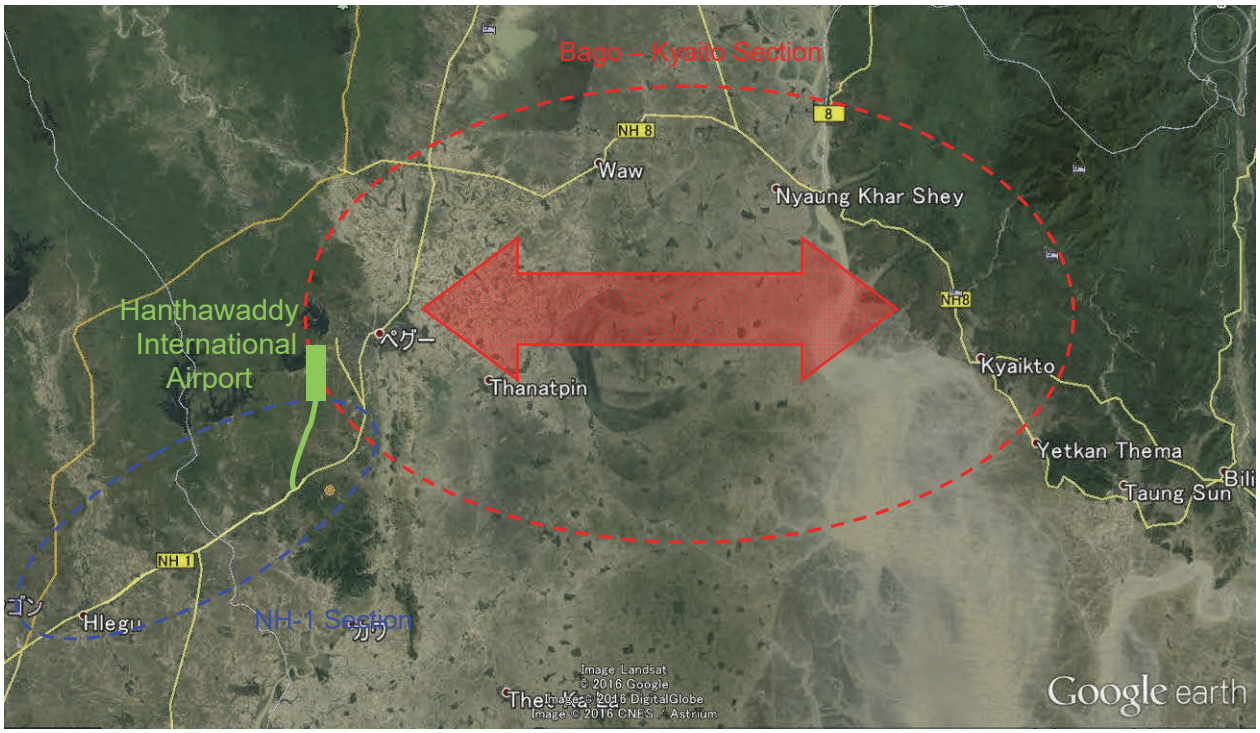
CHAPTER 5 ROAD PLANNING

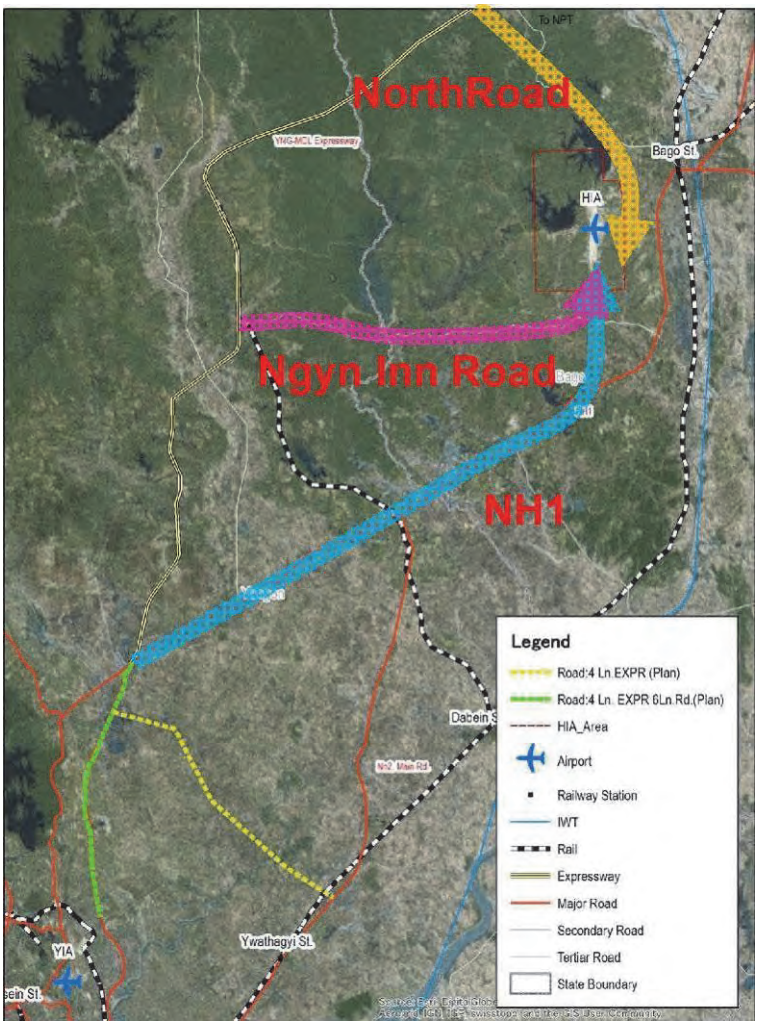
5.1 Outline of Road Planning

In this chapter, road planning for "Bago - Kyaito Section" and "NH-1 Section" is conducted (see Figure 5.1.1). For the Bago - Kyaito Section, the current existing NH-8 is basically two lanes and some parts widen to four lanes. In the future, this route, which will cover traffic as a part of EWEC, will be saturated and especially congested in city and town areas, which will then cause a reduction of travel speed. To solve this issue, a bypass shortening the distance between Bago and Kyaito is studied in this section. For the NH-1 section, the current NH-1 also will be saturated in the future because this route covers traffic to Yangon from the north side and the east side. Additionally, NH-1 will be one of access routes to Hanthawaddy International Airport (see Figure 5.1.2). Road planning for NH-1 is conducted considering the above conditions.



Source: JICA Survey Team based on Google Earth

Figure 5.1.1 Outline of Road Planning



Source: The Preparatory Study for Hanthawaddy International Airport

Figure 5.1.2 Hanthawaddy International Airport Access Expressway

5.2 Proposed Design Conditions

5.2.1 Design Standards

Basically, the Road Design Criteria in Myanmar (2015) is applied. The highway classification in this section is specified for main arterial roads, and the terrain of the location of New Bago-Kyaito road and NH-1 is classified as level.

5.2.2 Geometric Design Condition

The geometric design standards and design values to be applied are shown in Table 5.2.1.

Table 5.2.1 Geometric Design Standard

		ASIAN HIGHWAY CLASSIFICATION AND DESIGN STANDARDS	ASEAN HIGHWAY STANDARDS	Road Design Criteria in Myanmar	New Bago-Kyaito Road
Highway Classification		Class II (2 lanes)	Class II (2 lanes)	Main Arterial Road	Main Arterial Road
Terrain Classification		Level	Level	Level	Level
Design Speed (km/h)		80	80-100	80-100	80
Width (m)	Right of Way	40	40-60 (Rural)	45.75	45.75
Width (m)	Lane	3.5	3.5	3.5	3.5
	Shoulder	2.5	2.5	2.5	Without sidewalk: 2.5 (incl. 0.5m soft shoulder), With sidewalk: 0.5
	Median			3.0	3.0
Earth Slope		―	―	Fill: 1:1.5 – 1:1.8 Cut: 1:0.5-1:1.2	Fill: 1:2 Cut: 1:1.5
Type of pavement		Asphalt Concrete	Asphalt Concrete	Asphalt Concrete or Cement Concrete	Asphalt Concrete
Min.Horizontal Curve Radius		210	200	210 – 360	210
Min. Curve Length(m)		70	―	90-110	90
Max.Vertical Grade (%)		4	6	4	4
Min.Vertical Clearance (m)		4.5	4.5	4.5	4.5

		Road Design Criteria in Myanmar	Road Design Criteria in Myanmar	NH-1(Center lane)	NH-1(Side lane)
Highway Classification		Expressway	Sub Arterial Road	Expressway	Sub Arterial Road
Terrain Classification		Urban	Urban	Urban	Urban
Design Speed (km/h)		100	70	80**	70
Width (m)	Right of Way	122	45.75	IOC	IOC
Width (m)	Lane	3.5	3.25	3.5	3.25
	Shoulder	2.0 (structure can be reduced up to 1.0)	2.0 (structure can be reduced up to 0.5)	1.25*	2.0
	Median	3.0	0.5 (Paved stripe median)	1.6* (Median Facilities 0.6 Lateral Margin 0.5)	0.5(Lateral Margin)
Type of pavement		Asphalt Concrete	Asphalt Concrete	Asphalt Concrete	Asphalt Concrete
Min.Horizontal Curve Radius		440	255	210**	255
Min. Curve Length(m)		110	80	90**	80
Max.Vertical Grade (%)		3.0	6.0	4.0**	6.0
Min.Vertical Clearance (m)		5.0	4.5	5.0	5.0

* Regarding NH-1, width of shoulder is reduced in order to reduce impact of area and cost of structure.

** Regarding NH-1(Centre lane), the preferable design speed is 100km/h, but it difficult to follow the existing alignment. Therefore, the design speed is reduced to 80km/h.

Source: Prepared by JICA Survey Team based on Asian Highway Classification and Design Standards, ASEAN Highway Standards and Road Design Criteria in Myanmar 2015

5.3 Study on Cross Section

5.3.1 Number of Lanes

(1) New Bago-Kyaito Road

According to the result of traffic demand forecast between the Payagyi and Kyaito section, traffic volume will be approximately 80,000 PCU/day in 2035 which requires a total of six lanes in both directions. The existing NH-8 covers two lanes and the remaining four lanes are covered by the newly developed Bago-Kyaito Road.

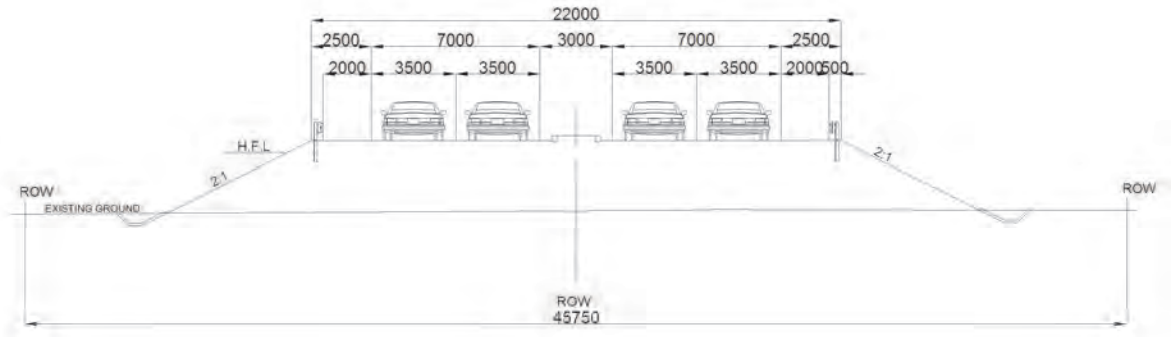
(2) NH-1

According to the result of traffic demand forecast, traffic volume would be approximately 150,000 PCU/day in 2035. The required number of lanes is calculated to be ten lanes in total for both directions. Under the conditions of the current demand forecast, the condition that heavy vehicles are to be allowed to pass on the expressway is not considered. Currently the MOC has a plan that the expressway will be widened to eight lanes, but, the passage of heavy vehicles on the expressway is not mentioned in the plan Widening to ten lanes will create a large impact on resettlement. As a realistic number of lanes, a total of eight lanes in both directions, which is four lanes for long distance traffic connecting New Bago-Kyaito Road and four lanes as compensation for the existing number of lanes for short distance traffic, is planned.

5.3.2 Typical Cross Section

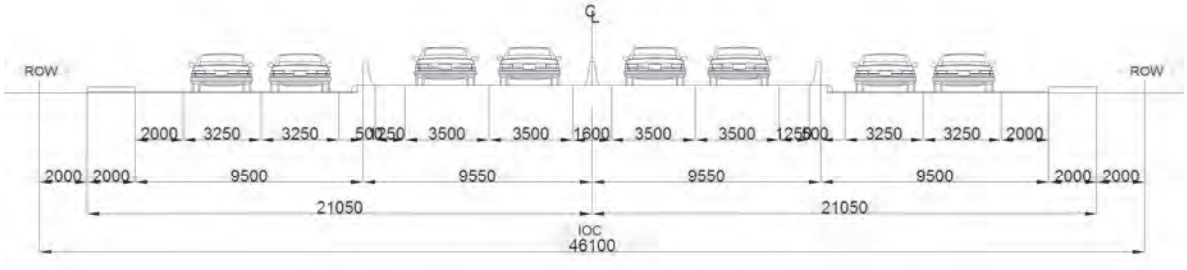
The typical cross sections of New Bago-Kyaito Road and NH-1 have been planned based on the required number of lanes mentioned in the previous section.

For New Bago-Kyaito Road, there is flood area during the rainy season. It's important to develop the road which will be passable during the rainy season, therefore, a proposed elevation is planned to be above H.F.L to protect the pavement structure from flooding.



Source: JICA Survey Team

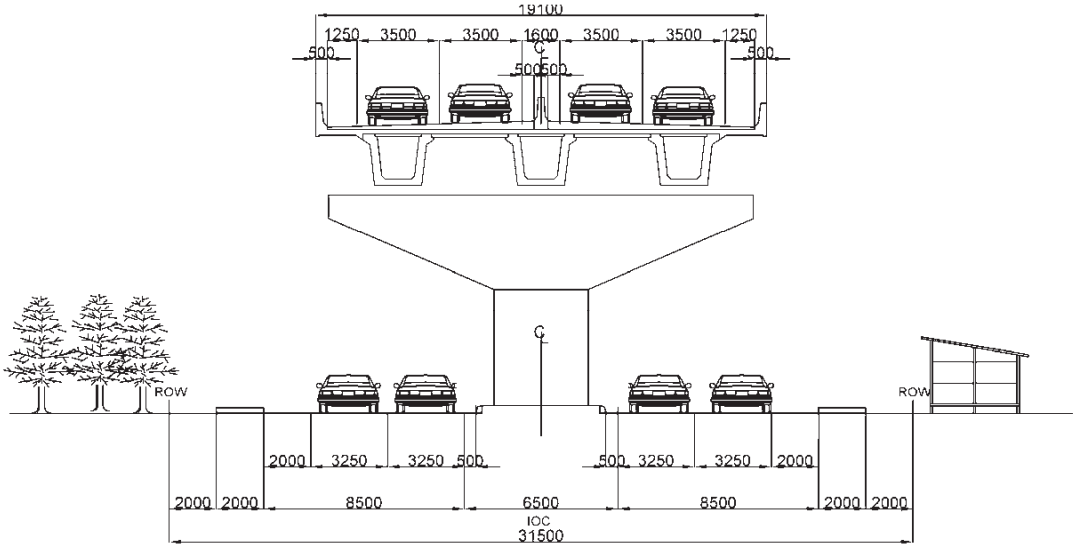
Figure 5.3.1 Typical Cross Section of New Bago-Kyaito Road



Source: JICA Survey Team

Figure 5.3.2 Typical Cross Section of NH-1(At Graded)

For viaduct/bridge sections, a minimized shoulder width is applied based on the Japanese practices in order to minimize construction cost as shown in Figure 5.3.3.



Source: JICA Survey Team

Figure 5.3.3 Typical Cross Section of NH-1(Elevated)

5.4 Alignment Study

5.4.1 Alignment Policy

(1) New Bago-Kyaito Road

Alignment of the New Bago – Kyaito Road is planned in consideration of the following policies.

- To connect the east side of Kyaito and Bago in as short a distance as possible
- To select an appropriate location on Sittaung River based on result of the comparison[1]
- To avoid control point (village, town and etc.)

Source: JICA Survey Team

Figure 5.4.1 Proposed Road Alignment and Control Points (Village / Town)

[1] The comparison result is shown on 6.2. in this report.

(2) NH-1

Alignment of NH-1 was selected along the existing NH-1 which has basically 100ft (30m) Right of Way (ROW). However geometric standards are not secured in some sections, and in that case some sections are required to modify the alignment as shown in Figure 5.4.3. In addition, there are shops and houses along NH-1 in city areas, therefore viaduct structures are applied to reduce the number of affected households. There are many structures (box culvert and bridge) on NH-1 as shown in Figure 5.4.2, therefore, the widening or replacement of the existing structure is required at grade sections. In viaduct sections, proper pier arrangement shall be required to avoid conflict with existing structures and secure a sight distance in next stage.

Source: JICA Survey Team

Figure 5.4.2 Existing Conditions of ROW

Source: JICA Survey Team

Figure 5.4.3 Sections Required to modify alignment

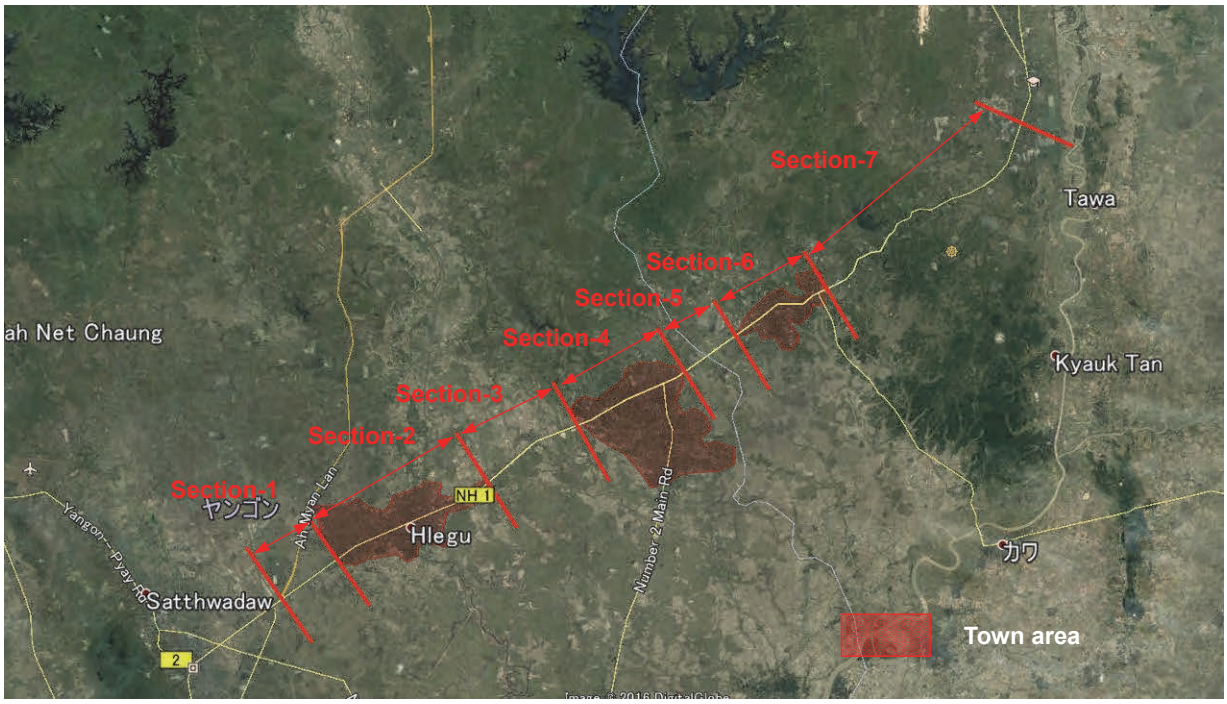
Source: JICA Survey Team

Figure 5.4.4 Shops along NH-1

Source: JICA Survey Team

Figure 5.4.5 Shops/Houses in Town

It is difficult to apply grade sections to town areas because it requires more space than the current road space and impacts a large number of shops/houses. Therefore, to reduce impact, viaduct structures are applied in town sections. Figure 5.4.6 Shows applied typical cross section by section.



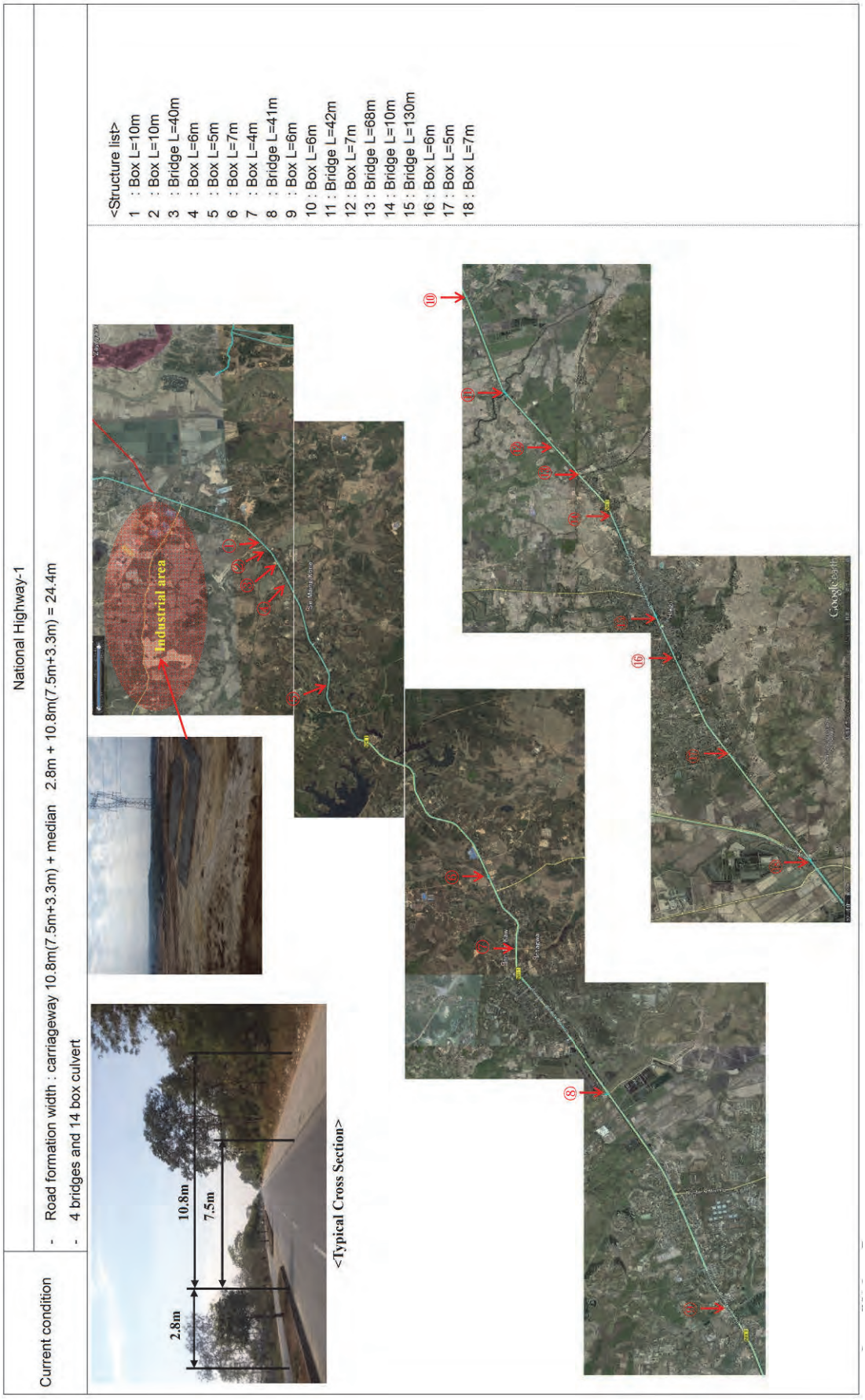
Source: JICA Survey Team

Figure 5.4.6 Each Section on NH-1

Table 5.4.1 Applied Cross Section for each Section

Section	Type of cross section	Length
Section-1	At grade	0+000 – 2+700(2.7km)
Section-2	Viaduct	2+700 – 10+000(7.3km)
Section-3	At grade	10+000 – 14+800(4.8km)
Section-4	Viaduct	14+800 – 19+900(5.1km)
Section-5	At grade	19+900 – 22+700(2.8km)
Section-6	Viaduct	22+700 – 26+900(4.2km)
Section-7	At grade	26+900 – 39+600(12.7km)

Source: JICA Survey Team



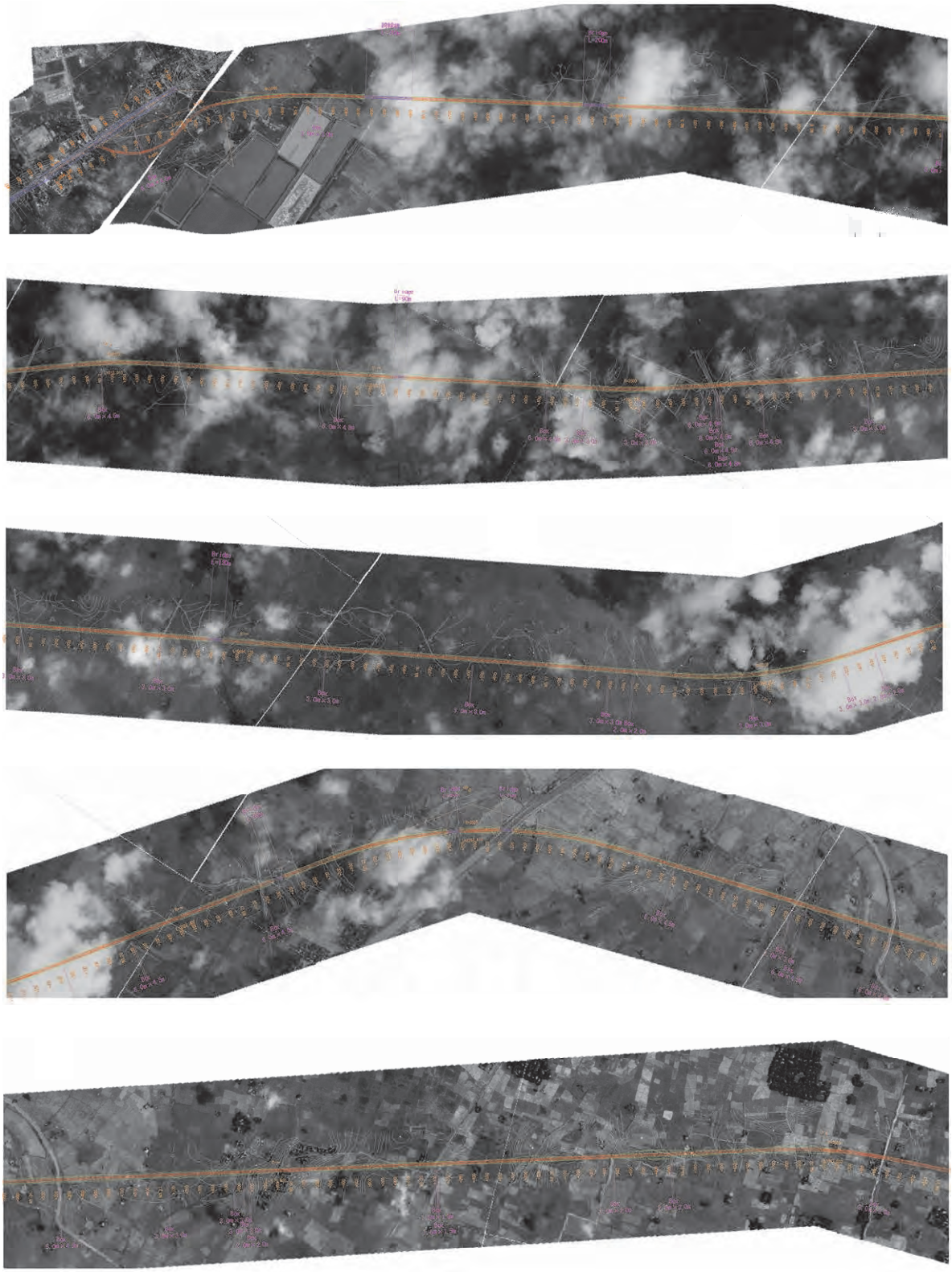
Source: JICA Survey Team

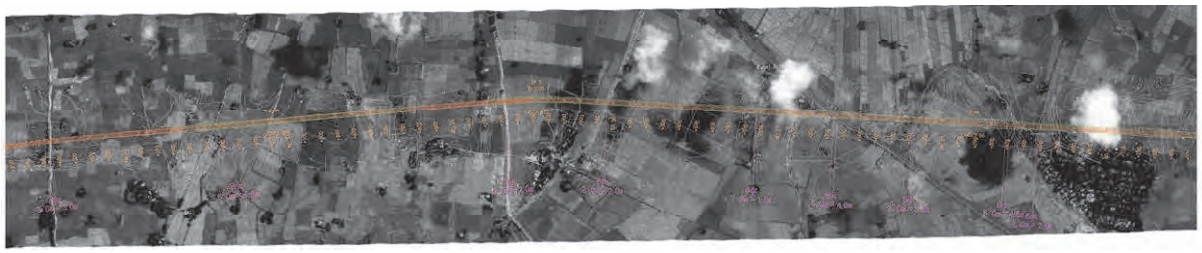
Figure 5.4.7 Location of Existing Structure in NH-1

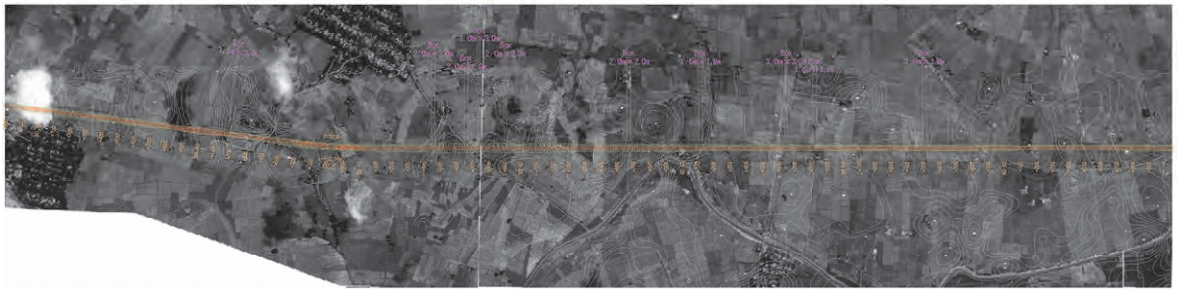
5.4.2 Proposed Alignment

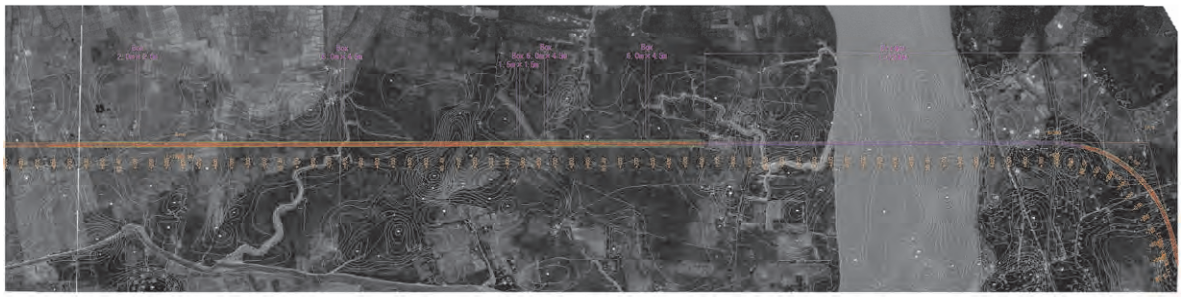
(1) New Bago-Kyaito Road

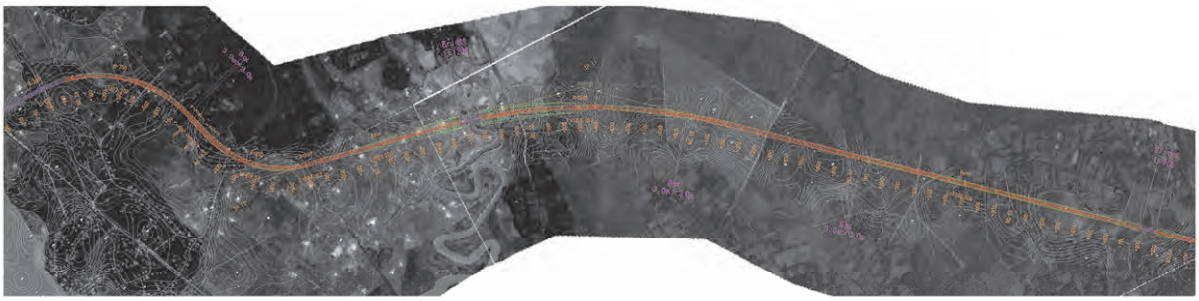
Proposed alignment for New Bago- Kyaito Road is shown in Figure 5.4.8.

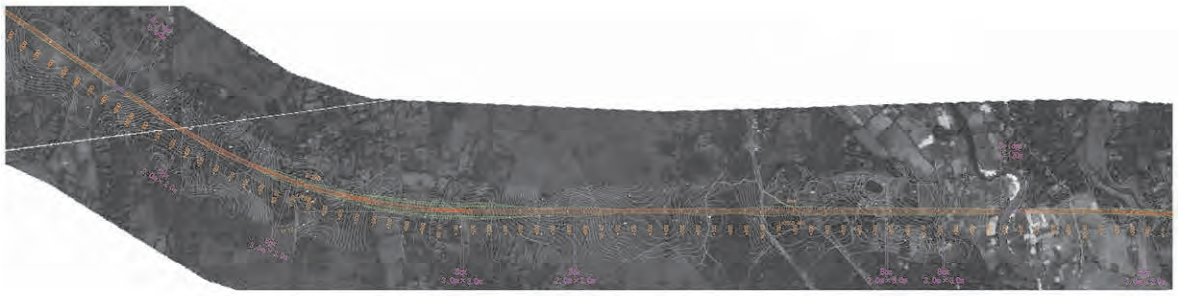


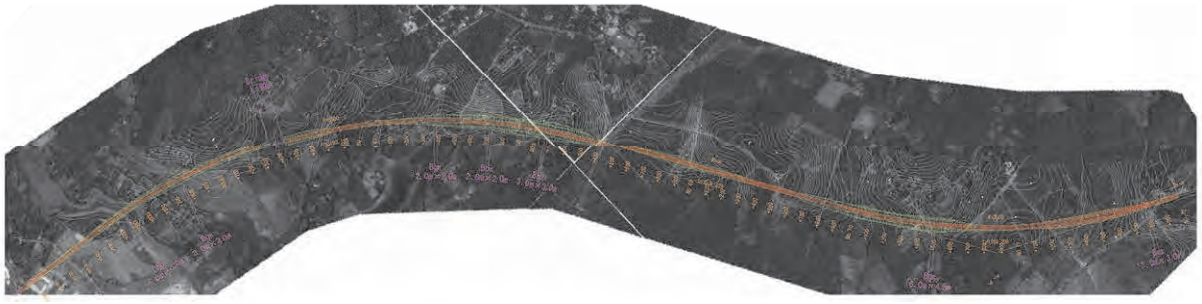










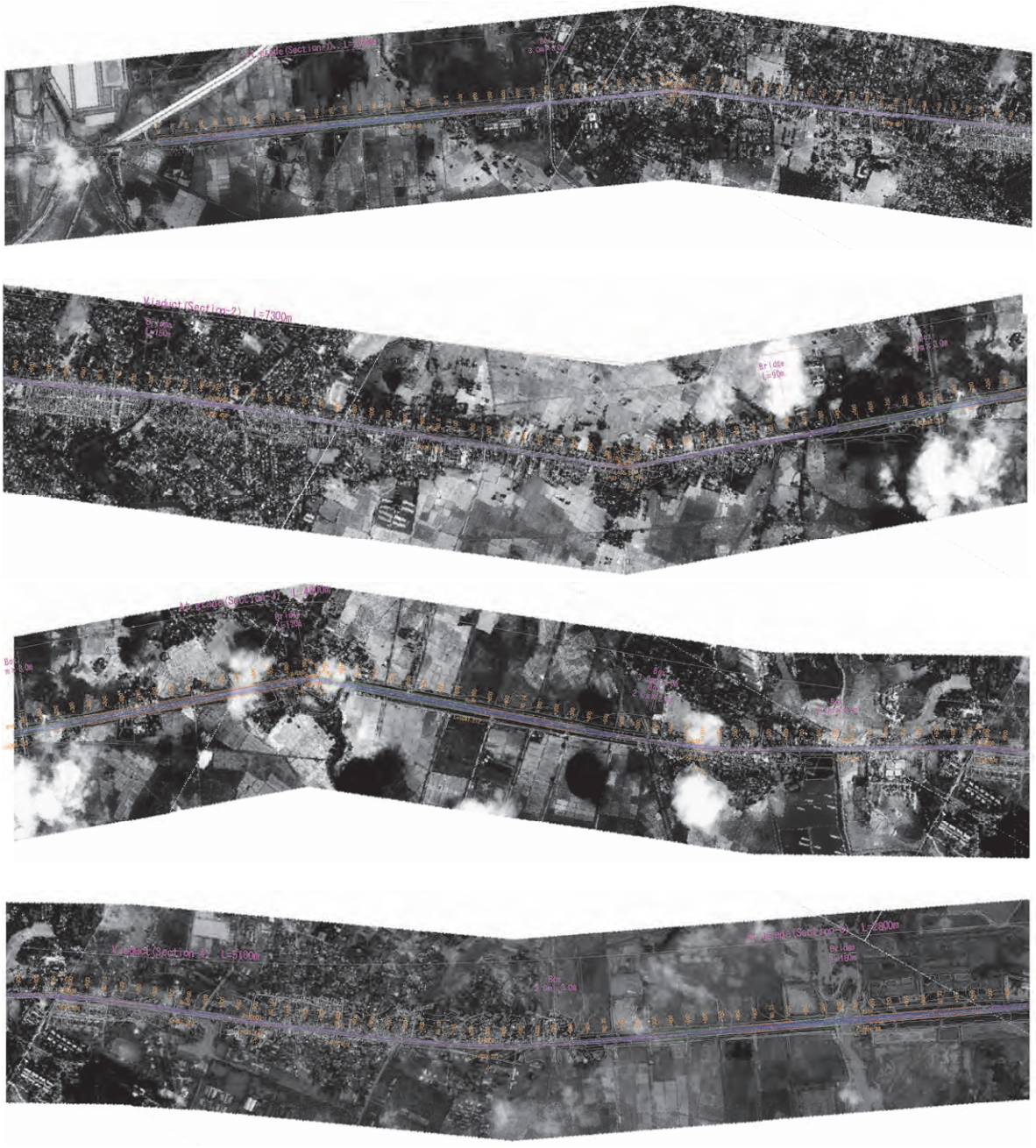


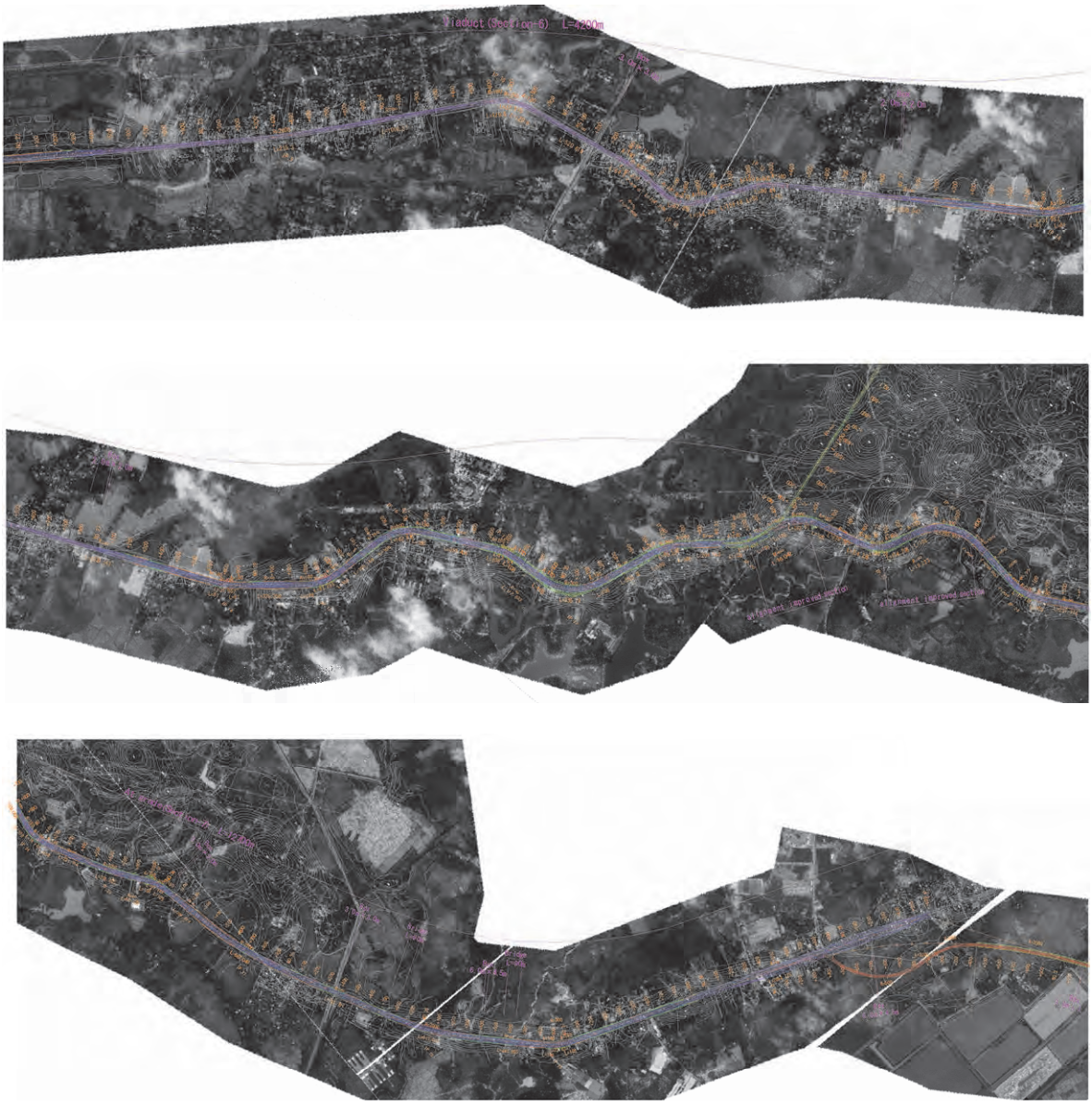
Source: JICA Survey Team

Figure 5.4.8 Proposed alignment of New Bago – Kyaito Road

(2) NH-1

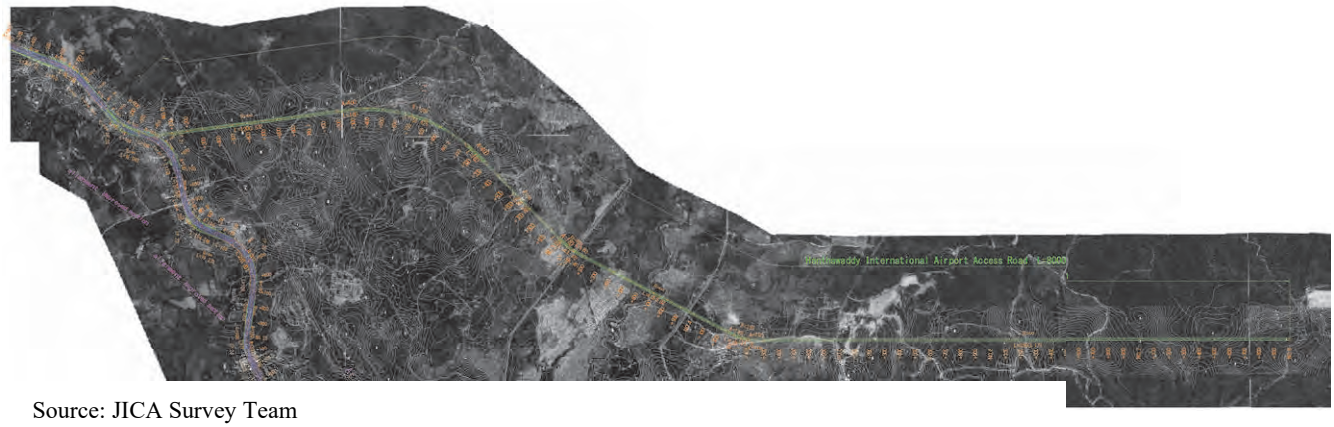
Proposed alignment for NH1 is shown in Figure 5.4.8 and Figure 5.4.9.





Source: JICA Survey Team

Figure 5.4.9 Proposed alignment of NH-1



Source: JICA Survey Team

Figure 5.4.10 Proposed alignment of between NH-1 and HIA

(3) Additional Facility

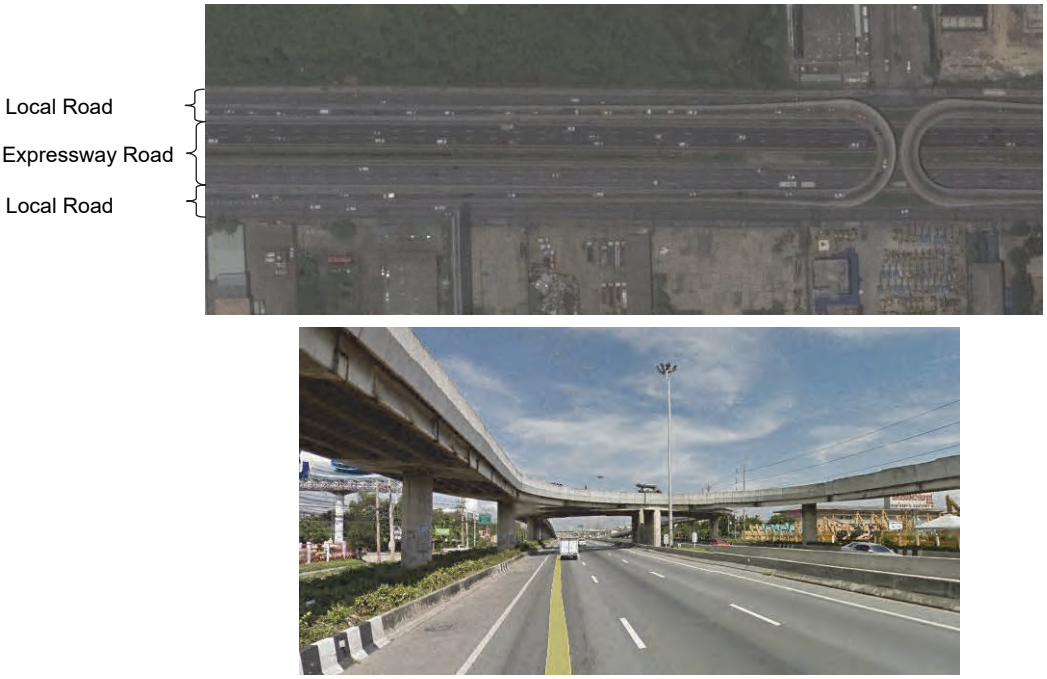
For the management of controlled access to the expressway, toll gates connecting local roads and the expressway and U turn flyover which connect inbound/outbound traffic divided by the expressway are required.

- Toll gate

Source: Google Earth

Figure 5.4.11 Example of Toll Gate Connecting from Local Road to Expressway at Grade

- U-turn fly over



Source: Google Earth

Figure 5.4.12 Example of U turn Fly Over

CHAPTER 6 BRIDGE AND VIADUCT PLANNING

6.1 Proposed Design Conditions

6.1.1 Design Standards

The principle design standards for bridge design that were applied are:

- AASHTO LRFD Bridge Design Specifications (2010, 5th edition)
- Specifications for Highway Bridges - Japan Road Association (JRA) (2002)

The bridge design has been conducted based on the design standards. Note that live loading is applied in accordance with AASHTO guidelines, and other design loads such as earthquake, temperature, wind, etc. are applied with modified JRA specifications considering local conditions.

6.1.2 Design Criteria

(1) Dead Load

Dead loads including the weight of all components of the structure and facilities such as utilities, pavement and future overlays are calculated based on those prescribed in AASHTO as shown in Table 6.1.1.

Table 6.1.1 Unit Weights of Bridge Materials 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 mix	22.5

Source: JICA Survey Team based on ASSHTO

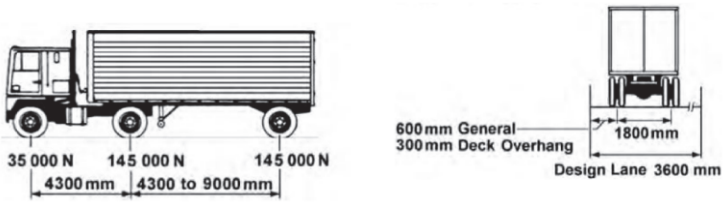
(2) Live Load

According to AASHTO LRFD, the live loads on the road bridges shall consist of:

- Design truck or design tandem, and
- Design lane load

a) Design Truck

The loading combination for spacing of wheels and axles of design vehicle specified in AASHTO LRFD is the layout given in Figure 6.1.1.



Source: ASSHTO

Figure 6.1.1 Characteristics of Design Truck (HS20-44)

b) Design Lane Load

The design lane load is a uniform linear load of 9.3 kN/m.

(3) Seismic Design

The proposed bridge site will be affected by earthquakes, especially near the Bago region. The Myanmar Earthquake Committee has prepared the earthquake zoning map of Myanmar. Seismic design shall be carried out in next stage for this project.

(4) Temperature

Mean maximum temperature in the site is 37.2°C and mean minimum 16.3°C based on past data in Kaba Aye, Bago and Belin as shown in 4.3.2. The temperature range for design shall be 15°C to 40°C with a mean of about 25°C (temperature rise 10°C, temperature fall 15°C) for ordinary bridges and 15°C to 50°C with a mean of about 25°C (temperature rise 10°C, temperature fall 25°C) for a steel plate deck .

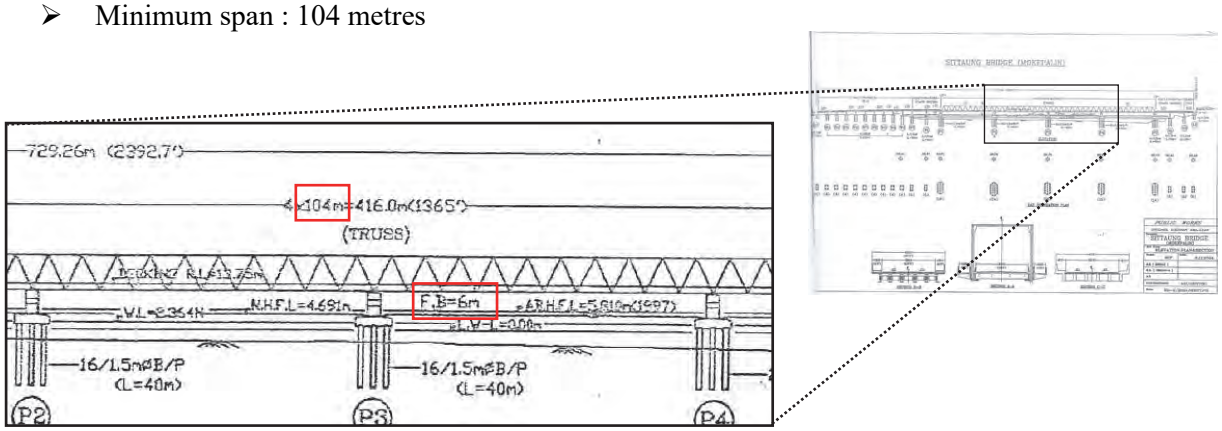
(5) Wind

The biggest cyclone was NARGIS with winds up to 54m/s swept through the delta coasts of Ayeyarwaddy and Yangon on May 2nd, 2008. There is a wind record with 49m/s wind speed at Yangon. Therefore the wind load acting on the superstructure should be considered carefully in the next design stage. If a suspension bridge, cable stayed bridge and other flexible bridges are applied for crossing the Sittaung River, a detailed study such as a wind tunnel test is necessary to examine the stability due to wind in the outline design stage or detailed design stage.

(6) Free board and Minimum Span for Bridge at New Sittaung Bridge

The free board and minimum span are set as below in reference to the existing Sittaung Bridge located approximately 7km upstream from the project site.

- Free Board : 6 metres above H.W.L
- Minimum span : 104 metres



Source: MOC

Figure 6.1.2 Free Board and Span Arrangement of the Existing Sittaung Bridge

6.2 Route Justification of New Sittaung Bridge

6.2.1 Introduction

As mentioned in Chapter 4, there is tidal bore twice a month on the Sittaung River. In this regard, a selection of crossing points over the river is quite important to minimize construction/maintenance cost and to mitigate the influence of river bank erosion by river flow and tidal bore. In this section, the optimum crossing point in Sittaung River is studied.

6.2.2 Selection of Optimum Route for New Sittaung Bridge

Possible alternatives are shown in Figure 6.2.1. Alternative 3 gives the longest bridge length, but gives the shortest road distance. On the other hand, alternatives 1 and 2 give shorter bridge lengths but give longer road lengths.

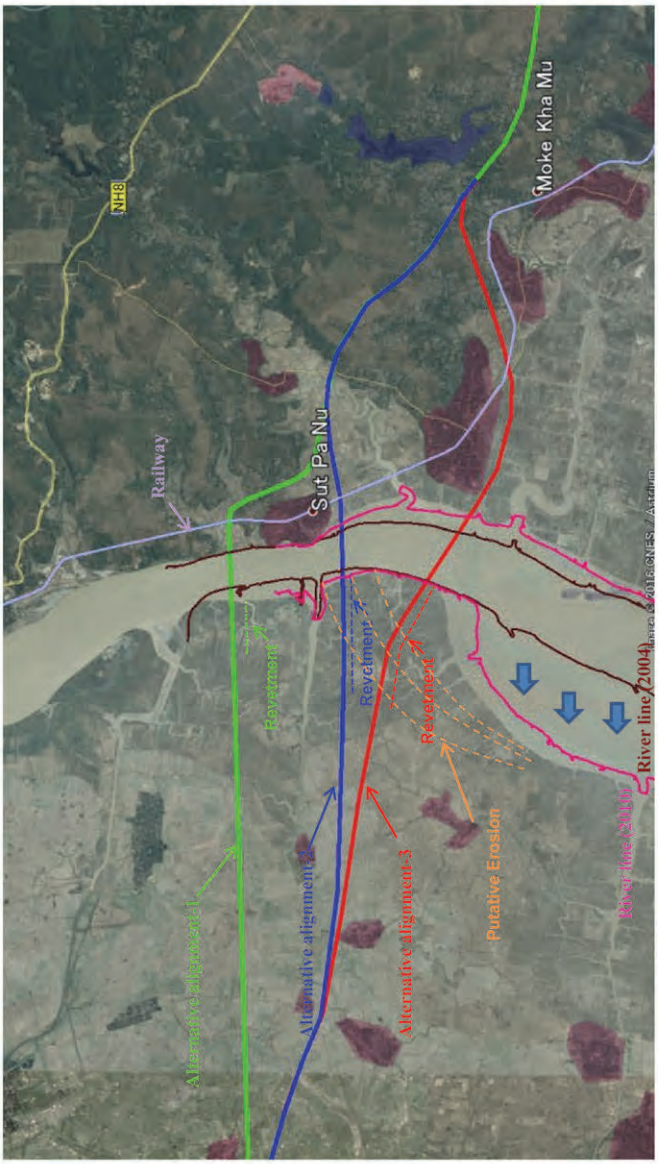
Source: Prepared by JICA Survey Team based on Google Earth

Figure 6.2.1 Possible Alternatives of Crossing Point for New Sittaung Bridge

As a result of the comparison study among these alternatives shown in Table 6.2.1, Alternative 1 is recommended as the optimum route for New Sittaung Bridge due to the following reasons:

- Most reasonable in economic aspect since smallest scale of revetment can be applied for future putative erosion
- Low possibility of large scale river bank erosion in future, considering past river course shifting shown in Figure 4.3.31.

Table 6.2.1 Comparative Study of Optimum Route Selection for New Sittaung Bridge

	Alternative alignment -1	Alternative alignment-2	Alternative alignment-3
Route	- Alignment to minimize bridge length - Bridge Length : approximately 2.0km* - Total Length : approximately 19.6km* - Revetment Length : approximately 0.5km*	- Alignment to minimize bridge length - Bridge Length : approximately 2.0km* - Total Length : approximately 19.0km* - Revetment Length : approximately 2.0km*	- Alignment on paddy field - Bridge Length : approximately 2.5km * - Total Length : approximately 18.9km* - Revetment Length : approximately 2.5km*
Map			
Social Impact	- Small number of residence are affected. - Mainly plantation(bitter leaf and rubber tree)	- Small number of residence are affected. - Mainly plantation(bitter leaf and rubber tree)	- Small number of residence are affected. - Mainly plantation(bitter leaf and rubber tree)
Economy	- Most Economical - Constuction Cost: 31.0 Billion JPY (1.00)	- Less expensive than alignment-1 and 2 - Constuction Cost: 31.8 Billion JPY (1.03)	- Most expensive alignment because of long length of bridge and rivetment. - Constuction Cost: 37.1 Billion JPY (1.22)
Constructability	- Construction period is shorter than alignment-1 and 2	- Construction period is shorter than alignment-1	- Construction period is longer than alignment-2, 3
Vulnerability to River Erosion	- Low possibility of large scale river bank erosion	- River Erosion is progressing year by year. Larege scale of revetment is required to privent erosion, though less than Alt-1.	- River Erosion is progressing year by year. Larege scale of revetment is required to privent erosion.
Evaluation	**Recommended**	Not Recommended	Not Recommended

*Length of road , bridge and revetment is at preliminary study

Source: JICA Survey Team

6.3 Study of Superstructure Type

6.3.1 Introduction

In this section, the optimum options for superstructure are proposed by comparable study with the necessary technical considerations or on the basis of experience of the Survey Team. The comparisons were conducted for the main portions on the project route, such as crossing point with main rivers and intersections. The alternatives are basically selected based on the following items:

- Road standard and Width composition
- Horizontal alignment and Vertical alignment
- External factors and External conditions
- Structural characteristic, Type of girder, required minimum span etc.
- Workability, Erection, Trafficability, Maintenance and Aestheticism
- Economic efficiency and Construction costs

For the comparison, at least, three alternatives were examined in consideration of the following evaluation criteria.

Table 6.3.1 Eligible Items for the Selection of Superstructure Type

Evaluation Criterion		Considered Items
a	Structural Stability	- Permanent Structure or Temporary structure - Earthquake Resistance and Ease of Travel
b	Constructability	- Construction Period - Ease of Erection Work - Ease of Substructure and Foundation Work
c	Economic Efficiency	- Construction Cost - Maintenance Cost
d	Maintenance	- Concrete structure (maintenance free) or Steel structure - Ease of Inspection and Maintenance
e	Environment and Social Impact	- Number of affected houses - Negative impact on environment during construction
f	Landscape	- Symbol of local development and/or a landmark of the region
g	New Technology /Technical Transfer	- Advanced technique, Useful technique or Common technique

Source: JICA Survey Team

6.3.2 New Bago – Kyaito Road

(1) New Sittaung Bridge

The New Sittaung Bridge is to be composed of a main bridge and approach bridges on both sides. The main bridge shall secure 6m of free board above the high water level (HWL) and the approach bridges shall connect the embankment portion. The types selected for the main bridges have been selected based on the engineering assessment of several criteria including span length, structural stability, constructability, construction cost, maintenance, technical transfer (introduction of new technology and skills into Myanmar) and aesthetic considerations.

1) Main Bridge

The following five alternatives are extracted for the bridge type selection in consideration of

necessary free board and minimum span and constructability in/over the Sittaung River as well as the points in the previous section.

Alt-1 : PC Box Girder Bridge

Alt-2 : Concrete Steel Composite Girder Bridge

Alt-3 : PC Extradosed Bridge

Alt-4 : Steel Truss Bridge

Alt-5 : Steel Arch Bridge

Table 6.3.2 to Table 6.3.4 show the comparison of bridge types for the New Sittaung Bridge. As a result of the comparison, "Hybrid PC Bridge with Steel Web" is proposed to be eligible option for the superstructure type by the following reasons. Detailed comparison should be carried out in following surveys such as F/S.

- Reasonable alternative in economical aspect
- New technology can be introduced in Myanmar
- Superior landscape

2) Approach Bridge

In order to keep continuity with the main bridge, the cross section of the approach bridge is designed based on the cross-section of the main bridge. Therefore, the span length of the approach bridge is set to 40-60m in consideration of girder depth restrictions and economical factors.

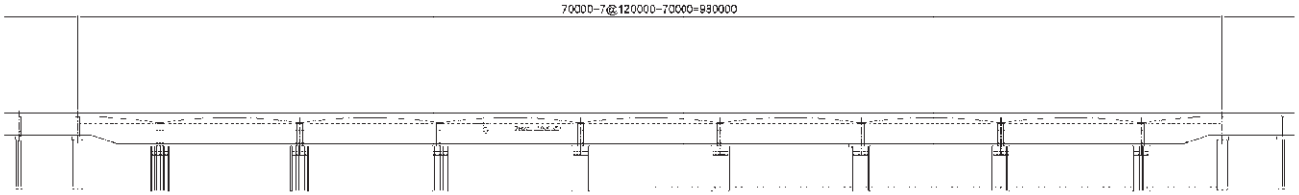
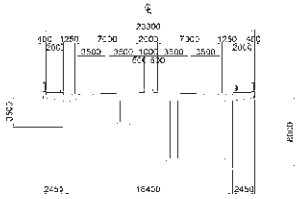
As shown in the previous section, the main superstructure of New Sittaung Bridge is Hybrid PC Bridge with Steel Web. Therefore, "Continuous PC Box Girder with 50m span" is proposed to match with their respective main bridges.

(2) Other Bridges

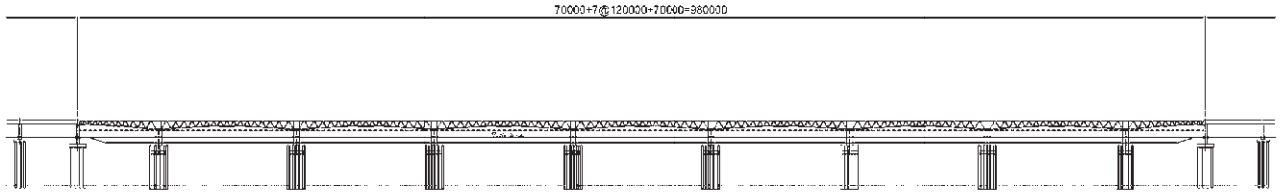
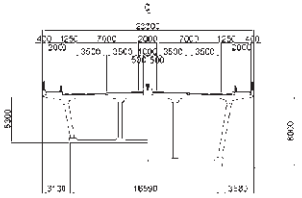
Other bridges are defined as those that must be planned along the proposed new road at points where the road crosses existing creeks and rivers, where there are no special conditions of the river or the topography. The proposed span length for other bridges can be 30m to 50m. The following economical bridge types are proposed for each applicable span:

- PC-I Composite Girder : 30m
- Steel – I Girder : 40m – 50m

Table 6.3.2 Bridge Type Selection for New Sittaung Bridge (1/3)

Side View	Typical Cross Section
Alternative-1: Nine (9) Span Continuous PC Box Girder Bridge **L = 980m (70m + 7x120m +70m)**	
	

Evaluation Criteria	Description	Evaluation
Structural Stability	PC slab is superior in durability. Multi-continuous spans are structurally strong for earthquake resistance and smooth driving.	A
Constructability	Cantilever method is a reliable and safety method in the river. Construction Cost is approximately 65 months.	B
Economic Efficiency	Construction Cost μ= 1.04 / LCC(100 year) μ= 1.00	A
Maintenance	Maintenance for PC bridge is almost free except expansion joints and bearing shoes.	A
Environmental and Social Impact	Almost no affected houses. Need construction of substructure and foundation in the river. Due care for water pollution must be taken.	B
Landscape	Variable cross section is aesthetical, but inferior to other alternatives as a symbolic structure in the project area.	C
New Technology / Technology Transfer	Steel pile sheet pile (SPSP) foundation is still advanced technology and PC Box girder is still useful in Myanmar.	B
Evaluation	**Secondarily Recommended (Most superior in Economic Efficiency, but inferior in land scape and technology transfer)**	

Alternative-2: Nine (9) Span Continuous Hybrid PC Bridge with Steel Web **L = 980m (70m + 7x120m +70m)**	
	

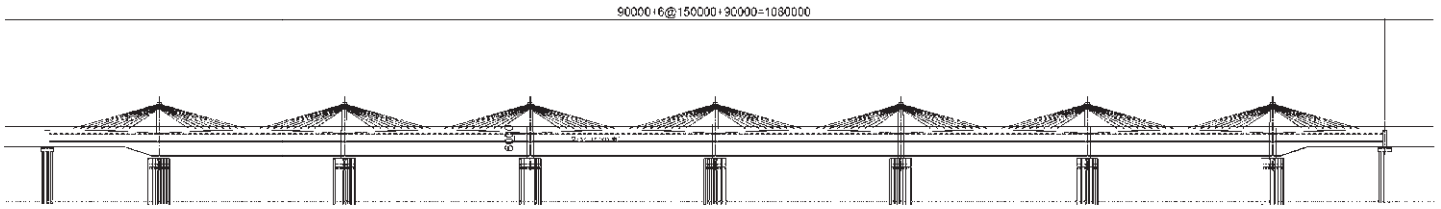
Evaluation Criteria	Description	Evaluation
Structural Stability	PC slab is superior in durability. Multi-continuous spans are structurally strong for earthquake resistance and smooth driving. 20% of superstructure weight can be reduced compared to PC box girder bridge, so that the configuration of substructure and foundation can be downsized.	A
Constructability	Cantilever method is a reliable and safety method in the river. Construction Cost is approximately 65 months.	B
Economic Efficiency	Construction Cost μ= 1.03 / LCC(100 year) μ= 1.17 (Maintenance for steel truss is additionally necessary unlike PC box girder bridge)	B
Maintenance	Maintenance for PC bridge is basically almost free although repainting for steel web is required as well as replacement of expansion joints and bearings. However, maintenance is almost free if weathering steel is applicable in the project site.	B+
Environmental and Social Impact	Almost no affected houses. Need construction of substructure and foundation in the river. Due care for water pollution must be taken.	B
Landscape	Variable cross section with steel web is aesthetical as a symbolic structure in the project area.	A
New Technology / Technology Transfer	Hybrid PC bridge with steel web is new technology girder and SPSP is still advanced technology in Myanmar.	A
Evaluation	**Primarily Recommended (Second superior in Economic Efficiency and concrete steel composite girder is new technology for Myanmar)**	

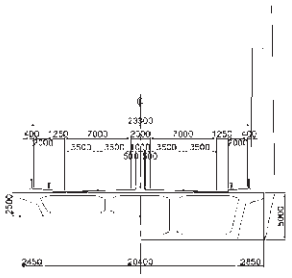
Source : JICA Survey Team

Table 6.3.3 Bridge Type Selection for New Sittaung Bridge (2/3)

Side View	Typical Cross Section

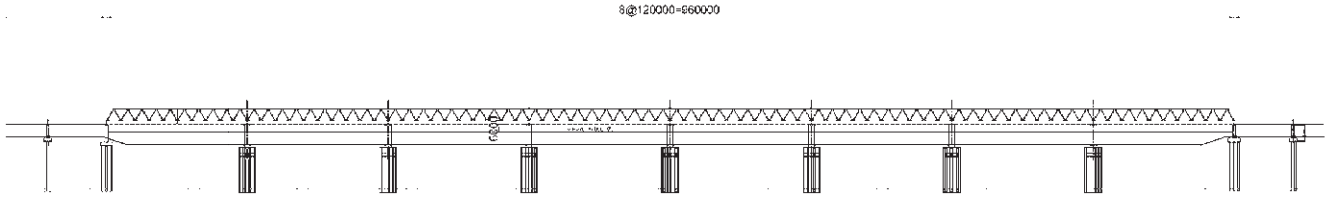
Alternative-3: Eight (8) Span Continuous PC Extradosed Bridge L = 1080m (90m + 6x150m + 90m)

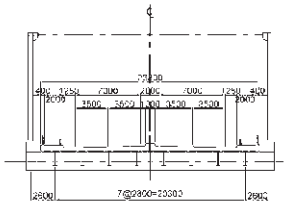




Evaluation Criteria	Description	Evaluation
Structural Stability	PC slab is superior in durability. Multi-continuous spans are structurally strong for earthquake resistance and smooth driving.	A
Constructability	Cantilever method is a reliable and safety method in the river. Construction Cost is approximately 75 months.	C
Economic Efficiency	Construction Cost μ= 1.50 / LCC(100 year) μ= 1.45	C
Maintenance	Maintenance for PC bridge is basically almost free although maintenance for outer-cables is required as well as replacement of expansion joints and bearings.	B
Environmental and Social Impact	Almost no affected houses. Need construction of substructure and foundation in the river. Due care for water pollution must be taken.	B
Landscape	Variable cross section and lower girder height are aesthetical. Main tower has a symbolic value and may become a landmark.	A
New Technology / Technology Transfer	Extradosed bridge and SPSP are still advanced technology, but not new technology in Myanmar.	B
Evaluation	Not Recommended (Most superior in landscape, but quite inferior to Alt-1 and 2 in economic efficiency)	

Alternative-4: Eight (8) Span Continuous Steel Truss Bridge L = 960m (8x120m)

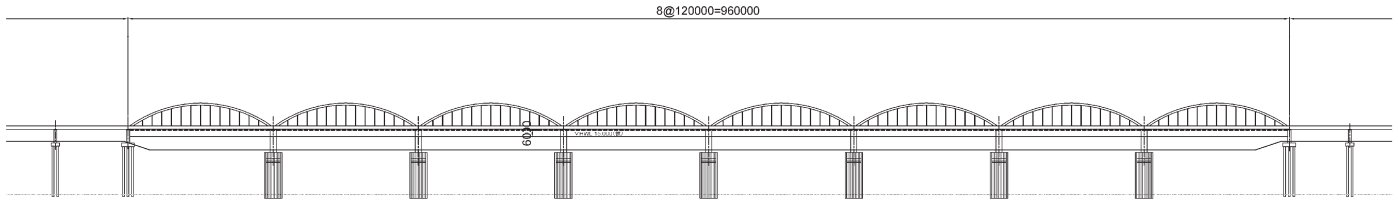
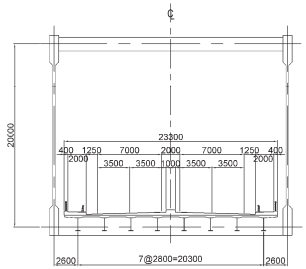




Evaluation Criteria	Description	Evaluation
Structural Stability	There are many practices in Myanmar. This type bridge has sufficient stability and strong for earthquake resistance due to light weight superstructure.	A
Constructability	Steel truss bridge is common in Myanmar, which is applied to existing Sittaung bridge. Construction Cost is approximately 57 months.	A
Economic Efficiency	Construction Cost μ= 1.00 / LCC(100 year) μ= 1.42 (Maintenance cost is highly required for repainting of steel materials unlike PC bridges)	C
Maintenance	Periodical repainting is required as well as replacement of expansion joints and bearings. Durability can be improved in applying weathering steel or thick anticorrosion painting, but inferior to PC bridges.	C
Environmental and Social Impact	Almost no affected houses. Need construction of substructure and foundation in the river. Due care for water pollution must be taken.	B
Landscape	Steel truss bridge is aesthetical and may become a landmark in the project area.	A
New Technology / Technology Transfer	Steel truss bridge is not technology in Myanmar although SPSP is still advanced technology.	C
Evaluation	Not Recommended (Superior in landscape, but quite inferior in economic efficiency and maintenance to PC bridges)	

Source : JICA Survey Team

Table 6.3.4 Bridge Type Selection for New Sittaung Bridge (3/3)

Side View	Typical Cross Section
Alternative-5: Eight (8) Span Continuous Steel Arch Bridge **L = 960m (8x120m)** 	

Evaluation Criteria	Description	Evaluation
Structural Stability	There are many practices in Myanmar. This type bridge has sufficient stability and strong for earthquake resistance due to light weight superstructure.	A
Constructability	There are many practices for long-span brides in Myanmar. Construction Cost is approximately 57 months.	A
Economic Efficiency	Construction Cost μ= 1.07 / LCC(100 year) μ= 1.52 (Maintenance cost is highly required for repainting of steel materials unlike PC bridges)	C
Maintenance	Periodical repainting is required as well as replacement of expansion joints and bearings. Durability can be improved in applying weathering steel or thick anticorrosion painting, but inferior to PC bridges.	C
Environmental and Social Impact	Almost no affected houses. Need construction of substructure and foundation in the river. Due care for water pollution must be taken.	B
Landscape	Steel arch bridge is aesthetical and may become a landmark in the project area.	A
New Technology / Technology Transfer	Steel arch bridge is not technology in Myanmar although SPSP is still advanced technology.	C
Evaluation	Not Recommended (Superior in landscape, but quite inferior in economic efficiency and maintenance to PC bridges)	

Source : JICA Survey Team

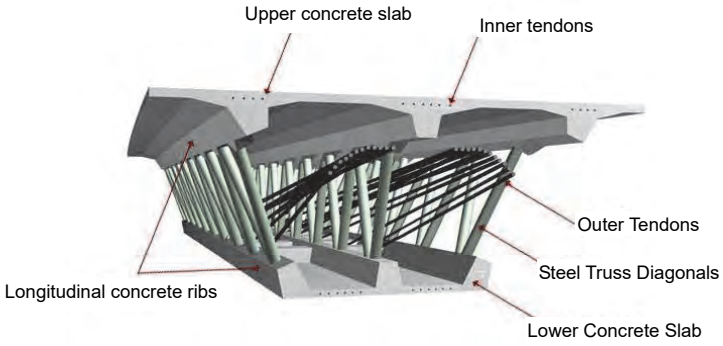
New Technology ***～Hybrid PC Bridge with Steel Web ～***

Hybridge PC Bridge with Steel Web is relatively new type of PC structure.

Characteristics of this bridge type are the following. Two types are introduced in this article.

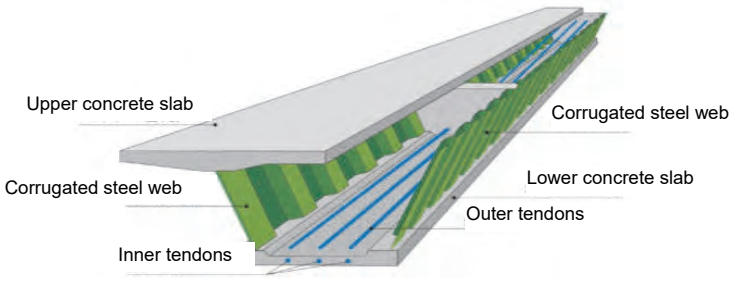
(1) Hybridg PC Bridge with Steel Truss Web

- ✧ *It can decrease the weight of superstructure by the replacement of concrete web to a light-weight steel truss on the PC Box girder. This can contribute to the downsize of substructure and foundation.*
- ✧ *Longer span can be applied by lightweight superstructure than normal PC Box girder.*
- ✧ *Fabricated steel web at factory enables labour saving at the construction site and cost reduction.*
- ✧ *It can give a more symbolic view than normal PC Box girder.*



(2) Hybrid PC Bridge with Corrugated Steel Web

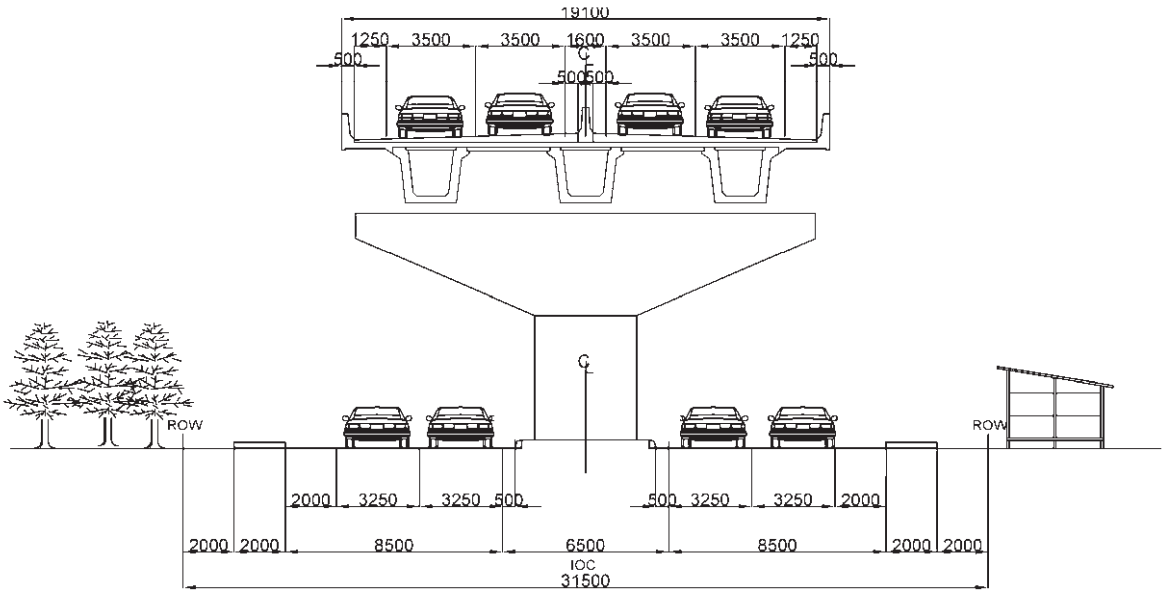
- ✧ *It can decrease weight of superstructure by replacement of concrete web to light-weight corrugated steel web on the PC Box girder. This can contribute to the downsize of substructure and foundation.*
- ✧ *Longer span can be applied by lightweight superstructure than normal PC Box girder.*
- ✧ *Fabricated corrugated steel web at factory enables labour saving at the construction site and cost reduction.*
- ✧ *Pre-stressing works for PC slabs is to be more efficient because of low horizontal stiffness by application of a corrugated steel web.*
- ✧ *It can give more a symbolic view than normal PC Box girder.*



6.3.3 Improvement of National Highway No.1

(1) General

As already described in Chapter 5, the construction of an expressway viaduct above the existing NH1 Street is planned. The typical cross section is shown in Figure 6.3.1.



Source: JICA Survey Team

Figure 6.3.1 Typical Cross Section for Viaduct Section on NH1

The NH1 is one of the major arterial roads in Myanmar, and is a very important route. However, the width is limited in the residential areas along the route. During the construction of the viaduct, it is necessary to secure space for traffic and safety. Therefore, the following principles need to be taken into consideration in this Study.

- To keep the space for detour during construction period as much as possible
- To ensure a shorter construction period by high mechanization, applying the pre-cast method and so on
- To mitigate adverse impacts against the existing traffic during construction.
- To be economically and technically reasonable

The viaduct section is mainly comprised of a standard section and special section such as crossing rivers and road intersections, etc. Therefore, the selection of the superstructure is conducted in two sections respectively.

(2) Viaduct for Standard Section

The following three alternatives are extracted for bridge type selection. Especially, as for PC Bridge, a Pre-cast PC Girder which is fabricated at factory and/or girder casting yard at sites under quality control are extracted since a great number of girders have to be fabricated in a short period.

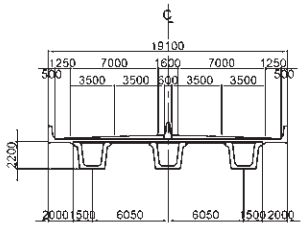
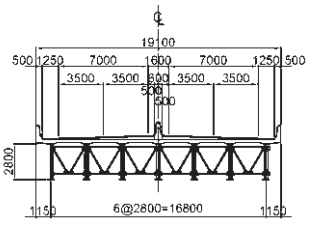
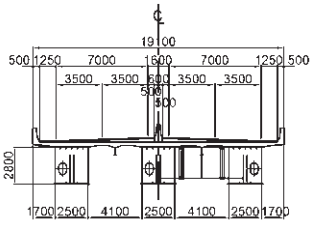
- PC-U Composite Girder : 40m (applicable length: 40～60m)
- Steel-I Girder: 50m (applicable length: 30～60m)
- Steel Box Girder : 70m (applicable length : 40m～)

Table 6.3.5 shows the comparison of bridge types for the standard section. As a result of the comparison of bridge type for Standard Section, “PC-U Composite Girder” is proposed as the

most suitable structure type for the Standard Section Viaduct by the following reasons. A detailed comparison shall be carried out in next stage.

- Most economical alternative, considering maintenance cost
- Construction period will be longer than steel-I girder. However, the difference is not much.
- New technology can be introduced in Myanmar

Table 6.3.5 Comparison of Bridge Type for Viaduct for Standard Section on NH1

Type	Alt-1 PC-I Composite Girder	Alt-2 Steel-I Girder	Alt-3 Steel Box Girder
Cross Section			
Span Length	@40m	@50m	@60m
Structural Feature	Pre-cast girder segments which are fabricated at a factory are assembled and erected at site. Pre-cast PC slab is used under RC slab.	It can be applied to a longer span. Thin plates and stiffened member.	It can be applied to a longer span. Thin plates and stiffened member.
Erection Method	Lifting method by lifting girder	Track Crane and Bent	Track Crane and Bent
Construction Period	It will be a short construction period at the site since it uses the pre-cast girder segment and pre-casting PC slab. Construction period is approximately 1 month/span including fabrication. (1.15)	It will be the shortest construction period among these alternatives. Construction Period is less than 1 month/span. But it is not so different. (1.00)	It will be short construction period at site. Construction Period is approximately 1 month /span included. (1.18)
Social Impact During Erection	- Erection will be carried out during the night time. - During erection, it is necessary to close to traffic.	- Erection will be carried out during the night time. - During erection, it is necessary to close to traffic.	- Erection will be carried out during the night time. - During erection, it is necessary to close to traffic.
Economic Efficiency (Cost Ratio /km)	- 1.20 (Construction) ++1.00 (LCC)	+1.00 (Construction) - 1.23 (LCC)	-1.17 (Construction) -1.44 (LCC)
Maintenance	+Maintenance is almost free although it is necessary to replace EXP joint an Bearing shoes once every 20-30 years.	- It is necessary to repaint once every 20-30 years as well as EXP joint an Bearing shoes according to the traffic condition.	- It is necessary to repaint once every 20-30 years as well as EXP joint an Bearing shoes according to the traffic condition.
Landscape	+It gives less heaviness than Steel-I Girder since the number of girders is less than Steel-I Girder. Smooth surface of girder makes side view look clear.	-It gives most heaviness among these alternatives since there is a greater number of girders.	+Due to the smooth surface of the girder, side view looks clear. It is possible to improve aesthetics by modifying girder shape.
New Technology	+It is the first trial for fabrication of many pre-cast PC girders in a factory and/or fabrication yard in Myanmar.	- Steel-I girder is popular technology. There are many practices in Myanmar.	- Steel box girder is still advanced technology but not new technology.
Evaluation	**Recommended**	Not Recommended	Not Recommended

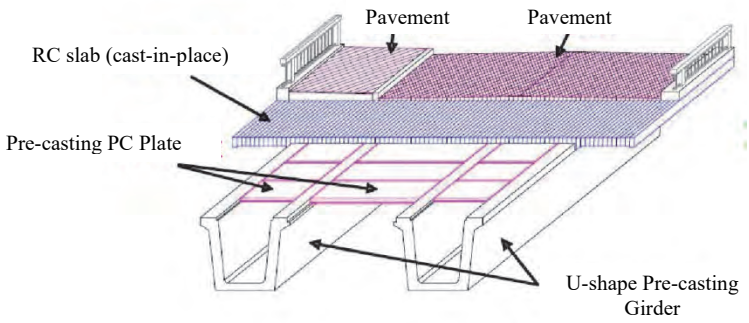
Source: JICA Survey Team

New Technology ***～ PC Composite Girder ～***

PC Composite girder is relatively new type of PC structure.

Characteristics of this bridge type are the following. This is a very suitable bridge type for the viaducts in the urban area.

- ✧ *High quality pre-casting girders can be fabricated at factory and/or casting yard in a short time.*
- ✧ *Fabrication of girders and pre-casting slabs at a factory and/or casting yard enables applying high-strength concrete, labour saving and cost reduction.*
- ✧ *Since the PC plate plays a role as the formwork and the scaffolding at the time of the slab construction, and the assembling and dismantling of hanging scaffolding for slab construction is unnecessary*
- ✧ *It can reduce the production of waste materials, noise and vibration at the site since the pre-casting girders are applied.*
- ✧ *U-shape girder improves stability at the time of erection.*



Source: Japan Pre-stressed Concrete Contractors Association

Sketch of PC-U Composite Girder

(3) Viaduct for Special Sections

A special section of the viaduct includes flyovers of intersection, junctions and river crossing portions. Generally the span length of the viaduct requires 60m to 80m at flyover of intersections and junctions. Considering the necessary span length, the Steel Box Girder and PC Box Girder are extracted for alternatives. For erection at intersections or junctions, the construction period should be minimized in order to mitigate adverse impact to existing traffic and residents. In this regard, the Steel Box Girder is proposed to be a reasonable bridge type for the special section since the construction period for PC Box Girder is usually longer.

6.4 Study of Foundation Type and Substructure Type

6.4.1 Introduction

In general, the below points were taken into account for the study of substructure and foundation type.

Substructure

- Economic efficiency
- Ease of construction
- Social impact during construction due to substructure shape in residential areas
- Low resistance against water flow in river
- Supporting load of substructure
- Conditions under viaducts

Foundation

- The water depth for prothe posed bridge sites
- Possibility of scouring (sufficient attention must be paid to scouring)
- Supporting load of foundation
- Depth of the supporting layer and soil properties at the sites

6.4.2 New Bago – Kyaito Road

(1) Substructure and Foundation Type for Main Bridge of the New Sittaung Bridge

Substructure Type

Wall type pier is selected since it has the lowest resistance against river flow.

Foundation Type

For the New Sittaung Bridge, the span length of the superstructure is arranged with 120m so that the dead load of structure is also relatively large. In addition, the resistance for future scoring due to river flow and tidal waves should be considered.

Four different foundation types such as Cast-in-Place Concrete Pile (CPCP), Steel Pipe Pile (SPP), Steel Pipe Sheet Pile (SPSP) and Concrete Caisson (CC) can be applied for the foundations according to Table 6.4.1. However, SPSP can be used not only as a permanent foundation, but also as a temporary cofferdam during river works. The application of SPSP would therefore be more reasonable than that of SPP in terms of saving cost and shortening construction time. Hence, we can narrow down the foundation types to be compared to three (CPCP, SPSP and CC).

The CPCP foundation, which is common in Myanmar, is not economical since i) the construction period for pile cap is restricted to the dry season so that the period might be extended ii) the number of required piles is will be high due to the considerable pile length from the riverbed and iii) stand pipes are necessary for the piles above the riverbed.

Table 6.4.2 shows the comparison of foundation types inside the river, suggesting that Steel Pipe Sheet Pile (SPSP) foundations have some comparative advantages in economic terms, resistance to scoring and application of new technology.

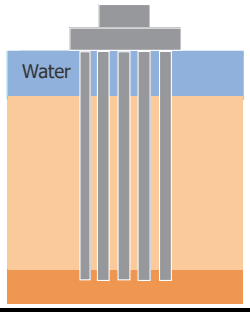
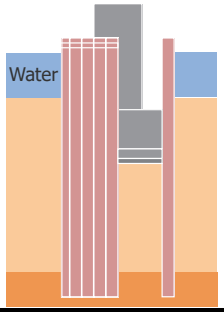
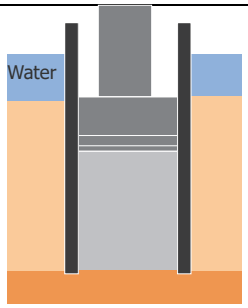
Table 6.4.1 Applicable Foundation Types (inside River) for New Sittaung Bridge

Criteria			Cast- in-place Concrete Pile	PHC / SC PIle	Steel Pipe Pile	Diaphragm wall	Steel pipe sheet pile	Caisson
Condition of Construction	Temporary Jetty	Depth < 5 m	△	○	○	×	○	△
		Depth > 5 m	△	△	○	×	○	△
	Environment	Vibration, Noise	○	×	×	○	△	○
		Impact on Adjacent Structure	○	×	△	○	△	△
	Loading	Normal	○	○	○	○	○	○
		Large	○	×	○	○	○	○
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	△	×	△	△	△	△
	Soil Condition	Clay (20 ≤ N)	○	○	○	○	○	○
		Sand/Gravel (30 ≤ N)	○	○	○	○	○	○

NOTE ○: Suitable, △: Possible, ×: Impossible

Source: JRA

Table 6.4.2 Comparison of Foundation Types inside River (New Sittaung Bridge)

Foundation Type	Cast in Place Concrete Pile	Steel Pipe Sheet Pile (SPSP)	Concrete Caisson
			
Workability on Water	**Inferior** - Temporary cofferdam is required separately. - Permanent casing is required. - Loading test is required.	**Superior** - Temporary cofferdam is not required separately. - Loading test is not required.	**Moderate** - Temporary cofferdam is not required separately. - Loading test is not required.
Work Period	**Moderate** - Driving of many piles takes time.	**Superior** - After driving steel pipe, construction is fast and safe.	**Moderate** - It takes time for excavation.
Against Ship Collision	**Inferior** - Because multi-pile structure.	**Superior** - Because rigid and massive structure.	**Superior** - Because rigid and massive structure.
Against Scoring	**Inferior** - Because multi-pile structure.	**Superior** - Because rigid and massive structure.	**Superior** - Because rigid and massive structure.
Safety of Works	**Moderate** - Temporary cofferdam is required separately.	**Superior** - Temporary cofferdam is not required separately.	**Superior** - Temporary cofferdam is not required separately.
Cost	**Inferior** (1.19)	**Superior** (1.00)	**Moderate** (1.15)
New Technology	**Much** - No introduction of new technology.	**One** - This technology is still new technology despite of one practice in grant aid project by JICA.	**Some** - No introduction of new technology.
Evaluation	Not Recommended	**Recommended**	Not Recommended

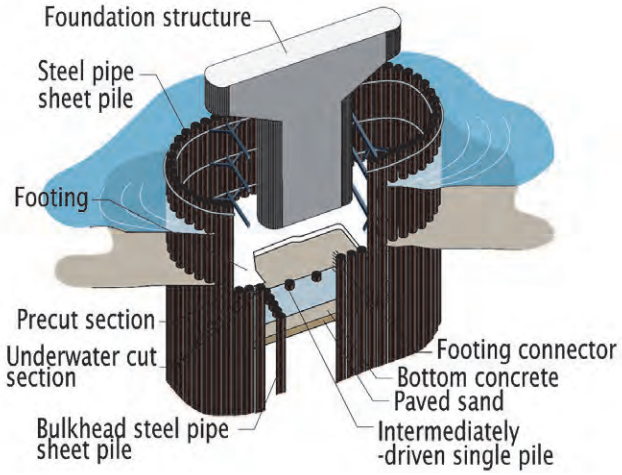
Source: JICA Survey Team

New Technology ***～Steel Pipe Sheet Pile(SPSP) Foundation～***

Apply to River Crossing Bridge

The SPSP Foundation method has been used to lay the foundation works for more than 2,000 bridges in Japan.

Compared to previous construction methods such as shutting down the river flow or constructing islands in the river, constructing dual-purpose SPSP for temporary cofferdam using steep pipe piles as cofferdam materials can reduce construction time and costs as well as make it easier to build in deep water or soft ground, where construction is often difficult.



(2) Substructure and Foundation Type for Standard Section

Substructure Type

1-Column and T-shape pier and reversed T-shape abutment are recommended for standard section on the Bago- Kyaito Road since these types are most economical and popular.

Foundation Type

Cast-in-place concrete piled foundations are recommended for the foundation types of piers and abutments on land (to be constructed on existing ground), due to their ease of constructability and procurement of materials/equipment as well as gaining experience in Myanmar.

6.4.3 Improvement of National Highway No.1

(1) Introduction

The Study of sub-structure and foundation is considered in the points below and carried out in the Standard Section and Special Section separately.

- Simple detour step (only one time or two times)
- Smoothest traffic flow
- Keep convenience for residents

- Avoid additional land acquisition as much as possible

(2) Substructure and Foundation Type for Standard Section

Substructure Type

1-Column & T-shape Type pier is recommended due to the following advantages:

- Detour procedure is simple due to two-step detours.
- To mitigate involuntary resettlement due to minimized road formation width
- Due to a smooth line of fencing, traffic flow is smooth.

Foundation Type

There are some sections located in residential areas. Therefore, the foundation and pile caps need to be constructed under restricted conditions. Besides, the quick, safest and most eco-friendly type should be selected.

In general, the widest construction yard during construction of foundation and pile cap is requited. The size of the pile cap is determined by the type and number of foundations. Therefore, the required width for the construction yard is one of the important factors in deciding the foundation type.

It seems that the foundation depth will be around 40m deep[13]. The construction depth of each foundation type is shown in Table 6.4.3.

Table 6.4.3 Possible Construction Depth Due to Foundation Type

	Depth which can be constructed (m) 10 20 30 40 50 60
Spread Foundation	
RC Pile	
PC Pile	
Steel Pipe Pile	
Bored Pile	
Bored Pile with Manual Excavation	
Open Caisson	
Pneumatic Caisson	

Source: JICA Survey Team

As shown in Table 6.4.3, various types of foundations can be applied to the Standard Section for NH1. However, following foundation type is not suitable to apply to this project in consideration of the condition of this project.

- Caisson

A caisson structure is applicable to bigger scale bridges, in general. If this foundation type is applied to a viaduct structure, the construction cost and period becomes much bigger and longer. Therefore, both of these methods are not applicable the section.

- PC Pile and Steel Pipe Pile

In general, the bearing capacities of PC pile and Steel Pipe Pile are rather smaller than other foundation types. In this project, it is necessary to bear both bound traffic by one foundation. Therefore, a large size of bearing capacity is required for one pile. However, recently, a new construction method has been established in Japan for the Steel Pipe Pile. It is called "Screw Steel

[13] According to the Data Collection Survey on the Project for Construction of Yangon Urban Expressway (YUEX), November 2014, JICA

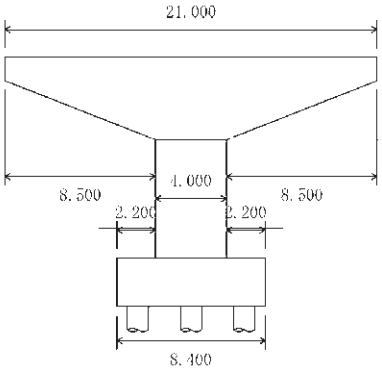
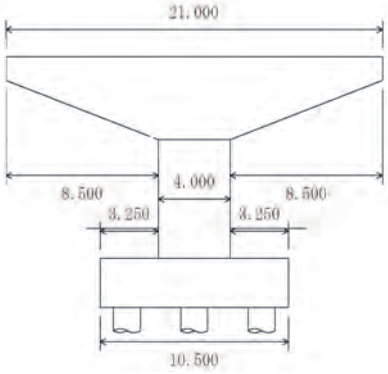
Pile Method". Tip resistance can increase by addition of a blade at the tip of a steel pile. In addition, due to the none-excavate construction method, skin friction becomes bigger than normal PC Pile and Steel Pipe Pile. As a result of these factors, the bearing capacity becomes same level as Bored Pile. Therefore, "Screw Steel Pile" is worthy of study as an alternative. The design and construction method of the Screw Steel Pile is referred to in "Specification for Design of Pile Foundation" and "Specification for Construction of Pile Foundation" published by Japan Road Association in January 2007.

In consideration with the above mentioned comments, the Bored Pile and Screw Steel Pile are compared in Table 6.4.4.

As a result of the study, "Screw Steel Pile" is selected as the recommended foundation type at areas where are difficult to secure enough construction yard from the following points of view, although further study is necessary depending on detailed geotechnical survey in next stage.

- Construction of one pile can be completed only one day
- Less vibration and noise
- Due to no excavation, site becomes clean.
- New technology can be introduced in Myanmar

Table 6.4.4 Comparison Foundation Type for Standard Viaduct Section on NH1

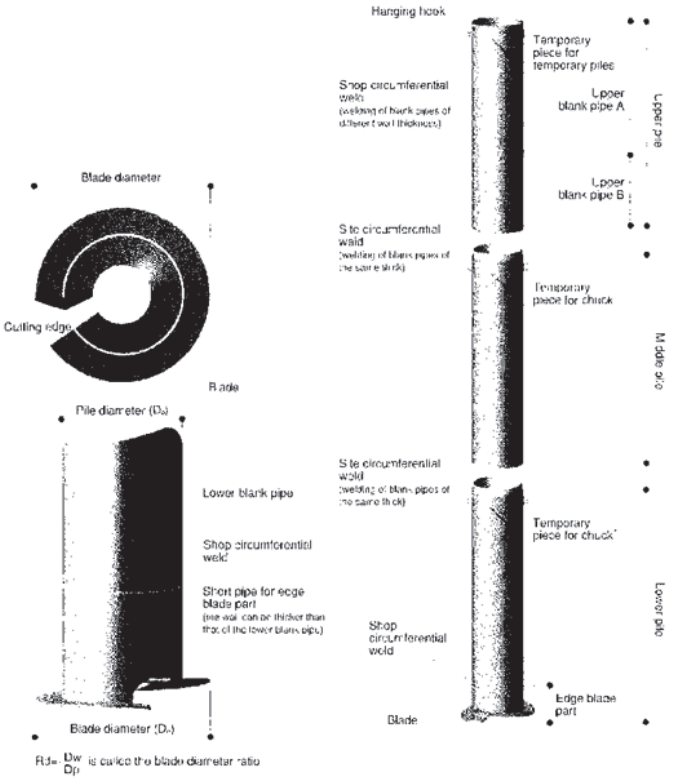
Type	Alt-1 : Screw Steel Pile	Alt-2 : Bored Pile
Sketch		
Foundation Size	D=1200mm, N=8	D=1500mm, N=6
Pile Cap Size	8.4m x 8.4m	7.5m x 10.5m
Structural Feature	- Maximum length of foundation is around 60m. - Construction method is screwing into the ground by rotation machine. - Bearing capacity is calculated by tip resistance at bottom blade and skin friction at outer surface of piles.	- Typical digging method is "Earth Drill" method. - Most typical foundation type, if there is enough space for construction yard - Bearing capacity is calculated by tip resistance at bottom and skin friction at outer surface of piles.
Constructability	+ Need only one day for the construction of a pile + Need less space for construction	- Need 2 days for the construction of a pile - Need more space for construction
Environmental and Social Impact During Construction	+ Expect low vibration and noise during piling work. + Due to the non-excavation method, no wasted soil is produced and the site becomes cleaner	- Expect some vibration and noise during excavation and piling. - Need a drainage system in order to avoid the leakage of bentonite water outside of construction yard - Need cover sheets for excavated soil and tire washing equipment for truck in order to avoid dust.
Construction Cost (Ratio)	1.16	1.00
New Technology	+ New technology can be introduced	- Most common foundation type
Evaluation	**Recommended**	Not Recommended

Source: JICA Survey Team

New Technology ***～Screw Steel Pile～***

Eco-friendly Method.
- ✧ *None-excavated method*
- ✧ *No bentonite circulation system*
- ✧ *Site becomes very clean. And, no dust is expected*

Compact Shape
Skin friction becomes bigger by compressing surrounding soil.



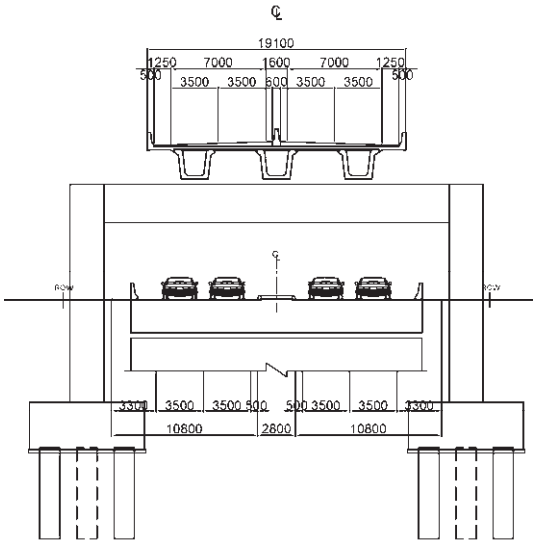
Sketch of Screw Steel Pile

(3) Substructure and Foundation Type for Special Section

Substructure Type

Substructure type at a special section is adopted the same type (1-Column & T-shape Type) as the standard section when the medium width (5.5m) of frontage road can be secured.

However, the rigid frame steel piers shall be applied to the locations where the viaduct needs to overpass existing bridges and to be widened or replaced as described in Figure 6.4.1.



Source: JICA Survey Team

Figure 6.4.1 Rigid Frame Steel Pier at Special Section

Foundation Type

The foundation and pile cap need to be constructed under restricted conditions. Besides, the quicke, safe and most eco-friendly type should be selected.

Therefore, the foundation type at a special section is basically applied as the same one as a standard section.

CHAPTER 7 PRELIMINARY CONSTRUCTION PLAN

7.1 Introduction

In this chapter, a preliminary construction plan and implementation schedule are proposed for the Project. The project roads are divided into two Sub-projects as below.

Sub-project 1 : Project for the Construction of New Bago – Kyaito Road

Sub-project 2 : Project for the Improvement of National Highway No.1

7.2 Preliminary Construction Plan

7.2.1 Proposed Contract Package for Civil Works

Considering the components of each sub-project, the following contract packages are proposed in this survey. Contract packages are basically divided by a certain length, which is around 20km, in order to clarify responsibilities for construction defects. A contract package is set for New Sittaung Bridge construction, in which advanced technology such as "Hybrid PC Bridge with Steel Web" is proposed, since the required capacity and experience for contractor is quite different from other sections.

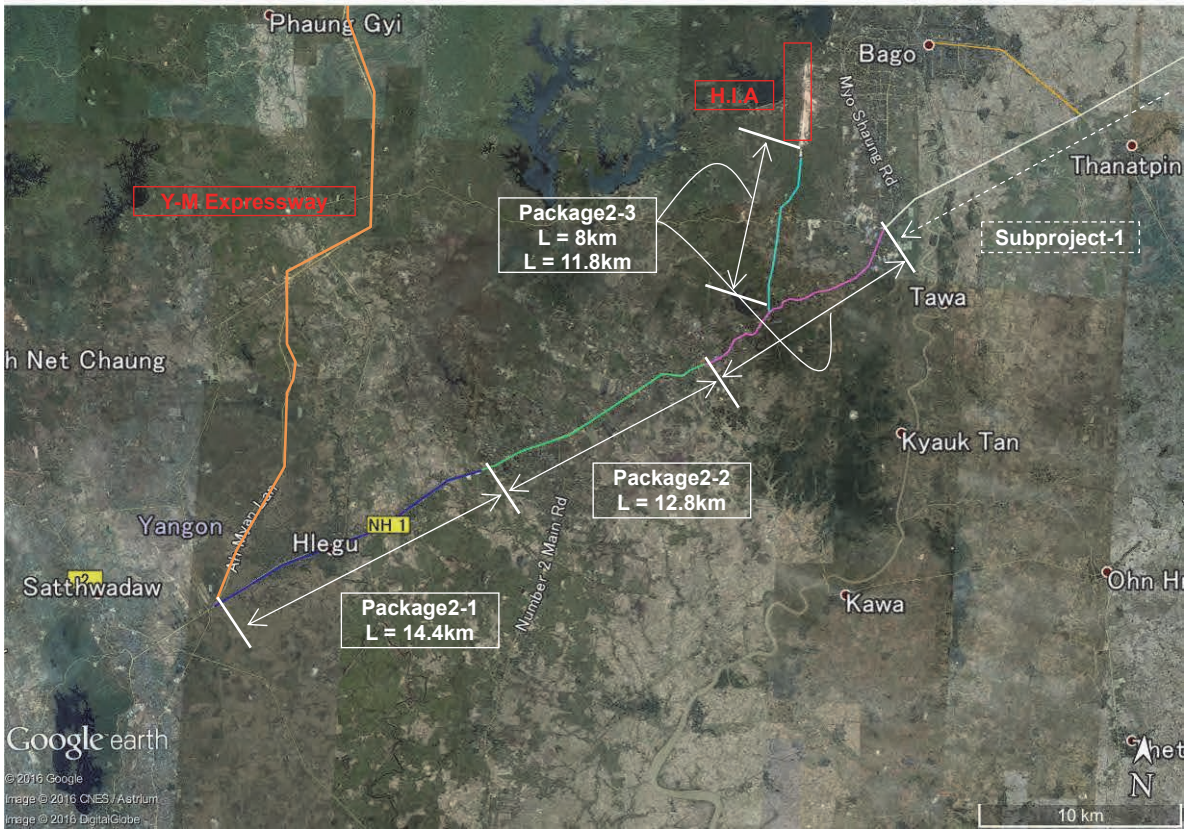
Table 7.2.1 Assumed Contract Packages for Each Sub-project

Sub-project Name	Package	Component	Length
Sub-project-1	Pk 1-1	AC pavement road (4-lane)	21.2km (At-grade section)
	Pk 1-2	AC pavement road (4-lane)	24.3km (At-grade section)
	Pk 1-3	New Sittaung Bridge & Approach road	7.0km (Bridge: Approx. 2.5km, Approach Rd. : 4.5km)
	Pk 1-4	AC pavement road (4-lane)	26.6km (At-grade section)
Sub-project-2	Pk 2-1	Widening of NH1 (8-lane)	14.4km (At-grade : 6.4km, Viaduct : 8km)
	Pk 2-2	Widening of NH1 (8-lane)	12.8km (At-grade : 2km, Viaduct : 10.8km)
	Pk 2-3	Widening of NH1 (8-lane)	11.8km (At-grade)
		Hanthawaddy International Airport Access Expressway (4-lane)	8.0km (At-grade)

Source: JICA Survey Team

Source: Prepared by JICA Survey Team based on Google Earth

Figure 7.2.1 Proposed Construction Package for Sub-project-1



Source: Prepared by JICA Survey Team based on Google Earth

Figure 7.2.2 Proposed Construction Package for Sub-project-2

7.2.2 Basic Concept for Construction

In this section, the basic concept for construction is described.

(1) Sub-project-1 : Project for the Construction of New Bago – Kyaito Road

It is considered that there is no critical constraints in this Sub-project due to new road construction, however, the below points should be taken into account.

Preparation of Access Temporary Road to Construction Sites

Access to temporary roads should be constructed in order to haul necessary materials, machinery and equipment to the construction site. As shown in Figure 7.2.1, four temporary roads branching from the existing arterial roads are planned to be constructed. These temporary roads are currently community roads for residents along the Project Area, so that the required mitigation measures should be prepared ahead of construction.

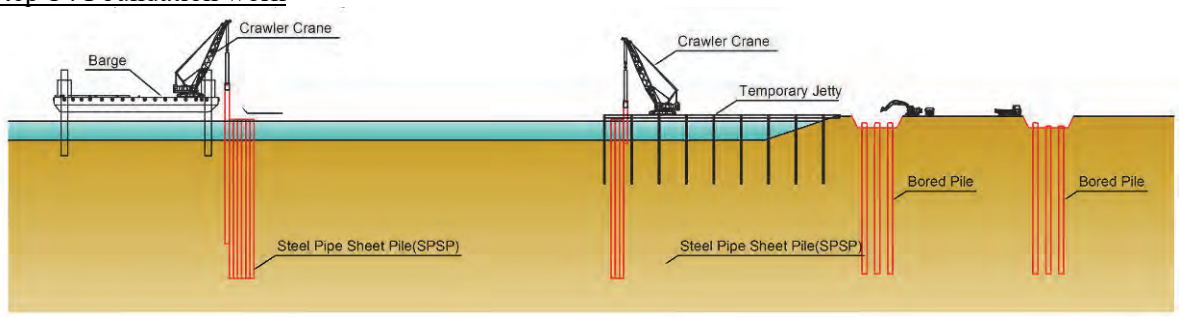
Construction of New Sittaung Bridge

Influence by tidal range and tidal waves should be taken into consideration for the construction plan since the bridge is located near a river mouth. In particular, the construction of the foundation might be severely affected. Accordingly, it is recommended that the foundation work in the deep river is conducted by barge crane, which can be lifted up and down by itself depending on the water level, and foundation work near the river bank is conducted on a temporary jetty as shown in Figure 7.2.3.

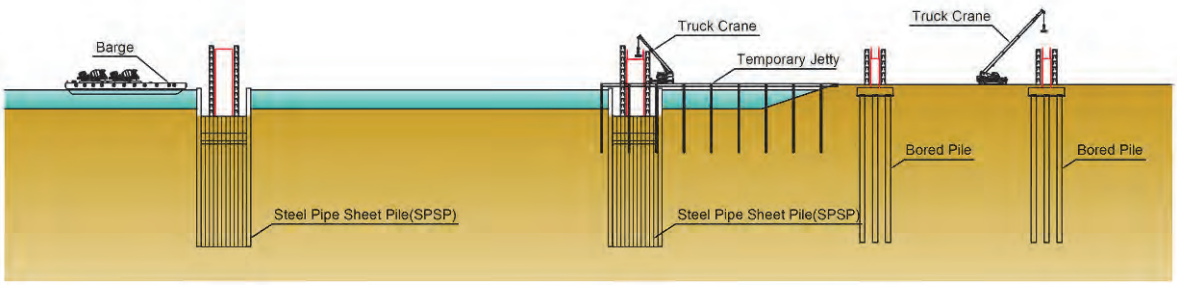
The superstructure is basically planned to be conducted by a balanced cantilever method and necessary materials, and equipment is to be hauled from bridge surface or temporary jetty.

Basic construction sequence is shown in Figure 7.2.3.

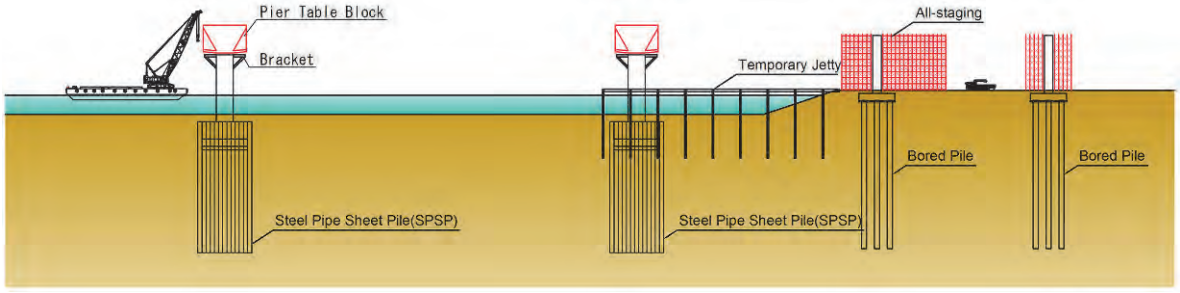
Step 1 : Foundation work



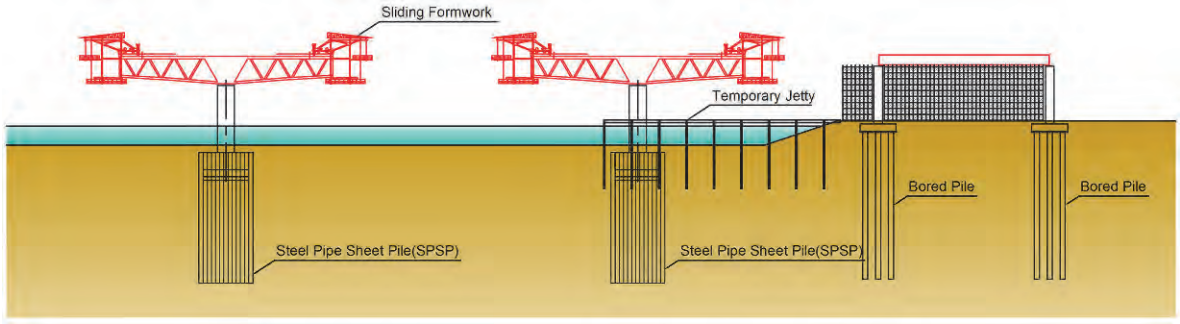
Step 2 : Substructure work



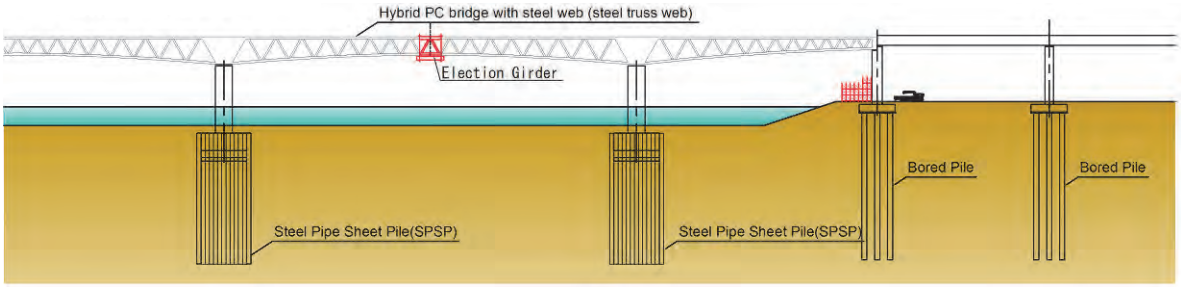
Step 3 : Installation of temporary support for superstructure



Step 4 : Superstructure work



Step 5: Element closure and Bridge surface work



Source: JICA Survey Team

Figure 7.2.3 Basic Construction Sequence for New Sittaung Bridge

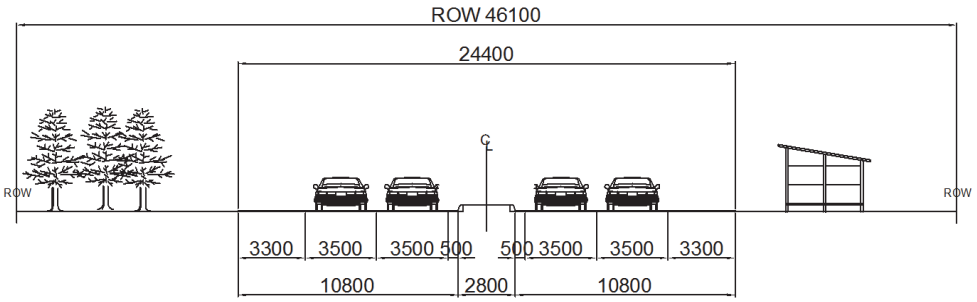
(2) Sub-project 2 : Project for the Improvement of National Highway No.1

The basic construction sequence is described in this section. Only one time traffic diversion is necessary for the improvement of NH1 as shown in Figure 7.2.4.

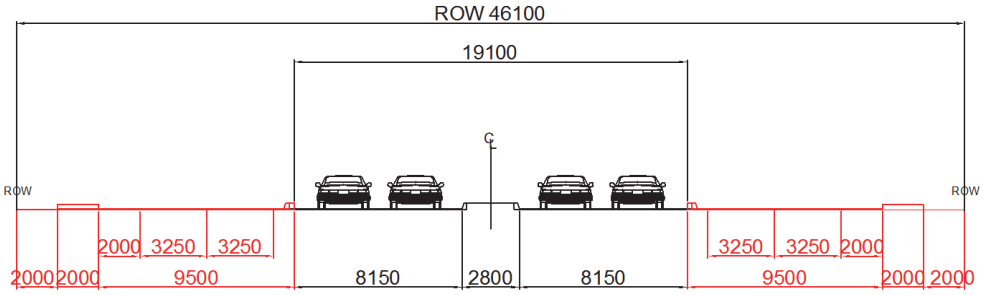
1) Basic Construction Sequence for the At-grade Section

Construction work for the at-grade section is easier than for the viaduct section since the required construction yard is basically secured and there are no critical constraints.

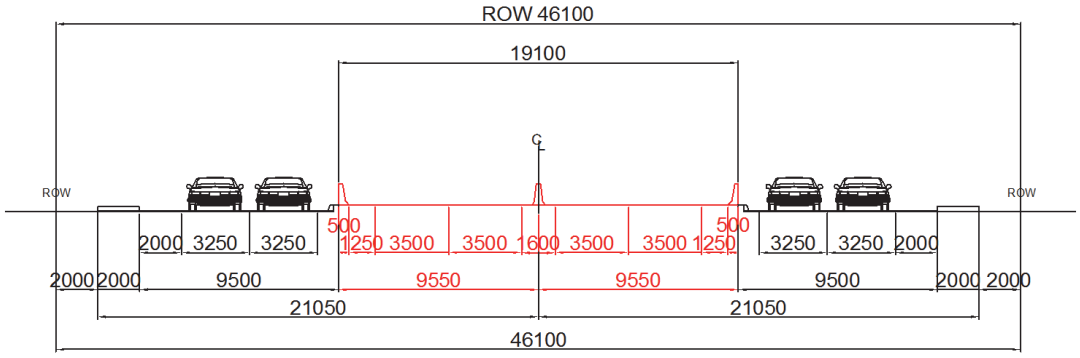
Step 0 : Current condition



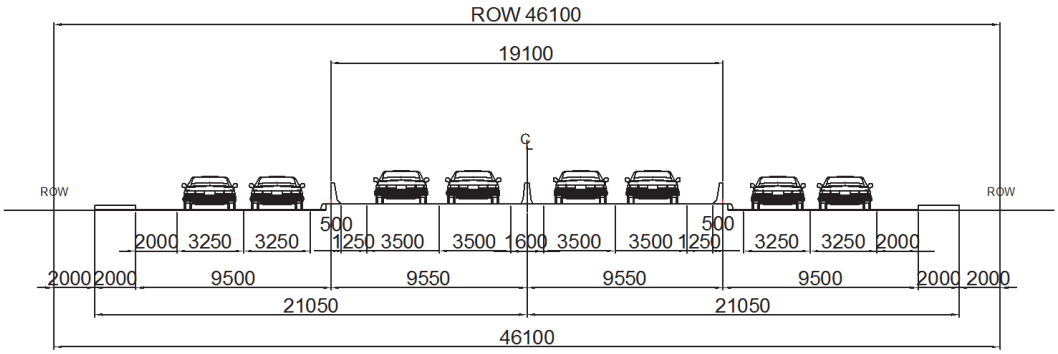
Step 1 : Construction of frontage road (arterial road)



Step 2 : Construction of expressway



Step 3 : Completion



Source: JICA Survey Team

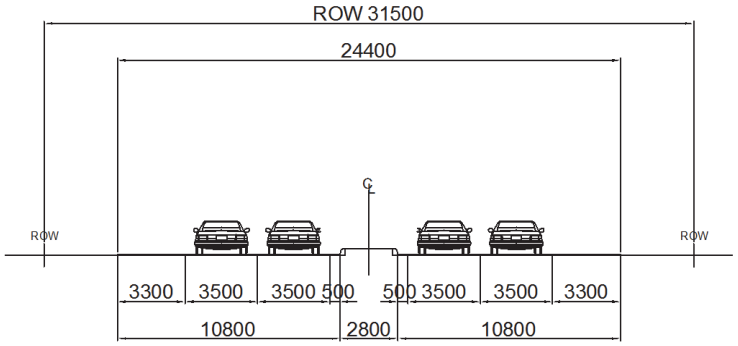
Figure 7.2.4 Basic Construction Step for Improvement of NH1 (At-grade Section)

2) Basic Construction Sequence for Viaduct Section

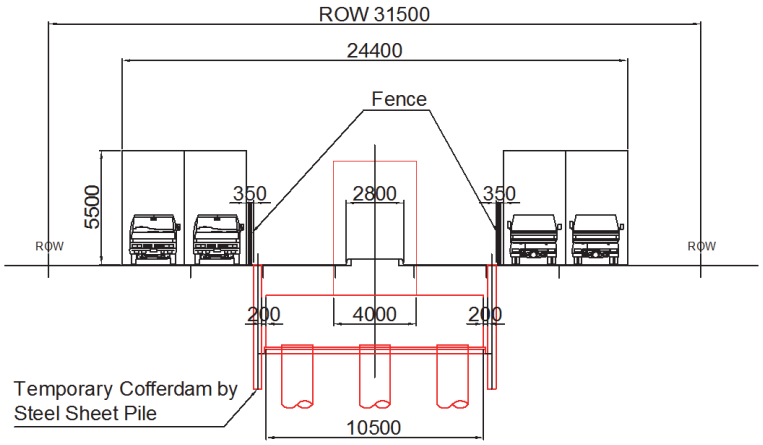
Diversion during Construction

Currently, there are four to six carriageways in National Highway No.1. In order to minimize traffic congestion and keep up the service level for residents living along the road, it is necessary to maintain the existing traffic even during construction of the viaduct. However, it is obvious that the width utilized for the detour road will be narrower than the existing road width. In order to maintain the existing traffic as much as possible, at least two carriageways will be secured in each direction. In consideration of the construction method for each work item, the work item for "Construction of Pile Cap" which is required is the widest construction yard. Therefore, a study on a detour plan and necessary construction yard will be carried out at the construction stage for the Pile Cap. After the study on the necessary width for the construction of the Pile Cap, approximately 11m width as construction yard will be required, even if a steel sheet pile is used to reduce the width of the necessary construction yard as described in Figure 7.2.5 (Step2).

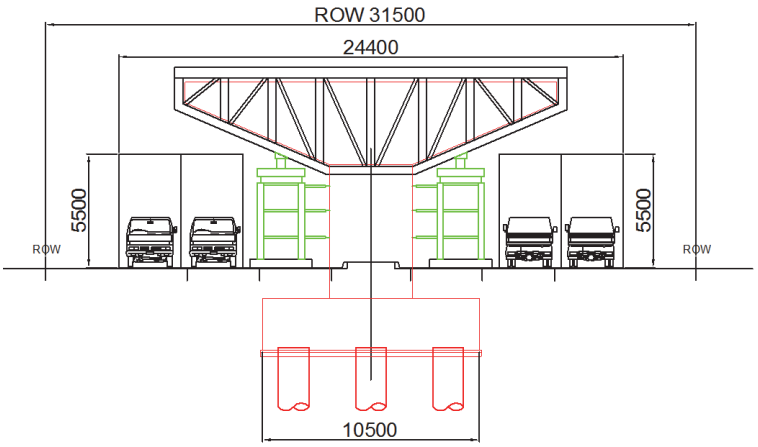
Step 0 : Current condition



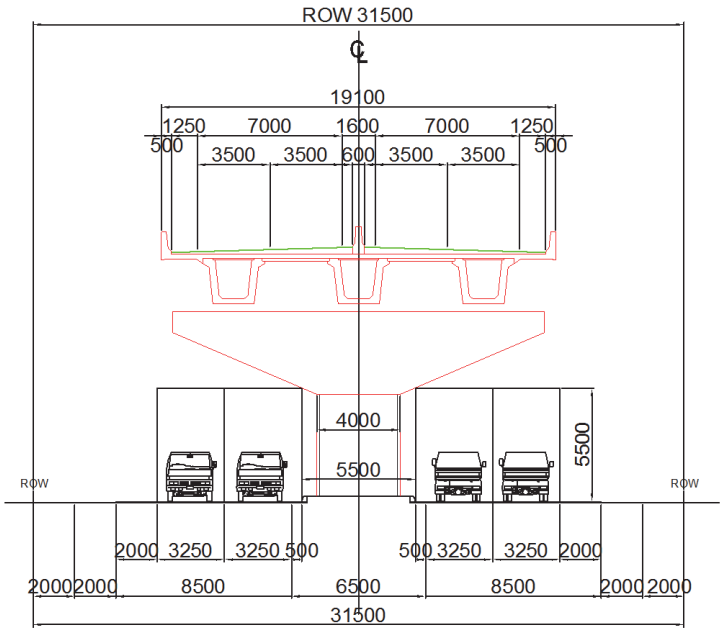
Step 1 : Diversion and foundation work



Step 2 : Substructure work (Expressway)



Step 3 : Erection of superstructure and bridge surface work



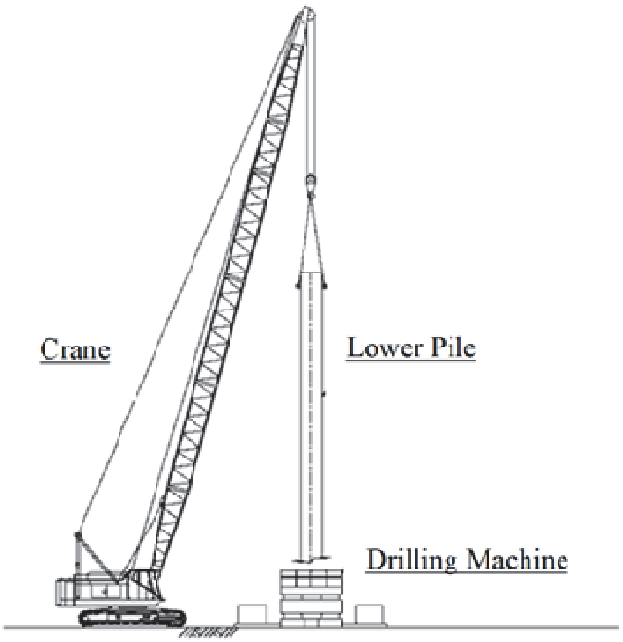
Source: JICA Survey Team

Figure 7.2.5 Basic Construction Steps for the Improvement of NH1 (Viaduct Section)

Screw Steel Pile

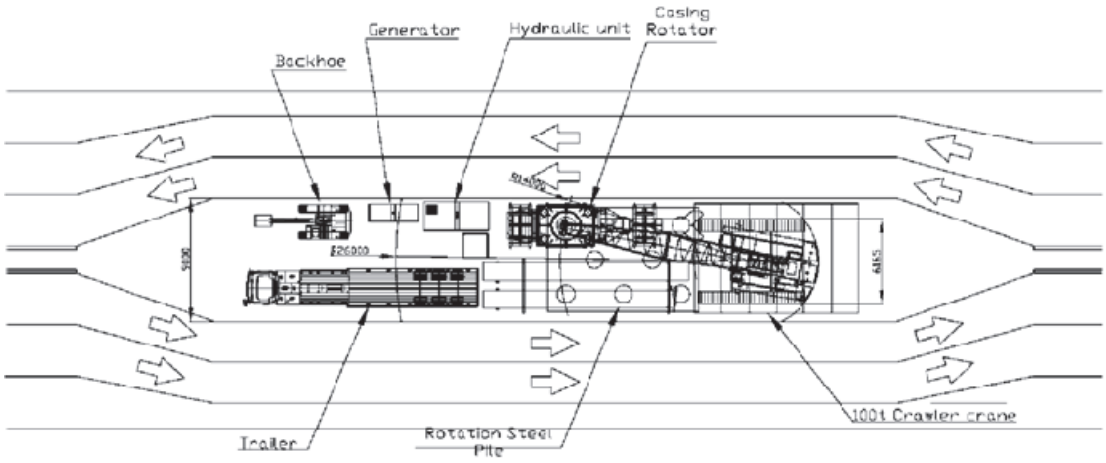
The recommended foundation type is the Screw Steel Pile type. After the levelling of ground and pile location survey, a casing rotator machine will be set and the installation of lower pile will be commenced. Connection between lower pile and upper pile will be by welding at the site.

Typical sketches for the construction of Screw Steel Pile and layout of equipment at the site are shown in Figure 7.2.6 and Figure 7.2.7 respectively.



Source: JICA Survey Team

Figure 7.2.6 Sketch for Construction of Screw Steel Pile



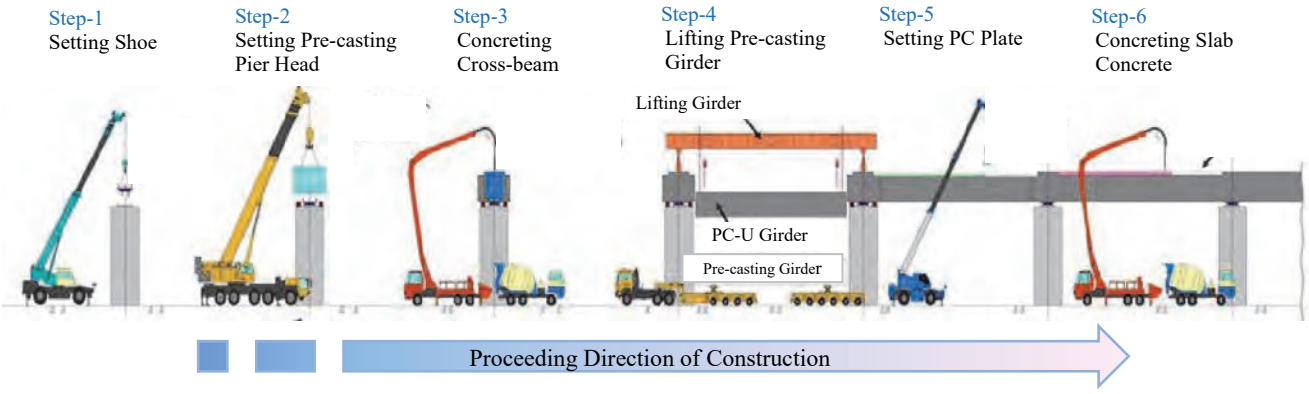
Source: JICA Survey Team

Figure 7.2.7 Sketch for Layout of Equipment

Superstructure : PC-U Composite Girder (Standard Section)

The PC-U Composite Girder' segment will be fabricated at a factory and/or fabrication yard and be transported by trailers to the erection site. In order to avoid negative impacts to detoured traffic as much as possible, erection work needs to be carried out at night time under traffic control.

During the construction of the substructure, girders will be fabricated at a factory and/or fabrication yard. Figure 7.2.8 shows the outline of the lifting erection method of PC-U Composite Girder.



Source: Japan Pre-stressed Concrete Contractors Association

Figure 7.2.8 Outline of Lifting Erection Method of PC-U Composite Girder

Superstructure : Steel Box Girder (Special Section)

The main girder of the Steel Box Girder consists of several blocks for each span. Basic assembly of each block will be carried out at erection the site. The erection of the main girder will be carried out by the launching erection method or erection by multi-axle truck at night time under traffic control in order to mitigate adverse impacts to existing traffic and residents. During the construction of the substructure, all steel members will be fabricated at a steel girder fabrication factories. Figure 7.2.9 shows the sample of the erection of steel box girder by launching erection method and erection by multi-axle truck.

Source: Nippon Sharyo HP (Left), Japan Bridge Association Inc. (Right)

Figure 7.2.9 Example of Erection by Launching Erection Method (Left) and Multi-Axle Truck(Right)

7.3 Implementation Schedule

For the establishment of an implementation schedule, the following assumptions are basically applied:

- Scheme of Japanese ODA loan will be applied
- Feasibility Study will be commenced in 2017
- Loan agreement will be signed in 2018
- Procurement of D/D consultant will begin after the pledges from the Myanmar government and the Japanese government

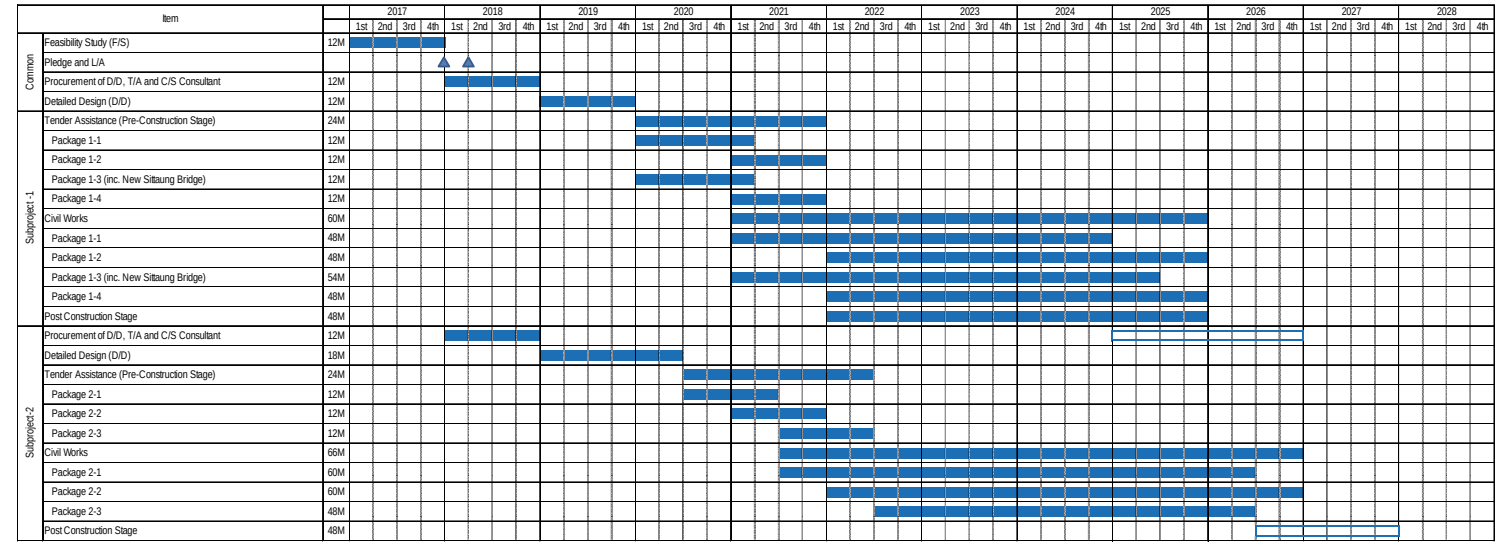
On the other hand, it is concerning that conflict between sub-projects at the construction stage might occur since a part of the hauling route may be same as NH1 between sub-projects. Thus, another option is proposed for smooth project implementation. Therefore the implementation schedule is established for the below two cases[14];

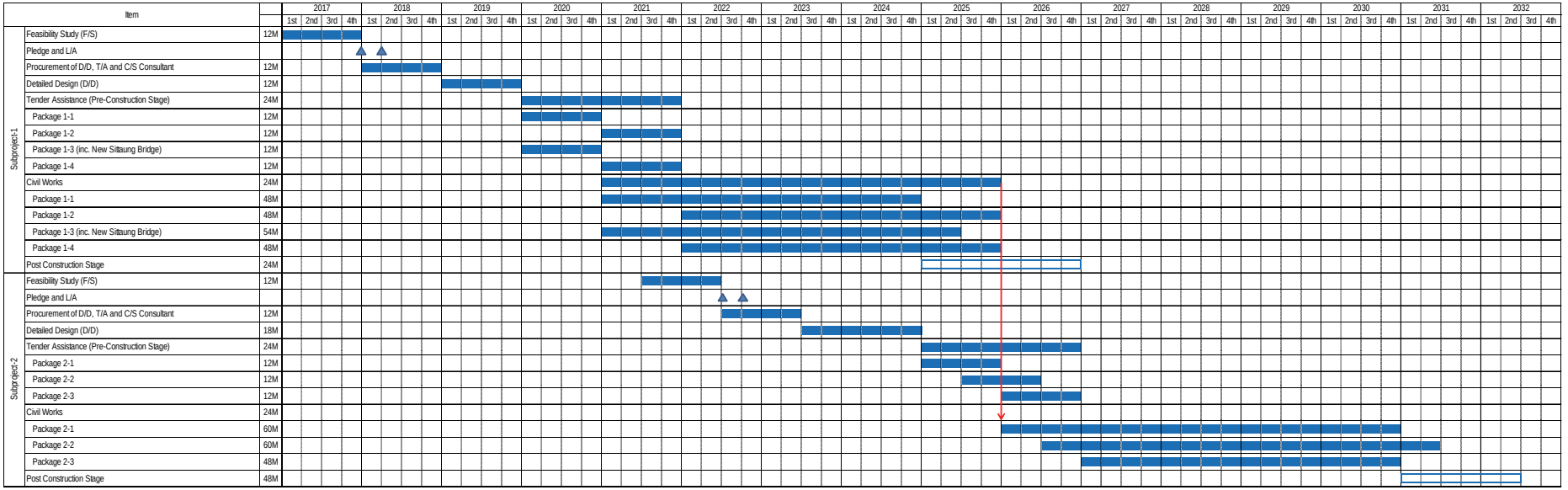
Case 1 : Sub-projects will be commenced at the same time

Case 2 : Construction of Sub-project-2 will be commenced after completion of Subproject-1

The implementation schedule for each case is shown in Figure 7.3.1.

[14] The adverse impact to the surroundings during construction, such as increase of traffic accident, severe traffic congestion, are concerned in the case-1. To avoide the impact, the phased construction can be one of options for project implementation. Comparing the congestion factor (Traffic Volume / Traffic Capacity) shown in Table 2.3.1 and Table 2.3.2, the future traffic demand in the section (Bago – Kyaito) would exceed the current traffic capacity earlier than the section (Y-M expressway connect – Bago). Thus, in the case-2, the construction works for the sub-project1 are assumed to be commenced prior to the sub-project 2.





Source : JICA Survey Team

Figure 7.3.1 Proposed Implementation Schedule (Upper ; Case-1, Bottom ; Case-2)

CHAPTER 8 PRELIMINARY COST ESTIMATES

8.1 General Condition

The finance scheme for each sub-project has not been determined yet. The following preconditions are assumed for the preliminary cost estimation in this survey:

- Date of Estimate : July 2016
- Exchange Rate : 1 US dollar = 109.2 Japanese Yen (JPY), 1189.0MMK
- Price Escalation : Not considered
- Consultant Fee : 8% of Construction Cost
- Physical Contingency : 5% of Construction Cost + Consultant Fee
- Administration Cost : 5% of Construction Cost + Consultant Fee

8.2 Result of Cost Estimates

8.2.1 Construction Cost (Base Cost)

The preliminarily estimated construction cost for each Sub-project is shown in Table 8.2.1 and Table 8.2.2 respectively.

Table 8.2.1 Estimated Construction Cost (Base Cost) for New Bago-Kyaito Road

Unit Mil.USD

Item	Package 1-1 (L=21.2km)	Package 1-2 (L=22.4km)	Package 1-3 (L=8.8km)	Package 1-4 (L=19.6km)	Total (L=72km)
Road Work	64.2	62.2	26.4	51.1	203.8
Structure Work	75.1	14.6	1.3	22.5	113.6
New Sittaung Bridge	0.0	0.0	180.7	0.0	180.7
Total	139.3	76.8	208.4	73.6	498.1

Source : JICA Survey Team

Table 8.2.2 Estimated Construction Cost (Base Cost) for New Bago-Kyaito Road

Unit Mil.USD

Item	Package 2-1 (L=14.4km)	Package 2-2 (L=12.8km)	Package 2-3 (L=19.8km)	Total (L=47km)
Road Work	47.2	35.6	81.8	164.6
Structure Work	380.3	430.3	47.5	858.1
Total	427.5	465.9	129.3	1,022.7

Source : JICA Survey Team

8.2.2 Total Project Cost

The total project cost is estimated as shown in Table 8.2.3.

Table 8.2.3 Estimated Project Cost

Unit : Mil.USD

Item	Sub-project-1	Sub-project-2	Total	Remark
Construction Cost	498.1	1,022.7	*1,520.8*	
Consultant Fee	40.0	82.0	*122.0*	8% of Construction Cost
Physical Contingency	27.0	55.0	*82.0*	Construction : 5%, Consul : 5%
Administration Cost	27.0	55.0	*82.0*	Construction : 5%, Consul : 5%
Land Acquisition Cost	37.0	44.0	*81.0*	
Total	*629.1*	*1,258.7*	*1,887.8*	

Note) Breakdown for land acquisition is shown in Table 10.4.3 (Chapter 10).
Source : JICA Survey Team

CHAPTER 9 ECONOMIC ANALYSIS

9.1 Introduction

9.1.1 Preconditions for Economic Analysis

The contribution of the projects to the national economy is analysed in this chapter. The Economic Internal Rate of Return (hereinafter referred to as EIRR) and Cost-Benefit Ratio (B/C) are adopted as evaluation indicators, and these indicators are calculated from annual benefit and cost of the projects with the discounted cash flow method.

The project consists of the following Sub-projects. EIRR and B/C of the following Sub-projects are calculated in this chapter.

- Sub-project 1: Project for Construction of New Bago – Kyaito Road, and
- Sub-project 2: Project for Improvement of National Highway No.1

Table 9.1.1 shows the preconditions such as project life, exchange rate, social discount rate and for the economic analyses.

Table 9.1.1 Preconditions for Economic Analysis

Items	Conditions	Remarks
Project life	20 years after opening 2026–2045 for Sub-project 1 2027–2046 for Sub-project 2	Starting year of design: 2018 Opening year: 2026 for the sub-project 1, 2027 for Sub-project 2
Exchange rate	1US dollar = 109.2 Japanese yen 1US dollar = 1,189.0 Myanmar kyat	Based on Preparatory Survey for Regional Development Project for Poverty Reduction Phase II
Social discount rate	12%	TA-8330 MYA: GMS East–West Economic Corridor Eindu to Kawkareik Road Improvement
Economic cost	Taxes and price escalation are deleted from financial prices	–

Source: JICA Survey Team

9.1.2 Vehicle Operating Cost

The economic benefit of the project consists of (1) the saving of Vehicle Operating Cost (VOC) and (2) reduction of travel cost. The economic benefit will be listed in the cash flow table from 2026 to 2045 for Sub-project 1, and from 2027 to 2046 for Sub-project 2.

Vehicle operation cost includes the purchasing and maintenance cost of vehicles, fuel cost, insurance cost, etc.

The analysis in this chapter utilizes the VOC data of "*Feasibility Study of Economics, Engineering, and Environmental Impacts of the Four-Lane Highway Widening Project (Phase II), Route No. 12,*

Section Lom Sak – Consan Intersection," which was prepared in in 2010 due to limited availability if inter-city VOC data in Myanmar. The VOC figures are adjusted to 2016 values by using Thailand's inflation rate, and then exchanged into Japanese Yen amounts. Table 9.1.2 indicates the adjusted VOC data by road conditions and vehicle classification. The VOC data corresponding to "flat roads" at 30 km/h was utilized in order to calculate VOC savings. The method to calculate VOC was also used in the pre-feasibility study of the "Survey Program for the National Transport Development Plan" and Final Report-1 of this Study.

Table 9.1.2 VOC by Vehicles Classification

Unit: Japanese Yen per kilometer

Road condition	Speed (km/h)	Passenger cars	Buses	2 axis trucks - small	2 axis trucks - large	3 and 4 axis trucks	Trailers
Flat roads	10	45.9	166.5	53.2	97.7	157.8	179.3
	20	28.3	96.8	29.6	56.6	95.8	113.4
	30	22.7	74.1	22.0	43.6	75.8	92.5
	40	20.1	63.5	18.5	37.6	66.9	83.4
	50	18.7	57.6	16.5	34.4	62.4	78.8
	60	17.9	54.3	15.3	32.9	60.5	77.1
Rolling roads	10	46.2	174.9	53.5	99.2	161.9	188.1
	20	28.5	106.7	29.9	59.0	100.3	128.4
	30	22.9	84.4	22.4	46.2	82.0	109.3
	40	20.3	73.7	18.7	40.1	73.5	100.8
	50	18.9	67.5	16.7	36.5	68.6	95.7
	60	18.1	62.4	15.5	34.5	66.0	89.9
Mountainous roads	10	46.8	194.0	54.4	105.8	175.0	225.7
	20	29.2	126.3	31.5	66.1	119.0	167.1
	30	23.7	104.6	24.1	53.4	100.9	149.0
	40	21.1	89.9	20.5	47.5	92.7	129.8
	50	19.6	84.6	18.3	43.9	87.5	126.6
	60	18.8	81.9	17.0	40.7	81.4	125.9

Source: "Feasibility Study of Economics, Engineering, and Environmental Impacts of the Four-Lane Highway Widening Project (Phase II), Route No. 12, Section Lom Sak – Consan Intersection"; the JICA Survey Team adjusts the VOC figures in 2010 to the value in 2016.

9.1.3 Reduction of Travel Time

The reduction of travel time is also a major part of economic benefit. The idea comes from the opportunity cost of working time. Thus, if the reduced time were used for working activity, this produced work is considered to be value added to the national economy.

In Myanmar, the average unit working revenue (working revenue per hour) is calculated from the GDP per capita. IMF's "World Economic Outlook Database, April 2016" estimates that the GDP per capita of Myanmar is USD1,416 in 2016. With this, the survey team can calculate their hourly income to be JPY21.5.

The Survey Team also calculated the increase of the hourly income (real term) in accordance with Myanmar's economic development by use of mid- and long-term GDP growth rate in the "2015 Article IV Consultation Staff Report[15]" by IMF and population growth "World Population Prospects" by UN Population Division[16]. Table 9.1.3 shows the annual growth rate of GDP per capita in five years (in the 2nd row) and hourly income every five years (in the 3rd row). Table 9.1.4 shows the number of passengers per vehicle.

This methodology is the same as Phase I of this project and the pre-feasibility study of the "Survey Program for the National Transport Development Plan" and Final Report-1 of this study.

[15] http://www.imf.org/external/pubs/ft/scr/2015/cr15267.pdf
[16] https://esa.un.org/unpd/wpp/DataQuery/

Table 9.1.3 Changes of Income per Hour

	2016–20	2021–25	2026–30	2031–35	2036–40	2041–45
Growth rate of GDP per capita per year	7.33%	6.22%	6.15%	6.27%	5.39%	5.29%
Income per hour (Japanese Yen)	21.5 (2016)	30.4 (2021)	40.8 (2026)	55.0 (2031)	74.6 (2036)	95.1 (2041)

Source: JICA Survey Team

Table 9.1.4 Number of Passengers per Vehicle

Unit: persons

Vehicle class	Passenger cars	2 axis trucks - small	2 axis trucks - large	3 axis trucks	More than 4 axis trucks	Trailers	Buses
Number of passengers	3.1	1.5	1.8	2.0	2.0	2.5	33.6

Note: The numbers of passengers include drivers and assistants
Source: JICA Survey Team

9.2 Economic Analysis of Sub-project 1

9.2.1 Economic Benefit

Changes in the traffic volumes of the project in 2025 and 2035 are indicated in Table 9.2.1 (vehicle-kilometres) and Table 9.2.2 (vehicle-hours). These figures include two cases: the *with-project* (assuming the project execution goes ahead as planned) and the *without-project* (the case that the project is not executed). Daily traffic volumes in 2025 and 2035 in both cases are calculated through the interpolation method, and traffic volumes from 2035 to 2045 are estimated assuming that annual average growth rate between 2025and 2035 which will continue after 2036.

Table 9.2.1 Change of vehicle-kilometres by vehicle class per day

Unit: vehicle-km

Vehicle class		Passenger cars	Buses	2 axis trucks - small	2 axis trucks - large	3 axis trucks	More than 4 axis trucks	Trailers	Total
2025	Without project	21,214,493	8,631,713	1,554,265	4,125,707	3,631,991	15,925,003	10,191,000	65,274,172
	With project	21,029,936	8,628,569	1,546,381	4,105,152	3,629,805	15,964,892	10,225,533	65,130,268
2035	Without project	72,132,297	23,975,204	4,791,654	12,941,314	11,205,625	49,418,486	31,680,226	206,144,806
	With project	70,895,663	23,648,204	4,737,270	12,780,168	11,154,198	49,361,088	31,649,515	204,226,106

Source: JICA Survey Team

Table 9.2.2 Change of vehicle-hours by vehicle class per day

Unit: vehicle-hour

Vehicle class		Passenger cars	2 axis trucks - small	2 axis trucks - large	3 axis trucks	More than 4 axis trucks	Trailers	Buses	Total
2025	Without project	1,140,803	432,509	101,630	269,875	240,281	1,067,712	683,814	3,936,624
	With project	1,101,837	419,165	98,535	261,164	234,642	1,049,680	673,115	3,838,138
2035	Without project	6,744,288	2,193,761	582,025	1,537,201	1,381,085	6,277,895	4,024,798	22,741,053
	With project	6,379,541	2,096,158	565,705	1,495,575	1,358,691	6,207,954	3,982,344	22,085,968

Source: JICA Survey Team

After the calculation of daily figures for vehicle-kilometres and vehicle-hours from 2026 (opening year of Bago–Kyaito Road) to 2045 (20 years after the opening of the road), differences between the without project and with project are calculated. The *daily reduction of vehicle operation cost* is calculated as the vehicle-kilometre difference multiplied by the VOC (Table 9.1.2, 30km/h of flat road). The *daily time saving* is calculated as the vehicle-hour difference multiplied by income per hour (Table 9.1.3). Both the *daily reduction of vehicle operation cost* and the *daily time saving* are multiplied by 300 (assuming 300 travelling days per year) to attain the corresponding annual values. Table 9.2.3 indicates the Economic Benefit of the Project in the period from 2026 to 2045.

Table 9.2.3 Economic Benefit of the Project

Unit: JPY million

Year	VOC savings	Travel cost savings	Total of economic benefit
2026	8,501	518	9,019
2027	11,064	1,372	12,437
2028	14,380	2,419	16,799
2029	18,663	3,693	22,356
2030	24,191	5,233	29,425
2031	31,320	7,084	38,404
2032	40,555	9,298	49,853
2033	52,459	11,935	64,395
2034	67,793	15,064	82,857
2035	87,529	18,766	106,295
2036	112,916	23,130	136,047
2037	143,716	28,264	171,980
2038	182,781	34,288	217,069
2039	232,299	41,342	273,641
2040	295,037	49,584	344,621
2041	374,481	59,200	433,680
2042	475,757	70,398	546,155
2043	604,080	83,419	687,499
2044	766,602	98,541	865,143
2045	972,352	116,077	1,088,429

Source: JICA Survey Team

9.2.2 Economic Cost

(1) Development cost

Development costs consist of construction, consulting service, land acquisition and administration cost. These costs are estimated in Chapter 8 and are used for this economic analysis; however, taxes, price escalation, and contingency are eliminated.

Table 9.2.4 indicates the development cost of the project expressed by economic price. The total development cost in economic price amounts to 66 billion Japanese yen, 83% of which is occupied by construction cost.

Table 9.2.4 Development Cost of the Project

Unit: JPY million

Year	Construction	Consulting services	Land acquisition	Administration cost	Total
2018	0	0	1,428	0	1,428
2019	0	870	1,224	44	2,138
2020	0	435	1,224	22	1,681
2021	10,879	653	204	577	12,312
2022	16,318	653	0	849	17,820
2023	10,879	653	0	577	12,108

2024	10,879	653	0	577	12,108
2025	5,439	435	0	294	6,168
Total	54,394	4,352	4,079	2,937	65,763

Source: JICA Survey Team

(2) Maintenance cost

Maintenance consists of regular maintenance and periodic maintenance, and periodic maintenance will be conducted every ten years and regular maintenance will be conducted every year. The Survey Team estimates that 2% of the construction cost will be used for regular maintenance cost, and 10% of the cost is used for periodic maintenance. Annual disbursement amounts for the maintenance cost are listed as shown in Table 9.2.5.

Table 9.2.5 Maintenance Cost of the Project

Unit: JPY million

Year	Maintenance cost	Percentage of construction cost
2026	1,088	2%
2027	1,088	2%
2028	1,088	2%
2029	1,088	2%
2030	1,088	2%
2031	1,088	2%
2032	1,088	2%
2033	1,088	2%
2034	1,088	2%
2035	6,527	12%
2036	1,088	2%
2037	1,088	2%
2038	1,088	2%
2039	1,088	2%
2040	1,088	2%
2041	1,088	2%
2042	1,088	2%
2043	1,088	2%
2044	1,088	2%
2045	6,527	12%

Source: JICA Survey Team

9.2.3 Economic Evaluation of the Project

(1) Calculation of EIRR and Cost-Benefit Ratio

Table 9.2.6 shows annual cash flow of Sub-project 1. The 5th column is net cash flow (economic benefit minus development cost minus maintenance cost). The Economic Internal Rates of Return (EIRR) of the projects which is calculated from annual net cash flow from 2018 to 2045 is 29.8%. The calculated EIRR exceeds 12%, which is commonly used for a benchmark of the social discount rate in developing countries. Therefore, the project is feasible from the point of national economic development.

The 6th column of the Table 9.2.6 gives the weight of the 12% discount ratio when the figure in 2016 is set 1.00. Annual figures of the weight decrease gradually from 0.80 in 2018 to 0.04 in 2045. The 7th column and 8th column are the discounted economic cost (development cost plus maintenance cost) times weight, and discounted economic benefit (economic benefit times weight), respectively. The cost-benefit ratio calculated from the sum of discounted economic benefit (323,782) divided by the sum of discounted economic cost (39,099) is 8.97.

Table 9.2.6 Cash Flow of the Project

Unit: JPY million

Year	Development Cost	Maintenance Cost	Economic Benefit	Net Cash Flow	Weight of 12% discount ratio (2016=1.00)	Discounted Economic Cost	Discounted Economic Benefit
2018	1,428			-1,428	0.80	1,138	
2019	2,138			-2,138	0.71	1,522	
2020	1,681			-1,681	0.64	1,068	
2021	12,312			-12,312	0.57	6,986	
2022	17,820			-17,820	0.51	9,028	
2023	12,108			-12,108	0.45	5,477	
2024	12,108			-12,108	0.40	4,890	
2025	6,168			-6,168	0.36	2,224	
2026		1,088	9,019	7,931	0.32	350	2,904
2027		1,088	12,437	11,349	0.29	313	3,575
2028		1,088	16,799	15,711	0.26	279	4,312
2029		1,088	22,356	21,268	0.23	249	5,123
2030		1,088	29,425	28,337	0.20	223	6,021
2031		1,088	38,404	37,317	0.18	199	7,016
2032		1,088	49,853	48,765	0.16	177	8,132
2033		1,088	64,395	63,307	0.15	158	9,379
2034		1,088	82,857	81,769	0.13	141	10,775
2035		6,527	106,295	99,767	0.12	758	12,342
2036		1,088	136,047	134,959	0.10	113	14,104
2037		1,088	171,980	170,892	0.09	101	15,918
2038		1,088	217,069	215,981	0.08	90	17,939
2039		1,088	273,641	272,553	0.07	80	20,191
2040		1,088	344,621	343,533	0.07	72	22,704
2041		1,088	433,680	432,593	0.06	64	25,511
2042		1,088	546,155	545,067	0.05	57	28,684
2043		1,088	687,499	686,411	0.05	51	32,239
2044		1,088	865,143	864,055	0.04	46	36,223
2045		6,527	1,088,429	1,081,901	0.04	244	40,689
			EIRR	29.8%		36,099	323,782
						B/C	8.97

Source: JICA Survey Team

(2) Sensitivity Analysis

Table 9.2.7 shows the results of sensitivity analysis. Increases in the development cost by 20% reduces EIRR by 1.7%, and the drop of economic benefit by 20% reduces EIRR by 2.1%; however, the EIRR still remains at a sufficiently high level. In addition, the increase of the annual and periodic maintenance costs does not change EIRR. Sub-project 1 is a high level of viability in terms of contribution to the national economy.

Table 9.2.7 Results of Sensitivity Analysis

Unit: Percent

Cases	EIRR
Base case	29.8
20% increase of development cost	28.1
20% increase of maintenance cost	29.8
20% reduction of economic benefit	27.7

Source: JICA Survey Team

9.3 Economic Analysis of Sub-project 2

9.3.1 Economic Benefit

Changes in traffic volumes of Sub-project 2 in 2025 and 2035 are indicated in Table 9.3.1 (vehicle-kilometres) and Table 9.3.2 (vehicle-hours). These figures include two cases: the *with-project* (assuming project execution goes ahead as planned) and the *without-project* (the case that the project is not executed). Daily traffic volumes in 2025 and 2035 in both cases are calculated through the interpolation method, and traffic volumes from 2036 to 2046 are estimated assuming that the annual average growth rate between 2025 and 2035 will continue after 2036.

Table 9.3.1 Change of vehicle-kilometres by vehicle class per day

Unit: vehicle-km

Vehicle class		Passenger cars	Buses	2 axis trucks - small	2 axis trucks - large	3 axis trucks	More than 4 axis trucks	Trailers	Total
2025	Without project	21,093,150	8,607,925	1,541,204	4,093,836	3,621,154	15,937,875	10,209,944	65,105,088
	With project	21,029,936	8,628,569	1,546,381	4,105,152	3,629,805	15,964,892	10,225,533	65,130,268
2035	Without project	72,297,901	24,054,410	4,737,382	12,778,090	11,048,551	48,590,805	31,146,568	204,653,707
	With project	70,895,663	23,648,204	4,737,270	12,780,168	11,154,198	49,361,088	31,649,515	204,226,106

Source: JICA Survey Team

Table 9.3.2 Change of vehicle-hours by vehicle class per day

Unit: vehicle-hour

Vehicle class		Passenger cars	Buses	2 axis trucks - small	2 axis trucks - large	3 axis trucks	More than 4 axis trucks	Trailers	Total
2025	Without project	1,152,862	438,560	100,158	265,421	238,164	1,064,894	683,096	3,943,155
	With project	1,101,837	419,165	98,535	261,164	234,642	1,049,680	673,115	3,838,138
2035	Without project	6,816,904	2,222,651	577,742	1,525,936	1,379,268	6,278,717	4,023,239	22,824,457
	With project	6,379,541	2,096,158	565,705	1,495,575	1,358,691	6,207,954	3,982,344	22,085,968

Source: JICA Survey Team

After the calculation of daily figures of vehicle-kilometres and vehicle-hours from 2027 (opening of the improved NH-1 Yangon–Bago section) to 2046 (20 years after the opening), differences between without project and with project are calculated. The *daily reduction of vehicle operation cost* is calculated as the vehicle-kilometre difference multiplied by the VOC (Table 9.1.2, 30km/h of flat road). The *daily time saving* is calculated as the vehicle-hour difference multiplied by income per hour (Table 9.1.3). Both the *daily reduction of vehicle operation cost* and the *daily time saving* are multiplied by 300 (assuming 300 travelling days per year) to attain the corresponding annual values. Table 9.3.3 indicates the Economic Benefit of Sub-project 2 during the period from 2027 to 2046.

Table 9.3.3 Economic Benefit of Sub-project 2

Unit: JPY million

Year	VOC savings	Travel cost savings	Total of economic benefit
2027	14,882	-2,401	12,481
2028	19,147	-3,141	16,007
2029	24,618	-4,025	20,592
2030	31,630	-5,079	26,551
2031	40,614	-6,328	34,285
2032	52,182	-7,806	44,376
2033	67,007	-9,548	57,459
2034	85,998	-11,597	74,402
2035	110,316	-14,000	96,316
2036	141,441	-16,812	124,629
2037	178,979	-20,096	158,883
2038	226,380	-23,925	202,455
2039	286,215	-28,380	257,834
2040	361,720	-33,556	328,164
2041	456,970	-39,560	417,410
2042	577,970	-46,514	531,456
2043	730,755	-54,558	676,197
2044	923,620	-63,851	859,770
2045	1,167,016	-74,573	1,092,443
2046	1,474,101	-86,931	1,387,170

Source: JICA Survey Team

9.3.2 Economic Cost

(1) Development cost

Development costs consist of construction, consulting service, land acquisition and administration cost. These costs are estimated in Chapter 8 and are used for this economic analysis; however, taxes, price escalation, and contingency are eliminated.

Table 9.3.4 indicates the development cost of the project expressed by economic price. The total development cost in economic price amounts to 131 billion Japanese yen, 85% of which is occupied by construction cost.

Table 9.3.4 Development Cost of the Project

Unit: JPY million

Year	Construction	Consulting services	Land acquisition	Administration cost	Total
2018	0	0	1,449	0	1,449
2019	0	1,787	1,449	89	3,325
2020	0	893	1,449	45	2,387
2021	5,584	1,340	483	346	7,753
2022	27,919	1,340	0	1,463	30,722
2023	22,336	1,340	0	1,184	24,859
2024	22,336	893	0	1,161	24,390
2025	22,336	893	0	1,161	24,390
2026	11,168	447	0	581	12,195
Total	111,678	8,934	4,830	6,031	131,472

Source: JICA Survey Team

(2) Maintenance cost

Maintenance consists of regular maintenance and periodic maintenance, and periodic maintenance will be conducted every ten years and regular maintenance will be conducted every year. The Survey Team estimates that 2% of the construction cost will be used for regular maintenance cost, and 10% of the cost is used for periodic maintenance. Annual disbursement amounts for the maintenance cost are listed as shown in Table 9.3.5.

Table 9.3.5 Maintenance Cost of the Project

Unit: JPY million

Year	Maintenance cost	Percentage to construction cost
2027	2,234	2%
2028	2,234	2%
2029	2,234	2%
2030	2,234	2%
2031	2,234	2%
2032	2,234	2%
2033	2,234	2%
2034	2,234	2%
2035	2,234	2%
2036	13,401	12%
2037	2,234	2%
2038	2,234	2%
2039	2,234	2%
2040	2,234	2%
2041	2,234	2%
2042	2,234	2%
2043	2,234	2%
2044	2,234	2%
2045	2,234	2%
2046	13,401	12%

Source: JICA Survey Team

9.3.3 Economic Evaluation of the Project

(1) Calculation of EIRR and Cost-Benefit Ratio

Table 9.3.6 shows the annual cash flow of Sub-project 2. The 5th column is net cash flow (economic benefit minus development cost minus maintenance cost). The Economic Internal Rates of Return (EIRR) of the projects which is calculated from annual net cash flow from 2018 to 2046 is 24.2%. The calculated EIRR exceeds 12%, which is commonly used for a benchmark of social discount rate in developing countries. Therefore, the project is feasible from the point of national economic development.

The 6th column of the Table 9.3.6 gives the weight of the 12% discount ratio when the figure in 2016 is set 1.00. Annual figures of the weight decrease gradually from 0.80 in 2018 to 0.03 in 2047. The 7th column and 8th column are the discounted economic cost (development cost plus maintenance cost) times weight, and discounted economic benefit (economic benefit times weight), respectively. The cost-benefit ratio calculated from the sum of discounted economic benefit (352,893) divided by the sum of discounted economic cost (65,723) is 5.37.

Table 9.3.6 Cash Flow of the Project

Year	Development Cost	Maintenance Cost	Economic Benefit	Net Cash Flow	Weight of 12% discount ratio (2016=1.00)	Discounted Economic Cost	Discounted Economic Benefit
2018	1,449			-1,449	0.80	1,155	
2019	3,325			-3,325	0.71	2,367	
2020	2,387			-2,387	0.64	1,517	
2021	7,753			-7,753	0.57	4,399	
2022	30,722			-30,722	0.51	15,565	
2023	24,859			-24,859	0.45	11,245	
2024	24,390			-24,390	0.40	9,851	
2025	24,390			-24,390	0.36	8,795	
2026	12,195			-12,195	0.32	3,927	
2027		2,234	12,481	10,248	0.29	642	3,588
2028		2,234	16,007	13,773	0.26	573	4,108
2029		2,234	20,592	18,359	0.23	512	4,719
2030		2,234	26,551	24,317	0.20	457	5,433
2031		2,234	34,285	32,052	0.18	408	6,264
2032		2,234	44,376	42,142	0.16	364	7,239
2033		2,234	57,459	55,225	0.15	325	8,369
2034		2,234	74,402	72,168	0.13	290	9,675
2035		2,234	96,316	94,083	0.12	259	11,183
2036		13,401	124,629	111,228	0.10	1,389	12,920
2037		2,234	158,883	156,649	0.09	207	14,706
2038		2,234	202,455	200,221	0.08	185	16,731
2039		2,234	257,834	255,601	0.07	165	19,025
2040		2,234	328,164	325,930	0.07	147	21,620
2041		2,234	417,410	415,176	0.06	131	24,553
2042		2,234	531,456	529,222	0.05	117	27,912
2043		2,234	676,197	673,963	0.05	105	31,709
2044		2,234	859,770	857,536	0.04	94	35,998
2045		2,234	1,092,443	1,090,209	0.04	83	40,839
2046		13,401	1,387,170	1,373,769	0.03	447	46,301
			EIRR	24.2%		65,723	352,893
						B/C	5.37

Source: JICA Survey Team

(2) Sensitivity Analysis

Table 9.3.7 shows the results of the sensitivity analysis. Increases in development cost by 20% reduces EIRR by 1.5%, and the drop of economic benefit by 20% reduces EIRR by 2.0%; however, it still remains at a sufficiently high level. In addition, the increase of the annual and periodic maintenance costs does not change EIRR. Sub-project 2 is at a high level of viability in terms of contribution to the national economy.

Table 9.3.7 Results of Sensitivity Analysis

Unit: Percent

Cases	EIRR
Base case	24.2
20% increase of development cost	22.7
20% increase of maintenance cost	24.1
20% reduction of economic benefit	22.2

Source: JICA Survey Team

9.4 Operation and Effect Indicators

Like other JICA funded road/bridge improvement projects in Myanmar and other countries, 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 2014 and targets in 2027 and 2035. Table 9.4.1 and Table 9.4.2 summarize operation and effect indicators of the Project.

Table 9.4.1 Operation and Effect Indicators of the Project (Sub-project 1)

Year	2014	2027			2035		
with project (with)/ without project (w/o)	w/o	w/o	with		w/o	with	
Route (existing/new)	existing	existing	existing	new	existing	existing	new
Traffic volume (PCU/day)*1	5,600	30,700*2	11,500	29,300	78,700*2	27,000	63,500
Average travel time (hour)	2.0	4.5	2.7 (-1.8)	1.1 (-3.4)	8.2*3	4.0 (-4.2)	1.6 (-6.6)
Average travel speed (km/h)	52.4	23.6	39.5	63.5	12.9	26.0	44.3
Congestion factor (V/C)*4	0.28	1.54	0.58	0.46	3.93	1.35	0.99

Note: *1 The weighted mean value by the section length (Bago–Payagyi: 29.6km, Payagyi–Kyaito: 75.4km and the New Road: 71.1km).
*2 Traffic volume of "without" Project is smaller than that of "with" Project because of the diversion to other routes to avoid the traffic congestion.
*3 Travel time would be 17.5 hour in a maximum case in 2035.
*4 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Survey Team

Table 9.4.2 Operation and Effect Indicators of the Project (Sub-project 2)

Year	2014	2027			2035		
with project (with)/ without project (w/o)	w/o	w/o	with		w/o	with	
Road condition (sub-arterial/ expressway)	Sub-arterial	Sub-arterial	Sub-arterial	Expressway	Sub-arterial	Sub-arterial	Expressway
Traffic volume (PCU/day)*1	7,900	54,200*2	15,900	43,400	124,300*2	45,600	91,300
Average travel time (hour)	0.6	1.0	0.7 (-0.3)	0.6 (-0.4)	1.8	0.9 (-0.9)	0.9 (-0.9)
Average travel speed (km/h)	56.6	37.0	53.3	60.4	19.9	40.7	39.5
Congestion factor (V/C)*3	0.12	0.94	0.28	0.60	1.94	0.71	1.14

Note: *1 The weighted mean value by the section length (existing NH1 from Bago to Y-M Expressway Connect: 36.6km, Improved NH1: 35.5km).
*2 Traffic volume of "without" Project is smaller than that of "with" Project because of the diversion to other routes to avoid the traffic congestion.
*3 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Survey Team

CHAPTER 10 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

10.1 Project Description

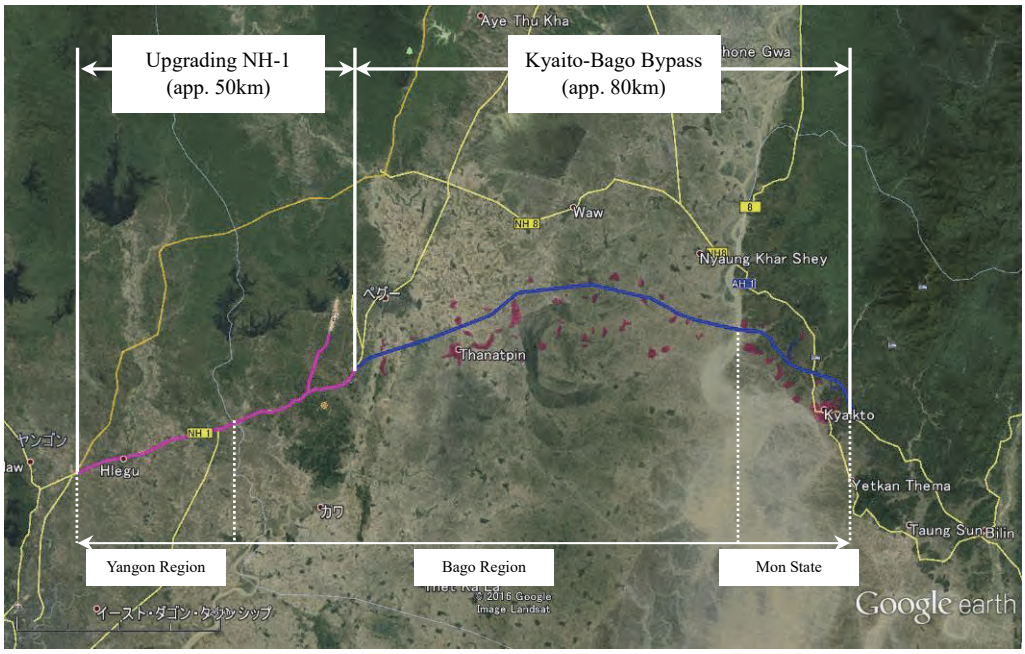
The prioritized projects and their locations under discussion are shown in the table and figure below.

In this chapter, two sub-projects are analysed for environmental and social considerations as Phase-2 projects.

Table 10.1.1 Project Activities

Area (Package)	Sub-Project	Activities
I. East West Economic Corridor for Phase-II	1. Construction of New Kyaito – Bago Road	New road construction (app. 80km) Location: Mon State -Bago Region Note) Including construction of 1km bridge for Sittaung River
	2. Upgrading of NH-1	Construction of a new viaduct on the existing highway No.1 and construction of new airport road (app. 40km) Location: Bago Region-Yangon Region

Source: JICA Survey Team



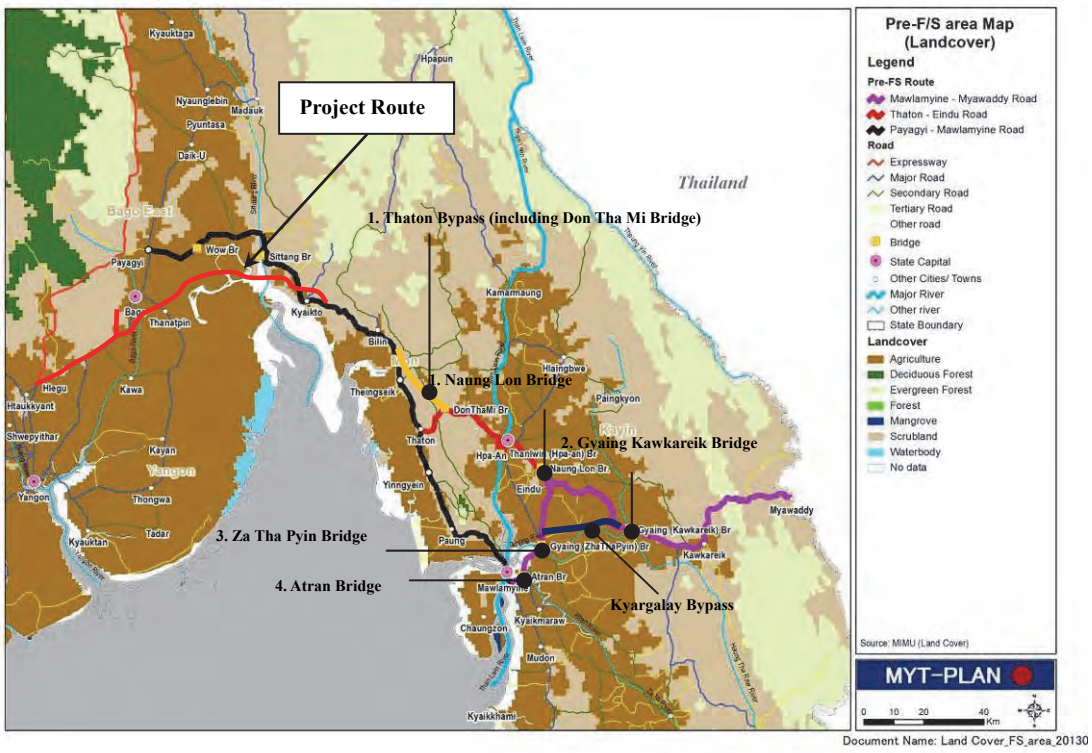
Source: JICA Survey Team

Figure 10.1.1 Project Location Map

10.2 Current Natural and Social Environmental Conditions

10.2.1 Land Use

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



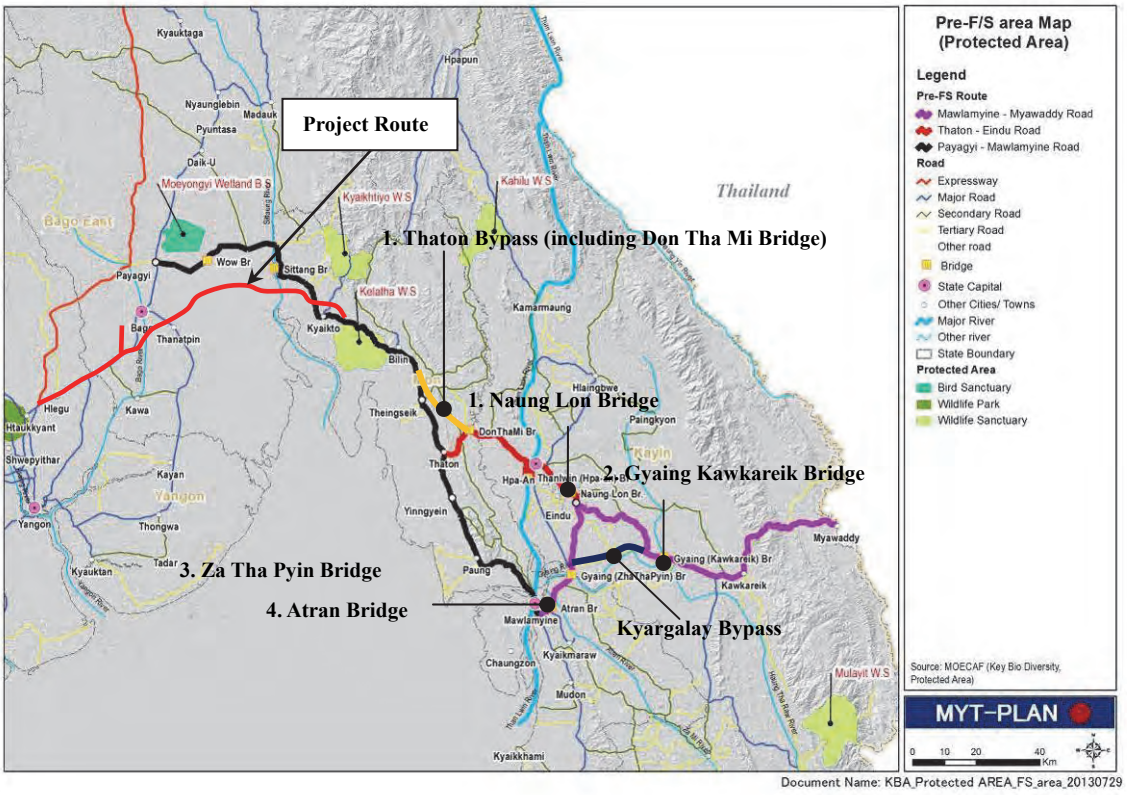
Source: The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (2014 JICA)

Figure 10.2.1 Land Use on the East-West Economic Corridor

10.2.2 Protected Areas

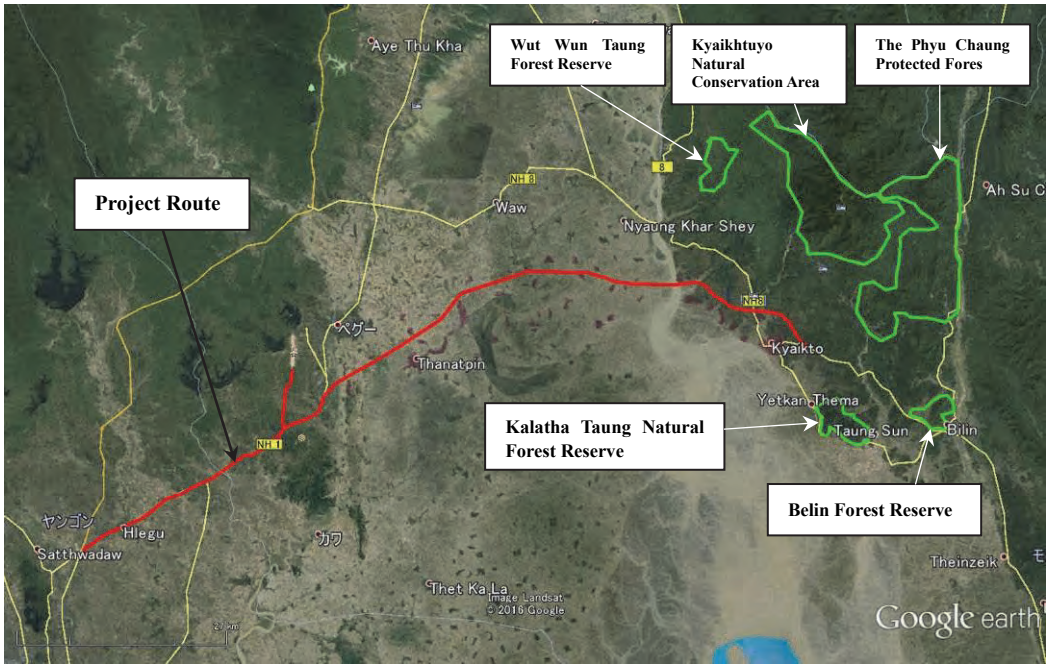
The following conservation zones are declared national parks by law. Although a wildlife sanctuary named Kelatha is located near beginning point of the Kyaito-Bago Bypass in the Kyaito Township, the alignment does not touch this sanctuary.

Additionally, any known considerable biological area or habitats of considerable species are not observed in the Project Area.



Source: The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (2014J ICA)

Figure 10.2.2 Protected Areas near the East-West Economic Corridor



Source: JICA Survey Team based on the natural protected map (Land Records 1944/Forest Department)

Figure 10.2.3 Detailed Protected Area Map in the Project Area

10.2.3 Socio-Economic

The Socio-Economic characteristics in the Project Area are shown below. The population is 2,054,000 in Mon State, 4,876,000 in Bago Region and 7,361,000 in Yangon Region, totaling 27.7% of Myanmar's population. The monthly average expenditure is 170,223 Kyat in Mon State, 160,330 Kyat in Bago Region and 195,060 Kyat in Yangon Region.

Table 10.2.1 Socio-Economic Situation in the Project Area

Item	State	Value	Remarks
Area (km^2) in 2014	Mon State	12,296	Total in Myanmar: 676,553
	Bago Region	39,403	
	Yangon Region	10,171	
Population (Persons x 1,000) in 2014	Mon State	2,054	Total in Myanmar : 51,486
	Bago Region	4,867	
	Yangon Region	7,361	
Population Density (Persons/km^2) in 2014	Mon State	167	National Average : 76
	Bago Region	124	
	Yangon Region	724	
Average Expenditure (Kyat/month) in 2012	Mon State	170,223	National Average : 167,434
	Bago Region	160,330	
	Yangon Region	195,060	
Poverty Line Note1) (Kyat/Year) in 2013	Mon State	345,093	National Average: 376,151
	Bago Region east	408,860	
	Yangon Region	354,860	

Note1) A regional perspective on poverty in Myanmar / UNDP 2013

Source: 2015 Myanmar Statistical Yearbook/ Central Statistical Organization, Ministry of National Planning and Economic Development

10.3 Environmental and Social Legislation in Myanmar

10.3.1 Environmental Consideration

(1) Environmental Policy, Strategy and Legal Framework

A legal system with regard to the environment is under establishment 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 Environmental Conservation and Forestry (hereinafter referred to as "MOECAF") has promulgated the Environmental Conservation Rules in 2014, and then Environmental Impact Assessment (EIA) Procedures and environmental quality standards have been 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 Pyidaungsu Hluttow Law No. 9/20/2130rh). The law stipulates which government body which 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 MOECAF, both of which will be explained later in this report.

Following the Environmental Conservation Law are two legal arrangements: Environmental Conservation Rules; and EIA Procedures.

2) Environmental Conservation Rules

Environmental Conservation Rules have been 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. However detailed guidelines for each responsible organization, environmental standards and criteria of EIA & IEE will be provided after 2014 in the "EIA Procedure".

3) EIA Procedures

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 MOECAF 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.

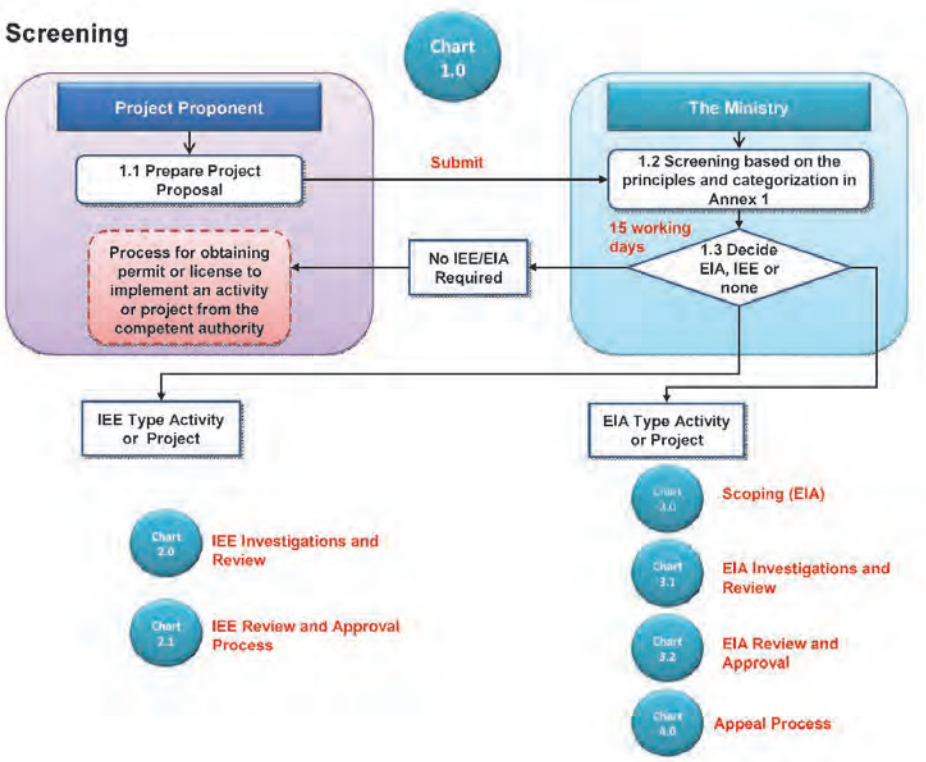
e) Members of the EIA Review Committee will be selected by the Minister of MOECAF and will include persons from the industry, academia and civil society, as well as government officials.

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.

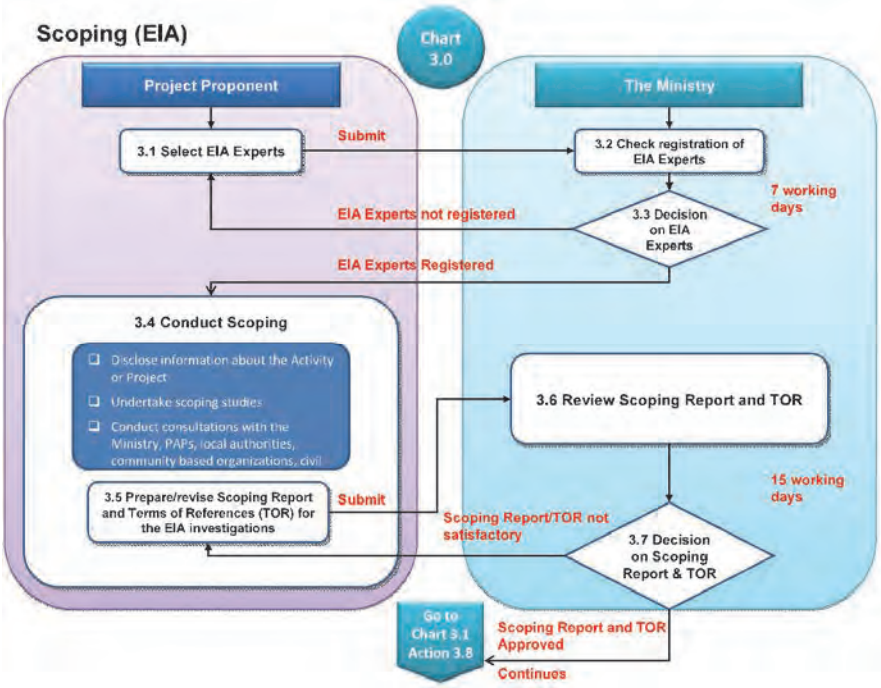
h) EIA can be carried out in Myanmar only by firms that are registered under ECD/MOECAF.

The EIA approval process is shown below.



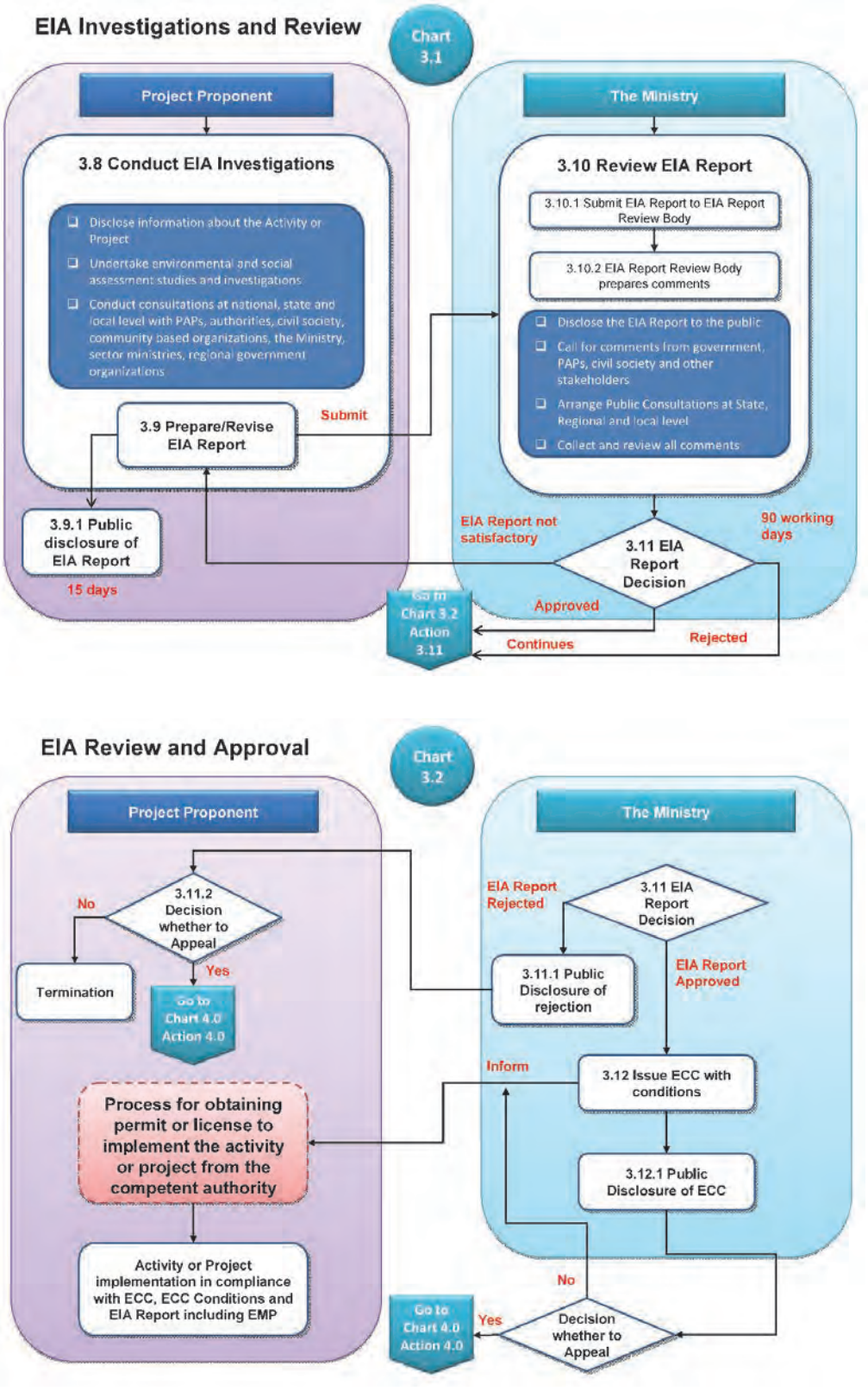
Source: EIA Procedure Law 2016 ANNEX 2 Environmental Assessment Procedure Flowchart

Figure 10.3.1 EIA Process-1 (screening)



Source: EIA Procedure Law 2016 ANNEX 2 Environmental Assessment Procedure Flowchart

Figure 10.3.2 EIA Process-2 (Scoping)



Source: EIA Procedure Law 2016 ANNEX 2 Environmental Assessment Procedure Flowchart

Figure 10.3.3 EIA Process-3 (Approval)

(3) Environmental Screening of the Project

According to EIA procedure law 2016 as shown in Table 10.3.1, the project including the construction of new road longer than 50km is categorized as an EIA project.

Thus the project with Bypass and Upgrading of NH-1 is required to conduct the EIA activities in accordance with the law.

The mandatory list of IEE and EIA is shown in below.

Table 10.3.1 EIA Project List for Transportation Project on EIA Procedure Law 2016

Project Type	Criteria		Adaptation		
	IEE	EIA	Sub-Pro1+2	Sub-Pro1	Sub-Pro2
127. Bridges, River Bridges and Viaducts (new construction)	Length≧0.2km but <50km	Length≧2km			Adapted EIA is required
128. Bridges, River Bridges and Viaducts (upgrading)	Length≧300m	All activities where the Ministry requires that the project shall undergo EIA			
130. Expressways and Highways (ASEAN Highway Standard; new construction or widening with one lane or more)	**Length≧2km but <50km**	**Length≧50km**	**Adapted EIA is required**	**Adapted EIA is required**	
131. Other Roads (state, region, urban; new construction or widening ≥ one lane)	L<50km	All projects proposed for EIA by IEE			
132. Road Improvement (upgrading from seasonal to all weather surface, widening of shoulders)	Length≧50km but <100km	Length≧100km			

Source: EIA Procedure Law 2016 (ANNEX 1/Categorization of Economic Activities for Assessment Purposes)

(4) Gaps between Draft EIA rules in Myanmar and JICA's Guideline

The Project is categorized as Category B, which is the required IEE level based on JICA Guidelines. Therefore, the following comparative analysis is just temporary and is not a mandatory requirement for JICA Guidelines.

EIA activities according to EIA rules are deemed to meet JICA's Guideline Policy, as seen below.

Table 10.3.2 Gaps between JICA Guidelines and Myanmar Legislation on EIA

JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	EIA Procedure (draft) (as of September 2014)	Gaps	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.	The project is required to prepare the EIA and obtain the environmental certificates	- (no difference)	Not required
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 draft EIA rules stipulate that IEE and EIA shall be written in the local language.	-	Not required

JICA Guideline (Appendix 2. EIA Reports for Category A Projects)	**EIA Procedure (draft)** (as of September 2014)	**Gaps**	**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.	A public disclosure of EIA is required	-	Not required
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.	The prescript public consultation is held with project affected persons and other relevant agencies at the scoping stage and draft EIA stage respectively after sufficient announcement of the meeting(s).	-	Not required
5. Consultations with relevant stakeholders, such as local residents, should take place if necessary 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.	The prescript public consultation is held with project affected persons and other relevant agencies such as PAPs, authorities, civil society, community based organizations, the Ministry, sector ministries, regional government organizations at scoping stage and draft EIA stage respectively.	-	Not required

Source: JICA Survey 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 10.3.3 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) *See details in the article 12.3.2 Social Considerations	
Land Acquisition Act	・ 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
The Land Nationalization Act (1953)	・ With some exceptions, stipulates that all types of agricultural land are owned by the President ・ Mentions that in case of a breach of the regulations, even the land exempted from government confiscation will be forfeited to the country without compensation ・ States that the President reserves rights to decide the crops to be gown on agricultural lands
Farmland Bill (2011)	・ 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 Survey Team

10.3.2 Social Consideration

(1) Land Acquisition and Resettlement Laws & 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 10.3.4 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 10.3.4 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
- Land Nationalization Act, 1953
- 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 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.

3) Land Nationalization Act (1953)

- 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.

4) Farm Land Law (2011)

- Calls for suitable compensation and indemnity in the case of repossession of farmland in the interest of the Union State.

5) 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 of Public needs to make compensation to the farmers without delay.

(2) Gap Analysis

Comparisons between current laws/regulations of the Government and JICA Guidelines for Environmental and Social Considerations (April, 2010) are shown in Table 10.3.5.

Table 10.3.5 Comparisons between Laws in Myanmar and JICA Guidelines

No.	JICA Guidelines	Laws and Guidelines in Myanmar	Gap relative to JICA GL	Project Policy
1	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL)	Not applicable	There is no regulation which mentions or requests to avoid or minimize involuntary resettlement and loss of livelihood means.	The Project examines alternatives to avoid or minimize resettlement impact.
2	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	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.	Same as 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)	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 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 assistance to improve or restore the livelihood.

No.	JICA Guidelines	Laws and Guidelines in Myanmar	Gap relative to JICA GL	Project Policy
4	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	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 significant difference.	Same as JICA GL
5	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	When compensation is not paid on or before land acquisition, the compensation amount awarded with interest rate must be paid.	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 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)	Not applicable	There is no regulation requesting to prepare resettlement action plan.	The Project prepares a resettlement action plan and makes it 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)	Not applicable	There is no regulation requesting to organize consultations with PAPs.	The Project holds 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. (JICA GL)	Not applicable	Ditto	The Project considers appropriate explanation when consultations are held.
9	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Not applicable	There is no regulation requesting participation of PAPs in planning, implementation, and monitoring of resettlement action plans.	The Project considers the appropriate participation of affected people.
10	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	1) Notice of compensation amount to PAPs directly: appeal to the court within six weeks from the date of compensation award 2) Notice of compensation amount to representatives of PAPs: i) within six weeks of receipt of compensation notice, or ii) within six months from the from the date of compensation award, whichever period shall be first expire (Land Acquisition Act (1894) Art. 18)	The procedure of grievance in the Myanmar context is direct settlement at the court, which is not necessarily easy or accessible to PAPs	The Project considers the grievance redress mechanism by utilizing the existing administration system to be convenient for PAPs.

No.	JICA Guidelines	Laws and Guidelines in Myanmar	Gap relative to JICA GL	Project Policy
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 those who encroach and who wish to take advantage of such benefits. (WB OP 4.12 Para. 6)	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 specific description of identifying affected people as early as possible in the national law.	The Project identifies and records the affected people at the project identification stage.
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)	Occupiers/stakeholders of lands to be acquired are explained about acquisition and claims to compensations. (Land Acquisition Act (1894) Article 9)	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)	Not Applicable	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)	Not Applicable	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)	Not Applicable	There is no regulation stipulating to provide particular attention to the vulnerable groups.	The Project pays particular attention to vulnerable groups.
16	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Not Applicable	There is no regulation stipulating to develop an A-RAP for a project with involuntary resettlement of fewer than 200 people.	Same as JICA GL

Source: JICA Survey Team

(3) Draft Compensation and Entitlement Matrix

Valuation for compensating the loss of land and its derivative (crops, plants etc.) shall be in accordance with the relevant laws in Myanmar with support of the project policy. For dwellings and other structures, it shall be based on replacement cost to be computed. Income assistance shall also be necessary to PAPs/PAHs in case the Project adversely affects such people. Inconvenience allowance shall be given to PAHs with severely affected structures, which require relocation and new construction.

The entitlement matrix is a matrix to systematically show 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. Based on the result of survey, the principles of compensation could be as follows:

(4) Compensation of Loss of Assets

All assets of the PAPs, including land, structure, plant/crop/livestock, and/or objects associated with the land, as well as other assets in the form of non-physical assets, shall be fairly compensated in accordance with the currently effective laws and regulations in Myanmar.

(5) Coverage of Compensation

The proposed coverage of compensation for the project can include the items listed below:

- Land: residential lands, business/commercial/industrial uses, traditional use rights (religious purpose etc.);
- Fixed assets: houses, structures and facilities to be affected;
- Job/Business opportunity: loss of continuity of job and business opportunity such as farming, fisheries, shops and other job activities;
- Income (Opportunity cost): expected income in case the resettlement would not be required (crops/trees, livestock, fish etc.);
- Living condition/Quality of life: damaged or downgraded living condition caused by the resettlement, and;
- Public facilities: government buildings, sensitive receptors like religious monuments, schools, hospitals/clinics, markets etc.

Note that PAPs who have no legitimate right to land (so called informal settlers) will be also included as part of the compensation coverage. Although such PAPs will be basically eligible to compensation for the loss of assets, they would have a chance to take other assistance like livelihood restoration when the government decides it necessary.

The entitlement matrix of the resettlement plan may be updated after the final design stage to reflect the relevant changes but the standards set in the original entitlement matrix cannot be lowered when the resettlement plan is revised and finalized. The Entitlement Matrix that should be followed when preparing the Resettlement Plan is shown in Table 10.3.6.

Table 10.3.6 Draft Entitlement Matrix

Type of Loss	Application	Entitled Person	Assistance Policy	Implementation Issues
1. Land (Classified as Forest Land, Agricultural Land, Residential or Commercial Land, and Land used for other rights)	Partial or entire loss of land	Land owner/ occupant or a person who has recognizable right to claim to the land.	- Provide cash compensation in the current replacement cost or land for land compensation acceptable to PAPs if feasible.	Fair cash compensation is generally accepted by PAPs.
2. Structure (Houses, Shops)	Partial or entire affected structure	Owner/Tenant	- For entire affected structure, cash compensation to PAPs at replacement cost which covers cost for materials, labour, transport of materials (Do not take into account depreciation of the asset or salvageable materials. - For partially affected structures, cash compensation for the affected portion of the structure to be computed based on the replacement cost.	
3. Loss of community structures (Community rest house, etc)	Partial or entirely affected structure		- Cash assistance at full replacement cost. - If possible, new structure will be replaced by the project proponent which is similar to the former one.	During the actual compensation time, careful discussion and negotiation will be made with relevant community leaders or sensitive receptors.
4. Crops	Loss of paddy and other crops	Owner of crops	- Cash compensation for loss of paddy or other crops yield at 320,000 kyats per acre, which is calculated based on the actual market price. - Income restoration is paid equivalent to six times the annual earning to PAPs. *PAPs will be noticed four months in advance for picking crops prior to clearance. For crops that are not in ripening stage, PAPs will be provided the full market value of production cost).	- Assistance amount is calculated based on the yield amount recorded in SLRD or confirmed at survey. - ADB under MOC has provided six years of payment for rice paddies and this is replicated in this project.
5. Trees	(i) Rubber	Owner of trees	- Cash compensation for loss of rubber trees is calculated as age of rubber trees in the current market price. - Income restoration is paid equivalent to six times the monthly earning to PAPs.	- Rubber Latex can be produced starting from 5- 6 years and a greater amount can be produced between 8 to 30 years old rubber trees in Myanmar.
	(ii) Other trees (commercial, home consumption)	Owner of trees	- Provide cash compensation for loss of trees at 10,000 kyats per tree..	

Type of Loss	Application	Entitled Person	Assistance Policy	Implementation Issues
6. Fishery	Impacts on fishing activity during construction time	Fishermen in Donthami, Naung Lon, Gyaing-Kawkareik, Atran and Gyaing-Zathapyin Bridge areas	- Cash compensation for loss of fishing opportunity is calculated with fish catches and current market price by fish type at each area during the construction period.	
7. Business Losses		PAPs who lose income for any type of business.	- For PAPs for income loss from shops, cash amount which is equivalent to six (6) months income.	
8. Vulnerable Allowance		Households headed by women, a disabled person, elderly (over 61 years old), poor household below poverty line or household including disabled family members.	- One time cash assistance for each vulnerable household is paid at 150,000 kyat.	- According to Poverty Profile in June 2011, total expenditure of 31345.92 kyats per adult per month is defined in poverty line.

Source: JICA Survey Team

10.4 Preliminary Environmental and Social Impact Assessment

In this article, the expected adverse natural and social impacts are summarized for prioritized route which has been concluded on the alternative analysis in the Chapter 5.

The predicted impacts are indicated on the scoping matrix, and then the baseline survey methodology and necessary mitigation measures are prepared prior to the next stage such as a feasibility study and EIA Study.

All these preliminary environmental and social analysis is conducted based on the literature survey and on-site environmental reconnaissance in March 2016.

10.4.1 Screening

According to the IEE and EIA mandatory list on "EIA procedure in 2016", construction of a bypass longer than 50km is categorized as an EIA project. On the other hand, this project will be classified as Category A of JICA Guidelines because the expected resettlement number exceeds 200 people. Thus the scoping and methodology for the baseline survey & analysis is prepared for the EIA Study in the future.

10.4.2 Scoping

The scope of the EIA study for the project is discussed in this section. The environmental scoping is conducted based on environmental reconnaissance conducted by the JICA Survey Team in March 2016.

The result of the scoping is indicated on the Leopold scoping matrix and reason tables. Impact factors, impacted items and degree of impact are shown on the following scoping matrix based on JICA's Guidelines.

(1) Scoping Matrix

Table 10.4.1 Scoping Matrix

	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 roads, toll gates, parking areas, access roads for bridges and other related facilities	Traffic restriction in construction area	Influx of construction workers, construction of base camp	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		
	2	Water pollution	**B**					B				B			
	3	Waste	**B**	B								B			
	4	Soil contamination													
	5	Noise and vibration	**B**						B				B		
	6	Ground subsidence													
	7	Odour													
	8	Sediment quality													

	No	Affected Activities / Impact Items (JICA)	Overall Rating	Pre/ During Construction 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 roads, toll gates, parking areas, access roads for bridges and other related facilities	Traffic restriction in construction area	Influx of construction workers, construction of base camp	Operation Phase: Increase of through traffic and travelling speed	Appearance/Occupancy of roads and related building structures including tunnel and embankment	Increasing influx of settlers
Natural Environment	9	Protected area													
	10	Ecosystem	C					C						C	
	11	Hydrology	B					B						B	
	12	Topography and geology													
Social Environment	13	Involuntary resettlement	A	A											
	14	The poor	C	C											
	15	Indigenous and ethnic people													
	16	Local economy such as employment and livelihood	B	B											
	17	Land use and utilization of local resources	B	B											
	18	Waste Usage	C	C											
	19	Existing social infrastructures and services	C	C							C			C	
	20	Social institutions such as local decision making institutions	C								C			C	
	21	Misdistribution of benefits and damage													
	22	Local conflict of interests	B									B			
	23	Cultural Heritage	C	C											
	24	Landscape													
	25	Gender													
	26	Right of Children													
	27	Infectious diseases such as HIV/AIDS	B									B			B
	28	Labour environment (including work safety)													
Others	29	Accidents	B						B		B		B		
	30	Cross Boundary impacts and climate change													

Note) Rating:
A: Serious impact is expected. B: Some impact is expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) No mark: Light impact expected. Detailed quantitative survey is not necessary.
Source: JICA Survey Team

Table 10.4.2 Reasons for Scoping

Area	No	Impacted Item on JICA Guidelines	Rating: Pre/ During Construction	Rating: Operation Phase	Reasons of the Rating
Pollution	1	Air pollution	B	B	**Construction phase:** Temporary negative impacts are expected on air quality due to construction machines and equipment. **Operation phase:** Negative impact is expected due to the increase in traffic number.

Area	No	Impacted Item on JICA Guidelines	Rating		Reasons of the Rating
			Pre/ During Construction	Operation Phase	
Pollution	2	Water pollution	B		**Construction phase:** Turbid water may be generated by earth works and excavation in the river where bridges are planned. Additionally organic polluted water may be discharged from the base camp. **Operation phase:** No serious impacts are expected
	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 serious impacts are expected
	4	Soil contamination			**Construction phase:** No impacts are expected **Operation phase:** No impacts are expected
	5	Noise and vibration	B	B	**Construction phase:** Noise generation is expected due to works of construction machines and equipment. **Operation phase:** Noise generation is expected because of the increase in traffic number and travelling speed.
	6	Ground subsidence			**Construction and operation phase:** No impacts are expected since activities which cause ground subsidence not expected.
	7	Odour			**Construction and operation phase:** No impacts are expected since activities which cause odour are not expected.
	8	Sediment quality			**Construction phase:** No impacts are expected since there are not any polluted lands nearby the Project Area. **Operation phase:** Road operation which causes impacts on sediment quality is not expected.
Natural Environment	9	Protected area			**Construction and Operation phase:** The alignment is not passing through any natural and cultural protected areas.
	10	Ecosystem	C	C	**Construction and Operation phase:** Although any designated protected areas and considerable species habitats have not been identified in the Project Area, the impacts made by the alteration of the ground and activities in the river will be assessed based on the baseline survey results.
	11	Hydrology	B	B	**Construction and Operation phase:** Construction of bridges may change the hydrological situation of the rivers.
	12	Topography and geology			**Construction and operation phase:** Considerable topography and geological sites are not located in the Project Area, thus no impact is expected.
Social Environment	13	Involuntary resettlement	A		**Pre-Construction phase:** 670 affected structures with 3,350 re-settlers are counted on satellite image. Actual affected number of re-settlers will be identified in the RAP survey in the next feasibility study. The estimated affected area, re-settlers and cost is shown in Table 10.4.3. Some fishermen are observed in the river, thus the degree of the impacts shall be assessed in the next stage. **Operation phase:** No impact is expected
	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:** Few impacts are expected
	15	Indigenous and ethnic people			**Pre-Construction phase:** Any indigenous and ethnic people are not observed in accordance with WB OP4.10 **Operation phase:** Few impacts are expected
	16	Local economy such as employment and livelihood	B		**Pre-construction phase:** Livelihood of residents and farmers may be affected by acquisition of agricultural area. **Operation phase:** Few impacts are expected.
	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:** Few impacts are expected.
	18	Water usage	C		**Construction phase:** Land acquisition may give and impact on the irrigation system and drinking water resources such as wells. **Operation phase:** Few impacts are expected.

Area	No	Impacted Item on JICA Guidelines	Rating		Reasons of the Rating
			Pre/ During Construction	Operation Phase	
Social Environment	19	Existing social infrastructures and services	C		**Pre-Construction and Construction phase:** Some schools or meeting places may be affected by land acquisition for widening the road. Additionally traffic restriction will impact commuting students. **Operation phase:** Few impacts are expected.
	20	Social institutions such as local decision making institutions	C	C	**Construction and operation phase:** Restriction of the construction area and existence of embankment may cause splitting of the community.
	21	Misdistribution of benefit and damage			**Construction and operation phase:** Misdistribution of benefit and damage caused by the road construction is not expected.
	22	Local conflict of interests	B		**Construction phase:** Local inhabitants and local authorities may request to ensure job opportunities as construction workers. **Operation phase:** No impact is expected
	23	Cultural heritage	C		**Pre-Construction and Construction Phase:** Some religious facilities such as Pagodas and monasteries may be affected by widening the road. **Operation phase:** No impact is expected
	24	Landscape			**Construction phase:** Few impacts are expected **Operation phase:** There are no law-based designated landscape areas around the Project Area.
	25	Gender			**Construction and operation phase:** Negative impacts specified for women are not expected.
	26	Right of children			**Construction and operation phase:** Negative impacts specified for children are not expected.
	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 provoke to provide habitats for mosquitoes that possibly transmit 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	Labour environment			**Construction phase:** Construction work environment needs to be considered in accordance with relevant laws and regulations. **Operation phase:** No impact is expected.
Others	29	Accidents	B	B	**Construction phase:** Construction vehicles may use existing local roads near residential areas, thus the number of traffic accident may increase. **Operation phase:** Risks of traffic accidents on the new road is expected due to an increase of travelling speed
	30	Cross boundary impacts and climate change			**Construction phase:** Significant deforestation is not expected on this project, and the number of construction machines is limited, thus few impacts are expected. **Operation phase: The d**riving distance between Kyaito to Bago will be shortened by the construction of the bypass, thus positive impacts are expected in the Project Area.

Note) Rating:
A: Serious impact is expected. B: Some impact is expected. C: Extent of impact is unknown (serious impact is not expected, but survey and analysis shall be done) No mark: Light impact expected. Detailed quantitative survey is not necessary.

Source: JICA Survey Team

(2) Preliminary Analysis for Affected Land and Cost

In the affected area, displaced persons and cost of land acquisition & resettlement will be identified and calculated after the actual site survey during the next step, feasibility study stage.

The following analysed data is prepared for preliminary analysis for the Project based on counting the number of structures on the satellite image and interviews with the local government.

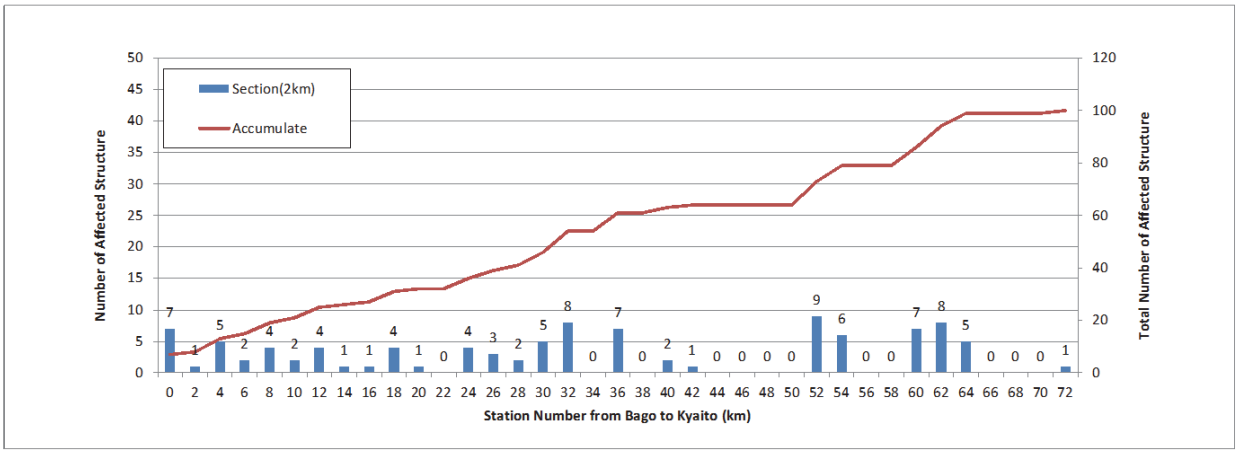
The number of identified affected structures on the planned alignment is 670 on the area affected by the project. The majority of the affected structures are located alongside the existing NH-1 road which passes the residential area. The affected structures on Bago-Kyaito Bypass and HIA access road are expected to be relatively small.

The affected land for Bago-Kyait Bypass and HIA access road is mainly agricultural land such as paddy land and rubber plantations; on the other hand the affected land for NH-1 is mainly residential land.

Table 10.4.3 Estimated Affected Area and Number of Resettled

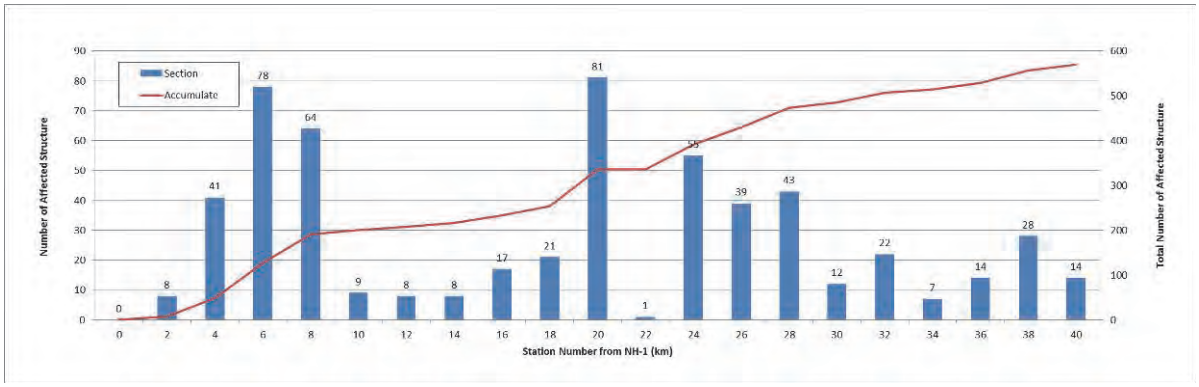
Name of Section	Project Impacts		Compensation Cost		Estimated Number of Resettled (persons)*6 2. x 5 persons/structure
	1. Area to be secured*1 (m^2)	2. Number of Affected Structure on the satellite image*2 (No. of building)	3. Land *3*4 (million kyat)	4. Structure*5 (million kyat)	
Bago – Kyaito Bypass (a+b)	**3,362,625**	**100**	**43,789**	**400**	**500**
a.New Sittaung Bridge	65,000	0	715	0	0
b.Other Road Section	3,297,625	100	43,074	400	500
Upgrading of NH-1 including HIA	**5,74,540**	**570**	**50,044**	**2,280**	**2,850**
Sub Total	**3,937,165**	**670**	**93,832**	**2,680**	**3,350**
Total Cost	**-**	**-**		**96,512**	**-**

Note) Methodology
*1: Area is planned road width (m) – ROW(m) x road length (m)
*2: Counting on the satellite image on the area to be secured
*3: Maximum value in the latest real transaction price (kyat / m^2) x area to be secured (m^2)
*4: Adopted land unit price based on interview with Bago township in March 2016: Residential land in Bago region 65,000 MMK/ m^2, agricultural land in Bago region 11,000/ m^2, residential land in Yangon Region 161,000 MMK/ m^2, agricultural land in Yangon Region 32,000 MMK/ m^2
*5: Adopted structure unit price is 4 million kyat/structure RAP survey result in Mon State and Kayin State 2014-2015
*6: Number of family members is approximately five people/household based on JICA RAP survey result in Mon State and Kayin State 2014-2015
*7: Other cost : crop compensation cost such as rice, rubber trees and fisheries, and livelihood assistance = 6 x (land and structure compensation price)
Source: JICA Survey Team



Source: JICA Survey Team

Figure 10.4.1 Distribution of Affected Structure (Kyaito – Bago Bypass)



Source: JICA Survey Team

Figure 10.4.2 Distribution of Affected Structure (Upgrading NH-1)

Current state of the roadside of NH-1 where the structures may be affected in the Yangon region

Current state of the roadside of NH-1 where the structures may be affected in the Bago region

Source: JICA Survey Team

Figure 10.4.3 Structures to be displaced along NH-1

10.4.3 Baseline Survey and Analysis Methodology

The expected baseline and survey and analysis methodologies are shown below.

Table 10.4.4 Baseline Survey and Analysis Methodology

Category	№	Impacted Item on JICA Guidelines	Baseline Survey	Forecast Analysis (in case of rate A, B or C)
Pollution	1	Air pollution	(1) Site measurement (2 points x 3 sites: Total of 6 points) (Point1: roadside air quality along the existing road side near considerable facility such as school, Point 2: ambient air quality in residential areas not road side 3 sites : 3 main villages to be selected from Kyaito, Bago and Yangon) Note) In the selection of the measurement locations priority must be given to the sensitive facilities of air pollution impact, such as schools, hospitals, residential area, so on) (2) Item CO, NO_2, SO_2 and TSP (3) Frequency One time Note) Collection of Secondary data, if any	**During Construction Phase:** Qualitative analysis **Operation Phase:** - Quantitative analysis (Puff model : calm wind model) or - Comparison analysis with other cases (monitored value with same traffic volume in the future)
	2	Water pollution	(1) Site measurement (1 point at each bridge) x 3 sites x 2 season (dry/rainy season) = 6 measurements) (2) Item BOD, pH, SS, temperature (3) Frequency Twice (dry and rainy season) Note) Secondary data collection, if any	**During Construction Phase:** Qualitative analysis and quantitative analysis based on other cases
	3	Waste	Sampling site survey is not required	**During Construction Phase:** Quantitative analysis of volume of cutting trees, excavated soil and other wastes.
	5	Noise and vibration	(1) Site measurement (same points with Air measurements) Total of 6 points Note) In the selection of the measurement location priority must be given to the sensitive facilities of noise impact, such as schools, hospitals, residential area, so on. (2) Item Noise : $L_{Aeq,\ 10min}$ 24hr/weekday Vibration: L_{10}, 24hr/weekday traffic volume and speed (3) Frequency One time Note)Secondary data collection, if any	**During Construction Phase:** Quantitative analysis based on construction machines on standard formation. **Operation Phase:** - Quantitative analysis Noise: ASJ CN-Model 2008 Vibration: Japanese Model or - Comparison analysis with other cases (monitored value with same traffic volume in the future)
Natural Environment	9	Protected area	Site survey is not required (Confirmation of designated protected area such as National Park and forest reserve)	**During construction and operation phase:** Qualitative analysis base on the literature survey and construction plan & traffic volume in the future (if protected area is located near project area)
	10	Ecosystem (Terrestrial Biology Freshwater or marine ecology)	(1) Site survey (line census or point census on typical environment along the road), literature and interview survey (2) Item Fauna and flora, ecosystem, considerable species such as listed species on IUCN or Myanmar's list (3) Frequency One time Note) Secondary data collection, if any	**During construction and operation phase:** Qualitative analysis base on the literature survey, site survey and construction plan & traffic volume in the future

Category	№	Impacted Item on JICA Guidelines	Baseline Survey	Forecast Analysis (in case of rate A, B or C)
Natural Environment	11	Hydrology	Site survey is not required (refer to river topographic survey and hydrological analysis by the JICA Survey Team)	**During construction and operation phase:** Quantitative analysis on following items based on the hydrographic analysis for bridge and drainage designing. - Impact on hydrological situation on the rivers and streams - Impact on flooding situation
Social Environment	13	Involuntary resettlement	Refer to RAP survey	**During construction phase:** Quantitative analysis based on RAP surveys
	14	The poor	Refer to RAP survey	**During construction phase:** Quantitative analysis based on RAP surveys
	15	Indigenous and ethnic people	Refer to RAP survey	**During construction phase:** Quantitative analysis based on RAP surveys
	16	Local economy such as employment and livelihood	Refer to RAP survey	**During construction phase:** Qualitative analysis based on RAP surveys
	17	Land use and utilization of local resources	Refer to RAP survey	**During construction phase:** Quantitative analysis based on RAP surveys (area of land acquisition by land use)
	18	Water usage	(1) Site survey (Totally selected 3 major villages along the road = 3 measurements) (2) Item - Underground water at well, if any(pH, BOD, Total Coliform, Conductivity, Temperature and water level of well) (3) Frequency One time Note)Secondary data collection, if any	**During construction and operation phase:** Qualitative analysis base on the baseline survey for following items - Impact on springs and wells, if any - Impact on watershed area
	19	Existing social infrastructures and services	Refer to RAP survey	**During construction phase:** Quantitative analysis based on RAP surveys
	22	Local conflict of interests	Site survey is not required	**During construction:** Qualitative analysis based on RAP surveys and opinions through stakeholder meeting(s)
	23	Cultural heritage	Refer to RAP surveys (Confirmation affected religious facilities)	**During construction:** Quantitative analysis based on RAP surveys and opinions through stakeholder meeting(s)
	24	Landscape	(1) Site survey (select cultural heritage or monument, if any in the affected area) (2) Item Taking photograph (3) Frequency One time	**Operation phase:** Qualitative analysis based on baseline survey, if any impacted sites are identified.
	27	Infectious diseases such as HIV/AIDS	Site survey is not required	**During construction phase:** Qualitative analysis based on baseline survey. Followings impacts are considered - Risks of HIV/AIDS - Risks of dengue fever - Other specific infection disease
Others	29	Accidents	Collection of traffic accident data from police station	**Operation phase:** Qualitative analysis based on baseline survey

Source: JICA Survey Team

10.4.4 Draft Environmental Management Plan

The environmental management plan includes mitigation measures and an implementation organization. All mitigation measures shall be conducted by the construction contractor under MOC or other project proponent. The costs for mitigation measures are secured in physical contingency of construction costs since all mitigation measures are common.

The expected environmental mitigation measures are shown below.

Table 10.4.5 General Environmental Management Plan

Category	No	Impacted Item on JICA Guidelines	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
Pollution	1	Air pollution	[Dust] ✓ Water sprinkling near residential area ✓ Law emission construction machinery shall be used to avid high emission of exhaust gases	Not required	Contractor	MOC
	2	Water pollution	[Turbid water and other items] ✓ Discharge turbid water through sedimentation pond and silt fence ✓ Installation of portable toilet for workers ✓ Appropriate waste and construction machines management ✓ Appropriate explanation and response shall be given to affected fishermen, if necessary	Not required	Contractor	MOC
	3	Waste	[Construction waste (trees and waste soil)] ✓ Obstacles shall not be dumped into the river and they shall be disposed at a disposal site prepared near the bank of the river. ✓ After considering the possibility of reuse, construction waste is disposed at disposal site [Garbage from base camp] ✓ Garbage at workers camp and waste oil shall be brought to disposal site or facility [Night soil] ✓ Temporary sanitation facility such as a septic tank shall be introduced to the workers camp.	✓ Demolished waste concrete shall be reused and/or disposed in designated disposal site.	[Const.] Contractor [Operation] MOC	MOC
	5	Noise and vibration	[Construction noise and Vibration] ✓ Installing noise barrier and selecting low-noise equipment if necessary. ✓ Avoiding work of heavy equipment during night time, if possible. ✓ Preparation of temporary accommodation in silent place for sensitive receptors ✓ Informing the construction schedule to surrounding communities to obtain their consensus.	✓ Vehicle travelling speed shall be controlled by state government if required	[Const.] Contractor [Operation] MOC	MOC
Natural Environment	10	Ecosystem	✓ Construction development area shall be marked and not be disturbed. ✓ Hazardous waste material should be stored properly before final disposal. ✓ Planting trees, vegetation, sodding in the public space. ✓ Installation of sedimentation ponds, silt fence and portable toilet not to disturb habitats of aquatic lives.	✓ Appropriate land use management not to cause unplanned development ✓ Setting up sign boards where animals crossing the road from the view of natural conservation	[Const.] Contractor [Operation] State government, MOC	MOC

Category	No	Impacted Item on JICA Guidelines	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
Natural Environment	11	Hydrology	✓ Monitoring of water level by installing critical water alarm system in the rainy season	✓ Monitoring of water level by installing critical water alarm system in the rainy season	[Const.] Contractor [Operation] MOC	MOC
Social Environment	13	Involuntary resettlement	✓ Holding a consultation meeting for understanding the compensation policy ✓ Appropriate compensation and social assistance in accordance with RAP	✓ Assessing whether resettlement requirements have been met, particularly with regards to livelihood and restoration and/or enhancement of living standards in accordance with RAP	Settlement Land Record Department (SLRD), MOAI	MOC
	14	The poor	✓ Holding a consultation meeting for understanding the compensation policy ✓ Appropriate social assistance in accordance with RAP	✓ Assessing whether resettlement requirements have been met, particularly with regards to livelihood and restoration and/or enhancement of living standards in accordance with RAP	SLRD, MOAI	MOC
	16	Local economy such as employment and livelihood	✓ Holding a consultation meeting for understanding the compensation policy ✓ Appropriate compensation and social assistance in accordance with RAP	✓ Assessing whether resettlement requirements have been met, particularly with regards to livelihood and restoration and/or enhancement of living standards in accordance with RAP	SLRD, MOAI	MOC
	17	Land use and utilization of local resources	✓ Holding a consultation meeting for understanding the compensation policy ✓ Appropriate land acquisition, compensation and social assistance for agricultural area ✓ Assistance of the establishment of land use maps in every township	✓ Management of appropriate land use in accordance with approved established new land use plan in every township and village	[Const.] SLRD, MOAI,D/D consultant [Operation] Local government	MOC
	18	Water usage	✓ Drainage facility, sedimentation pond and sheet are prepared to prevent turbid water generated by earth work in accordance with the site condition. ✓ Coffer dam, steel pipe sheet pile and multi pile foundation method shall be adapted to minimize turbid water. ✓ Domestic waste and other construction waste will be collected properly and disposed in the designated dumping site. ✓ Installation of portable toilet.	Not required	Contractor	MOC
	19	Existing social infrastructures and services	✓ Construction of a diversion road and existing community roads will be connected with the new bypass.	Not required	Contractor	MOC
	20	Social institutions such as local decision making institutions	✓ Diversion shall be set up during construction ✓ Current intersections and community paths shall be conserved not to cause community splitting	Not required	Contractor	MOC
	22	Local conflict of interests	✓ Local workforce is prioritized for construction of the road and bridges ✓ Implementation of appropriate education for hired workers from other areas	Not required	Contractor	MOC

Category	№	Impacted Item on JICA Guidelines	Major Mitigation Measures		Responsibility	
			Pre and During Construction phase	Operation phase	Implementation Agency	Responsible Agency
Social Environment	27	Infectious diseases such as dengue and HIV/AIDS	✓ Installation of sufficient drainage facilities not to provide habitat for vector mosquito ✓ Provision of adequate temporary sanitation facilities ✓ Enforcement of medical screening and periodical medical check-up ✓ In order to prevent spread of infectious diseases such as HIV/AIDS, awareness of the labourers is promoted	✓ Installation of sufficient facilities not to provide habitat for vector mosquito ✓ Implementation of periodical maintenance for drainages and bridges	[Const.] Contractor [Operation] MOC	MOC
Others	29	Accidents	✓ Deploying flagman at the gate and crossing points of the construction vehicles ✓ Installation of safety sign board ✓ Installing fence around the construction site to keep out local people such as children ✓ Installation of lighting in the night time near construction area ✓ Installation of parking area for idling construction machines ✓ Restricting mobilization speed in the construction site ✓ Safety training for the workers ✓ Safety patrol at the construction site by supervisors	✓ Installation of sign board for speed limit near schools and residential areas ✓ Establishment of school zones ✓ Enforcement of traffic control by police	[Const.] Contractor [Operation] MOC	MOC

Source: JICA Survey Team

10.5 Environmental and Social Recommendation

The following are recommendations on the next feasibility study financed by international donors.

[EIA]

- ✓ The project proponent in association with the project donor(s) shall conduct and obtain necessary environmental certificate(s) from authorized environmental agencies such as the Environmental Conservation Department of MOECAF before actual construction activities.
- ✓ The project proponent shall disclose project information and conduct sufficient explanation to the local stakeholders at the scoping stage, and then formulate consensus with the local stakeholders.
- ✓ The proponent and local government shall manage land use along the project road strictly not to cause unexpected land use.
- ✓ The construction contractor shall conduct necessary EIA and RAP in accordance with Myanmar's relevant laws and JICA Guidelines when new quarries and borrow pits are developed during the construction stage.

[RAP]

- ✓ It is recommended that the project proponent declares a cut-off date in accordance with WB OP4.12 before a series of RAP surveys not to inflow informal inhabitants
- ✓ The project proponent shall share its compensation policy on the prepared RAP in accordance with WB OP4.12 with other governmental organizations and apply the policy for actual compensation.

CHAPTER 11 CONCULUSIONS AND WAY FORWARD

11.1 Conclusions

As a result of the survey, the following conclusions were found;

- The construction of "New Bago – Kyaito Road" and "Improvement of National Highway No.1 (NH1)" are proposed to cope with insufficient road capacity and provide safety travelling in harmful situation by rapidly increase of traffic from the southeast region to Yangon. It will be also expected to provide a redundancy on East West Corridor (Yangon – Thaton – Myawaddy and Thaton – Dawei).
- The appropriate number of lanes for New Bago- Kyaito road and NH1would be four lanes (2+2) and eight lanes (4+4) for the elevated (or laterally widened) road respectively, based on the traffic demand forecast in this survey.
- Setting the road alignment of New Bago – Kyaito road need to be controlled to minimize involuntary resettlement (in passing through village and town etc.) and shorten the road length between Bago and Kyaito as much as possible.
- A hybrid PC bridge with steel web could be proposed for an eligible type of New Sittaung Bridge that contribute to an introduction of new bridge technology to Myanmar.
- New alignment of improved road structures for NH1 should follow basically the existing alignment but is required to improve some sections where breach the design criteria. The elevated viaduct structure is applied in the residential area to minimize involuntary resettlement by the project.
- A PC composite girder bridge is recommended to apply for the viaduct structure at the standard section of NH1. The PC girder could be produced in the factory or temporary yard which is systematically controlled for consistent quality and could be saved construction time.
- The elevated section of NH1 requires a long span bridge to cross over the traffic intersections, rivers/creaks or other existing structures. Steel box girder bridge would be eligible for these sections.
- The numbers of affected person, facilities and lands were preliminarily counted based on the preliminary plan drawings on the satellite map.
- The economic analysis is resulted in indicating the proposed projects are economically viable.

11.2 Way Forward to Following Surveys

- The route of Hanthawaddy International Airport (HIA) Access Road shall be finalized with appropriate justifications in the following study since the improvement of the existing NH1 is expected to actualize prospected financial return by early operation of the airport. Thus, a full scaled study should be conducted to evaluate the alternative access routes and justify the appropriateness of the routes based on the national road network plan.
- Traffic demand forecast was estimated based on the existing traffic data covered only for the road network in the area of southeast Myanmar during phase-1 using the person trips from/to HIA estimated in the existing JICA preparatory survey and road network model formulated in MYT-Plan. Further study for traffic demand forecast shall be required to justify the appropriate numbers of traffic lanes necessary to the project roads.
- The preliminary plan has been prepared based on the digital topographic map in 1:5,000 scale for New Bago – Kyaito Road and in 1:10,000 scale for NH1 which were produced from the available satellite images. A further detailed topographic survey shall be necessary to determine the alignment and structure layouts in details. Also the geotechnical survey shall be required for the further study of structural types.
- To verify the flood water level, discharge volume and scouring depth necessary to the detailed design, the additional hydrological and hydraulic study shall be conducted based on precise topographic map and reliable meteorological data, etc.
- Location of the New Sittaung Bridge is proposed near the river mouth. The applicability of the weathering steel shall be carefully examined by using the tests of exposure test pieces and flying salt in order to reduce the life cycle cost.
- A further detailed study on environmental and social considerations shall be required to support a project implementation agency to establish EIA and RAPs and to get necessary certificate(s) from authorized agencies such as ECD under MOECAF.
- After the explanation of Draft Final Report for Phase-II survey in 10 August 2016, MOC requests JICA Survey Team (JST) to conduct a feasibility study on the alternative route as shown in Appendix-2. Thus, JST conducted the initial study on the proposed route by MOC as shown in Annex-3. The study results indicates that the JICA Pre-F/S road is to be justified and ,on the other hand, the alternative route, improvement of the existing Thalyin – Thonegwa – Khayan – Kamarsai –Bago road proposed by MOC, is also a vital link to secure smooth logistic network from Thilawa SEZ. In this context, a further study/discussion is necessary to justify the objective and function for each proposed road.