase rate)	Myanmar	IFC	Japanese
NO_2 (μg/m^3)	Average for 24hrs	65.631	68.098 (+3.76%)	65.631	66.021 (+0.59%)	**200**	1 year 40 1 hour 200	76.53
PM_{10} (μg/m^3)	Average for 24hrs	74.820	**74.870 (+0.07%) (exceeding)**	74.820	**74.824 (+0.01%) (exceeding)**	**50**	50	SPM 100
CO (ppm)	Average for 24hrs	0.067	0.077 (+14.93%)	0.067	0.068 (+1.49%)	None	None	**10**
SO_2 (μg/m^3)	Average for 24hrs	9.55	9.62 (+0.73%)	9.55	9.56 (+0.104%)	**20**	20	106.65

Source: JICA Study Team

(4) Mitigation Measures

1) During Construction

It is expected that the degree of impacts such as dust from construction area is not serious. However, appropriate mitigation measures shall be implemented as shown below:

- ✓ Water sprinkling shall be carried out on earth construction road and construction yard near the residential area. Additionally surface treatment of the earth road should be considered if required.
- ✓ Periodical cleaning shall be done on paved road used as construction road.

2) After Construction

- ✓ Appropriate land use management should be done along the road. In general, commercial and industrial area shall be designated along the road so as not to cause air pollution directly to the residential area. Such buffer zone can secure diffusion distance and mitigate impacts from exhaust of vehicles.

(5) Evaluation

1) During Construction

Exhaust gases and dusts may be generated during construction. However, the adverse impact is not serious because the generation of dust is minimal due to limited earthwork area such as excavation points at pillars. Furthermore, mitigation measures such as sprinkling water and surface treatment is implemented when there is impaction of dust on the nearest residential and commercial areas.

2) After Construction

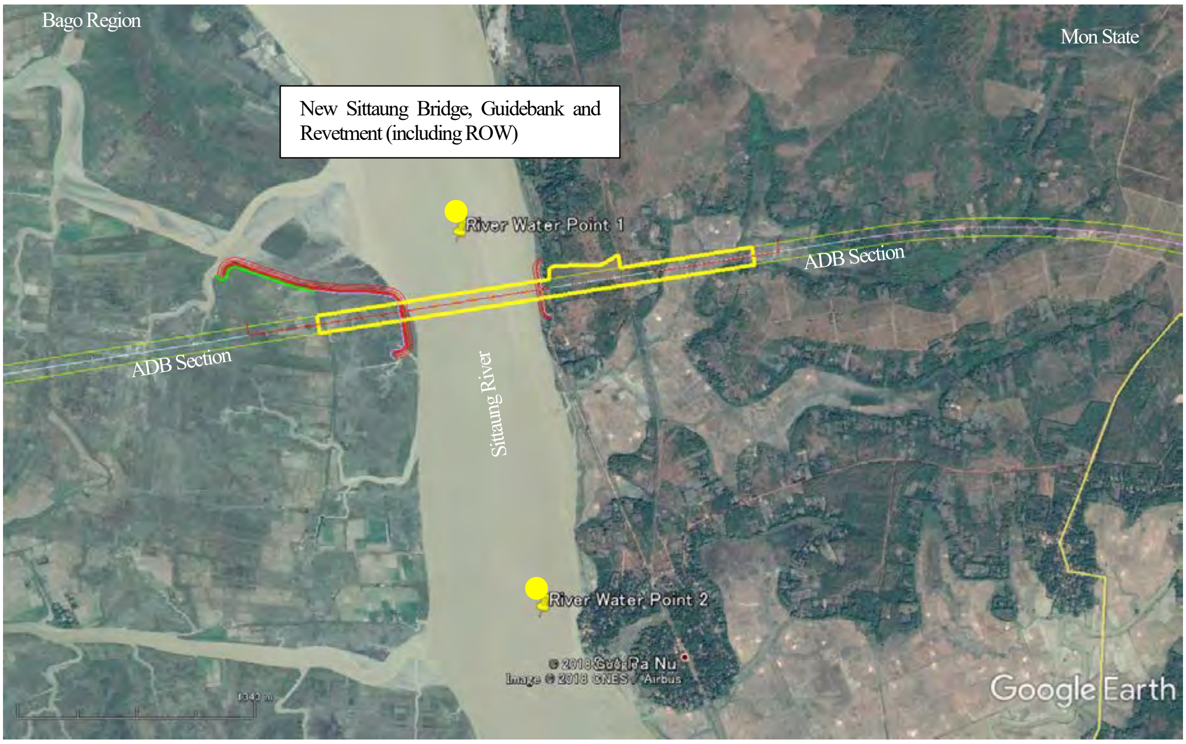
Air quality density will increase after construction due to existence of road and the driving of vehicles. However, air quality values on NO2, PM10, CO and SO2 will increase slightly, and these forecasted values satisfy the relevant standards values on traffic congestion. Thus, it is evaluated that the project does not give serious impacts on air quality.

11.7.2 Water Quality

(1) Result of Baseline Survey

1) Survey Points

2 Measurement points for water quality are shown in Figure 11.7.4



Source: JICA Study Team (based on Google Earth satellite image)

Figure 11.7.4 River Water Quality Sampling Points

2) Result of Measurement

The measured data for air quality is shown in Figure 11.7.4.

Only pH values in dry and rainy season satisfy the standard values. However, BOD and SS values are exceeding the Japanese standard. In general, land use takes place along the river in mainly soil surface of agricultural area thus turbid water of small streams flows into the main Sittaung River. Since sewerage system does not exist in some residential areas along the Sittaung River, SS and BOD values are exceeding standard values.

Table 11.7.4 Monitoring Date of River Water Quality

Location \ Parameter		Temperature [°C]	pH (hydrogen power) [no unit]	BOD (Biochemical Oxygen Demand) [mg/l]	SS (Suspended Solids) [mg/l]
River Water-1 Sittaung River (1.5km downstream from the bridge)	Rainy Season (Sep. 7th, 2017)	25	7.4	**12** (exceeding)	**212** (exceeding)
	Dry Season (Mar. 25th, 2018)	25	7.5	**14** (exceeding)	**62** (exceeding)
River Water-2 Sittaung River (2.7km downstream from the bridge)	Rainy Season (Sep. 7th, 2017)	25	7.1	**18** (exceeding)	**296** (exceeding)
	Dry Season (Mar. 25th, 2018)	25	7.6	**20** (exceeding)	**86** (exceeding)
Reference Standard	Japanese Standards	-	**6.5-8.5**	**3 (*3)**	**25**
	National Environmental Quality (Emission) Guidelines [Site Runoff and Wastewater Discharges (construction phase)]	-	6-9	30	50

Source: *1: Ministry of Environment in Japan (River Water Quality / Category B River)

(2) Potential Impacts

1) During Construction

Turbid water may be generated by earthworks and excavation in the river where bridges, guidebank and revetment are planned. Additionally, organic polluted water may be discharged from the base camp.

2) After Construction

Rain water with oil may run off from the road surface after paving the road.

(3) Impact Forecast

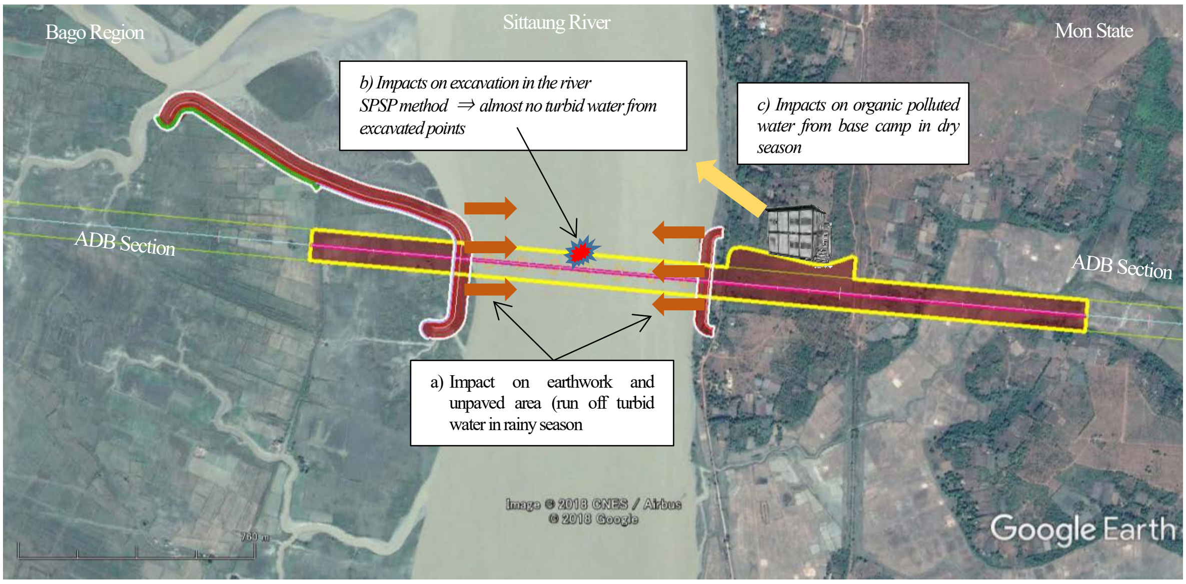
1) During Construction

Image of impacts during construction and forecasted data by source are shown in Figure 11.7.5.

Table 11.7.5 Forecasted Impacts Regarding Water Quality During Construction

Impacts \ Parameter		Forecast Condition	Forecasted Impacts
a) Impacts on earthwork and unpaved area	Run off turbid water from unpaved area after raining	Unpaved area max. 250,000 m2	Current SS : 296 mg/l Forecasted SS: 298 mg/l (* 0.97% increase)
b) Impacts on excavation in the river	Excavation at pillars in the river	Steel Pipe Sheet Piles (SPSP) methodology is adopted as piling of foundation works (see mitigation measure)	Turbid water does not come out from excavated point covered with sheet piles, thus negative impacts on turbid water is not caused.
c) Impacts on organic polluted water from the base camp	Discharge of domestic organic polluted water from the base camp	Number of Workers : 50 persons Water consumption: 60 l/person Total discharge water volume: 3,000 l/day Discharge BOD density*1: 30mg/l	Current SS : 14 mg/l Forecasted SS: 14.04 mg/l (* 0.26% increase)

*1: Environmental, Health, and Safety (EHS) Guidelines / General EHS Guidelines: Environmental Wastewater and Ambient Water Quality/ Table 1.3.1 Indicative Values for Treated Sanitary Sewage Discharges



Source: JICA Study Team (Based on Google Earth satellite image)

Figure 11.7.5 Image of Expected Impacts on Water Quality During Construction

Adoption of steel pipe sheet piles (SPSP) methodology can combine basic foundation pile and temporary cofferdam, making it possible to design and construct economically. Additionally since excavated soil is taken out and transported to other area, turbid water does not generate in the river.

Source: JFE Steel Co., Ltd.

Figure 11.7.6 Image of SPSP (Steel Pipe Sheet Piles) Methodology

2) After Construction

It has been pointed out that road surface water, including exhaust emission and adhesive material of vehicles, may give some adverse impacts on water quality in the Sittaung River. Thus, the degree of impacts are verified based on past analysis and /or researches in Japan.

According to a report which was studied by the National Institute for Land and Infrastructure Management under the Ministry of Land, Infrastructure and Tourism in Japan, 6 chemical substances including Zinc (Zn) and Lead (Pb) have been identified in the drainage water. However, all measured concentration satisfied the Japanese effluent standards.

Table 11.7.6 Water Quality from the Road Surface (2010)

Item \ Parameter	Measured Value		Standard (Discharged Water Standard Value in Japan)	Pollution Source
Zn	0.069－0.15	mg/l	2	Vehicle, Pavement
Hexavalent chromium	0.007 -0.042	mg/l	0.5	Vehicle
Water-soluble copper salt	0.026－0.046	mg/l	3	Vehicle, Pavement
Mn	0.08－0.49	mg/l	10	Auto-Chemical Products, Pavement and Concrete
Pb	0.013－0.075	mg/l	0.1	Vehicle, Pavement
B	0.039－0.092	mg/l	10	Vehicle, Auto-Chemical Products

Source: Technical Note of National Institute for Land and Infrastructure Management No.596 May 2010

(4) Mitigation Measures

1) During Construction

- ✓ Turbid water from unpaved construction area shall be treated in sedimentation pond and discharged into the river, if required.
- ✓ Waste oil shall be stored and disposed of to a designated site.
- ✓ Sanitation facilities at the labor camps and construction yard shall be provided. Also, the location of camps should avoid water sources such as springs and wells.
- ✓ Domestic waste water and night soil from base camp shall be treated and discharged to designated site and facilities.
- ✓ Septic tank for portable toilet and temporary toilet in the construction area and yard shall be used.
- ✓ Steel pipe sheet piles (SPSP) methodology shall be adopted so as not to generate turbid water at the excavated area in the river.

(5) Evaluation

During construction, turbid water is caused by construction in the area. However, forecasted impact by the project is less than 1 %. An appropriate methodology for piling foundation work is adopted so as not to generate turbid water in the river. Thus, it supposed that such negligible impacts will not cause significant impacts on the mudflats in the downstream.

It is confirmed that the water quality from the road surface doess not significant impacts based on previous study. Additionally, a wildlife specialist in Japan has commented that significant impacts on water quality were not detected in the case of Bridge Construction Project in Man Lake Ramsar Site in Okinawa Prefecture, Japan.

Therefore, it is unlikely to give significant impacts on water quality during and after construction.

11.7.3 Noise and Vibration

(1) Result of Baseline Survey

1) Noise

i) Survey Point

Baseline measurements have been conducted at 2 points as shown in Figure 11.7.1.

ii) Result of Measurement

The monitored values at 2 points from the nearest house in the project area satisfy the environmental standards in Myanmar.

The range of value is 44 - 45 dB(A) in the daytime and 41 – 45 dB(A) in the night, respectively

Table 11.7.7 Monitoring Date for Noise (March 22nd – 23rd, 2018)

Location			Survey Date	Daytime 7:00-22:00 dB(A)	Nighttime 22:00-7:00 dB(A)
Noise-1 (March 22nd, 2018) Bago Region, Waw Township, Shangai Village		At the nearest house (seasonal use)	March 22nd – 23rd, 2018	45	41
Noise-2 (March 23rd, 2018) Mon State, Kyaito Township, Sut Pa Nu Village		At monastery / school *(Sensitive Receptor)*	March 23rd – 24th, 2018	44	45
Standard	National Environmental Quality Guidelines (NEQG)	Residential, Institutional, Educational		55	45
		Industrial, Commercial*		70	70
	IFC Standards (International Finance Corporation)	Residential Area		55	45
		Commercial Area		70	70
Reference Standard	Japanese Standards Daytime: 6:00-22:00 Nighttime: 22:00-6:00	Along the trunk road		70	65

Source: JICA Study Team

* The project area is classified as non-residential area due to agricultural land-use

NEQG: National Environmental Quality Guidelines (MONREC, December 2015)

IFC Standard: Environmental, Health, and Safety (EHS) Guidelines Noise Management (April 2007)

Japan: Ministry of Environment (1998) Environmental Standards for Noise

2) Vibration

i) Survey Point

The survey points are the same as noise survey points.

ii) Result of Measurement

There are no vibration standard prescripts in Myanmar, thus the Japanese vibration standard along the trunk road has been applied on this ESIA. All monitored vibration levels have met the Japanese standard values.

Table 11.7.8 Monitoring Date for Vibration (March 22nd – 23rd, 2018)

Location			Survey Date	Daytime 7:00-20:00 dB	Nighttime 20:00-7:00 dB
Vibration-1 (March 22nd, 2018) Bago Region, Waw Township, Shangai Village		At the nearest house (seasonal use)	March 22nd – 23rd, 2018	22	29
Vibration-2 (23rd of March, 2018) Mon State, Kyaito Township, Sut Pa Nu Village		At monastery / school *(Sensitive Receptor)*	March 23rd – 24th, 2018	24	27
Standard	National Environmental Quality Guidelines (NEQG)	Residential, Institutional, Educational		-	-
		Industrial, Commercial		-	-
	IFC Standards (International Finance Corporation)	Residential Area		-	-
		Commercial Area		-	-
Reference Standard	Japanese Standards Daytime: 7:00 - 20:00 Nighttime: 20:00 - 7:00	Residential Area		65	60
		Commercial and Industrial Area		70	65

Source: JICA Study Team
* The project area is classified as non-residential area due to agricultural land-use
NEQG: National Environmental Quality Guidelines (MONREC, December 2015)
IFC Standard: Environmental, Health, and Safety (EHS) Guidelines Noise Management (April 2007)
Japan: Ministry of Environment (1998) Environmental Standards for Noise

(2) Potential Impacts

1) During Construction

Noise and vibration generation is expected due to operation of construction machines and equipment.

2) During Operation

Noise and vibration generation is expected due to driving of vehicles

(3) Impact Forecast

1) During Construction

I) Noise

i) Forecast Methodology

The noise during construction is coming from the operation of construction machines. The sound level is measured at 1 meter from the machines, the loudest noise from construction machines is 93 dB(A) for piling work and driving of sheet pile by using a vibrohammer. The noise level assessment during construction will consider sound level in different distances from the origins. Decay Formula Equation will be used in this assessment, which will be done on spare basis, as the Equation (1).

$L_{p2} = L_{p1} - 20 \log(r_2/r_1)$…………………………………………..(1)

When

L_{p1} = Sound level at distance r_1 from the origin

L_{p2} = Sound level at distance r_2 from the origin (forecasted value)

r_1, r_2 = Distance from the origin at sound level L_{p1} and L_{p2}

ii) Forecast Point and Forecasted Value

Quantitative forecast is conducted at the boundary of ROW 50m away from the centerline and monastery and school as sensitive receptor in Sut Pa Nu Village Mon State as shown is Figure 11.7.2

and Figure 11.7.3.

The forecasted value is 59 dB(A) at ROW boundary and 47 dB(A) at monastery/school, respectively. These values do not exceed the Japanese standards value for construction noise.

Table 11.7.9 Forecast Results for Construction Noise

Location	Forecast Point	Construction Activities and Related Machines	Sound Level at 1m from the Noise Source dB(A)	Background Level dB(A)	Forecasted value with BG dB(A)	Standard Value
Noise Forecast -1 Mon State, Kyaito Township, Sut Pa Nu Village	Boundary of ROW (50m from the centerline)	Piling Works (vibrohammer)	93	45	59	Myanmar National Environmental Quality Guidelines does not have any standard for construction noise. Thus Japanese standard has been applied. Japanese Construction Noise Standards 07:00-19:00 85 dB(A)
Noise Forecast -2 Mon State, Kyaito Township, Sut Pa Nu Village	At monastery / school (Sensitive Receptor, 340m from the centerline)	Piling Works (vibrohammer)	93	45	47	

Source: JICA Study Team

II.) Vibration

i) Forecast Methodology

The vibration during construction is coming from the operation of construction machines. The vibration level is measured at 1 meter from the machines, and the highest vibration from construction machines is 79 dB. The loudest noise from construction machines is 93 dB(A) for pilling work and driving of sheet pile by using a vibrohammer. The vibration level assessment during construction will consider vibration level in different distances from the origins. Decay Formula Equation will be used in this assessment, which will be done on a spare basis, as the Equation (1).

$$L_{vr} = L_{vr0} - 15\log10(r/r_0) - 8.68\alpha(r-r_0) \qquad (1)$$

When

L_{vr0} = Vibration level at distance r_0 from the origin (vibration at reference point) (dB)

r = Distance from vibration source to forecast point (m)

r_0 = Distance from vibration source to the reference point (m)

α = Friction damping coefficient (0.01-0.04)

ii) Forecast Point and Forecasted Value

Quantitative forecast is conducted at the boundary of ROW 50m away from the centerline and monastery and school as sensitive receptors in Sut Pa Nu Village, Mon State as shown in Figure 11.7.2 and Figure 11.7.3.

The forecasted value is 46 dB and 24 dB at the boundary of ROW and monastery, respectively, and the values satisfy the Japanese Construction Vibration Standard of 75 dB in the daytime.

Table 11.7.10 Forecast Results for Construction Vibration

Location	Forecast Point	Construction Activities and Related Machines	Sound Level at 1m from the Noise Source dB	Background Level dB	Forecasted Value with BG dB	Standard Value
Noise Forecast -1 Mon State, Kyaito Township, Sut Pa Nu village	Boundary of ROW (50m from the center line)	Piling Works (vibrohammer)	79	24	46	Myanmar National Environmental Quality Guidelines does not have any standard for construction vibration. Thus Japanese standard has been applied. Japanese Construction Vibration Standards 07:00-19:00 75 dB
Noise Forecast -2 Mon State, Kyaito Township, Sut Pa Nu village	At monastery / school (Sensitive Receptor, 340m from the center line)	Piling Works (vibrohammer)	79	24	24	

Source: JICA Study Team

2) After Construction

I.) Noise

i) Methodology and Forecast Points

The ASJ-2013 model in Japan is used for quantitative traffic noise forecast. Traffic number in the future (2025) is shown in Table 11.7.2.

One point is at the boundary of ROW and another point is selected as sensitive receptor for the prediction of air pollution. The locations of forecasts are shown in Figure 11.7.2 and Figure 11.7.3.

ii) Result of Forecast

The result of quantitative forecast is shown in Table 11.7.11
The forecasted values at the boundary of ROW and sensitive receptor are 59 dB(A) in the day time / 54 dB(A) in the night time and 57 dB(A) in the day time / 52 dB(A) in the night time respectively.
Based on the results of the forecast, all forecasted values satisfy Myanmar standards.

Table 11.7.11 Forecasted Noise After Construction (2025)

Location		Time Zone	Noise Level dB(A) Background Level	Forecasted Value with BG	Adopted Standard (Myanmar Standard)	Standard Value
Noise Forecast -1 Mon State, Kyaito Township, Sut Pa Nu Village	Boundary of ROW (50m from the centerline)	Daytime 7:00-22:00	45	59	70	Myanmar National Environmental Quality Guidelines *1 07:00-22:00 daytime Residential area: 55dB(A) Commercial / Industrial 70 dB(A) 22:00-07:00 Residential area: 55dB(A) Commercial / Industrial 70 dB(A)
		Nighttime 22:00-7:00	42	54	70	
Noise Forecast -2 Mon State, Kyaito Township, Sut Pa Nu Village	At monastery / school (Sensitive Receptor, 340m from the centerline)	Daytime 7:00-22:00	45	57	70	
		Nighttime 22:00-7:00	42	52	70	

Note) *1: NEQG: National Environmental Quality Guidelines (MONREC, December 2015)
Source: JICA Study Team

<u>II.) Vibration</u>

i) Methodology and Forecast Points

The formulation, which has been developed by the Ministry of Land, Infrastructure, Transport and Tourism in Japan, is used for quantitative traffic vibration forecast. Traffic number in the future (2025) is shown in Table 11.7.2.

One point is at the boundary of ROW and another point is selected as sensitive receptor for the prediction of air pollution. The forecasted locations are shown in Figure 11.7.2 and Figure 11.7.3.

ii) Forecast Point and Forecasted Value

The result of quantitative forecast is shown in Table 11.7.11.
The forecasted values at the boundary of ROW and sensitive receptor are 43 dB in the day time / 40 dB in the night time and 40 dB in the day time / 40 dB in the night time respectively.
With regard to the applied standard value, Japanese traffic vibration standard is adopted since there are no standard values on traffic vibration in Myanmar. Based on the result of the forecast, all forecasted values satisfy Japanese standards.

Table 11.7.12 Forecasted Vibration After Construction

<table>
<tr><th rowspan="2" colspan="2">Location</th><th rowspan="2">Time Zone</th><th colspan="3">Vibration Level dB</th><th rowspan="2">Standard Value</th></tr>
<tr><th>Background Level</th><th>Forecasted value with BG</th><th>Adopted Standard (Japanese Standard)</th></tr>
<tr><td rowspan="2">Noise Forecast -1
Mon State, Kyaito Township, Sut Pa Nu Village</td><td rowspan="2">Boundary of ROW (50m from the centerline)</td><td>Daytime 7:00-20:00</td><td>33</td><td>43</td><td>70</td><td rowspan="4">MNEQG does not have any standard for vibration, thus Japanese standard has been applied in this EIA.
Japanese Standard*1
07:00-20:00 daytime
Residential area: 65dB
Commercial / Industrial 70 dB
20:00-07:00
Residential area: 60dB
Commercial / Industrial 65 dB</td></tr>
<tr><td>Night time 20:00-7:00</td><td>24</td><td>40</td><td>65</td></tr>
<tr><td rowspan="2">Noise Forecast -2
Mon State, Kyaito Township, Sut Pa Nu Village</td><td rowspan="2">At monastery / school (Sensitive Receptor, 340m from Centerline)</td><td>Daytime 7:00-20:00</td><td>33</td><td>40</td><td>70</td></tr>
<tr><td>Nighttime 20:00-7:00</td><td>24</td><td>40</td><td>65</td></tr>
</table>

Note) *1: Article 16 Paragraph 1 Vibration Regulation Law in Japan (1977)
Source: JICA Study Team

(4) Mitigation Measures

1) During Construction

Forecasted values satisfy the standard value, thus mitigation measures are not required in general. However, the following mitigation measures shall be done to minimize forecasted adverse impacts.

- ✓ Construction activities and operation of construction machines shall be limited in the daytime and on weekdays.
- ✓ Construction machines shall be well-maintained and checked every day.
- ✓ Information disclosures, such as construction schedule and activities, shall be carried out in advance to the surrounding communities.

2) After Construction

Forecasted values satisfy the standard value, thus mitigation measures are not required in general. However, the following mitigation measures shall be implemented to harmonize with road development and land management along the road.

- ✓ Land use along the road shall be designated as commercial and industrial areas, and residential area shall be located behind such commercial area.
- ✓ Myanmar government shall control driving speed on the road.

(5) Evaluation

1) During Construction

As mentioned in the previous article, no standard values for construction noise and vibration have been established in Myanmar at the moment. Thus, it is recommended that other standards such as Japanese standards should be referred to in this ESIA.

The forecasted construction noise and vibration at 2 points are within Japanese standard limits, thus any mitigation measures are not necessary. Additionally, the implementation of mitigation measures minimize the impacts, and the degree of impacts will be within the acceptable level for inhabitants because of the limited period and time during construction.

2) After Construction

As a result of the quantitative analysis on the project case, all forecasted values are not exceeding the present noise level. Thus, it is unlikely to cause serious impacts on the project area.

11.7.4 Ecosystem and Protected Area

(1) Outline of Baseline Survey

1) Surveyed Items and Schedule

Surveyed items and survey dates for mammals, birds, amphibians, reptiles, insects, fishes, phytoplanktons, zooplanktons, benthos and floras are shown in next table. It is noted that bird survey has been conducted during migratory season.

The survey points for terrestrial, aquatic, guidebank and revetment are shown in Figure 11.7.7.

Table 11.7.13 Surveyed Items and Survey Dates on Faunas and Floras

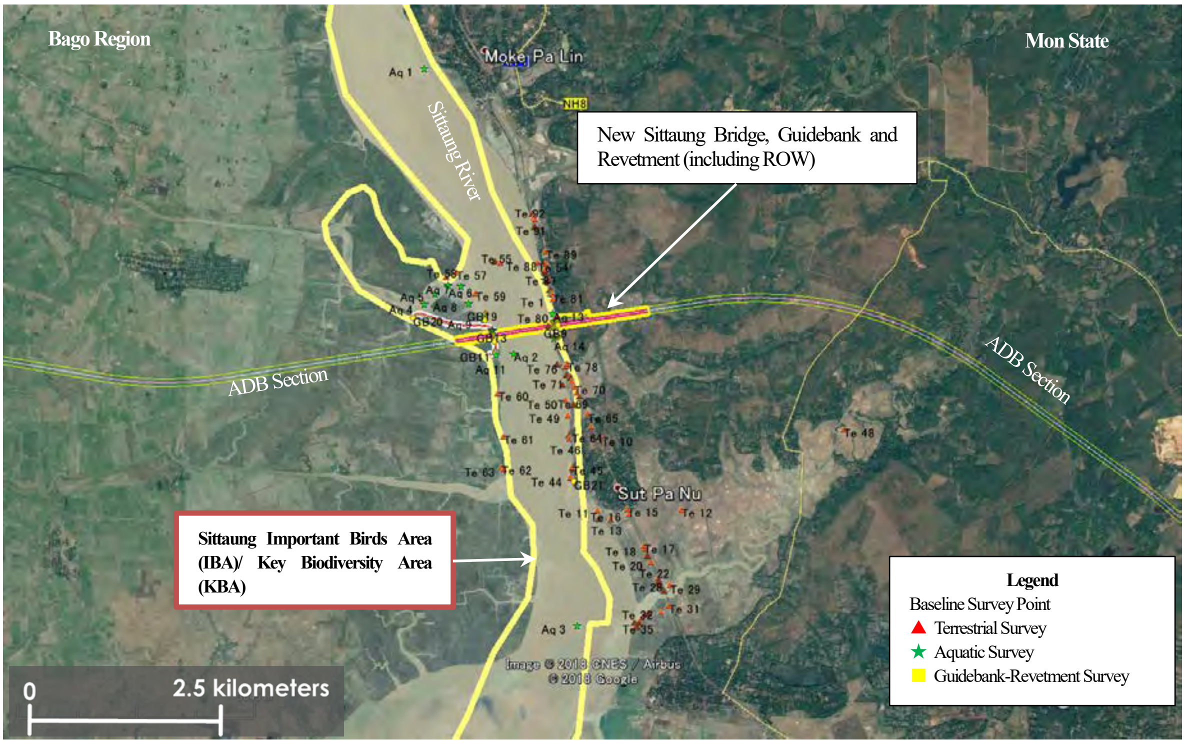
Item			Surveyed Area (Survey Range)	Date	Time	Remarks (Season)
1	Terrestrial Survey	Mammals	East Bank	Feb. 3rd – 4th, 2018	06:00-17:00	Dry Season
			West Bank	Feb. 5th, 2018	06:00-17:00	Dry Season
2		Birds	East Bank (approx.1km)	Feb. 3rd – 4th, 2018	07:00-10:00 15:00-18:00	Dry Season (migration season)
			West Bank (approx.1km)	Feb. 5th, 2018	07:00-10:00 15:00-18:00	Dry Season (migration season)
3		Amphibians	East Bank	Feb. 3rd – 4th, 2018	19:00-23:00	Dry Season
			West Bank	Feb. 5th, 2018	19:00-23:00	Dry Season
4		Reptiles	East Bank	Feb. 3rd – 4th, 2018	19:00-23:00	Dry Season
			West Bank	Feb. 5th, 2018	19:00-23:00	Dry Season
5		Insects (Dragonflies and Butterflies)	East Bank	Feb. 3rd – 4th, 2018	06:00-17:00	Dry Season
			West Bank	Feb. 5th, 2018	06:00-17:00	Dry Season
			West Bank (Guidebank)	May 23rd, 2018	09:00-13:00	Rainy Season
6		Floras	East Bank	Feb. 3rd – 4th , 2018	06:00-17:00	Dry Season
			West Bank	Feb. 5th, 2018	06:00-17:00	Dry Season
			Sittaung River (Embankment)	May 22nd, 2018	10:00-13:30	Rainy Season
			Shangai Creek and Sittaung River (Guidebank)	May 23rd, 2018	09:00-13:00	Rainy Season
7	Aquatic Survey	Fishes	Sittaung River	Feb. 4th, 2018	07:00-17:00	Dry Season
			Sittaung River (Embankment)	May 22nd, 2018	10:00-13:30	Rainy Season
			Shangai Creek and Sittaung River (Guidebank)	May 23rd, 2018	09:00-13:00	Rainy Season
8		Phytoplanktons	Sittaung River	Feb. 2nd , 2018	08:00-11:00	Dry Season
9		Zooplanktons	Sittaung River	Feb. 2nd, 2018	14:00-17:00	Dry Season
10		Benthos	Sittaung River	Feb. 3rd, 2018	08:00-11:00	Dry Season

Source: JICA Study Team

2) Surveyed Areas

The survey points for terrestrial, aquatic, guidebank and revetment is shown in Figure 11.7.7.

With regard to bird survey, approximately 1km range from the project area is covered by using a telescope.



Source: JICA Study Team (Based on Google Earth satellite image)

Figure 11.7.7 Fauna and Flora Survey Areas and Points

(2) Survey Result

1) Mammals

No species were observed in the project area in this survey, since the survey area has been developed as a paddy field and crop area. However, according to interviews with villagers, small species such as Micromys minutus and Callosciurus erythraeus are observed in the crop field and plantation area.

2) Birds

A total of (27) families of terrestrial and aquatic birds representing (51) species were identified in the survey area as shown in the next table.

All observed species are categorized as Least Concern on the Red List of International Union for Conservation of Nature (IUCN), any considerable species such as those in categories EX, EW, EN, VU and NT were not observed.

15 species were residents and 36 species migrated from other area. Both resident migratory species were feeding in the open land, forests and swampy part of the river, and roosting and nesting in the nearest forests and grass area. It appears that the project area is one of the feeding areas, and the same environment for feeding was observed in the surrounding area.

Table 11.7.14 Survey Results on Birds

No	Order Name	Family Name	Common Name	Scientific Name	IUCN status	Type	Typical Feeding Target	Feeding Area	Roosting Environment	Nesting Place
1	Falconiformes	Falconidae	Black-Shouldered Kite	*Elanus caeruleus*	LC	Resident	Insects, amphibians, reptiles, small birds	Open land, forest	Forest	Forest
2			Black-Eared Kite	*Milyus lineatus*	LC	Resident	Birds, bats, rodents	Open land, forest	Forest	Japan, India
3			Oriental Honey-buzzard	*Pernis ptilorhynchus*	LC	Migratory	Insects, small mammals, reptiles	Woodland, open areas	Forest	Asia from central Siberia east to Japan
4	Columbiformes	Columbidae	Red-Collared Dove	*Steptopelia tranquebarica*	LC	Migratory	Grass, other seeds, cereals	Cultivation, scrub, deciduous country	Plain	India, Nepal, Bhutan, Bangladesh, Myanmar, Thailand, Cambodia, Laos, Vietnam, China, Taiwan, Indonesia and Philippines
5	Psittaciformes	Psittacidae	Rose-Ringed Parakeet	*Psittacula eupatria*	LC	Migratory	Buds, fruits, vegetables, nuts, berries, and seeds	Farmlands and orchards	Forest	South and South-East Asia, ranging from Pakistan, through most of India (including the Andaman Islands and Narcondam Island), Sri Lanka, much of Nepal, Bhutan and Bangladesh (including Cocos Island), into Southern and Central Myanmar, Central Thailand, Southern and Western Laos, much of Cambodia and Southern Vietnam
6	Cuculiformes	Cuculidae	Plaintive Cuckoo	*Cacomantis merulinus*	LC	Resident	Invertebrates	Woodland, scrub, grassland, farmland	Forest edge	Forest edge
7			Greater Coucal	*Centropus sinensis*	LC	Migratory	Insects, caterpillars, bird eggs, nestlings, fruits and seeds	Jungle, cultivation, urban gardens	Forest	Indian Subcontinent and Southeast Asia
8	Strigiformes	Strigidae	Short-Eared Owl	*Asio flammeus*	LC	Resident	Small mammals	Open areas	Grasslands, open areas, low trees	Trees
9	Apodiformes	Apodidae	Asian Palm-Swift	*Cypsiurus balasiensis*	LC	Migratory	Insects	Cultivation	Palm leaf	Tropical Asia from India to the Philippines
10	Coraciformes	Alcedinidae	White-Throated Kingfisher	*Hlacyon smyrnensis*	LC	Migratory	Large crustaceans, insects, earthworms, rodents, snakes, fish and frogs	Bamboo near water	Roadside banks, grassland	Asia, from Turkey east through the Indian subcontinent to the Philippines
11			Black-Capped Kingfisher	*Hlacyon pileata*	LC	Migratory	Fish, large insects	Along estuaries and rivers	Tunnel in an earth bank	India (including the Andaman and Nicobar Islands where they occur even on remote islands like Narcondam), Sri Lanka, Kansu, Shansi, Korea, Malay Peninsula, Thailand, Myanmar, Ryu kyu Islands, Hainan, Philippines
12		Meropidae	Green Bee-Eater	*Merops orientalis*	LC	Resident	Insects	Grassland, thin scrub and forest often quite far from water	Grasslands and in open forests	Grasslands and in open forests
13	Piciformes	Ramphastida e	Coppersmith Barbet	*Megalaima naemacephala*	LC	Resident	Insects	Top branches of tall trees	Inside the trees	Inside the trees
14	Passeriformes	Dicruridae	Black Drongo	*Dicrurus macrocercus*	LC	Resident	Insects, grasslands	Among the branches	Trees	Trees
15		Corvidae	Large-Billed Crow	*Corvus japonensis*	LC	Resident	Wide range of items, anything appearing edible, alive or dead, plant or animal	On the ground or in trees	In woodland, parks and gardens, cultivated regions	In woodland, parks and gardens, cultivated regions
16		Aegithinidae	Common Iora	*Aegithina tiphia*	LC	Resident	Insects	Among the branches	Trees	In the fork of a tree
17		Laniidae	Brown Shrike	*Lanius cristatus*	LC	Migratory	Insects	Grasslands	Trees or bushes	Northern Asia from Mongolia to Siberia
18		Passeridae	House Sparrow	*Passer domesticus*	LC	Resident	Insects and many other foods, seeds of grains and weeds	Agricultural lands	Spiny shrubs and trees less than 7 ft	Trees, urban and rural areas
19	Passeriformes		Eurasian Tree-Sparrow	*Passer montanus*	LC	Resident	Predominantly a seed-eater, preferring smaller seeds of low herbs and grasses, including cultivated cereals	Agricultural lands	Cultivated areas with hedgerow trees, orchards, and gardens	Urban areas, gardens, agricultural lands and rural areas
20		Motacillidae	Paddy field Pipit	*Anthus rufulus*	LC	Resident	Mainly adult and larval insects.	Short grassland and	Open country, short grassland,	It builds its nest on the ground under a slight prominence, a tuft of

No	Order Name	Family Name	Common Name	Scientific Name	IUCN status	Type	Typical Feeding Target	Feeding Area	Roosting Environment	Nesting Place
							Stomach contents included weevils, ants, termites, and bugs	cultivation with open bare ground	paddy-fields, stubble fields and cultivations, also airfields	grass, or at the edge of a bush
21			White Wagtail	*Motacilla alba*	LC	Migratory	Beetles, dragonflies, small snails, spiders, worms, crustaceans, to maggots found in carcasses and, most importantly, flies in the order Diptera	Bare areas and urban areas especially paved areas such as car parks	Crevices in stone walls and similar natural and man-made structures	Western Europe and the Mediterranean
22			Western Yellow Wagtail	*Motacilla flava*	LC	Migratory	Wide variety of terrestrial and aquatic invertebrates; also some plant material, especially seeds	Near water, such as wet meadows	Damp or wet habitats with low vegetation, from damp meadows, marshes, waterside pastures	Temperate Europe and Asia
23			Eastern Yellow Wagtail	*Motacilla tschutschensis*	LC	Migratory	Insects	Near water, such as wet meadows	Tussocks	Australia, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, Canada, China, Christmas Island, Hong Kong, India, Indonesia, Lao People's Democratic Republic, Malaysia, Micronesia, Federated States of Mongolia, Myanmar, Nepal, Palau, Philippines, Russian Federation (Central Asian Russia, Eastern Asian Russia), Singapore, Taiwan, Province of China, Thailand; United States, Viet Nam
24		Sturnidae	Jungle Myna	*Acridotheres fuscus*	LC	Migratory	Fruit, grain and insect s	Near water or rice fields	Forest and cultivation	Tropical southern Asia from Nepal, Banglad esh, Pakistan, India and Burma eas t to Indonesia.
25			Common Myna	*Acridotheres tristis*	LC	Migratory	Insects, arachnids, cr ustaceans, reptiles, small mammals, seeds, grain and fruits and discarded waste from human habitation	Grass	Open woodland, cultivation and around habitation	Iran, Pakistan, India, Nepal, Bhutan, Bangladesh, Sri Lanka, Afghanistan, Uzbekistan, Tajikistan, Turkmenistan, Myanmar, Singapore, peninsular Thailand, Indo-China and China
26		Alaudidae	Oriental Skylark	*Alauda gugula*	LC	Migratory	Seeds and insects	Open grasslan ds	Open grassland	Southern, central and eastern Asia
27		Muscicapidae	Oriental Magpie-Robin	*Copsychus saularis*	LC	Migratory	Insects and other invertebrates	Urban gardens, forests	Urban gardens, forests	Tropical southern Asia from Bangladesh, interior India, Sri Lanka and eastern Pakistan east to Indonesia, Thailand, south China, Malaysia, and Singapore.
28			Eastern Stonechat	*Saxicola maurus*	LC	Migratory	Insects	Grassland and shrubs	Open rough scrubland or rough grassland with scattered shrubs	Temperate Asia and easternmost Europe and winters in the Old World tropics.
29			Taiga Flycather	*Ficedula albicilla*	LC	Migratory	Flying insects and other arthropods, including adult and larval lepidopterans, hymenopterans (including ants) and beetles (Coleoptera)	Open forest, forest edges	Open forest, forest edges, moist woodland, open country with scattered trees	Bangladesh, Bhutan, Cambodia, China, India, Japan, Kazakhstan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, Russian Federation (Central Asian Russia, Eastern Asian Russia), Tajikistan, Thailand, Uzbekistan, Viet Nam
30		Pycnonotidae	Red-Vented Bulbul	*Pycnonotus cafer*	LC	Migratory	Fruit, nectar, buds and invertebrates, occasionally vertebrates	Dry scrub, open forest, plains and cultivated lands	Drier deciduous woodland, sparse secondary forest, scrub, orchards and gardens, and mature forests	Tropical southern Asia, Indian subcontinent, including Sri Lanka extending east to Myanmar and parts of Tibet
31			Streak-Eared Bulbul	*Pycnonotus blanfordi*	LC	Migratory	Fruit, berries and many insects	Subtropical or tropical moist lowland forests	Inland and coastal), bamboo, open mixed deciduous woodland, semi-desert, cultivation area	Myanmar, Thailand and Peninsular Malaysia

No	Order Name	Family Name	Common Name	Scientific Name	IUCN status	Type	Typical Feeding Target	Feeding Area	Roosting Environment	Nesting Place
32		Hirundinidae	Common Sand-Martin	*Riparia riparia*	LC	Migratory	Small insects, mostly gnats and other flies	Near water, coasts, rivers and streams,	Larger bodies of water, such as rivers, lakes or even the ocean, reed beds	The whole of Europe and the Mediterranean countries, part of northern Asia and also North America
33			Dusky Crag-Martin	*Ptyoprogne concolor*	LC	Resident	Insects	Mountainous areas with cliffs and gorges	Mountainous areas with cliffs and gorges	Under a cliff overhang or on a man-made structure
34			Ban Swallow	*Hirundo rustica*	LC	Migratory	Insects	Water source, sheltered ledge	Barns or other outbuildings, Agricultural area	Europe, Asia, Africa and the Americas
35			House Swallow	*Hirundo tahitica*	LC	Resident	Mainly flying ants and Apocrita, beetles, termites	Mangroves, open country, forested hills, and human habitations	Human habitation, urban or rural settings, most parts of the world	Riverbanks, in and around around human habitation
36		Timaliidae	White-Throated Babbler	*Turdoides gularis*	LC	Resident	Insects and small trees	Scrub and bushes in semi-desert, borders of cultivation, thorn hedges, thickets, patches of bamboo	Shrub, herb and cultivation area	Bushes and semi-desert region
37		Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	LC	Migratory	Insects, adults and larvae	Open farmland, scrub, forest edges and gardens	Deciduous forests, scrub lands, mangroves, open woodlands, urban parks and gardens	South Asia, from Pakistan and India to South China, and Indonesia
38			Plain Prinia	*Prinia inornata*	LC	Migratory	Small invertebrates, chiefly insects and their larvae	Forest edges and gardens	wet lowland grassland, open woodland, scrub and sometimes gardens	Bangladesh, Bhutan, Cambodia, China, India, Indonesia, Lao People's Democratic Republic, Myanmar, Nepal, Pakistan, Sri Lanka, Taiwan, Province of China, Thailand, Viet Nam
39	Pelecaniformes	Ardeidae	Grey Heron	*Ardea cinea*	LC	Migratory	Insects, and their larvae	Wetlands	Forest	Eurasia, Africa, North America, Greenland, and Australia
40			Indian Pond-Heron	*Ardeola grayii*	LC	Migratory	Crustaceans, aquatic insects, fishes, tadpoles and sometimes leeches, crickets, dragonflies and bees	Marshy wetlands, garbage heaps, edge of ponds, and floating vegetation	Well-watered lawns or even dry grassland, marshy wetlands, edge of ponds	Southern Iran and east to Pakistan, India, Burma, Bangladesh and Sri Lanka
41			Chinese Pond-Heron	*Ardeola bacchus*	LC	Migratory	Insects, Small frogs, worms, aquatic invertebrates, fish, mollusks, worms, some terrestrial insects and even small birds	Paddy fields, swamps, shallow fresh and salt water wetlands and ponds in China	Ponds, riverbanks; also in mangroves and at tidal pools	Russian Far East, NE & E China and Japan SW to NE India (Assam) and N Myanmar. Winters in Andaman Is, Malay Peninsula, Indochina, Borneo and Sumatra, and NE to Ryukyu Is.
42			Eastern Cattle Egret	*Bubulcus coromandus*	LC	Migratory	Small vertebrate, insects, especially grasshoppers, crickets, flies (adults and maggots), and moths, as well as spiders, frogs, and earthworms	Seasonally inundated grasslands, pastures, farmlands, wetlands, cattle or other large mammals and rice paddies	Grass land, near wetlands and bodies of water	Southern and Eastern Asia and Australasia
43			Great Egret	*Ardea alba*	LC	Migratory	Fish, frogs, small mammals, and occasionally small reptiles and insects	Near wetlands and bodies of water in urban and suburban areas.	Tree and reed beds	Asia, Africa, the Americas, and southern Europe
44			Intermediate Egret	*Mesophoyx intermedia*	LC	Migratory	Frogs, snakes, insects, fish	Freshwater swamps, billabongs, floodplains and wet grasslands with dense aquatic vegetation	Freshwater swamps, billabongs, floodplains and wet grasslands with dense aquatic vegetation	Africa, South and Southeast Asia, to China, Japan, New Guinea and Australia

No	Order Name	Family Name	Common Name	Scientific Name	IUCN status	Type	Typical Feeding Target	Feeding Area	Roosting Environment	Nesting Place
45			Little Egret	*Egretta garzetta*	LC	Migratory	Mainly fish, amphibians, small reptiles, and birds	Shallow water and on land	Shores of lakes, rivers, canals, ponds, lagoons, marshes and flooded land	Temperate regions of Europe, Asia, Africa and Australia
46	Charadriiformes	Vanellidae	Grey-Headed Lapwing	*Vanellus cinereus*	LC	Migratory	Insects, worms and mollusks	Shallow water	Swamps, near rivers and rice fields	Northeast China and Japan
47		Pluvialidae	Pacific Golden-Plover	*Pluvialis fulva*	LC	Migratory	Insects and crustaceans and some berries.	Urban grasslands, tidal flats, and agricultural fields.	Urban grasslands, tidal flats, and agricultural fields.	Arctic tundra from northernmost Asia into western Alaska
48		Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC	Migratory	Insects, spiders, mollusks, crustaceans and annelid worms, tadpoles, adult frogs and toads, small fish and some plant material, such as seeds	Coastal shores, estuaries and salt marshes, to inland wetlands, riverbanks, pools,	Along river, ponds, or lakes	Europe, east across central Asia, to Kamchatka and Sakhalin, Russia, and Japan
49			Common Greenshank	*Tringa nebularia*	LC	Migratory	Small invertebrates, small fish and amphibians.	Shallow water, or by sweeping the bill sideways through the water	Taiga zone, in forest clearings, woody moorland, open bogs and marshes, and eutrophic lakes,	Europe and Asia, from northern Scotland and Scandinavia, east through central Asia and Russia, to eastern Siberia
50			Whimbrel	*Numeniua phaeopus*	LC	Migratory	Insects, crustaceans, berries, many crabs, also amphipods and other crustaceans, marine worms, small mollusks.	Mudflats, rocky shores, sandy beaches, salt marshes, flooded agricultural fields, grassy fields near coast	Shores, mudflats, marshes, tundra	Much of subarctic North America, Asia and Europe as far south as Scotland
51		Sternidae	Little Tern	*Sternula albifrons*	LC	Migratory	Fish, insects, annelid worms and mollusks	Shallow waters of channels, estuaries and lagoons, in the surf on beaches,	Sheltered coastal environments	Europe, scattered along the coast and inland in parts of Africa, in much of western, central and the extreme east and south of Asia, and in northern parts of Australia

Note) IUCN Red List Category: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE)

Source: JICA Study Team

3) Amphibians and Reptiles

A total of (10) families of amphibians and reptiles representing (14) species were identified in the survey area as shown in Table 11.7.15.

All observed species are categorized as Least Concern (LC) or Not Evaluated (NE) on the Red List of International Union for Conservation of Nature (IUCN), no considerable species such as those in categories EX, EW, EN, VU and NT were observed. All these are common species in the project area, and the same feeding, nesting and breeding areas exist not only in the project area, but also outside of the project area.

Table 11.7.15 Survey Results on Amphibians and Reptiles

No	Order Name	Family Name	Common Name	Scientific Name	IUCN status
1	Anura	Dicroglossidae	Long-Legged Cricket Frog	*Zakerana syhadrensis*	LC
2			Paddy Frog	*Zakerana limnocharis*	-
3		Rhacophoridae	White-Lipped Tree Frog	*Polypedates leucomystax*	LC
4		Bufonidae	Black-Spectacled Toad	*Duttaphrynus melanostictus*	LC
5	Squamata	Agamidae	Indo-Chinese Forest Lizard	*Calotes mystaceus*	NE
6			Oriental Garden Lizard	*Calotes versicolor*	-
7		Gekkonidae	Tokay Gecko	*Gekko gecko*	NE
8		Scincidae	Common Sun Skink	*Eutropis multifasciata*	LC
9		Colubridae	Indo-Chinese Rat Snake	*Ptyas korros*	LC
10			Pegu Kukri Snake	*Oligodon cruentatus*	LC
11		Elapidae	Monocled Cobra	*Naja kaouthia*	LC
12			Indian Cobra	*Naja naja*	LC
13		Viperidae	Eastern Russell's Viper	*Doboia russelii*	LC
14		Hydrophiidae	Beaked Sea Snake	*Enhydrina schistosa*	LC

Note) IUCN Redlist Category: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE)
Source: JICA Study Team

4) Insects

A total of (10) families of dragonflies and butterflies representing (28) species were identified in the survey area as shown in Table 11.7.16.

All observed species are categorized as Least Concern (LC) or Not Evaluated (NE) on the Red List of International Union for Conservation of Nature (IUCN), no considerable species such as those in categories EX, EW, EN, VU and NT were observed. All they are common species in the project area, and the same feeding and breeding areas exist not only in the project area, but also outside of the project area.

Table 11.7.16 Survey Results on Dragonflies and Butterflies

No		Family	Common name	Scientific name	IUCN Status
1	Dragonfly	Coenagriidae	Orange Marsh Dart	*Ceriagrion rubiae*	-
2			Azure Dartlet	*Enallagma parvum*	-
3			Senegal Golden Dartlet	*Ischnura senegalensis*	LC
4		Platycnemididae	Yellow Bush Dart	*Copera marginipes*	LC
5		Anisoptera/Gomphidaeict	Common Clubtail	*Ictinogomphaus rapax*	-
6		Libellulidae	Ditch Jewel	*Brachythemis contaminata*	LC
7			Ground Skimmer	*Diplacodes trivialis*	LC
8			Ruddy Meadow Skimmer	*Neurothemis intermedia*	LC
9			Pied Paddy Skimmer	*Neurothemis tullia*	LC
10			Green Marsh Hawk	*Orthetrum Sabina*	LC
11			Yellow Tailed Skimmer	*Potamacha congener*	-
12			Marsh Glider	*Rhodothemis Phyllis*	-
1	Butterfly	Papilionidae	Common Mormon	*Papilio polytes romulus*	-
2		Pieridae	Common Emigrant/Lemon Emigrant	*Catopsilia crocale crocale*	-

No		Family	Common name	Scientific name	IUCN Status
3			Common Emigrant/Lemon Emigrant	*Catopsilia pomona pomona*	-
4			Mottled Emigrant	*Catopsilia pyanthe pyanthe*	-
5			Chocolate Albatross	*Appias lyncida elenosa*	-
6			Common Crow	*Euploea core godartii*	-
7			Powdered Baron / Malay Baron	*Euthalia monina monina*	-
8				*Euploea hecabe contubernalis*	-
9		Danaidae	Blue Tiger	*Danaus limniace limniace*	-
10		Satyridae	Long-Brand Bushbrown	*Mycalesis visala visala*	-
11		Nymphalidae	Common Sergeant	*Athyma perius perius*	-
12			Common Baron	*Euthalia aconthea gurda*	-
13			Peacock Pansy	*Junonia almana almanac*	-
14			Sailer Butterflies / Sailers	*Neptis zaida putoria*	-
15			Common Tiger	*Danaus genutia*	-
16		Lycaenidae	Common Pierrot	*Castalius rosimon*	-

Note) IUCN Redlist Category: Extinct(EX), Extinct In the Wild (EW),Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE), "-" Not identified
Source: JICA Study Team

5) Fishes

30 species were identified on the site survey and 12 species were listed based on interview with fishermen. Most of the identified species are categorized as NE, LC and DD except for “Butter Catfish” categorized as NT (Near Threatened).

According to information on the IUCN website, original distributed area is in South Asia such as Bangladesh, India, Pakistan and Sri Lanka. Thus it is supposed that this species may stay in the Sittaung River seasonally. This species is common food fish in South Asia such as Bangladesh, India, Pakistan and Sri Lanka, thus population is decreasing due to this overexploitation. According to IUCN information, This species is considered an esteemed food fish in the Indian subcontinent and is the subject of targeted fisheries. It is occasionally caught and exported as an ornamental fish.

It is also noted that DD is “Data Deficit” meaning that data is insufficient to evaluate the risk of extinction and NE is “Not Evaluated” meaning that the species are not yet assessed.

Among totally 41 identified species, 30 species are migratory fish. Migratory fishes can be categorized into 5 types as described below. The identified number of each migratory type and migratory type of each fishes are shown in the list below and Table 11.7.17 respectively.

a) Anadromous: Anadromous fish are born in freshwater, then migrate to the ocean as juveniles where they grow into adults before migrating back into freshwater to spawn. [4 species]

b) Catadromous: Catadromous fish are born in saltwater, then migrate into freshwater as juveniles where they grow into adults before migrating back into the ocean to spawn. [2 species]

c) Amphidromou: Amphidromous fish are born in freshwater/estuaries, then drift into the ocean as larvae before migrating back into freshwater to grow into adults and spawn. [13 species]

d) Potamodromous: Potamodromous fish are born in upstream freshwater habitats, then migrate downstream (still in freshwater) as juveniles to grow into adults before migrating back upstream to spawn. [10 species]

e) Oceanodromous: Oceanodromous fish are born near spawning grounds, then drift on ocean currents as larvae before settling as juveniles to grow into adults before migrating back to spawning grounds. [1 species]

Table 11.7.17 Survey Result on Fishes

	Order	Family	Common Name	Scientific Name	Local name	IUCN Red List Status	Identification	Migratory fish or Not	Types of Fish Migration
1	*Clupeiformes*	Clupeidae	Hilsa shad	*Tenualosa ilisha**	Nga-tha-lauk	NE	on site	Migratory	Anadromous 1
2			Toli shad	*Tenualosa toil**	Nga-tha-lauk-yout-pha	NE	on site	Migratory	Anadromous 2
3			Rohtee	*Osteobrama alfredianus*		NE	on site	Not	-
4		Engraulididae	Common hairfin anchovy	*Setipinna tenuifilis**	Nga-byar	NE	on site	Migratory	Amphidromous 1
5			Burma hairfin anchovy	*Setipinna wheeleri**	Nga-byar	NE	on site	Not	-
6	*Siluriformes*	Ariidae	Soldier catfish	*Osteogeneiosus militaris**	Nga-yaung	NE	on site	Migratory	Potamodromous 1
7		Siluridae	Butter catfish	*Ompok bimaculatus*	Nga-nu-than	**NT**	on site	Migratory	Potamodromous 2
8		Bagridae	Gangetic mystus	*Mystus cavasius**	Nga-zin-yine	LC	on site	Migratory	Amphidromous 2
9			Kerala mystus	*M. armatus**	Nga-zin-yine	LC	on site	Not	-
10			Long whiskers catfish	*M. gulio**	Nga-zin-yine	LC	on site	Migratory	Anadromous 3
11			Striped dwarf catfish	*Mystus vittatus*		LC	on site	Not	-
12		Clarridae	Philippine catfish	*Clarias batrachus*	Nga-khu	LC	on site	Migratory	Potamodromous 3
13	*Mugiliformes*	Mugilidae	Corsula	*Rhinomugil corsula**	Nga-zinn	LC	on site	Migratory	Anadromous 4
14			Squaretail mullet	*Ellochelon vaigiensis**	Ka-ba-lu	NE	on site	Migratory	Catadromous 1
15	*Perciformes*	Polynemidae	Fourfinger threadfin	*Eleutheronema tetradactylum**	Ka-ku-yan	NE	on site	Migratory	Amphidromous 3
16		Sillagoginidae	Flathead solliago	*Sillaginopsis panijus**	Nga-pa-lwe	NE	on site	Migratory	Amphidromous 4
17		Trichiuridae	Largehead hairtail	*Trichiurus lepturus*	Nga-da-gon	NE	on site	Migratory	Amphidromous 5
18		Gobiidae	Tank goby	*Glossogobius giuris*	Ka-tha-poe	LC	on site	Migratory	Amphidromous 6
19			-	*Odontamblyopus rubicundus*	Nga-phyan-ni	NE	on site	Migratory	Amphidromous 7
20		Gobiidae	-	*Apocryptes bato*	Nga-phyan	NE	on site	Migratory	Amphidromous 8
21		Osphronemidae	Thick lipped gourami	*Trichogaster labiosa*	Nga-pyin-tha-let-khout	LC	on site	Not	-
22		Ambassidae	Indian glassy fish	*Parambassis ranga*	Nga-zin-set	LC	on site	Migratory	Potamodromous 4
23		Channidae	Striped snakehead	*Channa striata*	Nga-pa-naw	LC	on site	Migratory	Potamodromous 5
24		Sciaenidae	Pama croaker	*Otolithoides pama**	Nga-poke-thin	NE	on site	Migratory	Amphidromous 9
25			Belanger's croaker	*Johnius belangerii**	Nga-poke-khone	NE	on site	Migratory	Amphidromous 10
26	*Scorpaeniformes*	Platycephalidae	Bartail flathead	*Platycephalus indicus*	Nga-kyauk-pharr	DD	on site	Migratory	Oceanodromous 1
27	*Tetraodontiformes*	Tetraodontidae		*Chonerhinos naritus*	Nga-pu-tinn	NE	on site	Migratory	Amphidromous 11
28	*Cypriniformes*	Cyprinidae	Large razorbelly minnow	*Salmophasia bacaila*	Nga daung shay	LC	on site	Migratory	Potamodromous 6
29			Swamp barb	*Puntius chola*	Nga-Khone-ma	LC	on site	Migratory	Potamodromous 7
30	*Pleuronectiformes*	Cynoglossidae	Bengal tongue sole	*Cynoglossus cynoglosssus*	Nga-khway-shar	NE	on site	Not	-
31	*Decapoda*	Palaemonidae		*Exopalaemon stylifera*	Pa-zun-pyaw		on site	Not	-
32			Gaint perch/ Baramundi	*Lates sp.*			Interview	Migratory	Catadromous 2
33			Bronze featherback	*Notopterus sp.*			Interview	Migratory	Potamodromous 8
34			Pangas catfish	*Pangasius sp.*			Interview	Migratory	Potamodromous 9
35			Paradise threadfin	*Polynemus sp.*			Interview	Migratory	Amphidromous 12
36			Spottail needlefish	*Strongylura sp.*			Interview	Not	-
37				*Osteobrama sp.*			Interview	Not	-

	Order	Family	Common Name	Scientific Name	Local name	IUCN Red List Status	Identification	Migratory fish or Not	Types of Fish Migration
38			Wallago	*Wallago sp.*			Interview	Migratory	Potamodromous 10
39			Burmese carplet	*Amblypharyngodon sp.*			Interview	Not	-
40			Catfish	*Arius sp.*			Interview	Not	-
41			Spotted scat	*Scatophagus sp.*			Interview	Migratory	Amphidromous 13

Note) IUCN Red List Category: Extinct (EX), Extinct In the Wild (EW),Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE) "-" Not identified
*: Commercial species
Source: JICA Study Team

6) Planktons and Benthos

Found in lakes, streams, and oceans, Phytoplanktons are single-celled organisms that make their own food from sunlight through photosynthesis. Phytoplanktons occur almost anywhere where water and sunlight are available. While there are thousands of different types of phytoplanktons, there are several main categories that make up the most commonly occurring organisms. They are the primary producer and essential in the food chain and food web. According to the result of the present survey, species composition of phytoplanktons were low (35 species) due to the effect of high turbidity of the Sittaung River.

A type of plankton, zooplanktons consist of tiny, free-floating animals that can be found in the streams, rivers, and seas. Hundreds of thousands of different species of animals are part of zooplanktons. They are usually located near the surface of the water, or rarely on a depth of 1,000 feet. The diet of zooplankton is based on the algae and bacteria and tiny animals in the form of phytoplanktons. The number of zooplanktons was low in the survey area as they feed on phytoplanktons which were relatively quite low in the survey area.

Benthic organisms live on or just beneath the bottom of the lagoon or in the intertidal zone (mainly mudflats). They crawl over, burrow into, or are attached to the sediments or anything else on the bottom. Benthic organisms are important links in the estuarine food chains, providing an important food source for fishes, birds, and mammals. Without benthic organisms, these larger animals would not be able to survive. It is quite logical that the presence of only 5 species of benthos is probably due to the absence of mudflats in the project area and the area does not belong to the intertidal zone.

Table 11.7.18 Survey Results on Planktons

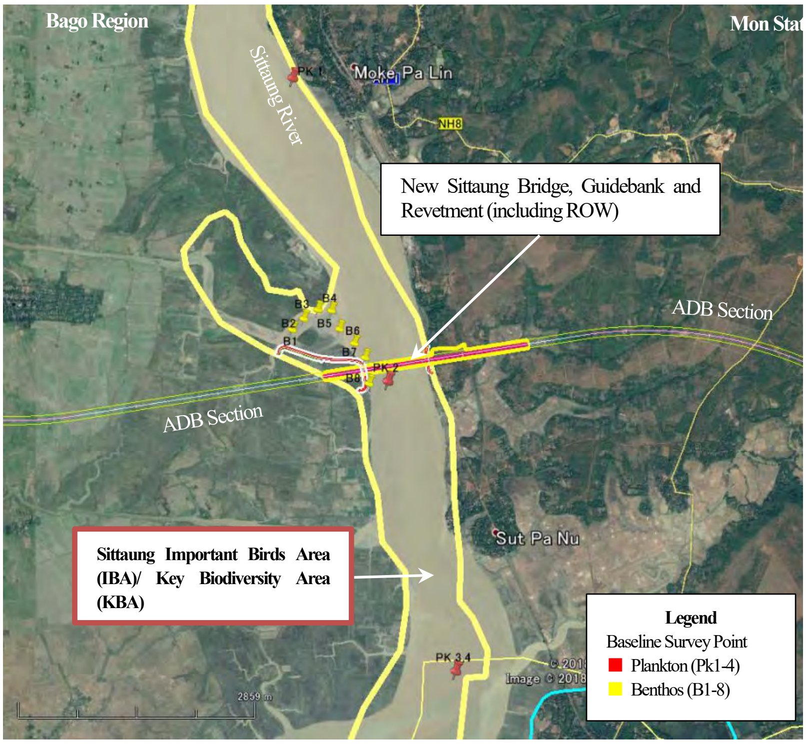
No	Type	Phylum	Class	Order	Family	Genus	Scientific name	Sampling Point			
								1	2	3	4
1	Phytoplankton	Cyanophyta	Cyanophyceae	Nostocalrs	Nostocaceae		Nostoc commune Vaucher.		+	+	
2				Oscillatoriaceales	Oscillatoriaceae		Lyngbya sp. Agardh *ex* Gomont			+	
3							Oscillatoria limosa		+	+	
4					Allacoseiraceae		Aulacoseira granulate (Ehrenberg) Simonsen	+	+	+	
5				Allacoseirales							
6		Bacillariophyta	Coscinodiscophyceae				Aulacoseira muzzanensis (Meister) Krammer		+		
7				Biddulphiineae	Hemiaulaceae		Cerataulina bicornis		+		
8				Thalassiosirales	Thilassiosiraceae		Thalassiosira oestrupii (Ostenfeld) Hasle	+		+	
9					Skeletonemataceae		Skeletonema costatum (Greville) Cleve	+		+	
10					Leptocylindriaceae		Leptocylindrus minimus			+	
11				Coscinodiscales	Coscinodisceae		Coscinodiscus centralis Ehrenberg	+	+	+	
12							Coscinodiscus granii Gough	+	+	+	
13							Coscinodiscus radiatus Ehrenberg	+	+	+	
14							Coscinodiscus oculus-iridis var. borealis		+	+	
15							Coscinodiscus perforatus var. *cellulosa* Grunow		+	+	
16							Coscinodiscus oculus-iridis Ehrenberg			+	
17							Coscinodiscus wailesii Gran and Angst			+	
18				Hemiaulales	Bellerocheaceae		Bellerochea malleus (Brightwell) Van Heurck	+			
19				Lithodesmiales	Lithodesmiaceae		Syringodium americanum Ehrenberg			+	
20											
21		Bacillariophyta	Fragilariophyceae	Fragilariales	Fragilariaceae		Synedra sp.1			+	
22							Synedra ulna Ehrenberg		+	+	
23			Bacillariophyceae	Bacillanales	Bacillariaceae		Cylindrothica closterium Lewin & Reimann			+	
24							Nitzschia filiformis (Smith) Hust			+	
25							Nitzschia delicatissima Cleve		+	+	
26							Nitzschia sigma (Kützing) Smith		+	+	
27							Nitzschia			+	
28				Surirellales	Entomoneidaceae		Surirella terryi Terry		+	+	
29				Naviculales	Naviculaceae		Trachyneis aspera (Ehrenberg) Cleve			+	
30							Craticula cuspidate (Kützing) Mann			+	
31							Gyrosigma spencerii (Quekett) Cleve			+	
32			Dinophyceae	Prorocentrales	Prorocentraceae		Prorocentrum gracile Schütt			+	
33				Gonyaulacales	Ceratiaceae		Ceratium dens Ostenfeld and Schumidt			+	
34			Zygnematophyceae				Ceratium furcoides (Levander) Langhans		+	+	
35				Zygnematales	Zygnemataceae		Spirogyra borgenana Transeau		+	+	
36			Chlorophyceae				Spirogyra protecta	+		+	
37				Sphaeropleales	Hydrodictyaceae		Pediastrum simplex		+	+	
38	Zooplankton	Rotifera	Monogononta	Plioma	Brachionidae	*Brachionus*	Brachionus falcatus	+	+	+	
39		Chaetognatha	Sagittoidea	Aphragmophora	Sagittidae	*Sagitta*	Sagitta sp.			+	
40		Arthopoda	Branchiopoda	Cladocera	Bosminidae	*Bosmina*	Bosmina longirostris	+	+	+	+
41							Bosmina longirostris var. *cornuta*	+	+	+	+
42					Chydoridae	*Allona*	Allona sp.	+			
43					Daphnidae	*Ceriodaphnia*	Ceriodaphnia sp.		+		
44						*Moina*	Moina sp.	+	+	+	+
45			Crustacea	Calanoida	Paracalanidae	*Acrocalanus*	Acrocalanus gibber	+	+	+	+
46							Acrocalanus longicornis	+	+	+	+
47						*Bestiolina*	Bestiolina sp.	+	+	+	+
48							Pseudodiaptomus sp.	+	+	+	+
49					Pontellidae	Labidocera	Labidocera euchaeta	+	+	+	+
50					Acartiidae	Acartiella	Acartiella sp.	+	+	+	
51				Cyclopoida	Oithonidae	Oithona	Oithona nana	+	+	+	+
52							Oithona rigida	+	+	+	+
53		Arthopoda	Crustacea	Harpacticoida	Euterpinidae	Euterpina	Euterpina acutifrons	+	+	+	+
54					Ectinosomatidae	Microsetella	Microsetella norvegica	+			
55				Mysidacea	Mysidae		Young mysid	+	+	+	+
56				Decapoda			Megalopa larvae of crab	+	+	+	+
57		Chordata	-	-	-	-	Fish larvae	+	+	+	+

Source: JICA Study Team

Table 11.7.19 Survey Results on Benthos

No	Phylum	Class	Order	Family	Scientific name	Sampling Point							
						1	2	3	4	5	6	7	8
1	Annelida	Polychaeta	Errantia	Glyceride	*Glycera sp.*				+				
2	Mollusca	Gastropoda	Mesogastropoda	Littorinidae	*Litorina planaxis*				+		+		
3			Neogastropoda	Ranellidae	*Cymatium pteifferianum*	+							
4	Arthropoda	Crustacea	Decapoda	Ocypodidae	*Ilyoplax pusillus*			+	+	+			
5		Insecta	Diptera	Dolichopodiae	*Diptera sp.*	+		+		+			+

Source: JICA Study Team



Source: JICA Study Team (Based on Google Earth satellite image)

Figure 11.7.8 Plankton and Benthos Survey Areas and Points

7) Flora

A total of 170 species were identified in the survey area. In these species, "Borassus flabellifer" is categorized as EN, while "Shorea cinerea", "Abarema bigemina" and "Santalum album" are categorized as VU, respectively, as shown in the table below.

Table 11.7.20 Survey Results on Flora

No	Family	Scientific name	Common Name	Type	Red List Status
1	Arecaceae	*Borassus flabellifer*	Htan	Tree	**EN**
2		*Cocos nucifera*	Ohn	Tree	NE
3	Aloaceae	*Aloe vera*	Shazaung-let-pet	Herb	NE
4	Acanthaceae	*Acanthus ebracteatus*	Khaya	Shrub	LC
5		*Hygrophila phlomoides*	Migyaung kunbat	Herb	NE
6		*Hygrophila phlomoides Nees*	Myanmar Linseed	Herb	-
7		*Justicia gendarussa*	Willow-leaved justicia	Shrub	-
8	Amaranthaceae	*Aerva javanica*	On-hnye	Herb	NE
9		*Alternanthera sessilis*	Sessile joyweed	Small tree	LC
10	Anacardiaceae	*Bouea burmanica*	Mayan	Tree	-
11		*Linnea coromandelica*	Nebe	Tree	LC
12		*Mangifera calonrura*	Taw-tha-yet	Tree	DD
13		*Mangifera indica*	Tha-yet	Tree	NE
14		*Spondias pinnata*	Gwe	Tree	DD
15	Annonaceae	*Annona muricata*	Duyin –awza	Small tree	NE
16	Apocynaceae	*Alstonia scholaris*	Taung-mayo	Tree	LC
17	Aquifoliaceae	*Ilex sulcala*	Sauk yo	Tree	NE
18	Asclepiadaceae	*Sarcolobus carinatus*	Ka-yu	Climber	LC
19		*Sarcolobus globosus*		Climber	LC
20	Asteraceae	*Chromolaena odorata*	Bezat	Shrub	LC
21		*Eclipta alba*	Kyeit- hmon	Herb	LC
22	Bignoniaceae	*Heteropharagma adnophylla*	Phat than	Tree	-

No	Family	Scientific name	Common Name	Type	Red List Status
23		*Markhamia stipulata*	Ma-hlwa	Tree	-
24		*Oroxylum indicum*	Kyaung –sha	Tree	-
25	Bombacaceae	*Bombax ceiba*	Letpan	Tree	NE
26		*Ceiba pentandra*	Le-moh-pin	Tree	LC
27	Caeasalpiniaceae	*Bauhina ornada*	Swe-daw –new	Climber	LC
28	Caeasalpiniaceae	*Bauhina pottsii*	Swe-daw	Small tree	LC
29		*Bauhina sulphurea*	Swe-daw	Tree	-
30		*Caesalpinia pulcherrima*	Sein-pan –galay	Small tree	-
31		*Cassia angustifolia*	Pwegaing	Shrub	LC
32		*Cassia bicapsularis*	Dan-kywe	Shrub	LC
33		*Cassia fistula*	Ngu	Tree	LC
34		*Cassia mimosoides*	Mezali	Shrub	-
35		*Cassia Multijuga*	Thiho-ngu	Small tree	-
36		*Delonix regia*	Sein-pan	Tree	LC
37		*Senna siamea*	Taw-mezali	Tree	NE
38		*Tamarindus indica*	Magyi	Tree	LC
39	Caricaceae	*Bhesa robusta*	Gwe-dauk	Tree	LC
40		*Carica papaya*	Thin-baw	Small tree	DD
41	Combretaceae	*Combretum acuminatum*	Nabu-new	Climber	NE
42		*Terminalia bellerica*	Thit-seint	Tree	NE
43		*Terminalia catappa*	Banda	Tree	NE
44	Convolvulaceae	*Erycibe citriniflora*	Eikhmwe	Small tree	LC
45		*Ipomaea bona*	Kyan-hin –nyunt	Climber	LC
46		*Ipomaea reptans*	Ye-kanzun	Climber	LC
47	Cucurbitaceae	*Citrullus lanatus*	Hpaye	Climber	LC
48		*Cucumis saativus*	Thakha	Climber	-
49		*Cucurbita moschata*	Hpayan	Climber	-
50		*Trichosanthes cucurmerina*	Thabut kha	Climber	-
51	Dipteracarpaceae	*Parashorea dussoudii*	Kaduk	Tree	-
52		*Shorea cinerea*	Kadut-n	Tree	**VU**
53	Dipteracarpaceae	*Shorea entic*	Thit-ya	Tree	-
54	Elaeacarpaceae	*Elaeocarpus griffithis*	Kalaminkye	Tree	NE
55	Euphorbiaceae	*Aporusa willosula*	Thit-khauk	Small tree	NE
56		*Baccaurea parviflora*	Kanaso	Small tree	NE
57		*Croton joufra*	Thet-yin –gyi	Tree	LC
58		*Emblica officinalis*	Zibyu	Tree	NE
59		*Euphorbia antiquorum*	Kun	Small tree	NE
60		*Macaranga senticulate*	Phet-Wun	Small tree	NE
61		*Macaranga albus*	Phet-waing	Tree	-
62		*Ricinus communis*	Kyet-su	Small tree	-
63		*Euphorbia neriifolia L.*	Indian Spurge Tree	Small tree	-
64	Fabaceae	*Butea superba*	Pauk-new	Climber	-
65		*Desmodium oblongum*	Kyu	Shrub	LC
66		*Dilochos uniflorus*	Pe-bi-zat	Climber	LC
67		*Millettia pachycarpa*	Mi-gyaung new	Climber	-
68		*Ptcrocarpus macrocarpus*	Thit padauk	Tree	NE
69		*Albizia lebbeck*	Siris tree	Tree	-
70		*Mimosa pudica L*	Sensitive Plant	Herb	LC
71		*Mimosa pigra L.*	Giant sensitive tree	Herb	-
72		*Erythrina indica*	Coral tree	Tree	LC
73		*Rhynchosia minima*	Least snout-bean	Herb	-
74		*Sesbania bispinosa*	Sesbania Pea	Herb	LC
75	Flacauritiaceae	*Hydnocarpus heterophyllus*	Kalaw-so	Tree	-
76	Hypericaceae	*Calophyllun amoenum*	Tharipii	Tree	-
77		*Cratoxylum nexiifolium*	Bebya	Tree	-
78		*Mesua ferrea*	Gangaw	Tree	-
79	Lamiaceae	*Ocimum americanum*	Pin-sein	Herb	LC
80		*Clerodendrum speciosissimum Van Geert ex C.Morren*	Japanese Glorybower	Shrub	-
81		*Mentha arvensis L.*	Field mint	Herb	LC
82	Lauraceae	*Litiea monapetala*	Ondon	Small tree	NE
83	Lythraceae	*Lagerstroemia floribunda*	Pyinma	Tree	LC
84		*Lawsonia alba*	Dan	Shrub	LC

No	Family	Scientific name	Common Name	Type	Red List Status
85	Mimosaceae	*Abarema bigemina*	Danyin	Tree	**VU**
86	Mimosaceae	*Acacia concinna*	Kinmun-gin	Climber/Creeper	NE
87	Oxalidaceae	*Auerrhoa carambola*	Zaung-yar	Small tree	NE
88	Poaceae	*Bambusa polymorpho*	Kyathaung-wa	Bamboo	NE
89		*Gigantochloa auriculata*	Thaik-wa	Bamboo	NE
90		*Gigantochloa nigrociliata*	Wa-ya	Bamboo	NE
91		*Gigantochloa wanat E.G.Camus*	Wa-net	Bamboo	NE
92		*Pseudoraphis brunoniana*	Myet	Grass	NE
93		*Saccharum spontanensis*	Kaing	Grass	NE
94		*Thyrsostachys siamensis*	Hti-Yo –wa	Bamboo	NE
95	Papilionaceae	*Erythrina crista*	Kathit	Small tree	NE
96	Passifloraceae	*Adenia caediophylla*	Kyet-hin-kha-nwe	Climber/Creeper	NE
97	Piperaceae	*Piper bettle*	Kun	Climber/Creeper	NE
98		*Piper betle L.*	Betelvine	Climber	-
99		*Piper longum*	Nga yoke kaung	Climber/Creeper	NE
100		*Piper nigrum*	Sayo	Climber/Creeper	NE
101	Rhamnaceae	*Ziziphus oenopila*	Supauk-pin	Shrub	NE
102		*Ziziphus rugosa*	Taw-zi	Small tree	NE
103	Rhizophoraceae	*Carallia brachiata*	Mani –awga	Tree	NE
104	Rubiaceae	*Morinda angustifolia*	Yeyo	Small tree	NE
105	Rutaceae	*Aegle marmelos*	Okshit	Tree	NE
106		*Citus hystrix*	Shauk- cho	Small tree	NE
107		*Citus maxima*	Kywe-gaw	Small tree	NE
108		*Murraya koenigii*	Pyindawthein	Small tree	NE
109	Santalaceae	*Santalum album*	Nant-thar-phyu	Small tree	**VU**
110	Mimosaceae	*Acacia concinna*	Kinmun-gin	Climber/Creeper	NE
111	Mimosaceae	*Acacia pennata*	Suboke	Climber/Creeper	M
112		*Adenanthera pavonia*	Ywe	Tree	NE
113		*Albizia chinensis*	Kayan	Tree	-
114		*Albizia lebbek*	Kokko	Tree	NE
115		*Albizia procera*	Sit-pin	Tree	LC
116		*Leucaena glauea*	Bawzagaing	Tree	-
117		*Pithecellobium dulce*	Kala-magyi	Tree	NE
118	Moraceae	*Artocarpus heterophyllus*	Peinne	Tree	-
119		*Ficus altissima*	Naung-peinne	Tree	-
120		*Ficus annulata*	Naung-tha-phan	Tree	-
121		*Ficus glabella*	Naung-tha-bye	Tree	-
122		*Ficus glomerata*	Naung-tha-phan	Tree	-
123		*Ficus indica*	Naung-tha-bye	Tree	DD
124		*Ficus virens*	Naung-gyin	Tree	-
125		*Ficus chartacea*	Tha-phan	Tree	-
126		*Ficus religiosa*	Pipal	Tree	-
127		*Ficus hispida L.f.*	Hairy fig	Tree	-
128	Moringaceae	*Moringa oleifera*	Dan-da-lum	Tree	NE
129	Myrtaceae	*Eucalyptus comaldulensis*	U-ca-lit	Tree	NE
130		*Eugenia amplexicaulis*	Thabya-ge	Tree	NE
131		*Syzygium attenuatum*	Thabye	Tree	NE
132		*Syzygium grande*	Thabye-gyi	Tree	NE
133		*Syzygium oblatum*	Thabye-ni	Tree	NE
134		*Syzygium polyanthum*	Malaga	Tree	NE
135		*Psidium guajava*	Malaka	Small tree	NE
136	Nyetaginaceae	*Bougainvillea glabra*	Sekku pan	Climber/Creeper	LC
137	Oleaceae	*Jasminium scandens*	Taw-Sabe	Shrub	-
138	Oxalidaceae	*Auerrhoa carambola*	Zaung-yar	Small tree	NE
139	Poaceae	*Bambusa polymorpho*	Kyathaung-wa	Bamboo	NE
140		*Gigantochloa auriculata*	Thaik-wa	Bamboo	NE
141		*Gigantochloa nigrociliata*	Wa-ya	Bamboo	NE
142		*Gigantochloa wanat E.G.Camus*	Wa-net	Bamboo	NE
143		*Pseudoraphis brunoniana*	Myet	Grass	NE
144		*Saccharum spontanensis*	Kaing	Grass	NE
145		*Thyrsostachys siamensis*	Hti-Yo –wa	Bamboo	NE
146	Passifloraceae	*Adenia caediophylla*	Kyet-hin-kha-nwe	Climber/Creeper	NE

No	Family	Scientific name	Common Name	Type	Red List Status
147	Piperaceae	*Piper bettle*	Kun	Climber/Creeper	NE
148		*Piper longum*	Nga yoke kaung	Climber/Creeper	NE
149		*Piper nigrum*	Sayo	Climber/Creeper	NE
150	Rhamnaceae	*Ziziphus oenopila*	Supauk-pin	Shrub	NE
151		*Ziziphus rugosa*	Taw-zi	Small tree	NE
152	Rhizophoraceae	*Carallia brachiata*	Mani –awga	Tree	NE
153	Rubiaceae	*Morinda angustifolia*	Yeyo	Small tree	NE
154	Rutaceae	*Aegle marmelos*	Okshit	Tree	NE
155		*Citus hystrix*	Shauk- cho	Small tree	NE
156		*Citus maxima*	Kywe-gaw	Small tree	NE
157		*Murraya koenigii*	Pyindawthein	Small tree	NE
158	Tiliaceae	*Microcos paniculata*	Mya-yar	Small tree	-
159	Verbenaceae	*Clerodendrum patasites*	Phet –kha	Small tree	-
160	Verbenaceae	*Gmelina arborea*	Ya ma nay	Tree	NE
161		*Tectona grandis*	Kyun	Tree	NE
162	Vitaceae	*Vitex trifolia*	Kyaung- ban	Small tree	-
163	Urticaceae	*Bochmeria hamiltoniana*	Kya-sha	Shrub	-
164	Zingiberaceae	*Curcuma caesia Roxb.*	Black turmeric / Hta-min-sok	Herb	-
165	Capparaceae	*Crateva religiosa*	Three-leaved caper	Tree	-
166	Boraginaceae	*Heliotropium indicum*	Indian heliotrope	Herb	LC
167	Malvaceae	*Hibiscus lunarifolius*	Chinbaung-yaing	Shrub	-
168	Meliaceae	*Sandoricum koetjape*	Santol	Tree	-
169	Cyperaceae	*Cyperus compressus L.*	Poorland flatsedge	Herb	LC
170	Solanaceae	*Physalis minima*	Wild gooseberry	Herb	LC
171	Onagraceae	*Ludwigia adscendens*	Water primrose	Herb	-

Note) Extinct(EX),Extinct In the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE), "-" Not identified
Source: JICA Study Team

Features of considerable species categorized as EN and VU in the IUCN Red List are shown below.

Only "Shorea cinerea" is a native species which has been identified out of 100m range (right of way : ROW). However, based on IUCN information, original distributed area is hilly and mountainous area with elevation 400-1200m of southern part of Myanmar such as Tanintharyi Region. Thus it is supposed that this individual may be planted by villager or prominence individual.

Additionally the other 3 species are not native species, they may also prominence individual or planted by villager.

Table 11.7.21 Features of Considerable Flora Species

Name of Species	IUCN Status	Countries Distributed	Major Threat (based on IUCN)	Situation on Site	Identified Location
Borassus flabellifer 	EN	Madagascar	There is loss of habitat due to expanding agriculture and increasing fire frequency **in Madagascar.**	Identified individual is cultivated, not natural	Out of the project area (ROW)
Shorea cinerea	VU	Lao People's Democratic Republic, Malaysia, **Myanmar (only Tanintharyi Region)**, Thailand, Viet Nam	This is a woody plant used for timber in general. This species has had a 30–50% population reduction in the past three generations (300 years) due to loss of habitat for expanding agriculture, exploitation of the species and forest clear cutting. Decline is likely to continue into the future.	This species was recorded out of ROW, however, based on IUCN information, original distributed area is hilly and mountainous area (elevation 400-1200m) of southern part of Myanmar. Thus this individual may be planted by villager or prominence individual.	Out of the project area (ROW)
Abarema bigemina	VU	Sri Lanka	No description However, native is in Sri Lanka and the number of individuals has decreased.	Recorded individual is not natural.	Out of the project area (ROW)
Santalum album	VU	China, India	Fire, grazing and most importantly,	Recorded individual is not natural.	Out of the

Name of Species	IUCN Status	Countries Distributed	Major Threat (based on IUCN)	Situation on Site	Identified Location
		(Karnataka, Tamil Nadu), Indonesia (Lesser Sunda Is.), Philippines	exploitation of the wood for fine furniture and carving and also for oil are threatening the species. Smuggling is assumed to have reached alarming proportions.		project area (ROW)

Source: IUCN Red List (http://www.iucnredlist.org as of Oct. 2018)

(3) Evaluation Regarding Critical Natural Habitat

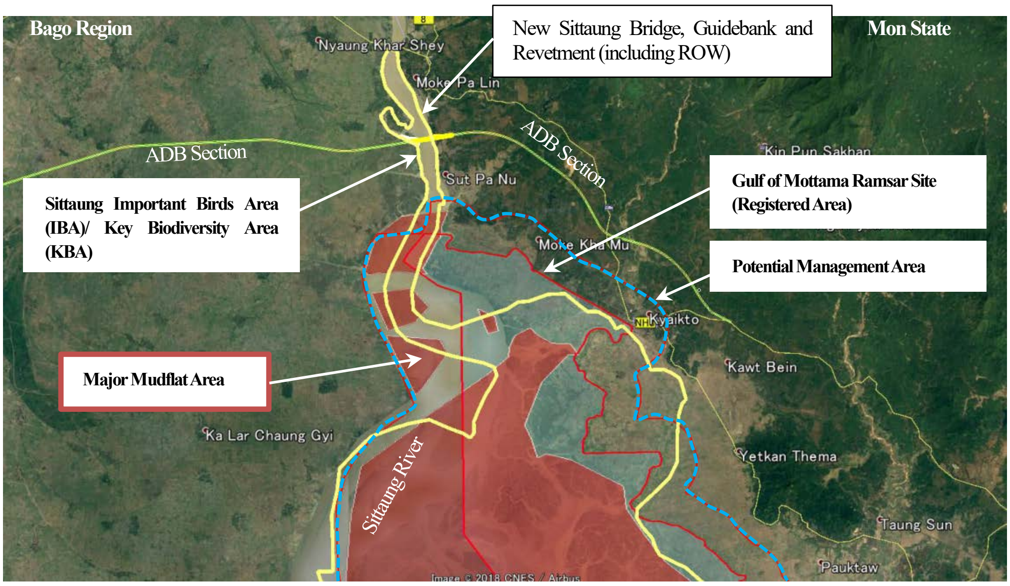
As explained in the previous article on "Natural Habitat Areas", the planned bridge is passing through a part of IBA/ KBA. Based on the result of fauna-flora surveys, the project area including a part of IBA/KBA is evaluated whether it is categorized as an important natural habitat in accordance with the JICA Guidelines for Environmental and Social Considerations (2010) as shown below.

As a result of the analysis regarding critically natural habitat as shown in Table 11.7.22, it is evaluated that the project site as a part of IBA/KBA is NOT categorized as critically natural habitat in accordance with JICA Guidelines.

Table 11.7.22 Assessment Regarding Critical Natural Habitat

Criteria under JICA Guideline*1	Fact and Evaluation	Applicability
Criteria-1 Habitats important for the species that are classified into "Critically Endangered (CR), "Endangered (EN)", "Vulnerable (VU)", and "Near Threatened (NT)" under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species	According to secondly data for IBA/KBA, some considerable species categorized as CR, EN and NT are listed up as shown in Table 10.2.8 and 10.2.10. However such considerable bird species have not been observed in the bird survey during migratory season in 2018. Additionally 1 fish species and 3 flora species have been recorded out of ROW, however, native and main distribution area is not project area. The project area is developed as an agricultural and paddy area without any natural vegetation forests. Thus it is speculated that any desirable nesting and roosting areas are not existing in the project area. In the river area, there are no main mudflat areas as feeding area for migratory birds and other fauna-flora species. (See main mud-flat area in Figure 11.7.9) Thus although some considerable species have been observed out of ROW and Sittaung River, the project area is not main distributed area nor/or important area as feeding and nesting.	Criteria is not applicable for the project area in the part of Gulf of Mottama IBA/KBA
Criteria-2 Habitats important for endemic species and/or limitedly distributed species	In the fauna-flora surveys, such endemic and/or limitedly distributed species have not been observed.	Criteria is not applicable for the project area in the part of Gulf of Mottama IBA/KBA
Criteria-3 Internationally important habitats that support migratory species and/or flock-forming species	The most important function for bird's wintering spot is securing of feeding. Considerable migratory birds can find their targets in mudflat area. In the project area, no major mudflat is observed. The main mudflat exists in the Potential Management area and registered area of the Ramsar Site.	Criteria is not applicable for the project area in the part of Gulf of Mottama IBA/KBA
Criteria-4 Critically endangered ecosystems and/or unique ecosystems	Since the project area is developed as an agricultural area, such critically endangered ecosystem and/or unique ecosystem is not observed.	Criteria is not applicable for the project area in the part of Gulf of Mottama IBA/KBA
Criteria-5 Areas related to important evolutionary processes	Past study regarding important evolutionary processes is not reported in this area.	Criteria is not applicable for the project area in the part of Gulf of Mottama IBA/KBA

Source: *1: Answers to Frequently Asked Questions About Japan International Cooperation Agency (JICA)'S Guidelines For Environmental and Social Considerations (July 20, 2011, revised on February 5, 2016)



Source: JICA Study Team (Based on Google Earth satellite image)

Figure 11.7.9 Major Mudflat Distribution in IBA / KBA and Ramsar Site

(4) Potential Impacts

1) During Construction

The project area is almost a developed area such as paddy field and rubber tree plantation. However construction activities with noise and vibration and the generation of turbid water in the river may give some impacts on the surrounding ecosystem. Additionally, the cutting of rubber forest may give impact on its ecosystem.

The alignment is not passing through any law-based natural protected areas. Potential management area is located 3.6 km away downstream and the registered Mottama Gulf Ramsar Site as a law-based protected area is located downstream 5.5 km away from the project area. Construction activities and construction noise and vibration may give impacts on some species which have feeding areas near project area, and turbid water which is generated from construction area may give impacts on the ecosystem in the Gulf of Mottama Ramsar Site.

Furthermore, the project area is passing through the Sittaung Important Birds Area (IBA) and Key Biodiversity Area (KBA) which are proposed by international NGOs. Although IBA and KBA are not law-based protected areas, it is expected that project activities may give some impacts.

2) After Construction

An existence of structures such as bridge, approach road and guidebank, and the traffic flow with noise and vibration may give adverse impacts on some species which have feeding area in the project area

(5) Impact Forecast

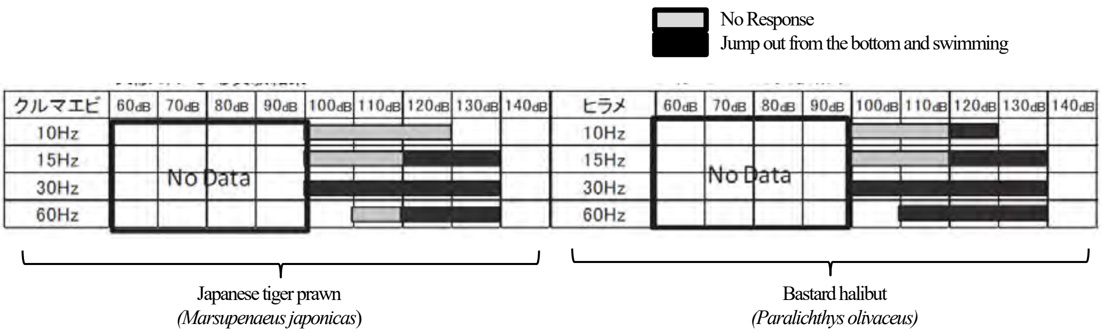
1) During Construction

Expected impact factor and degrees in the project area, IBA and Mottama Ramsar Site during construction are shown below:

Table 11.7.23 Impact Item and Factor on Fauna and Flora During Construction

Impact Area and Degree / Impacted Factor	Affected Area	
	Project Area and surrounding area within 500m / IBA-KBA	Ramsar Site Potential Management Area: Approx. 3.6km away Ramsar Registered Area: Approx. 5.5km away
1.Alternation of land due to earthwork and cutting trees	1) Land Area Paddy field and rubber trees are alternated by earthwork in the affected area. Most of fauna species avoid this area and stay in the same habitats outside of the project area. With regard to flora, since the main land is used as a paddy field, there are no considerable adverse effects on the ecosystems, and the impacts on the ecosystem are not serious. 2) River Area Excavation at planned pillars may give adverse impacts on aquatic life such as fishes, benthos and plants. Some considerable fauna-flora species have been recorded in the survey. General species living in the affected area may be impacted, but the same habitats are distributed in the surrounding area.	No impacts are expected because a direct alternation in Ramasr Site is not planned
2.Human Activities	1) Land Area Mammal species and birds avoid feed and roosting in ROW; however, the same condition exists outside of ROW. 2) River Area Birds and fishes avoid feeding in ROW; however such species exhibit the same condition outside of ROW.	No impacts are expected because human activities in the project area are not confirmed in Ramsar Site.
3.Construction Noise and Vibration	1) Land Area Mammal species and birds avoid feeding and roosting in ROW; however, the same condition exists outside of ROW. The estimated noise and vibration level on the boundary of ROW is 59 dB(A) noise and 46 dB vibration, respectively. It is not likely to give significant impact on feeding area and roosting area. However, mitigation measures for the minimization of construction of noise and vibration should be in place. 2) River Area Birds and fishes avoid feeding in ROW, and exhibit the same condition outside of ROW. It is predicted that a steady source of noise such as operation of construction machines does not give serious impacts on birds; however, unsteady noise such as piling by drop hammer may pose a threat to birds and keep them away from the construction area. The surrounding area has the same environment for feeding and roosting. With regard to vibration impact on fishes in the water, according to the reference, it is observed that more than 100 dB vibration gives impacts on fishes and shellfishes. However, the vibration level of vibrohammer is approx. 80 dB, thus it is expected that the given impact is not serious. (See Figure 11.7.10)	[Estimated noise level] · Background Level: 45 dB(A) · Forested level: 45 dB(A) at Management and Core Area [Estimated vibration level] · Background Level: 24 dB · Forested level: 24 dB at Management and Core Area Construction noise and vibration does not give any impact on the Ramsar Site.
4.Generation of Turbid water in the river and organic polluted water	1) Impact from Excavation of Pillars in the River Steel pipe sheet piles (SPSP) methodology is adopted so as not to generate turbid water at excavated area in the river, thus the impact is at negligible level. 2) Impact from the Construction Area (Turbid Water) Developed and opened area as a construction area may generate turbid water during rainy season. Forecasted data is shown below: · Current SS: 296 mg/l (Rainy Season) · Forecasted SS: 298 mg/l (Rainy Season) Increase rate is less than 1% and does not cause significant impact 3) Impact from Organic Polluted Water Organic polluted water may be generated from the base camp. Forecasted density of BOD is show below: · Current BOD: 14 mg/l (Dry Season) · Forecasted BOD: 14.04 mg/l (Dry Season) Increase rate is less than 0.3% and does not cause significant impact	←Ditto
5.Changing Hydrological Situation	Construction of pillars in the river may change the hydrological situation and give impact on the surrounding feeding area such as mud-flat for birds and other fauna species. According to hydrological simulation, the height of water surface may change in the range of approx. 120 m to downstream side. In this area, no mudflat is observed. Thus, it is not likely to give any impacts on the ecosystem, especially for birds.	←Ditto The Potential Management Area and registered Ramsar Site are located more than 3.6km and 5.5km away, respectively, from the project area, thus no impact is predicted from the project during construction.

Source: JICA Study Team



Source: The Influence That Vibration To Occur By Marine Construction Gives To The Benthos Of The Peripheral Sea Area (July, 2008/ Kana UEDA)

Figure 11.7.10 Impact of Vibration Level on Aquatic Fauna Based on Other Study

With regard to bird species, no considerable species such as those in categories EX, EW, EN, VU and NT are observed. No considerable species in the secondary data IBA/KBA as shown in Table 11.2.10 have been observed in the baseline survey because the survey area is quite a small area outside of IBA / KBA area which has a distribution of approx. 110,000 ha. Also, the main feeding and roosting areas for main considerable migratory birds is the mudflat area located at least 3.6km away from the project area. Thus, the project does not give any significant impact on such species. Additionally, some considerable fishes and flora species have been identified. However, according to the description of IUCN, the reasons why species are threatened are described mainly in the native area and not in all identified areas. Thus, the project activities do not give serious impacts on such species.

2) After Construction

The expected impact factor and degrees in the project area, IBA and Mottama Ramsar Site after construction are shown below:

Table 11.7.24 Impact Items and Factors on Fauna and Flora After Construction

<table>
<tr><td rowspan="2">Impact Area and Degree
Impacted Factor</td><td colspan="2">Affected Area</td></tr>
<tr><td>Project area and the surrounding area within 500m / IBA-KBA</td><td>Ramsar Site
Potential Management Area: Approx. 3.6km away
Ramsar Registered Area: Approx. 5.5km away</td></tr>
<tr><td>1. Road kill</td><td>Road kill of mammals and birds are expected, thus the following mitigation measures are required for minimization of impacts:
· Setting up of fence at the boundary of ROW for road kill prevention
· Setting up of LED handrail light in the bridge section so as not to attract insects and bats (under consideration: See Figure 11.7.11
· Setting up of pole more than 4m in height so that moving vehicles will not get hit by flying birds (under consideration: See Figure 11.7.12)</td><td>Some birds may come to the project area for feeding. Thus, mitigation measures are required.
⇐Ditto</td></tr>
<tr><td>3.Traffic noise and vibration</td><td>Forecasted noise and vibration levels at the boundary of ROW and 250m in KBA/IBA are shown below:

[Noise] Project Area 100-500 m range (KBA/IBA)
<table>
<tr><td rowspan="2">Point
From the centerline</td><td rowspan="2">Time</td><td colspan="2">Noise Level dB(A)</td></tr>
<tr><td>BG</td><td>Forecast</td></tr>
<tr><td rowspan="2">ROW
(50m away)</td><td>Daytime</td><td>45</td><td>59</td></tr>
<tr><td>Nighttime</td><td>42</td><td>54</td></tr>
<tr><td rowspan="2">250m away</td><td>Daytime</td><td>45</td><td>58</td></tr>
<tr><td>Nighttime</td><td>42</td><td>53</td></tr>
</table>
Note) Day 7-22hrs, Night 22-7hrs, BG:Background

[Vibration] 100-500m range (KBA/IBA)
<table>
<tr><td rowspan="2">Point
From the centerline</td><td rowspan="2">Time</td><td colspan="2">Vibration Level dB</td></tr>
<tr><td>BG</td><td>Forecast</td></tr>
<tr><td rowspan="2">ROW
(50m away)</td><td>Daytime</td><td>33</td><td>43</td></tr>
<tr><td>Nighttime</td><td>24</td><td>40</td></tr>
<tr><td rowspan="2">250m away</td><td>Daytime</td><td>33</td><td>41</td></tr>
<tr><td>Nighttime</td><td>24</td><td>40</td></tr>
</table>
Note) Day 7-20hrs, Night 20-7hrs, BG:Background

Mammal and bird species which are feeding and roosting on the boundary of ROW may be led to avoid the project area after the opening of the new bridge. However, some bird species such as Helons are observed near the current Sittaung Bridge, thus such species is not likely to give significant impact on the birds' feeding area and roosting areas.</td><td>Forecasted noise and vibration levels at the boundary of Potential Management Area and Registered Ramsar Site are shown below:

[Noise] Ramsar Site (3.6km – 5.5km)
<table>
<tr><td rowspan="2">Point
From the centerline</td><td rowspan="2">Time</td><td colspan="2">Noise Level dB(A)</td></tr>
<tr><td>BG</td><td>Forecast</td></tr>
<tr><td rowspan="2">P. Management Area (3.6km)</td><td>Daytime</td><td>45</td><td>49</td></tr>
<tr><td>Nigh time</td><td>42</td><td>45</td></tr>
<tr><td rowspan="2">Registered Area (5.5km)</td><td>Daytime</td><td>45</td><td>49</td></tr>
<tr><td>Nighttime</td><td>42</td><td>44</td></tr>
</table>
Note) Day 7-22hrs, Night 22-7hrs, BG:Background

[Vibration] Ramsar Site (3.6km – 5.5km)
<table>
<tr><td rowspan="2">Point
From the centerline</td><td rowspan="2">Time</td><td colspan="2">Vibration Level dB</td></tr>
<tr><td>BG</td><td>Forecast</td></tr>
<tr><td rowspan="2">Management Area 3.6km)</td><td>Daytime</td><td>33</td><td>38</td></tr>
<tr><td>Nighttime</td><td>24</td><td>36</td></tr>
<tr><td rowspan="2">Core Area (5.5km)</td><td>Daytime</td><td>33</td><td>37</td></tr>
<tr><td>Nighttime</td><td>24</td><td>35</td></tr>
</table>
Note) Day 7-20hrs, Night 20-7hrs, BG:Background

Forecasted noise and vibration levels decay according to distance from the bridge, and these forecasted values are not at significant levels.
Thus, it is not likely to give significant impact on birds' feeding and roosting areas in Ramsar Site.</td></tr>
<tr><td>4. Lighting along the bridge and road</td><td>Lighting may give adverse impacts on the birds' roosting area on the grass and fishes in the river.
Thus, the leaking light should be minimize by the implementation of mitigation measures as follows:
· Setting up of light with cover so as not to irradiate the river surface and outside of the road (See Figure 11.7.11)</td><td>In general, illuminance is inversely proportional to the square of the distance, thus the illumination level at 3.6km from the bridge is approx. 0.02% of ROW boundary.
The project gives few impacts on lighting.</td></tr>
<tr><td>5. Impact on the Water Quality</td><td>• No turbid water is generated by the project
• No organic polluted water is generated by the project
• With regard to surface water quality from carriage way, it does not give serious impacts on Zn and Pb in accordance with case study in Japan*Note-1
*Note-1 See Article 10.7.2 Water Quality (3) Impact forecast, 2) After Construction
Technical Note of National Institute for Land and Infrastructure Management No.596 May 2010</td><td>←Ditto</td></tr>
<tr><td>6. Expansion of development</td><td>The land along the road and bridge may be developed without any regulation. Such development may give adverse impacts on KBA/IBA. Thus, the following mitigation measures are necessary:
· Establishment of land use plan in the project area and KBA/IBA and implementation of appropriate land use management so as not to cause unplanned development</td><td>The land along the road and bridge may be developed without any regulation. Such development may give adverse impacts on the Ramsar Site. Thus, the following mitigation measures are necessary:
· Establishment of land use plan in Ramsar Site and implementation of appropriate land use management so as not to cause unplanned development</td></tr>
</table>

Note*1: The Influence That Vibration To Occur By Marine Construction Gives To The Benthos Of The Peripheral Sea Area (July, 2008/ Kana UEDA)

(6) Mitigation Measures

1) During Construction

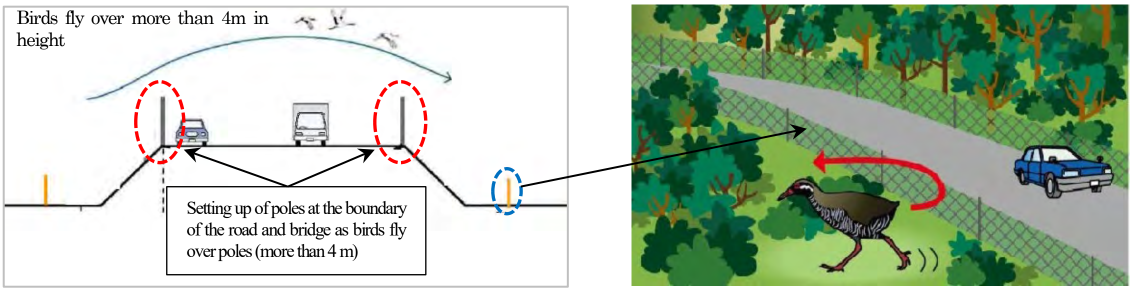
- ✓ ROW shall be marked and all relevant construction workers should be informed not to conduct development activities outside of the project area
- ✓ Waste oil shall be stored and disposed of into a designated site so as not to leak into the water body
- ✓ Adoption of steel pipe sheet piles (SPSP) methodology so as not to generate significant turbid water at excavated area in the river
- ✓ Adoption of lower noise and vibration construction method and machines
- ✓ Lighting in the river shall be minimized at nighttime so as not to give adverse impacts on the fishes' lifecycle
- ✓ Implementation of detailed comprehensive fauna-flora monitoring during detailed design and construction (See special ecosystem monitoring in the article on EMP)

2) After Construction

- ✓ Setting up of fence at the boundary of ROW for road kill prevention
- ✓ Setting up of pole more than 4m in height so that moving vehicles will not get hit by flying birds (under consideration)
- ✓ Setting up of LED handrail light in the bridge section so as not to attract insects and bats (under consideration)
- ✓ Setting up of light with cover so as not to irradiate the river surface and outside of the road in keeping with sound lifecycle of fishes
- ✓ Establishment of a land use plan in the project area, KBA/IBA and Ramsar Site, and implementation of appropriate land use management so as not to cause unplanned development
- ✓ Implementation of detailed comprehensive fauna-flora monitoring after construction (See special ecosystem monitoring in the article on EMP)

Source: Panasonic Eco-solutions (Project name: Shin Meishin Expressway Asuka IC- Nabeta IC in Japan)

Figure 11.7.11 Handrail Lighting System



Source: National Institute for Land and Infrastructure Management (NILIM)

Figure 11.7.12 Mitigation Measures for Road Kill Prevention

(7) Evaluation

1) Project Area Including KBA/IBA

The project area is developed as a paddy field and rubber tree plantation with human activities. Thus, considerable habitats such as natural forests and mudflat for mammal and birds specie in the project area are not observed. Although some considerable species have been observed out of ROW and Sittaung River, the project area is not main distributed area nor/or important area as feeding and nesting.

Furthermore, according to result of planktons and benthos survey, the number of observed species is quite low, and it is evaluated that level of natural diversity is not rich due to the effect of high turbidity in the Sittaung River.

During construction, noise and vibration from construction activities may give impacts on feeding and roosting area of birds and fishes near the project area. However, similar habitats exist outside of the project area and such species can avoid the impacted area during the impacted period.

After construction, some impacts such as road kill, traffic noise, lighting and human activities due to the new development are expected in the project area. However, the implementation of mitigation measures minimizes these expected adverse impacts. Thus, it is not likely to give serious impacts on the ecosystem in the project area and KBA/IBA.

With regard to the result of the analysis on critically natural habitats, it is evaluated that the project area in the part of Sittaung KBA/IBA is not a critically natural habitat in accordance with criteria under JICA Guidelines.

2) Mottama Gulf Ramsar Site

According to information regarding the Mottama Gulf Ramsar Site, some considerable species such as "spoon-billed sandpiper" categorized as CR on the IUCN Red List migrated from the northern area and uses the Ramsar Site as wintering spot. Especially, most of the migratory aquatic birds use the mudflat as feeding and roosting areas during migratory season.

Critical habitats for fauna species such as Potential Management Area and the registered Ramsar Site are located more than 3.6km and 5.5 km away downstream from the project area, respectively.

According to wildlife specialists in Myanmar and Japan, the following opinions, discussion and conclusions have been given:

Table 11.7.25 Impact Items and Factors on Fauna and Flora After Construction

No	Discussions and Conclusions		
	Expected Impacts and Opinions (Name of Specialist)	Answer from JST Based on Forecast Results	Conclusion
1	Noise, vibration and lighting may give impacts on Ramsar Site. (Dr. Aye and Dr. Murata)	Distance from the project area to buffer zone and core area is approx. 3.6km and 5.5 km, respectively. Noise, vibration and lightning are sufficiently weak and smaller at Ramsar Site. JST has indicated the quantitative forecasts of the specialist.	Project does not give significant impacts
2	Hydrological situation may change and mudflat for feeding and roosting decreases. Hence, the project may give significant impacts. (Dr. Aye and Dr. Murata)	The most important factor for the creation of mudflat is the hydrological situation and accumulated soil from the upstream and downstream by breaking bore. According to hydrological analysis, the project gives only approx. 100m range from the bridge downstream. Additionally, project activities do not give significant impacts on accumulated mudflat soil. Thus, the project doses not give significant impacts on mudflat as the birds' feeding and roosting areas.	Project does not give significant impacts
3	Expansion of land development may give significant impacts on KBA/IBA and Ramsar Site in the future. (Dr. Murata)	The project implementation agency is MOC and controls only project area, thus the MOC can manage land use in ROW. However, other areas belong to private owners and the local government, thus the local government shall manage such land areas near the Ramsar Site and IBA/KBA so as not to give significant impacts on natural habitats.	In the project area, MOC can manage land use appropriately. However, the local government should control other land use and pollution.

Note) JICA Study Team has explained project outline based on Appendix 4 – Presentation Material for Public Consultation Meetings and discussed about the major impacts item, degree and necessary mitigation measures.
Dates of interview:
Dr. Aye Thant Zin (Professor, Zoology Department, Mawlamyine University) / Aug. 10th, 2018.
Dr. Koichi MURATA (Professor, College of Bioresource Sciences, Nihon University, Japan / Representative of Zoorasia in Kanagawa Prefecture, Japan) / October 18th, 2018

As shown in the result of discussions with wildlife specialists, noise, vibration, lighting and the changing hydrological situation do not give significant impacts on Ramsar Site.

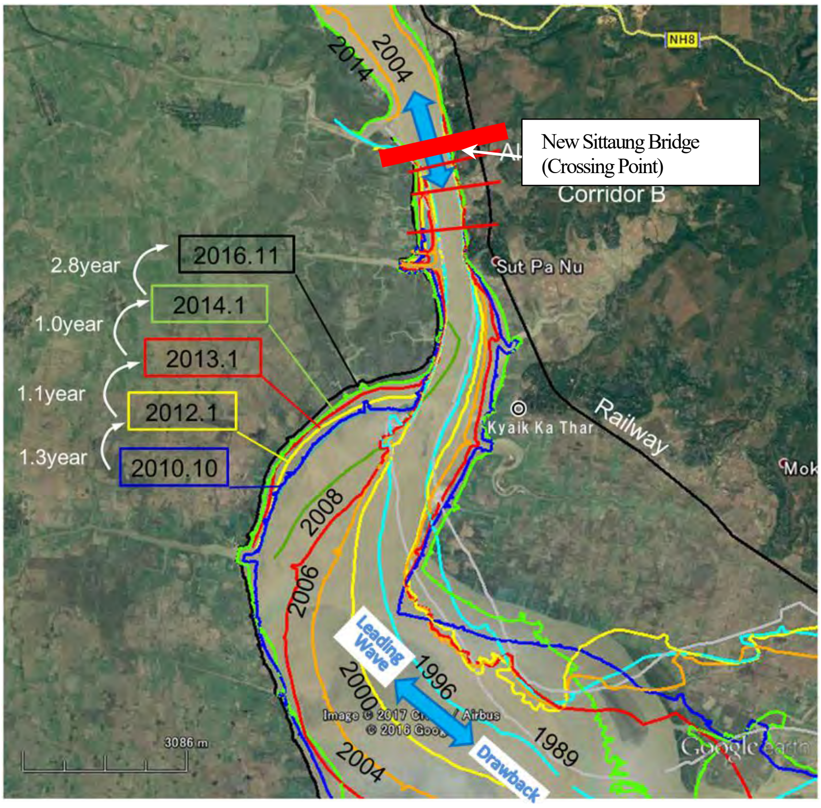
Thus, at the moment, they are not likely to give serious impacts on Ramsar Site if such mitigation measures are conducted appropriately. However, with regard to land use management in the future, Mon State and Bago Region need to establish land use plan in the KBA/IBA and Ramsar Site not to conduct development activities without proper management. Furthermore, adequate pollution control for waste water and solid waste should be done.

11.7.5 Hydrology

(1) Result of Baseline Survey

1) River Channel and Tidal Bore

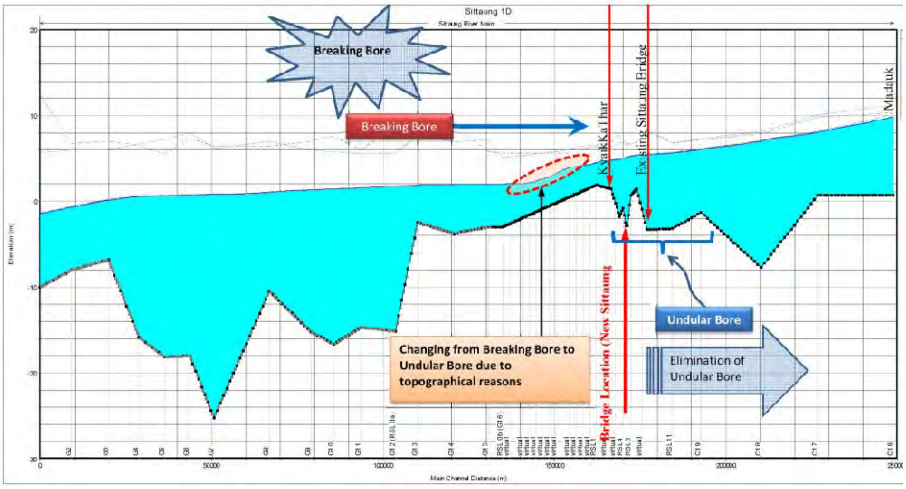
Sittaung River is a part of the area which is affected by tidal bore once in two weeks. Thus, the river route has been shifting due to tidal bore and flooding as shown in Figure 11.7.13. It shows that the proposed bridge location is most stable in the past 30 years. The highest water level by flooding and breaking bore recorded did not reach the existing village road in the East Bank, Kyaito Township.



Source: JICA Study Team based on Google Earth and NASA (Landsat TM)

Figure 11.7.13 Shifting of Bank Lines Around the Proposed Bridges

In the Sittaung River, tidal bore generates breaking bore and gives impacts on the shifting of the river. The distance from Sittaung River mouth to Kyaik Ka Thar Village is approximately 63km, and this area is affected by breaking bore. However, this breaking bore changes to undular bore after Kyaik Ka Thar due to topographic condition as shown in Figure 11.7.14. Thus, the area of planned bridge is not impacted by breaking bore and is more stable than southern downstream from Kyaik Ka Thar Village.



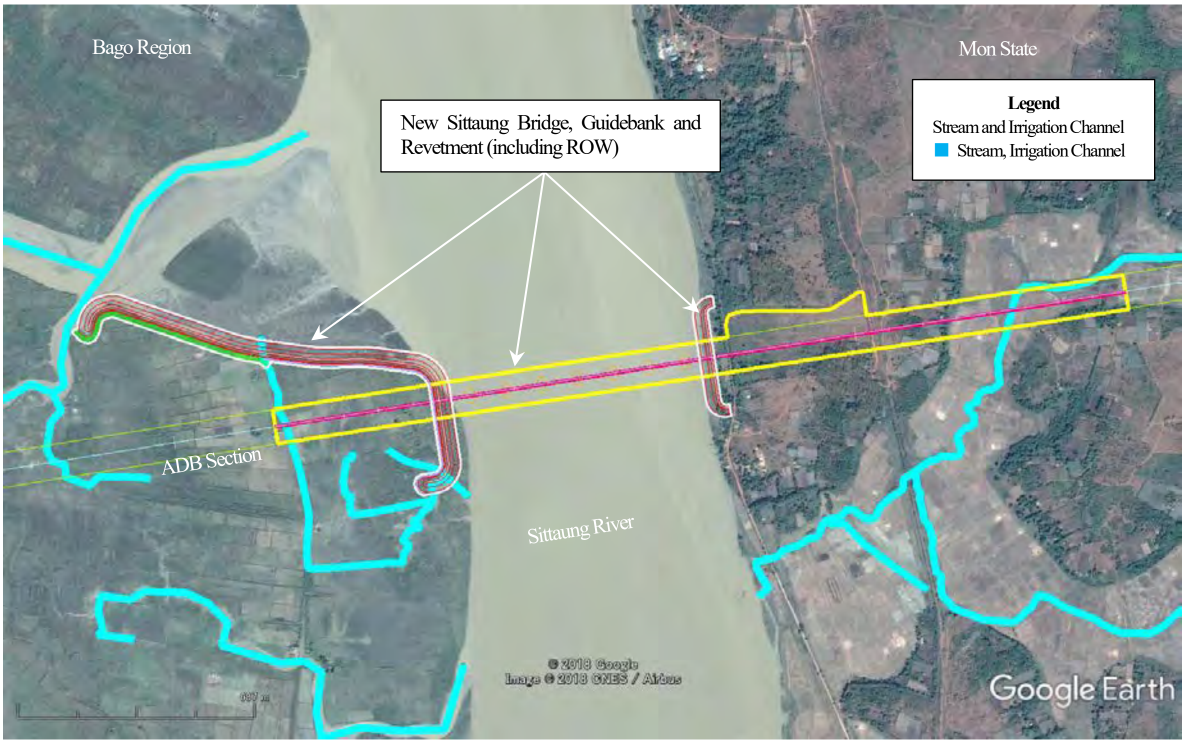
Source: JICA Study Team

Figure 11.7.14 Longitudinal Section of Sittaung River and Mechanism of Tidal Bore

2) Distribution of Small Stream

The distribution of small streams and creeks in the project area are shown in Figure 11.7.15.

On the west bank in Bago Region, a couple of irrigation streams are passing through the approach road and guidebank. On the other hand, only one irrigation river is crossing the approach road on the east bank in Mon State.



Source: JICA Study Team (based on Google earth satellite map)

Figure 11.7.15 Location of Small Streams and Creeks in the Project Area

(2) Potential Impacts

1) During and After Construction

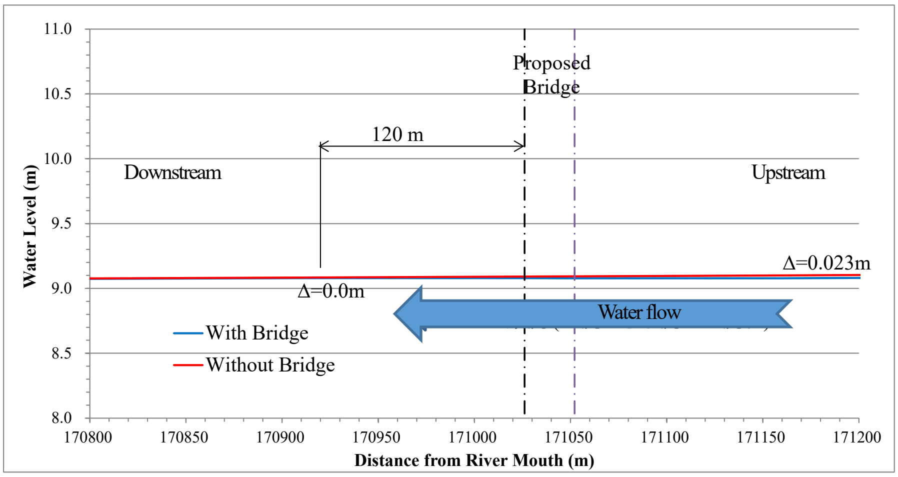
Construction of bridge, guidebank and revetment may change the hydrological situation of the rivers.

Earthwork section and construction of structures may give impacts on small streams in agricultural land.

(3) Impact Forecast

1) During and After Construction

As mentioned in the article on "(1) Result of Baseline Survey", the selected bridge crossing point is the most stable location based on past flooding record and shifting of river channel in the past 30 years. According to hydrological simulation by the construction of piers in the Sittaung River, it is estimated that the surface water level may change to a maximum 2-3 cm in the range of 100m downstream. However, this impact does not reach more than approx. 100m away downstream as shown in the next figure.



Source: JICA Study Team (based on Google earth satellite map)

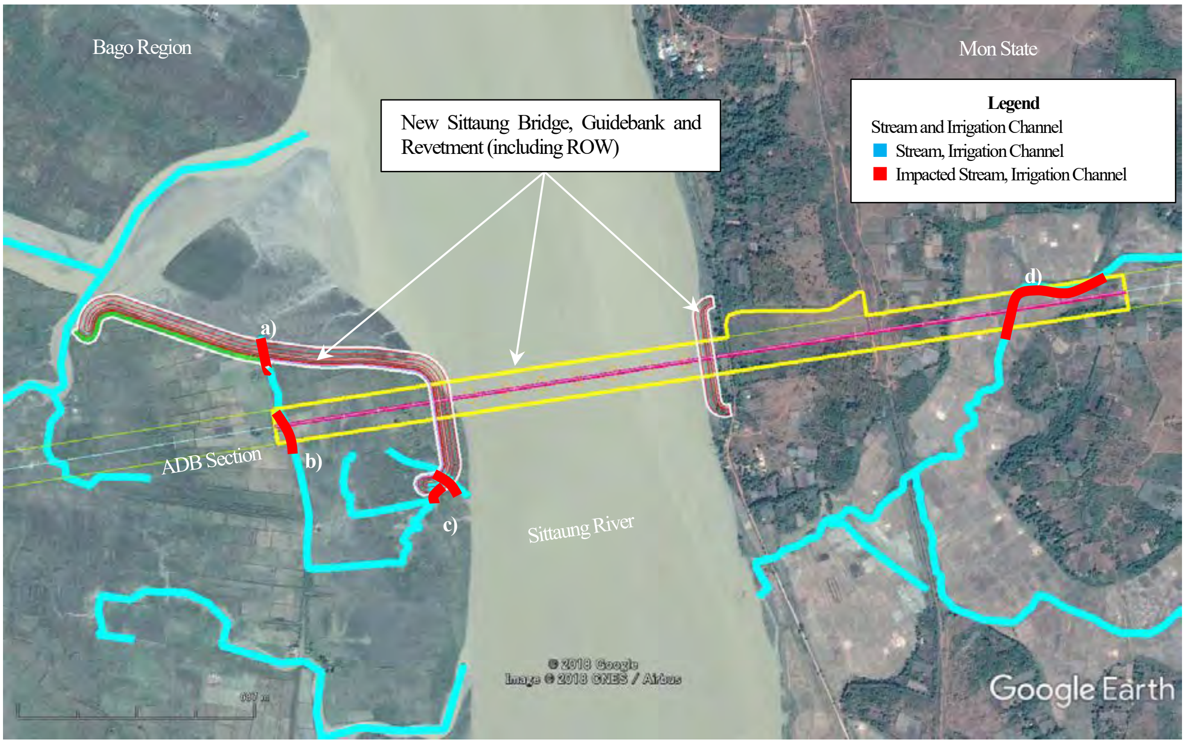
Figure 11.7.16 Degree of Water Level Changes After Construction

Thus, it is expected that the existence of bridge does not give significant impacts on the hydrological situation.

Furthermore, the construction of guidebank and revetment keeps the river channel stabilized in the project area.

With regard to the impacts on streams and irrigation channel, a total of approximately 600m of streams and irrigation channels are affected by the project as shown in Figure 11.7.17 and Table 11.7.26.

Streams and irrigation channels are indispensable for agricultural field in the project area, thus mitigation measures are necessary so as not to affect agricultural activities.



Source: JICA Study Team (based on Google earth satellite map)

Figure 11.7.17 Impacted Streams and Creeks in the Project Area

Impacted streams and channels are shown below:

Table 11.7.26 Impacted Streams and Irrigation Channels

Impacted Stream and Irrigation			Length of Affected Stream
	Affected Structure	Location	
a)	Guidebank	Bago Region	80 m
b)	Approach Road	Bago Region	100 m
c)	Guidebank	Bago Region	100 m
d)	Approach Road	Mon State	350 m
	Total		630 m

Source: JICA Study Team

(4) Mitigation Measures

1) During and After Construction

- ✓ Construction of guidebank and revetment to stabilize hydrological situation in the project area
- ✓ Diversion of irrigation channels and/or streams shall be setup, if the project activities give impacts on such streams

(5) Evaluation

According to hydrological analysis, the existence of bridge pillars in the Sittaung River does not give significant impacts on the hydrological situation of the current Sittaung River. It means that the changing hydrological situation does not give impact on the situation of mudflat in Ramsar Site.

In the land area, construction of structures such as approach road and guidebank may give impacts on streams and irrigation channels. However, diversion channels such as alternative open irrigation channels, crossing water pipe and culvert are constructed as mitigation measures. Thus, it is not like to give significant impacts on the hydrological situation in the project area.

11.7.6 Local Economy Such as Employment and Livelihood

(1) Result of Baseline Survey

1) Occupation of Project Affected Persons

Project Affected Household are defined as those who has direct impact to their residences, assets or their income source caused by land acquisition. They are regarded as PAPs in RAP survey and the Socio-Economic Survey to them were conducted. With regard to their occupation, the survey results are shown in Table 11.7.27. Most of PAPs are farming rice and other crops and orchard.

Table 11.7.27 Occupations of Project Affected Unit Heads

Occupation \ Intersection	Bago Region (West Side)		Mon State (East Side)		Total	
	No.	%	No.	%	No.	%
(1) Dependent	1	12.5	0	0.0	1	5.3
(2) Student	0	0.0	0	0.0	0	0.0
(3) Casual Employee	0	0.0	1	9.1	1	5.3
(4) Wage Worker (Long -Term Contract)	0	0.0	1	9.1	1	5.3
(5) Farming Rice and Other Crops	6	75.0	1	9.1	7	36.8
(6) Farming Vegetables	0	0.0	0	0.0	0	0.0
(7) Orchard	0	0.0	7	63.6	7	36.8
(8) Livestock	0	0.0	1	9.1	1	5.3
(9) Fishery	0	0.0	0	0.0	0	0.0
(10) Handicraft	0	0.0	0	0.0	0	0.0
(11) Government Employee	0	0.0	0	0.0	0	0.0
(12) Shop Owner	1	12.5	0	0.0	1	5.3
(13) Retired or Over Working Age	0	0.0	0	0.0	0	0.0
(14) Others	0	0.0	0	0.0	0	0.0
Total	8	100.0	11	100.0	**19**	**100.0**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

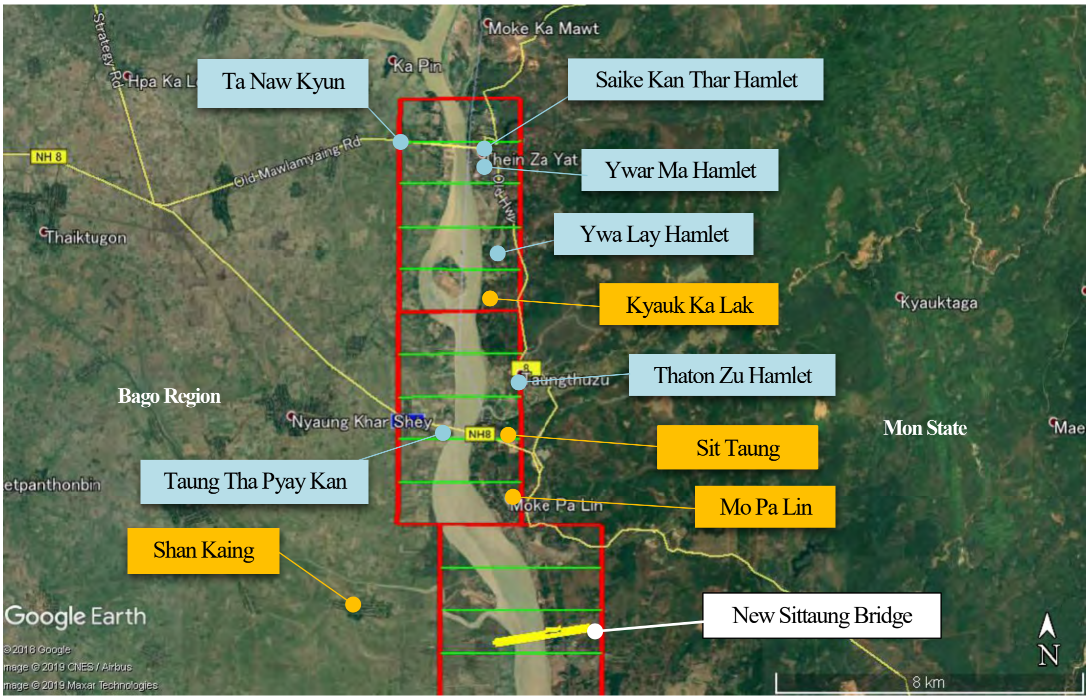
2) Fishery in the Project Area

While those who have direct impact by lad acquisition are covered in RAP as shown above, it was suggested that the fishermen in the Sittaung river may have indirect impact by the Project during public consultation and RAP socialization. Therefore, the assessment of the impact to the fishermen is presented below.

i) Number of Fishermen and Boat

Interviews were conducted to the village leader and leader of fisherman's group of 16 villages/ communities (1) Su Pa Nu, 2) Mo Pa Lin, 3) Shan Kaing, 4) Taung Tha Pyay Kan, 5) Sit taung, 6) Saike Kan Thar Hamlet (Thein Za Yat Village), 7) Ywar Ma Hamlet (Thein Za Yat Village), 8) Ta Naw Kyun, 9) Ywa Lay Hamlet (Thein Za Yat Village), 10) Kyauk Ka Lak Village, 11) Thaton zu Hamlet (Thein Za Yat Village), 12) Kyaikto south, 13)

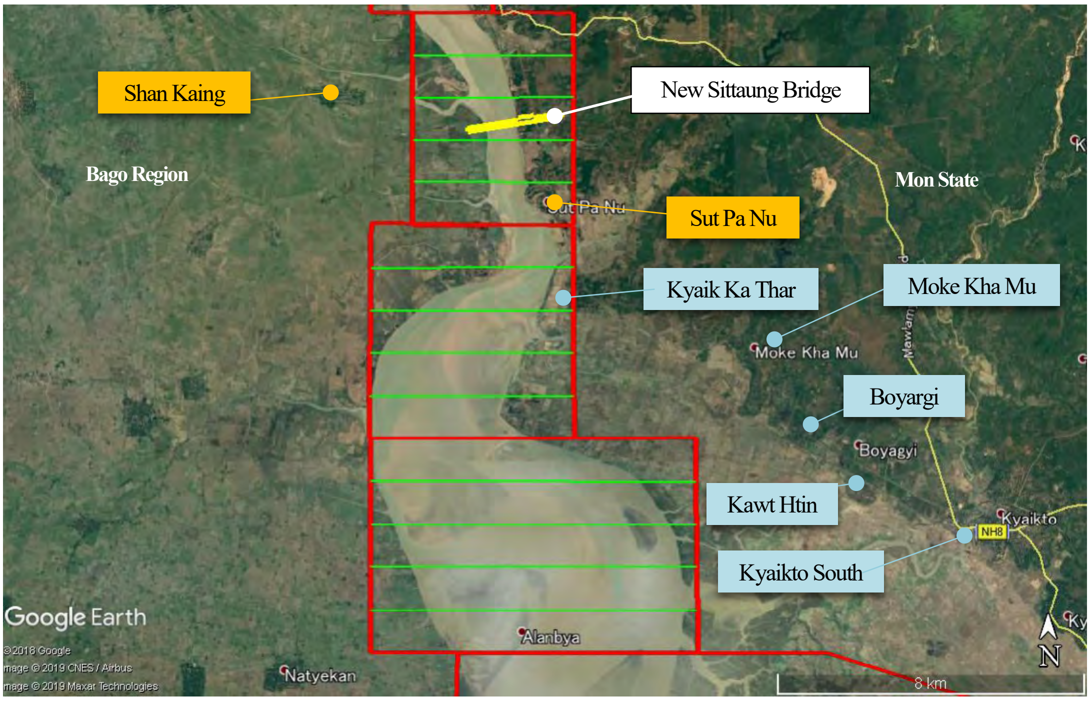
Boyargi, 14) Kawt Htin, 15) Moke Kha Mu, 16) Kyaik Ka Thar) nearest to the location of New Sittaung Bridge alongside of the Sittaung river as shown in Figure 11.7.18 and Figure 11.7.19. Since Fisheries Cooperative Associations are not established in these areas, fishermen who have main income from fishing have been identified by village leader and leader of fisherman's group. Generally, fishermen's means of livelihood and income source varies in each fisherman's family. In the project area, it was identified that some fishermen depends on only fishing as a whole family, and some fishermen engage mainly in fishing but family member also obtain income from other activity such as agriculture and shop operation. As a result of the interview, some fishermen in 5 villages out of 16 villages are identified to be using project area for fishing. The identified fishermen in the 5 villages are totally 219. The identified villages and the number of identified fishermen are shown in Table 11.7.28.



Note: The text box shown in orange color are the villages/ communities using the project site as fishing ground

Source: JICA Study Team Based on Google Earth Map

Figure 11.7.18 Location of the 16 villages/ communities which interviews on fishing ground were conducted (Upstream side of the New Sittaung Bridge)



Note: The text box shown in orange color are the villages/ communities using the project site as fishing ground

Source: JICA Study Team Based on Google Earth Map

Figure 11.7.19 Location of the 16 villages/ communities which interviews on fishing ground were conducted (Downstream side of the New Sittaung Bridge)

Table 11.7.28 Number of Recognized Fishermen

No.	Village	Township	State/Region	Number of Fishermen (Full-Time)
1	Sut Pa Nu	Kyaikto	Mon	72
2	Mo Pa Lin	Kyaikto	Mon	45
3	Shan Kaing	Waw	Bago	1
4	Sittaung	Kyaikto	Mon	100
5	Kyauk Ka Lak	Kyaikto	Mon	1
			Total	219

Source: JICA Study Team

Total estimated fishing boat is approximately 240 / day round trip in the Sittaung River in accordance with village leader.

Table 11.7.29 Traffic Number in the Sittaung River

No.	Name	Estimated Number Number / day (round trip)
1	Fishing Boat	240
2	Cargo ship	20
3	Ferry boat (between East-West bank)	8
	Total	268

Source: JICA Study Team (interview with village leader of Su Pa Nu village)

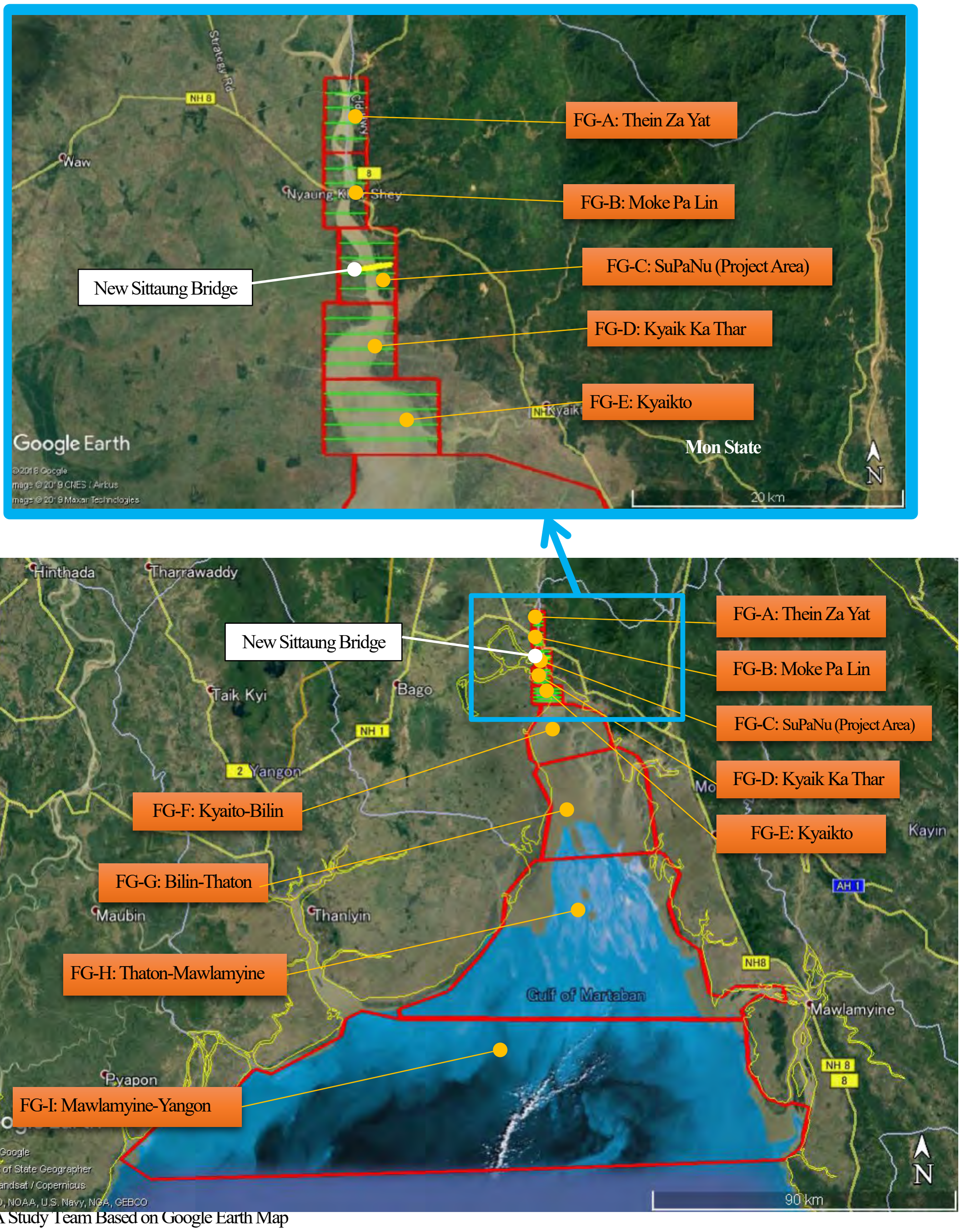
ii) Main Fishing Ground and activities

Main fishing ground(s) have been identified based on the interview survey. In this interview survey, fishermen were interviewed on main fishing ground(s). The main fishing grounds for 5 target fishermen villages and the frequency of use are shown below.

The major fishing ground (FG) for fishermen in the 16 villages can be classified into 9 areas from FG-A to FG-I. The project area falls under FG-C: Su Pa Nu (Project Area). The area of FG-C is 6.44 km^2 which accounts for 0.06% of total area of app. 10,500 km^2 covering FG-A to FG-I. Generally, the FG-A to FG-E or FG-F area tends to be used by fishermen engaging in fishing in daily trip basis with small-size boat. On the other hand, FG-F to the south tends to be used by fishermen fishing in around 10 days trip basis with large-size boat. According to the interview, the small-size boats are around 25 ft and the large-size boats are around 40ft although the size of fishing boat differs depending on the each fishermen.

As described in i), it was found out that fishermen living in the above 5 villages are using the FG-C as a fishing ground, however their fishing ground is not limited to FG-C and they also use other area other than the project area.

In the Project area, Hilsa Shad and Soldier croaker are major fish type for fishing. The identified fish species in site survey are shown in Table 11.7.17. The fishing method used by fishermen varies depending on the fishing ground and fishermen; however, major fishing method used in the project area is Drift gill net method.



Source: JICA Study Team Based on Google Earth Map

Figure 11.7.20 Nine (9) Main Fishing Grounds for Target Five (5) Fishermen Villages

(2) Potential Impacts

1) During Construction

Livelihood of residents, farmers and fishermen may be affected by acquisition of agricultural land and traffic restriction in the river.

2) After Construction

No impact is expected due lack of resettlement, land acquisition and traffic restriction plans after construction.

However, a group of fishermen using the gill net method may be impacted due to the existence of piers in the river.

On the other hand, traveling time to Yangon is shortened due to the commencement of new bridge and bypass.

(3) Impact Forecast

1) During Construction

i) Impacts on Agriculture

Approximately 25 ha (62.53 acres) of agricultural land such as paddy field, farming land and rubber plantation is affected by the project. The breakdown of the affected land area by land type and villages are shown in Table 11.7.30.

Table 11.7.30 Summary of Lands to be Acquired under Proposed Alignment

State /Region	Village	Approximated Amount of Land to be Acquired						Total	
		No. of Affected Land Owner (No.)	Crop Land (acre)	No. of Affected Land Owner (No.)	Garden Land (acre)	No. of Affected Land Owner (No.)	Residential Land (acre)	No. of Affected Land Owner*1 (No.)	Total Land (acre)
Bago Region	Shan Kaing	7	22.85	0	0	0	0	7	22.85
Mon State	Sut Pa Nu	3	6.12	7	23.65	0	0	8	29.77
Mon State	Khalon	4	8.91	1	1.00	0	0	4	9.91
Total		**13*2**	**37.88**	**8**	**24.65**	**0**	**0**	**18*3**	**62.53**

*1 No. of Affected Land owner shows PAHs who have impact on Crop Land or/ and Garden Land.
*2 1 PAH has 2 crop land in Sut Pa Nu and Kha Lun, therefore total PAHs who impacted on land is totally 13
*3 As mentioned in *2, PAHs has land plot both in Sut Pa Nu and Kha Lun, therefore total no. of affected owner is totally 18
Source: JICA Study Team

In association with the impact to the agricultural land, agricultural crops and trees will also be impacted. The estimated impact to the crops are mainly paddy and peas and beans and the estimated yield amount to be impacted are 2,625 basket on paddy and 457 basket on peas and beans as shown in Table 11.7.31. The major kind of trees in the project area are Rubber and Betel vine. The impact forecast to the trees by type are also broken down in Table 11.7.32.

Table 11.7.31 Inventory of Affected Crops

State/Region	Village	Crop Type	No. of Affected Crop owner (No.)	Yield (Basket)	Crop Type	No. of Affected Crop owner (No.)	Yield (Basket)
Bago Region	Shan Kaing	Paddy	7	1,371	Peas and Beans	7	457
Mon State	Sut Pa Nu	Paddy	1	258	Peas and Beans	0	0
Mon State	Khalon	Paddy	2	996	Peas and Beans	0	0
Total			**10**	**2,625**		**7**	**457**

1 Basket=20.9 kg
Source: JICA Study Team

Table 11.7.32 Inventory of Affected Trees

Type	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Khalon (Mon State)		Total	
	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees
	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)
Rubber	0	0	3	3,808	1	530	4	4,338
Betel vine	0	0	5	9,365	0	0	5	9,365
Mango	0	0	4	5	0	0	4	5
Betel nuts	0	0	1	4	0	0	1	4
Jack Fruit	0	0	3	9	0	0	3	9
Danyin	0	0	2	3	0	0	2	3
Plam	0	0	1	1	0	0	1	1
Pomelo	0	0	1	1	0	0	1	1
Guava	0	0	1	4	0	0	1	4
Tikto	0	0	0	0	1	1	1	1
Kinmunchin	0	0	0	0	1	1	1	1
Banana	0	0	2	140	1	6	3	146
Dannalun	0	0	1	2	0	0	1	2
Bamboo	0	0	4	1,550	0	0	4	1,550
Kokeko	0	0	1	1	0	0	1	1
Banyan	0	0	1	1	0	0	1	1
Thit mwe	0	0	1	7	0	0	1	7
Total	**0**	**0**	**31**	**14,901**	**4**	**538**	**35**	**15,439**

Source: JICA Study Team

ii) Impacts on Fishery

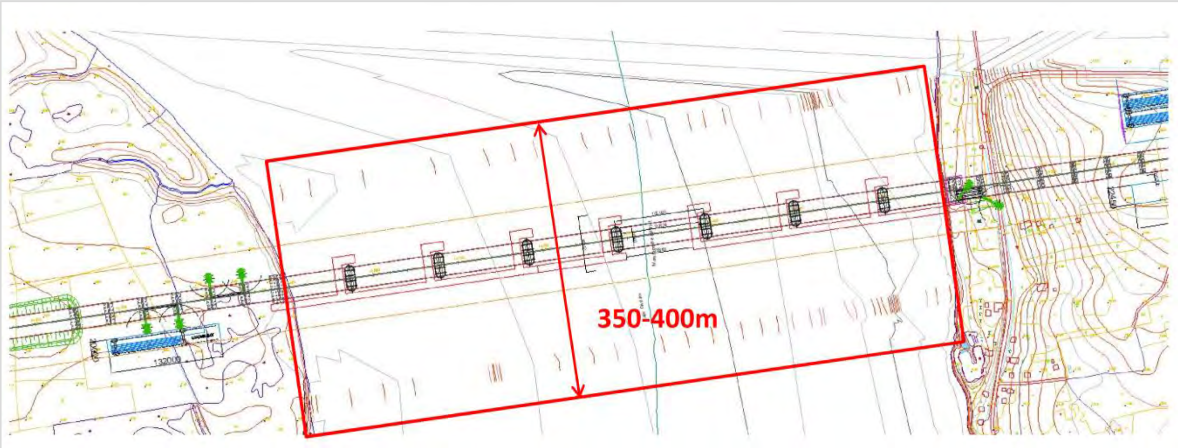
During construction, some impacts are expected as shown in Table 11.7.33.

Table 11.7.33 Impact Items on Fishery During Construction

Impact Item and Potential	Impact Forecast
(1) Impacts on fishes and aquatic species Generation of turbid water and construction noise and vibration may give impacts on fishes and habitats of aquatic species	Turbid water is not generated because the steel pipe sheet piles method is adopted for foundation works. Fishes and aquatic species may be led to avoid the construction area temporarily within 200 m range up-downstream during construction as shown in the following figure (Figure 11.7.21) However, according to a study in Japan, more than 100 dB [note-1] vibration gives impacts on fishes. In these construction activities, since vibrohammer with less than 80 dB vibration is adopted, the degree of impact is not significant.
(2) Impacts on fishing activities and fishing area Construction-restricted area is established and may give impacts on fishing activities and fishing ground	Traffic restriction and setting up of prohibited fishing area from the view of safety may give impacts on fishing activities and fishing ground. For the interviewed 16 villages, 9 fishing ground s are identified as shown in Figure 11.7.20 and its total area of the 9 fishing ground is approximately 10,500 km2. On the other hand, the project area falls under FG-C and its area is 6.44 km2 (0.06% of total area of 9 fishing grounds). Moreover, within the FG-C, the prohibited fishing area during construction will be not the whole area of the FG-C but limited to the 400m range of the upstream and downstream side of the bridge location (see Figure 11.7.21), which area is 0.42 km2 (6.5% of FG-C and 0.004% of total area of 9 fishing grounds). Regarding with the prohibited fishing area during construction, navigation channel (NC) will be secured therefore fishermen can move to upstream or downstream of the project area through NC. Although identified fishermen in 5 villages presented in Table 11.7.28 use FG-C as a fishing ground, those fishermen use not only FG-C but also other area as a fishing ground. Furthermore, it was mentioned that any fishermen have right to use any fishing ground, and

	some similar fishing grounds are distributed near project are in the project area can shift to another fishing area during construction phase and accordingly the degree of the impact to fishery is not significant.

Note-1: Reference *1: The Influence That Vibration To Occur By Marine Construction Gives To The Benthos Of The Peripheral Sea Area (July, 2008/ Kana UEDA) See Figure 11.7.10
Source: JICA Study Team



Source: JICA Study Team

Figure 11.7.21 Construction-Restricted Area (Prohibited Fishing Area) During Construction

2) After Construction

i) Impacts on Fishery

During construction, some impacts are expected as shown in Table 11.7.34.

Table 11.7.34 Impacted Items on Fishery after Construction

Impact Item and Potential	Impact Forecast
(1) Impacts on fishes and aquatic species Generation of turbid water from road surface and traffic noise and vibration may give impacts to fishes and habitats of aquatic species	Road surface water does not give any impacts on aquatic species because water quality does not exceed standard values under general circumstances. Fishes and aquatic species may be led to avoid the area when the bypass and bridge opens. However such species come back under the bridge because desirable habitats are created due to setting up of riprap for the prevention of scouring at piers. (See Table 11.7.21.)
(2) Impacts on fishing activities and fishing area Existence of piers may give impact on fishing activities	Fishermen using the gill net method may be impacted by the existence of bridge piers after construction. However, according to an interview with the fishery department in Kyaikto Township, fishermen can avoid the piers and use other fishing grounds. On the other hand, traveling time to Yangon is shortened due to commencement of new bridge and bypass, thus it will benefit the local economy. It will also lead to the fishermen and/or traders' better accessibility to the markets and enhance their economic activity.

Source: JICA Study Team

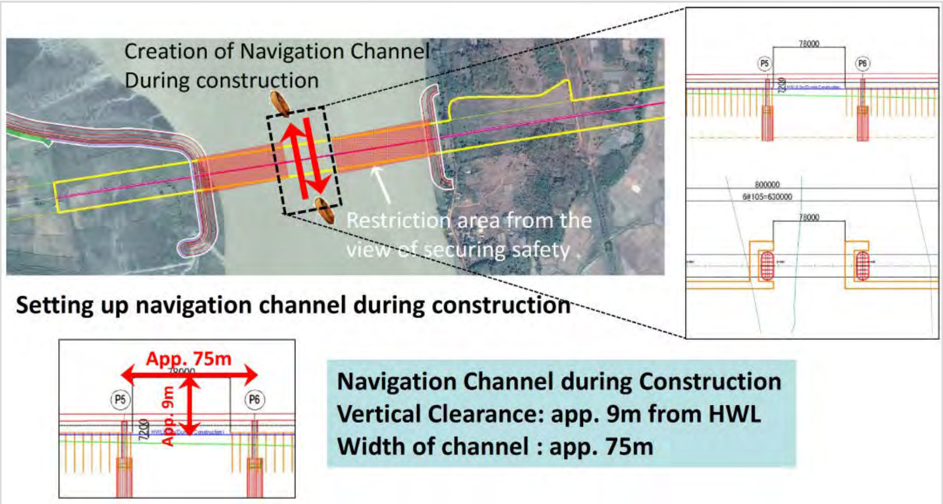
(4) Mitigation Measures

1) During Construction

Major mitigation measures are as follows;

- ✓ Holding of consultation meetings for understanding of compensation policy and livelihood restoration programs for project affected persons who lose agricultural lands such as paddy field and rubber plantation

- ✓ Implementation of adequate compensation in accordance with approved RAP
- ✓ Appropriate methodology for foundation work such as steel pipe sheet piles method for minimization of turbid water shall be taken so as not to give serious impacts on the habitats of fishes (see Figure 11.7.6).
- ✓ Appropriate methodology and machines shall be selected for the minimization of noise and vibration impacts, so as not to give serious impacts on the habitats of fishes.
- ✓ Setting up of navigation channel with necessary vertical clearance during construction as shown in Figure 11.7.22.
- ✓ Establishment of grievance redress mechanism for solution of issues involving farmers and fishermen



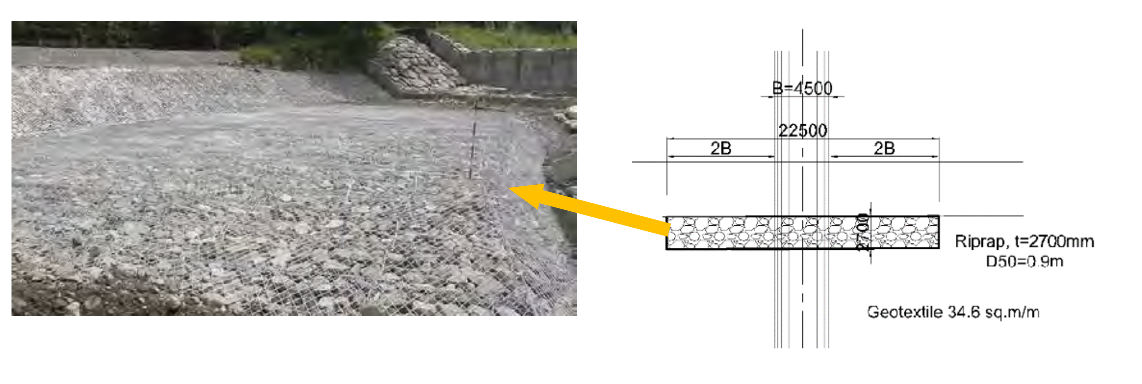
Source: JICA Study Team

Figure 11.7.22 Image of Navigation Channel

2) After Construction

Major mitigation measures are as follows:

- ✓ Construction of riprap – which aquatic species can use as habitat – for the prevention of scouring at piers
- ✓ Establishment of grievance redress mechanism for the solution of issues involving farmers and fishermen



Source: JICA Study Team

Figure 11.7.23 Image of Riprap at Piers (As Habitat for Aquatic Species)

(5) Evaluation

Although around approximately 25 ha of agricultural land is acquired due to construction of bridge and approach road, appropriate compensation policy in accordance with Myanmar laws and JICA Guidelines is established and implemented by the Myanmar Government.

Impacts on turbid water, noise and vibration are minimized by various mitigation measures, thus it is not likely to give serious impacts on fishes and other aquatic species.

On the other hand, the establishment of restricted area within 400m range from the construction area gives a certain degree of impacts on fishermen who use the restricted area as main fishing ground. However, such fishermen have some alternative fishing grounds, and they can shift to these fishing grounds. Thus, the project does not give significant impacts on fishermen's livelihood.

Furthermore, the shortening of traveling time from the project area to Yangon area gives positive impacts on trading and transportation. It will also lead to the fishermen and/or traders' better accessibility to the markets and enhance their economic activity. Thus, the project does not cause serious negative impacts and brings positive impacts on the local economy.

11.8 Environmental Management Plan

11.8.1 Mitigation Measures

The Environmental Management Plan (hereinafter referred to as "EMP") consists of mitigation measures and environmental monitoring plan in general.

Mitigation measures are prepared for minimizing the adverse negative impacts during and after construction. Necessary mitigation measures based on the result of impact forecasts are shown in Table 11.8.1.

Implementation of mitigation measures shall be monitored during construction, and the effectiveness of the mitigation measures shall be verified based on the result of quantitative forecasts. Furthermore, the accumulations of monitoring data might lead to the implementation of adequate mitigation measures in the future.

In general, the cost of mitigation measures during construction are included as construction cost except for special mitigation measures. With regard to special mitigation measures for ecosystem, the items and expected cost are shown in Table 11.8.2.

Table 11.8.1 Environmental and Social Mitigation Measures

Area	No.	Item	Draft Mitigation Measures: During Construction	Draft Mitigation Measures: After Construction	Responsibility: Implementation Agency	Responsibility: Responsible Agency
Pollution	1	Air pollution	☐ Water sprinkling shall be carried out on earth construction road and construction yard near the residential area. Additionally, surface treatment of the earth road should be considered if required. ☐ Periodical cleaning shall be done on paved road used as construction road.	☐ Appropriate land use management should be done along the road. In general, commercial and industrial area shall be designated along the road so that the residential area will not be directly affected by air pollution.	[During Const.] Contractor (Construction Company) [After Const.] MOC and local authority (Bago Region and Mon State)	[During Const.] MOC [After Const.] MOC and Local Authority
	2	Water pollution	☐ Turbid water from unpaved construction area shall be treated in sedimentation pond and discharged into the river, if required ☐ Waste oil of construction machines shall be stored and disposed of to a designated site ☐ Construction machines shall be maintained so as not to leak oil in the base camp site. ☐ Provision of sanitation facilities at the labor camps and construction yard. Also, the location of camps should be at least 200 m away from water sources. ☐ Domestic wastewater and night soil from base camp shall be treated and discharged of at designated sites and facilities. ☐ Use septic tank for portable toilet and temporary toilet in the construction area and yard ☐ Adoption of steel pipe sheet piles (SPSP) methodology so as not to generate turbid water at excavated area in the river.	Not required	[During Const.] Contractor	[During Const.] MOC
	3	Waste	[Construction waste (Waste soil, cut trees, waste oil and hazardous materials)] ☐ Waste soil from the land section of muck soil from the river section is used in the construction area for temporary earthwork and as embankment material of ADB bypass road section. Muck soil is excavated from the river section, transported and the necessary process is taken for reusing it as construction material. ☐ Cut trees are sold to villagers as building materials and for other purposes. ☐ Waste oil of the construction machines is collected and disposed of through a licensed agent such as fuel station ☐ Waste chemical and hazardous material are stored at the base camp site and disposed of through a licensed agent [Domestic waste and night soil from base camp and offices] ☐ Domestic solid waste is burned and buried in the construction area, and/or such domestic solid wastes are collected by private waste collector in the village. ☐ Domestic wastewater and night soil	☐ Illegal disposal should be monitored and prevented.	[During Const] Contractor [After Const.] MOC and local authority (Bago Region and Mon State)	[During Const] MOC [After Const.] MOC and local authority

Area	No.	Item	Draft Mitigation Measures		Responsibility	
			During Construction	After Construction	Implementation Agency	Responsible Agency
			shall be treated though septic tank and discharged into the natural stream. Water quality of the effluent shall be confirmed before discharging into the natural water body.			
	4	Soil contamination and sediment	☐ Excavated soil on the land and in the river shall be analyzed and quality shall be confirmed if it is under standard values. Polluted soil shall be treated and used as construction material if excavated soil is polluted. ☐ Construction machines shall be maintained so as not to leak oil in the base camp site. ☐ Waste soil from construction machines is collected and disposed of through a licensed agent such as fuel station ☐ Waste chemical and hazardous material are stored at the base camp site and disposed of through a licensed agent	Not required	[During Const] Contractor	[During Const] MOC
	5	Noise and vibration	[Construction noise and vibration] ☐ Construction activities and operation of construction machines shall be limited in the daytime and on weekday ☐ Construction machines shall be well-maintained and checked everyday ☐ Information disclosures, such as construction schedule and activities, shall be carried out in advance to the surrounding community.	☐ Land use along the road shall be designated as commercial and industrial areas, and the residential area shall be located behind such commercial area ☐ Myanmar government shall control the driving speed on the road (MOC requests to police department regarding strict speed control)	[During Const] Contractor [After Const] MOC and Local Authorities	[During Const] [After Const] MOC and Local Authorities
	6	Odor	☐ Domestic solid waste is burned and buried in the construction area. ☐ Domestic wastewater and night soil shall be treated though septic tank and discharged into the natural stream. Water quality of the effluent shall be confirmed before discharging into the natural water body. ☐ Waste soil of the construction machines is collected and disposed of through a licensed agent such as fuel station. ☐ Waste chemical and hazardous material are stored at the base camp site and disposed of through a licensed agent.	Not required	[During Const] Contractor	[During Const] MOC
Natural Environment	7	Protected area and Ecosystem	☐ ROW shall be marked and all relevant construction workers and communities shall be informed not to conduct development activities outside of the project area ☐ Waste oil shall be stored and disposed of into the designated site so as not to leak into the water body and on land. ☐ Adoption of steel pipe sheet piles (SPSP) methodology for not to generate significant turbid water at excavated area in the river. ☐ Adoption of lower noise and vibration construction method and machines ☐ Lighting in the river shall be minimized	☐ Setting up of fence at the boundary of ROW for road kill prevention ☐ Setting up of pole more than 4m in height so that moving vehicles will not get hit by flying birds (under consideration) ☐ Setting up of LED handrail light in the bridge section so as not to attract insects and bats (under consideration) ☐ Setting up of light with cover so as not to irradiate the river surface and outside of the	[During Const] Contractor [After Const] Contractor *Management of KBA shall be done by MOC, MONREC and local authorities	[During Const] MOC [After Const] MOC, MONREC and local authorities

Area	No.	Item	Draft Mitigation Measures: During Construction	Draft Mitigation Measures: After Construction	Responsibility: Implementation Agency	Responsibility: Responsible Agency
			at nighttime so as not to cause adverse impacts on the fishes' lifecycle ☐ Implementation of detailed comprehensive fauna-flora monitoring during mobilization and construction (See special ecosystem monitoring in the article on EMP)	road in keeping with sound lifecycle of fishes ☐ Implementation of detailed comprehensive fauna-flora monitoring after construction (See special ecosystem monitoring in the article on EMP) ☐ Establishment of land use plan in the project area, KBA/IBA and Ramsar Site and implementation of appropriate land use management so as not to cause unplanned development		
	8	Hydrology	☐ Construction of guidebank and revetment to stabilize hydrological situation north wide of the project area ☐ Diversion of irrigation channels and/or streams shall be set up if the project activities give impacts on such streams	Not required	[During Const] Contractor	[During Const] MOC
	9	Topography and geology	☐ The slope gradient for embankment is adopted 1:2 in accordance with the Guideline of Earthwork (Japan Road Association) ☐ Implementation of slope protection such as turf work, planting treatment, concrete block retaining wall and retaining wall	Not required	[During Const] Contractor	[During Const] MOC
Social Environment	10	Resettlement	[Before Const.] ☐ Holding of consultation meetings for understanding of compensation policy ☐ Appropriate compensation and implementation of livelihood restoration program in accordance with approved RAP by Myanmar Government ☐ Monitoring and assessment regarding the livelihood of PAPs shall be conducted, and appropriate restoration and enhancement of living standards shall be considered in accordance with JICA's Guidelines and related laws and regulation in Myanmar.	Not required	[Before Const] MOC and Local Authorities	[Before Const.] MOC and Local Authorities
	11	Local economy such as employment and livelihood	[Before Const.] ☐ Holding consultation meetings for understanding of compensation policy and livelihood restoration programs for project affected persons who loses agricultural land such as paddy field and rubber plantation ☐ Implementation of adequate compensation in accordance with approved RAP [During Construction] ☐ Appropriated methodology for foundation work such as steel pipe sheet piles method for minimization of turbid water shall be taken so as not to give serious impacts on habitats of fishes. ☐ Appropriate methodology and machines shall be selected for minimization of	☐ Construction of riprap – which aquatic species can use as habitat – for the prevention of scouring at piers ☐ Establishment of grievance redress mechanism for the solution of issues involving farmers and fishermen	[Before Const] MOC and local authorities [During Const] Contractor [After Const] Contractor	[Before Const] MOC and local authorities [During Const] [After Const] MOC

Area	No.	Item	Draft Mitigation Measures: During Construction	Draft Mitigation Measures: After Construction	Responsibility: Implementation Agency	Responsibility: Responsible Agency
			noise and vibration impacts so as not to give serious impacts on the habitats of fishes. ☐ Setting up of navigation channel with the necessary vertical clearance during construction ☐ Establishment of grievance redress mechanism for the solution of issues involving farmers and fishermen			
	12	Land use and utilization of local resources	[Before Const] ☐ Implementation of consultation with affected landowners and formulation of basic compensation policy before actual land acquisition.	☐ Establishment of land use plan and management plan in the project area so as not to cause unplanned development ☐ Pollution control shall be done by Myanmar Government when industrial zone is located in the project area	[Before Const] MOC and local authorities [After Const] MOC and Local Authorities	[Before Const] MOC and local authorities [After Const] MOC and Local Authorities
	13	Water usage	☐ Alternative measures for water provision shall be prepared if water level and water quality at the nearest well change during construction. ☐ Diversion of irrigation channels and/or streams shall be setup, if the project activities give impacts on such streams	☐ Alternative measures for water provision shall be prepared if water level and water quality at the nearest well change	[During Const] Contractor [After Const] MOC	[During Const] [After Const] MOC
	14	Existing social infrastructures and services	☐ Detour and access road to social infrastructure such as school and meeting place for commuters and users shall be provided, if required. Such access road should be secured in the same place from the view of connecting the communities.	Not required	[During Const] Contractor	[During Const] MOC
	15	Social institutions such as local decision-making institutions	↑ Ditto	Not required	[During Const] Contractor	[During Const] MOC
	16	Local conflict of interests	☐ Local workforce is prioritized for the construction of the bridge and other structures ☐ Implementation of appropriate education for hired workers from other areas, if any	Not required	[During Const] Contractor	[During Const] MOC
	17	Landscape	☐ Adoption of monotone color harmonized with the surrounding current landscape	Not required	[During Const] Contractor	[During Const] MOC
	18	Gender	☐ Installation of security light in the crossing road under bridge and approach road ☐ Provision of job opportunities and fair salary between genders. ☐ More female workers shall be encouraged to be employed as skilled and unskilled labors. At least 10% of female workers should be hired as unskilled labor at equal wages.	Not required	[During Const] Contractor	[During Const] MOC
	19	Rights of children	☐ No employment under the age of 18 (Article 6.21 " Child Labor" of Conditions Of Contract For Construction For Building And Engineering Works Designed by the	Not required	[During Const] Contractor	[During Const] MOC

Area	No.	Item	Draft Mitigation Measures: During Construction	Draft Mitigation Measures: After Construction	Responsibility: Implementation Agency	Responsibility: Responsible Agency
			Employer Multilateral Development Bank Harmonized Edition (June 2010) General Conditions/ International Federation Of Consulting Engineers (FIDIC) shall be followed			
	20	Infectious diseases such as HIV/AIDS	☐ Installation of sufficient drainage facilities so as not to provide habitat for vector mosquitoes ☐ Provision of adequate temporary sanitation facilities ☐ Enforcement of medical screening and periodical medical check-up for workers ☐ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness-raising among the labors is promoted during construction. ☐ Article 6.7 “Health and Safety” of Conditions of Contract For Construction for Building and Engineering Works Designed by the Employer Multilateral Development Bank Harmonized Edition (June 2010) General Conditions/ International Federation Of Consulting Engineers (FIDIC) shall be followed.	☐ Implementation of periodical maintenance for drainages	[During Const] Contractor [After Const] MOC	[During Const] [After Const] MOC
	21	Labor environment and safety	☐ Relevant laws in Myanmar such as “the Workmen’s Compensation Act”, “the Factories Act”, “the Leave and Holidays Act”, “the Law relating to Overseas Employment”, “the Labor Organization Law”, “the Settlement of Labor Dispute Law”, “the Social Security Law” and “the Minimum Wages Law” shall be followed. ☐ Additionally, Article 23 on Occupational Health and Safety, Labor and Working Conditions in IFC Performance Standard 2 shall be applied. ☐ Chapter 6 “Staff and Labor” including 6.6 “Facilities for Staff” of Conditions of Contract for Construction for Building and Engineering Works Designed by the Employer Multilateral Development Bank Harmonized Edition (June 2010) General Conditions/ International Federation Of Consulting Engineers (FIDIC) shall be followed.	Not required	[During Const] Contractor	[During Const] MOC and Local Authorities
Others	22	Accident	☐ Deployment of a flagman at the gate of construction area and intersections for traffic management ☐ Installation of safety sign board such as speed limit and residential area in the project area ☐ Installation of fence around the construction site to keep out the local people such as children ☐ Installation of lighting facility at nighttime in the construction area ☐ Restriction of mobilization speed to less than 20km/h in the construction site ☐ Implementation of safety training for	☐ Installation of sign board for safety (speed limit) ☐ Installation of crosswalk and pedestrian bridge at appropriate points ☐ Implementation of traffic safety campaign for citizen ☐ Enforcement of traffic control by police	[During Const] Contractor [After Const] Installation of facilities and sign boards, safety campaign: Contractor Traffic Control: Police department in Bago and Mon	[During Const] MOC [After Const] MOC and Local Authorities

Area	No.	Item	Draft Mitigation Measures		Responsibility	
			During Construction	After Construction	Implementation Agency	Responsible Agency
			the workers ☐ Securing of temporary diversion roads for villagers, if construction activities give adverse impacts to current roads in the project area ☐ Adoption of appropriate construction method and facilities considering the tidal bore ☐ Appropriate notification and safety instruction to construction workers in advance of the construction activity		State	
	23	Cross boundary impacts and climate change (Generation of Green House Gases (CO_2))	According to quantitative forecast on CO2, the project gives positive impact. However implementation of mitigation measures can minimize adverse impacts. ☐ Prohibition of unnecessary operation of construction machines ☐ Periodical (daily, weekly and monthly) checking and maintenance of construction machines shall be done	According to quantitative forecast on CO2, the project gives positive impact. However implementation of mitigation measures can minimize adverse impacts. ☐ Strengthening of speed control by the police department (MOC requests to police department regarding strict speed control) ☐ Strengthening of car inspection mechanisms to restrict vehicles from discharging high emissions (MOC requests to Ministry of Transportation and Communication, Road Transport Administration Department regarding appropriate implementation of car inspection)	[During Const] Contractor [After Const] MOC and Local Authorities	[During Const] MOC [After Const] MOC and Local Authorities

Note) Rating: A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impacts are not expected, but survey and analysis shall be done) D: Few impacts are expected. Detailed quantitative survey is not necessary. (+: Positive impacts, - : Negative impacts)
Source: JICA Study Team

Table 11.8.2 Cost of Special Mitigation Measures

Mitigation Measures	Cost (USD)
1. Setting up of LED handrail light in the bridge section	2.7 Million
2. Setting up of pole more than 4m in height so that moving vehicles will not get hit by flying birds	0.8 Million
Total	3.5 Million

Source: JICA Study Team

11.8.2 Environmental Monitoring Plan

The environmental monitoring plan will be established based on the impacted items and the degree of impacts. These monitoring results and the implementation of mitigation measures shall be observed and managed by the project proponent, contractor, supervision consultant, environmental authorized agency, local governments and relevant ministries.

The direct cost of monitoring during and after construction is 425,400 (USD) and 177,600 (USD), respectively. Additionally cost of special ecosystem during detailed design and construction stage by MOC in cooperation with detailed design consultant and supervision consultant is 250,000 (USD) as shown below;

Table 11.8.3 Estimated Monitoring Cost

Cost	Cost (USD)	Remarks
1. Monitoring Cost during Construction (4 years)	425,400	Monitoring is conducted by the Contractor
2. Special Ecosystem Monitoring (Detailed design stage (1 year) and construction stage (4 years)	250,000	Monitoring is conducted by MOC and the detail ed design consultant
3. Monitoring Cost after Construction (3 years)	177,600	Monitoring is conducted by MOC (including special ecosystem monitoring)
Total	853,000	

Source: JICA Study Team

During construction, the Construction Contractor shall prepare Environmental Management Plan for Construction (CEMP) and obtain permission from PMU and carry out the task under the supervision of the Consultant.

Table 11.8.4 Environmental Monitoring Plan Pre- and During Construction Phase (4 years)

Area	No.	Item	Parameter	Method	Location	Frequency per Year	Direct Cost (in thousands USD)	Conservation Target[*3]
Natural Environment	1	Air pollution	NO_2, $PM_{2.5}$,PM_{10}, SO_2, CO and Ozone	Base on the National Environmental Quality (Emission) Guidelines and / or the same methodology of baseline surveys	**2 Locations** Where baseline monitoring was carried out	**4 time / year x 4 years** (2 times / Dry and Rainy Season)	**16.0** (4 times /year x 500 USD / point x 2 points x 4years)	**National Environmental Quality (Emission) Guidelines** **[Air Emissions]** **Maximum limit values of ambient air quality parameters** 1. Nitrogen Dioxide (NO^2) · 1 year: 40 $\mu g/m^3$ · 1 hour: 200 $\mu g/m^3$ 2. Ozone · 8-hour daily max.: 100 $\mu g/m^3$ 3. PM_{10} (Ø< 10μm) · 1 year: 20 $\mu g/m^3$ · 24 hours: 50 $\mu g/m^3$ 4. $PM_{2.5}$ (Ø< 2.5μm) · 1 year: 10 $\mu g/m^3$ · 24 hours: 25 $\mu g/m^3$ 5. Sulphur Dioxide (SO_2) · 24 hours: 20 $\mu g/m^3$ · 10-minutes: 500 $\mu g/m^3$ **Japanese Standard** 6. Carbon Monoxide (CO) · 24 hours: 10 ppm · 8 hours: 20ppm
	2	Water quality	BOD, COD, Oil & Grease, pH, Total Coliform, T-N, T-P and TSS	Based on the National Environmental Quality (Emission) Guidelines and / or the same methodology of baseline surveys	**2 Locations** Upstream of construction area and downstream of construction area	**4 time / year x 4 years** (2 times each / Dry and Rainy Season)	**6.4** (4 times /year x 200 USD / point x 2 points x 4 years)	**National Environmental Quality (Emission) Guidelines** **[Site Runoff and Wastewater Discharges (Construction Phase)]** 1. BOD : 30 mg/l 2. COD : 125 mg/l 3. Oil and Grease : 10 mg/l 4. pH : 6-9 5. Total coliform bacteria[4]: 400 count/100ml 6. T-N : 10 mg/l 7. T-P : 2 mg/l 8. TSS : 50 mg/l
	3	Waste	Volume of waste soil, cut tree and domestic garbage	Record volume of generated waste in the project area	**Waste storage and collection points**	**4 times / year x 4 years**	**3.2** (4 times /year x 200 USD/time x 4 years)	Waste Management Law (No.1996-766 of October 1996) Generated construction waste and domestic shall be reused or disposed of designated site.
	4	Soil contamination and sedimentation quality	As, Cd, Cr6, Se Cu, Pb, Benzene, Carbon Tetrachloride, 1,2-Dichloroethane, 1,1-Dichloroethylene, Cis-1,2-Dichloroethylene, Dichloroethylene, Thetrachloroethylene, Trichloroethylene 1,1,1-Trichloroethane 1,1,2-Trichloroethane	Same methodology of baseline surveys	**3 Locations** Station-1 and 2: Excavated point at piers on the land in Bago Region and Mon State Station-3: Excavated point in the river	**1 time** **(before excavation)**	**3.0** (1 time x 1,000 USD / point x 3 points)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target 1. Thailand Standard Soil Quality Standards for Habitat and Agriculture, Notification of the National Environmental Board, Thailand (No. 25, B.E. 2547/ 2004) 2: Japanese Standard: Environmental Quality Standards for Soil Pollution, Ministry of Environment/ 1991)
	5	Noise and vibration	Construction noise (dB(A)L_{Aeq})	Noise: 24hrs of continuous measurement (at least 10min in an hour x 24hours)	2 Locations (same as forecasted points during construction)	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**32.0** (Noise and Vibration 2 items (noise/vibration) x 500 USD /point x 2 locations x 4 times / year x 4 year)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Japanese Standard during construction [Noise] dB(A) Reference standard in Japan 07:00-19:00: 85 dB(A)
			Construction vibration (mm/sec)	Vibration 24hrs of continuous	↑ Ditto	**4 times / year x 4 years**		[Vibration] dB Reference standard in Japan

Area	No.	Item	Parameter	Method	Location	Frequency per Year	Direct Cost (in thousands USD)	Conservation Target[*3]
			*Unit shall be converted from mm/s to dB	measurement (at least 10min in an hour x 24hours)		(2 times / Rainy and Dry Season)		07:00-19:00 : 75 dB
Natural Environment	6	Odor	Oil, chemicals and garbage odor	Sensory evaluation	Base camp site and storage	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**1.6** (4 times /year x 100 USD/time x 1 point x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target No significant impact
Natural Environment	7	Protected area and ecosystem	General flora – fauna survey	Visual survey	Project Area	**4 times / year x 4 years** (2 time / Rainy and Dry Season)	**32.0** (4 times /year x 20,000 USD/time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Observed species do not change before and during construction
Natural Environment	8	Topography and geology	Condition of embankment	Visual survey (taking picture)	Project Area (approach road, guidebank and revetment)	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**1.6** (4 times /year x 100 USD/time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Soil erosion, slope failure and landslide are not observed.
Social Environment	9	Involuntary resettlement	Payment and implementation of social assistance in accordance with RAP	Consultation meeting with and / or survey of the project affected persons (PAPs)	Affected area	Refer to RAP monitoring plan	Refer to RAP monitoring plan	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target JICA Guidelines: Compensation shall be completed prior to the actual construction activities and securing of livelihood standards Note: If compensation regarding land acquisition before construction is implemented, this monitoring shall be done by internal and external monitoring body
Social Environment	10	Local economy such as employment and livelihood	Impacts on fishery (fishing ground, income and comments)	Identification based on interviews with fishermen and site survey	Project area and fishermen villages up & downstream	**3 times / year x 4 years** (1 time / Rainy season, 2 times /Dry Season)	**12.0** (3 times /year x 1,000 USD/time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Impacts on fishery shall be minimized based on implementation of mitigation measures such as construction of navigation channel
Social Environment	11	Water usage	Impacts on irrigation and stream	Visual survey (taking picture)	Irrigation channels and stream in the project area	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**1.6** (4 times /year x 100 USD / time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Impacts on irrigation shall be minimized and / or alternative routes shall be secured as mitigation measures
Social Environment	12	Existing social infrastructures and services	Impacts on public infrastructures such as road crossing project area	Visual survey (taking picture)	Crossing roads under the bridge and approach road in the project area	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**3.2** (4 times /year x 200 USD / time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Access route, community & agricultural road shall be secured
Social Environment	13	Local conflict of interests	Construction workers by community	Confirmation of workers' list from the contractor	Project area (base camp site)	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**8.0** (4 times /year x 500 USD / time x 4 years) Including "Gender" , "Rights of children" and	There are not law-based criteria nor international guidelines to be followed, thus following is established as conservation target Employment opportunity shall be provided

Area	No.	Item	Parameter	Method	Location	Frequency per Year	Direct Cost (in thousands USD)	Conservation Target[*3]
							"Infectious Diseases"	fairly for each village
	14	Landscape	Condition of landscape (color of structure)	Visual inspection and taking photo	Project area (structure color)	**2 times / year x 4 years** (1 time / Dry and Rainy Season)	**0.8** (2 times /year x 100 USD / time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target The color of structure shall adopt the monotone color harmonized with the surrounding landscape
	15	Gender	Construction workers (gender)	Confirmation of workers list from contractor	Project area	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	Including Local Conflict of interest	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Employment opportunity shall be provided fairly from the view of gender
	16	Rights of children	Construction workers	Confirmation of workers list from contractor	Project area	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	Including Local Conflict of interest	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target FIDIC 2010 (General Condition) No employment under the age of 18
	17	Infectious diseases such as HIV/AIDS	Number of infected patient	Confirmation of health check list from contractor	Project area (base camp site)	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	Including Local Conflict of interest	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Infectious diseases are not caused by the project
	18	Labor Environment	Construction worker's condition	Confirmation of safety devices and conditions via interviews	Project area (base camp site)	**3.2** (4 times /year x 200 USD / time x 4 years)	**3.2** (4 times /year x 200 USD / time x 4 years)	The following laws and guidelines shall be followed 1. The Factories Act 1951 2. IFC Performance Standard 2 Labor and Working Conditions 3.FIDIC 2010
Other	19	Accident	Number of accidents	Confirmation of accidents list from local government/ police department	Project area	**3.2** (4 times /year x 200 USD / time x 4 years)	**3.2** (4 times /year x 200 USD / time x 4 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target No accidents are caused by construction activities
	20	Cross boundary impacts and climate change	Frequency of maintenance of construction machines	Confirm record of maintenance of construction machines	Project area	**4 times / year x 4 years** (2 times / Rainy and Dry Season)	**1.6** (2 times /year x 200 USD / time x 4 years)	There are not law-based criteria nor international guidelines to be followed, thus following is established as conservation target Construction machines shall be well-maintained so as not to generate much GHGs such as CO2
Total Cost During Construction : *425,400 (USD)* for 4 years (During Construction)								

Remarks
*1: Frequency and timing of monitoring shall be modify at detailed design stage
*2: The cost indicates direct cost, not including consultant fee, overhead and personal expense
*3: Conservation Target: If quantitative values exist, such values are prioritized as target based on Myanmar Laws, International Guidelines and other references. If quantitative values do not exist, qualitative target is established as project base.

Source: JICA Study Team

Environmental monitoring survey plan for operation phase is proposed as follows. Proposed monitoring period is at least three (3) years.

Table 11.8.5 Environmental Monitoring Plan After Construction Phase (3 Years)

Area	No.	Item	Parameter	Method	Location	Frequency per Year	Direct Cost (in thousands USD)	Conservation Target[*3]
Natural Environment	1	Air pollution	NO_2, $PM_{2.5}$,PM_{10}, SO_2, CO and Ozone	Base on the National Environmental Quality (Emission) Guidelines and / or same methodology as baseline surveys	**2 Locations** Where baseline monitoring was carried out.	**2 time / year x 3 years** (1 time / Dry and Rainy Season)	**6.0** (2 times /year x 500 USD / point x 2 points x 3years)	**National Environmental Quality (Emission) Guidelines** **[Air Emissions]** **Maximum limit values of ambient air quality parameters** 1. Nitrogen Dioxide (NO_2) · 1 year: 40 $\mu g/m^3$ · 1 hour: 200 $\mu g/m^3$ 2. Ozone · 8-hour daily max.: 100 $\mu g/m^3$ 3. PM_{10} (Ø< 10μm) · 1 year: 20 $\mu g/m^3$ · 24 hours: 50 $\mu g/m^3$ 4. $PM_{2.5}$ (Ø< 2.5μm) · 1 year: 10 $\mu g/m^3$ · 24 hours: 25 $\mu g/m^3$ 5. Sulphur Dioxide (SO_2) · 24 hours: 20 $\mu g/m^3$ · 10-minutes: 500 $\mu g/m^3$ **Japanese Standard** 6. Carbon Monoxide (CO) · 24 hours: 10 ppm · 8 hours: 20ppm
	2	Noise and vibration	Traffic noise (dB(A)L_{Aeq})	Noise: 24hrs of continuous measurement (at least 10min in an hour x 24hours)	2 Locations (same as forecasted points during construction)	**2 times / year x 3 years** (1 time / Rainy and Dry Season)	**12.0** (Noise and Vibration 2 items (noise/vibration) x 500 USD /point x 2 locations x 2 times / year x 3 year)	Myanmar National Environmental Quality Guidelines [Noise] dB(A)/ Commercial and industrial Area 07:00-22:00: 70 dB(A) 22:00-07:00 70dB(A)
			Traffic Vibration (mm/sec) *Unit shall be converted from mm/s to dB	Vibration 24hrs of continuous measurement (at least 10min in an hour x 24hours)	↑ Ditto	**2 times / year x 3 years** (1 time / Rainy and Dry Season)		There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target -Japanese Standard [Vibration] dB 07:00-20:00 : 70 dB 20:00-07:00: 65 dB
Natural Environment	3	Protected area and ecosystem	Fauna and flora	Same as baseline surveys	Project Area and Ramsar Site	**3 years**	**150.0** (50,000 USD/year x 3 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Observed species do not change after construction
	4	Topography and geology	Condition of embankment	Visual survey (taking picture)	Project Area (approach road, guidebank and revetment)	**2 times / year x 3 years** (1 time / Rainy and Dry Season)	**0.6** (2 times /year x 100 USD/time x 3years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Soil erosion, slope failure and landslide are not observed.
Social Environment	5	Local economy such as employment and livelihood	Impacts on fishery (fishing ground, income and comments)	Identification based on interviews with fishermen and site survey	Project area and fishermen villages up & downstream	**2 times / year x 3 years** (1 time / Rainy and Dry Season)	**6.0** (2 times /year x 1,000 USD/time x 3 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target The project does not give significant impacts on fishing ground
	6	Land use and utilization of local resources	Condition of land use	Visual survey (taking picture) Interview with local government	Project area (along the approach road and bridge)	**2 times / year x 3 years** (1 time / Rainy and Dry Season)	**1.2** (2 times /year x 200 USD/time x 3years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Appropriate land use shall be established and managed by local government

Area	No.	Item	Parameter	Method	Location	Frequency per Year	Direct Cost (in thousands USD)	Conservation Target*3
	7	Water usage	Impacts on irrigation and stream	Visual survey (taking picture)	Irrigation channels and stream in the project area	**2 times / year x 3 years** (1 times / Rainy and Dry Season)	**0.6** (2 times /year x 100 USD / time x 3years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Impacts on irrigation shall be minimized and / or alternative routes shall be secured as mitigation measures
	8	Landscape	Condition of landscape (color of structure)	Visual inspection and taking photo	Project area (structure color)	**1 times / year x 3 years** (1 time / Dry season)	**0.3** (1 time /year x 100 USD / time x 3 years)	There are no law-based criteria nor international guidelines to be followed, thus the following is established as conservation target Color of structure shall adopted a monotone color harmonized with surrounding landscape
Other	9	Accident	Number of accidents	Confirmation of accidents list from local government/ police department	Project area	**1 time / year x 3 years**	**0.9** (1 time /year x 300 USD / time x 3 years)	There are not law-based criteria nor international guidelines to be followed, thus following is established as conservation target There is no significant occurrence of traffic accidents.
Total Cost During Construction : *177,600 (USD)* for 3 years (After Construction)								

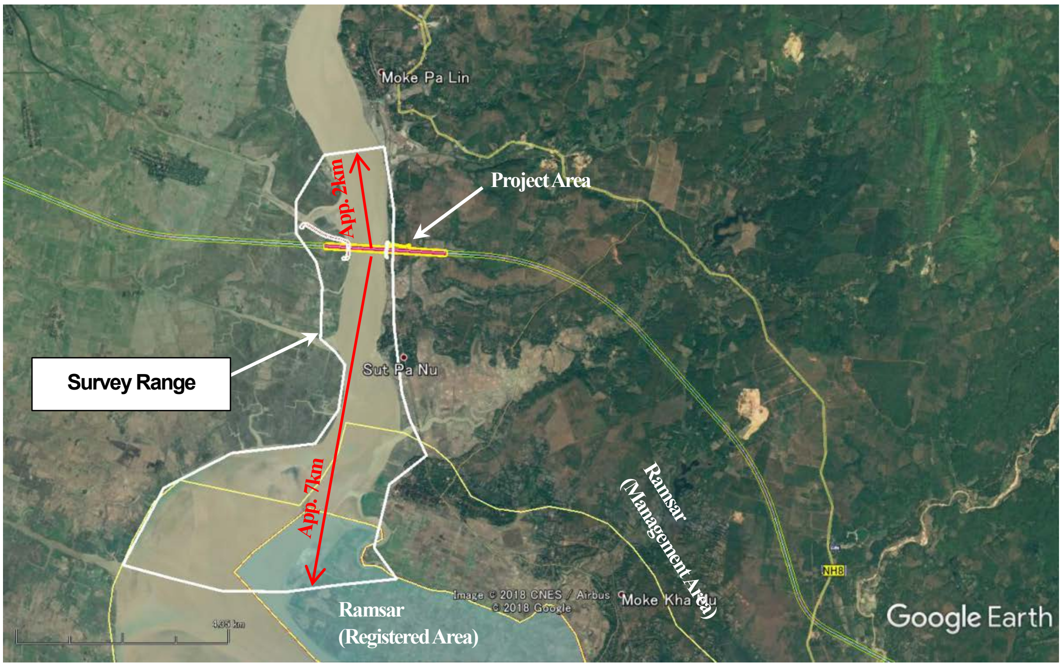
Remarks
*1: Frequency and timing of monitoring shall be modified at the detailed design stage
*2: The cost indicates direct cost, not including consultant fee, overhead and personal expense
*3: Conservation Target: If quantitative values exist, such values prioritized as target based on Myanmar Laws, International Guidelines and other references. If quantitative values do not exist, qualitative target is established as project base.

Table 11.8.6 is the special ecosystem monitoring plan. In the special ecosystem monitoring, when considerable species listed as CR, EN, VU and NT on IUCN Redlist are recorded during, the degree of impacts regarding the project shall be analyzed and taken appropriate mitigation measures.

Table 11.8.6 Special Ecosystem Monitoring Plan during Construction and After Construction

Survey Item \ Survey Period			Survey Season: Dry Season (Migratory Season)	Survey Season: Rainy Season (Not Migratory Season)	Number of Survey Days	Remarks (Number of survey points and area)
Birds Survey	Migratory Birds Survey	Birds Species Survey	Nov-Dec	Jul-Aug	Continuous for 3 days	7-point census
			Jan-Feb	No need	Continuous for 3 days	Line census
Physical Habitat Survey	Mud flat Survey	Record mudflat area	Nov-Dec	No need	One day	Survey Area 2km upstream of the bridge to 7km downstream
	Noise Survey	Ambient noise for 24hrs	Nov-Dec	No need	4 points / 24 hours	1 point: upstream of bridge area 2 points: bridge area 3 points: management area 4 points: core area
Fauna-Flora Survey	Flora Survey	Fauna Species Survey	Nov-Dec	Jul-Aug	3 days	Survey Area (both bank) 2km upstream of the bridge to 7km downstream
	Fauna Survey	Fishes Species Survey Benthos Survey Zooplanktons and Phytoplanktons	Nov-Dec	Jul-Aug	4 points	1 point : up stream of bridge area 2 points: bridge area 3 points: management area 4 points: core area
Cost/ Year						50,000 USD/ year
Detailed Design Stage : 1 year (supported by the Detailed Design Consultant)						50,000 USD / year
Construction Stage: 4 years (supported by the Consultant for Construction Supervision)						200,000 USD / 4 years
Post Construction: 3 years (Conducted by MOC)						150,000 USD/ 3 years

Remarks: All fauna-flora survey: Coordinates and number of the individuals for all observed individuals shall be recorded
Fishes survey: Recorded individuals shall be categorized as juvenile, young and adult
Source: JICA Study Team



Source: JICA Study Team

Figure 11.8.1 Area of Special Ecosystem Monitoring During and After Construction

11.8.3 Monitoring Organization

(1) During Construction

The objectives and design of the EMP and Environmental Monitoring Plan is described in the earlier sections of this chapter. There is a necessity to form a proper 'Institutional Framework' for the effective implementation of the formulated environmental management and monitoring plan. The elements of this 'Institutional Framework' will coordinate and work with each other throughout the project, i.e. during pre-construction, construction and operation stage.

The implementation of formulated environmental mitigation measures comes with a cost, so the budgeting of EMP is necessary and also the financial source that will provide this budget are discussed in this section.

The suggested elements of 'Institutional Framework' for implementing EMP during construction will be as follows:

a) Project Management Unit (PMU) under Ministry of Construction
b) Construction Supervision Consultant (CSC)
    - Project Management Consultant (PMC)
    - Environmental Consultant (EC)
c) Project Construction Contractor - Construction Company (PCC)
d) Authorized Environmental Agency
    - Environmental Conservation Department (ECD), under Ministry of Natural Resources and Environmental Conservation (MONREC)

e) Local Government – Bago Region and Mon State

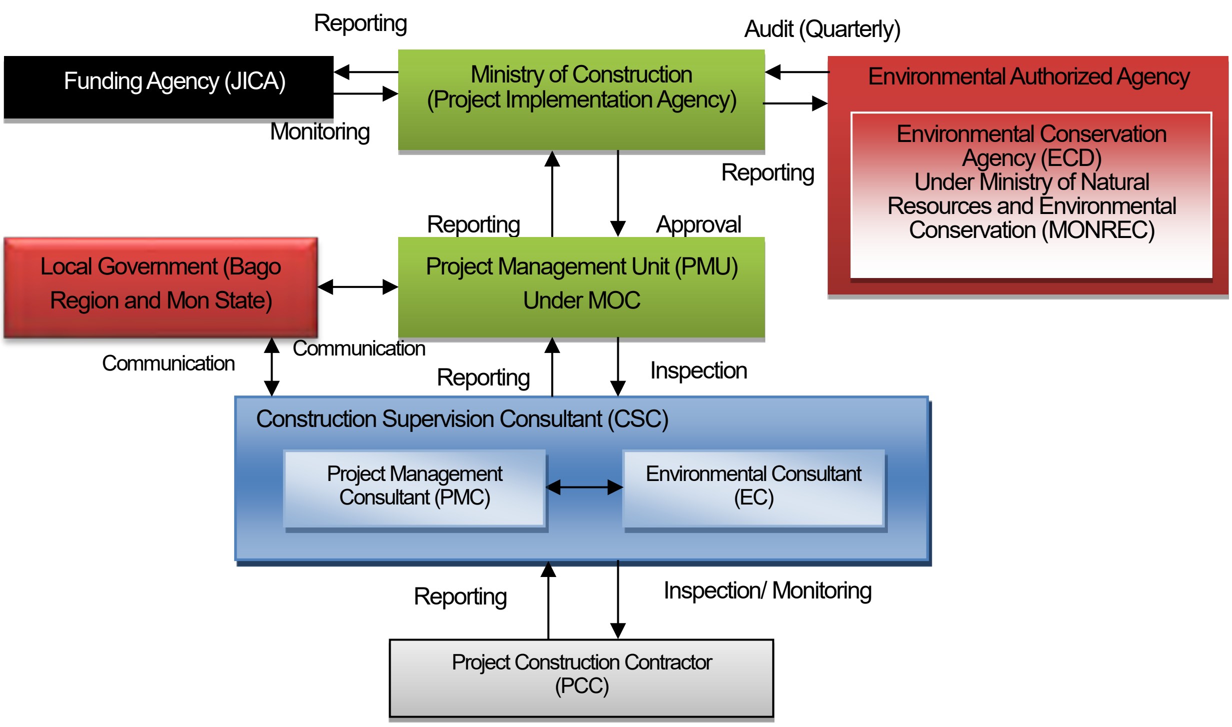
f) Funding Agency – JICA

The above stated elements are part of the 'Institutional Framework' that will work together to effectively implement the formulated 'Environmental Management Plan'. The roles and responsibilities of these elements are given in Table 11.8.7.

Table 11.8.7 Environmental Management Organization during Construction

Name of Organization	Roles and Responsibilities
a) Project Management Unit under MOC (PMU)	· Initiate the coordination process among the concerned organizations (Elements of Institutional Framework) for EMP implementation. · Oversee the implementation of the EMP by PMU and CSC · Review and approve monthly – Environmental Report from CSC and send the report to ECD, MONREC
b) Construction Supervision Consultant (CSC)	· CSC works in association with Project Construction Contractor (PCC) & the Environmental Consultant (EC) on a full-time basis at the project site office. · PMC mainly looks after managing engineering and construction-related activities.
Environmental Consultant (EC)	· EC inspects the implementation of mitigation measures and environmental monitoring conducted by PCC · EC reviews and corrects the Environmental Monitoring Report (EMR) submitted by PCC and then submit it to PMU after inspection.
c) Project Construction Company (PCC)	· PCC implements the approved EMP (mitigation measures) under the observation of PMC and EC. · PCC submits EMR for all conducted mitigation measures on site to the EC on a weekly and/or monthly basis.
d) Authorized Environmental Agency (ECD/MONREC)	· Inspect and audit of periodical environmental monitoring report · Inspect the implementation of mitigation measures on site, as required · Request for necessary action and additional surveys and the implementation of mitigation measures, if required
e) Local Government Bagor Region and Mon State	· Monitor the construction activities · Request for necessary action and additional surveys and the implementation of mitigation measures, if required
f) Funding Agency (JICA)	· Review of periodical environmental monitoring report · Request for necessary action and additional surveys and implementation of mitigation measures, if required

Source: JICA Study Team



Source: JICA Study Team

Figure 11.8.2 Environmental Management Implementation Organization during Construction

(2) After Construction

The major authorities for implementing EMP after construction are as follows:

a) Ministry of Construction (MOC)

b) Local Government – Bago Region and Mon State

c) Authorized Environmental Agency

- Environmental Conservation Department (ECD), under the Ministry of Natural Resources and Environmental Conservation (MONREC)

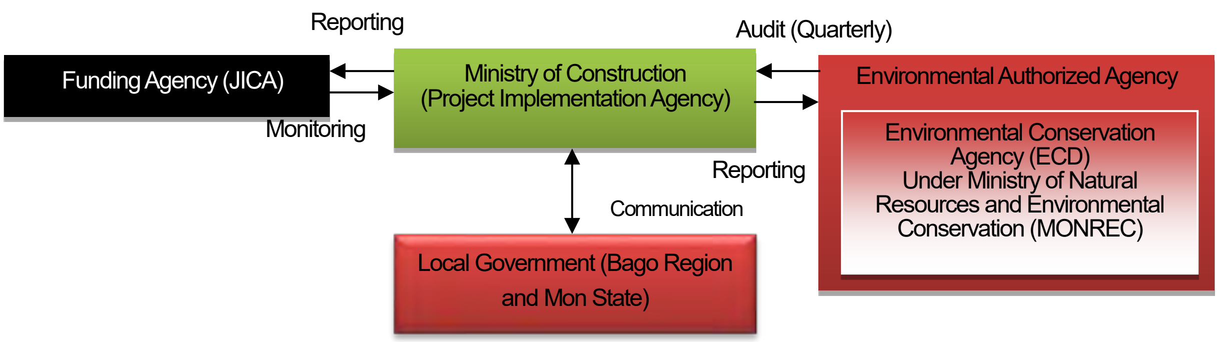
d) Funding Agency – JICA

The roles and responsibilities of each organization are shown below:

Table 11.8.8 Environmental Management Organization After Construction

Name of Organization	Roles and Responsibilities
a) Ministry of Construction (MOC)	· Initiate the coordination process among the concerned organizations (Elements of Institutional Framework) for EMP implementation. · Oversee the implementation of the EMP by PMU and CSC · Review and approval monthly - Environmental Report from CSC and send the report to ECD, MONREC
b) Local Government Bago Region and Mon State	· Monitor the construction activities · Request for necessary action and additional surveys and implementation of mitigation measures, if required
c) Authorized Environmental Agency (ECD/MONREC)	· Inspect and audit periodical environmental monitoring report · Inspect the implementation of mitigation measures on site, as required · Request for necessary action and additional surveys and implementation of mitigation measures, if required
d) Funding Agency (JICA)	· Review the periodical environmental monitoring report · Request for necessary action and additional surveys and implementation of mitigation measures, if required

Source: JICA Study Team



Source: JICA Study Team

Figure 11.8.3 Environmental Management Implementation Organization After Construction

11.8.4 Grievance Redress Mechanism

Complaints and conflicts may arise during construction, land acquisition and compensation process. These complaints and conflicts can be of many kinds. It could be:

I. EIA

i) Unexpected natural and social adverse impacts by the project construction activities

II. Land Acquisition and Compensation

ii) Errors in the identification of people and property affected by the project;

iii) Disagreement on land, either between the affected person and the expropriation agency, or between two neighbors;

iv) Conflict over the ownership of a property between two affected persons;

v) Disagreement over the assessment of property;

vi) Family problems (estates, divorces) that raise disputes between heirs or members of the same family regarding a property, parts of a property or other property;

vii) Disagreement about resettlement measures, location of a resettlement site, type of compensation or habitat proposed, characteristics of the parcel, quality of the new areas of use, etc.

The aim of the Grievance Redress Mechanisms (GRM) is to ensure that grievances and concerns raised by PAPs or other people within the communities can be effectively dealt with in a timely and satisfactory manner. Given the potential for quick and effective resolution on the ground, utilizing local dispute mechanisms as a first step in line with current traditional practices makes the mechanism more effective. Normally, a grievance redress mechanism is developed to ensure that:

i) All complaints related to natural and social impacts by the project, resettlement, compensation and others assistances are appropriately dealt with;

ii) It can be easily accessed by those who have complaints related to resettlement and other assistance; and

iii) Adequate measures are taken to resolve the issues raised.

Grievance related to any aspect of the project or sub-project shall be handled through a consultative manner appropriately, easily and speedily. The Grievance Redress Committee (GRC) is suited as the main entity that takes care of the issues. The composition of the GRC includes the following members:

i) Representatives from PMU/DOB and regional DOB;

ii) Representatives from DOH;

iii) Village Tract leader/ Representatives from the relevant community (at least 1 female member);

iv) Representatives from Township Women Association;

v) Township GAD, MOHA;

vi) Township officer of DALMS, MOALI;

vii)Ministry of Natural Resources and Environmental Conservation;

viii)Ministry of Agriculture, Livestock and Irrigation;

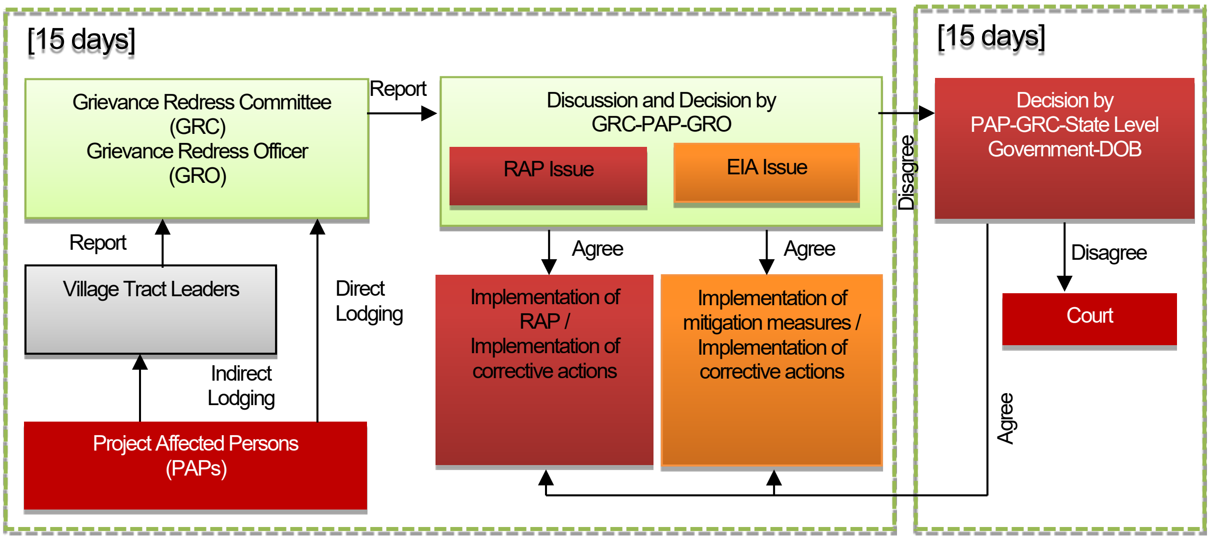
ix) Other relevant organization, if any.

The GRC member are mainly composed of relevant officials at township level. However, depending on the type of the complaint or the situation, the GRC may also ask representatives of the relevant organization to take part in the procedure of grievance resolution, such as state/ regional government, contractor and consultants. For the gender perspective, the GRC should include few female members.

A possible scheme for grievance redress mechanism is illustrated in Figure 11.8.4 and its process is as follows:

1) PAPs can lodge claims or complaints on natural and social impacts, resettlement and compensation directly to the GRC or indirectly through the village tract. A Grievance Redress Officer (GRO) at the corresponding township in GRC is responsible for the contact;
2) The chairperson of the GRC/GRO assigns an officer-in-charge from the RIC members in accordance with the nature of the lodged complaint in order to interview the PAP concerned who raised the issue; **[5 days]**
3) The GRC holds discussions based on the evidences obtained, takes an approach and makes an initial decision. The appointed officer starts negotiation with the PAP in consultation with the RIEC; **[10 days]**
4) In case an agreement is not achieved between the concerned PAP and the GRM within 15 working days from the day the complaint is lodged, the case is to be forwarded to the DoB and the corresponding State government in addition to the GRC. The relevant section in DoB reviews the documents and discusses with the PAP until an agreement is obtained; and **[15 days]**
5) If, however, the agreement is not reached within 15 days at this stage, the case may to be sent to the court for legal steps.

Once grievance are raised in the GRC, the contents of the grievances, status of the resolution process shall be recorded until closure of complaint.



Source: JICA Study Team

Figure 11.8.4 Scheme for Grievance Redress Procedure

This GRM will be separately established from the one to be established for ADB road section since the project proponent will be different organization. However, the proposed GRM of ADB are almost same mechanism with GRM of JICA Bride section. Any issues related to the project such as RAP matter or EIA matter can be raised to the GRC. The component of the GRC are almost same in both GRM. Also, the same steps to be followed both in JICA GRM and ADB GRM as both GRM propose to discuss firstly in the township level and secondly in the state/regional level if not resolved in the first step.

It is also noted that GRM procedures will have to be disclosed and discussed with various stakeholders of the communities around the project area including PAPs of RAP and fishermen to the extent possible in order to ensure that they recognize the GRM, and agree and understand the process. The mechanism is usually established just after the public consultation meeting by re-investigating the RAP contents during the detailed design stage. A plaintiff (PAP) will not need to bear the cost in case the case could be finalized within the committee. The management cost is enough within the total RAP implementation cost. However, the plaintiff is to bear the relevant cost which the domestic legal system defines in case a suit at law would be filed

11.9 Public Consultation for EIA

11.9.1 Summary of Public Consultation

(1) Legal Background and Objectives

The EIA Procedure 2015 prescripts the necessity of public consultation as follows;
The Project Proponent shall conduct the following:

> a) Arrange for appropriate public consultation through all phases of the IEE and EIA process as required by Articles 34, 50, and 61; and
>
> b) Disclose to the public in a timely manner all relevant project-related information in accordance with this Procedure, except for those which may relate to national security concerns as informed by the Ministry.

In the case of EIA project, the proponent shall conduct public consultation meetings twice, at scoping and EIA survey stages, respectively, as EIA Procedure 2015 indicates.

> [Article 50] (only relevant article)
>
> As part of the Scoping, the Project Proponent shall ensure that the following public consultation and participation process is carried out:
>
> b) Arrange the required complement of consultation meetings as advised by the Ministry, with local communities, potential PAPs, local authorities, community-based organizations and civil society, and provide appropriate and timely explanations in press conferences and media interviews.
>
> [Article 61]
>
> As part of the EIA investigations, the Project Proponent shall undertake the following consultation process:
>
> b) Arrange consultation meetings at national, regional, state, Nay Pyi Taw Union Territory and local levels, with PAPs, authorities, community-based organizations and civil society.

On the other hand, JICA Guidelines also prescripts that public consultation meetings shall be done twice for Category A project – which is required by EIA – at scoping and draft EIA stages, respectively.

(2) Overview of Public Consultation

The public consultation meetings for EIA have been held twice at scoping and preparation of draft EIA, respectively. The overview such as date and venue for the meetings are shown below.

Table 11.9.1 Overview of the Public Consultation

Objectives of the Meeting (Date and Venue)	Agenda	Major Attendee	Number of Opinions and questions	Methodology
1st Public Consultation in Bago Region Scoping Stage PC (June 15th, 2017 13:00~14:00 Ammata-yama Monastery (east monastery), Shan Kaing Village, Waw Township, Bago Region)	1. Project outline 2. Expected positive and negative impacts 3. Alternative analysis 4. Tentative schedule of the Study 5. Exchange of opinions	Total: 174 (Male: 103, Female: 51) Government: 8, Parliament: 1, PAPs: 155, NGOs and Community Specific Group: 6, Media: 1,JICA Study Team: 3	✓ Actual number of opinions raised: 2 ✓ No. of summarized opinions:2	1) Information Disclosure ✓ Disclosure on 2 newspapers 1 week prior to the meeting ✓ Verbal notification through township and village tract leader to community 2) Language English and Burmese
1st Public Consultation in Mon State Scoping Stage PC (June 16th, 2017 13:00~14:00 Shin Uppaghotta Pavillion, Sut Pa Nu Village, Kyaikto Township, Mon State)	1. Project outline 2. Expected positive and negative impacts 3. Alternative analysis 4. Tentative schedule of the Study 5. Exchange of opinions	Total: 176 (Male:75, Female: 91) Government: 2, , PAPs: 165, NGOs and Community Specific Group: 9 , JICA Study Team: 3	✓ Actual number of opinions raised: 6 ✓ No. of summarized opinions: 6	
2nd Public Consultation in Mon State Draft EIA Stage PC (August 28th, 2018: 09:46 ~ 11:18am at Sin U Pa Gote Ta Monastery, Sut Pa Nu Village, Kyaikto Township, Mon State)	1. Project outline 2. Result of impact forecast 3. Mitigation measures 4. Environmental management plan 5. Tentative construction schedule 6. Exchange of opinions	Total: 96 (Male: 67, Female: 29) Government: 21, Local Stakeholders: 53, PAPs: 7, NGOs and Community Specific Group: 2 , Media: 3, JICA Study Team: 3, E Guard Environmental Services: 7	✓ Actual number of opinions raised: 5 ✓ No. of summarized opinions: 3	
2nd Public Consultation in Bago Region Draft EIA Stage PC (August 29th, 2018: 09:37 ~ 10:48am at Village Administrator Office, Shan Kaing Village, Waw Township, Bago Region)	1. Project outline 2. Result of impact forecast 3. Mitigation measures 4. Environmental management plan 5. Tentative construction schedule 6. Exchange of opinions	Total: 60 (Male: 44, Female: 16) Government: 11, Parliament: 1, Local Stakeholders: 36, NGOs and Community Specific Group: 2, JICA Study Team: 3, E Guard Environmental Services: 7	✓ Actual number of opinions raised: 7 ✓ No. of summarized opinions: 6	

Source: JICA Study Team

11.9.2 Opinions in the Public Consultation

(1) 1st Public Consultation on Scoping Stage

The opinions, questions and answers during the discussion session are shown below;

Table 11.9.2 Opinions in the 1st Public Consultation Bago Region (15th of June, 2017)

No	Major Opinions and Answers				
	Questions / Comments		Answer		Reaction of the Questioner
	Name/Position	Question/Comment	Name/Position	Answer	
1	Parliament Member (Male)	On behalf of the villagers, a parliament member inquired how much of the agricultural and residential land would be affected and which places that would be affected were still unknown at this time. The villagers would ask again in the next meeting. All the villagers agreed. (Comment)	JICA Study Team	Comments were confirmed	-
2	Villager (Male)	This was a big chance that their village would develop, so all the villagers agreed to and were happy to hear about the new bridge project. For the first meeting, they did not have any questions at all. (Comment)	JICA Study Team	Comments were confirmed	-

Source: JICA Study Team

Table 11.9.3 Opinions in the 1st Public Consultation Mon State (June 16th, 2017)

No	Major opinion and Answer				
	Questions / Comments		Answer		Reaction of the Questioner
	Name/Position	Question	Name/Position	Answer	
1	Head Administrative of the Village (Male)	Regarding the names of the two existing Sittaung bridges (Sittaung-Thein Zayat Bridge and Sittaung - Mokepalin Bridge), a Sut Pa Nu villager wanted to give the bridge name "Sittaung Bridge – Sut Pa Nu", and all the villagers from Sut Pa Nu Village agreed.	JICA Study Team	JICA Study Team would consider and inform the government	Accepted the answer
2	Villager (Male)	Regarding the consideration for the construction area, the villagers felt that the land and the residential area would not be affected too much and the area was a suitable place.	JICA Study Team	JICA Study Team continued considering this point in the study	Accepted the answer
3	Villager (Female)	They were worrying about their income from fishing during the construction period because over 60 houses were owned by fishermen.	JICA Study Team	JICA Study Team would consider this in the study and inform the government	Accepted the answer
4	Villager (Female)	If the bridge implementation was confirmed , they would be happy because they could probably get jobs during the construction period	JICA Study Team	JICA Study Team would consider this request and inform the government	Accepted the answer
5	Villager (Male)	As per information from the Sut Pa Nu Village, there was one ancient pagoda near the bank of Shan Kaing Village and it was sunk under water.	JICA Study Team	JICA Study Team would consider this request and inform the government. (Based on the interview it was confirmed that it was located outside of the construction area.)	Accepted the answer
6	Villager (Male)	Along with the trunk road / bridge development, the villagers wanted to have access road and regional development such as school construction.	JICA Study Team	JICA Study Team would inform the Myanmar government and JICA.	Accepted the answer

Source: JICA Study Team

(2) 2nd Public Consultation on Draft EIA (During EIA Study)

The opinions, questions and answers during the discussion session are shown below:

Table 11.9.4 Opinions in the 2nd Public Consultation Mon State (August 28th, 2018)

No	Major Opinions and Answers				
	Questions / Comments		Answer		Reaction of the Questioner
	Name/Position	Question/Comment	Name/Position	Answer	
1	Villager (Fisherman) (Male)	He asked impacts on fishing areas and fishes due to the using of heavy machinery and the existence of laborers during the construction.	MOC	During the construction stage, an 8-meter wide and 9-meter enough navigation channel would be opened to move along the river. The construction area is prohibited to be used as fishing ground from the view of avoiding accident, but construction activities do not give any impacts on fishes. After construction, fishermen can use the same fishing ground without any restriction. Note) The impact on fishes and fishery are evaluated in 11.7.6.	Accepted the answer
2.	Leader of fishermen (Male)	He heard that the limit would be 5 miles upstream to 5 miles downstream from the bridge construction site. Moreover, it could affect their livelihood because it is the main fishing area for local fishers.	MOC and JICA Study Team	Only construction area will be restricted during construction for safety reason, however there is no limitation for fisheries after construction of the bridge.	Accepted the answer
3.	Village Administrator (Male)	He wanted to conclude the opinions of villagers. Basically, all villagers welcomed	MOC	Questions from betel leaf growers and farmers were warmly welcomed. The MOC	Comments are confirmed.

No	Major Opinions and Answers				
	Questions / Comments		Answer		Reaction of the Questioner
	Name/Position	Question/Comment	Name/Position	Answer	
		the project. Although there were some misunderstandings during the discussions, most of villagers understood the conclusions.		came after explaining about the project to the Chief Minister of Mon State and having to await the higher authorities for final decision.	
			JICA Study Team	The Chief Minister of Mon State would come again to negotiate with the local fisherfolks and to collect survey data on fishers.	-

Source: JICA Study Team

Table 11.9.5 Opinions in the 2nd Public Consultation Bago Region (August 29th, 2018)

No	Major Opinions and Answers				
	Questions / Comments		Answer		Reaction of the Questioner
	Name/Position	Question/Comment	Name/Position	Answer	
1.	Policeman (Male)	He said that they had to settle the cases of encroachment under section (476). Form (7) is very important for farmers. In order to prevent undesirable encroachments and conflicts on land ownership, legal agreements should be carefully read so as not to leave any blanks before signing up. (comment)	JICA Study Team	Comments were confirmed	-
2.	Villager (Male)	He wanted to know whether the entitlement of the villagers would be affected after 2023.	JICA Study Team	If both the Japanese and Myanmar governments agreed to the findings, the construction of bridge would materialize.	Accepted the answer
3.	Township Officer, Waw Agriculture Department (Male)	He asked which extent of paddy fields would be affected in Bago Region and how this would impact the Right of Way of the road passing through these fields.	JICA Study Team	The boundary of the road is measured by ADB. Thus, they will come and explain about the road.	Accepted the answer
4.	Villager (Female)	She wanted to know about the compensation for the paddy fields beside the embankment after the termination of the project.	JICA Study Team	It was not considered yet, but if the rest of the paddy field beside the embankment would be difficult to cultivate, then they would be compensated.	Accepted the answer
5.	Villager (Male)	He asked whether the flow of Sittaung River and erosion of banks would be changed or not due to the construction of the bridge.	JICA Study Team	According to the project, the embankments would be built on both sides so that erosion could be minimized. The flow of water could change within 100 meters downstream from the base of the bridge, but flow would become normal at over 100 meters from the base of the bridge.	Accepted the answer
6	Member of Parliament (Male)	He stated that the attitude of the public was very important. The local people needed to attend public consultation meetings so that they could express their attitudes, needs and discuss openly in a transparent manner. He added that in Myanmar, EIA was not carried out in the past, but it had become mandatory nowadays for development projects like the Sittaung Bridge Project. The EIA results of this project were satisfactory based on the data presented. If there were any serious impacts, the Myanmar Government would arrange for compensation. The arrangement would be done based on the policy of the Ministry of Agriculture, Livestock, and Irrigation. The budget of Myanmar Government would be used for compensation.	JICA Study Team	Comments were confirmed	

Source: JICA Study Team

11.10 Schedule toward Project Implementation

11.10.1 Necessary Environmental Activities and Expected Schedule

Iit is expected that Japan International Cooperation Agency (JICA) is the funding agency and MOC is the implementation agency for the New Sittaung Bridge.

The expected process for the implementation of the project after submission of the draft EIA to ECD is shown below.

With regard to ECD's duration of review of the draft EIA, Article 68 of EIA Procedure 2015 mentions as follows:

Article 68
If it is determined by the Ministry that the EIA Report does not satisfy requirements, then the Project Proponent shall be called upon by the Department to undertake the necessary amendments as directed by the Ministry. The Ministry shall deliver its final decision within ninety (90) working days of receipt of the EIA Report. In case of Complex Projects, or if the Ministry requires the EIA Report to be amended, then the timeline will be extended accordingly.

Source: EIA Procedure 2015

MONREC shall respond whether an amendment is required or not within 90 days after receiving the draft EIA report. The points to be revised are directed by ECD within 90 days, and the proponent shall submit the amended final EIA Report to ECD.

Table 11.10.1 Expected Process for the Implementation of the Project (as of February 2020)

Step	Items	Expected Period (Duration)	Related Organization
Step-1	Submission of draft EIA from MOC (Ministry of Construction) to MONREC (Ministry of Natural Resources and Environmental Conservation)	January 2019	MOC, ECD (Environmental Conservation Department) under MONREC
Step-2	Reviewing by ECD (including resubmission of updated EIA from MOC)	Feb-December 2019 (prescript duration is minimum of 90 working days)	ECD and related ministries
Step-3	EIA approval from ECD/ MONREC	By March 2020	ECD under MONREC

Source: JICA Study Team

Table 11.10.2 Expected Environmental Schedule

Confidential

Source: JICA Study Team

11.11 Other Items and Activities to be Considered

11.11.1 Activities to be Conducted Under the Responsibility of Construction Contractor

In general, adequate information regarding candidate places of the quarry sites, borrow pits, construction roads and construction yard shall be given from MOC to the Contractor in the tender documents.

However the Contractor has rights to make decision to development of new quarry sites and borrow pits, construction of roads and construction yard, and operates after getting permit from the Project Management Unit (PMU) and other relevant organizations.

In this chapter, necessary permissions, activities and environmental considerations for development new sites are described.

Table 11.11.1 Necessary Process and Permissions to be Obtained during Construction

Item	Necessary Action by the Contractor	Remarks
1. Development and/or use of quarry and borrow pit	1-1: Licensed quarry should be selected and contracted	See candidate quarry site (Figure 11.11.1Figure 11.11.2)
	1-2: Obtain environmental approval from ECD under MOREC (if ECD requests for EMP, IEE or EIA)	The following durations are necessary after submission of required report (1) EMP: 30 working days (2) IEE: 60 working days (3) EIA: 90 working days
	1-3: Obtain development permission from the General Administration Department of township and distract	The Contractor shall submit the plan and EMP to the GAD township and district 6-12 months are necessary for the issuance of permit.
	1-4: Negotiate with the landowner regarding the development of quarry in accordance with the approved RAP in this project	The Contractor, together with MOC, shall negotiate with the landowner in accordance with the approved RAP.
2. Development of construction road	2-1: The Contractor shall submit the traffic and access road plan upon discussion with the Consultant and the local government (See tentative construction road: Figure 11.11.4)	MOC should discuss with local government about the preference of road condition after construction, whether for temporary use or permanent occupation.
	2-2: In case of temporary use, the contractor shall negotiate with the landowner and/or property owner and set the appropriate cost in accordance with the approved RAP	In case of permanent occupation, Myanmar government shall compensate for the appropriate replacement cost in accordance with the approved RAP
3. Development of Construction Yard	3-1: The Contractor shall submit activities & facilities plan such as office, workshop, concrete plant, asphalt plant and stock yard. (See Figure 11.11.5 for tentative construction yard)	If the contractor constructs the construction yard outside of the project area, the Contractor shall incur the expense of securing the compound. The Contractor shall pay the appropriate price in accordance with the approved RAP.
	3-2: The Contractor shall submit the EMP for the facilities in the construction yard	-

Note: Cutting tree permission is required if the trees are located in the government land. Private trees shall be obtained from the owner after the appropriate compensation has been made.
Source: JICA Study Team

11.11.2 Predicted Impacts and Mitigation Measures

(1) Development and / or Use of Quarry and Borrow Pit

1) Necessary Volume of Quarry and Soil

The necessary volume of quarry and borrow for the construction of approach road and construction road are shown in Table 11.11.2.

Required materials such as soil and crushed stone are secured from the existing quarry and borrow pits around the project area as shown in Table 11.11.3, Figure 11.11.1 and Figure 11.11.2.

The Contractor shall consider the environmental and social impacts and takes the necessary process when the Contractor needs to open new quarry and borrow pits. Predicted impact items and general mitigation measures are shown in the next article.

Table 11.11.2 Necessary Volume of Quarry and Soil

Item	Necessary Volume	Secured Volume from existing sites (see Table 11.11.3)
1. Soil (Borrow)	149,752 m^3	534,200 m^3
2. Crusher Run	214,802 m^3	323,800 m^3

Source: JICA Study Team

Table 11.11.3 Existing Quarry and Borrow Pit near Project Area

No	Name of Quarry/ Borrow Pit [Distance from the Project Area]	Coordinate		Owner	License		Remaining Area (Capacity *1,000m3)	Productivity
		Latitude(S)	Longitude(E)		Validity	Size		
1	Sein TharaPhu (Quarry-1)[10km]	17.497768	96.907478	U Chit Sein	Valid	Large	11.33 ha (226.6)	700 t/day
2	Kan Pwint Oo Co. Ltd. (Quarry-2)[9.5km]	17.489210	96.909706	(not identify)	Under Renewal	Large	4.86 ha (97.2)	600 t/day
	Total remaining capacity (Quarry)						**323.8**	-
3	U Ye' Win (Borrow pit-1) [3.5km]	17.427771	96.931709	U Ye' Win	No License	-	1.62 ha (32.4)	No info
4	U Thaung Htay (Borrow pit-2) [3.5m]	17.413479	96.938861	Ko Thaung Htay Family	Still applying	Small	7.28 ha (145.6)	700 t/day
5	No name (Borrow pit-3) [48km]	17.476204	96.444740	(Not identified)	No License	-	0.81 ha (16.2)	No info
6	No name (Borrow pit-4) [48km]	17.479589	96.434074	(Not identified)	No License	-	16.19 ha (323.8)	No info
7	No name (Borrow pit-5) [5.5km]	17.451345	96.888039	(Not identified)	No License	-	0.81 ha (16.2)	No info
	Total remaining capacity (Borrow Pit)						**534.2**	

Note) Remaining capacity : remaining area (m2) x 2 m depth
Source: JICA Study Team

Source: JICA Study Team based on Google Earth

Figure 11.11.1 Existing Quarry and Borrow Pits in Mon State

Source: JICA Study Team based on Google Earth

Figure 11.11.2 Existing Quarry and Borrow Pits in Bago Region

2) Expected Adverse Impacts Due to New Development of Quarry and Borrow Pit

As mentioned in the previous article (Table 10.11.1), the Contractor shall take the necessary and appropriate process to obtain an environment and development permit if new quarry and/or borrow pits are required.

In this article, the typical impacted items and reasons are analyzed based on scoping matrix, and general mitigation measures are indicated.

The Contractor shall refer to the following scoping and mitigation measures, and obtain the necessary environmental permission from ECD, if required.

Table 11.11.4 Scoping Matrix for the New Development of Quarry and Borrow Pits

	No	Factor / Impact Item	Rating During Construction	Pre / During Construction: Land acquisition and loss of properties	Change of land use plan, control of various activities by regulations for the construction	Reclamation of wetland, etc.	Deforestation and cutting trees	Alteration of the ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment and vehicles in the compound	Influx of construction workers and staying in the construction yard and offices	Establishment and operation of crusher plant, concrete plant and asphalt plant	Blasting of rock	Transportation of materials(soil and crushed stone)
Pollution	1	Air pollution	B-	—	—	—	—	B-	B-	—	B-	B-	—
	2	Water pollution	B-	—	—	—	—	B-	—	B-	B-	—	—
	3	Waste	B-	—	—	—	B-	—	—	B-	—	—	—
	4	Soil contamination	B-	—	—	—	—	—	—	—	B-	—	B-
	5	Noise and vibration	A-	—	—	—	—	—	B-	—	B-	A-	—
	6	Ground subsidence	—	—	—	—	—	—	—	—	—	—	—
	7	Odor	B-	—	—	—	—	—	—	B-	B-	—	—
	8	Sediment quality (same as soil contamination)	B-	—	—	—	—	—	—	—	B-	—	B-
Natural	9	Protected area	—	—	—	—	—	—	—	—	—	—	—
	10	Ecosystem	B-	—	—	B-	B-	B-	B-	—	—	B-	—
	11	Hydrology	—	—	—	—	—	—	—	—	—	—	—
	12	Topography and geology	B-	—	—	—	—	B-	—	—	—	—	—
Social	13	Involuntary resettlement	C	C	—	—	—	—	—	—	—	—	—
	14	The poor	C	C	—	—	—	—	—	—	—	—	—
	15	Indigenous and ethnic people	—	—	—	—	—	—	—	—	—	—	—
	16	Local economy such as employment and livelihood	C	C	—	—	—	—	—	—	—	—	—
	17	Land use and utilization of local resources	C	—	C	—	C	—	—	—	—	—	—
	18	Waste usage	C	—	—	—	—	C	—	—	—	—	—
	19	Existing social infrastructures and services	C	—	—	—	—	C	—	—	—	—	—
	20	Social institutions such as local decision-making institutions	—	—	—	—	—	—	—	—	—	—	—
	21	Misdistribution of benefits and damage	—	—	—	—	—	—	—	—	—	—	—
	22	Local conflict of interests	—	—	—	—	—	—	—	—	—	—	—
	23	Cultural heritage	—	—	—	—	—	—	—	—	—	—	—
	24	Landscape	C	—	—	—	—	C	—	—	—	—	—
	25	Gender	—	—	—	—	—	—	—	—	—	—	—
	26	Rights of children	C	—	—	—	—	—	—	C	—	—	—
	27	Infectious diseases such as HIV/AIDS	C	—	—	—	—	—	—	C	—	—	—
	28	Labor environment (including work safety)	B-	—	—	—	—	—	B-	B-	—	B-	—
Other	29	Accidents	B-	—	—	—	—	—	B-	B-	—	B-	B-
	30	Cross Boundary impacts and climate change	B-	—	—	—	—	—	B-	—	—	—	—

Note) Rating: A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) —: Light impact is expected. Detailed quantitative survey is not necessary. +: Positive Impacts, -: Negative Impacts
Source: JICA Study Team

Table 11.11.5 Scoping Matrix and Reasons for the New Development of Quarry and Borrow Pits

Area	№	Impacted Item on JICA Guidelines	Rating	Reasons for the Rating (Only During Construction Phase)
Pollution	1	Air pollution	B-	Temporary negative impacts are expected due to cutting and excavation, blasting, operation of construction machines, equipment and relevant plants.
	2	Water pollution	B-	Cutting and rock and soil extraction do not generate waste water. However, run-off water by rain includes high density turbid water. Additionally, domestic organic polluted water and night soil from offices are expected. Chemical polluted water may be discharged from plant and material storage if the facilities are not managed properly. Thus, mitigation measures shall be carried out.
	3	Waste	B-	Domestic waste and night soil from offices are expected. Additionally, construction waste may be generated from the plant.
	4	Soil contamination	B-	Chemicals such as oil at facilities may pollute the surface and underground soil in the compound. If quarry and soil are contaminated, adverse impacts are given in the project area.
	5	Noise and vibration	A-	Generation of noise and vibration is expected due to works of construction machines, equipment and related plants. A significant impact is predicted if blasting method is used at quarry.
	6	Ground subsidence	–	No impacts are expected since activities which cause ground subsidence are not expected.
	7	Odor	B-	Domestic waste from offices and operation of plants may cause bad smell.
	8	Sediment quality (see No4 Soil Contamination)	B-	Chemicals such as oil at facilities may pollute the surface and underground soil in the compound. If quarry and soil are contaminated, adverse impacts are given in the project area.
Natural Environment	9	Protected area	–	Protected area and its surrounding area shall not be selected as quarry and borrow pit.
	10	Ecosystem	B-	Reclamation of wetland, cutting trees, cutting ground, operation machines and blasting give adverse impacts on the ecosystem.
	11	Hydrology	–	No impacts are expected since there are no permanent natural rivers around the project site. However, general mitigation measures shall be done.
	12	Topography and geology	B-	Slope failure and soil erosion may be caused by cutting land and extraction of materials.
Social Environment	13	Involuntary resettlement	C	Resettlement and land acquisition may be caused by the new development of quarry and borrow pits
	14	The poor	C	Inhabitants and shop owners in the developed area who are under the poverty line may be affected by the development of quarry and borrow pits.
	15	Indigenous and ethnic people	–	No indigenous and ethnic people were observed in this area in accordance with WB OP4.10.
	16	Local economy such as employment and livelihood	C	Economic activities such as shops, cultivation of crops and commercial forests existing in the developed area may be impacted due to the development of quarry and borrow pits.
	17	Land use and utilization of local resources	C	Land uses such as agricultural land and/or commercial forests existing in the developed area may be impacted due to development of quarry and borrows pits.
	18	Water usage	C	Land acquisition may give impacts on irrigation facilities and drinking water resources such as wells if they exist in the developed area.
Social Environment	19	Existing social infrastructures and services	C	Schools, hospitals, religious facilities and public utilities may be impacted if they exist in the developed area.
	20	Social institutions such as local decision making institutions	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	21	Misdistribution of benefit and damage	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	22	Local conflict of interests	–	Only qualified quarry and borrow pits are used, thus it is expected that there would be no conflicts among quarry and land owners.
	23	Cultural heritage	–	The area which is located in a cultural heritage site shall not be selected as quarry and borrow pits site.
	24	Landscape	C	Cutting trees, hill and rock may change the topographic feature.

Area	No	Impacted Item on JICA Guidelines	Rating	Reasons for the Rating (Only During Construction Phase)
	25	Gender	–	According to interview with the authority regarding gender in Myanmar, no issues on gender in infrastructure area are observed. Thus, no impacts are expected on this item.
	26	Rights of children	C	Child laborers may be hired in quarry and borrow pit sites
	27	Infectious diseases such as HIV/AIDS	C	Infectious diseases such as STDs are possible to be spread due to inflow of construction workers. Furthermore, alteration on the ground by cut land and filling may trigger the formation of habitats for mosquitoes that could possibly transmit malaria and dengue fever.
	28	Labor environment	B-	Construction work environment needs to be considered in accordance with relevant laws and regulations.
Other	29	Accidents	B-	Construction vehicles may use the existing local roads near residential areas, thus the number of traffic accident may increase.
	30	Cross boundary impacts and climate change	B-	Operation of construction machines generate GHGs.

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) D–: Light impact is expected. Detailed quantitative survey is not necessary.
+: Positive Impacts, -: Negative Impacts
Source: JICA Study Team

3) Recommended Mitigation Measures

Recommended mitigation measures for the development of quarry and borrow pits are shown in Table 11.11.6.

Table 11.11.6 Recommended Mitigation Measures for the Development of Quarry and Borrow Pit

Area	No.	Item	Draft Mitigation Measures	Responsibility	
			During Construction	Implementation Agency	Responsible Agency
Pollution	1	Air pollution	☐ Water sprinkling shall be carried out in the compound so as not to give dust impacts on the nearest residential area. ☐ Periodical maintenance for facilities and machines shall be done ☐ Periodical cleaning shall be done on paved road used as construction road	Contractor (Construction Company)	MOC
	2	Water pollution	☐ Turbid water from unpaved construction area shall be treated in sedimentation pond and discharged into the nearest stream, if required ☐ Waste oil shall be stored and disposed of into the designated site ☐ Provision of sanitation facilities on site ☐ Domestic waste water and night soil from site shall be treated and discharged into the designated site and facilities. ☐ Use of septic tank for portable toilet and temporary toilet in the site	Contractor	MOC
	3	Waste	☐ Waste oil of the facilities and machines shall be collected and disposed of through a licensed agent such as fuel station. ☐ Waste chemical and hazardous material shall be stored on site and disposed of through a licensed agent ☐ Domestic solid waste is collected and disposed at the nearest designated disposal site ☐ Domestic waste water and night soil shall be treated though septic tank and discharged into the natural stream. Water quality of the effluent shall be confirmed before discharging into the natural water body.	Contractor	MOC
	4	Soil Contamination and Sediment	☐ Excavated borrow soil shall be analyzed and confirmed if the quality is under standard values. Polluted soil shall not be used. ☐ Facilities and construction machines shall be maintained so as not to leak oil and chemicals. ☐ Waste oil of facilities and machines shall be collected and disposed of through a licensed agent ☐ Waste chemical and hazardous material shall be stored on site and disposed of by a licensed agent	Contractor	MOC

Area	No.	Item	Draft Mitigation Measures During Construction	Responsibility Implementation Agency	 Responsible Agency
	5	Noise and Vibration	☐ Activities in quarry and borrow pits shall be limited in the daytime and on weekdays. ☐ Facilities and machines shall be well-maintained and checked everyday ☐ Information disclosure such as blasting schedule shall be conducted in advance to the surrounding community.	Contractor	MOC
	6	Odor	☐ Domestic solid waste is collected and disposed at the nearest designated disposal site ☐ Domestic wastewater and night soil shall be treated though septic tank and discharged to natural stream. Water quality of the effluent shall be confirmed before discharging it into the natural water body. ☐ Waste oil of facilities and machines are collected and disposed of through a licensed agent ☐ Waste chemical and hazardous material are stored on site and disposed of through a licensed agent	Contractor	MOC
Natural Environment	7	Ecosystem	☐ Boundary of quarry and borrow pit shall be marked and all relevant workers and communities shall be informed not to conduct development activities outside of boundary ☐ Waste oil shall be stored and disposed of to a designated site so as not to leak water body	Contractor	MOC
	8	Topography and geology	☐ Implementation of slope protection such as turf work, planting treatment, concrete block retaining wall and retaining wall at the end of construction period	Contractor	MOC
Social Environment	9	Resettlement	☐ Holding of consultation meetings with landowner(s) for understanding of compensation policy ☐ Appropriate compensation and implementation of livelihood restoration program in accordance with approved RAP by Myanmar Government	Contractor and Local Authorities	MOC and Local Authorities
	10	The Poor	☐ Appropriate livelihood restriction program shall be considered in accordance with approved RAP	Contractor	MOC
	11	Local economy such as employment and livelihood	☐ Holding of consultation meetings for understanding of compensation policy and livelihood restoration programs for project affected persons who lose agricultural lands such as paddy field and rubber plantation ☐ Implementation of adequate compensation in accordance with approved RAP	Contractor	MOC
	13	Land use and utilization of local resources	☐ Implementation of consultation with affected landowners and formulation of basic compensation policy before actual land acquisition.	Contractor	MOC
	12	Water usage	☐ Appropriate compensation shall be done in accordance with approved RAP, if water usage facilities area such as wells are affected ☐ Alternative measures for water provision shall be prepared if water level and water quality at the nearest well change during the operation of quarry and borrow pits. ☐ Diversion of irrigation channels and/or streams shall be setup, if the activities give impacts on such streams	Contractor	MOC
	13	Existing social infrastructures and services	☐ Developing of quarry and borrow pits shall avoid areas adjacent to school, hospital, religious facilities and other public facilities. ☐ Detour and access road to social infrastructure such as school and meeting place for commuters and users shall be provided, if required. Such access road should be secured at the same place from the view of connecting the communities	Contractor	MOC
	14	Landscape	☐ Adoption of monotone color for the construction of facilities harmonized with the surrounding current landscape ☐ Replanting shall be done at the end of construction period	Contractor	MOC
	15	Gender	☐ Provision of job opportunities and fair salary between genders. ☐ More female workers shall be encouraged to be employed as skilled and unskilled labors. At least 10% of female workers should	Contractor	MOC

Area	No.	Item	Draft Mitigation Measures During Construction	Responsibility Implementation Agency	 Responsible Agency
			be hired as unskilled labor at equal wages.		
	16	Rights of children	☐ No employment under the age of 18	Contractor	MOC
	17	Infectious diseases such as HIV/AIDS	☐ Installation of sufficient drainage facilities so as not to provide habitat for vector mosquitoes ☐ Enforcement of medical screening and periodical medical check-up for workers ☐ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness-raising among the laborers is promoted during construction	Contractor	MOC
	18	Labor Environment and Safety	☐ Relevant laws in Myanmar such as “the Workmen’s Compensation Act”, “the Factories Act”, “the Leave and Holidays Act”, “the Law relating to Overseas Employment”, “the Labor Organization Law”, “the Settlement of Labor Dispute Law”, “the Social Security Law” and “the Minimum Wages Law” shall be followed ☐ Additionally Article 23 of Occupational Health and Safety, Labor and Working Conditions in IFC Performance Standard 2 shall be applied.	Contractor	MOC
Others	19	Accident	☐ Deployment of flagman at the gate for traffic management ☐ Installation of safety sign board such as speed limit and residential area near site ☐ Installation of fence around the construction site to keep out the local people such as children ☐ Installation of lighting facility in the night time on site ☐ Restriction of mobilization speed to less than 20km/h in the construction site ☐ Implementation of safety training for the workers (especially blasting methodology and standard operation procedure)	Contractor	MOC
	20	Cross Boundary impacts and climate change	☐ Prohibition of unnecessary operation of facilities and machines ☐ Periodical (daily, weekly and monthly) checking and maintenance of facilities and machines shall be done	Contractor	MOC

Source: JICA Study Team

(2) Development of Construction Road

1) Location of Construction Road

To enable the efficient construction works on both bank sides and shorten the construction period, access roads are necessary for both sides. The typical cross section and route of the access road is shown in Figure 11.11.3 and Figure 11.11.4, respectively.

The existing route A on the east bank in Mon State has sufficient width of four (4) meters for the construction of access road and is expected to be utilized as a construction road. Widening and installation of lay-by for construction vehicles are necessary on some portions along the route.

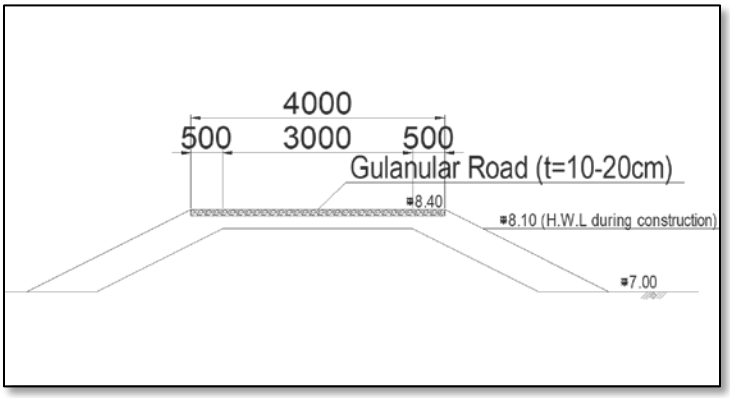
On the East bank in Bago Region, the existing route does not connect to the construction site and passes through the residential area (village). Thus, half of the route bypassing the residential area should be newly developed and the other section should be widened and raised up.

The total length of the access road is 23.8 km, and cost of land acquisition is estimated at approximately 45,000 USD. The contractor shall negotiate with the landowner and compensate in accordance with the approved RAP.

Table 11.11.7 Length and Cost of Access Road During Construction

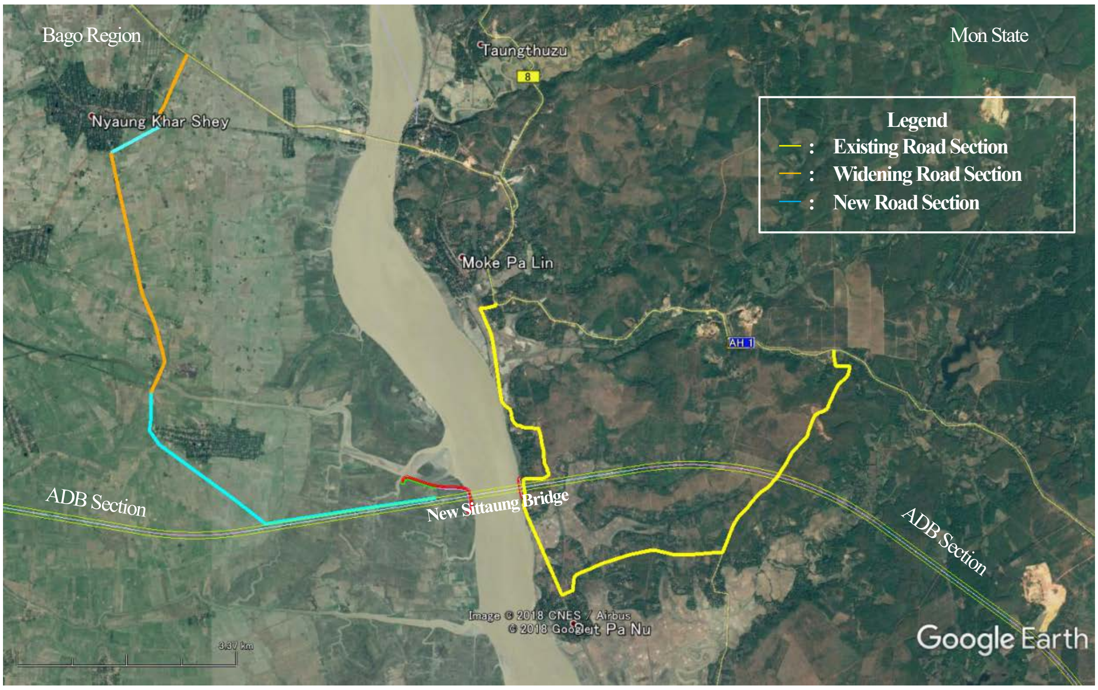
Area \ Road Type		Existing Road	Widening and Elevated	New Road	Total
1. East Bank (Mon State)	Road Length	12.3km	0	0	12.3km
	Acquired Land (estimated cost)	0	0	0	0
2. West Bank (Bago Region)	Road Length	0	5.0km	6.5km	11.5km
	Acquired Land (estimated cost)	0	2.5 ha (12,500 USD)	6.5 ha (32,500 USD)	9.0 ha (45,000 USD)
	Total	12.3km	5.0km	6.5km	23.8km

Estimated land cost: Approximately 5 USD/m2 (Based on replacement cost in RAP Survey)
Source: JICA Study Team



Source: JICA Study Team based on Google earth

Figure 11.11.3 Typical Cross Section of Access Road During Construction



Source: JICA Study Team based on Google earth

Figure 11.11.4 Access Road Plan During Construction

2) Expected Adverse Impacts Due to Construction of Access Road (In the Case of New and Widening of the Road)

As mentioned in Table 10.11.1, the Contractor shall take the necessary and appropriate process in securing the environment and development permission for the construction of access road.

According to opinions from the community, the widening of existing road and/or new construction of access road is desirable for the community because the current community road is not in good condition especially during rainy season. Thus, it is recommended that the Contractor discusses with MOC and local government about the necessity of leaving the access road after construction period.

In this article, typical impacted items and reasons are analyzed based on scoping matrix, and the general mitigation measures are indicated.

The Contractor shall refer to following scoping and mitigation measures and obtain the necessary environmental permission from ECD, if required. According to EIA Procedure 2015, since the total road length for the new development is less than 50km, IEE and EIA is not required. However, the Contractor shall confirm with MONREC about the necessary action.

Table 11.11.8 Scoping Matrix for the New Development of Construction Access Road

	No	Factor / Impact Item	Rating during Construction	During Construction: Land acquisition and loss of properties	Change of land use plan, control of various activities by regulations for the construction	Reclamation of wetland, etc.	Deforestation and cutting trees	Alteration of the ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment, machines and vehicles	Influx of construction workers (construction yard is not necessary)
Pollution	1	Air pollution	B-	—	—	—	—	B-	B-	—
	2	Water pollution	B-	—	—	—	—	B-	—	—
	3	Waste	B-	—	—	—	B-	—	—	—
	4	Soil contamination	B-	—	—	—	—	B-	—	—
	5	Noise and vibration	B-	—	—	—	—	—	B-	—
	6	Ground subsidence	B-	—	—	—	—	B-	—	—
	7	Odor	—	—	—	—	—	—	—	—
	8	Sediment quality (same as soil contamination)	B-	—	—	—	—	B-	—	—
Natural	9	Protected area	—	—	—	—	—	—	—	—
	10	Ecosystem	B-	—	—	B-	B-	B-	B-	—
	11	Hydrology	B-	—	—	—	—	B-	—	—
	12	Topography and geology	B-	—	—	—	—	B-	—	—
Social	13	Involuntary resettlement	B-	B-	—	—	—	—	—	—
	14	The poor	C	C	—	—	—	—	—	—
	15	Indigenous and ethnic people	—	—	—	—	—	—	—	—
	16	Local economy such as employment and livelihood	C	C	—	—	—	—	—	—
	17	Land use and utilization of local resources	C	—	C	—	C	—	—	—
	18	Waste Usage	C	—	—	—	—	C	—	—
	19	Existing social infrastructures and services	C	—	—	—	—	C	—	—
	20	Social institutions such as local decision making institutions	—	—	—	—	—	—	—	—
	21	Misdistribution of benefits and damage	—	—	—	—	—	—	—	—
	22	Local conflict of interests	B-	—	—	—	—	—	—	B-
	23	Cultural Heritage	C	—	—	—	—	C	—	—
	24	Landscape	—	—	—	—	—	—	—	—
	25	Gender	—	—	—	—	—	—	—	—
	26	Rights of children	C	—	—	—	—	—	—	C
	27	Infectious diseases such as HIV/AIDS	C	—	—	—	—	—	—	C
	28	Labor environment (including work safety)	B-	—	—	—	—	—	B-	B-
Other	29	Accidents	B-	—	—	—	—	—	B-	B-
	30	Cross boundary impacts and climate change	B-	—	—	—	—	—	B-	—

Note) Rating: A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) —: Light impact is expected. Detailed quantitative survey is not necessary. +: Positive Impacts, -: Negative Impacts
Source: JICA Study Team

Table 11.11.9 Scoping Matrix and Reasons for Access Road

Area	No	Impacted Item on JICA Guidelines	Rating	Reasons of the Rating (Only Construction Phase)
Pollution	1	Air pollution	B-	Temporary negative impacts are expected due to earthwork and operation of construction machines.
	2	Water pollution	B-	Earthwork activities in the paddy field and nearby stream may cause turbid water.
	3	Waste	B-	Cut trees and waste soil may occur in the affected area.
	4	Soil contamination	B-	Materials from quarry and borrow pit may cause pollution near the access road
	5	Noise and vibration	B-	Generation of noise and vibration is expected due to the operation of construction machines.
	6	Ground subsidence	B-	Construction of the road may cause ground subsidence adjacent to embankment especially in the paddy field
	7	Odor	–	No adverse impacts are expected due lack of base camp site for these activities
	8	Sediment quality (see No4 Soil Contamination)	B-	Materials from quarry and borrow pit near the access road may be polluted
Natural Environment	9	Protected area	–	Protected area and its surrounding area shall not selected as quarry and borrow pit.
	10	Ecosystem	B-	Reclamation of wetland, cutting trees and operation machines may give adverse impacts on the ecosystem.
	11	Hydrology	B-	Construction of the access road may give impact on the existing streams
	12	Topography and geology	B-	Slope failure and soil erosion may be caused by embankment
Social Environment	13	Involuntary resettlement	B-	Land acquisition is caused due to widening of existing road and construction of new access road
	14	The poor	C	Land owner who is under poverty line may be affected by land acquisition
	15	Indigenous and ethnic people	–	No indigenous and ethnic people were not observed in this area in accordance with WB OP4.10
	16	Local economy such as employment and livelihood	C	Economic activities such as cultivation of crops and commercial forests may be impacted due to development of access road
	17	Land use and utilization of local resources	C	Land use such as agricultural land and/or commercial forests may be impacted due to development of access road
	18	Water usage	C	Land acquisition may give impacts on irrigation facilities and drinking water resources such as wells if they exist in the developed area.
Social Environment	19	Existing social infrastructures and services	C	Schools, hospitals, religious facilities and public utilities may be impacted if they exist in the developed area.
	20	Social institutions such as local decision making institutions	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	21	Misdistribution of benefit and damage	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	22	Local conflict of interests	B-	Local inhabitants and local authorities may request to ensure job opportunities as construction workers fairly.
	23	Cultural heritage	C	Cultural heritage such as pagoda may be located in the affected area
	24	Landscape	–	Construction of access road does not give significant impacts to current landscape
	25	Gender	–	According to an interview with authority regarding gender in Myanmar, no issues on gender in infrastructure area are observed. Thus no impacts are expected on this item.
	26	Right of children	C	Child laborers may be hired as simple workers in the project area
	27	Infectious diseases such as HIV/AIDS	C	Infectious diseases such as STDs are possible to be spread due to inflow of construction workers. Furthermore, alteration on the ground by filling may trigger the formation of habitats for mosquitoes that could possibly transmit malaria and dengue fever.
	28	Labor environment	B-	Construction work environment needs to be considered in accordance with relevant laws and regulations.
Other	29	Accidents	B-	Construction vehicles use the existing local roads near residential areas, thus the number of traffic accidents may increase.

Area	№	Impacted Item on JICA Guidelines	Rating	Reasons of the Rating (Only Construction Phase)
	30	Cross boundary impacts and climate change	B-	Operation of construction machines generate GHGs.

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) —: Light impact is expected. Detailed quantitative survey is not necessary.
+: Positive Impacts, -: Negative Impacts
Source: JICA Study Team

3) Recommended Mitigation Measures

Recommended mitigation measures for the access roads are shown in Table 11.11.10.

Table 11.11.10 Recommended Mitigation Measures for the Access Roads

Area	No.	Item	Draft Mitigation Measures	Responsibility	
			During Construction	Implementation Agency	Responsible Agency
Pollution	1	Air pollution	☐ Water sprinkling shall be carried out in the construction area so as not to give dust impacts on the nearest residential area. Surface treatment should be considered if required. ☐ Periodical maintenance for facilities and machines shall be done	Contractor (Construction Company)	MOC
	2	Water pollution	☐ Turbid water shall be minimized at river and stream ☐ Waste oil shall be stored and disposed of into the designated site	Contractor	MOC
	3	Waste	☐ Waste oil of facilities and machines shall be collected and disposed through a licensed agent ☐ Cut trees shall be reused or disposed of at a designated place	Contractor	MOC
	4	Soil contamination and sediment	☐ Excavated borrow soil shall be analyzed and confirmed if the quality is under standard values. Polluted soil shall not be used. ☐ Facilities and construction machines shall be maintained so as not to leak oil and chemicals. ☐ Waste oil of facilities and machines shall be collected and disposed through a licensed agent	Contractor	MOC
	5	Noise and vibration	☐ Activities in quarry and borrow pits shall be limited in the daytime and on weekdays ☐ Facilities and machines shall be well-maintained and checked everyday ☐ Information disclosure of construction schedule shall be carried out in advance to the surrounding community.	Contractor	MOC
	6	Ground subsidence	☐ Ground condition shall be monitored during construction and the appropriate countermeasure shall be taken if ground subsidence is found	Contractor	MOC
Natural Environment	7	Ecosystem	☐ Boundary of quarry and borrow pit shall be marked and all relevant workers and communities shall be informed not to conduct development activities outside of the boundary ☐ Waste oil shall be stored and disposed to designated site not to leak water body	Contractor	MOC
	8	Topography and geology	☐ Implementation of slope protection such as turf work, planting treatment, concrete block retaining wall and retaining wall at the end of construction period	Contractor	MOC
Social Environment	9	Resettlement	☐ Holding of consultation meetings with landowner(s) for understanding of compensation policy ☐ Appropriate compensation and implementation of livelihood restoration program in accordance with approved RAP by Myanmar Government	Contractor and Local Authorities	MOC and Local Authorities
	10	The Poor	☐ Appropriate livelihood restriction program shall be considered in accordance with approved RAP	Contractor	MOC
	11	Local economy such as employment and livelihood	☐ Holding of consultation meetings for understanding of compensation policy and livelihood restoration programs for project affected persons who lose agricultural lands such as paddy field and rubber plantation	Contractor	MOC

Area	No.	Item	Draft Mitigation Measures During Construction	Responsibility Implementation Agency	 Responsible Agency
			☐ Implementation of adequate compensation in accordance with approved RAP		
	12	Land use and utilization of local resources	☐ Implementation of consultation with affected landowners and formulation of basic compensation policy before actual land acquisition.	Contractor	MOC
	13	Water usage	☐ Appropriate compensation shall be done in accordance with approved RAP, if water usage facilities area affected such as wells ☐ Alternative measures for water provision shall be prepared if water level and water quality at the nearest well changes during operation of quarry and borrow pits. ☐ Diversion of irrigation channels and/or streams shall be setup, if the activities give impacts to such streams	Contractor	MOC
	14	Existing social infrastructures and services	☐ Detour and access road to social infrastructure such as school and meeting place for commuters and users shall be provided, if required. Such access road should be secured at same place basically from the view of community's connection.	Contractor	MOC
	15	Gender	☐ Provision of job opportunities and fair salary between genders. ☐ More female workers shall be encouraged to be employed as skilled and unskilled labors. At least 10% of female workers should be hired as unskilled labor at equal wages.	Contractor	MOC
	16	Right of Children	☐ No employment under the age of 18	Contractor	MOC
	17	Infectious diseases such as HIV/AIDS	☐ Installation of sufficient drainage facilities so as not to provide habitats for vector mosquitoes ☐ Enforcement of medical screening and periodical medical check-up for workers ☐ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness-raising among the laborers is promoted during construction	Contractor	MOC
	18	Labor Environment and Safety	☐ Relevant laws in Myanmar such as "the Workmen's Compensation Act", "the Factories Act", "the Leave and Holidays Act", "the Law relating to Overseas Employment", "the Labor Organization Law", "the Settlement of Labor Dispute Law", "the Social Security Law" and "the Minimum Wages Law" shall be followed ☐ Additionally, Article 23 of Occupational Health and Safety, Labor and Working Conditions in IFC Performance Standard 2 shall be applied.	Contractor	MOC
Others	19	Accident	☐ Deploying of flagman at the gate for traffic management ☐ Installation of safety sign board such as speed limit and residential area near site ☐ Installation of fence around the construction site to keep out the local people such as children ☐ Installation of lighting facility on site at nighttime ☐ Restriction of mobilization speed to less than 20km/h in the construction site ☐ Implementation of safety training for the workers (especially blasting methodology and standard operation procedure)	Contractor	MOC
	20	Cross Boundary impacts and climate change	☐ Prohibition of unnecessary operation of facilities and machines ☐ Periodical (daily, weekly and monthly) checking and maintenance of facilities and machines shall be done	Contractor	MOC

Source: JICA Study Team

(3) Construction Yard and Camp Site

1) Candidate Location of the Construction Yard

The candidate locations of the construction yards and installed facilities are shown in Figure 11.11.5 and Table

11.11.11.

Source: JICA Study Team based on Google Earth

Figure 11.11.5 Candidate Location of Construction Yard

Table 11.11.11 Expected Facilities in the Construction Yard

Item	Description
Location	Sut Pa Nu village, Kyaikto Township, Thaton District, Mon State
Current Land use	Agricultural Area
Estimated Area	Approx. 2 ha
Expected installed facilities	Office, work shop, concrete plant, accommodation for workers, storage and parking space
Number of Workers	Approx. 100 workers (including skilled workers)

Source: JICA Study Team

2) Expected Adverse Impacts of Construction Yard Including Activities such as Operation of Plants

These candidate locations of the construction yard have been identified during feasibility study as a part of cost estimation of the project. However, the candidate location is proposed by the construction contractor and approved by the project proponent before actual construction activities.

The contractor shall refer to the following predicted adverse impacts and mitigation measures, take the necessary process and obtain approval in accordance with relevant EIA laws and JICA Guidelines during mobilization.

Expected adverse impacts during construction and their reasons are shown below:

Table 11.11.12 Scoping Matrix for Construction Yard

	No	Impact Item \ Factor	Rating During Construction	Pre-During Construction: Land acquisition and loss of properties	Change of land use plan, control of various activities by regulations for the construction	Reclamation of wetland, etc.	Deforestation and cutting trees	Alteration of the ground by cut land, filling, drilling, tunnel, etc.	Operation of construction equipment and vehicles	Influx of construction workers and staying in construction yard and offices	Establishment and operation of plants and material storage (asphalt plant, etc.)
Pollution	1	Air pollution	B-	–	–	–	–	B-	B-	–	–
	2	Water pollution	B-	–	–	–	–	–	B-	B-	–
	3	Waste	B-	–	–	–	B-	–	–	B-	–
	4	Soil contamination	B-	–	–	–	–	B-	–	–	B-
	5	Noise and vibration	B-	–	–	–	–	–	B-	–	B-
	6	Ground subsidence	–	–	–	–	–	–	–	–	–
	7	Odor	B-	–	–	–	–	–	–	B-	–
	8	Sediment quality	B-	–	–	–	–	–	B-	–	–
Natural	9	Protected area	–	–	–	–	–	–	–	–	–
	10	Ecosystem	B-	–	–	–	–	–	–	B-	–
	11	Hydrology	–	–	–	–	–	–	–	–	–
	12	Topography and geology	–	–	–	–	–	–	–	–	–
Social	13	Involuntary resettlement	–	–	–	–	–	–	–	–	–
	14	The poor	–	–	–	–	–	–	–	–	–
	15	Indigenous and ethnic people	–	–	–	–	–	–	–	–	–
	16	Local economy such as employment and livelihood	–	–	–	–	–	–	–	–	–
	17	Land use and utilization of local resources	–	–	–	–	–	–	–	–	–
	18	Waste usage	–	–	–	–	–	–	–	–	–
	19	Existing social infrastructures and services	–	–	–	–	–	–	–	–	–
	20	Social institutions such as local decision-making institutions	–	–	–	–	–	–	–	–	–
	21	Misdistribution of benefits and damage	–	–	–	–	–	–	–	–	–
	22	Local conflict of interests	B-	–	–	–	–	–	–	B-	–
	23	Cultural heritage	–	–	–	–	–	–	–	–	–
	24	Landscape	–	–	–	–	–	–	–	–	–
	25	Gender	–	–	–	–	–	–	–	–	–
	26	Rights of children	C	–	–	–	–	–	–	C	–
	27	Infectious diseases such as HIV/AIDS	C	–	–	–	–	–	–	C	–
	28	Labor environment (including work safety)	B-	–	–	–	–	–	B-	B-	B-
Other	29	Accidents	B-	–	–	–	–	–	B-	B-	–
	30	Cross Boundary impacts and climate change	B-	–	–	–	–	–	B-	–	B-

Note) Rating: A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) –: Light impact is expected. Detailed quantitative survey is not necessary. +: Positive Impacts, -: Negative Impacts

Source: JICA Study Team

Table 11.11.13 Scoping Matrix and Reasons for Construction Yard

Area	№	Impacted Item on JICA Guidelines	Rating	Reasons of the Rating (Only Construction Phase)
Pollution	1	Air pollution	B-	Temporary negative impacts are expected due to operation of construction machines, plants and equipment.
	2	Water pollution	B-	Domestic organic polluted water and night soil from offices are expected. Additionally, chemical polluted water may be discharged from the plant and material storage if the facilities are not managed properly.
	3	Waste	B-	Domestic waste and night soil from offices are expected. Additionally, construction waste may be generated from the plant.
	4	Soil contamination	B-	Materials for facilities and chemicals such as oil may pollute the surface and underground soil in the compound.
	5	Noise and vibration	B-	Generation of noise and vibration is expected due to operation of construction machines, equipment and plants.
	6	Ground subsidence	–	No impacts are expected since activities which cause ground subsidence are not expected.
	7	Odor	B-	Domestic waste from offices and operation of plants may cause bad smell
	8	Sediment quality (See No.4 soil contamination)	B-	Materials for facilities and chemicals such as oil may pollute the surface and underground soil in the compound, and such polluted soil comes out to the nearest steam and/or water body.
Natural Environment	9	Protected area	–	No impacts are expected since there are no national parks, natural protected and critical habitats area near project site.
	10	Ecosystem	B-	Operation of construction machines, plants, discharging domestic polluted water may give impacts on the surrounding area
	11	Hydrology	–	No impacts are expected since there are no streams in the candidate location. Furthermore, activities in the construction yard do not give any impact on the hydrological situation of the Sittaung River.
	12	Topography and geology	–	Considerable topography and geological sites are not located in the Project Area, thus no impact is expected. Furthermore, any plans of construction embankment do not exist in the compound.
Social Environment	13	Involuntary resettlement	–	No resettlement and land acquisition are caused (Land acquisition is done by Myanmar Government before construction stage)
	14	The poor	–	Since land acquisition is done by Myanmar government before construction, there are no issues during construction
	15	Indigenous and ethnic people	–	No indigenous and ethnic people are not observed in accordance with WB OP4.10
	16	Local economy such as employment and livelihood	–	Since land acquisition is done by Myanmar government before construction, there are no issues during construction
	17	Land use and utilization of local resources	–	Since land acquisition is done by Myanmar government before construction, there are no issues during construction
	18	Water usage	–	There are no irrigation system and streams in the compound
Social Environment	19	Existing social infrastructures and services	–	No impacts are expected in the affected area because there are no schools, clinics, meeting places and religious facilities in the affected area.
	20	Social institutions such as local decision making institutions	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	21	Misdistribution of benefit and damage	–	No impacts are expected because there are no activities which give adverse impacts on this item.
	22	Local conflict of interests	B-	Local inhabitants and local authorities may request to ensure job opportunities for construction workers fairly.
	23	Cultural heritage	–	No impacts are expected because there is no law-based registered cultural heritage in the candidate location
	24	Landscape	–	Construction of construction yard does not give significant impacts on the current landscape

Area	No	Impacted Item on JICA Guidelines	Rating	Reasons of the Rating (Only Construction Phase)
	25	Gender	–	According to interview with the authority regarding gender in Myanmar, no issues on gender in infrastructure area are observed. Thus, no impacts are expected on this item
	26	Rights of children	C	Child labor may be hired as simple workers in the project area
	27	Infectious diseases such as HIV/AIDS	C	Infectious diseases such as STDs are possible to be spread due to inflow of construction workers. Furthermore, alteration on the ground by filling may trigger the formation of habitats for mosquitoes that could possibly transmit malaria and dengue fever.
	28	Labor environment	B-	Construction work environment needs to be considered in accordance with relevant laws and regulations.
Other	29	Accidents	B-	Construction vehicles use existing local roads near residential areas, thus the number of traffic accident may increase.
	30	Cross boundary impacts and climate change	B-	Operation of construction machines generate GHGs.

Note) Rating:
A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) –: Light impact is expected. Detailed quantitative survey is not necessary.
+: Positive Impacts, -: Negative Impacts
Source: JICA Study Team

3) Recommended Mitigation Measures

Recommended mitigation measures are shown in Table 11.11.14.

Table 11.11.14 Recommended Mitigation Measures for Construction Yard

Area	No.	Item	Draft Mitigation Measures	Responsibility	
			During Construction	Implementation Agency	Responsible Agency
Pollution	1	Air pollution	☐ Water sprinkling shall be carried out in the construction area so as not to give dust impacts on the nearest residential area. Surface treatment should be considered if required. ☐ Periodical maintenance for facilities and machines shall be done	Contractor (Construction Company)	MOC
	2	Water pollution	☐ Turbid water shall be minimized at river and stream ☐ Waste oil shall be stored and disposed of into the designated site	Contractor	MOC
	3	Waste	☐ Waste oil of facilities and machines shall be collected and disposed through a licensed agent ☐ Cutting trees shall be reused or disposed of at a designated place	Contractor	MOC
	4	Soil Contamination and Sediment	☐ Excavated borrow soil shall be analyzed and confirmed if the quality is under standard values. Polluted soil shall not be used. ☐ Facilities and construction machines shall be maintained so as not to leak oil and chemicals. ☐ Waste oil of facilities and machines shall be collected and disposed through a licensed agent	Contractor	MOC
	5	Noise and Vibration	☐ Activities in quarry and borrow pits shall be limited in the daytime and on weekdays ☐ Facilities and machines shall be well-maintained and checked everyday ☐ Information disclosure of construction schedule shall be conducted in advance to the surrounding community.	Contractor	MOC
	6	Ground Subsidence	☐ Ground condition shall be monitored during construction and appropriate countermeasure shall be taken if ground subsidence is found	Contractor	MOC
Natural Environment	7	Ecosystem	☐ Boundary of quarry and borrow pit shall be marked and all all relevant workers and communities shall be informed not to conduct develop activities outside of the boundary ☐ Waste oil shall be stored and disposed of into the designated site so as not to leak water body	Contractor	MOC

Area	No.	Item	Draft Mitigation Measures	Responsibility	
			During Construction	Implementation Agency	Responsible Agency
	8	Topography and geology	☐ Implementation of slope protection such as turf work, planting treatment, concrete block retaining wall and retaining wall at the end of construction period	Contractor	MOC
Social Environment	9	Resettlement	☐ Holding of consultation meetings with landowner(s) for understanding of compensation policy ☐ Appropriate compensation and implementation of livelihood restoration program in accordance with approved RAP by Myanmar Government	Contractor and Local Authorities	MOC and Local Authorities
	10	The Poor	☐ Appropriate livelihood restriction program shall be considered in accordance with approved RAP	Contractor	MOC
	11	Local economy such as employment and livelihood	☐ Holding of consultation meetings for understanding of compensation policy and livelihood restoration programs for project affected persons who lose agricultural land such as paddy field and rubber plantation ☐ Implementation of adequate compensation in accordance with approved RAP	Contractor	MOC
	12	Land use and utilization of local resources	☐ Implementation of consultation with affected landowners and formulation of basic compensation policy before actual land acquisition.	Contractor	MOC
	13	Water usage	☐ Appropriate compensation shall be done in accordance with approved RAP if water usage facilities area such as wells are affected ☐ Alternative measures for water provision shall be prepared if water level and water quality at the nearest well change during the operation of quarry and borrow pits. ☐ Diversion of irrigation channels and/or streams shall be set up if the activities give impacts on such streams	Contractor	MOC
	14	Existing social infrastructures and services	☐ Detour and access road to social infrastructure such as school and meeting place for commuters and users shall be provided, if required. Such access road should be secured in the same place from the view of connecting the communities	Contractor	MOC
	15	Gender	☐ Provision of job opportunities and fair salary between genders. ☐ More female workers shall be encouraged to be employed as skilled and unskilled labors. At least 10% of female workers should be hired as unskilled labor at equal wages.	Contractor	MOC
	16	Rights of children	☐ No employment under the age of 18	Contractor	MOC
	17	Infectious diseases such as HIV/AIDS	☐ Installation of sufficient drainage facilities so as not to provide habitat for vector mosquitoes ☐ Enforcement of medical screening and periodical medical check-up for workers ☐ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness of the labors is promoted during construction	Contractor	MOC
	18	Labor Environment and Safety	☐ Relevant laws in Myanmar such as "the Workmen's Compensation Act", "the Factories Act", "the Leave and Holidays Act", "the Law relating to Overseas Employment", "the Labor Organization Law", "the Settlement of Labor Dispute Law", "the Social Security Law" and "the Minimum Wages Law" shall be followed ☐ Additionally, Article 23 of Occupational Health and Safety, Labor and Working Conditions in IFC Performance Standard 2 shall be applied.	Contractor	MOC
Others	19	Accident	☐ Deployment of flagman at the gate for traffic management ☐ Installation of safety sign board such as speed limit and residential area near site ☐ Installation of fence around the construction site to keep out the local people such as children ☐ Installation of lighting facility on site at nighttime ☐ Restriction of mobilization speed to less than 20km/h in the construction site	Contractor	MOC

Area	No.	Item	Draft Mitigation Measures	Responsibility	
			During Construction	Implementation Agency	Responsible Agency
			☐ Implementation of safety training for the workers (especially blasting methodology and standard operation procedure)		
	20	Cross Boundary impacts and climate change	☐ Prohibition of unnecessary operation of facilities and machines ☐ Periodical (daily, weekly and monthly) checking and maintenance of facilities and machines shall be done	Contractor	MOC

Note) Rating: A: Serious impact is expected. B: Some impacts are expected. C: Extent of impact is unknown (serious impacts are not expected, but survey and analysis shall be done) No mark and D: Few impacts are expected. Detailed quantitative survey is not necessary. (+: Positive impacts, - : Negative impacts)

Source: JICA Study Team

11.12 Results of Review on the ADB-EIA and Recommendations

11.12.1 Results of Review on the ADB-EIA

The final EIA for the ADB section (the construction of 61.4 km bypass) has prepared by ADB Technical Assistance Team in accordance with ADB Safeguard Policy Statement 2009 and relevant Myanmar Laws, and has submitted from ADB to MOC in the middle of July 2019. The final ADB-EIA has shared with JICA side, and then the EIA has reviewed by JST in August 2019.

It has been confirmed that the following requirements are satisfied in accordance with relevant EIA laws in Myanmar, JICA Guidelines and Operational Policies of World Bank/IFC basically. Hence it is evaluated that an implementation of the bypass road does not have any significant adverse impacts on pollution, natural and social environment.

- ✓ Analysis items (Pollution items, natural environment items and social items)
- ✓ Quantitative forecasts and evaluation in accordance with environmental standards (air quality and noise level along the bypass section)
- ✓ Timing and number of local stakeholder meeting (Scoping and draft EIA stage)
- ✓ Preparation of appropriate mitigation measures and monitoring plan

11.12.2 Recommendations for Harmonization of both Projects

Although the ADB-EIA has well-prepared in accordance with relevant guidelines and laws, however the following collaborations between JICA and ADB during detailed design and construction stage might maximize the effectiveness of the both projects and minimize negative impacts.

- ✓ According to ADB's analysis regarding ecosystem based on secondly data, some considerable species such as Spoon-billed Sand-piper, Sonneratia Griffithil, Narrow Sawfish and Broadfin Shark have been identified, thus appropriate mitigation measures are considered when such considerable species are recorded during the Special Ecosystem Monitoring.
- ✓ Sharing information regarding special ecosystem monitoring for preparation of appropriate mitigation measures during detailed design
- ✓ Sharing the updated environmental management plan (EMP) for mutual confirmation during detailed design
- ✓ Holding periodical meetings with PMUs, contractors and supervision consultants for the bypass and bridge section respectively for solution of common issues.

CHAPTER 12 RESETTLEMENT ACTION PLAN (RAP)

12.1 Project Description

The Project is composed of the construction of approximately 61.4km of new bypass road from Kyaikto to Bago, the construction of approximately 2.5km of New Sittaung Bridge and the upgrading of the Thuwunna RLTC. The feasibility study for the New Sittaung Bridge and the Thuwunna RLTC were conducted by JICA and the feasibility study for new bypass road section is separately conducted by the Asian Development Bank (ADB) respectively.

Table 12.1.1 Outline of the Entire Project

Project Name	East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section)
Objectives	To improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to the vitalization of Myanmar's trade.
Project Summary	1.JICA Section: (1) Construction of New Sittaung Bridge (4 lanes – 2.5km), Guidebank and Revetment (2) Upgrading of Thuwunna Research Laboratory and Training Center 2.ADB Section : Construction of New Bypass (4 lanes -61.4km)
Objectives of the JICA Study	Implementation of following necessary studies for examination to be implemented as a Japanese loan project (the purpose, project cost, implementation schedule, implementation (procurement / construction) method, project implementation system, operation / maintenance system, environmental and social considerations, etc.)
Project Area	S Mon State, Bago Region and Yangon Region of Myanmar
Responsible Agency	Ministry of Construction(MOC), Department of Bridge (DOB) and Department of Highways (DOH)

Source: JICA Study Team

Source: JICA Study Team

Figure 12.1.1 Project Location Map

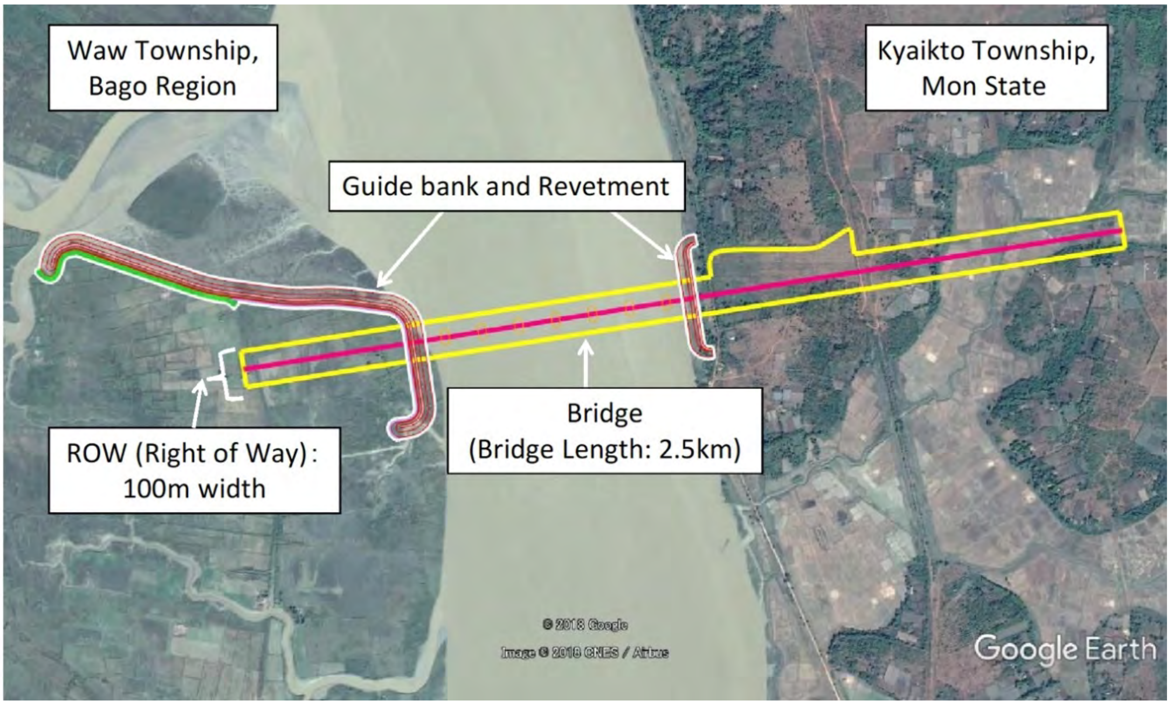
12.2 Necessity of Land Acquisition and Resettlement

The subject of the study for this Resettlement Action Plan (RAP) is the New Sittaung Bridge of about 2.5 km total length. The component of the New Sittaung Bridge consists of the bridge part and the guidebank and revetment. The outline of the project components are shown Table 12.2.1 and Figure 12.2.1 shows the detailed location of the project. As a result of the implementation of the Project, some land acquisition, impact to private assets and resettlements are expected. Thus, RAP for the Project is necessary to be prepared. On the other hand, (2) Reconstruction of facilities in Thuwunna Central Training Center expects to be implemented on the land owned by MOC. In addition, any other residences, buildings and agricultural crops are not expected to be impacted, therefore RAP is not necessary to be prepared for the Reconstruction of Thuwunna Central Training Center.

Table 12.2.1 Project Outline and Main Component for RAP

Component	Structure Specification	Location
1. Main Bridge with Approach Bridge and Approach Road	Main Bridge: L=800m, W=22.0 m, Right of Way (ROW)=100m	East Bank: Kyaito Township, Thaton District, Mon State West Bank: Waw Township, Bago District, Bago Region
	Approach Bridge: L=240m (right), L=960m (left) , W=22.0 m, ROW=100m	
	Approach Road: L = 248m (right), L = 252m (left), W=23.5 m, ROW=100m	
2. Guidebank and Revetment	Guidebank Length L = app. 1.5km, (West side bank)	Guidebank: Waw Township, Bago District, Bago Region
	Revetment Length = app. 0.3km (East side bank)	Revetment : Kyaito Township, Thaton District, Mon State

Note) Other facilities such as quarry, borrow pit, construction road and storage space of excavated soil in the river which will be decided by construction contractor during construction stage are not included for this RAP
Source: JICA Study Team



Source: JICA Study Team

Figure 12.2.1 Detailed Location of the Project

12.3 Policy and Legal Framework

12.3.1 Relevant Laws and Regulations in Myanmar

Currently in Myanmar, there is no comprehensive law stipulating land acquisition and resettlement. The Land Acquisition Act, enacted in 1894, is still the legal basis for land acquisition in Myanmar. The Land Nationalization Act 1953 which was repealed by the Farmland Law 2012 determines nationalization of farmlands and procedures for conversion of farmlands for other purposes (La Na 39). Resettlement-related issues are depicted in some of the existing laws and regulations. However, in most cases, details such as procedures and conditions related to resettlement issues are yet to be determined. Table 12.3.1 indicates relevant Myanmar laws and regulations for land acquisition and resettlement which are applicable to lower Myanmar where the Project Area is located.

Table 12.3.1 Relevant Laws in Myanmar

- Constitution of the Republic of the Union of Myanmar, 2008
- Land Acquisition Act, 1894 (Amended in 1937 (Adaptation of Laws Orders), and 1940 (Burma Act 27)
- Farmland Law, 2012
- Farmland Rules, 2012
- Vacant, Fallow and Virgin Lands Management Law, 2012
- Vacant, Fallow and Virgin Lands Management Rules, 2012
- Forest Law, 2018
- Transfer of Immovable Property Restriction Law, 1987
- The Law Amending the Disposal of Tenancies Law, 1965
- The Lower Burma Town and Village Land Act, 1899 (amendment , 2015)
- The Land and Revenue Act 1876 (Amended in 1945 (Burma Act No 12), 1946 (Burma Act No 64), and 1947 (Burma Act No 6)
- The Lower Burma Land Revenue Manual, 1876
- National Land Use Policy, 2016
- Development Committee Law, 1993
- Directions of Central Land Committee

Source: Prepared based on "Guidance Note on Land Issues Myanmar" UNHCR, UNHABITAT

Among these national laws, relating clauses in key laws are shown as follows.

1) Constitution of the Republic of the Union of Myanmar (2008)

37. The Union:

(a) is the ultimate owner of all lands and all natural resources above and below the ground, above and beneath the water and in the atmosphere in the Union;

(b) shall enact necessary law to supervise extraction and utilization of State-owned natural resources by economic forces;

(c) shall permit citizens right of private property, right of inheritance, right of private initiative and patent in accord with the law.

357. The Union shall protect the privacy and security of home, property, correspondence and other communications of citizens under the law subject to the provisions of this Constitution.

2) Land Acquisition Act (1894)

- Stipulates that the Government holds rights to take over land where the State asserts that such land is needed for public purposes
- Outlines relevant procedures of land acquisition and the method of valuation of land.

3) Farm Land Law (2012)

- Calls for suitable compensation and indemnity in case of repossession of farmland in the interest of the Union State.

4) Farm Land Rules (2012)

- Stipulates for farmers right to work on the farmland.
- States that when farmlands are converted into different forms of land based on the interest of the State or Public, the Stare of Public needs to make compensation to the farmers without delay.

12.3.2 JICA's Policy on Resettlement

JICA has policies on resettlement, which are stipulated in JICA Guidelines on Environmental and Social Considerations (April, 2010). The key principle of JICA policies on involuntary resettlement is summarized below:

a. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

b. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

c. People who must be resettled involuntary and people whose measures of livelihood will be hindered or losses must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

d. Compensation must be based on the full replacement cost[1] as much as possible.

e. Compensation and other kinds of assistance must be provided prior to displacement.

f. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

g. In preparing a resettlement action plan, consultations must be prompted in the planning, implementation, and monitoring of resettlement action plans.

h. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. In addition to the above policies, JICA also applies for the following policies stipulated in World Bank OP 4.12.

i. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefit.

j. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

k. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

[1] WB OP 4.12 defines the replacement cost as follows:
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.
For land in urban areas, it is the pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration .
For houses and other structures, it is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, 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.

l. Provide support for the transition period (between displacement and livelihood restoration).

m. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc.

n. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, an abbreviated resettlement plan is to be prepared.

12.3.3 International Practices on Resettlement

Most international funding organizations and donors developed polices and guidelines for environmental social considerations including resettlement occurring under development projects. In principle, international practices on resettlement are conducted based on such polices and guidelines. The EWEC Project is composed of the JICA bridge section and the ADB bypass section, therefore major polices and guidelines applicable for the project are listed hereunder:

- JICA Guidelines for Environmental and Social Considerations (April, 2010)
- World Bank (WB) Environmental and Social Safeguard Policies: Operational Policy on Involuntary Resettlement (OP 4.12)
- Asian Development Bank (ADB) Safeguard Policy: Safeguard Policy Statement 2009 (SPS)

For the project of the bridge section, an RAP is prepared based mainly on the JICA Guidelines which also cite WB OP 4.12 but also referring to ADB SPS. However, the RP of ADB bypass sections mainly follows ADB SPS and satisfies the requirement of ADB SPS, therefore it is not necessarily same as the contents of JICA RAP.

12.3.4 Gap Analysis

In principle, there are no gaps in the policies of international donors, therefore no gaps between the JICA Guidelines and ADB SPS is expected, although some gaps are often found between the policies of international donors and the laws and guidelines in the respected counties. The comparisons between current laws/regulations of the Government of Myanmar, JICA Guidelines for Environmental and Social Considerations (April, 2010) and ADB Safeguard Policy Statement (2009) are shown in Table 12.3.2.

Table 12.3.2 Comparisons between Laws in Myanmar, JICA Guidelines and ADB SPS

No.	JICA Guidelines	ADB Safeguard Policy Statement (2009)	Laws and Guidelines in Myanmar	Gap between JICA GL and ADB SPS (Upper column) Gap between JICA GL and Laws in Myanmar (Lower column)	Project Policy
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	The objectives are to avoid involuntary resettlement wherever possible; to minimize involuntary resettlement by exploring project and design alternatives. (Para 3, Safeguard Requirements 2)	Not applicable	In the ADB SPS, avoidance and minimization are parallelly described. (There is no difference.) There is no regulation which mentions or requests avoiding or minimizing	The project examines alternatives to avoid or minimize resettlement impact.

No.	JICA Guidelines	ADB Safeguard Policy Statement (2009)	Laws and Guidelines in Myanmar	Gap between JICA GL and ADB SPS (Upper column) / Gap between JICA GL and Laws in Myanmar (Lower column)	Project Policy
				involuntary resettlement and loss of livelihood means.	
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	The objectives are to avoid involuntary resettlement wherever possible; to minimize involuntary resettlement by exploring project and design alternatives. (Para3, Safeguard Requirements 2) 43. The objectives of ADB's safeguards are to: (i) avoid adverse impacts of projects on the environment and affected people, where possible; (ii) minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible. (Para43, A. Overarching Statement on ADB's Commitment and Policy Principles, V. Safeguard Policy Statement)	Market-value compensation shall be paid(Land Acquisition Act, 23(1) and 23(2)) Compensation or indemnity is provided for farmland acquisition for the interest of the State or public (Farmland Law (2012) Art. 26, Farmland Rules (2012) Art. 64).	There is no difference. There is no difference.	Follow JICA GL
3	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	In the case of economically displaced persons, regardless of whether or not they are physically displaced, the borrower/client will promptly compensate for the loss of income or livelihood sources at full replacement cost. The borrower/ client will also provide assistance such as credit facilities, training, and employment opportunities so that they can improve, or at least restore, their income-earning capacity, production levels, and standards of living to pre displacement levels. (Para 12, Safeguard Requirements 2)	Damages to standing crops/trees, lands, movable/immovable properties, relocation cost, economic activities are requested to compensate. (Land Acquisition Act (1894) Art. 23, Farmland Rules (2012) Art. 67)	There is no difference. There is no stipulation of improving or at least restoring living standard, income opportunities, and production levels to pre-project levels in the Myanmar legal framework.	The project considers the assistance to improve or restore the livelihood.
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	The rate of compensation for acquired housing, land and other assets will be calculated at full replacement costs. (Para10, Safeguard Requirements 2)	Land and other property: Market-value compensation shall be paid (Land Acquisition Act, Articles 23(1) and 23(2)) Crops: Compensation at three times of the value calculated based on the average production of crops in the current market price of that area is provided. (Farmland Rules (2012) Art. 67)	There is no difference. Land and other property: There is no clear indication of the method of valuation of compensation price although the law stipulates the compensation at market value. Crops: There is no difference.	Follow JICA GL
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Pay compensation and provide other resettlement entitlements before physical or economic displacement.(Para 11)	When compensation is not paid on or before land acquisition, compensation amount awarded with interest rate must be paid.	There is no difference. There is no clear indication about timing of compensation payment in the Myanmar legal framework.	The project supports the compensation process so that the compensation and other kinds of assistance to be

No.	JICA Guidelines	ADB Safeguard Policy Statement (2009)	Laws and Guidelines in Myanmar	Gap between JICA GL and ADB SPS (Upper column) Gap between JICA GL and Laws in Myanmar (Lower column)	Project Policy
					provided prior to displacement.
6	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	The borrower/client will prepare a resettlement plan if the proposed project will have involuntary resettlement impacts.(Para 17, Safeguard Requirements 2) The borrower/client will provide relevant resettlement information, including information from the documents in para. 26 in a timely manner, in an accessible place and in a form and language(s) understandable to affected persons and other stakeholders. For illiterate people, suitable other communication methods will be used.(Para 27, Safeguard Requirements 2)	Not applicable	There is no difference. There is no regulation requesting to prepare resettlement action plan.	The project prepares resettlement action plan and make available to the public.
7	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	The borrower/client will conduct meaningful consultation with affected persons, their host communities, and civil society for every project and subproject identified as having involuntary resettlement impacts. Meaningful consultation is a process that (i) begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle; (ii) provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people; and (v) enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues. (Para.28, Safeguard Requirements 2)	Not applicable	There is no difference. There is no regulation requesting to organize consultations with PAPs.	The project will hold consultations with the affected people and their communities on sufficient information made available to them in advance.
8	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	Not Applicable	Not applicable	There is no difference.	The project considers appropriate explanation when consultations are held.

No.	JICA Guidelines	ADB Safeguard Policy Statement (2009)	Laws and Guidelines in Myanmar	Gap between JICA GL and ADB SPS (Upper column) / Gap between JICA GL and Laws in Myanmar (Lower column)	Project Policy
	(JICA GL)			There is no regulation requesting to use a form, manner and language understandable for affected persons to be used in consultation.	
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Carry out meaningful consultations with affected persons, host communities, and concerned non-government organizations. Ensure their participation in planning, implementation, and monitoring and evaluation of resettlement programs. (Para.2)	Not applicable	There is no difference.	The project considers the appropriate participation of affected people.
				There is no regulation requesting participation of PAPs in planning, implementation, and monitoring of resettlement action plans.	
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Establish a grievance redress mechanism to receive and facilitate resolution of the affected persons' concerns. (Para. 2)	1) Notice of compensation amount to PAPs directly: appeal to the court within 6 weeks from the date of compensation award 2) Notice of compensation amount to representatives of PAPs: i) within 6 weeks of receipt of compensation notice, or ii) within 6 months from the from the date of compensation award, whichever period shall be first expire (Land Acquisition Act (1894) Art. 18)	There is no difference.	The project considers the grievance redress mechanism by utilizing the existing administration system to be convenient for PAPs.
				The procedure of grievance in the Myanmar context is direct settlement at the court, which is not necessarily easy or accessible to PAPs	
11	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP 4.12 Para. 6)	Screen the project early on to identify past, present, and future involuntary resettlement impacts and risks. (Para.1) The borrower/client will conduct socioeconomic survey(s) and a census, with appropriate socioeconomic baseline data to identify all persons who will be displaced by the project and to assess the project's socioeconomic impacts on them. For this purpose, normally a cut-off date will be established by the host government procedures. In the absence of such procedures, the borrower /client will establish a cut-off date for eligibility. Information regarding the cutoff date will be documented and disseminated throughout the project area. (Para.15, Safeguard Requirements 2)	A notification of land acquisition or public purposes is published in the Gazette, which is also published at the convenient place in the concerned municipality. (Land Acquisition Act (1894) Article 4)	There is no difference.	The project identifies and records the affected people at the project identification stage.
				There is no specific description of identifying affected people as early as possible in the national law. In addition, there is no Myanmar law regarding the cut-off date.	

No.	JICA Guidelines	ADB Safeguard Policy Statement (2009)	Laws and Guidelines in Myanmar	Gap between JICA GL and ADB SPS (Upper column) Gap between JICA GL and Laws in Myanmar (Lower column)	Project Policy
12	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP 4.12 Para. 15)	Displaced persons in a project area could be of three types: (i) persons with formal legal rights to land lost in its entirety or in part; (ii) persons who lost the land they occupy in its entirety or in part who have no formal legal rights to such land, but who have claims to such lands that are recognized or recognizable under national laws; and (iii) persons who lost the land they occupy in its entirety or in part who have neither formal legal rights nor recognized or recognizable claims to such land. The involuntary resettlement requirements apply to all three types of displaced persons. (Para.7, Safeguard Requirements 2)	Occupiers/stakeholders of lands to be acquired are given an explanation about acquisition and claims to compensations. (Land Acquisition Act (1894) Article 9)	There is no difference. Detailed procedures as well as eligibility criteria are not clearly defined. Also, there is no specific indication about displaced persons without titles.	The project considers eligibility for assistance to all households whose income sources or assets are confirmed as affected due to project implementation.
13	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para. 11)	Preference will be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (Para.9, Safeguard Requirements 2)	Not Applicable	There is no difference. There is no regulation stipulating to give land-based resettlement strategies.	The project considers the land-based resettlement strategies.
14	Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4. 12, para.6)	The rate of compensation for acquired housing, land and other assets will be calculated at full replacement costs. The calculation of full replacement cost will be based on the following elements: (i) fair market value; (ii) transaction costs; (iii) interest accrued, (iv) transitional and restoration costs; and (v) other applicable payments, if any. (Para.10, Safeguard Requirements 2)	Not Applicable	There is no difference. There is no regulation stipulating to provide support for the transition period.	The project considers the support for the transition period.
15	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities, etc. (WB OP 4.12 Para. 8)	As part of the social impact assessment, the borrower/client will identify individuals and groups who may be differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status. Where such individuals and groups are identified, the borrower/client will propose and implement targeted measures so that adverse impacts do not fall disproportionately on them and they are not disadvantaged in relation to sharing the benefits and opportunities resulting from development. (Para.16, Safeguard Requirements 2)	Not Applicable	There is no difference. There is no regulation stipulating to provide particular attention to the vulnerable groups.	The project pays particular attention to vulnerable groups.

Source: JICA Study Team

12.4 Land Acquisition and Resettlement Scope

12.4.1 Summary of Project Impact

(1) Summary of Project Affected Households and Persons

This RAP survey was conducted based on the design prepared for the Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) - Construction of New Sittaung Bridge. Almost all of affected households for the project were surveyed with prepared socioeconomic questions. As a result of the survey, a total number of 20 households or 106 people located in 3 villages, 2 townships and 2 regions are regarded as Project Affected Households (PAHs) or Project Affected Persons (PAPs) respectively.

It is found out that among the total 20 PAHs, 16 PAHs (86 PAPs) are categorized as households losing 10% or more of their productive land and/or income source. As 3 PAHs will lose their residential house and 1 PAH will have an impact on their seasonal house, a total of 4 PAHs and 24 PAPs are required to be resettled. In addition, 4 PAHs comprising of 17 PAPs falls under Vulnerable Affected Households (VAHs). The detailed definition of the VAHs are described in 12.4.1(3)9) Vulnerability. Among all of the PAHs and PAPs, there are no informal settlers who do not have formal legal title to land or recognizable right to claim to the land. A category-wise outline of PAHs and PAPs are described in Table 12.4.1.

It is also noted that the impact to the livelihood of fishermen is not expected therefore the fishermen are not considered as project affected persons for the project. The information on fishery was analyzed in the Environmental Impact Assessment (EIA) prepared for the project. The summary of the expected impact to the fishery is described in Chapter 10.7.6 Local Economy such as Employment and Livelihood.

Table 12.4.1 Summary of Project Affected Households and Persons

	No. of PAHs/ PAPs							
	Total		of which					
			Households losing 10% or more of their productive land and/ or income source		Relocation Households		Vulnerable households	
Location	No. of PAHs	No. of PAPs	No. of PAHs	No. of PAPs	No. of PAHs	No. of PAPs	No. of PAHs	No. of PAPs
Shan Kaing Village, Waw Township, Bago District, Bago Region	8	38	5	24	1	3	2	6
Sut Pa Nu Village,Kyaito Township,Thaton District, Mon State	8	49	8	49	3	21	2	11
Kha Lun Village,Kyaito Township,Thaton District, Mon State	4	19	3	14	0	0	0	0
Total	**20**	**106**	**16**	**87**	**4**	**24**	**4**	**17**

Source: JICA Study Team

(2) Summary of Inventory of Loss Assets Survey Result

1) Land

Land acquisition will mainly involve agricultural land, specifically garden land and crop land, but some structures developed on agricultural land will also be impacted. Note that the original land use status for structures fall under agricultural land and compensation of entitlement will be considered as agricultural land rather than residential land and or other land use.

For bridge construction including guide bank and embankment, a total of 62.53 acres (253,050 m^2) of land will be acquired and the table below breaks down expected acres of land on a per village basis.

Most of the affected garden land is located in Sut Pa Nu Village, which comprises of 23.65 acres of land, while only 1 acre of affected garden land and no affected garden land exists in Kha Lun Village and Shan Kaing Village respectively. Such garden lands are occupied with trees such as rubber and betel vines which are the major livelihood of people in this region.

Regarding with the crop land, 22.85 acres (92,471 m^2) of affected land located in the Bago Region side and the remaining 15.03 acres (60,824m^2) of crop land are in Mon State which mostly consists of paddies, peas and beans.

Table 12.4.2 Summary of Lands to be Acquired under Proposed Alignment

State /Region	Village	Approximated Amount of Land to be Acquired						Total	
		No. of Affected Land Owner (No.)	Crop Land (acre)	No. of Affected Land Owner (No.)	Garden Land (acre)	No. of Affected Land Owner (No.)	Residential Land (acre)	No. of Affected Land Owner*1 (No.)	Total Land (acre)
Bago Region	Shan Kaing	7	22.85	0	0	0	0	7	22.85
Mon State	Sut Pa Nu	3	6.12	7	23.65	0	0	8	29.77
Mon State	Khalon	4	8.91	1	1.00	0	0	4	9.91
Total		**13*2**	**37.88**	**8**	**24.65**	**0**	**0**	**18*3**	**62.53**

* 1 No. of Affected Land owner shows PAHs who have impact on Crop Land or/ and Garden Land.
*2 1 PAH has 2 crop land in Sut Pa Nu and Kha Lun, therefore total PAHs who impacted on land is totally 13
*3 As mentioned in *2, PAHs has land plot both in Sut Pa Nu and Kha Lun, therefore total no. of affected owner is totally 18
Source: JICA Study Team

2) Structure

A total of 4 main structures and 8 secondary structures will also be impacted due to land acquisition. The affected 3 houses are located in Sut Pa Nu Village, Mon State and 1 Seasonal House is located in Shan Kaing Village, Bago Region. Affected Secondary Structures are composed of 5 Huts, 2 Toilets and 1 water tank and all of them are located in Mon State. Details are shown in Table 12.4.3.

Table 12.4.3 Inventory of Affected Structures

State/Region	Village	No. of Structure Affected	Structure Type	No. of Secondary Structure Affected	Structure Type
Bago Region	Shan Kaing	1	1 Seasonal House	0	
Mon State	Sut Pa Nu	3	3 Houses	8	5 Huts + 2 Toilets +1 Water tank
Mon State	Kha Lun	0		0	
Total		**4**		**8**	

Source: JICA Study Team

3) Trees and Crops

As mentioned above, a total of 62.53 acres (253,050 m^2) of agricultural land will need to be acquired by the project. The garden lands are mainly used for growing trees such as rubber, betel vines etc. The crop lands are used mainly for growing paddy and varieties of peas and beans. Affected crops and yields are shown in Table 12.4.4 and all affected trees by types regardless of commercial or home consumption are also broken down in Table 12.4.5.

Regarding with the affected crops, they are owned by 10 PAHs, which composed of 10 PAHs of paddy owners and 7 PAHs of peas and beans owners. Among those affected crop farmers, 1 farmer is a tenant farmer who rents land from land owner, while 9 affected farmers are agricultural land owners. The tenant farmer grows both paddy as well as peas and beans.

In respect to the trees, a total of 15,439 trees are identified in the project area. Among the 3 villages and 2 regions of the project locations, the trees are mainly in Sut Pa Nu Village and Khalon Village of the Mon State side, while there are no trees affected in Shan Kain Village of the Bago Region side. The owners of the affected tress shown in the table are disaggregate numbers of the owners of each types of trees, therefore the number of affected tree owners disaggregated by villages are 0 PAHs in Shan Kaing Village, 6 PAHs in Su Pa Nu Village and 1 PAH in Khalon Village. Among those 7 tree owners, there is 1 PAH who grows trees on rented land in Sut Pa Nu Village. The other 6 PAHs possess their trees on their own land.

Table 12.4.4 Inventory of Affected Crops

State/Region	Village	Crop Type	No. of Affected Crop owner (No.)	Yield (Basket)	Crop Type	No. of Affected Crop owner (No.)	Yield (Basket)
Bago Region	Shan Kaing	Paddy	7	1,371	Peas and Beans	7	457
Mon State	Sut Pa Nu	Paddy	1	258	Peas and Beans	0	0
Mon State	Khalon	Paddy	2	996	Peas and Beans	0	0
Total			**10**	**2,625**		**7**	**457**

1 Basket = 20.9 kg
Source: JICA Study Team

Table 12.4.5 Inventory of Affected Trees

Type	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Khalon (Mon State)		Total	
	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees	No. of Affected Tree owner	No. of Affected Trees
	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)	(No.)
Rubber	0	0	3	3,808	1	530	4	4,338
Betel vine	0	0	5	9,365	0	0	5	9,365
Mango	0	0	4	5	0	0	4	5
Betel nuts	0	0	1	4	0	0	1	4
Jack Fruit	0	0	3	9	0	0	3	9
Danyin	0	0	2	3	0	0	2	3
Plam	0	0	1	1	0	0	1	1
Pomelo	0	0	1	1	0	0	1	1
Guava	0	0	1	4	0	0	1	4
Tikto	0	0	0	0	1	1	1	1
Kinmunchin	0	0	0	0	1	1	1	1
Banana	0	0	2	140	1	6	3	146
Dannalun	0	0	1	2	0	0	1	2
Bamboo	0	0	4	1,550	0	0	4	1,550
Kokeko	0	0	1	1	0	0	1	1
Banyan	0	0	1	1	0	0	1	1
Thit mwe	0	0	1	7	0	0	1	7
Total	**0**	**0**	**31**	**14,901**	**4**	**538**	**35**	**15,439**

Source: JICA Study Team

(3) Summary of Socio-Economic Survey Result

1) Gender

Table 12.4.6 shows the number of PAHs based on the census survey. According to the survey result, 18 PAHs are male headed households and 2 PAHs are female headed households. The number comprises 90% of male headed household and 10 % of female headed household.

Table 12.4.6 Gender of PAHs

Gender of Household Head	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Kha Lun (Mon State)		Total	
	No.	%	No.	%	No.	%	No.	%
Male headed HH	7	88%	7	88%	4	100%	18	90%
Female headed HH	1	13%	1	13%	0	0%	2	10%
Total	**8**	**100%**	**8**	**100%**	**4**	**100%**	**20**	**100%**

Source: JICA Study Team

2) Ethnicity

Distribution of PAHs by ethnicity is presented in Table 12.4.7. It is found that all of the project affected households are Barmar. However, the information of 1 PAH was unavailable since the PAH is living outside of Myanmar, therefore the survey result on the 1 PAH is not reflected in the Table.

Table 12.4.7 Ethnicity of PAHs

State/Region	Village	Ethnicity			
		Barmar	Mon	Others	Total
Bago Region	Shan Kaing	8	0	0	8
Mon State	Sut Pa Nu	7	0	0	7
Mon State	Kha Lun	4	0	0	4
Total		**19**	**0**	**0**	**19**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

3) Religion

Table 12.4.8 shows the distribution of PAHs by religion in the project site. As a result of the survey, 100% of the PAHs in the project area are Buddhist, although the information of 1 PAH was not accessible.

Table 12.4.8 Religion of PAHs

State/Region	Village	Religion				
		Buddhist	**Christian**	**Islamic**	**Hindu**	**Total**
Bago Region	Shan Kaing	8	0	0	0	8
Mon State	Sut Pa Nu	7	0	0	0	7
Mon State	Kha Lun	4	0	0	0	4
Total		**19**	**0**	**0**	**0**	**19**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

4) Daily Languages of PAHs

Daily language used by PAHs is shown in Table 12.4.9. It shows that all of the PAHs in project area communicate in Burmese languages on a daily basis.

Table 12.4.9 Daily Language Used by PAHs

State/Region	Village	Daily Language used			
		Burmese	Mon	Others	Total
Bago Region	Shan Kaing	8	0	0	8
Mon State	Sut Pa Nu	7	0	0	7
Mon State	Kha Lun	4	0	0	4
Total		**19**	**0**	**0**	**19**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

5) Education Level of Household Heads

The education level of household heads in the bridge alignment and the additional revetment area is shown in Table 12.4.10. In accordance with the surveyed results, there are 6 household heads that have the monastic education, 7 household heads have completed the primary education level, 2 household heads accomplished middle school education and 3 have attained a high school education in the project area. Moreover, it is found that there is only one household head that completed the University/Graduate level.

Table 12.4.10 Education Level of Household Heads

Education Level	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Khalon (Mon State)		Total	
	No.	%	No.	%	No.	%	No.	%
No education	0	0.0	0	0.0	0	0.0	0	0.00
Monastic	1	12.5	1	14.3	4	100.0	6	31.58
Primary	3	37.5	4	57.1	0	0.0	7	36.84
Middle	0	0.0	2	28.6	0	0.0	2	10.53
High School	3	37.5	0	0.0	0	0.0	3	15.79
University	0	0.0	0	0.0	0	0.0	0	0.00
Graduate	1	12.5	0	0.0	0	0.0	1	5.26
Total	**8**	**100.0**	**7**	**100.0**	**4**	**100.0**	**19**	**100.0**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

6) Occupation of Household Heads

Table 12.4.11 shows the main occupation of household heads in the project area where the bridge alignment and additional revetment exits. It is found that in Sut Pa Nu Village, 5 household heads are growing orchards, and the rest of the household heads are wage workers and annual crop farmers. In Kalong Village, 2 household heads are engaging in orchard plantation, and the other 2 household heads are a casual employee and the other raising livestock. For Shan Kaing Village, the main occupation of household heads is farming rice and crops. Out of all the households in Shan Kaing Village on the Bago side, 6 household heads are farmers, one household head is a shop owner and one household head is dependent. For combining both the Bago Region side and Mon State side, 7 household heads (36.84%) are found farming rice and crops, 7 household heads (36.84%) grow orchards, and the rest of them have different occupations. This result shows that the agriculture is the major occupation in the project area.

Table 12.4.11 Occupation of Household Heads

Occupation	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Khalon (Mon State)		Total	
	No.	%	No.	%	No.	%	No.	%
Dependent	1	12.5	0	0.0	0	0.0	1	5.26
Student	0	0.0	0	0.0	0	0.0	0	0.00
Odd Job (Casual Employee)	0	0.0	0	0.0	1	25.0	1	5.26
Wage Worker (Long Term contract)	0	0.0	1	14.3	0	0.0	1	5.26
Farming Rice and Other Crops	6	75.0	1	14.3	0	0.0	7	36.84
Farming Vegetables	0	0.0	0	0.0	0	0.0	0	0.00
Orchard	0	0.0	5	71.4	2	50.0	7	36.84
Livestock	0	0.0	0	0.0	1	25.0	1	5.26
Fishery	0	0.0	0	0.0	0	0.0	0	0.00
Handicraft	0	0.0	0	0.0	0	0.0	0	0.00
Government Employee	0	0.0	0	0.0	0	0.0	0	0.00
Shop Owner	1	12.5	0	0.0	0	0.0	1	5.26
Retired or over working age	0	0.0	0	0.0	0	0.0	0	0.00
Others	0	0.0	0	0.0	0	0.0	0	0.00
Total	**8**	**100.0**	**7**	**100.0**	**4**	**100.0**	**19**	**100.0**

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

7) Annual Income of PAHs

Table 12.4.12 shows that the range of the annual income of the PAHs in the project area. According to the survey result, the PAHs have an annual income between 10,000.001-20,000,000 kyat in the project area. Out of the total 19 PAHs, 5 (26%) PAHs earn below 10,000,000 kyat and 20,000,001- 30,000,000 kyat. Although all of the PAHs in Shan Kaing Village earn less than 30,000,000 kyat annually, 4 PAHs in Sut Pa Nu Village and in Kha Lun Village earn more than 30,000,001 kyat annually. 1 PAH in Sut Pa Nu Village earns 30,000,001 - 40,000,000 kyat, 1 PAH also in Sut Pa Nu Village earns 40,000,001 - 50,000,000 kyat and 2 PAHs in Kha Lun Village earn above 50,000,000 kyat per year.

Table 12.4.12 Distribution of PAHs by Annual Income

Annual Income (Kyat)	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Kha Lun (Mon State)		Total	
	No.	%	No.	%	No.	%	No.	%
10,000,000 or Below	4	50%	0	0%	1	25%	5	26%
10,000,001 – 20,000,000	2	25%	3	43%	1	25%	6	32%
20,000,001 – 30,000,000	2	25%	2	29%	0	0%	4	21%
30,000,001 – 40,000,000	0	0%	1	14%	0	0%	1	5%
40,000,001 – 50,000,000	0	0%	1	14%	0	0%	1	5%
Above 50,000,000	0	0%	0	0%	2	50%	2	11%
Total	**8**	100%	**7**	100%	**4**	100%	**19**	100%

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

8) Annual Expenditure of PAHs

The annual expenditure range by PAHs in the project area is displayed in Table 12.4.13. Of those surveyed, the majority of the PAHs spend less than 15,000,000 kyat per year, that is, 16 PAHs, and they accounts for 85%. As for the rest of the PAHs, 1 PAH spends 15,000,001 – 20,000,000 kyat and 2 PAHs spend above 20,000,000 kyat annually.

Table 12.4.13 Distribution of PAHs by Annual Expenditure

Annual Expenditure (Kyat)	Shan Kain (Bago Region)		Sut Pa Nu (Mon State)		Khalon (Mon State)		Total	
	No.	%	No.	%	No.	%	No.	%
5,000,000 or Below	5	63%	0	0%	1	25%	6	32%
5,000,001 – 10,000,000	2	25%	3	43%	1	25%	6	32%
10,000,001 – 15,000,000	1	13%	2	29%	1	25%	4	21%
15,000,001 – 20,000,000	0	0%	0	0%	1	25%	1	5%
Above 20,000,000	0	0%	2	29%	0	0%	2	11%
Total	**8**	100%	**7**	100%	**4**	100%	**19**	100%

Note: Information on 1 PAHs are not included in this table.
Source: JICA Study Team

9) Vulnerability

In Myanmar, there is no official definition of vulnerable groups at present. In this project, however, particular attention is paid to respective groups. For vulnerable groups, the project defines a household headed by woman, disabled person, a household headed by elderly (over 60 years old), a household including a person with disability, a household below the poverty line, a household including indigenous peoples, a household headed by child and a landless households by referring JICA and other international practices.

Regarding with the poverty line, there is no poverty line defined by Government. However, the "An analysis of poverty in Myanmar" was published by the Government of Myanmar and the World Bank in 2017 and the poverty line was established as the household expenditure per adult per day of 1,303 kyat (0.92 USD in the JICA exchange rate as of September 2018) or the household expenditure per capita per day of 1,241 kyat (0.88 USD in the JICA exchange rate as of September 2018).

For the criteria of the indigenous person, the definitions WB OP 4.10 is referred. The details of the applicability of the criteria is verified in Appendix E Checklist of Applicability on Indigenous People. Table 12.4.14 shows that there are 2 vulnerable households in Sut Pa Nu Village, Mon State and 2 vulnerable households in Shan Kaing Village, Bago Region among interviewed PAHs. Of them, 2 PAHs are categorized as household headed by a woman, 2 PAHs are categorized as household headed by an elderly person and 1 PAH is categorized as a household including a member of person with disability. There are no PAHs which: fall under the poverty line; are a household including indigenous people; are a household headed by a child; nor are there landless households.

Table 12.4.14 Number of Vulnerable People among PAHs

Vulnerability	Bago Region	Mon State	Mon State	Total
	Shan Kaing	Sut Pa Nu	Kha Lun	
	No.	No.	No.	No.
Household headed by woman	1	1	0	2
Household headed by elderly person (over 60)	2	0	0	2
Household including a person with disability	0	1	0	1
Household below the poverty line	0	0	0	0
Household including indigenous peoples	0	0	0	0
Household headed by child	0	0	0	0
Landless households	0	0	0	0
Total	2*	2	0	4*

* 1 PAH in Bago Region falls under 2 vulnerable criteria; therefore the total vulnerable PAH is 4.
Note: Information on 1 PAH are not included in this table.
Source: JICA Study Team

10) Project Acceptability

As shown in Table 12.4.15, 100% of PAHs expressed a positive response or accepted the project. Typical opinions for "Yes" for the project are:

i) Improve quality of life; and

ii) Improve accessibility.

Although there are no PAHs who disagree with the project implementation, they think the major negative impact of the project could be:

i) Loss of income/land.

The following points are the major opinions from PAHs:

i) Conduct fair compensation for lost assets;

ii) Desire to implement the project soon.

Table 12.4.15 Project Acceptability

Project Acceptability					
State/Region	Village	Answer			
		Yes		No	
		No.	%	No.	%
Bago Region	Shan Kaing	8	42.11	0	0
Mon State	Sut Pa Nu	7	36.84	0	0
Mon State	Khalon	4	21.05	0	0
Total		19	100.00	0	0

Note: Information on 1 PAH are not included in this table.
Source: JICA Study Team

12.5 Compensation Entitlements and Entitlement Matrix

(1) Cut-off Date

The cut-off date (COD) for entitlements is recognized by international institutions such as WB, JICA and ADB. It is a tool to determine eligibility for entitled assistance. The COD is set on in order to avoid influx of population into the project area, and people who encroach on the area after the COD are not entitled to compensation or any other form of resettlement assistance. Although the census begins normally on the COD, the COD could also be the date the project area was delineated, prior to the census, provided that there has been an effective public dissemination of information on the area delineated, according to World Bank OP 4.12. Based on the concept, the COD for this project was declared on 1 January 2018 by MOC. A non-objection letter from the chief minister of Mon State and Bago Region followed. Then, the announcement was officially posted on the bulletin board of the township administration of Kyaikto Township of Mon State and Waw Township of Bago Region for informing the public. In addition, PAPs were reminded verbally several times during socialization meetings and census and SES interview surveys.

As mentioned, additional land and structure development is to be limited after the COD, and the policy is being explained and understood among the PAPs in occasions such as public consultation meetings, interviewing, etc. In addition, local administrations and local officials of MOC in charge of the matter monitor the situation and try to collect information on unfair development or illegal encroachment of people from the dwellers and so on.

Although the design may be revised and adjusted during DD stage, the COD will not be re-declared. Instead, the COD declared during F/S stage will be re-informed in the times of socialization meeting to be held before census and IOL update of DD stage. The continuous monitoring to prevent the influx of people and ineligible new development should be conducted by local administrations. Any disputes that are unresolved or that come after the Census/IOL will be referred to the project proponent or Grievance Redress Mechanism.

(2) Entitlement Matrix

The entitlement matrix is a matrix to systematically show the relations of compensation, which includes type of loss, application, person entitled, assistance policy and responsible entity. The matrix is developed based on the impact identified through the census survey and other related activities. In this Project, the Entitlement Matrix was prepared as Table 12.5.1 to show the eligibility conditions and the main compensation measures proposed to PAPs according to the type of impact. It should be noted that depending on the type of impact, the PAP may be eligible for one or more compensation measure.

This entitlement matrix of the resettlement plan may be updated after the detailed design stage to reflect the relevant changes, but the standards set in the original entitlement matrix should not be changed when the resettlement plan is revised and finalized. It is also noted that the assistance policy for each item for each eligibility should be harmonized with ADB bypass sections as much as possible, although ADB RP is prepared in accordance with ADB SPS.

Table 12.5.1 Entitlement Matrix

	Type of loss/ impact	Application	Eligible Persons	Entitlements	Implementation issues
1	Land				
1.1	Agricultural Land (Crop Land and Garden Land)	Marginal loss (less than 10% of total agricultural landholding of the household)	Land owner/ Occupant or a person who has recognizable right to claim to the land	(A) Cash compensation at replacement cost for the affected land area	(a) Replacement cost for agricultural land should include the market value of 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.
1.2		Severe loss (10% or more than 10% of total agricultural landholding of the household)	Land owner/ Occupant or a person who has recognizable right to claim to the land	(A) Cash compensation at replacement cost for the affected land area (B) Assistance for SAH as specified in 5.1 (C) Be entitled to participate in Income Restoration Program (IRP)	(a) Replacement cost for agricultural land should include the market value of 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. (b) If the remaining area of the land plot is no longer economically viable (too small area or the shape is difficult for cultivation) and if the land user requests, the entire plot shall be acquired and compensated by replacement cost. (c) IRP will be elaborated during RAP updating .
1.3	Residential Land	Full or Partial Impact	Land owner/ Occupant or a person who has recognizable right to claim to the land	(A) Cash compensation at replacement cost for the affected land area	(a) Replacement cost for residential land should include the market value of land of equal size and use, plus the cost of any registration and transfer taxes. (b) If the remaining area of the land plot is no longer economically viable (too small area or the shape is difficult for usage) and if the land user requests, the entire plot shall be acquired and compensated by replacement cost.
2	Structure				
2.1	Residential House	Loss of partial houses	House owner regardless of tenure status	(A) Cash compensation at replacement cost for the affected portion with no depreciation and no deduction for salvageable materials (B) Assistance to repair the remaining portion of structure	(a) Replacement cost for houses and other structures should include the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees.

2.2		Full Impact (Relocation)	House owners whose houses are built on their own land	(A) Cash compensation at replacement cost for the affected portion with no depreciation and no deduction for salvageable materials (B) Relocation options (i) Regardless of affected land type, AHs will be allowed to rebuild their houses on their non-affected land area. (ii) AHs will purchase replacement land for self-relocation with the cash compensation at replacement cost received for the affected land. **Relocation assistance** (C)Transportation assistance; (D)Relocation assistance as prescribed in Item 5.2 and 5.3 (E) Assistance for SAH as specified in 5.1 (F)Be entitled to participate in the IRP	(a) Replacement cost for houses and other structures should include the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees. (b) The transportation assistance will be determined during the RAP updating (c) AHs will be provided with the notice of land clearance 6 months in advance in a particular segment of the Project
2.3		Loss of full houses (Relocation)	Owner regardless of tenure status (Squatter)	(A) Cash compensation at replacement cost for the affected portion with no depreciation and no deduction for salvageable materials **Relocation assistance** (C)Transportation assistance; (D)Relocation assistance as prescribed in Item 5.2 and 5.3 (E) Assistance for SAH as specified in 5.1 (F)Be entitled to participate in the IRP	(a) Replacement cost for houses and other structures should include the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees. (b) The transportation assistance amount will be determined during the RAP updating (c)APs will be noticed 6 months prior to site clearance
2.4	Secondary Structures (Structures such as <u>hut, toilet, water tank</u>, fences, wells etc.)	Partial or Full Impact	Owners of the structure	(A) Cash compensation at replacement cost for the affected portion with no depreciation and no deduction for salvageable materials (B) If removal is required, for movable structures, assessment on ability to move the dismantled structure will be considered. Assistance will be provided to cover the replacement	(a) Replacement cost for houses and other structures should include the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees.

				costs of site preparation, dismantling, moving and rebuilding the structure	
3	Crops and Trees				
3.1	Annual Crops	Loss of Annual Crops	Crop owners (regardless of the ownership of land)	(A) Cash assistance which is equivalent to 3 years value of crops (market price) in the areas which PAPs can no longer cultivate If the impact to the crops accounts for 10 % or more than 10% of income sources of the households, following assistance shall also be provided. (B) Assistance for SAH as specified in 5.1 (C) Be entitled to participate in the IRP	(a) DPs will be given 6 months' notice to harvest rice prior to site clearance and not-plant for next season (b) If crops are not in ripening stage, PAPs will be provided the full market value of production cost)
3.2	Trees	Loss of Trees	Tree owners (regardless of the ownership of land)	(A) Fruits tree / Production Tree: Cash compensation at market price for loss of crops/fruits calculated as number of years needed to bear fruit (B) Timber tree / Shade Tree: Cash compensation equivalent to the market price of the tree as timber/firewood If the impact to the crops accounts for 10 % or more than 10% of income sources of the households, following assistance shall also be provided. (B) Assistance for SAH as specified in 5.1 (C) Be entitled to participate in the IRP	(a)The AHs have the right to use salvageable trees (b) Assistance amount is calculated based on yield amount recorded in DALMS or confirmed at survey
4	Loss of Business/work/employment				
4.1	Loss of Business (Shops/ Restaurant other business such as fish pond or laterite quarry)	Non-direct impact (The residual portion is still viable for business after repairing) the business (which relocation of the	Owners of the business (shop/restaurant/other business such as fish pond or laterite quarry)	(A) Cash assistance for the income loss during the period of the business disruption while the remaining structure is being repaired	(a) The amount will be based on either official evidence of income (such as tax receipts or similar evidence) or otherwise based on assessed minimum wage in the project area multiplied by an assessed

		business is not required)			reasonable period required to carry out the repairs.
4.2		Direct impact to the business (In which the relocation and re-establishment of the business is required because of the entire portion is affected by the COI or the residual portion is unviable to continued business after repairing)	Owners of the business (shop/restaurant/other business such as fish pond or laterite quarry)	(A) Cash assistance for the income loss during the relocation and re-establishment of the affected business in new place	(a) The amount will be based on either official evidence of income (such as tax receipts or similar evidence) or otherwise based on assessed minimum wage in the project area multiplied by an assessed reasonable period required to carry out the business relocation and re-establishment in the new place.
4.3	Loss of leasehold due to end of agreement before expiry	Loss of leasehold of Land and structure	Tenants who are operating business (including agriculture) on the rented land	(A) One-time assistance in looking for alternative place to rent, plus transportation costs to move to the new place: $250/household	
4.4	Employment	Temporary disruption of employment	Employees of affected business who will experience temporary or loss of employment due to the business disruption	(A) Cash assistance equivalent to lost wages for the period for the business disruption up to 3 months	(a) Employees are to confirm whether they have been working for the affected business HH at least 6 months at the time of business disruption. They have to show their employment contract, or their actual employment status must be confirmed by the village administrators. (b) The amount of lost wages to be based on official employment records or standard wages for similar work in the project areas assessed by the Township General Administration.
4.5		Permanent loss of employment	Employees of the affected business who will experience permanent loss of employment due to the business disruption	(A) Cash assistance equivalent to lost wages for 6 months and entitled to participate in the vocational training if they are not able to find alternative employment	(a) Employees are to confirm whether they have been working for the affected business HH at least six months at the time of business disruption. They have to show their employment contract, or their actual employment status must be confirmed by the village administrators. (b) The amount of lost wages to be based on official employment records or standard wages for similar work in the project area as assessed by the Township General Administration.
5	Special Assistance				

5.1	Assistance for SAH		AHs who will have 10% or more than 10% of total production landholding or relocation households	(A) Cash assistance for 3 months based on the minimum subsistence level	(a)Subsistence level based on poverty rate of $1.25 per day per person
5.2	Relocation stabilization assistance		Residential relocation but non-vulnerable households (Non-vulnerable households are the PAHs who do not fall under any of the criteria described in 5.5)	(A) Relocation stabilization assistance for 2 months	(a) Level and types of relocation assistance to be provided to relocation households will be determined by the Regional/State General Administration during RAP updating
5.3			Residential relocation and vulnerable households (Vulnerable households are the PAHs who fall under one or more of the criteria described in 5.5)	(A) Relocation stabilization assistance for 4 months	(a) Level and types of relocation assistance to be provided to relocation households will be determined by the Regional/State General Administration during RAP updating
5.4	Transportation Assistance		Relocation household	(A) One-time cash assistance for transportation cost for moving	(a) The transportation assistance amount will be determined during the RAP updating
5.5	Vulnerable assistance		Vulnerable Households who fall under one or more of the criteria below; (i) Poor households; (ii) Female headed households; (iii) Households including a person with disability; (iv) Households headed by elderly; (v) landless households; (vi) ethnic minority	(A) Cash assistance: 300,000 Kyat/ household (B) Be entitled to participate in IRP	(a) Households that fall into more than one vulnerability criterial are entitled to receive the assistance once.
5.6	Income Restoration Program (IRP)		Vulnerable Households (Vulnerable households are the PAHs who fall under one or more of the criteria described in 5.5)	(A) IRP supporting through IRP implementation	(a) The IRP supporting will be in-kind or through-IRP. (b) The relevant supporting amount will be elaborated during RAP updating
5.7			Households losing 10-30 % of total production landholding	(A) IRP supporting through IRP implementation	(a) The IRP supporting will be in-kind or through-IRP. (b) The relevant supporting amount will be elaborated during RAP updating
5.8			Households losing 30-70 % of total production landholding	(A) IRP supporting through IRP implementation	(a) The IRP supporting will be in-kind or through-IRP. (b) The relevant supporting amount will be elaborated during RAP updating
5.9			Households losing more than 70% of total production landholding	(A) IRP supporting through IRP implementation	(a) The IRP supporting will be in-kind or through-IRP. (b) The relevant supporting amount will be elaborated during RAP updating

5.10			Relocation households	(A) IRP supporting through IRP implementation	(a) The IRP supporting will be in-kind or through-IRP. (b) The relevant supporting amount will be elaborated during RAP updating
6	Public Assets				
6.1	Public Assets	Partial or Full Impact	Affected communities which owns the public assets	(A) For the affected shrine: compensation for affected land and affected structures at replacement cost and costs for the related religious activities when dismantling and reconstruction of the shrine; (B) For the affected gas pipeline sections: Concrete boxes will be constructed to protect the pipeline sections (C) For other structures: Cash compensation at replacement cost to reconstruct the affected structures	

Source: JICA Study Team

12.6 Income Restoration Program

12.6.1 Overview of Livelihood Impacts

In the project area, there are no direct impact to the shops or kiosks identified, but loss of productive farming land is the major cause of the impacts to the livelihood of PAHs. The PAHs will be entitled to receive compensation for affected items such as lands and crops etc. as described in Entitlement Matrix, but they may be have difficulty to restore their standard of life to pre-project level without taking any action such as purchasing new farmland and restore the scale of agricultural activity to the pre-project level or generating income by seeking new business opportunity.

Therefore, the Income Restoration Program (IRP) as supplemental support is proposed to aiming at improving or restoring and stabilizing the livelihoods of PAHs at least to pre-project levels after land acquisition and resettlement. The program is intended to 1) To improve vocational skills and income levels or at least restore pre-project levels, or 2) to improve the living standard and production level of PAPs in their new places by (a) providing technical assistance to continue farming or raising livestock/cattle, (b) creating job opportunities by vocational training and (c) creating career opportunities through vocational training and job creating activities in/around the project area. Those training sessions may be provided together with in-kind/materials support.

The target of IRP is to be set at (i) the Severely Affected Households (SAHs) composing of those who will lose 10% or more of their production/income-generating assets and relocation households and (ii) the VAHs, as those people are regarded as to be significantly impacted by the Project in terms of restoration/rehabilitation of their livelihood.

In the Project, 16 households of (i) SAHs and 4 households of (ii) VAHs are identified. It is noted that among the 16 SAHs, 4 households are also regarded as VAHs, therefore a total of 16 eligible PAHs to participate in the IRP are identified during feasibility study. The final figures of the SAHs and VAHs will be updated during the DMS survey in the detailed design stage of the Project.

12.6.2 Preliminary Needs Assessment

In the Feasibility Study Stage, a preliminary needs assessment for the IRP was undertaken to support in designing income restoration measures to be involved in IRP. The survey target in preliminary assessment was all the PAHs regardless of eligibility of IRP. This survey was conducted from 16th to 17th of May, 2019 by the JICA Study Team (JST). JST clarified objectives for conducting the survey with PAHs before the survey and interviewed each of the representatives of the PAHs. The results of the questions are presented below.

(1) Tendency of the attitudes towards income restoration activities of PAHs

As an expected income restoration activity, the likely attitude of PAHs towards income restoration after the Project can be categorized to the following points:

(1) Do nothing (Not planning to restore the income after project)

(2) Purchase replacement farmland /stores and restore the income at least to the pre-project level

(3) Change current income earning activity and try to find/ start new job to restore the income at least to the pre-project level

(4) No idea at this moment

(5) Others (Specify)

The interview survey result is shown in Table 12.10.1. Considering the majority of the PAHs depend on agricultural activities, 10 PAHs do not want to change their occupation and therefore intended to purchase replacement farmland and continue agricultural activities. On the other hand, 7 PAHs are interested in new business opportunities and would like to alter their economic activities. Although 1 PAH answered that she will not attempt to do any activity for income restoration although she does not fall under SAHs nor VAHs. Two PAHs have no idea at the current stage.

Table 12.6.1 Tendency of the attitudes towards income restoration activities of PAHs

Tendency of the attitudes towards income restoration activities of PAHs	No. of PAHs
(1) Do nothing (Not planning to restore the income after project)	1
(2) Purchase replacement farmland / stores and restore the income at least to the pre-project level	10
(3) Change current income earning activity and try to find/ start new job to restore the income at least to the pre-project level	7
(4) No idea at this moment	2
(5) Others (Specify)	0
Total	**20**

Source: JICA Study Team

(2) Willingness for participation and preference of IRP

Regarding the IRP, willingness for participation for IRP was interviewed to the representative of PAHs. According to the survey result, 16 household heads answered that he/she would like to attend IRP, whilst 4 household heads were not interested. Regarding to the household members, 15 household members from 11 PAHs are willing to participate in IRP. In regard to the perspective of gender-balance, 81% are male household heads and 19% are female household heads who are interested in IRP as the number of male household heads are greater than female household heads. On the other hand, gender balance of household members are almost equal, 7 male household members answered they are interested, while 8 female household members replied the same.

Table 12.6.2 Number of PAHs who Wish to Attend IRP

Household-head		Household-members	
Yes	No	Yes	No
16	4	11	9

Source: JICA Study Team

Table 12.6.3 Number of PAPs who Wish to Attend IRP by Gender

Household-head			Household-members		
Total	Male	Female	Total	Male	Female
16	13	3	15	7	8

Source: JICA Study Team

In addition, Table 12.6.4 shows the preference of IRP program from each PAHs. Most of PAHs showed interest on technical assistance for agricultural activity and would like to continue farming/tree plantation, while 2 PAHs are seeking new business opportunity and are interested in opening a restaurant and some shops in the project area. Other 2 PAHs have not decided the future plan yet and they answered they may consider the future plan after determination of compensation price. One PAH is not interested in IRP because the PAH has enough income source which will not be affected by the Project and therefore are not worrying about their livelihood after land acquisition and resettlement caused by the Project.

As a noteworthy comment raised by 3 PAHs, it was mentioned that some assistance of loans for PAHs are favorable because they can invest in some goods, etc., for their income-generating activity.

Table 12.6.4 Preference of IPR Selected by PAHs

	Preferences of IRP affected households	No. of PAHs
	Provide technical assistance for those who want to continue farming or raising livestock/cattle	
1	Buy replacement paddy land to continue farming/ tree planation	15
2	Cow fattening	0
3	Duck raising	0
4	Raising chicken/pig	0
5	Raising cow and goat	0
	Provide technical assistance or/and small business/service models for those who want to do business	
6	Buy a tractor for renting to the farmers	0
7	Buy backhoe for road construction	0
8	Buy buses to do the bus-service in the area	0
9	Buy cars for transportation service	0
10	Buy harvesting machines to do the service in the local	0
11	Buy small trucks for transportation service	0
12	Buy trawlergies	0
13	Buy tuk tuks for transportation service	0
14	Open agricultural machinery shops	0
15	Open an organic agricultural products shop	0
16	Open beauty salons	0
17	Open betel leaves shops	0
18	Open clothing shops	0
19	Open cold drinks shop selling juice, coca cola etc.	0
20	Open construction materials shops	0
21	Open electronics repairing/selling shop	0
22	Open fruit shops	0
23	Open furniture selling goods	0
24	Open gasoline stations	0
25	Open grocery shops	0
26	Open mini-marts	0
27	Open pea and bean selling shops	0
28	Open rice shop	0
29	Open rubber shops	0
30	Open shop selling agricultural tools.	0
31	Open shop selling fertilizer and pesticide	0
32	Open small motorcycle repairing/selling shops	0
33	Open small restaurants	2
34	Open souvenir shops	0
35	Open tea shops	0
36	Open vegetable shops	0
37	Open welding shops	0
	Create career opportunities through vocational trainings and job creating activities	
38	Work in the construction sites	0
39	**Others**	0
40	**Not yet decided**	2
41	**Not interested at all**	1
	Total	**20**

Source: JICA Study Team

12.6.3 Proposed Framework of IRP

The framework of IRP is prepared as described below. The detailed contents of IRP shall be further designed and implemented based on the framework.

Table 12.6.5 Framework of Income Restoration Program

Name of Program	Income Restoration Program (IRP)
Objectives	The primary objectives are described as follows; a) To improve vocational skills and improve or restore the income levels at least to the pre-project levels b) To improve living standard and production level of PAPs in their new places
Period	To be examined and decided during detailed design stage based on the detailed needs assessment as well as the monitoring result of livelihood rehabilitation status of affected persons during implementation stage.
Target	(i) the SAHs who will lose 10% or more of their production/income-generating assets and relocation households; (ii) the VAHs of the Project who will fall under any of the criteria of followings; a) Household headed by a woman; b) Household headed by elderly; c) Household including a person with disability; d) Household below the poverty line; (e) Household including indigenous peoples; (f) Household headed by child; (g) Landless households.
Responsible/ Implementation Organization	Responsible Organization is PMU (DOB) supported by resettlement specialist of the consultant team. The IRP will be implemented by service provider such as other concerned ministry or NGO in cooperation with Regional Government and other concerned local authorities under management of PMU (DOB) with resettlement specialist.
Approach	In order to develop and implement the IRP, PMU (DOB) supported by resettlement specialist will take following processes and approaches; 1) Identification of eligible PAHs based on the updated RAP prepared during the DMS survey in the detailed design stage of the Project; 2) Consultation with IRP eligible households and carry out detailed needs assessment survey as well as the capacity assessment of eligible households to engage in the IRP; 3) Discuss with local administration and relevant agencies such as relevant ministry or NGOs on the availability of technical cooperation program or vocational training program; 4) Coordinate with local administration and PMU (DOB) for review and approval of the IRP; 5) Implementation of specific IRP activities and supporting eligible PAHs to participate to the IRP; 6) Regular monitoring of the status of the IRP implementation and providing support to the participants as required;
Potential Income Restoration Program	The program to be proposed under IRP can be classified to three main categories. Those programs are intended to be provided in the combination of technical assistance/vocational training and in-kind/materials support. In addition, those shall ensure equal opportunities for man and woman as well as the equal and effective participation of man and woman by considering gender aspect. (a) Providing technical assistance to continue farming or raging livestock/cattle; To achieve the first objective of providing the technical assistance for those who want to continue farming or raising livestock/cattle, the program will provide assistance and organizing training courses on agricultural extension models to the eligible households. (b) creating job opportunities by vocational training; With the objective of providing technical assistance or/and small business/service models for those who want to do business locally, the program will provide them with technical advice, small business/service models and other training courses, study tours, and some in-kind/materials support for business establishment. (c) Create career opportunities through vocational training and job creating activities in/around the project area. To create career opportunities through vocational training and job creating activities, the program will organize training courses that suit their needs, capacity and provide supplementary training, consultations, allowance and other support to participants attending the courses as well as tools/equipment for career establishment after being trained.
Monitoring	Both internal and external monitoring shall be included (a) Internal monitoring shall be done by regular checking of the status/progress of the IRP as well as the issues raised and measures taken during the IRP. (b) External monitoring shall be done by regular checking of the status/ progress of the IRP and the livelihood restoration status of participated PAHs. Monitoring of IRP will be conducted under the scope of RAP monitoring and also be reported in the RAP monitoring.
Grievance Redress mechanism	Receive the information (complaints, requests) made by PAPs and local residents and keep them as records, take necessary actions, and responses will be done base on the type of received information by not only collaboration with PMU (DOB) and concerned local authorities but also regular consultation with PAHs.
Information disclosure	Job recruitment notifications will be posted in the visible and easily accessible places for PAPs and PAHs.

Source: JICA Study Team

12.7 Implementation Framework

The Department of Bridges (DoB) is the core responsible body for the resettlement action plan as the driving force of the Project. Besides DoB, the Ministry of Agriculture, Livestock and Irrigation (MOALI) and the Ministry of Home Affairs (MOHA), Ministry of Social Welfare, Relief and Resettlement (MSWRR) shall be involved in managing land issues and compensation. Local authorities at state, township and village levels must be constituents as well. A possible example of the organizations concerned and the roles involved in the resettlement action plan is shown in Table 12.7.1. The organizations are to form a consortium chaired by DoB, the so-called Resettlement Implementation Committee (RIC), to go ahead with the activities of the resettlement action plan in harmony with stakeholders.

Processes regarding major RAP implementation activities are as follows:

1) RAP approval: the RAP is created by the Project entity (DoB) with assistance of resettlement specialists/ consultants, examined and approved within the entity and submitted to JICA.

2) Budget securement and approval: The RIC including Project entity re-valuates the RAP budget plan, introduces the revised budget to Central government. After tabling the budget is to be approved.

3) Compensation payment: The entity explains and gets approval on compensation coverage from PAPs. The PAP can negotiate the coverage with the entity. After attaining an agreement in a writing form, compensation must be conducted for sure. The land ownership is transferred to the entity by contract. Internal and external monitoring activities help to secure the process of compensation and check the flow.

Table 12.7.1 Roles of Organizations to Implement the Resettlement Action Plan

Organization	Composition	Major Roles
Department of Bridge (DoB), MOC		Overall Execution of the Project Directs the PMU/DOB Responsibilities for approving Updated RAP (URAP) Securing resources related RAP
Project Management Unit (PMU), DoB		- Responsibilities to update RAP - Responsibility to coordinate all organizations concerned on RAP activities - To supervise RAP implementation activities - Responsible organization of IRP implementation
Resettlement Implementation Committee (RIC)	- PMU/DOB, MOC - DOH, MOC - State/Regional Government (Mon State and Bago Region) - District (Bago District and Thaton District) - Township (Waw Township and Kyaito Township) - MONREC - Department of Industrial Crops Development (DICD), MOALI	- To examine and valuate the awards (entitlement, compensation), usually led by respective township administrator - To valuate compensation of agricultural products (crops, trees, livestock) - To examine and valuate the awards (entitlement, compensation), usually led by respective township administrator - To valuate compensation of agricultural products (crops, trees, livestock) - In cooperation with the related organizations and stakeholders, - To drive RAP implementation activities - To administrate the schedule and progress of compensation and livelihood assistance - To contact for grievance redress
Department of Agricultural Land Management and Statistics (DALMS),		- - To investigate farmland conditions to be acquired (area size, ownership, etc.) - - To prepare application for land acquisition in case of legal ownership

Organization	Composition	Major Roles
MOALI		- - To survey replacement cost of lands - - To monitor unfair farm land trading in cooperation with township/village administrators
General Administration Department (GAD), MOHA		- - To monitor unfair land trading in cooperation with township/village administrators
District Government (Township, village)		- To monitor encroachment of illegal settlers into the project area after the COD - To manage relocation site
State Government (Bago, Mon)		- To supervise the district government - To issue land lease grant
Monitoring Experts		- Internal Monitoring - DoB in assistance with GAD - External Monitoring – Experts in accordance with the TOR

Source: JICA Study Team

12.8 Grievance Redress Mechanism

Complaints and conflicts may arise during the construction, land acquisition and compensation process. These complaints and conflicts can be of many kinds. It could be:

I. Land Acquisition and Compensation

i) Errors in the identification of people and property affected by the Project;
ii) Disagreement on land, either between the affected person and the expropriation agency, or between two neighbors;
iii) Conflict over the ownership of a property between two affected persons;
iv) Disagreement over the assessment of property;
v) Family problems (estates, divorces) that raise disputes between heirs or members of the same family regarding a property, parts of a property or other property;
vi) Disagreements about resettlement measures, location of a resettlement site, type of compensation or habitat proposed, characteristics of the parcel, quality of the new areas of use, etc.;

II. EIA

vii) Unexpected natural and social adverse impacts by the project construction activities;
viii) Other issues related to the Project.

The aim of the Grievance Redress Mechanisms (GRM) is to ensure that grievances and concerns raised by PAPs or other people within the communities can be effectively dealt with in a timely and satisfactory manner. Given the potential for quick and effective resolution on the ground, utilizing local dispute mechanisms as a first step in line with current traditional practices makes the mechanism more effective. Normally, a grievance redress mechanism is developed to ensure that:

i) All complaints related to resettlement, compensation and other assistances are appropriately dealt with;
ii) Easily access for those who have complaints related to resettlement and others assistance; and
iii) Adequate measures are taken to resolve raised issues.

Grievances related to any aspect of the Project or sub-projects shall be handled through a consultative manner appropriately, easily and speedily. The Grievance Redress Committee (GRC) is suited as the main entity that takes care of the issues. The composition of the GRC includes the following members:

i) Representatives from PMU/DOB and regional DOB;
ii) Representatives from DOH;
iii) Village Tract leader/ Representatives from the relevant community (at least 1 female member);
iv) Representatives from Township Women Association;
v) Township GAD, MOHA;
vi) Township officer of DALMS, MOALI;
vii) Ministry of Natural Resources and Environmental Conservation;
viii) Ministry of Agriculture, Livestock and Irrigation;

ix) Other relevant organization, if any.

The GRC members are mainly composed of relevant officials at the township level. However, depending on the type of complaint or the situation, the GRC may also ask representatives of the relevant organization to take part in the procedure of grievance resolution, such as state/regional government, contractor and consultants. For the gender perspective, the GRC should include few female members.

A possible scheme for grievance redress mechanism is illustrated in Figure 12.8.1 and its process is as follows:

1) PAPs can lodge claims or complaints on natural and social impacts, resettlement and compensation directly to the GRC or indirectly through the village tract. A Grievance Redress Officer (GRO) at the corresponding township in GRC is responsible for the contact;

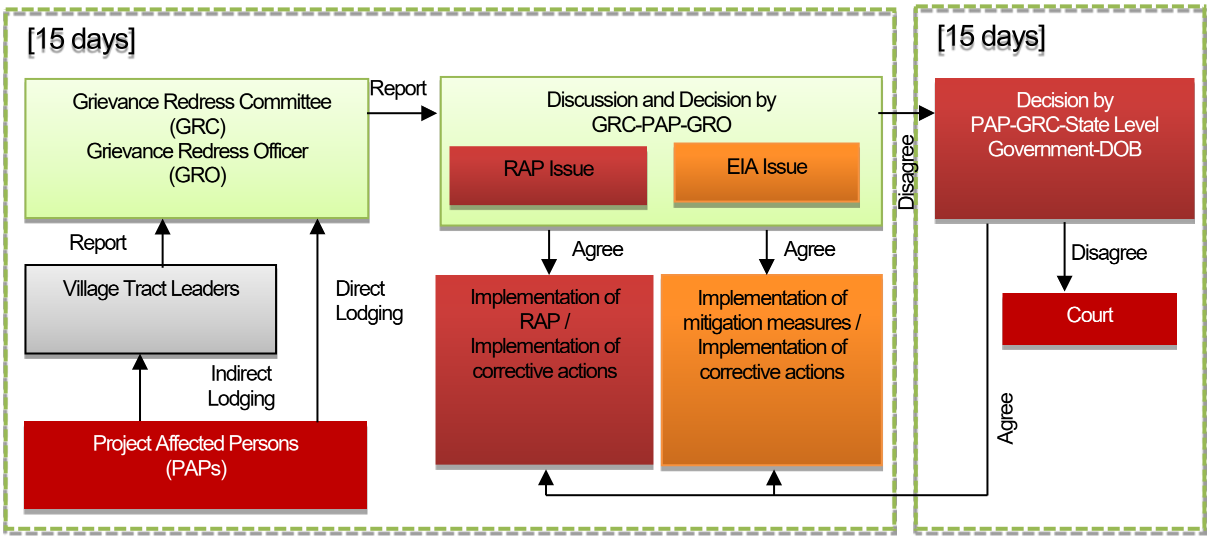
2) The chairperson of the GRC/GRO assigns an officer-in-charge from the GRC members in accordance with the nature of the lodged complaint in order to interview the PAP concerned who raised the issue; **[5 days]**

3) The GRC holds discussions based on the evidences obtained, takes an approach and makes an initial decision. The appointed officer starts negotiation with the PAP in consultation with the RIEC; **[10 days]**

4) In case an agreement is not achieved between the concerned PAP and the GRM within 15 working days from the day the complaint is lodged, the case is to be forwarded to the DoB and the corresponding state government in addition to the GRC. The relevant section in DoB reviews the documents and discusses with the PAP until an agreement is obtained; and **[15days]**

5) If, however, the agreement is not reached within another 15 days at this stage, the case may to be sent to the court for legal steps.

Once grievances are raised in the GRC, the contents of the grievances and status of the resolution process shall be recorded until closure of the complaint.



Source: JICA Study Team

Figure 12.8.1 Scheme for Grievance Redress Procedure

This GRM will be separately established from the one to be established for the ADB road section since the project proponent will be a different organization. However, the proposed GRM of ADB are almost the same mechanism with GRM of JICA Bridge section. Any issues related to the Project such as RAP matter or EIA matter can be raised to the GRC. The components of the GRC are almost same in both GRM. Also, the same steps to be followed both in JICA GRM and ADB GRM as both GRM propose to first discuss on the township level, and secondly on the state/regional level if it's not resolved in the first step.

It is also noted that GRM procedures will have to be disclosed and discussed with various stakeholders of the communities around the project area including PAPs of RAP and fishermen to the extent possible in order to ensure that they recognize the GRM, and agree and understand the process. The mechanism is usually established just after the public consultation meeting by re-investigating the RAP contents during the detailed design stage. A plaintiff (PAP) will not need to bear the cost in case if the case can be finalized within the committee. The management cost is enough within the total RAP implementation cost. However, the plaintiff is to bear the relevant cost which the domestic legal system defines in case a suit at law would be filed.

12.9 Monitoring Activity

Monitoring activity normally consists of internal and external monitoring. The main purpose of the monitoring activity is to ensure that all PAPs who lost their respective houses, land or other livelihood assets have been provided with sufficient compensation and assistance according to the policies and procedures which is described in RAP.

12.9.1 Internal Monitoring

The specific objectives of Internal Monitoring are to oversee RAP implementation to ensure resettlement objectives are met and that resettlement activities are on track. DoB alternatively referred to as Internal Monitoring Agent (IMA) shall be responsible for internal monitoring. The involvement of PAPs in monitoring activities should also be encouraged. As such, village heads and household representatives will continually be consulted during monitoring activities. It will be undertaken by DoB with support from resettlement specialists/consultants with the assistance from RIC. Internal Monitoring will consist of monthly reports during the implementation of this RAP.

The main tasks of the IMA include:

- Regular supervision and monitoring the RAP implementation as designed and planned in coordination with RIC;
- Ensuring the timely and complete disbursement of compensation and assistance to each PAHs in accordance with agreements between RIC and PAHs; and
- Recording all grievances raised by PAPs and ensuring that all complaints are promptly addressed.

12.9.2 External Monitoring

External monitoring should be periodically carried out conducted by an independent local/international External Monitoring Agent (EMA) to provide an independent view on the achievement of the RAP. Furthermore, the External Monitor will conduct its assessment based on reviewing Project documentation such as compensation records, reviewing Internal Monitoring reports, conducting field visits, and interviewing PAPs and relevant authorities. External monitoring reports should be provided on a quarterly basis during the implementation of RAP and IRP and biannual basis during the post-resettlement and IRP period for 2 years.

The main activities of external monitoring should include:

- Reviewing and verification internal monitoring results;
- Identifying any discrepancy between assistance provided and its actual implementation;
- Assessing the effectiveness, impact and sustainability of resettlement activities, particularly with regards to livelihood and restoration and/ or enhancement of living standards; and
- Providing recommendations, if necessary regarding the resettlement activities to achieve the principles and objectives of JICA guideline, and relevant laws.

12.10 Information Disclosure, Consultation and Participation

12.10.1 Background and objectives of the consultation

Public consultation is an important phase in the implementation and success of RAP implementation. It is an activity that consists of holding meetings to inform the public about the Project and gather the opinions and suggestions of the affected people. The objective is to sufficiently involve the population to obtain their adhesion to the Project. Thus, the Project must inform, consult and give the opportunity for the Project Affected Persons to participate in all stages of the process in a constructive manner.

Insofar as the land acquisition and resettlement for public purpose is the Government action that may affect the well-being of the population, it is mandatory that the people affected by the Project be fully informed of the intentions of the public authorities. Project disclosure and consultation at an early stage provides a good venue for PAPs to express their opinions, apprehensions, and even objections. It opens grounds for discussion, and allows the Implementing Office to address issues raised, most of which can be incorporated into the final design and resettlement plan.

Generally, in the RAP preparation process, meetings inviting PAPs in different two stages are planned, firstly prior to the preparation of RAP and secondly after preparation of Draft RAP. Table 12.10.1 shows the general objectives of the meeting in each stage.

Table 12.10.1 Activities for Public Consultation Meetings

Category	Milestone and Objectives
1st Stage (Before RAP Preparation)	Prior to Preparation of RAP a. To inform the PAPs about: i) the activities and scope of work of the Project; ii) the expected adverse impacts such as loss of property and displacement; iii) the no-worse off policy of JICA and World Bank, iv) the activities, process of RAP survey and declaration of Cut-off date b. To encourage PAPs to express their ideas, concerns and apprehensions, and other related issues.
2nd Stage (After Draft RAP Preparation)	After Preparation of Draft RAP a. To inform the PAPs about the RAP survey result; b. To inform the PAPs about the compensation policy to be followed; c. To ask the PAPs to give their comments/objections on the RAP; d. To inform the PAPs about the future schedule and process of the RAP

Source: JICA Study Team

12.10.2 Result of the Consultation

(1) Outline of RAP Socializations Conducted

Concerning the Project, 3 public consultation (socialization) meetings were held in concerned villages with PAPs. The first two took place prior to the preparation of RAP and the third after data collection and preparation of Draft RAP.

After conducting of first meeting held on 20th December, the project component of guide bank and revetment was added, therefore the additional socializations were held to inform the project scope of work at the earliest possible time to additional PAPs concerned. The outline of conducted meetings is shown in Table 12.10.2.

In the stage of updating RAP during DD, RAP socializations are to be held before additional survey and draft Updated RAP (URAP) stage.

Table 12.10.2 Outline of RAP Socializations Conducted

No.	Category of RAP Socialization (Date and Location of the Meeting)	Agenda of the Meeting and Language	Target Component of the Project/ Major Participants	Notification of the Meeting
1	1st Stage Before RAP Preparation (20th December 2017 10:00~12:00 Monastery of Village, Sut Pa Nu Village, Kyaikto Township, Mon State)	MOC and Eguard has explained project summary, Law & Guideline to be followed, Process and Schedule of RAP, and then exchange opinions have been conducted in Burmese.	Target Component: Bridge Total: 29 (Male: 22, Female: 7) Government: 6, PAPs: Local People 16 (Including 8 PAPs) , JICA Study Team: 3, Eguard: 4	The venue and date of the meetings have been notified by MOC, local government and village leader directly to the project affected persons at lease 2-3 days prior to the meeting after identification of PAPs.
2	1st Stage Before RAP Preparation (20th December 2017 14:30~15:30 General Administrative Office, Shan Kaing Village, Waw Township, Bago Region)		Target Component: Bridge Total: 34 (Male:28, Female: 6) Government: 8, , Local People: 19 (Including 2PAPs), JICA Study Team: 3, Eguard: 4	
3	1st Stage Before RAP Preparation (13th June 2018 10:00~12:00 Monastery of Village, Sut Pa Nu Village, Kyaikto Township, Mon State)	MOC and Eguard has explained project summary, Law & Guideline to be followed, Process and Schedule of RAP, and then exchange opinions have been conducted in Burmese.	Target Component: Guide bank and revetment Total: 20 (Male: 19, Female: 1) Government: 4, PAPs: Local People 11 (Including 4 PAPs) , JICA Team: 1, Eguard: 4	The venue and date of the meetings have been notified by MOC, local government and village leader directly to the project affected persons at lease 2-3 days prior to the meeting after identification of PAPs.
4	1st Stage Before RAP Preparation (14th June 2018 10:00~12:00 General Administrative Office, Shan Kaing Village, Waw Township, Bago Region)		Target Component: Guide bank and revetment Total: 25 (Male:17, Female: 8) Government: 4, Local People: 16 (Including 6 PAPs), JICA Team: 1, E Guard: 4	
5	2nd Stage After Draft RAP Preparation (28th August, 2018: 02:30 ~ 03:40pm at Sin U Pa Gote Ta Monastery, Sut Pa Nu Village, Kyaikto Township, Mon State)	MOC in cooperation with the JICA Study Team has explained about the project summary, law and guidelines to be followed, RAP survey result, the compensation policy and entitlement and future process and schedule of RAP, and then exchange of opinions have been conducted in Burmese.	Target Component: Bridge, Guide bank and revetment Total: 18 (Male: 11, Female: 7) Government: 1, PAPs: 7 , JICA Study Team: 3, Eguard Environmental Services: 7	The venue and date of the meetings have been notified by MOC, local government and village leader directly to the project affected persons at lease 2-3 days prior to the meeting.
6	2nd Stage After Draft RAP Preparation (29th August, 2018: 11:00 ~ 11:40am at Village Administrator Office, Shan Kaing Village, Waw Township, Bago Region)		Target Component: Bridge, Guide bank and revetment Total: 16 (Male: 10, Female: 6) MOC : 1, PAPs: 5 (out of 8 people), JICA Study Team: 3, Eguard Environmental Services: 7	

Source: JICA Study Team

(2) Summary of Opinions and Answers on RAP Socialization

Summary of Opinion and answer on the series of RAP socialization are shown in Table 12.10.3 to Table 12.10.8.

Table 12.10.3 Opinions and Answers on 1st RAP Socialization (Mon State)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question/Comment	Name/Position	Answer	
1	PAPs/Villager (Female)	I want to know how the compensation will be paid for affected rubber trees	DOB/MOC	RAP survey will be conducted after this socialization and all assets including land, structures and tress will be entitled for compensation. For trees, the calculation method is also based on age of the trees, i.e., how many times of produce from the tree (e.g., mango tree, two times in a year), etc. Compensation amount for each affected unit will be based on the market price surveyed through local peoples and concerned government authorities such as DOA, Department of Agricultural Land Management and Statistics (DALMS), GAD and MOC, etc.	Accepted the answer
2	PAPs/Villager (Male)	According to the bridge alignment, farmlands that I bought recently will be affected. I have a plan to develop a fish pond and poultry farm on this farmland and it will be affected when the Project is implemented.	DOB/MOC	Compensation will be considered for only existing assets. Once the cut-off date is declared, any additional business activity or encroachments will not be eligible for compensation. Therefore, I would like to suggest you not to do new business activity or new development as it will be risk investment in economic terms.	Accepted the answer
3	PAPs/Villager (Male)	Village will be developed more due to this Project and we are happy to hear about the construction of a new bridge.			-
4	PAPs/Villager	For example, if affected house is under construction, should it be continued or not until is finished.	DOB/MOC	Construction can be completed for the whole structure, but the current completion status of the structure will be recorded during the survey and compensation will be calculated upon it.	Accepted the answer
5	Village Chief (Male)	If any accident happens, villagers have to go Waw Hospital urgently. It is difficult to reach the hospital in time due to weak transportation network of Kyaikto Township and Waw Township. Is it possible to access the New Sittaung Bridge and new road directly from the road inside of the village near the railway? If direct access is possible, it will be very convenient for villagers to travel to Waw Township for any urgent matters.	DOB/MOC	Although the design standard of the bridge and road is not finalized yet, the concept of the Project is that the road/ bridge should be connected to a major highway. Therefore, direct access from the road inside of the village might be difficult. Thus, please use the existing road to the nearest junction and access the new project road and bridge.	Accepted the answer

Source: JICA Study Team

Table 12.10.4 Opinions and Answers on 1st RAP Socialization (Bago Region)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question	Name/Position	Answer	
1	PAPs/Villager (Male)	I am not sure whether my farmlands will be affected or not as I don't know the exact location of the bridge alignment. How is the compensation rate if farm lands are affected?	DOB/MOC	The detailed alignment will be informed during interview survey with affected persons. Compensation will be paid with government budget. We will survey market price for affected farmlands and assess the compensation rate in this feasibility survey stage. The final compensation price will be decided in the detailed design stage.	Accepted the answer
2	PAPs/Villager (Male)	After the New Sittaung Bridge, will any vehicles such as tractors or Trawalergyi (Agricultural vehicles) be allowed to pass through?	DOB/MOC	For safety reasons as well as the road / bridge design standards, there will be a limitation of vehicle types which are allowed to pass through the Bridge. Basically, only vehicles that are officially registered and possess a license plate can pass.	Accepted the answer
3	PAPs/Villager (Male)	Does the road alignment pass the Shan Kaing Village?	DOB/MOC	The road section is not fixed yet since it is survey section of ADB and they will start the survey from now on. Therefore, ADB will explain on road alignment separately in the future.	Accepted the answer
4	PAPs/Villager (Male)	Will construction vehicles use the village road to access the construction site?	DOB/MOC	At the moment, we cannot say exactly. If village road is used for transportation of construction materials, upgrading the existing road will be needed.	Accepted the answer
5	PAPs/Villager (Male)	The existing village road is not good condition and we want MOC to upgrade our existing road.	DOB/MOC	Please request this issue to Parliament members to be able to submit to Parliament. MOC may be able to consider this issue and upgrade the road with budget allocation from the government.	Accepted the answer
6	Village Chief (Female)	Regarding the affected area on the Bago Region side (right bank side), the land owner sometimes live on the Mon State side (left bank side). Also, the registered land owner is sometimes not actual land owner. Therefore, some project affected persons are not attending this meeting.	DOB/MOC	In the RAP site survey to be started soon, the actual affected persons will be re-confirmed and the survey team will visit them individually. At that time, the contents of the meeting such as project summary and Guidelines and laws for compensation will be explained.	Accepted the answer

Source: JICA Study Team

Table 12.10.5 Opinions and Answers on 2nd RAP Socialization (Mon State)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question	Name/Position	Answer	
1.	Village Chief (Male)	Is there any consideration for local people in bridge design? For example, will there be a sidewalk accessible by local people?	JICA Study Team	At this moment, we cannot say if a sidewalk will be included or not as the detail design (and operational policy) of the bridge is not decided yet. However, all the vehicles which obtained license plate can access the bridge, and will be accessible by local people too.*	Accepted the answer
2.	PAPs/ Villager (Male)	When will the construction start? Should the farmers stop the work on affected land right now?	JICA Study Team	As we are now at F/S stage, it is difficult to say construction starting date. However, the construction starting date will be informed in advance.	Accepted the answer
3.	PAPs/Villager (Male)	Can farmers continue plantation on their lands?	JICA Study Team / Sub-Consultant	Paddy, beans or other seasonal crops and existing perennial plants can be continued until the project implementation. However, perennial plants like rubber that needs to wait for 4 or 5 years for the production stage should not be grown. As we declared in COD in January 2018, new development shall not be considered or compensated. As this is F/S stage, it will take time to start construction. Construction work may not be started at least within in one year.	Accepted the answer
4.	PAPs/Villager (female)	I am worry about my income as all of my land may be impacted.	JICA Study Team / Sub-Consultant	All the PAPs shall get compensation at market price and RAP shall consider for all kinds of project impact.	Accepted the answer
5.	PAPs/Villager (Male)	Is possible to consider land to land compensation?	Sub-Consultant	As we might aware that available land are decreasing nowadays, so it is difficult to compensate back land to land. However, land compensation would be cash compensation equivalent with market price.	Accepted the answer
6.	PAPs/Villager (Male)	We would like to suggest developing a sidewalk for the bridge as local people would like to cross the bridge for daily purposes.	JICA Study Team	We will take it into account.	Accepted the answer

* The necessity of the sidewalk was re-examined under MOC and it was concluded that no sidewalk will be installed because the bridge will be developed as "Access Controlled Expressway" considering the purpose of the East-West Economic Corridor Highway Development Project and the roles of the road and bridge.

Source: JICA Study Team

Table 12.10.6 Opinions and Answers on 2nd RAP Socialization (Bago Region)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question	Name/Position	Answer	
1	PAPs/Villager (Male)	How far is it from the bridge location to Shan Kaing Village?	JICA Study Team	Approximately 1.5 miles (2km)	Accepted the answer
2	PAPs/Villager (Male)	Will all the area of our land which we own be occupied, or only the project affected area?	Sub-Consultant	Only the area which is impacted by Project will be acquired. Therefore, people can continue their activity on the remaining land which is not impacted.	Accepted the answer
3	PAPs/Villager (Male)	Due to the guide bank construction, some farm lands will be divided into two parts and it may be difficult to continue the farming activity at the remaining area which is close to the river side. I want to know any consideration for this impact.	JICA Study Team	We will take into account this issue and consider the compensation plan if the remaining land is useless or other activities cannot be done.	Accepted the answer
4	PAPs/Villager (Female)	Can we continue faming activity if the Project does not start right now?	Sub-Consultant	Yes, you can continue. As we declared in the COD January 2018, we would like to suggest not to develop long term business. There would be no consideration and compensation for new development.	Accepted the answer
5	PAPs/Villager (Male)	As the road alignment seems far from our village, we would like to suggest the road alignment to be closer to our village. Our local people will greatly appreciate it if the road will pass through or near our village. So, we would like to suggest the road will pass through near our village and we will be happy upon land acquisition.	JICA Study Team	As our bridge location was confirmed by both JICA and MOC, it is difficult to change location. However, the road alignment is part of ADB project. Please also suggest this to ADB team. We will share this information to ADB.	Accepted the answer

Source: JICA Study Team

Table 12.10.7 Opinions and Answers on 3rd RAP Socialization (Mon State)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question/Comment	Name/Position	Answer	
1	Daw Htay Htay / PAPs / Villager (Female) Representative of land owner	Currently the concerned PAH lives in overseas. When does MOC want to contact the landowner and need documents of registration on properties?	MOC	Documents are not necessary now. It should be obtained when the landowner comes back from overseas during the vacation.	Accepted the answer
2	Daw Win Htay/ PAPs/ Villager (Female) Betal leaf landowner	Will compensation be paid once or twice for loss of property?	JICA Study Team	In general, once for compensation payment. However, the MOC and JICA will discuss this matter with ADB	Accepted the answer
3	U Than Tun Naing/ PAPs/ Villager (Male) Rubber landowner	To what extent is my land impacted and what is the owner's right for the impact?	MOC	MOC side clarified the affected area, and then MOC replied that all your affected land will be compensated.	Accepted the answer
4.	Daw Win Htay/ PAPs/ Villager (Female) Betal leaf landowner	In the compensation policy, how does the policy consider growing crops between survey stage and the actual compensation time?	MOC	Compensation will be made for those crops existing at the time of cut-off date.	Accepted the answer
			JICA Study Team	A survey will be carried out before the construction period in the Detailed Design Stage and compensation will be made on age and number of plants. The current stage is the Feasibility Study, thus final evaluation will be done in the next survey.	Accepted the answer
5	U Than Tun Naing/ PAPs/ Villager(Male) Rubber landowner	Compensation for rubber tree plantation should consider the age of the trees.	MOC	It is not guarantee for the compensation in consideration with age. However, opinions such as this is considered for the finalization of the compensation policy.	Accepted the answer

Source: JICA Study Team

Table 12.10.8 Opinions and Answers on 3rd RAP Socialization (Bago Region)

No	Major opinion and Answer				
	Question/Comment		Answer		Reaction of questioner
	Name/Position	Question	Name/Position	Answer	
1	U Po/PAPs/ Villager Shan Kaing Village (Male)	The compensation rate for the paddy fields should be same, it should not be changed depending on the detailed location and condition. It is important that the compensated amount for effected land has to be enough to buy another land.	JICA Study Team	The price of compensation for the land is finally negotiated based on the rate set at detailed design stage. Besides, the compensation rate may change according to time and circumstances.	Accepted the answer
			Township Officer, Waw Agricultural Department	The compensation for the impacted land has to be carried out. The compensation for the crops will be carried out according to the criteria of the Ministry of Agriculture, livestock and Irrigation, at the rate of three times the value of the crop.	Accepted the answer
2	U Po,/PAPs/ Villager Shan Kaing Village (Male)	Can we still continue cultivating the affected land?	JICA Study Team	The Project has not started yet. It will need to take some years before it will begin. Thus, the owners can still cultivate at the moment.	Accepted the answer

Source: JICA Study Team

12.10.3 Activity on Information Disclosure

Another important activity for promoting the people's understanding of the Project is information disclosure. Explanation and discussion in the public consultation is part of the information disclosure and the RAP document and the related information of the RAP is required to be disclosed in accordance with JICA guideline and WB OP4.12. Apart from the public consultation (socialization), the activity of information disclosure is planned as below.

1) FS stage (RAP preparation stage)

In the FS stage, the finalized this RAP (in English) will be uploaded on JICA's website and made available to the public.

2) DD stage (Updated RAP)

After updating RAP in DD stage, the approved updated RAP will be translated into Burmese and disclosed in the location where PAPs can access it, such as local administration offices.

12.11 Cost and Financing

The cost and financing aspects for the implementation of the resettlement process at this stage of preliminary design are presented hereunder. The budget items include detailed costs of land acquisition, relocation, and income restoration and other administrative cost for RAP implementation.

12.11.1 Basic Calculation for Compensation Amount

In this RAP, approximate costs are estimated based on the results from the Replacement cost survey (RCS), socio-economic survey and other related information. Basic calculation methods are described below. In order to harmonize the compensation amount with the one in the RP of road section, the RP for ADB section is also mutually referred.

- Cash compensation for the loss of all types of lands including (Crop Land, Garden Land, and Residential Land): the amount is calculated based on current market prices and information obtained by interviews with local PAPs, gov. staff from Township DALMS and local GADs as well as examples of a neighboring similar projects.
- Cash compensation for the affected structures: this amount is calculated based on market prices of construction materials, construction fee and interviews with the structure owners. It is noted that depreciation of the asset and value of salvage materials are not taken into account.
- Cash assistance to cover business (income) loss of affected annual crops, fruits trees and other productive trees (especially paddy, peas and beans, rubber and other fruits tree in this Project) for the transition period:
  - Paddy/other crops: 3 times of annual yield from the crop
  - Rubber: 3 times of annual production from the tree (replacement cost of tree as timber wood is also considered under the category below)
  - Other fruits or production tree: 3 times of annual production from the tree

    Note: the amount is based on current market prices obtained through interviews and compensation method used by other projects near similar project areas.
- Cash compensation for the loss of timber/shade trees on affected land: the amount is based on current market prices obtained through interviews and compensation method used by other projects near similar project areas.
- Cash assistance to cover business loss (income) for affected structure including (shop & shop with residents) for transition period: Cash assistance for the income loss during the relocation and re-establishment of the affected business in new place
- Vulnerable allowance for VAH ((i) Poor households; (ii) Female headed households; (iii) Households including a person with disability; (iv) Households headed by elderly; (v) landless households; (vi) ethnic minority): apply up to 300,000 kyats per household in this Project based on minimum subsistence level.
- Other special assistance such as SAH assistance and relocation stabilization assistance are referring to other projects as well as coordinated with the plan of road section.

12.11.2 RAP Implementation Budget

The estimated RAP implementation budget for the Project is summarized in Table 12.11.1. Within the categories of land and structures, compensation for affected trees, crops, income restoration and vulnerable allowance have been included.

DoB (MOC) is responsible for providing adequate funds for land acquisition and resettlement related to the Project. It is important to note that these figures need to be updated during updating of the RAP in the Detailed Design stage.

Table 12.11.1 RAP Implementation Budget

No.	Activity/ Cost Item	Unit	Unit Price (MMK/unit)	Quantity	Estimated Budget		Note
					MMK	USD	
1	**Compensation Cost**						
1.1	Compensation for Land						
1.1.1	Crop Land (Waw)	acre	22,129,830	22.85	505,666,616	337,111	
	Crop Land (Kyaikto)	acre	41,186,072	15.03	619,026,662	412,684	
1.1.2	Garden Land	acre	12,294,350	24.65	303,055,728	202,037	
	Sub-total 1.1				**1,427,749,005**	**951,833**	
1.2	Compensation for Structures / Secondary structures						
1.2.1	Structures	item	-	4	22,484,000	14,989	Cost for structure and secondary structure were individually valuated
1.2.2	Secondary Structures	item	-	8	1,100,000	733	Cost for structure and secondary structure were individually valuated
1.2.3	Transportation assistance	HH	150,000	4	600,000	400	Relocation cost for those whose houses are affected
	Sub-total 1.2				**24,184,000**	**16,123**	
1.3	Compensation for Crops						
1.3.1	Paddy	Basket	21,000	2,625	55,125,000	36,750	3 times of crop yield amount (Annual Production x income of 3 years)
1.3.2	Peas and Beans	Basket	105,000	457	47,985,000	31,990	3 times of crop yield amount (Annual Production x income of 3 years)
	Sub-total 1.3				**103,110,000**	**68,740**	
1.4	Compensation for Trees						
1.4.1	Rubber Trees	Tree	-	4,338	244,694,419	163,130	Tree cost + 3 times of annual production
1.4.2	Fruits/ Production Tree	Tree	-	9,542	37,125,000	24,750	3 times of annual production
1.4.3	Timber and Shade Trees	Tree	-	1,559	2,705,000	1,803	Tree cost
	Sub-total 1.4				**284,524,419**	**189,683**	
	Sub-total 1				**1,839,567,424**	**1,226,378**	
2	**Other Assistance**						
2.1	Other Cash Assistance						
2.1.1	SAH Assistance	Person	158,625	87	13,800,375	9,200	112.5 USD/person
2.1.2	Relocation stabilization assistance for Non-vulnerable household	HH	282,000	2	564,000	376	200 USD/HH

2.1.3	Relocation stabilization assistance for Vulnerable household	HH	564,000	2	1,128,000	752	400USD/HH
2.1.4	Transportation assistance	HH	150,000	4	600,000	400	Relocation cost for those whose houses are affected
2.1.5	Vulnerable Allowance	HH	300,000	4	1,200,000	800	For PAHs with woman-headed, person with disability, elderly etc.
	Sub-total 2.1				**17,292,375**	**11,528**	
2.2	IRP Assistance						
2.2.1	Vulnerable Households	HH	634,500	4	2,538,000	1,692	450 USD/HH
2.2.2	Household losing 10-30% total production landholding	HH	705,000	4	2,820,000	1,880	500 USD/HH
2.2.3	Household losing 30-70% total production landholding	HH	1,128,000	12	13,536,000	9,024	800 USD/HH
2.2.4	Household losing more than 70% total production landholding	HH	2,115,000	0	0	0	1,500 USD/HH
2.2.5	Relocation Household	HH	1,128,000	4	4,512,000	3,008	800 USD/HH
	Sub-total 2.2				**23,406,000**	**15,604**	
	Sub-total 2				**40,698,375**	**27,132**	
3	**RAP Implementation Cost**						
3.1	Public Consultation	Set			4,000,000	2,667	
3.2	IRP Service Provider	Set			70,500,000	47,000	
3.3	External Monitoring	Set			60,000,000	40,000	
	Sub-total 3				**134,500,000**	**89,667**	
4	**Total (1+2+3)**				**2,014,765,799**	**1,343,177**	
5	Contingency (+10%)				201,476,580	134,318	
6	**Grand Total (4+5)**				**2,216,242,379**	**1,477,495**	

Note1) : 1 USD = 1,500 MMK (As of January 2020)

Note 2): The compensation amount of Fruits tree/ Production Tree should be estimated based on the age of the trees. Therefore, it should be re-calculated at the time of the updating RAP.

Source: JICA Study Team

12.12 Implementation Schedule

Following the preparation of RAP in F/S stage, the updating and formal approval of the RAP is to be conducted in DD stage after approval of the Project and then disbursement of compensation and assistance to each PAHs are to be implemented. The implementation of RAP, particularity payment of the compensation, is required prior to any displacement according to the JICA guideline. Key steps to update and implement the RAP are set out below:

1) RAP approval (FS stage): the RAP is prepared by the project entity (DoB) with assistance of the JICA Study Team, examined and approved within the entity as well as JICA.

2) RAP update (DD stage): the Updated RAP (URAP) will be prepared based on the detailed design and approved by MOC and JICA. In the preparation of URAP, the RAP socialization are to be held prior to the survey and URAP draft stage.

3) Re-valuation of Budget by Resettlement Implementation Committee (RIC): RIC will be established and the RAP budget will be re-valuated by RIC.

4) Notification and negotiation with PAPs: RIC will notify to the PAPs and negotiate the compensation price. The price will be finalized and agreement on the price with PAPs will be prepared in written form.

5) Budget securement and approval: After obtaining agreement with PAPs, RIC will sum up and re-valuates the RAP budget plan, submit the revised budget to Union government through Ministry of Finance & Planning (MOPF) for approval.

6) Implementation of RAP: After budget is verified, RIC will disburse the payment of the compensation to each PAPs.

7) Handover the sections: PMU (MOC) will give the Contractor right of access to, and possession of, all parts of the Site where payments of compensation, resettlement of Displaced Persons (DPs) and relocation of relevant properties are completed.

The schedule for the activities relating to the RAP preparation, updating and implementation are shown in Table 12.12.1.

Table 12.12.1 RAP Implementation Schedule

Confidential

* (RIC): Resettlement Implementation Committee
Source: JICA Study Team

12.13 Result of Review on ADB RP and Recommendations

12.13.1 Result of Review on ADB RP

For the ADB bypass section, the ADB RP was prepared by ADB Technical Assistance Team in accordance with ADB SPS and relevant Myanmar laws. The ADB RP was finalized on April 2019 and shared with JICA side, thereafter JICA Study Team reviewed the ADP RP in August 2019.

As the result of the review, it was confirmed that ADB RP satisfies the requirement of JICA Guidelines and WB OP 4.12 Annex A, mainly the following issues, therefore appropriate environmental and social considerations particularly on RAP related issues will be ensured for the ADB section as well.

As the result of the review, it was confirmed that ADB RP satisfies the following major requirements of JICA Guidelines and WB OP 4.12 and Myanmar relevant law, mainly the following issues, therefore appropriate environmental and social considerations particularly on RAP related issues will be ensured for the ADB section.

- ✓ Analysis of legal framework
- ✓ Planning of the Institutional Framework for implementation of RP
- ✓ Establishment of the resettlement measures including compensation entitlement and estimation of the necessary budget through census survey, SES, IOL survey and RCS
- ✓ Monitoring system and Grievance Redress Mechanisms
- ✓ Holding of consultation with PAPs and building the consensus on the contents of the RP

12.13.2 Recommendations

Although the JICA Bridge section and the ADB Road Section are separately planned to be financed as well as to be implemented, both RAPs shall be well-harmonized in order to minimize the negative impact and to maximize the effectiveness of the both projects. During FS stage, some of the items have already been harmonized between ADB and JICA section, however, further harmonization are necessary in the updating and implementation of both RAPs. Major issues to be considered are followings;

(1) Harmonization of the Eligibility, Entitlement and the Price of Compensation /Assistance

1) Eligibility: During updating RAPs in DD stage, the detailed eligibility criteria and detailed survey method should be harmonized such as SAHs and VAHs (the Poor, indigenous peoples, landless, etc.)

2) Entitlement: During updating RAPs in DD stage, the detailed contents of the entitlement should be harmonized especially on the items not defined in the Myanmar Law such as Category of Land type, Business loss, Assistance for Informal settlers, Other special Assistance (SAH assistance, Vulnerable Assistance, Transportation Assistance, Relocation stabilization assistance) and IRP.

3) Unit Price of Compensation/ Assistance: During conducting survey in DD stage, the unit price for each compensation/assistance and the detailed survey method of Replacement Cost Survey (RCS) should be harmonized

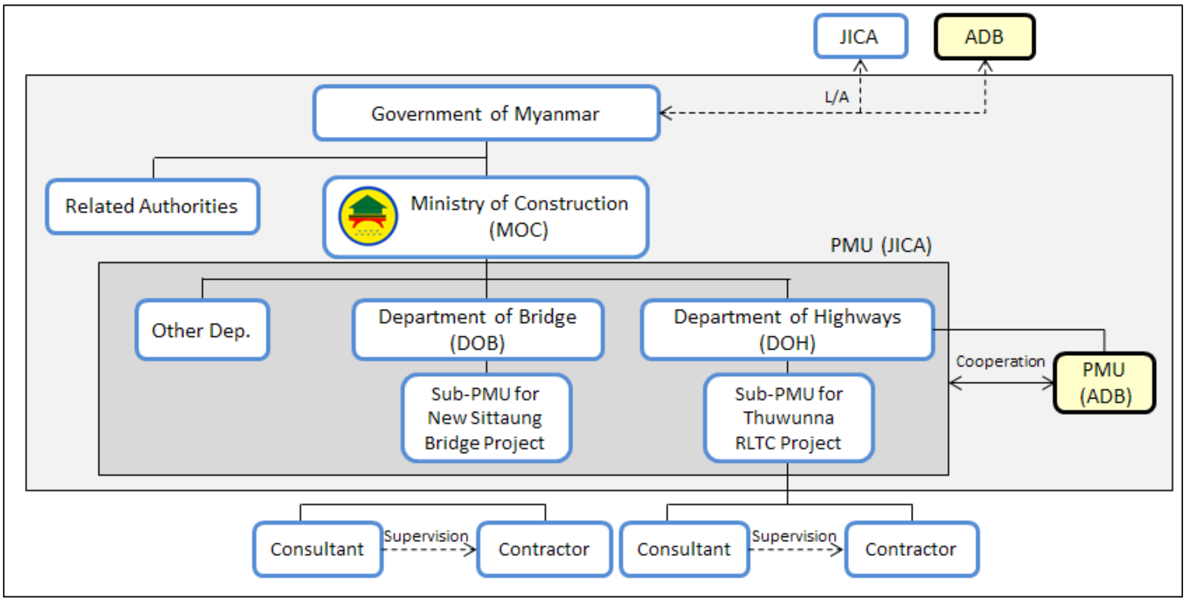
(2) Institutional Framework: similar framework and institutional structure shall be established particular in terms of Procedure of RAP update to the RAP implementation, timing of establishment of the RIC, member of the RIC.

(3) Grievance Redress Mechanism (GRM): similar GRMs shall be established and applied for both ADB and JICA sections on such as procedure of GRM, timing of establishment of the GRM and the member of the Grievance Redress Committee.

CHAPTER 13 PROJECT IMPLEMENTATION PLAN

13.1 Implementation Organization

The project implementation organization will be organized so that the MOC can implement the Project smoothly and effectively as well as coordinate with project stakeholders. As aforementioned, since the upgrading of the Thuwunna RLTC shall be also implemented under this Project which will be mainly under the charge of DOH, the Executing Agency shall be MOC to manage both project components. It is recommended that a Project Management Unit (PMU) will be established under MOC for smooth project implementation before the commencement of the detailed design stage as illustrated in Figure 13.1.1.



Source: JICA Study Team

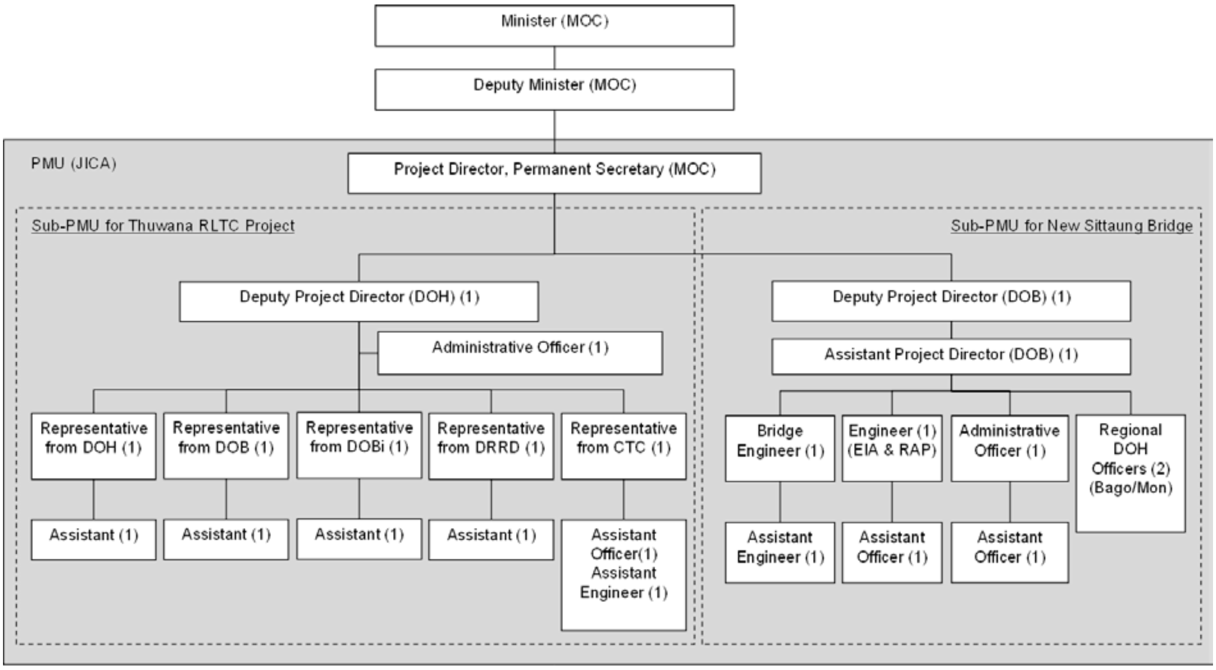
Figure 13.1.1 Proposed Implementation Organization Structure

The aim of the establishment of PMU is to implement the Project smoothly and effectively as well as maintain smooth and timely coordination with project stakeholders to fulfill the responsibilities listed below. Thus, the PMU should be organized by the internal staff of MOC as proposed in Figure 13.1.2.

【Key Responsibilities of PMU】

- Financial management
- Contract administration
- Procurement of Consultants and Contractors
- Pre-construction work comprising detailed design, land acquisition, relocation/resettlement, acquisition of environmental approval
- Construction Management (traffic safety management, supervision, progress monitoring etc.)

- Coordination with relevant authorities and projects
- Project Evaluation



Source: JICA Study Team

Figure 13.1.2 Proposed Organization Structure of PMU

13.2 Implementation Schedule

The project implementation schedule is established based on the assumptions listed in Table 13.2.1. The project implementation schedule is shown in Figure 13.2.1.

Table 13.2.1 Assumptions for Implementation Schedule

Item	Assumption
Confidential	

Source: JICA Study Team

Confidential

Source: JICA Study Team

Figure 13.2.1 Project Implementation Schedule

CHAPTER 14 PROJECT COST ESTIMATE

14.1 Introduction

The project cost estimation for the New Sittaung Bridge including upgrading of the Thuwunna RLTC is based on the quantities obtained from the preliminary design. Eligible portions of the Project are assumed to be funded through the JICA loan scheme. It is assumed that the government of Myanmar will allocate funds for non-eligible portions of the Project.

14.2 Condition for Cost Estimation

14.2.1 Term of Cost Estimation

The unit prices of resources (materials, equipment and labors) adopted for this cost estimation are those prices as of [redacted] for the New Sittaung Bridge and as of [redacted] for the Thuwunna RLTC.

14.2.2 Exchange Rate

The exchange rates adopted for this cost estimation are shown below.

- USD 1.0 = JPY [redacted]
- MMK 1.0 = JPY [redacted]
- USD 1.0 = MMK [redacted]

14.2.3 Price Escalation

The price escalation is set at [redacted]% for Foreign Currency and [redacted]% for Local Currency.

14.2.4 Physical Contingency

The physical contingency is set at [redacted]% for Construction and [redacted]% for Consultancy Service for the New Sittaung Bridge and those for the Thuwunna RLTC is [redacted]% for both Construction and Consultancy Service.

14.2.5 Provisional Sum for Construction

The provisional sum is not considered.

14.2.6 Administration Cost

The administration cost incurred for establishment of the organization in MOC and implementation of the Project is set at [redacted]% of Construction and Consultancy Service.

14.2.7 Tax and Duties

(1) Commercial Tax

Commercial Tax (corresponding to VAT) of [redacted]% is considered.

(2) Import Tariff

[redacted]% of the construction work and consultancy service is considered for import duties on the Project.

14.2.8 Rate of Interest during Construction

[redacted]% for both the construction work and the consultancy service is considered.

14.2.9 Rate of Front-end Fee

Front-end fee is not set at this stage.

14.2.10 Cost for Dispute Board

Dispute board cost is considered in this estimation.

14.2.11 Contract Package

Three packages are assumed for this Project as shown in the following table.

Table 14.2.1 Proposed Contract Package

Package No.	Package Component	Procurement Method
	Confidential	

Source: JICA Study Team

14.3 Result of Cost Estimate

14.3.1 Construction and Equipment Cost (Base Cost)

The basic cost estimation is performed base on the results of the preliminary design.

The following basic cost is estimated excluding the price escalation and physical contingency.

Table 14.3.1 Construction Cost (Construction of New Sittaung Bridge)

Confidential

Source: JICA Study Team

Table 14.3.2 Equipment Cost (Procurement of Equipment for Thuwunna RLTC)

Confidential

Confidential

Confidential

Source: JICA Study Team

Table 14.3.3 Construction Cost (Building Works for Thuwunna RLTC)

Confidential

Source: JICA Study Team

14.3.2 Total Project Cost

The total project cost is shown in Table 14.3.4 and Table 14.3.5.

Table 14.3.4 Project Cost (JPY Version)

Confidential

Source: JICA Study Team

Table 14.3.5 Project Cost (USD Version)

Confidential

Source: JICA Study Team

CHAPTER 15 ECONOMIC AND FINANCIAL ANALYSIS

15.1 Economic Analysis

15.1.1 Preconditions for the Economic Analysis

This section explains the economic analysis to evaluate the effectiveness of the Project from the viewpoint of Myanmar's national economy. Economic Internal Rate of Return (EIRR) and Cost-Benefit Ratio (B/C) are adopted as evaluation indicators. These indicators are calculated using annual cash inflow (economic benefit) and cash outflow (economic cost) with the discounted cash flow method.

(1) Project Period

Project period is set to be a total of 27 years. Design and construction are assumed to start from 2020 and opening year is assumed to be the end of 2026.

(2) Exchange Rate

The exchange rates are set as follows.

- 1 USD = 109JPY (Japanese yen)
- 1 USD = 1,500MMK (Myanmar kyat)

(3) With project Case and Without Project Case

"With project" is defined as the case with the Bago-Kyaikto Expressway project where JICA finances the New Sittaung Bridge and ADB finances the road section and "without project" is defined as the case without the projects. Economic benefit realized by the implementation of projects is calculated as the difference between "without project" and "with project".

(4) Social Discount Rate

The social discount rate is set to be 12%. This criterion is same as the "Preparatory Survey for the Project for Strengthening Connectivity of International Highway in Mekong Region".

15.1.2 Economic Benefit

Reduction of Vehicle Operating Cost (VOC) and travel time saving are considered as the economic benefits of the projects. The economic benefit is calculated by taking the difference between "without project" and "with project".

(1) Reduction in Vehicle Operating Cost (VOC)

Vehicle operating cost includes the purchasing and maintenance cost of vehicles, fuel cost, and insurance cost, etc.

The analysis in this chapter utilizes the VOC data obtained from the Office of Transport and Traffic Policy Planning (OTP) in Thailand which was prepared in 2013 due to the limited availability of VOC data in Myanmar. The VOC figures are adjusted to 2019 values by using Thailand's inflation rate and then exchanged into Japanese Yen amounts. Table 15.1.1 indicates the adjusted VOC data by vehicle classification. By referring to the average travel speed in Chapter 3, VOC data corresponding to "4-lanes plain road" at 60 km/hr was utilized in order to calculate the VOC reduction.

Table 15.1.1 VOC by Vehicle Classification

Unit: Japanese yen per vehicle-kilometer

Road Condition	Speed (km/hr.)	Passenger car	Bus	2 axes truck	3 and 4 axes truck	Trailer
4-lanes Plain road	10	55.64	93.13	70.18	94.59	235.24
	20	24.05	40.31	25.88	37.52	67.32
	30	20.39	33.39	22.66	31.08	53.59
	40	19.22	30.90	19.73	28.44	50.08
	50	18.63	29.69	18.16	27.90	48.43
	60	17.72	52.90	27.93	48.87	29.65
	70	18.08	53.19	28.59	50.15	29.98
	80	18.38	54.40	29.54	52.35	30.53
	90	19.04	55.83	30.97	54.80	31.63
	100	19.62	58.90	32.98	58.21	33.02

Source: JICA Study Team

Table 15.1.2 indicates daily travel distance by vehicle category for both "with project" and "without project" cases which are calculated in Chapter 3 based on the ADB's Toll Strategy (TS1).

Table 15.1.2 Daily Travel Distance by Vehicle Category

Unit: vehicle-kilometer

Year	With project/ without project	Passenger car	Bus	2 axes truck	3 axes truck	4 axes truck	Trailer
2025	With project	58,403,100	9,386,000	22,253,200	2,299,300	8,282,800	4,460,700
	Without project	58,574,700	9,400,000	22,297,600	2,306,900	8,318,900	4,464,500
	Difference	171,600	14,000	44,400	7,600	36,100	3,800
2035	With project	151,481,700	17,801,300	54,394,500	5,272,900	19,241,200	10,379,500
	Without project	152,888,400	18,017,300	54,854,200	5,460,600	19,621,700	10,497,200
	Difference	1,406,700	216,000	459,700	187,700	380,500	117,700
2045	With project	220,876,800	18,226,100	68,992,400	6,725,100	24,537,800	13,249,300
	Without project	222,014,700	18,305,000	69,232,400	6,916,200	24,768,500	13,207,600
	Difference	1,137,900	78,900	240,000	191,100	230,700	-41,700

Source: JICA Study Team

Daily reduction of vehicle operating cost is calculated by multiplying the difference in daily travel distance (rows 4, 7, and 10 in Table 15.1.2) by the VOC (Table 15.1.1). The daily reduction of vehicle operating cost is multiplied by 260 (assuming 260 weekdays per year) to attain the corresponding annual values.

(2) Travel Time Saving

Travel time saving is another economic benefit. The idea comes from that time spent for travelling corresponds to the opportunity cost of working time. Thus, if the implementation of the Project results in reducing travel time and the reduced time is used for working activity, this work is considered to be value added to the national economy.

Myanmar people's time value is calculated by available GDP data in 2016. GDP is divided by the labor force population (34.24 million) to calculate annual GDP per labor force. Then it is divided by 260 days and 7 hours to calculate time value per hour. With this, the Survey Team calculated the time value per hour to be JPY92.96.

The Survey Team also calculated the increase of the time value per hour in accordance with Myanmar's economic development by use of mid- and long-term GDP growth rate in the "2018 Article IV Consultation Staff Report" by the IMF and population growth in the "World Population Prospects" by the UN Population Division. Table 15.1.3 shows the annual growth rate of GDP per capita and hourly income in respective years. Table 15.1.4 shows the number of passengers per vehicle which is based on "Feasibility Study Bago-Kyaikto Expressway Volume I: Main Report July 2019, ADB".

Table 15.1.3 GDP Per Capita and Time Value per Hour

	2016	2020	2025	2030	2035	2040	2045
Growth rate of GDP per capita per year	5.25%	5.84%	6.32%	5.95%	6.12%	5.77%	5.89%
Income per hour (Japanese Yen)	92.96	116.58	157.16	211.79	283.31	378.23	501.26

Source: JICA Study Team

Table 15.1.4 Number of Passengers per Vehicle

Unit: Persons

Vehicle class	Passenger car	Bus	2 axes truck	3 axes truck	4 axes truck	Trailer
Number of passengers	2.92	23.19	2.32	2.17	2.32	2.25

Source: Feasibility Study Bago-Kyaikto Expressway Volume I: Main Report July 2019, ADB

This methodology to calculate the time value is the same as the "Preparatory Survey for the Project for Strengthening Connectivity of International Highway in Mekong Region, December 2016, JICA".

Table 15.1.5 indicates daily travel time by vehicle category for both "with project" and "without project" cases which are calculated in Chapter 3 based on the ADB's Toll Strategy (TS1).

Table 15.1.5 Daily Travel Time by Vehicle Category

Unit: vehicle-hour

Year	With project/ without project	Passenger car	Bus	2 axes truck	3 axes truck	4 axes truck	Trailer
2025	With project	1,393,100	201,900	579,300	57,600	197,200	104,900
	Without project	1,402,900	203,300	582,700	58,400	199,400	105,300
	Difference	9,800	1,400	3,400	800	2,200	400
2035	With Project	5,312,700	548,400	1,969,400	178,700	620,000	328,700
	Without project	5,402,900	560,100	2,023,800	195,100	652,000	337,900
	Difference	90,200	11,700	54,400	16,400	32,000	9,200
2045	With project	8,886,000	646,700	2,813,000	255,400	887,900	472,600
	Without project	9,018,000	657,800	2,886,300	279,700	926,500	478,400
	Difference	132,000	11,100	73,300	24,300	38,600	5,800

Source: JICA Study Team

Daily travel time saving is calculated by multiplying the difference in daily travel time by vehicle category (row 4, 7 and 10 in Table 15.1.5)by the time value per hour (Table 15.1.3) and by the number of passengers by vehicle category (Table 15.1.4). The daily travel time saving is multiplied by 260 to calculate the annual value, which is the same method as the calculation of VOC reduction.

Table 15.1.6 shows the economic benefits of annual VOC reduction and travel time savings and the total economic benefit from 2027 to 2046.

Table 15.1.6 Economic Benefit of the Project

Unit: million Japanese yen

Year	VOC reduction	Travel time saving	Total economic benefit
2027	3,911	6,445	10,356
2028	5,167	8,877	14,044
2029	6,615	11,957	18,572
2030	8,278	15,907	24,186
2031	10,185	20,933	31,119
2032	12,367	27,303	39,669
2033	14,856	35,348	50,205
2034	17,692	45,482	63,174
2035	20,917	58,298	79,215
2036	20,329	63,105	83,435
2037	19,704	68,315	88,019
2038	19,040	73,960	93,000
2039	18,334	79,701	98,035
2040	17,584	86,016	103,600
2041	16,790	92,837	109,626
2042	15,947	100,205	116,152
2043	15,054	108,163	123,218
2044	14,109	116,760	130,869
2045	13,108	126,189	139,297
2046	12,050	136,385	148,435

Source: JICA Study Team

15.1.3 Economic Cost

(1) Investment Cost

Investment cost consists of construction, consulting service, land acquisition and administration cost. These costs are estimated in Chapter 9 and Chapter 14 and are used for this economic analysis. Taxes, price escalation, and interest during construction are eliminated from the investment cost.

Table 15.1.7 indicates the investment cost of Bago-Kyaikto Expressway project (both the New Sittaung Bridge and the road section). The total economic cost amounts to [redacted] billion Japanese yen.

Table 15.1.7 Investment Cost of the Project

Unit: million Japanese yen

Year	New Sittaung Bridge				Bago-Kyaikto Highway	Total
	Construction	Consulting Services	Land acquisition	Administration	Construction, etc.	
Confidential						

Source: JICA Study Team

(2) O&M Cost

O&M cost consists of routine maintenance, toll system and periodic maintenance for Bago-Kyaikto Expressway project (both the New Sittaung Bridge and the road section). Table 15.1.8 shows annual O&M cost from 2027 to 2046.

Table 15.1.8 Annual O&M cost

Unit: million Japanese yen

Year	New Sittaung Bridge	Bago-Kyaikto Highway	Total
2027	115	275	391
2028	115	343	459
2029	115	346	462
2030	118	354	472
2031	118	949	1,067
2032	115	357	473
2033	115	363	478
2034	118	373	491
2035	115	375	491
2036	126	4,888	5,014
2037	115	379	495

Year	New Sittaung Bridge	Bago-Kyaikto Highway	Total
2038	118	393	511
2039	115	400	516
2040	115	414	529
2041	230	1,713	1,944
2042	115	449	564
2043	115	472	587
2044	115	499	614
2045	118	535	653
2046	126	6,519	6,644

Source: JICA Study Team

15.1.4 EIRR and Cost-Benefit Ratio

Table 15.1.9 shows the annual cash flow of the Project. The 2nd column describes the economic benefit which is explained in Table 15.1.6. The 3rd column indicates the economic cost which is the total of investment and O&M costs. The 4th column is net cash flow (economic benefit minus economic cost). Economic Internal Rates of Return (EIRR) of the projects which is calculated from annual net cash flow from 2020 to 2046 is 24.6%. The EIRR exceeds 12%, a benchmark of social discount rate in developing countries which is commonly used. Therefore, the projects are feasible from the point of national economic development.

The 5th column calculates the weight of the 12% discount ratio by setting the figure in 2019 to be 1.00. Annual figures of the weight decrease gradually from 0.89 in 2020 to 0.05 in 2046. The 6th and 7th columns of economic benefit and economic cost in present value are calculated by multiplying these figures of weighted discount ratio by economic benefit and cost respectively. The cost-benefit ratio calculated from the sum of economic benefit in present value ([redacted]) divided by the sum of economic cost in present value ([redacted]) is 3.78.

Table 15.1.9 Cashflow of the Project

Unit: million Japanese yen

Year	Economic benefit	Economic cost	Net cashflow	Weight of 12% discount ratio (2019=1.00)	Economic benefit (present value)	Economic cost (present value)
Confidential						

Year	Economic benefit	Economic cost	Net cashflow	Weight of 12% discount ratio (2019=1.00)	Economic benefit (present value)	Economic cost (present value)
Confidential						

Source: JICA Study Team

15.1.5 Sensitivity Analysis

Table 15.1.10 shows results of sensitivity analysis. Increase in investment cost by 20% reduces EIRR by approximately 1.9% (22.7%) and increase in O&M cost by 20% does not change EIRR by (24.6%). Decrease in economic benefit by 20% reduces EIRR by 2.3% (22.3%). In either case, EIRR remains high compared with the 12% of social discount rate and therefore the projects can be said to be viable from the viewpoint of the national economy.

Table 15.1.10 Results of Sensitivity Analysis

Cases	EIRR
Base case	24.6%
20% increase in investment cost	22.7%
20% increase in O&M cost	24.6%
20% decrease in economic benefit	22.3%

Source: JICA Study Team

15.2 Financial Analysis

This section analyzes the financial feasibility of the Project. Specifically, it verifies financial feasibility of the project cash flow using Financial Internal Rate of Return (FIRR) and analyzes how likely the revenue from tolling can cover the initial investment and O&M expenses. While ADB's financial analysis is based on the nominal price, financial analysis by the JICA Study Team in this section uses the real price.

15.2.1 Revenue from Tolling

The projects are expected to generate revenue from collecting tolls. JICA Study Team used three types of Toll Strategy (TS1, TS2, and TS3) from ADB's "Feasibility Study Bago-Kyaikto Expressway" to verify the financial feasibility of the Project. TS1 is the "business as usual" case, TS2 is ADB's median toll rate in 2018 and TS3 is a 150% price increase of TS1. Table 15.2.1 shows ADB's Tolling Strategy (TS1, TS2, and TS3) in respective years.

Table 15.2.1 Tolling Strategy of the Project

Unit: $USD/km

Toll Strategy	Year	Passenger car	Bus	2 axes truck	3 axes truck	4 axes truck	Trailer
TS1	2019	0.0061	0.0186	0.0282	0.0490	0.0663	0.1159
	2025	0.0069	0.0211	0.0320	0.0556	0.0753	0.1315
	2035	0.0085	0.0257	0.0390	0.0677	0.0917	0.1603
	2045	0.0103	0.0313	0.0475	0.0826	0.1118	0.1954
TS2	2019	0.0122	0.0306	0.0408	0.0490	0.0612	0.1020
	2025	0.0139	0.0347	0.0463	0.0556	0.0695	0.1158
	2035	0.0169	0.0423	0.0565	0.0677	0.0847	0.1411
	2045	0.0206	0.0516	0.0688	0.0826	0.1032	0.1720
TS3	2019	0.0092	0.0448	0.0679	0.1182	0.1600	0.2797
	2025	0.0104	0.0509	0.0771	0.1341	0.1816	0.3174
	2035	0.0127	0.0620	0.0940	0.1635	0.2214	0.3869
	2045	0.0155	0.0756	0.1146	0.1993	0.2699	0.4717

Source: Feasibility Study Bago-Kyaikto Expressway Volume I: Main Report July 2019

Since ADB's Tolling Strategies assume inflation of 2% per annum, the JICA Study Team excluded the price rise of the tolling due to inflation for financial analysis in real terms when calculating the revenue. Table 15.2.2 shows travel distance between Bago and Kyaikto which is based on the traffic demand forecast in Chapter 3. Table 15.2.3 indicates revenue from tolling in respective years.

Table 15.2.2 Daily Travel Distance between Bago and Kyaikto

Unit: vehicle-kilometer

Toll Strategy	Year	Passenger car	Bus	2 axes truck	3 axes truck	4 axes truck	Trailer
TS1	2025	571,129	84,565	0	0	25,604	4,400
	2035	1,517,989	150,741	511,373	190,354	346,067	72,059
	2045	1,886,873	132,450	767,458	279,629	520,579	140,556
TS2	2025	545,736	84,551	0	2,303	29,552	5,511
	2035	1,481,416	150,531	424,030	192,321	461,223	102,163
	2045	1,899,503	131,693	543,665	299,500	549,873	111,597
TS3	2025	546,189	82,383	0	0	0	0
	2035	1,578,708	166,848	317,326	157,080	334,299	69,868
	2045	2,219,355	156,393	664,295	228,545	416,694	87,966

Source: JICA Study Team

Table 15.2.3 Revenue from Tolling

Unit: million JPY

Toll Strategy/Year	2027	2030	2035	2040	2045
TS1	486	1,008	1,917	2,334	2,859
TS2	689	1,346	2,516	2,796	3,118
TS3	945	2,010	3,859	4,560	5,450

Source: JICA Study Team

15.2.2 Expenses

(1) Investment Expense

Investment expense consists of construction, consulting service, land acquisition and administration cost and tax. These costs are estimated in Chapter 9 and Chapter14 and are used for this financial analysis. Price escalation and interest during construction are eliminated from the investment expense.

Table 15.2.4 indicates the investment expense of Bago-Kyaikto Expressway project (both the New Sittaung Bridge and the road section). The total expense amounts to [redacted] billion Japanese yen.

Table 15.2.4 Investment Expense of the Project

Unit: million Japanese yen

Year	New Sittaung Bridge					Bago-Kyaikto Highway	Total
	Construction	Consulting Services	Land acquisition	Administration	Tax	Construction, etc.	
Confidential							

Source: JICA Study Team

(2) O&M Expenses

O&M cost consists of routine maintenance, toll system and periodic maintenance for Bago-Kyaikto Expressway project (both the New Sittaung Bridge and the road section). Table 15.2.5 shows annual O&M expenses from 2027 to 2046.

Table 15.2.5 Annual O&M expenses

Unit: million Japanese yen

Year	New Sittaung Bridge	Bago-Kyaikto Highway	Total
2027	115	275	391
2028	115	343	459
2029	115	346	462

2030	118	354	472
2031	118	949	1,067
2032	115	357	473
2033	115	363	478
2034	118	373	491
2035	115	375	491
2036	126	4,888	5,014
2037	115	379	495
2038	118	393	511
2039	115	400	516
2040	115	414	529
2041	230	1,713	1,944
2042	115	449	564
2043	115	472	587
2044	115	499	614
2045	118	535	653
2046	126	6,519	6,644

Source: JICA Study Team

15.2.3 Results of the Financial Analysis

Table 15.2.6, Table 15.2.7, and Table 15.2.8 show the cash flow of the projects for TS1, TS2, and TS3 respectively. The 2nd column indicates revenue from collecting tolls. The 3rd and 4th columns show investment and O&M expenses and the total of these expenses is shown in the 5th column. The 6th column describes net cash flow which is revenue minus total expense.

Table 15.2.6 Cashflow of the Project (TS1)

Unit: million Japanese yen

Year	Revenue from tolls	Investment expense	O&M expense	Total expense	Net cashflow
Confidential					

Confidential

Source: JICA Study Team

Table 15.2.7 Cashflow of the Project (TS2)

Unit: million Japanese yen

Year	Revenue from tolls	Investment expense	O&M expense	Total expense	Net cashflow

Confidential

Year	Revenue from tolls	Investment expense	O&M expense	Total expense	Net cashflow
Confidential					

Source: JICA Study Team

Table 15.2.8 Cashflow of the Project (TS3)

Unit: million Japanese yen

Year	Revenue from tolls	Investment expense	O&M expense	Total expense	Net cashflow
Confidential					

Source: JICA Study Team

FIRRs for TS1, TS2 and TS3 are -10.2%, -7.8% and -2.6% respectively meaning in either case, revenue from tolls alone cannot cover all the investment and O&M expenses. Project under TS3 is the most profitable among three cases and is more than four times as profitable as TS1.

As Table 15.2.9 shows, in every case, revenue can cover annual O&M expenses. After financing O&M expenses, revenues from TS1, TS2 and TS3 can cover 19.5%, 30.1% and 66.8% of investment expense respectively.

Table 15.2.9 Summary of Financial Analysis

Unit: million Japanese yen

Toll Strategy	Total Revenue	Total CAPEX	Total OPEX	FIRR	Cover ratio of CAPEX
TS1	37,703			-10.2%	19.5%
TS2	45,785	[redacted]	22,854	-7.8%	30.1%
TS3	73,828			-2.6%	66.8%

Source: JICA Study Team

CHAPTER 16 OPERATION AND EFFECT INDICATORS

16.1 Introduction

JICA has been utilizing a system of Operation and Effect Indicators in order to quantitatively inspect and evaluate project performance since 2000.

- Operation Indicator: A quantitative indicator to measure the operational status of a project
- Effect Indicator: A quantitative indicator to measure the effects generated by a project

These indicators used for JICA ODA loan projects correspond with the outcome indicators used for World Bank projects. The overall project includes the construction of Bago-Kyaikto expressway including the New Sittaung Bridge and upgrading of the Thuwunna RLTC, however operation and effect indicators were separately proposed since the project objectives are different as describe heretofore.

In this chapter, the proposed operation and effect indicators of the project are summarized to evaluate the project performance.

16.2 Proposed Operation and Effect Indicators for New Sittaung Bridge

Like other road/bridge improvement projects in Myanmar and other countries funded by JICA, the traffic volume and travel time are set as operation and effect indicators for the Project, respectively.

- Operation Indicator: Annual average daily traffic (PCU/day), and
- Effect Indicator: Average travel time (hours per vehicle), average travel speed (km/h) and conversion factor (V/C).

The operation and effect indicators are prepared showing present performances in 2017 and targets in 2028, 2035 and 2045.Table 16.2.1, Table 16.2.2, and Table 16.2.3 summarize operation and effect indicators for the New Sittaung Bridge for each tolling scenario.

Table 16.2.1 Proposed Operation and Effect Indicators for the Project(TS1)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	33,377	19,880	43,849	61,738	54,358	85,049
Average travel time (hour)	2.27	2.12	0.80	2.48	1.02	2.85	1.27
Average travel speed (km/h)	41.3	44.3	83.7	37.8	65.2	33.0	52.4
Congestion factor (V/C)*2	0.91	1.08	0.25	1.42	0.77	1.77	1.06

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

Table 16.2.2 Proposed Operation and Effect Indicators for the Project (TS2)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	33,288	19,998	42,207	64,463	53,421	80,117
Average travel time (hour)	2.27	2.12	0.80	2.42	1.05	2.84	1.21
Average travel speed (km/h)	41.3	44.4	83.1	38.8	63.7	33.0	55.1
Congestion factor (V/C)*2	0.91	1.08	0.25	1.37	0.81	1.74	1.00

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

Table 16.2.3 Proposed Operation and Effect Indicators for the Project (TS3)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	35,752	17,604	49,385	56,661	55,218	80,723
Average travel time (hour)	2.27	2.20	0.78	2.68	0.98	2.91	1.21
Average travel speed (km/h)	41.3	42.6	85.3	35.0	68.1	32,2	55.2
Congestion factor (V/C)*2	0.91	1.16	0.22	1.60	0.71	1.79	1.01

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

In addition to the above indicators, Table 16.2.4, Table 16.2.5 and Table 16.2.6 show future number of passengers and cargo volume by vehicle category for the New Sittaung Bridge in 2028, 2035 and 2045 respectively, as supplemental indicators.

Table 16.2.4 Supplemental Operation and Effect Indicators for the Project (TS1)

Vehicle type	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	12,755	4,217	7,086	1,832	2,548	3,949	32,386
		new	6,055	2,018	2,048	449	33,738	35,301	79,610
	2035	existing	14,950	4,560	9,002	2,366	5,195	6,342	42,415
		new	20,184	6,727	12,992	2,250	65,408	51,018	158,579
	2045	existing	15,705	4,432	9,112	2,136	22,061	14,517	67,963
		new	29,232	9,548	19,256	4,950	81,176	44,061	188,223
Cargo volume (thousand tons / day)*1	2017	existing	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	48,380	17,010	26,879	7,165	-	-	99,523
		new	22,968	8,184	7,769	1,756	-	-	40,677
	2035	existing	56,708	18,493	34,144	9,254	-	-	118,600
		new	76,560	27,280	49,280	8,800	-	-	161,920
	2045	existing	59,571	17,974	34,563	8,353	-	-	120,461
		new	110,880	38,720	73,040	19,360	-	-	242,000
Traffic volume (cargo vehicles) (veh. /day)	2017	existing	1,723	266	826	373	-	-	3,187
	2028	existing	5,498	1,943	3,054	814	-	-	11,309
		new	2610	930	883	200	-	-	4,622
	2035	existing	6,444	2,102	3,880	1,052	-	-	13,477
		new	8700	3,100	5,600	1000	-	-	18,400
	2045	existing	6,769	2,043	3,928	949	-	-	13,689
		new	12,600	4,400	8,300	2,200	-	-	27,500

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.
Source: JICA Study Team

Table 16.2.5 Supplemental Operation and Effect Indicators for the Project (TS2)

Vehicle type	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	13,418	4,143	5,901	1,589	2,737	4,378	32,165
		new	5,150	2,018	2,582	497	32,380	34,812	77,439
	2035	existing	17,703	4,544	5,216	1,545	6,888	8,650	44,547
		new	17,168	6,727	16,704	3,150	63,656	48,699	156,104
	2045	existing	22,228	3,189	6,287	2,151	19,409	12,163	65,428
		new	21,112	10,633	20,648	3,600	82,344	44,061	182,398
Cargo volume (thousand tons / day)*1	2017	exiting	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	50,896	16,800	22,383	6,213	-	-	96,292
		new	19,536	8,184	9,794	1,942	-	-	39,456
	2035	existing	67,149	18,427	19,786	6,043	-	-	111,406
		new	65,120	27,280	63,360	12,320	-	-	168,080
	2045	existing	84,314	12,932	23,848	8,4123	-	-	129,507
		new	80,080	43,120	78,320	14,080	-	-	215,600
Traffic volume (cargo vehicles) (veh. /day)	2017	exiting	1,723	266	826	373	-	-	3,187
	2028	existing	5,784	1,909	2,544	706	-	-	10,942
		new	2220	930	1,113	221	-	-	4,483
	2035	existing	7,631	2,094	2,248	687	-	-	12,660
		new	7400	3,100	7,200	1400	-	-	19,100
	2045	existing	9,581	1,470	2,710	956	-	-	14,717
		new	9,100	4,900	8,900	1,600	-	-	24,500

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.
Source: JICA Study Team

Table 16.2.6 Supplemental Operation and Effect Indicators for the Project (TS3)

Vehicle type	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	14,518	4,511	7,870	1,955	3,293	4,677	36,824
		new	3,550	1,628	3,828	675	33,118	34,260	77,058
	2035	existing	23,020	5,711	9,190	2,353	5,125	6,261	51,660
		new	11,832	5,425	12,760	2,250	68,620	55,656	156,543
	2045	existing	18,327	5,630	11,224	2,917	7,855	6,482	52,434
		new	24,592	8,246	15,544	2,700	96,944	53,337	201,363
Cargo volume (thousand tons / day)*1	2017	exiting	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	55,068	18,294	29,851	7,645	-	-	110,858
		new	13,464	6,600	14,520	2,640	-	-	37,224
	2035	existing	87,317	23,162	34,859	9,201	-	-	154,538
		new	44,880	22,000	48,400	8,800	-	-	124,080
	2045	existing	69,515	22,832	42,574	11,408	-	-	146,329
		new	93,280	33,440	58,960	10,560	-	-	196,240
Traffic volume (cargo vehicles) (veh. /day)	2017	exiting	1,723	266	826	373	-	-	3,187
	2028	existing	6,258	2,079	3,392	869	-	-	12,597
		new	1530	750	1,650	300	-	-	4,230
	2035	existing	9,922	2,632	3,961	1,046	-	-	17,561
		new	5100	2,500	5,500	1000	-	-	14,100
	2045	existing	7,899	2,595	4,838	1,296	-	-	16,628
		new	10,600	3,800	6,700	1,200	-	-	22,300

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.

Source: JICA Study Team

16.3 Proposed Operation and Effect Indicators for Thuwunna RLTC

16.3.1 Validity of the Project Implementation

The project aims to strengthen the function of RLTC through the reconstruction of Research Laboratory and Training Facilities and procurement of necessary training equipment for these facilities. The objectives are to strengthen the government's administration of the construction sector in line with recent changes in the construction sector in Myanmar, and the organizational reform of the Ministry of Construction by upgrading the training facility for MOC staff.

In addition, this project will improve the skill level of construction workers by upgrading vocational training facilities, and strengthen quality control of construction works by upgrading research laboratory facilities.

Furthermore, this improvement of vocational training will contribute to the market needs in the construction sector and is expected to lead to the improvement of employment rate as well as poverty reduction.

The expected achievement of the project objectives also contributes to the priority areas in the basic policies of Japan's assistance to Myanmar, which are the following: 1) development of infrastructure and related systems necessary for sustainable economic development; and 2) capacity building and development of systems to sustain the economy and society according to Japan's "Government Development Assistance (ODA) Country Data Book 2017".

16.3.2 Proposed Indicators

Upgrading of Thuwunna RLTC includes two components with different goal values. Hence, it is necessary to set optimal indicators for each goal.

The 1st component – or the redevelopment of training facilities for MOC staff and skilled labor– is expected to contribute towards improving skills and knowledge of various types of human resources in the construction sector in Myanmar. Provision of training will upgrade the skills of MOC staff, including both administrative officers and engineers responsible for construction administration. Vocational training will be provided to skilled workers in a variety of construction fields to meet the required skill level among ASEAN countries.

The 2nd component – or the redevelopment of the Research Laboratories – is expected to upgrade the quality control function of MOC to meet ASEAN standards.

The proposed operation and effect indicators for RLTC is summarized in Table 16.3.1.

Table 16.3.1 Proposed Operation and Effect Indicators for Thuwunna RLTC

Operation and Effect Indicators (Draft)	Baseline Value (2019)*[1]	Target Value(2029)	Available means of data and Monitoring methodology
1. Quantitative Indicators			
1-1. Prospective number of MOC staff trained at the Training Center per year	1,061 pers.(2017/18)	2,000 pers.	Collect data from the Center
1-2. Prospective Number of MOC Staff Training Courses	21 courses	30 courses	Ditto
1-3. Prospective number of workers trained at the Training Center per year	Training : 150pers Assessment Course : 160pers	Training : 1,440 pers (30 pers x 16 courses x 3 times) Assessment Course :960 pers (20 pers x 16 courses x 3times)	Ditto
1-4. Prospective number of Vocational Training Courses	Training : 5types Assessment Course : 8 types	Training : 16 types (level I) Assessment Course :16 types	Ditto
1-5. Laboratory test	Laboratories provide BS base test.	All laboratories provide test responding to ASEAN standards.	Ditto
1-6. Quality assurance of Laboratory	Only one laboratory has been applied to ISO.	All laboratories becomes ISO certified laboratories	Ditto
2. Qualitative Indicators			
2-1. Type of training provided in the RLTC	More administration courses are provided, rather than planning and technical courses.	More courses will be provided for planning, project management, and quality assurances.	Collect data from the Center
2-2. Satisfaction degree with training contents by MOC staff	Generally, trainees are satisfied with training contents.	Trainees are satisfied with the training contents, facility and equipment.	Collect data through Q&A to participants
2-3. Evaluation by construction companies		Construction companies are satisfied with level of skilled workers who own the certificate issued by the RLTC	Collect data through Q&A at the target construction companies
2-4. Quality of constructions in the country		Contractors are satisfied with the quality of test provided at RLTC	Collect data through Q&A at the target construction companies

Note*[1]: Baseline value and target value to be arranged through the discussion with the authority of Myanmar side.
Source: JICA Study Team

CHAPTER 17 CONCLUSIONS AND RECOMMENDATIONS

17.1 Conclusions

The conclusions of this Survey are as follows;

- It is concluded that the Project is technically and economically feasible and is acceptable from the viewpoints of environmental and social considerations.
- The location of the New Sittaung Bridge was carefully set considering the site geometry (especially pertaining to past shifts in the riverbank), economic efficiency and minimizing adverse impacts to both the environment and the resettlement of people. The final alignment avoids the Mottama Ramsar Site but needs to pass the Important Bird Area (IBA) and the Key Biodiversity Area (KBA). Thus the Special Ecosystem Monitoring Plan is prepared in order to assess influence on the IBA/KBA area by the Project during implementation stage.
- It is justified that 22m width with the emergency bays for both side of bridges shall be applied to the New Sittaung Bridge in order to harmonize to the future possible upgrading to the "Primary" class stipulated in the ASEAN Highway Standards as well as the demand for reduction of the initial construction cost, although the initial operation would be as "Class-I" road with access control.
- The structural types for the New Sittaung Bridge were carefully studied and it is designed with the following technical aspects;

  The main bridge is 800m in length and the superstructure type is steel narrow box girder supported by oval-shape RC piers and Steel Pipe Sheet Pile (SPSP) foundations.

  The approach bridge is a total of 1,200m in length and the superstructure type is PC-I composite girder supported by RC piers/abutments and cast-in-situ RC piles.
- DOB is an eligible implementation agency for construction of the New Sittaung Bridge as they have enough experience on a similar scale of international projects although technical assistance is necessary to develop the technical capacity further.
- It is necessary that upgrading of the Thuwunna RLTC is implemented under this Project in order to enhance technical capacity of MOC and develop human resources so that a proper implementation body for proper and sustainable O&M of the project expressway is expected to be developed through advanced technical trainings to MOC's engineers in the Thuwunna RLTC.

17.2 Recommendations

- It is recommended that the Project Management Unit should be established with enough staff as proposed in Chapter 13 before commencement of the detailed design.

- It is necessary for MOC to get an environmental clearance certificate as early as possible otherwise the Project will be delayed.
- To maximize the effectiveness of the Project and harmonization between ADB and JICA, the following coordination should be taken through periodical coordination meetings and other opportunities during implementation of the Project;

Table 17.2.1 Necessary Coordination with ADB during Implementaion Stage

Item	Timing	Details
Design	Detailed Design	− Design criteria − Road configuration − Vertical alignment at the construction boundaries − Effective planning of access roads to the construction sites
EIA	The entire implementation	− Countermeasures when considerable species are identified during environmental monitoring activities − Sharing the updated environmental management plan (EMP) − Sharing environmental monitoring results continuously including special ecosystem monitoring
RAP	The entire implementation	− Eligibility, entitlement and price for compensation − Institutional frameworks such as members of the RIC − Harmonized establishment of Grievance Redress Mechanism (GRM)
Implementation Schedule	Detailed Design	− Opening date
Operation and Maintenance	Before opening	− Initial implementation body and development plan − Toll policy (rate, location of toll plaza etc.)

Source: JICA Study Team

- To make the Thuwunna RLTC more effective, functioned, developed and sustainable, the followings are recommended;
  - In order to provide more comprehensive and effective training to MOC staff, it is necessary to identify the clear image of MOC personnel and establish a strategic HR training plan, in order to properly respond to and prepare for the reformation of MOC;
  - In order to establish the functional role of the Thuwunna RLTC's Laboratory as the only public laboratory for the construction sector in Myanmar, institutional aspects such as an accreditation system, quality control system, etc. are necessary. These accreditation system and quality control system will help to develop business model of the RLTC for sustainable operation. (including fee charging system and autonomous budget management system);
  - In order to establish a quality management system for testing operation, it is important to obtain the ISO certification in not only building field but also other fields as well to improve confidence in the MOC laboratory;
  - Reorganization and integration of the laboratories by type of tests, for more efficient operation and management of the laboratories; and
  - In the future, it is important to enhance research work on construction methods and materials that match Myanmar's climate and available materials. Space for future expansion is proposed in the site plan.