Ministry of Construction
Republic of the Union of Myanmar

Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) in the Republic of the Union of Myanmar

Final Report

Volume 1

Main Report

February 2020

Japan International Cooperation Agency

Oriental Consultants Global Co., Ltd.
Nippon Koei Co., Ltd.
International Development Center of Japan Inc.
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Currency Equivalents

USD 1.00 = MMK1,500 = JPY 109.0 (January 2020)
*MMK: Myanmar Kyat

Location Map and Site Conditions around East-West Economic Corridor and National Highway

①NH8 Toll Gate (BOT)

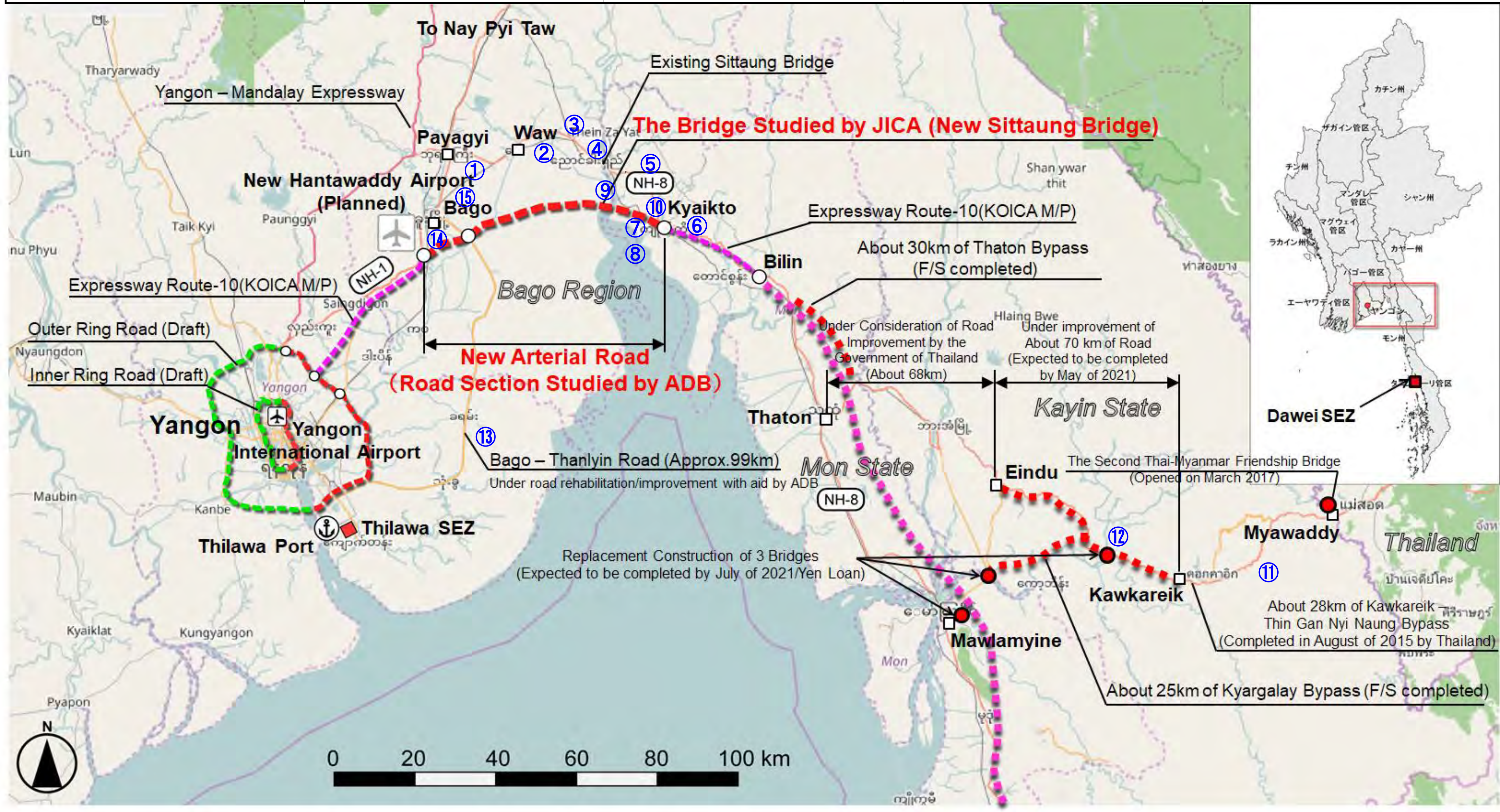
②NH8 Waw City

③NH8 (West area of the existing Sittang Bridge)

④The existing Sittang Bridge (oparated in 2008)

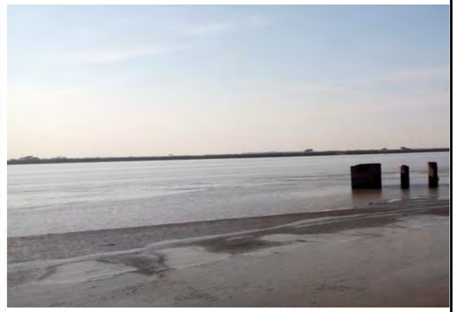
⑤NH8 (East area of the existing Sittang Bridge)

⑥NH8 Kyaito City



⑦Crossing River Point of the New Sittang Bridge on the left bank (1)

⑧Crossing River Point of the New Sittang Bridge on the left bank (2)



⑨Crossing River Point of the New Sittang Bridge on the left bank (Paddy Field Zone)

⑮NH1 Bago City

⑭NH1 (South of Bago City)

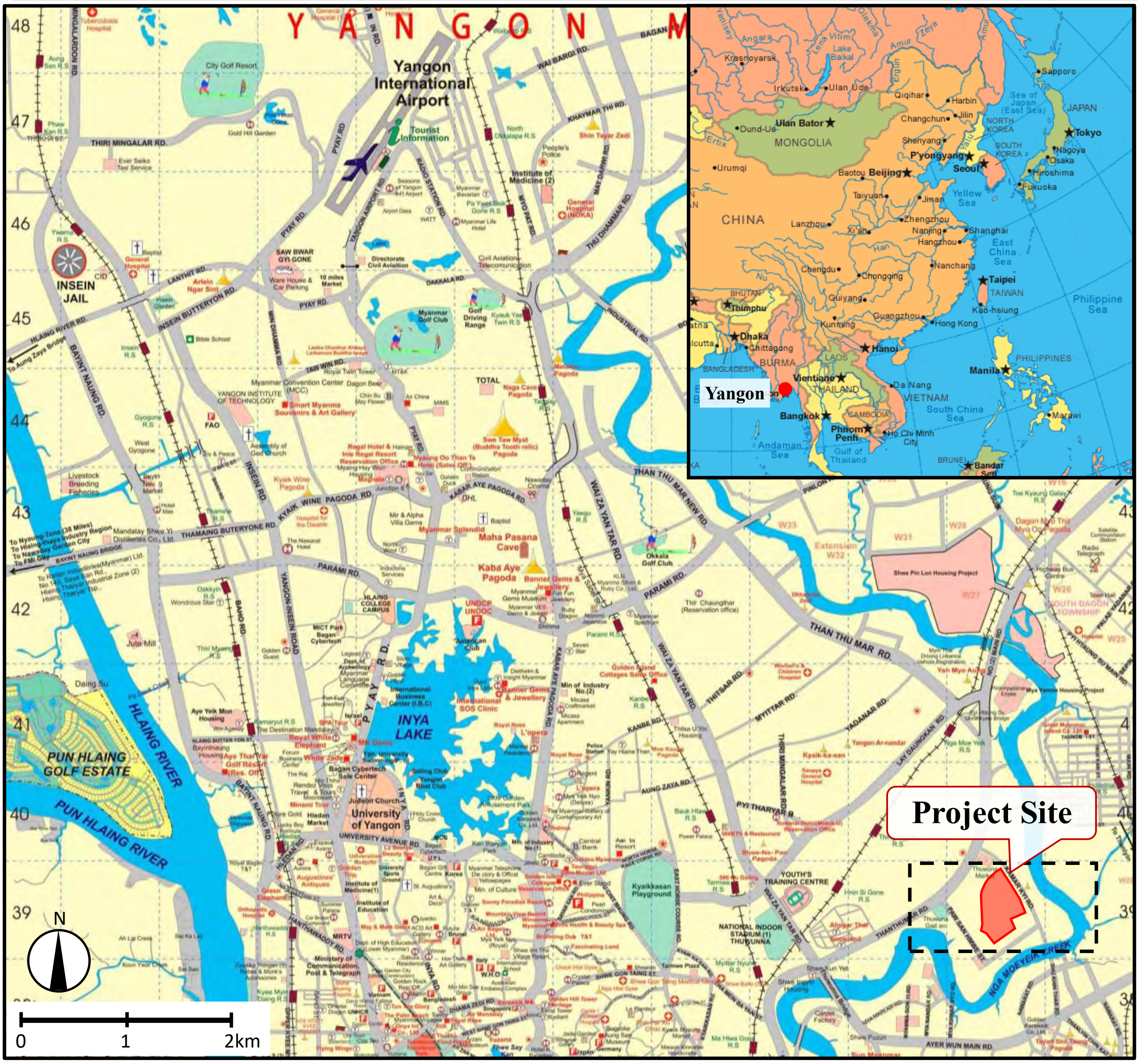
⑬Thilawa-Bago Road

⑫Eindu - Kawkareik

⑪Kawkareik - Thin Gan Nyi Naung Bypass

⑩Crossing River Point of the New Sittang Bridge on the right bank (Plantation Zone)

Location Map around Thuwunna Research Laboratory and Training Center



Perspective of the Project (New Sittaung Bridge)

Perspective of the Project (New Sittaung Bridge)

Perspective of the Project (New Sittaung Bridge)

Perspective of the Project (New Sittaung Bridge)

Bird's Eye View of Thuwunna Research Laboratory and Training Center

Perspective View of the Vocational Training Center

Perspective View of the Hostels

Interior Perspective View of Research Laboratory

Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section)

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background of the Project

The Republic of the Union of Myanmar (hereinafter referred to as "Myanmar") has had continuing high economic growth with the shift to democratization (March 2011). There is active trade with neighboring Thailand in the background. Trade between the two countries is expected to further expand in the future, but the current maritime transport via the Malay Peninsula is very inefficient. As an alternative means of transportation to the sea, it is expected that the East-West Economic Corridor (hereinafter referred to as "EWEC") connecting the two countries as well as other ASEAN countries by land will be developed soon. The other countries' section of EWEC has been improved with international standards that can correspond to international logistics. On the other hand, there are many bottleneck sections that impede smooth land transportation, such as weight limitation due to aging bridges, incorrect alignment and profiles such as steep and sharp curves, passage through dense urban areas, etc. Therefore, the government of Myanmar has put the development of the route as a high priority and has promoted improvement through the support of international organizations and the Thai government.

As a result, from the Thai border to the Thaton and Mawlamyine section, the roadway has been improved to a two-lane paved road corresponding to international standards, thereby domestic and international logistics are expected to be activated. Meanwhile, issues such as traffic congestion and deterioration of safety are beginning to surface. Especially, traffic congestion is predicted to occur due to the mixture of regional traffic and transit traffic because the existing road passes through the urban area from the Bago to Kyaikto section about 100 km from Thaton to Yangon. Therefore, in order to separate regional traffic and transit traffic to ensure safety, it is necessary to build an alternative highway that can divert the traffic from urban areas in this section.

Moreover, in response to logistics promotion in line with the country's economic growth, a lot of roads and bridges have been constructed recently in Myanmar and results in lack of technical capacity and human resources. Thus, MOC needs to strengthen technical training programs which will improve the technical and project management skills of engineers in MOC. To reflect to this, enhancement of the Thuwunna Central Training Center (hereafter referred to as "Thuwunna CTC")'s function and Research Laboratories' quality control function are strongly required. However it was recognized that advanced trainings and quality inspections cannot be provided sufficiently in the existing Thuwunna CTC and laboratories due to its aging and insufficient facilities. Hence, the upgrading of the CTC and Research Laboratories facilities is strongly required for providing the necessary advanced trainings and quality inspections for sustainable operation, maintenance and management of highways and bridges including this Project road.

Under these circumstances, the Japan International Cooperation Agency (hereinafter referred to as "JICA") decided to implement a Feasibility Study (F/S) necessary for the development of the new road between Bago and Kyaikto and upgrading the existing training center including laboratories for quality inspections of construction materials, in cooperation with the Asian Development Bank (hereafter referred to as "ADB"). The JICA's Study (hereafter referred to as "the Study") is concerned for the "Construction of the New Sittaung Bridge" and "Upgrading Thuwunna Research Laboratory and Training Center" (hereinafter referred to as "the Project") and ADB's Study is concerned for the construction of the road section from Bago to Kyaikto section.

1.2 Outline of the EWEC Project

The objective of the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) (hereinafter referred to as "the EWEC Project") is the development of a new arterial road of about 63.9km connecting Bago to Kyaikto including the construction of New Sittaung Bridge and the upgrading of Thuwunna Research Laboratory and Training Center (hereafter referred to as "Thuwunna RLTC"). In addition, the subject of the Study is the New Sittaung Bridge section which is about 2.5km in length as well as upgrading of Thuwunna RLTC, studied in the view of the JICA loan. The outline of the EWEC Project is shown in Table S 1.2.1.

Table S 1.2.1 Outline ofthe EWEC Project

Project Name	East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section)
Project Purpose	To improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to the vitalization of Myanmar's trade.
Project Outline	<u>Study object of JICA's loan</u> ・Construction of New Sittaung Bridge (total length of 2.5km) ・Upgrading of Thuwunna Research Laboratory and Training Center <u>Study object of ADB's loan</u> ・Construction of new arterial road except for New Sittaung Bridge (total length of 61.4km)
Project Area	Mon State, Bago Region and Yangon Region of Myanmar
Related Government Agency	Ministry of Construction(MOC), Department of Bridge (DOB) and Department of Highways (DOH)

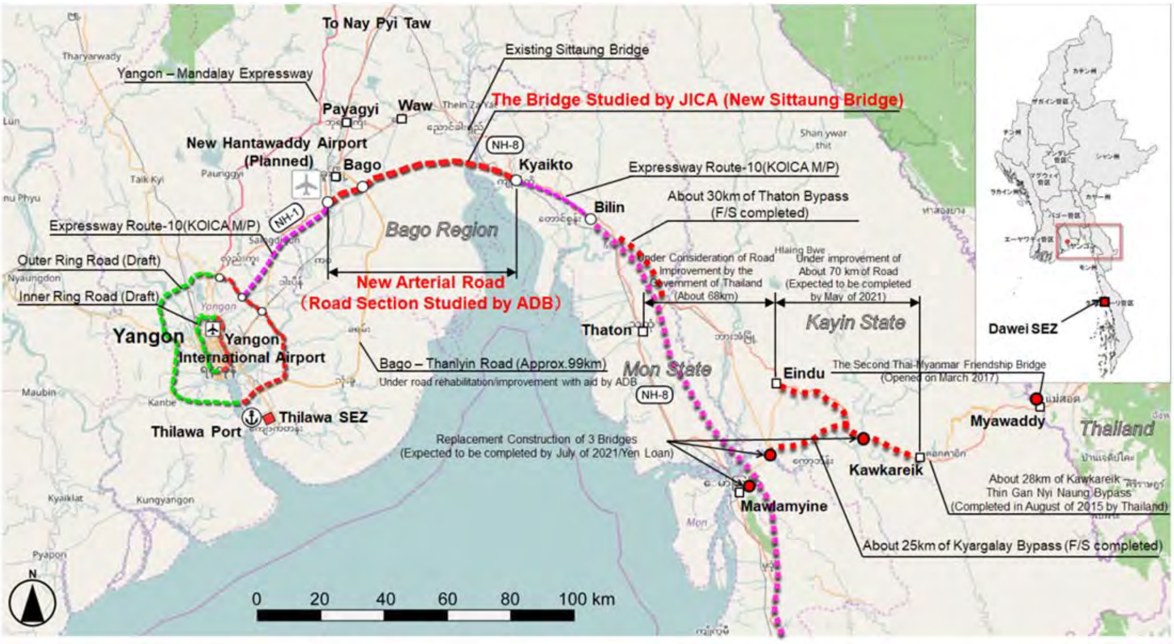
Source: JICA Study Team

1.3 Objective of the Study

The objective of the Study is to conduct a necessary survey, such as objectives, outline, project cost, implementation schedule, implementation method (procurement, construction), project implementation organization, operation and maintenance system, environmental and social considerations, etc., for the examination for implementation of construction of New Sittaung Bridge and upgrading of Thuwunna RLTC under the EWEC Project as Japan's loan cooperation.

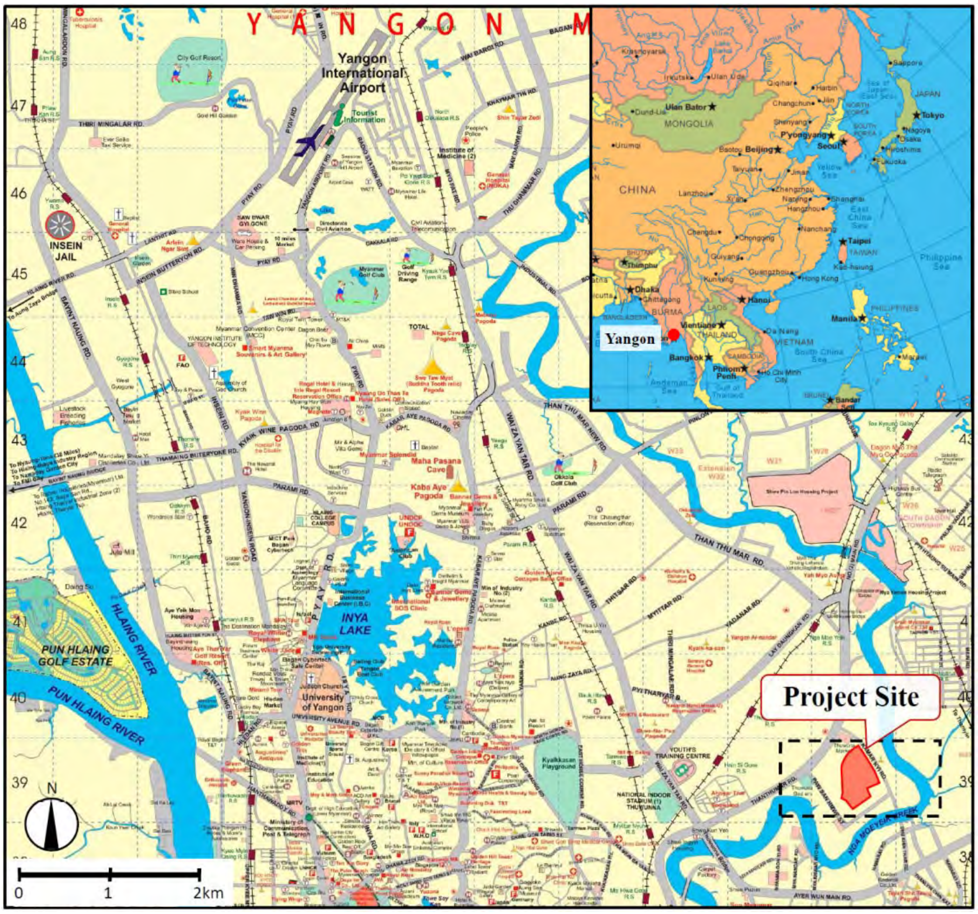
1.4 Study Area

The details of the EWEC Project area are shown in Figure S 1.4.1 and Figure S 1.4.2.



Source: JICA Study Team

Figure S 1.4.1 Project Location Map (New Sittaung Bridge)

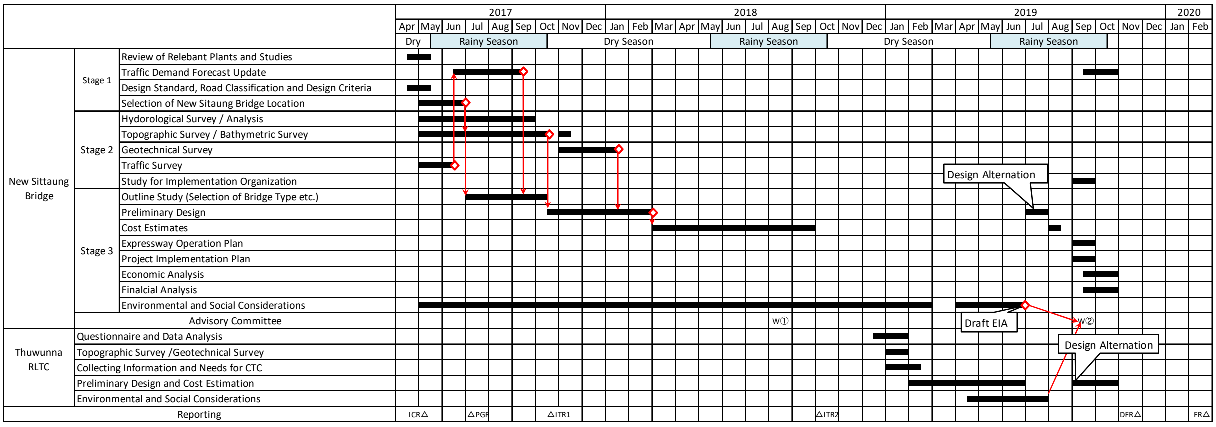


Source: JICA Study Team

Figure S 1.4.2 Project Location Map (Thuwunna RLTC)

1.5 Study Schedule

The work schedule of the Study is shown in Figure S 1.5.1.



Source: JICA Study Team

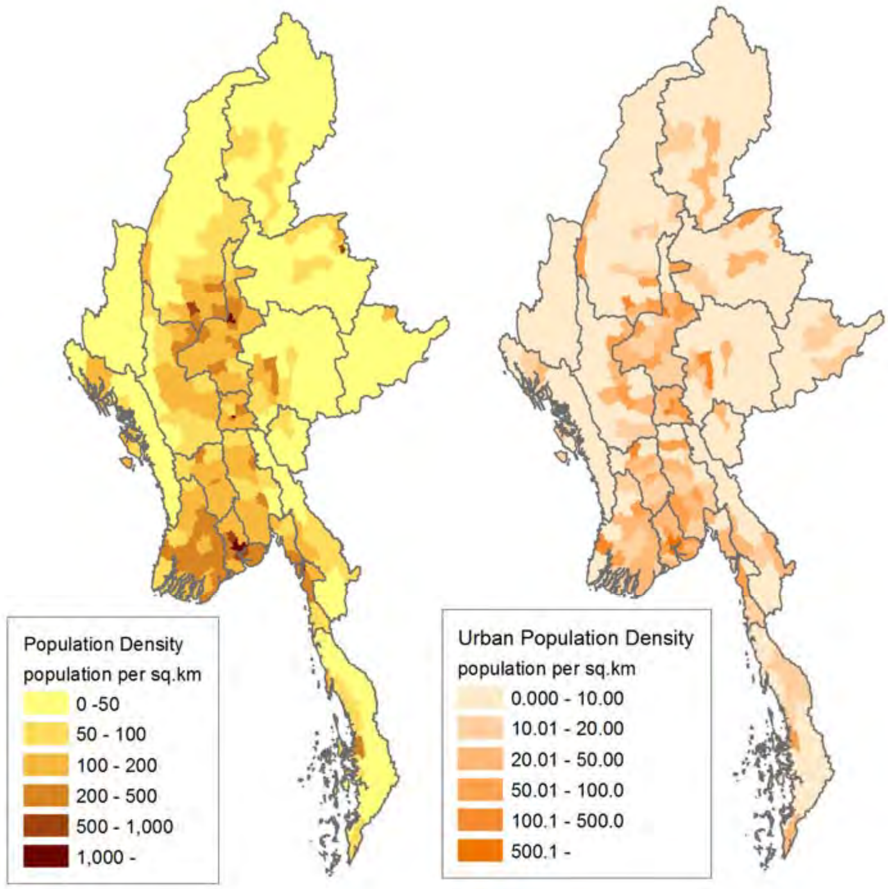
Figure S 1.5.1 Work Schedule of the Study

2. GENERAL APPRECIATION AND PURPOSE OF THE PROJECT

2.1 Socio-Economic Conditions of the Project Area

2.1.1 Population and GDP

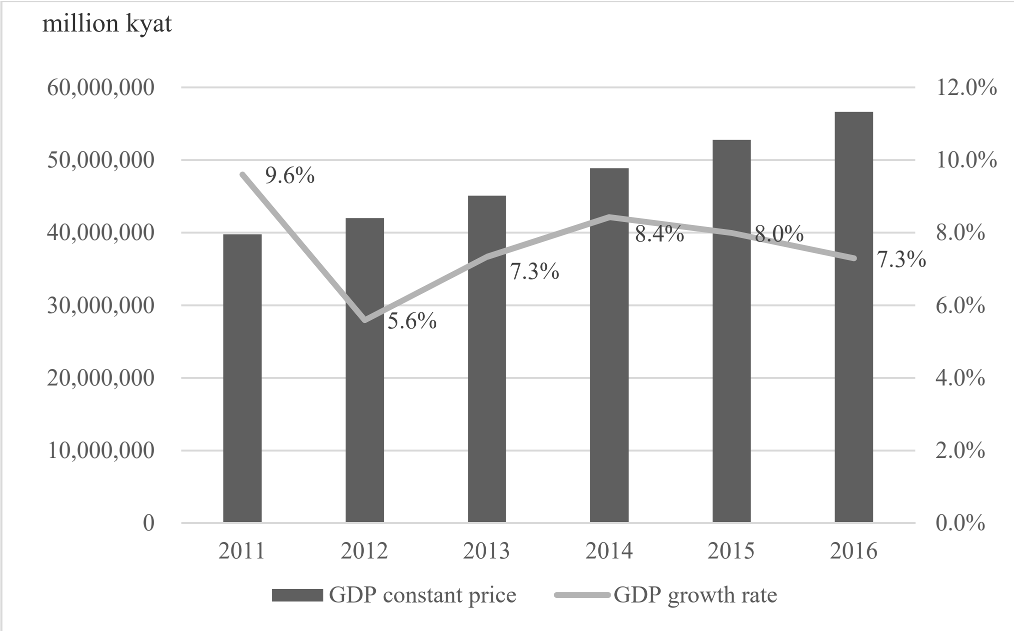
According to the census result, the total population in Myanmar is 51.49 million as of 2014. The project area (Bago Region and Mon State) accounts for 13.4% and 7.6% in terms of population and area respectively. Population density in the project area, the mean density of Bago Region and Mon State, is 133.9 people/km^2 which is almost twice compared with the national average of 76.1 people/km^2.



Source: 2014 Population and Housing Census of Myanmar

Figure S 2.1.1 Population Density in 2014

Figure S 2.1.1 indicates the real GDP and GDP growth rate in Myanmar from 2011 to 2017. The GDP growth rate has been steady for the last several years, recording 8.4% in 2013/2014, 8.0% in 2014/2015, and 7.0% in 2015/2016. GDP growth rate in 2016/2017 was 5.9%. Projections from IMF suggest that Myanmar will maintain its steady economic growth in the near future. It shows that the estimated GDP growth rate in 2017/2018 is 6.8% while in 2018/2019 and 2019/2020 it will be 6.4% and 6.6% respectively.



Source: 2016 Myanmar Statistical Yearbook, Ministry of National Planning and Economic Development

Figure S 2.1.2 Real GDP and GDP Growth Rate

2.2 Road Network in Myanmar

2.2.1 Introduction

(1) Road and Bridge Condition in Myanmar

The total length of roads in Myanmar is approximately 142,400km and MOC manages about 42,100km (29.5% of total). The paved ratio is about 71% of the total and it has been improving year by year.

Regarding bridge condition, there are 514 bridges in Myanmar of which the length is over 54m (as of 2016). Many bridges in Myanmar are designed, constructed and maintained by MOC directly, while some roads are being maintained under BOT scheme. Financial and technical support for bridge construction in Myanmar began with the “Bridge Engineering Training Center Project” (BETC Project) by JICA, which was implemented from 1969 to 1975. This project significantly contributed to the capacity development of MOC staff and increased the number of bridge engineers in Myanmar.

Some existing bridges have critical problems, such as deterioration, because of their aging and insufficient structural capacity, and have become bottlenecks in the road network.

2.2.2 Expressway and National Highways

The total length of Expressway in Myanmar is currently 586km and there is only one route, Yangon-Mandalay Expressway, which has four-carriageway and can serve as a high-speed arterial road for the northern and southern direction of the country.

The National Highway Network with a total length of about 20,000km covers the whole country and it is controlled under the jurisdiction of MOC. Although some highways in urban areas are maintained by private companies under BOT, national highways in rural areas are mainly maintained by MOC directly and the road conditions are comparatively poor compared with highways.

2.2.3 International Highways

(1) Asian Highways

Asian Highways is the international highway network initially established by UNESCAP in 1959, with approximately 141,000km length of road networks covering 32 countries. In Myanmar, there are four Asian Highways with a total length of 3,003km. New Sittaung Bridge is planned on a bypass route which is a part of AH1 (Myawaddy-Yangon-Mandalay-Tamu) as well as the GMS East-West Economic Corridor.

(2) ASEAN Highways

ASEAN Highways comprise of 23 routes with a total length of about 38,400km and are under development for the purpose of the establishment of efficient, integrated, safe and environmentally sustainable regional land transport corridors linking all ASEAN countries. ASEAN Highways link Myanmar to China, India, and Thailand, and are playing important roles as major international road networks in the country.

(3) GMS Economic Corridor

The Greater Mekong Subregion (hereinafter referred to as “GMS”) is a natural economic area consisting of Cambodia, China, Lao PDR, Myanmar, Thailand and Vietnam. The GMS Economic Corridor consists of nine corridors. New Sittaung Bridge is planned on a bypass route of the GMS EWEC as well as AH1, which connects the regional hubs such as Bago and Mawlamyine, with Yangon.

Source: Review of Configuration of the Greater Mekong Subregion Economic Corridors (ADB)

Figure S 2.2.1 Proposed Realignment and/or Extension on the GMS Economic Corridors

2.3 Road Transportation in Myanmar

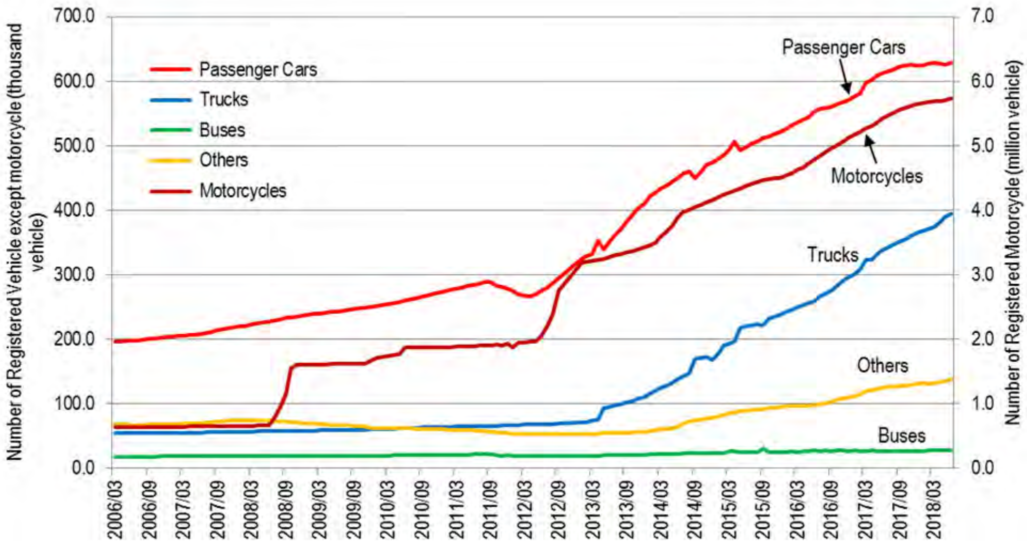
2.3.1 Number of Motor Vehicles

Import of motor vehicles in Myanmar had been restricted by the control of import permission since 1997 because of a shortage of foreign currency reserve. Thereafter, the restriction of the import of completed vehicles was removed gradually from September 2011 to July 2012. As the result, imported and registered vehicles have increased rapidly since 2012 as shown in the following table and figure. As of March 2018, 5.7 million motorcycles, 628,000 passenger cars, 374,000 trucks and 28,000 buses are registered in Myanmar.

Table S 2.3.1 Registered Motor Vehicles and Annual Growth Rate

	Passenger Cars		Trucks		Buses		Motorcycles		Others		Total	
FY 2017/18	628,054	5%	374,287	16%	28,010	5%	5,690,773	8%	132,871	11%	6,853,995	8%
FY 2016/17	596,549	11%	322,533	29%	26,801	3%	5,271,105	14%	120,014	23%	6,337,002	14%
FY 2015/16	536,471	8%	250,529	29%	25,937	-3%	4,631,007	8%	97,316	13%	5,541,260	9%
FY 2014/15	494,657	14%	193,559	55%	26,746	21%	4,276,696	19%	86,041	40%	5,077,699	20%
FY 2013/14	434,169	31%	124,597	67%	22,151	12%	3,595,474	12%	61,291	13%	4,237,682	15%
FY 2012/13	331,468	24%	74,546	10%	19,812	1%	3,219,213	65%	54,070	1%	3,699,109	56%
FY 2011/12	267,561	-4%	67,750	4%	19,579	-7%	1,955,505	4%	53,352	-11%	2,363,747	2%
FY 2010/11	279,066	10%	64,888	6%	20,944	6%	1,883,958	8%	59,665	-5%	2,308,521	8%
FY 2009/10	254,797	6%	61,132	4%	19,807	1%	1,749,083	8%	62,585	-8%	2,147,404	7%
FY 2008/09	239,895	8%	58,857	3%	19,683	2%	1,612,423	145%	68,102	-9%	1,998,960	94%
FY 2007/08	222,661	8%	57,211	3%	19,291	2%	658,997	2%	74,682	7%	1,032,842	4%
FY 2006/07	206,020	5%	55,382	1%	18,857	5%	646,872	1%	69,625	2%	996,756	2%
FY 2005/06	196,314	-	54,801	-	18,038	-	641,777	-	68,358	-	979,288	-

Source: The Myanmar Information System (MMSIS)



Source: The Myanmar Information System (MMSIS)

Figure S 2.3.1 Registered Motor Vehicles by Type

2.4 Upper Plans

2.4.1 Master Plans

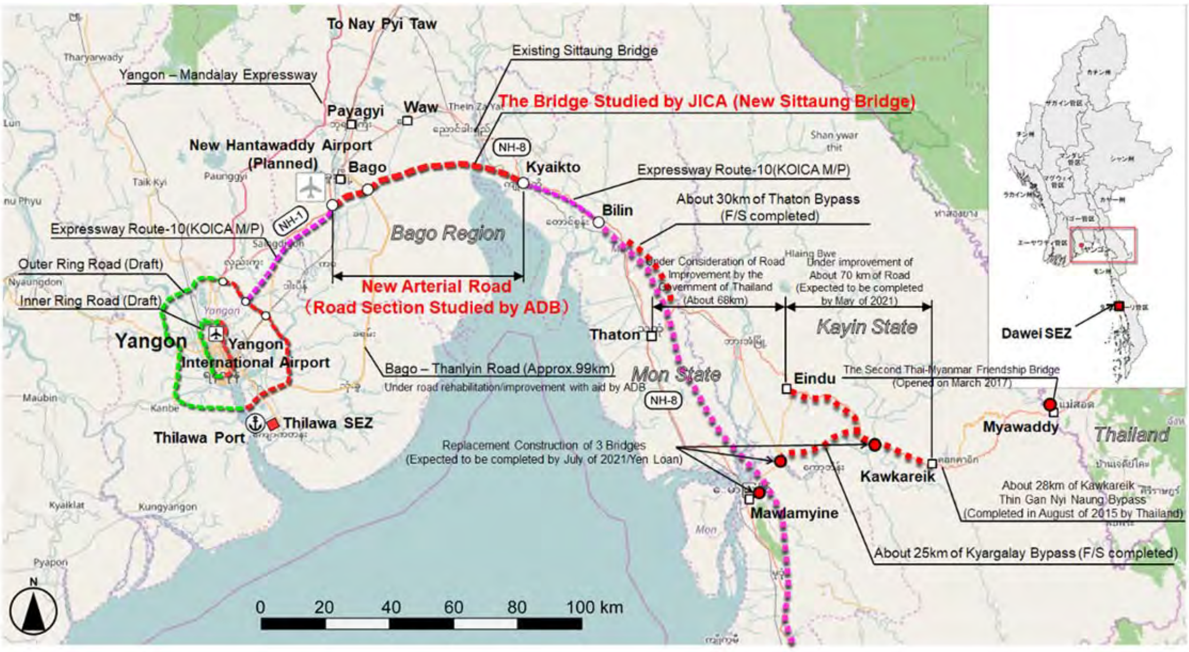
There are some national-level plans for arterial road development in Myanmar, such as National Comprehensive Development Plan (NCDP) announced by the Former President, Thein Sein, 30-Year Road Development Plan established by MOC, Myanmar National Transport Master Plan (MYT-Plan) prepared by JICA, and Arterial Road Network Development Master Plan prepared by KOICA.

2.4.2 Road Development Plans

There are some national-level plans for road development in Myanmar, such as a Five-Year Road and Bridge Development Plan for the 30-Year Long Term Plan established by MOC, and Expressway and National Highways planned in the study of the ARND-MP.

2.5 Current Road Condition of the East West Economic Corridor

The following figure and table show the summary of the current road condition and ongoing/future road development of the EWEC. The Myanmar section on the EWEC connects Myawaddy, the border area with Thailand, to the Yangon urban area with approximately 380km in total length.



Source: JICA Study Team

Figure S 2.5.1 Current Road Network and Development Project along the EWEC

Table S 2.5.1 Outline of Current Road Condition along the EWEC (Myanmar Section)

Road Section	Length	Lane	Pavement Type	O & M
Yangon*-Payagyi	68km	2 to 4	A/C	1) Yangon-Bago by BOT (Max Highway) 2) Bago-Payagyi by BOT(Shwe Than Lwin Highway)
Payagyi – Thaton	130km	2	A/C	BOT (Shwe Than Lwin Highway)
Thaton - Eindu	68km	2	Penetration Macadam	1) Thaton – Hpa-an by BOT (Shwe Than Lwin Highway) 2) Hpa-an-Eindu by (Aye Ko Family Construction)
Eindu - Kawkareik	70km	2	Penetration Macadam	MOC
Kawkareik-Myawaddy	42km	2 to 4	A/C	MOC

* From the entrance of Yangon-Mandalay Expressway
Source: JICA Study Team based on the information provided by MOC

2.6 Current Situation of Road and Bridge Operation and Maintenance

MOC operates and manages major roads in Myanmar, having approximately 42,100km in total length. As for bridges, DOB under MOC manages approximately 5,000 bridges in Myanmar. While some major highways are under operation and maintenance by BOT scheme as aforementioned, the Maintenance Section in both DOH and DOB is mainly in charge of O/M works of responsible roads and bridges in collaboration with the Road and Bridge Special Units which are distributed in the whole country.

Recently, with technical and financial assistances by international agencies such as JICA and ADB as well as its significant economic growth, a lot of road and bridge constructions have been implemented, thus the number of roads and bridges responsible by MOC has increased drastically. Moreover, due to such technical assistance, the advanced technologies have been introduced to Myanmar, therefore higher level of technical capacity is required for proper and sustainable operation and maintenance of such infrastructures. Under such circumstances, it is recognized that technical capacity including quality control of construction/maintenance works and human resource development on operation and maintenance of roads and bridges is one of urgent tasks for MOC.

2.7 Current Situation of the Thuwunna CTC and Research Laboratories under MOC

Technical capacity development including quality control of construction/maintenance works and human resource development is one of priority tasks in MOC. Especially, the Thuwunna Central Training Center (CTC) and Research Laboratories have a major role of training engineers and skilled labors in MOC, and quality inspection activities especially for construction/maintenance materials.

The CTC has been conducting technical training for the MOC staff (both engineers and administrative staff), as well as vocational training and assessments for skilled labors.

The CTC facilities are roughly divided into training buildings, trainee dormitories, office, common areas and staff residence. Technical training for MOC staff as well as technical training and assessment of skilled laborers are all held in the same facilities on site. Because the location of CTC facilities has a particularly high level of water, there are buildings which suffer from severe deterioration, where the walls are likely to come off from structural frames. Such buildings are currently used as warehouses where unused equipment items are piled up. The procedure to discard such unused equipment would take a quite long time, so even the equipment which had been broken for years had to be kept on site, i.e. in existing deteriorated buildings.

And there are four laboratories in the site, which are the research laboratories of Department of Highways (DOH), the Department of Bridge (DOB), the Department of Building (DOBi), the Department of Rural Road Development (DRRD). These laboratories were constructed 1960s and 1970s and are currently under management of MOC. These laboratories has been constructed and developed to mainly conduct quality inspections of construction materials such as asphalt concrete, concrete, soil, rebar at the laboratories as well as at the constructions sites.

The laboratory’s roles and activities should expand and effectively functioned in order to cope with expanding needs for quality assurance, transition of testing method to ASTM standards from BS, needs for acquisition of ISO certifications and MOC’s renovation policy to establish a new department called “Thuwunna Research Laboratory and Training Department” which will be responsible for all research and laboratory functions and training functions. However, in spite of such needs, the existing facilities and equipment suffer from significant deterioration due to its aging so that the functions are very limited.

2.8 Major Issues of in the Vicinity of the Project

Major issues in the vicinity of the Project are as follows:

- It is forecasted that traffic demand on the East-West Corridor will increase drastically. For the section between Thaton and Myawaddy as a part of the GMS EWEC, it has specifically initiated road improvements corresponding to the future traffic demand by the support of international organizations such as JICA and ADB, however road improvement on the remaining sections of the East-West Corridor are not scheduled yet due to the conflict with the existing BOT contracts, difficulty in widening the existing road on the limited ROW (populated area) as well as lack of development budget. The section from Yangon to Thaton is expected to increase the traffic in merging the traffic from the southeastern part of the country and would be one of the critical future bottlenecks.
- Moreover, deterioration in traffic environment caused by large freight vehicles passing through the populated area mixed together with regional traffic is a concern. The situation will worsen along with the expanding traffic volume in the future.

- It is a top priority to ensure the redundancy (substitutability) of the road network. Redundancy is the means not only to reduce traffic congestion but also provide an alternative function to divert the traffic for alleviating/reducing the social disruption and economic loss in emergency events caused by natural disasters or serious accidents. The Yangon - Mandalay Expressway consists of the north-south corridor that has already provided an alternative route for the national road (Yangon - Mandalay road). However, the East–West Corridor has very few sections having alternative routes. Particularly, the section between Bago and Thaton where the traffic is highly concentrated is meaningfully required for redundancy on the East–West Corridor.
- In addition, in line with logistic promotion and remarkable economic growth in Myanmar, a lot of roads and bridges have been constructed recently and results in lack of technical capacity and human resources. Under such circumstances, for proper and sustainable road /bridge operation and maintenance including this project road, it is a challenge for MOC to enhance its technical capacity and develop human resources. To reflect to this, enhancement of the Thuwunna Central Training Center (hereafter referred to as "Thuwunna CTC")'s function and Research Laboratories' quality control function are strongly required. However it was recognized that advanced trainings and quality inspections cannot be provided sufficiently in the existing Thuwunna CTC and laboratories due to its aging and insufficient facilities.

2.9 Purpose of the Project

The purpose of the Project is to improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to the vitalization of Myanmar's trade.

3. TRAFFIC DEMAND FORECAST

3.1 Objectives and Methodology

The objectives of the traffic demand forecast are i) estimation of future traffic volume by type of vehicle on New Sittaung Bridge and other major road segments such as existing bridge, and ii) preparation of indicators showing a socio-economic impact by developing New Sittaung Bridge such as vehicular travel time saving and reduction of vehicular distance traveled.

For the future traffic demand forecast, information on traffic demand by type of vehicle in the origin-destination (OD) matrices in future and future road network including length by road segment and free-flow speed decided by road type and road capacity defined by road class and number of lanes etc., is required.

The existing road network was built based on the existing road network provided by the "Project for Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA) (JICA, 2014)" and the road network built in Pre-feasibility Study in 2016 based on "The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (hereafter, National Transport M/P) (JICA, 2014)". The future road network for 2025, 2035 and 2045 are prepared by the "Greater Mekong Subregion East West Economic Corridor Bago – Kyaikto Road Development Project (ADB, 2019)" and other relevant projects based on existing road projects in Myanmar.

Future traffic demand in 2025, 2035 and 2045 is calculated by the following steps;

- Existing OD matrices as of 2013 are built by merging the existing vehicular OD matrices prepared by YUTRA and National Transport M/P.
- OD matrices in 2013 estimated by YUTRA and National Transport M/P are based on the estimated population in 2012 including that which was overestimated in some regions/states, therefore, OD matrices in 2013 are adjusted with the results of Population Census in Myanmar in 2014.
- Vehicular OD matrices in 2013 are updated and calibrated to OD matrices in 2017 (present OD matrices) based on the results of traffic survey carried out in 2017.
- The growth of future vehicular trip prepared by YUTRA and National Transport M/P is based on the assumption of GDP growth in 2015-2035 in 7.0% p.a. and 7.2% p.a. in medium growth case respectively. The future GDP growth rate is updated based on the IMF Country Report in 2017 and the growth of future vehicular trip in 2025, 2035 and 2045 are adjusted in accordance with updated GDP growth.
- Additional trip generation in the future, namely, vehicular trip generation relevant to Hanthawaddy Airport and cross-border truck generation in EWEC are prepared by Pre F/S and it is confirmed and considered in future vehicular trips.
- Future vehicular OD matrices are estimated by the present pattern method based on present OD matrices and future vehicular trips in 2025, 2035 and 2045.
- Future vehicular OD matrices are assigned on the future road network by shortest route search method and future traffic volume by road segment are calculated.

3.2 Traffic Survey

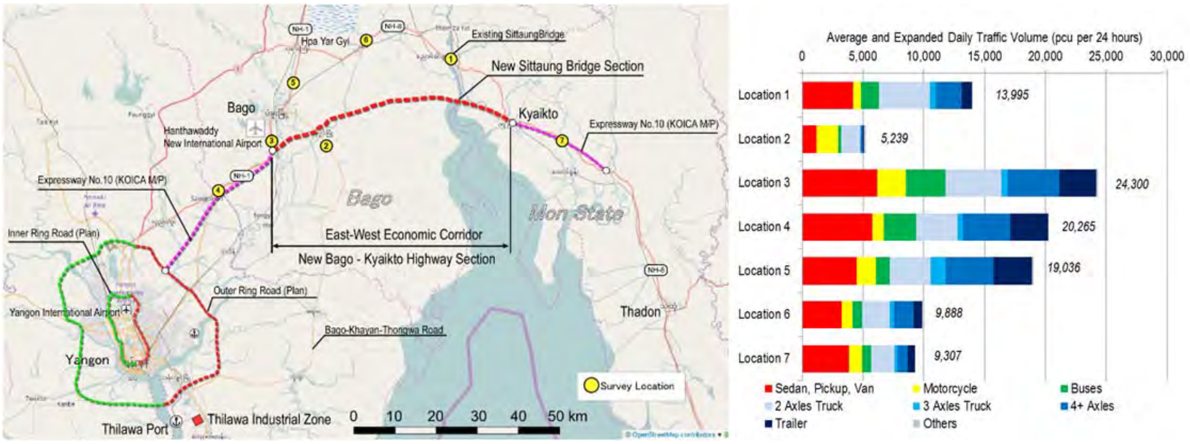
To obtain current traffic volume and to understand the characteristics of the existing bridge and other major road sections, traffic count surveys at seven (7) locations consisting of a 24 hours survey at two (2) locations and a 16 hours at five (5) locations were carried out on two (2) weekdays each in May 2017. At the same time, a roadside interview survey at two (2) locations was also performed.

According to the results of the surveys, the average traffic volume of the two (2) survey days over the existing bridge is 11,446 vehicles per day in total of both direction consisting of motorcycles 19%, passenger cars 37%, buses 6%, 2-3 axles trucks 27%, and 4 axles trucks and trailers 11%.

Table S 3.2.1 Traffic Survey Contents and Locations

No	Location	Traffic Count	Roadside Interview	Survey Day
1	Existing Sittaung Bridge	24 hours	10hours (7:30-17:30)	2 Weekdays
2	Bago-Kahyan-Thongwa Road	16 hours (5:30-21:30)	10hours (7:30-17:30)	2 Weekdays
3	NH-1 Bago South	24 hours	-	2 Weekdays
4	NH-1 Yangon-Bago	16 hours (5:30-21:30)	-	2 Weekdays
5	NH-1 Bago-Hpa Yar Gyi	16 hours (5:30-21:30)	-	2 Weekdays
6	NH-8 Hpa Yar Gyi – Sittaung Bridge	16 hours (5:30-21:30)	-	2 Weekdays
7	NH-8 Kyaikto East	16 hours (5:30-21:30)	-	2 Weekdays

Source: JICA Study Team

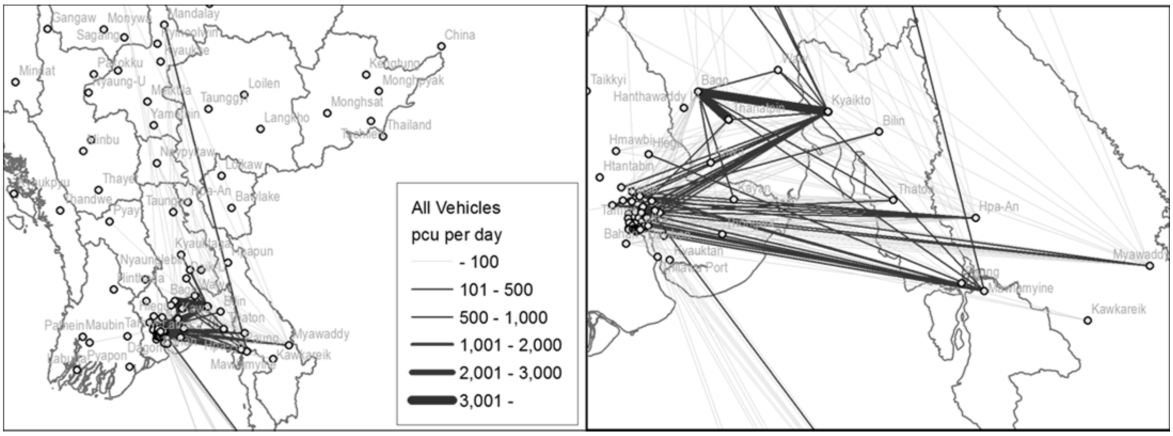


Source: JICA Study Team

Note: Passenger Car Unit (PCU) of motorcycle is 0.3, sedan, pickup and van 1.0, mini bus 1.5, large bus 2.0, 2 axles truck 1.5, 3 axles truck 2.0, 4 axles truck 2.25, trailer 2.5 and others 0.3.

Figure S 3.2.1 Traffic Survey Location Map and Processed Daily Traffic Volume

Based on the results of the roadside interview survey, the origin and destination of vehicular trip over the existing Sittaung Bridge and Bago-Kahyan-Thongwa Road is visualized as shown in the following figure. Traffic over the existing bridge is mainly passenger cars between Bago and Kyaikto, and trucks traveling between Bago – Kyaikto, Yangon – Mawlamyine, etc.



Source: JICA Study Team

Figure S 3.2.2 Desire Line of Roadside OD Interview Survey at Location 1 and 2

3.3 Results of Traffic Demand Forecast

Based on the demand forecast and analysis by the "Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)", the future traffic demand in the following three (3) toll scenarios prepared by ADB's report was forecasted.

Table S 3.3.1 Toll Strategy 1 (TS1)

		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	15.0	0.0061	0.0069	0.0085	0.0103
Toll Class 2	2-Axle Truck	69.0	0.0282	0.0320	0.0390	0.0475
Toll Class 3	3-Axle Truck	120.0	0.0490	0.0556	0.0677	0.0826
Toll Class 4	4 & 5 Axle Heavy truck	162.5	0.0663	0.0753	0.0917	0.1118
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	284.0	0.1159	0.1315	0.1603	0.1954
Toll Class 6	Median Bus and Large bus	45.5	0.0186	0.0211	0.0257	0.0313

Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

Table S 3.3.2 Toll Strategy 2 (TS2)

		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	30.0	0.0122	0.0139	0.0169	0.0206
Toll Class 2	2-Axle Truck	100.0	0.0408	0.0463	0.0565	0.0688
Toll Class 3	3-Axle Truck	120.0	0.0490	0.0556	0.0677	0.0826
Toll Class 4	4 & 5 Axle Heavy truck	150.0	0.0612	0.0695	0.0847	0.1032
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	250.0	0.1020	0.1158	0.1411	0.1720
Toll Class 6	Median Bus and Large bus	75.0	0.0306	0.0347	0.0423	0.0516

Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

Table S 3.3.3 Toll Strategy 3 (TS3)

		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	22.5	0.0092	0.0104	0.0127	0.0155
Toll Class 2	2-Axle Truck	103.5	0.0679	0.0771	0.0940	0.1146
Toll Class 3	3-Axle Truck	180.0	0.1182	0.1341	0.1635	0.1993
Toll Class 4	4 & 5 Axle Heavy truck	243.8	0.1600	0.1816	0.2214	0.2699
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	426.0	0.2797	0.3174	0.3869	0.4717
Toll Class 6	Median Bus and Large bus	68.3	0.0448	0.0509	0.0620	0.0756

Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

According to the results of the traffic assignment, the future traffic volume of New Sittaung Bridge is forecasted as shown in the following tables. Future traffic volume in Toll Strategy 1 (TS1) for New Sittaung Bridge is forecasted to 88.8 thousand pcu/day in 2045, 83.5 thousand pcu/day in 2045 in TS2 and 83.2. thousand pcu/day in 2045 in TS3.

Table S 3.3.4 Future Daily Traffic Volume of Existing and New Bridge in TS1

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	22,400	12,500	34,900	14.77%
2035	30,100	64,100	94,200	10.44%
2045	49,900	88,000	137,900	3.88%

Source: JICA Study Team

Table S 3.3.5 Future Daily Traffic Volume of Existing and New Bridge in TS2

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	23,500	12,400	35,900	15.17%
2035	32,500	66,000	98,500	10.62%
2045	45,400	83,500	128,900	2.73%

Source: JICA Study Team

Table S 3.3.6 Future Daily Traffic Volume of Existing and New Bridge in TS3

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	24,500	10,700	35,200	14.89%
2035	34,400	58,200	92,600	10.16%
2045	39,900	83,200	123,100	2.89%

Source: JICA Study Team

Table S 3.3.7 uture Daily Traffic Volume New Sittaung Bridge in TS1

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Car (veh/day)	Bus (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	400	100	8,700	1,300	10,500
2035	8700	3,100	5,600	1000	22,400	2,200	43,000
2045	12,600	4,400	8,300	2,200	27,800	1,900	57,200

Source: JICA Study Team

Table S 3.3.8 Future Daily Traffic Volume New Sittaung Bridge in TS2

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Car (veh/day)	Bus (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	500	100	8,300	1,300	10,200
2035	7400	3,100	7,200	1400	21,800	2,100	43,000
2045	9,100	4,900	8,900	1,600	28,200	1,900	54,600

Source: JICA Study Team

Table S 3.3.9 Future Daily Traffic Volume New Sittaung Bridge in TS3

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Car (veh/day)	Bus (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	0	0	8,300	1,200	9,500
2035	5100	2,500	5,500	1000	23,500	2,400	40,000
2045	10,600	3,800	6,700	1,200	33,200	2,300	57,800

Source: JICA Study Team

Development of the Bago-Kyaikto Highway including the New Sittaung Bridge is expected to reduce the travel distance and the travel time as shown in the following tables. The travel distance and the travel time reduction are regarded as a socio-economic benefit generated by the Project.

Table S 3.3.10 Future Travel Distance Reducation per Day by the Project in TS1

		('000) Vehicle-km per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	22,253.2	2,299.3	8,282.8	4,460.7	58,403.1	9,386.0	105,085.0
	Without Case	22,297.6	2,306.9	8,318.9	4,464.5	58,574.7	9,400.0	105,362.6
	Project Impact	44.4	7.5	36.2	3.8	171.6	14.1	277.6
2035	With Case	54,394.5	5,272.9	19,241.2	10,379.5	151,481.7	17,801.3	258,571.1
	Without Case	54,854.2	5,460.6	19,621.7	10,497.2	152,888.4	18,017.3	261,339.4
	Project Impact	459.7	187.7	380.5	117.7	1,406.7	216.0	2,768.2
2045	With Case	68,992.4	6,725.1	24,537.8	13,249.3	220,876.8	18,226.1	352,607.5
	Without Case	69,232.4	6,916.2	24,768.5	13,207.6	222,014.7	18,305.0	354,444.3
	Project Impact	239.9	191.1	230.7	-41.7	1,137.9	78.9	1,836.8

Source: JICA Study Team

Table S 3.3.11 Future Travel Time Reducation per Day by the Project in TS1

		('000) Vehicle-hour per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	579.3	57.6	197.2	104.9	1,393.1	201.9	2,534.1
	Without Case	582.7	58.4	199.4	105.3	1,402.9	203.3	2,552.0
	Project Impact	3.4	0.7	2.2	0.4	9.8	1.4	18.0
2035	With Case	1,969.4	178.7	620.0	328.7	5,312.7	548.4	8,958.0
	Without Case	2,023.8	195.1	652.0	337.9	5,402.9	560.1	9,171.9
	Project Impact	54.4	16.3	32.1	9.2	90.2	11.7	213.9
2045	With Case	2,813.0	255.4	887.9	472.6	8,886.0	646.7	13,961.6
	Without Case	2,886.3	279.7	926.5	478.4	9,018.0	657.8	14,246.7
	Project Impact	73.3	24.3	38.6	5.8	132.0	11.0	285.1

Source: JICA Study Team

Table S 3.3.12 Future Travel Distance Reducation per Day by the Project in TS2

		('000) Vehicle-km per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	22,233.8	2,294.2	8,285.1	4,458.2	58,056.8	9,382.7	104,710.9
	Without Case	22,271.1	2,303.9	8,318.7	4,465.3	58,255.7	9,400.5	105,015.2
	Project Impact	37.3	9.7	33.6	7.1	198.8	17.8	304.3
2035	With Case	54,443.6	5,267.1	19,173.9	10,348.0	150,820.1	17,855.9	257,908.5
	Without Case	54,777.2	5,441.6	19,590.4	10,468.7	151,807.6	18,030.1	260,115.6
	Project Impact	333.7	174.5	416.6	120.7	987.5	174.2	2,207.1
2045	With Case	69,085.0	6,719.3	24,468.3	13,242.7	220,986.8	18,294.0	352,796.0
	Without Case	69,085.1	6,887.9	24,758.0	13,244.3	221,808.3	18,323.7	354,107.4
	Project Impact	0.1	168.6	289.8	1.7	821.5	29.7	1,311.4

Source: JICA Study Team

Table S 3.3.13 Future Travel Time Reducation per Day by the Project in TS2

		('000) Vehicle-hour per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	580.4	57.0	197.1	104.8	1,390.6	201.9	2,531.7
	Without Case	582.8	57.7	199.1	105.2	1,401.2	203.3	2,549.3
	Project Impact	2.4	0.7	2.0	0.4	10.7	1.4	17.6
2035	With Case	1,981.0	178.4	614.5	326.4	5,300.0	546.1	8,946.4
	Without Case	2,033.8	194.1	648.9	335.8	5,384.3	556.3	9,153.1
	Project Impact	52.8	15.7	34.4	9.4	84.2	10.1	206.7
2045	With Case	2,830.7	257.2	886.7	473.8	8,890.6	649.1	13,988.1
	Without Case	2,883.8	277.4	921.5	477.5	9,008.8	658.4	14,227.4
	Project Impact	53.0	20.2	34.8	3.7	118.2	9.3	239.3

Source: JICA Study Team

Table S 3.3.14 Future Travel Distance Reducation per Day by the Project in TS3

		('000) Vehicle-km per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	22,272.6	2,291.8	8,292.7	4,465.3	58,127.3	9,337.0	104,786.7
	Without Case	22,283.7	2,298.1	8,313.6	4,470.6	58,376.5	9,353.2	105,095.7
	Project Impact	11.1	6.3	20.9	5.3	249.1	16.3	308.9
2035	With Case	54,458.6	5,289.8	19,248.9	10,374.5	151,630.2	17,841.0	258,843.0
	Without Case	54,766.8	5,435.1	19,558.0	10,463.5	152,552.5	17,987.6	260,763.5
	Project Impact	308.1	145.3	309.1	89.0	922.3	146.6	1,920.5
2045	With Case	68,634.9	6,627.7	24,216.6	13,053.5	220,832.2	18,149.3	351,514.2
	Without Case	68,933.3	6,808.4	24,494.4	13,084.8	221,808.4	18,276.7	353,406.0
	Project Impact	298.4	180.6	277.8	31.3	976.3	127.4	1,891.8

Source: JICA Study Team

Table S 3.3.15 Future Travel Time Reducation per Day by the Project in TS3

		('000) Vehicle-hour per day						
		2 axles truck	3 axles truck	4 axles truck	Trailer	Passenger Car	Bus	Total
2025	With Case	582.2	57.4	199.1	105.5	1,387.7	201.3	2,533.2
	Without Case	584.0	58.0	200.4	105.9	1,398.8	202.8	2,549.7
	Project Impact	1.8	0.6	1.3	0.3	11.1	1.5	16.5
2035	With Case	2,017.6	184.0	631.4	333.4	5,341.5	550.1	9,058.0
	Without Case	2,064.9	198.4	661.9	342.3	5,425.0	560.7	9,253.2
	Project Impact	47.2	14.4	30.5	8.9	83.4	10.7	195.2
2045	With Case	2,820.0	256.7	887.2	470.0	8,804.7	642.4	13,881.0
	Without Case	2,889.8	275.9	923.8	478.1	8,940.2	653.1	14,160.8
	Project Impact	69.8	19.2	36.6	8.0	135.5	10.7	279.8

Source: JICA Study Team

4. DEVELOPMENT POLICY OF NEW SITTAUNG BRIDGE

4.1 Road Classification

MOC has a plan that the Project Road, the East - West Economic Corridor Highway (New Bago – Kyaikto Section), is to be constructed as a highway (Non-access controlled road) during the initial stage.

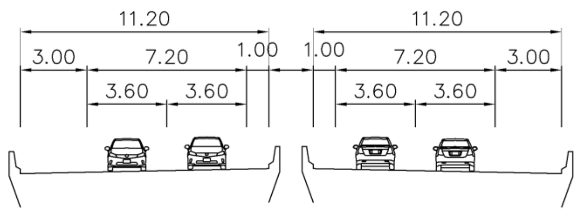
On the other hand, the development of a new expressway (ER-10) which connects Pathein to Kyaikto via Bago was planned in the ARND-MP. The Project Road would be upgraded to an expressway (Access controlled road) as a part of the new expressway (ER-10) in the future.

Through the confirmation by a series of discussions, MOC requested that the New Sittaung Bridge is to be constructed with a 4-lane asphalt paved road corresponding to the "expressway classification". Considering this, the following geometric design standard and road classification is applied to the New Sittaung Bridge among applicable options shown in Table S 4.1.1 and Figure S 4.1.1

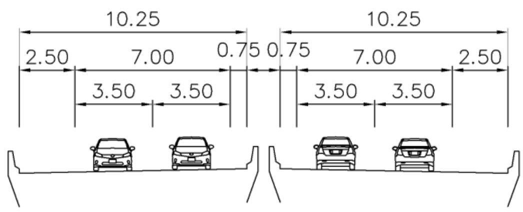
Table S 4.1.1 Cross Section Elements on MOC Road Design Criteria and ASEAN Highway Standards

Standard	MOC Road Design Criteria		ASEAN Highway Standards	
Classification	Expressway	Main Arterial	Primary	Class-I
Description	Access controlled	Non-access controlled	Access controlled	Non-access controlled
Design Speed (Level - Rolling)	120 - 100	100 - 80	120 - 100	110 - 80 (ASEAN)
Lane	3.60 (Rural) 3.50 (Urban)	3.50 (Rural) 3.25 (Urban)	3.75	3.5
Right Shoulder	3.00 (Rural) 2.00 (Urban)	2.50 (Rural) 2.00 (Urban)	3.00	3.00
Left Shoulder	1.00	0.75	-	-
Median	4.00 (Rural) 3.00 (Urban)	3.00 (Rural) 0.50 (Urban)	4.00	4.00

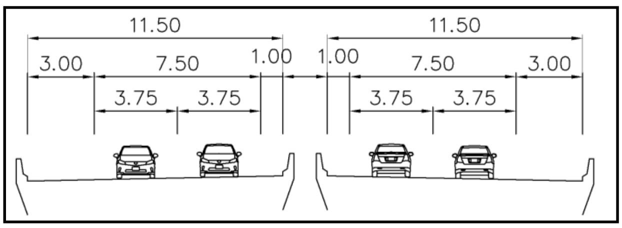
Source: MOC Road Design Criteria, ASEAN Highway Standards



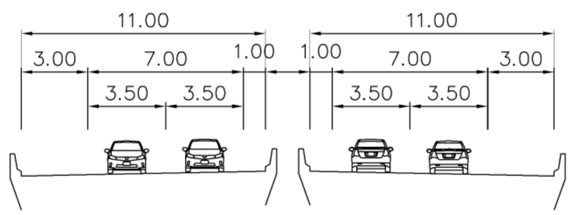
Expressway (Rural) in MOC Criteria



Main Arterial (Rural) in MOC Criteria



Primary in ASEAN Highway Standards



Class-I in ASEAN Highway Standards

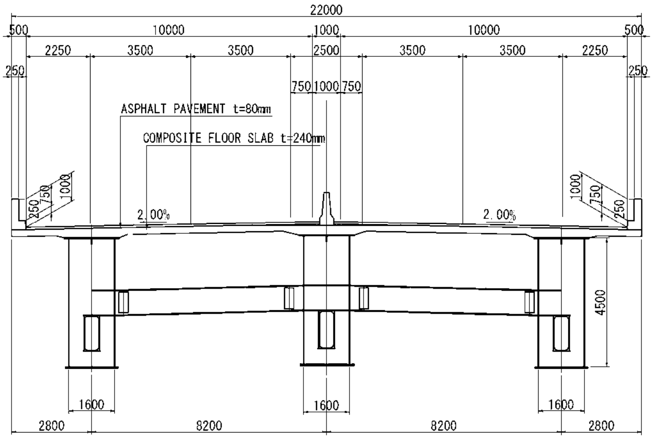
Source: JICA Study Team

Figure S 4.1.1 Typical Cross Section on MOC Road Design Criteria and ASEAN Highway Standards

4.2 Cross Section of New Sittaung Bridge

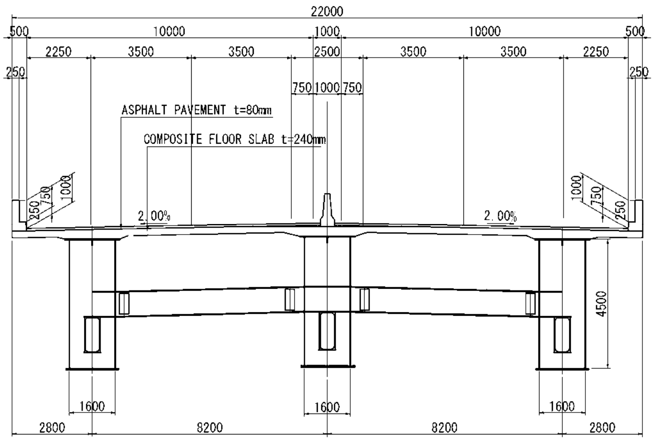
The road classification and typical cross section as shown in Figure S 4.1.1 were approved in the 2nd Technical Committee dated on 24 October 2019. However, the need for a reduction of the initial construction cost has arisen because of a strong request by MOC, since the required construction cost to construct to an expressway corresponding fully to the "Primary" class in the ASEAN Highway Standard is much higher than what the MOC expected.

Based on a series of discussions with MOC, both the sections of ADB and JICA could be applied with "Class-I" stipulated in the ASEAN Highway Standards for the initial construction stage, although New Kyaikto-Bago road would be upgraded to "Primary" class depending on the increase of traffic demand in the future. In this context, for the New Sittaung Bridge, it was concluded that the following cross section shall be adopted to harmonize with the future upgrading to a Primary class road.



Source: JICA Study Team

Figure S 4.2.1 Typical Cross Section of New Sittaung Bridge Development (Initial Operation Stage)



Source: JICA Study Team

Figure S 4.2.2 Typical Cross Section of New Sittaung Bridge Development (Future Operation Stage)

5. LOCATION OF NEW SITTAUNG BRIDGE

5.1 Corridors Selection prior to Alignment Setting for Bridge Site

5.1.1 Extraction of Candidate Corridors

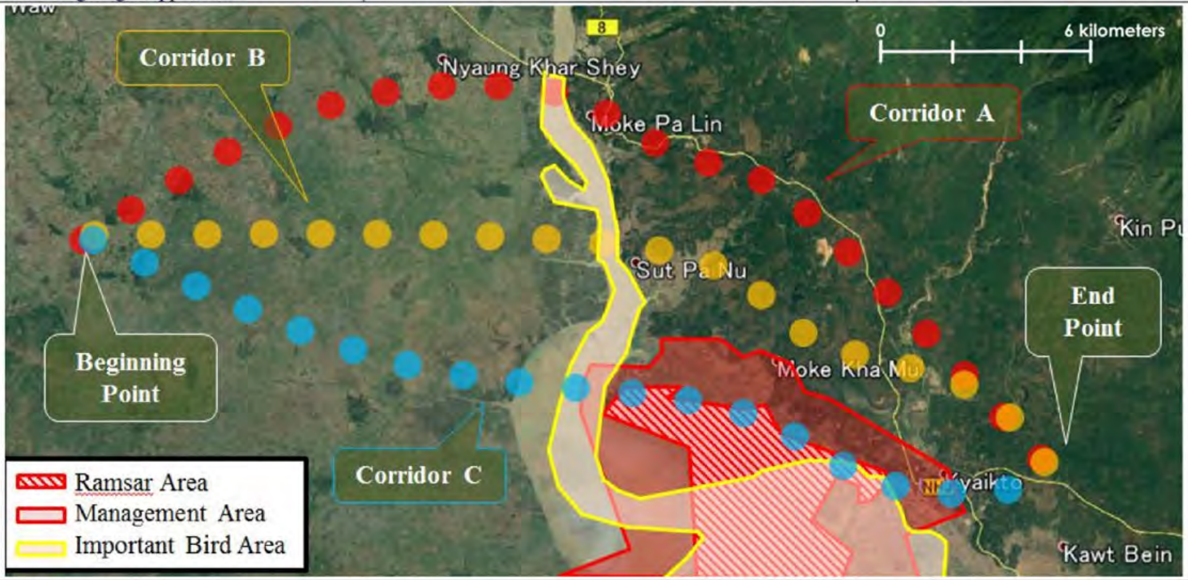
Among the possible corridors passing through the project area studied in the Pre-F/S, three corridors were extracted as the possible candidates as listed below:

- **Corridor "A",** which runs mostly along the existing National Highway No.8 and crossing the Sittaung River beside the existing Sittaung Bridge.
- **Corridor "B",** which covers the possible alignments proposed in Pre-F/S running through Sut Pa Nu village and crossing the Sittaung River approximately 7km downstream from the existing Sittaung Bridge.
- **Corridor "C",** which is the shortest connection between New Bago City and Kyaikto City and crossing the Sittaung River approximately 13km downstream from the existing Sittaung Bridge.

5.1.2 Comparative Study for the Selection of Eligible Corridor

The comparative study was conducted by multi-criteria analysis for the selection of an eligible corridor for the East - West Economic Corridor Highway (New Bago – Kyaikto Section), which is shown in Table S 5.1.1.

Table S 5.1.1 Comparison of the Corridor for New Bago – Kyaikto Highway

Alternative	Corridor A		Corridor B		Corridor C	
Summary	✓ Along the existing highway (NH8). ✓ New bridge beside the existing Sittaung Bridge. ✓ Road length: app. 45km ✓ Sittaung river crossing length: app. 650m		✓ Short road length.: app. 40km ✓ Short river crossing length: app. 750m		✓ Short road length: app. 40km ✓ Long river crossing length: app. 2.8km	
Alternative Corridors						
Riverbank stability/ Influence for erosion	✓ "Relatively stable" but scoured by minor tidal wave	A	✓ "Relatively stable" but scored by minor tidal wave	A	✓ Unstable scored by tidal bore ✓ Large erosion at present	C
Construction cost (Ratio with lowest cost)	✓ "Reasonable" because of shorter bridge length but longer distance of road ✓ (1.03)	A	✓ "Reasonable" because of shorter bridge length. ✓ (1.00)	A	✓ "Very High" because of longer bridge length. ✓ (1.87)	C
Environmental Impact (Impact on Ramsar site and IBA/KBA)	✓ Corridor does not pass through Ramsar site, but it passes through IBA/ KBA partially	B	✓ Corridor does not pass through Ramsar site, but it passes through IBA/ KBA partially	B	✓ Corridor passing through Ramsar site and IBA/KBA	C
Social Environmental Impact (Land Acquisition and Resettlement)	✓ 13 residential areas in the corridor	C	✓ 5 residential areas in the corridor	B	✓ 2 residential areas in the corridor	A
Total assessment	Score = 50/80, (Disqualified)		**Recommended** Score = 60/80		Score = 20/80 (Disqualified)	

Source: JICA Study Team

5.2 Selection of Eligible Alignment

5.2.1 Alignment Setting in Suitable Corridor

Upon the results of the comparative study on the corridor selection, it was recommended to find an eligible alignment for the new bridge location within the range of Corridor "B". Several alternative alignments can be proposed taking into account the control points including the existing facilities (road, railway and irrigation facilities, etc.), and local communities. The most eligible bridge site should be selected by the criteria considering the suitability of a bridge site crossing a river.

For selecting a suitable site for the New Sittaung Bridge, field reconnaissance was conducted by the JICA Study Team to get an impression of the landscape and to extract the possible types of structures for the bridge site. Four probable alternative sites were selected on the site which is likely to serve the need of the bridge with reasonable cost.

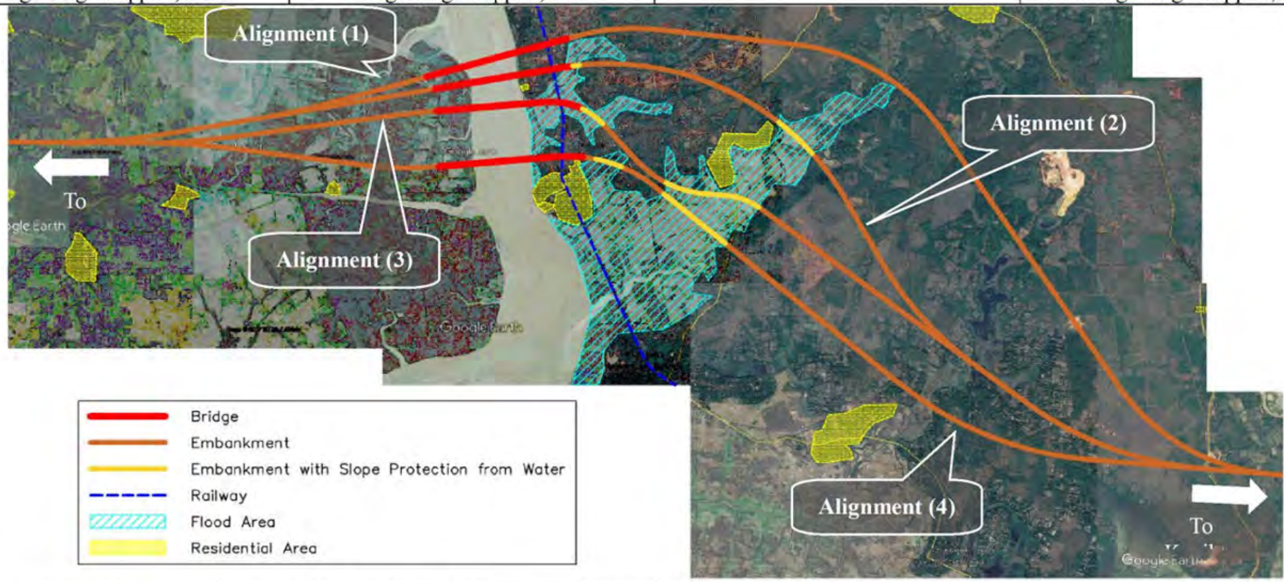
Within a certain width of Corridor "B", four possible alternative alignments were proposed as below:

- **Alignment (1)**, which stretches on most upstream side amongst the alternatives (700m from Pre-F/S route), becomes the longest route length but can avoid passing through the flood area on the left bank.
- **Alignment (2)**, which runs through the second most upstream side amongst the alternatives (400m upstream side from Pre-F/S route), crosses the narrowest point of the river and passes through a mostly hilly area except some flood areas on the left bank.
- **Alignment (3)**, which overlays the route proposed by Pre-F/S.
- **Alignment (4)**, which runs through of the furthest downstream side amongst the alternatives (850m from Pre-F/S route), which is the shortest route length but passes thru some flood areas on the left bank.

5.2.2 Comparative Study for the Suitable Bridge Site (Alignment)

The selection of alignments was conducted similarly to the selection method of a corridor based on the multi-criteria analysis. The comparative study for alignment of the New Sittaung Bridge is shown in Table S 5.2.1. As a result, it was recommended that Alignment (2) should be the most eligible alignment for crossing the Sittaung River.

Table S 5.2.1 Comparison of the Route for New Sittaung Bridge

Alternative	**Alignment (1)**		**Alignment (2)**		**Alignment (3)**		**Alignment (4)**	
Summary	✓ Avoiding flood area all along the alignment ✓ Road length: app. 22km ✓ River crossing length: app. 880m ✓ Bridge length: app. 2,200m		✓ Avoiding flood area at river crossing point. ✓ Road length: around 22km ✓ River crossing length: app. 720m ✓ Bridge length: app. 2,100m		✓ Pre-F/S Alignment. ✓ Road length: app. 21km ✓ River crossing length: app. 800m ✓ Bridge length: app. 2,200m		✓ Avoiding flood area at river crossing point. ✓ Road length: app. 21km ✓ River crossing length: app. 870m ✓ Bridge length: app. 2,200m	
Sketch								
Riverbank Erosion (10 years erosion ratio (m/year))	✓ Tolerably stable East (9.0m /year) West (2.1m/year)	B	✓ Relatively stable East (1.8m/year) West (4.8m/ year)	A	✓ Unstable East (0.5m/year) West (20.0m/year)	C	✓ Unstable East (0.6m/year) West (30.3 m/year)	C
Approach Road	✓ No flood area along the alignment.	A	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B
Construction Cost (Ratio)	✓ Intermediate (1.08)	B	✓ Lowest (1.00)	A	✓ Reasonable (1.03)	A	✓ Reasonable (1.06)	B
Land Acquisition and Compensation	✓ 17 households are affected.	B	✓ 26 households are affected.	B	✓ 20 households are affected.	B	✓ 29 households are affected.	B
Evaluation	Score = 50/80		**Recommended** Score = 60/80		Score = 40/80, (Disqualified)		Score = 30/80, (Disqualified)	

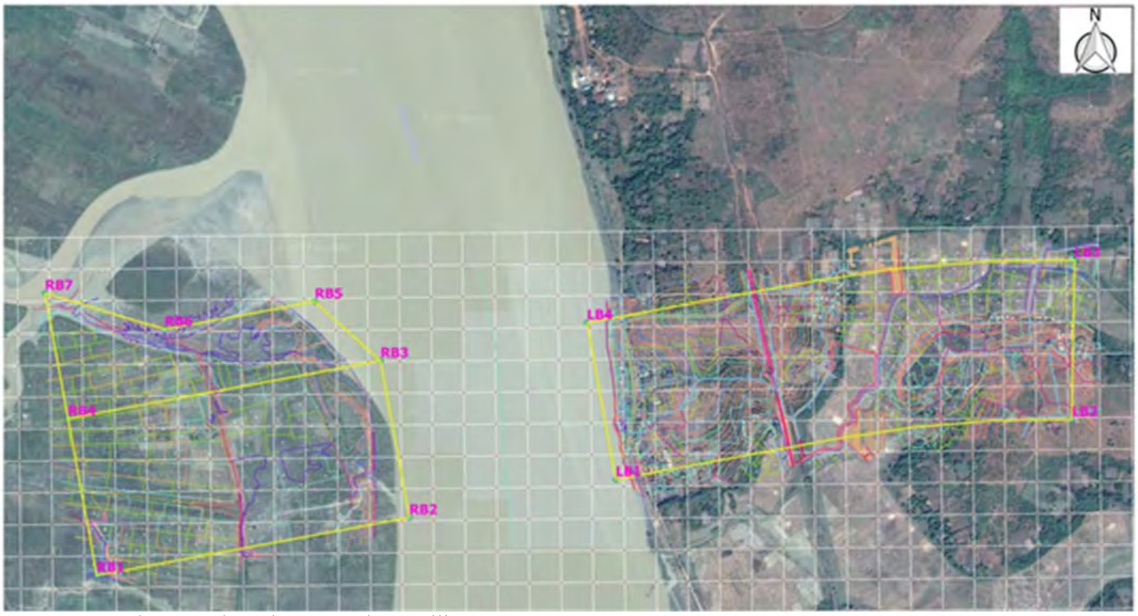
Source: JICA Study Team

6. NATURAL CONDITION SURVEYS

6.1 Topographic Survey

6.1.1 Survey Outline

The objective of the survey is to provide preliminary data regarding the topographic formation and hydrographical change of the area along the Sittaung River. The location of the survey is in and around the candidate site of the New Sittaung Bridge crossing the estuary of Sittaung River. The land to be connected by the bridge designed in the Project was extracted as the area of topographic survey.



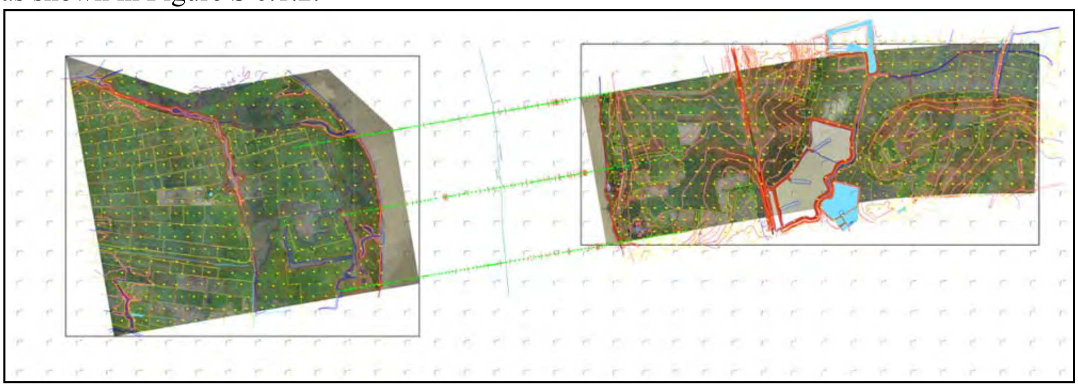
Source: JICA Study Team based on Google Satellite Map

Figure S 6.1.1 Topographic Mapping Area

6.1.2 Survey Results

(1) Topographic Survey Acquired by UAV

The aerial ortho photo image is obtained by converting the aerial photograph of the central projection using the Digital Terrain Model (hereinafter refer to as “DTM”), the Exterior Orientation (hereinafter refer to as “EO”) parameter and the aerial photograph. A topographic map was produced with 1:1,000 scale as shown in Figure S 6.1.2.



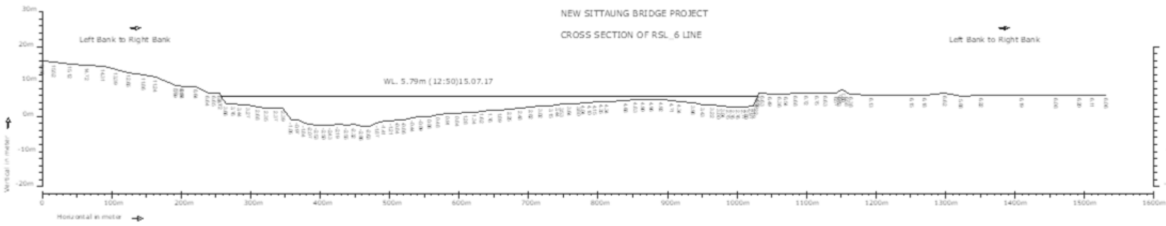
Source: JICA Study Team

Figure S 6.1.2 Topographic Map

(2) River Survey

1) River Bed Height

The river bed height was determined by subtracting the depth from the water level of simultaneous observation. The river cross sectional data nearby the bridge crossing section is shown in Figure S 6.1.3.



Source: JICA Study Team

Figure S 6.1.3 River Cross Section at Bridge Crossing Section

2) River Water Level

Fixed point observation for the water level was carried out by recording the gauge scale. A part of the results is shown in Table S 6.1.1.

Table S 6.1.1 Water level Measurement Result

Date	Time	W.L .(m)	Date	Time	W.L. (m)	Date	Time	W.L. (m)
25/5/2017	6:00	5.683	26/5/2017	1:00	5.203	27/5/2017	1:00	5.313
	7:00	5.378		2:00	5.158		2:00	5.233
	8:00	5.158		3:00	5.075		3:00	5.093
	9:00	5.02		4:00	4.808		4:00	5.043
	10:00	4.941		5:00	4.788		5:00	4.983
	11:00	4.887		5:03	5.493		5:45	5.943
	12:00	4.878		5:15	5.683		6:00	5.933
	13:00	4.74		5:30	5.803		6:15	6.023
	14:00	4.673		5:45	5.893		6:30	6.123
	15:00	4.614		6:00	5.943		6:45	6.193
	16:00	4.511		6:15	5.913		7:00	6.113
	16:15	4.517		6:30	5.903		7:15	6.093
	16:17	5.501		6:45	5.863		7:30	6.043
	16:30	5.511		7:00	5.823		7:45	5.973
	16:45	5.531		8:00	5.623		8:00	5.913
	17:00	5.945		9:00	5.413		9:00	5.713
	17:15	5.916		10:00	5.323		10:00	5.533
	17:30	5.918		11:00	5.243		11:00	5.433
	17:45	5.993		12:00	5.158		12:00	5.333
	18:00	5.998		13:00	5.013		13:00	5.243
	19:00	5.949		14:00	4.923		14:00	5.153
	20:00	5.693		15:00	4.833		15:00	5.043
	21:00	5.547		16:00	4.793		16:00	4.963
	22:00	5.378		16:50	6.013		17:00	4.933

Date	Time	W.L .(m)	Date	Time	W.L. (m)	Date	Time	W.L. (m)
	23:00	5.318		17:00	5.893		17:30	6.223
	24:00	5.253		17:15	6.073		17:45	6.183
				17:30	6.153		18:00	6.163
				17:45	6.093		18:15	6.423
				18:00	6.253		18:30	6.353
				18:15	6.433		18:45	6.513
				18:30	6.373		19:00	6.513
				18:45	6.273		19:15	6.413
				19:00	6.273		19:30	6.413
				20:00	6.053		19:45	6.363
				21:00	5.853		20:00	6.323
				22:00	5.733		21:00	6.023
				23:00	5.613		22:00	5.823
				24:00	5.473		23:00	5.683
							24:00	5.553

Source: JICA Study Team

6.2 Hydrological and Hydraulic Survey

6.2.1 Meteorological Conditions

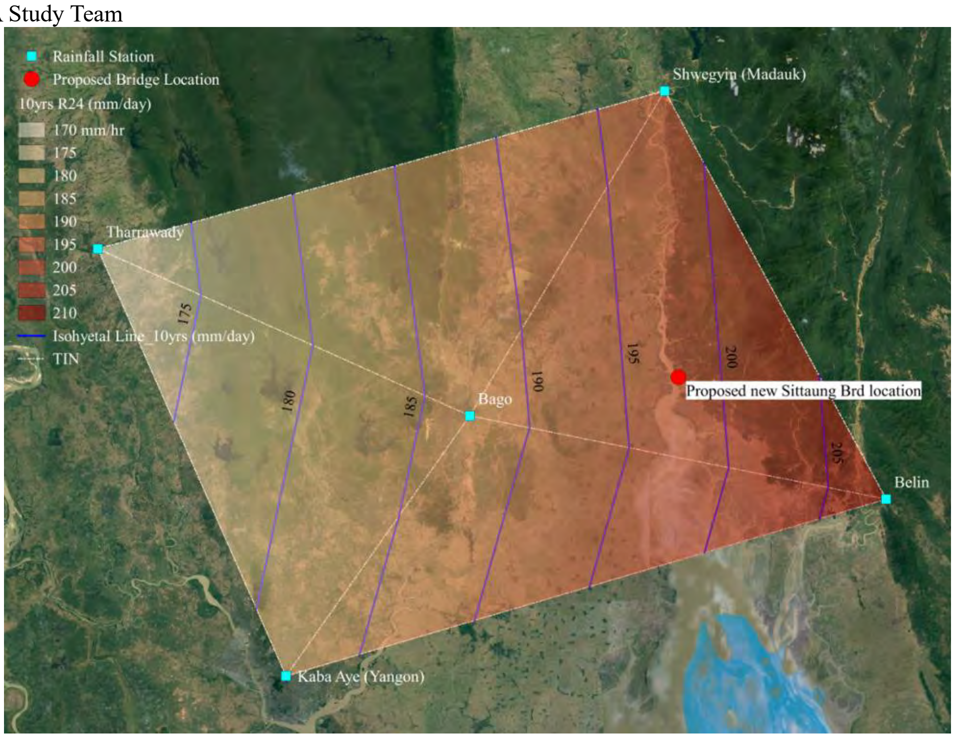
Regarding the general weather condition, the data for the monthly mean maximum/minimum temperature, relative humidity, maximum wind speed, evaporation and sunshine hours were collected from DMH.

The past data for daily rainfall at the surrounding 5 stations was collected. The annual mean rainfall ranges from 3,481mm at Shwegyin to 5,695mm at Belin. Also, the annual rainfall fluctuates between each station significantly. Regarding the seasonal fluctuation of rainfall, 95% or more of annual rainfall is brought by the rainy season from May to October, with the highest amount of rainfall in July or August. From the annual maximum daily rainfall (extremal value) data at 5 stations, the 24-hour rainfalls of 2 to 500 year probabilities are calculated, and IDF curve (probable rainfall intensity) at each station is predicted. There are about 1.2 times difference for probability values of the 5 stations, and the regional deviation is big. Therefore, the maximum probability values at the proposed bridge are set as prorated value by GIS software. (For reference, the spatial distribution map of 10-years probability daily rainfall is plotted in Figure S 6.2.1.) The probable rainfall intensity at proposed bridge is shown in Table S 6.2.1.

Table S 6.2.1 Calculation Results of IDF (Intensity-Duration-Frequency) at Proposed Bridge

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

Source: JICA Study Team



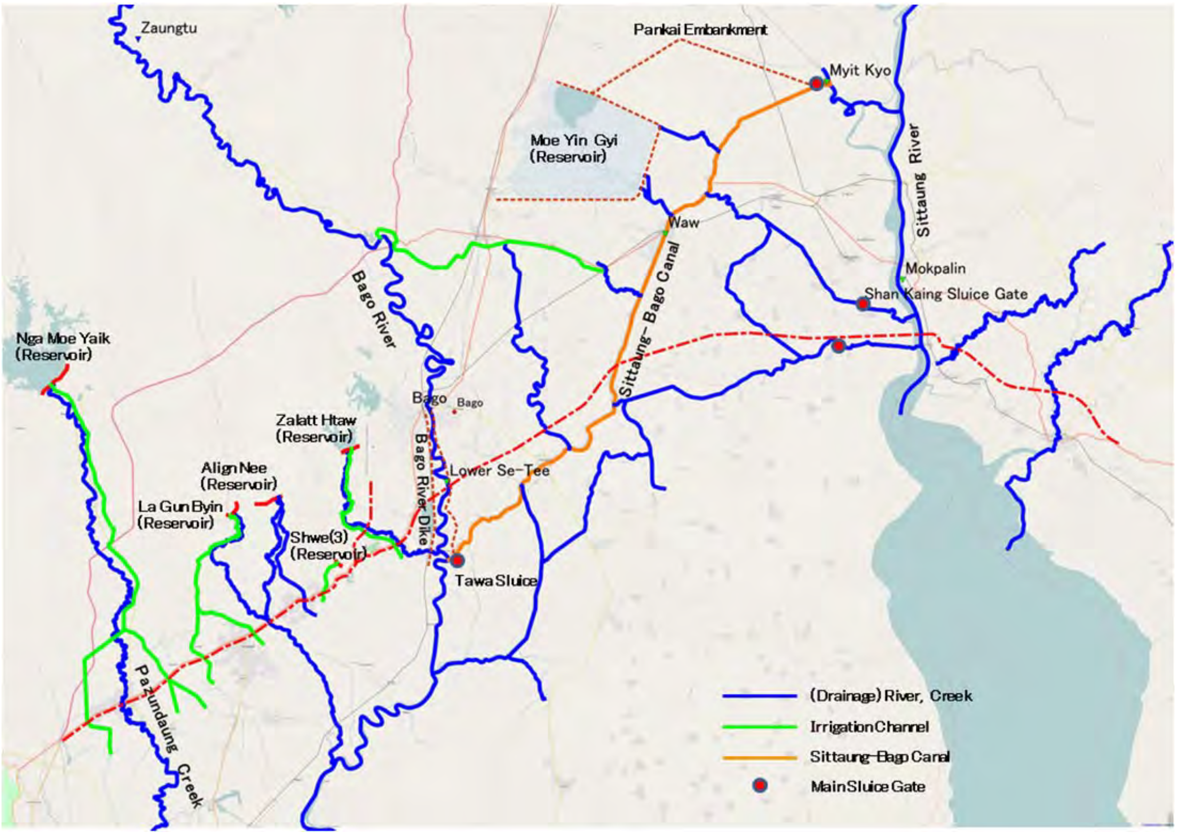
Source: JICA Study Team, DMH, Google Earth Map

Figure S 6.2.1 Probable Daily Rainfall - Isohyetal Map (10-years Return Period)

6.2.2 Hydrological / Hydraulic Conditions

In and around the target area, there are two big river basins (Bago and Sittaung River basins), as well as the Sittaung-Bago Canal that connects the rivers, and many drainage/irrigation creek systems. The related drainage / irrigation network in the target area is shown in Figure S 6.2.2.

The Sittaung-Bago canal was renovated in 2014 and now protects residents from flooding and is an important water supplier for local irrigation. The canal has 1 interconnected reservoir and 6 sluices. Besides these, there is a large number of sluices of which most are not clearly documented, because they were constructed by local residents. Sluices have regularly regulated the in- and outflow of tributaries, and a tidal effect is seen on both ends from the canal. The gate on the Sittaung side is normally closed except during the dry season, and the opening-closing timing of gate at the flooding time will be decided by relations between the inside / outside water levels of the inland area, Bago and Sittaung Rivers.



Source: JICA Study Team

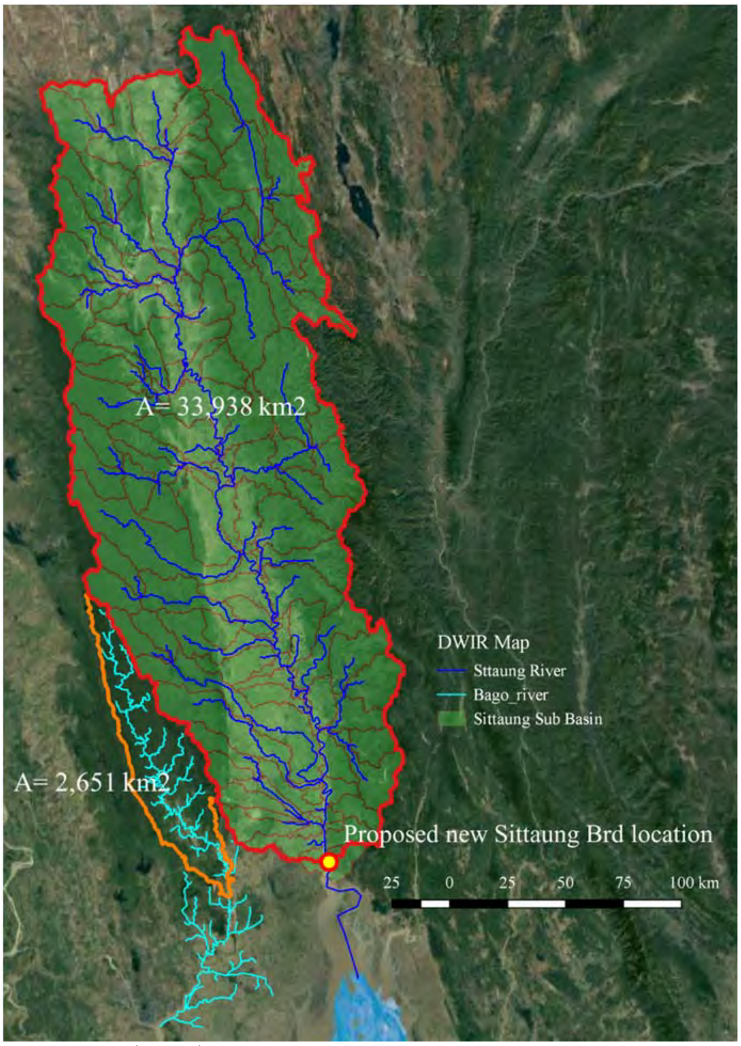
Figure S 6.2.2 Drainage and Irrigation Channel Network around Proposed Roads

The catchment basins and sub-basins for the related rivers or creeks at the proposed bridge/road are identified as shown in Figure S 6.2.3.

From the collected "hydrological data / digital elevation model / tidal information", the river profile, flow regime (discharge -duration curve), seasonal / daily flow pattern and water level pattern of Sittaung River and the general tidal chart were clarified, and the astronomical tide (tide curve) at 2 tide gauge stations in the outer sea was predicted.

And, in order to grasp the influence of tidal bore and the relationship of water-level fluctuation between the points at the proposed bridge and the outer sea, the fixed-point observation of water level, video shooting and bibliographic survey were performed.

From the observation results, the actual run-up speed of tidal bore approximates the theoretical run-up speed of a tsunami having 2-3m of water depth. And the actual tide curve at the proposed bridge location does not draw the tide curve like outer-sea, and it is found that it is changed considerably affected by the tidal bore.



Source: JICA Study Team, DWIR, Google Earth

Figure S 6.2.3 Catchment Area Map

6.2.3 Hydrological Analyses

Past annual maximum discharges (extremal values) of 3 stations (Madauk, Taungoo, Bago) for the design discharge were collected, and the probable discharges at 3 discharge stations were analyzed. Also, the probability water-level at 4 stations (Madauk, Taungoo, Bago, Myit Kyoe) are analyzed.

In order to analogize the correlation among the flood-level the vicinity of the proposed bridge site, the probability values at the gauging stations, and the calculated water-levels by hydraulic analyses, an interview survey for actual flood levels was conducted with inhabitants. The reported water levels were measured as Myanmar datum (MSL) by survey device (total station). The reported Historical high water Level (HHWL) at the point closer to the proposed bridge is 9.01m, and the annual mean highest water level is 7.68m.

6.2.4 Hydraulic Analyses

(1) General

The hydraulic phenomena (rising tide, falling tide, tidal bore, etc. in addition to the river's own flooding) at the tidal compartment of the river need to simulate all temporal motions, as the tide level changes from moment to moment. Therefore, the range of numerical calculation shall be targeted for all of the tidal area from river mouth to Madauk of non-tidal area.

Also, since the river survey range of this study is conducted in a limited area, the channel topography which becomes insufficient is assumed and interpolated by using the following data and GIS software.

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

(2) Hydraulic Design Criteria of Bridge

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

In this study, the design return period is adopted as 100-year return period. And the clearance from the bridge girder to the high water level is applied with the Japanese standard because the practicable standard has not been established in Myanmar.

(3) Analysis Software

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

(4) Hydraulic Analyses and Precondition

The hydraulic analyses were conducted by the following procedures.

- ✓ To estimate the roughness coefficient of the river channel by simulating from the calculated astronomical tide levels at Amherst and observation water level at fixed-point observation location during the observation period.
- ✓ Calculation is conducted under the mixed flow regime, since the flow regime shows a mixture of sub-critical and super-critical flow by the run-up for tidal-bore and flood / ebb tide.
- ✓ To conduct the calculation case at the time of flood (of each return period) by using the above roughness coefficient estimated from the real tide level.
- ✓ As an additional case, the rising value of static water level by barometric depression at the time of "Cyclone Nargis" (2008) is added to the downstream boundary condition.

The design flood discharge and the hydraulic parameters for input conditions are shown in Table S 6.2.2 and Table S 6.2.3, respectively.

Table S 6.2.2 Design Flood Discharge (only Upland Flow)

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

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

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

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

Source: JICA Study Team

Table S 6.2.3 Hydraulic Parameters for Input

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

Source: JICA Study Team

(5) Hydraulic Analyses and the Results

1) dimensional Hydraulic Analysis

The results for the design water levels of each return period are shown in Table S 6.2.4.

The results under an unsteady flow condition of 1-dimensional analysis are shown in Figure S 6.2.4 for water level distribution and Figure S 6.2.5 for velocity distribution. Also, the results under a steady flow condition are shown in Figure S 6.2.6 for hydraulic cross section at the proposed bridge site.

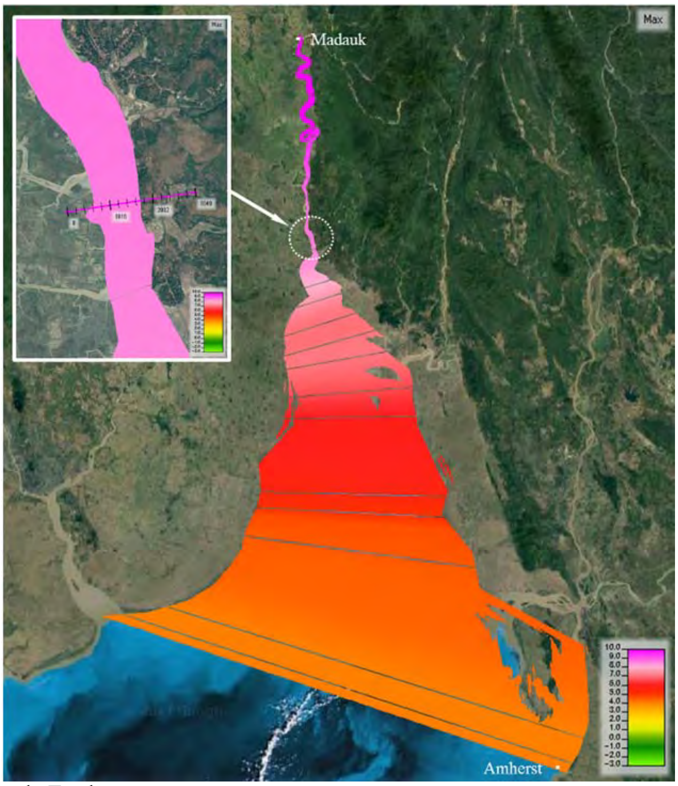
Table S 6.2.4 Design Flood Discharges (Qmax/Qmin) and Flood Levels at Proposed Bridge

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

Input Upland Flow: 8400 m^3/s

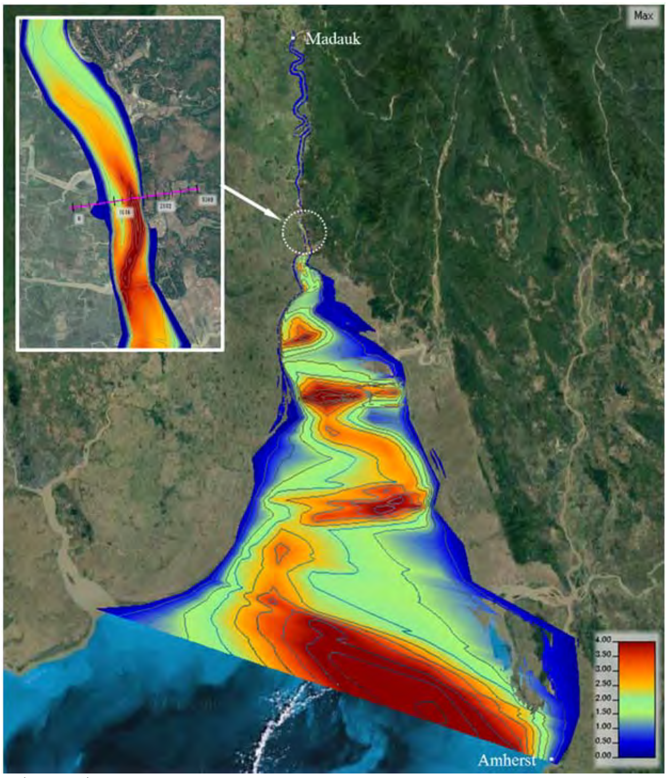
Interviewed Water Level near Bridge: 9.008 m (Point 10, Right bank side)

Source: JICA Study Team



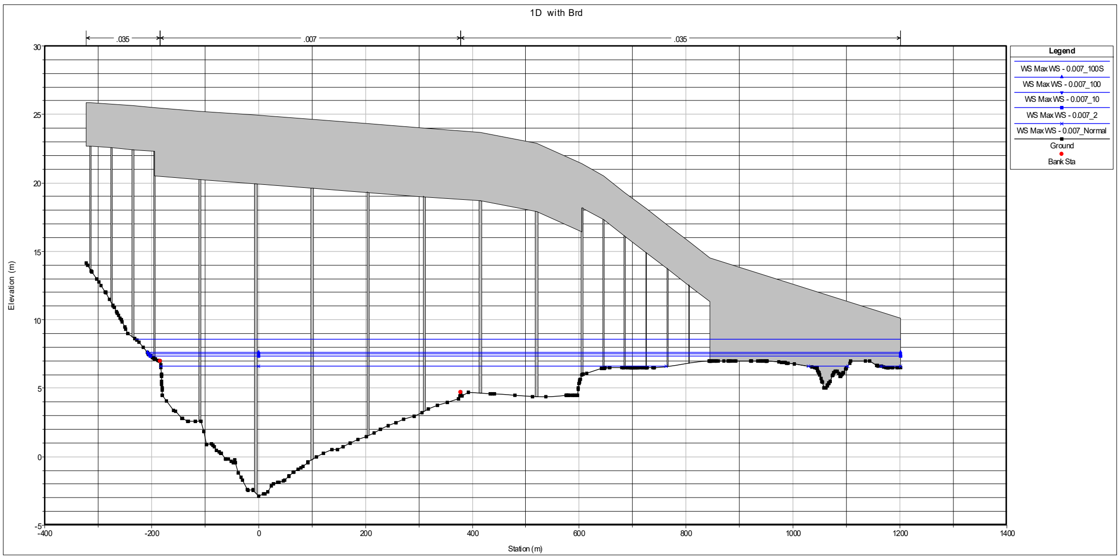
Source: JICA Study Team, Google Earth

Figure S 6.2.4 Water Level Distribution of 1-Dimensional Hydraulic Analysis (100-yrs)



Source: JICA Study Team, Google Earth

Figure S 6.2.5 Velocity Distribution of 1-Dimensional Hydraulic Analysis (100-yrs)



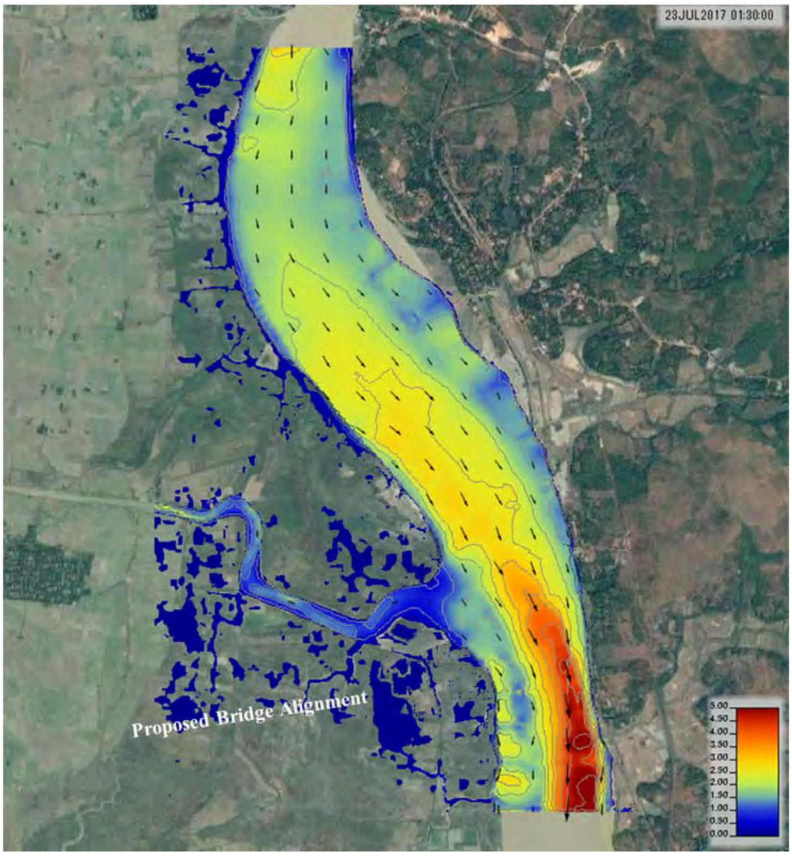
Source: JICA Study Team

Figure S 6.2.6 Hydraulic Cross-sectional Profile at Proposed Bridge

2) 2-dimensional Hydraulic Analysis

The 2-dimensional analysis was performed since the velocity vector at each riverbed point is not obtained from the 1-dimensional analysis. The calculation case is 1 case only, and the calculation condition is under the steady flow of design discharge (100 year with storm surge).

Figure S 6.2.7 shows the velocity vector distribution map.



Source: JICA Study Team

Figure S 6.2.7 Velocity Vector Distribution Map by 2-Dimensional Analysis (100-yrs)

6.2.5 Hydrological Assessments

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

- ✓ Since the hydraulic analysis area is a huge area, the necessary and sufficient topographic, bathymetric and hydrological surveys were not conducted in this study. In order to clarify the river morphology/characteristics, tidal motions (flood-/ebb tide) and the unique hydraulic phenomenon (tidal bore), these detailed surveys shall be conducted.
- ✓ Further fixed-point observations for the water level / flow discharge including other points shall be performed, and more detailed hydraulic analyses shall be performed by special hydraulic software. Furthermore, detailed hydraulic studies will be needed, in order to reproduce the special / un-usual hydraulic phenomena.
- ✓ Even if the proposed guide-bank and revetment for both bank sides are installed, a risk of erosion and scour may remain due to unforeseen natural events (flood, storm surge by cyclone, etc.) on the surrounding riverbank and/or proposed bank. The monitoring for morphological change of the surrounding riverbank and bed is necessary into the future. Hence, it is recommended to extend the surveying range to the proposed bridge position for the periodic bathymetric survey between the existing railway bridge and the existing road bridge presently conducted by DWIR. In addition, the installation of water-level gauging at the proposed bridge cross-section shall be recommended.

6.3 Geotechnical Survey

6.3.1 Survey Outline

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

- Boring at 2 points in the river and 2 points in land
- Standard Penetration Test (SPT) : every 1m
- Laboratory tests

Source: JICA Study Team based on Google Satellite Map

Figure S 6.3.1 Location of Borehole Investigation

6.3.2 Borehole Investigation Results

Table S 6.3.1 shows the survey quantities or borehole investigation.

Table S 6.3.1 Survey Quantities of Boring Works

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

Source: JICA Study Team

Based on the results from 4 borehole investigation, soil profile for the alignment of new bridge can be formulated. The soil layers are divided in 2 layers depending on soil produced condition, Alluvium deposit soil layer and Weathered residual soil layer, and a total of 7 different layers have been recognized. The 7 different layers observed in the Project Area are described from top to bottom as follows.

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

6.3.3 Laboratory Test Results

From disturbed samples by SPT and undisturbed samples with Denison Sampler, the laboratory soil test as shown in Table S 6.3.2 were conducted. Results of soil physical property tests and soil engineering tests are summarized in Table S 6.3.3 and Table S 6.3.4 respectively.

Table S 6.3.2 Quantities of Laboratory Soil Tests

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

Source: JICA Study Team

Table S 6.3.3 Results of Soil Physical Property Tests

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution (%)			
		GL (m)	EL (m)		W (%)	Gs	Gravel	Sand	Silt	Clay
BH-01	P-5	5.00	-5.14	F	29.30	2.699	-	27.74	64.26	8.00
	P-14	14.00	-14.14	SM (or) SC	18.43	2.702	3.35	55.34	14.11	27.20
	P-18	18.00	-18.14	F	28.43	2.699	-	26.43	17.68	55.90
	P-30	30.00	-30.14	SM (or) SC	20.35	2.712	2.09	48.62	20.28	29.00
	P-43	43.00	-43.14	SM (or) SC	16.76	2.642	1.22	84.36	7.12	7.30
	P-54	54.00	-54.14	F	25.64	2.672	0.87	37.46	22.97	38.70
BH-02	P-7	7.00	-6.79	F	36.16	2.692	-	1.22	85.78	13.00
	P-20	20.00	-19.79	SM (or) SC	29.11	2.681	-	81.60	11.60	6.80
	P-28	28.00	-27.79	F	25.74	2.843	0.47	39.79	23.13	36.60
	P-39	39.00	-38.79	SM (or) SC	15.73	2.648	5.29	67.54	7.07	20.10
	P-52	52.00	-51.79	F	19.49	2.694	-	0.65	56.75	42.60
	P-60	60.00	-59.79	F	17.81	2.647	-	30.23	28.58	41.20
BH-03	P-10	10.00	-4.36	SM (or) SC	25.88	2.708	-	82.60	14.70	2.70
	P-20	20.00	-14.36	SM (or)	20.68	2.692	-	80.32	17.58	2.10

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution (%)			
		GL (m)	EL (m)		W (%)	Gs	Gravel	Sand	Silt	Clay
				SC						
	P-32	32.00	-26.36	SM (or) SC	16.69	2.671	3.23	68.80	7.97	20.00
	P-38	38.00	-32.36	SP-SM (or) SP-SC	10.45	2.653	1.49	89.49	5.62	3.40
	P-45	45.00	-39.36	F	25.11	2.722	-	22.33	27.58	50.10
	P-56	56.00	-50.36	SM (or) SC	15.64	2.712	15.02	54.93	9.85	20.20
BH-04	P-5	5.00	+13.19	SM (or) SC	19.71	2.705	8.48	58.20	13.31	20.00
	D-1	8.00	+10.19	MH	41.22	2.624	-	13.40	34.70	51.90
	D-2	10.00	+8.19	MH	37.15	2.685	2.27	30.38	42.75	24.60
	P-18	20.00	-1.81	F	33.75	2.712	-	17.22	31.78	51.00
	P-36	38.00	-19.81	SM (or) SC	13.60	2.705	19.14	56.55	10.61	13.70
	P-43	45.00	-26.81	SP-SM (or) SP-SC	16.56	2.701	30.66	60.74	3.60	5.00
	P-51	53.00	-34.81	F	26.50	2.643	-	17.96	41.94	40.10
	P-57	59.00	-40.81	SM (or) SC	14.55	2.664	4.13	64.59	14.68	16.60

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

Source: JICA Study Team

Table S 6.3.4 Results of Soil Engineering Tests

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

Source: JICA Study Team

7. PRELIMINARY DESIGN ON NEW SITTAUNG BRIDGE

7.1 Preliminary Road Design for New Sittaung Bridge

7.1.1 Geometric Design Criteria

The New Sittaung Bridge as a part of the East - West Economic Corridor Highway (New Bago – Kyaikto Section) will be developed as Primary Road Classification, considering future possible extension, which is the road classification for an access-controlled expressway in ASEAN Highway Standards. The geometric design criteria for preliminary road design is given in Table S 7.1.1

Table S 7.1.1 Comparison of the Route for New Sittaung Bridge

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

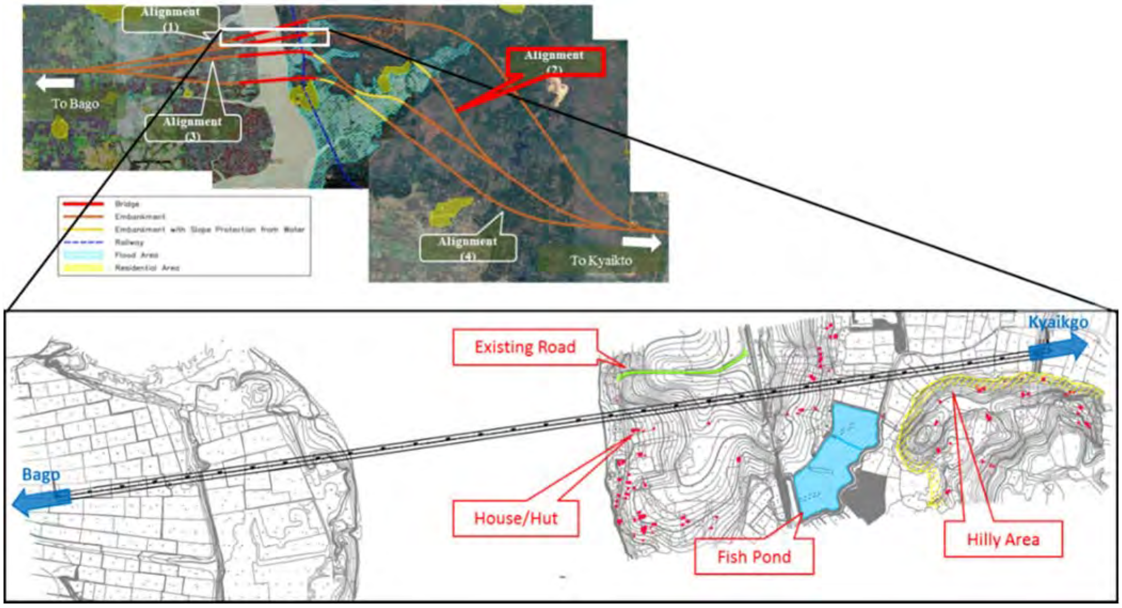
Source: JICA Study Team

7.1.2 Horizontal Alignment

The horizontal alignment around the Sittaung River crossing is determined taking into account the following conditions:

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

The horizontal alignment around the Sittaung River crossing is shown in Figure S 7.1.1.



Source: JICA Study Team

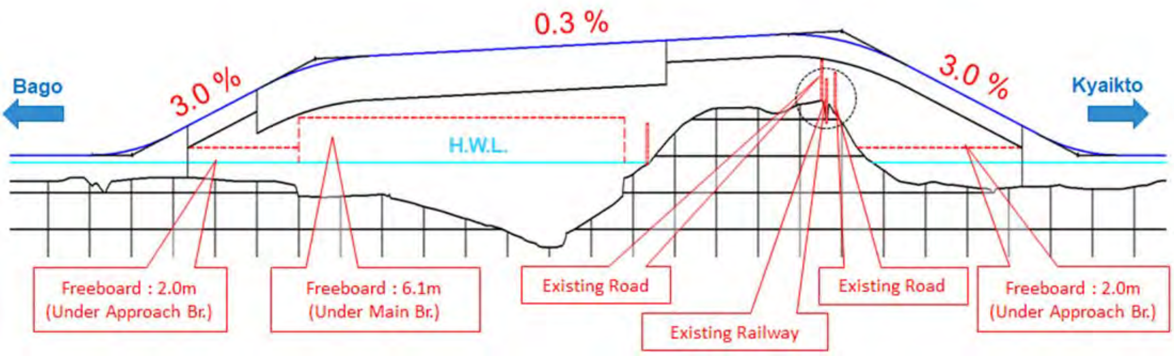
Figure S 7.1.1 Horizontal Alignment of the New Sittaung Bridge

7.1.3 Vertical Alignment

The vertical alignment around the Sittaung River crossing is determined taking into account the following conditions:

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

Vertical alignment around the Sittaung River crossing is shown in Figure S 7.1.2.



Source: JICA Study Team

Figure S 7.1.2 Vertical Alignment of the New Sittaung Bridge

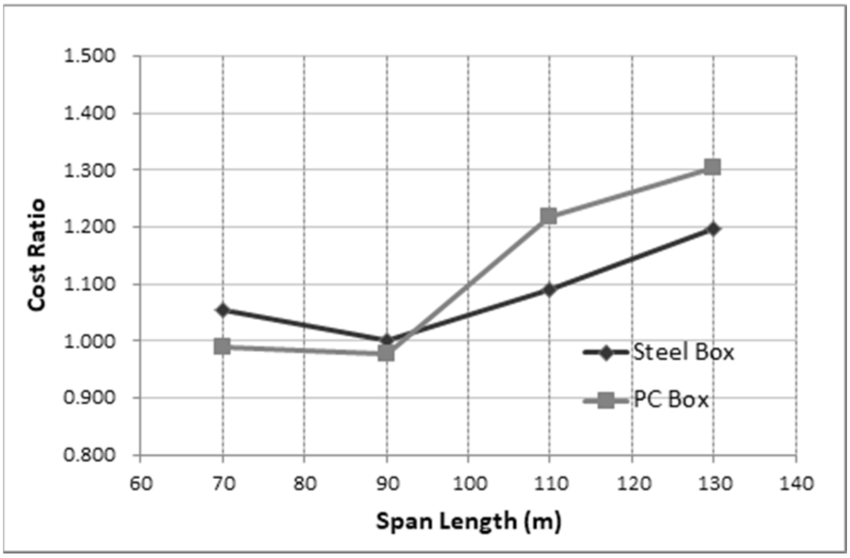
7.2 Preliminary Bridge Design for New Sittaung Bridge

7.2.1 Main Bridge

(1) Span Arrangement

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

- Since the Sittaung River is not used as a water way, there is no specification of navigation clearance, thus, the minimum span length is desirable to follow the existing Sittaung Bridge (Mokepalin), which is 104m.
- As the result of the case study shown in Figure S 7.2.1 , 105 to 110m span is an economically reasonable option
- The proposed span length is desirable in order to effectively mitigate river flow block by piers



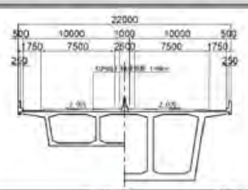
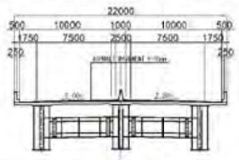
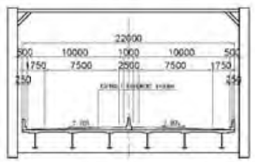
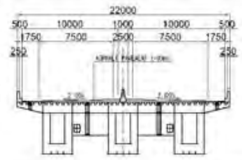
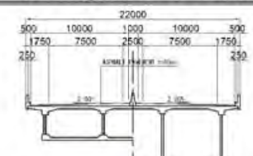
Source: JICA Study Team

Figure S 7.2.1 Study on Economical Span Length of New Sittaung Bridge

(2) Bridge Type

Five alternatives were considered for the main bridge type. As a result of comparative study as shown in Table S 7.2.1, the "Steel Narrow Box Girder with Composite Deck Slab" was selected since this type is the most economical, has the shortest construction period, and new technology can be introduced to Myanmar.

Table S 7.2.1 Secondary Bridge Type Selection of Main Bridge

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

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

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

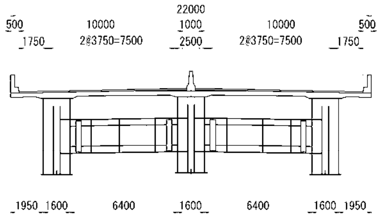
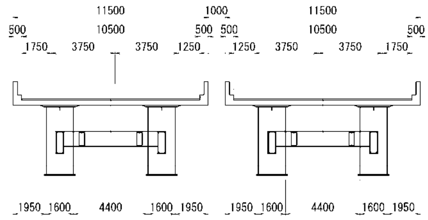
Source: JICA Study Team

(3) Bridge Cross Section

As shown in Table S 7.2.2, 2 alternatives were compared to determine the suitable bridge cross section for the main bridge of the New Sittaung Bridge. The location of the New Sttaiung Bridge is at an open area so that resistance to wind should be studied carefully.

As a result of a comparative study, the integrated type shall be applied to the main bridge, since the separated type cannot satisfy the required wind resistance.

Table S 7.2.2 Study Result and Comparison Table for Bridge Cross Section for Main Bridge

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

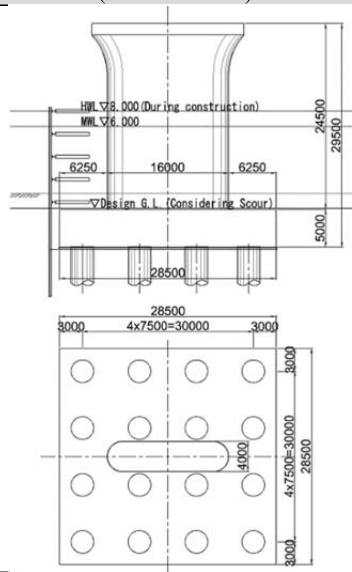
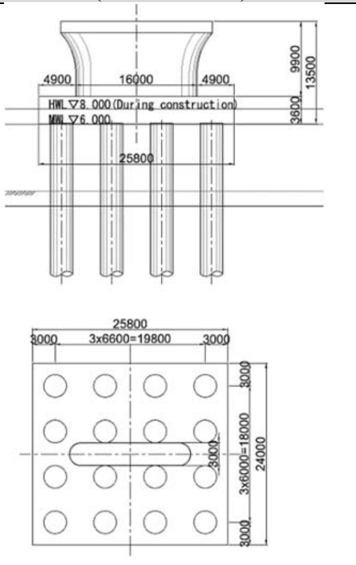
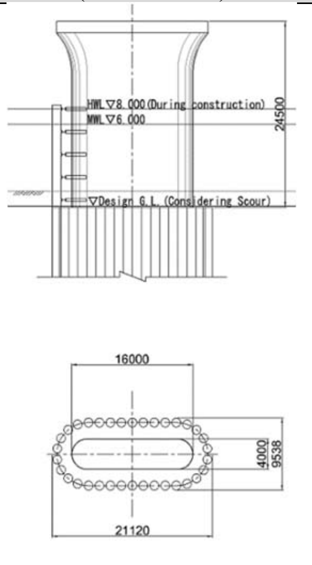
◎ : Excellent ○ : Good △ : Moderate × : Not good or Inapplicable

Source: JICA Study Team

(4) Foundation Type and Pile Diameter

As the result of a comparative study as given in Table S 7.2.3, the "Steel Pipe Sheet Pile" type is recommended to be applied as foundation type for the main bridge since it is most economical option. In addition, as the result of a comparative study regarding pile diameter as shown in Table S 7.2.4, a diameter of 1200mm is recommended since this type is most economical and gives the shortest construction period.

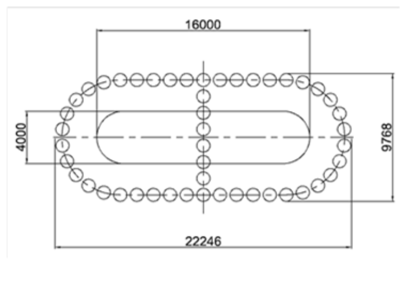
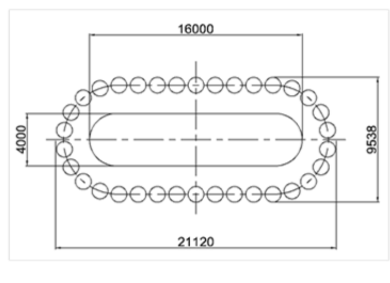
Table S 7.2.3 Comparative Study of Foundation Type for Main Bridge

	Alt-1 Cast-in-Place Concrete Pile (Diameter=3.0 m)		Alt-2 Multiple-pile Foundation (Diameter=3.0 m)		Alt-3 Steel Pipe Sheet Pile (Diameter=1.3m)	
View						
Construction Cost	1.56	-	1.17	△	1.00	◎
Construction Period	15 months	△	11 months	○	13 months	○
Evaluation	Not Recommended (Expensive option)		Not Recommended (Expensive option)		**Recommended (Most economical)**	

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

Source: JICA Study Team

Table S 7.2.4 Comparison of Pile Diameter for Steel Pipe Sheet Pile

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

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

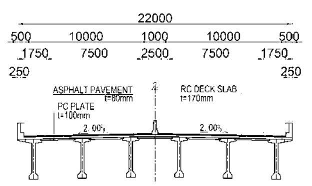
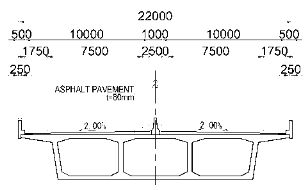
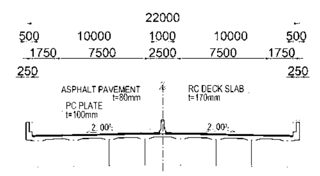
Source: JICA Study Team

7.2.2 Approach Bridge

(1) Bridge Type

Since there is no large size of crossing structure, a 30 to 50m span length of bridge is economically reasonable for the approach bridge. In this context, 3 alternatives were considered for a comparative study on bridge type of approach bridge as shown in Table S 7.2.5. As the result of the study, "PC-I Girder Bridge" was selected since this type is the most economical option.

Table S 7.2.5 Comparison table for Superstructure Type Selection of Approach Bridge

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

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

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

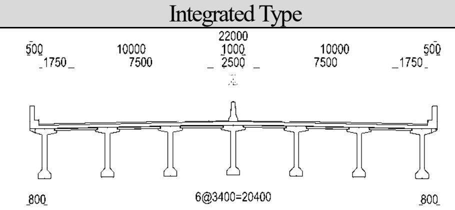
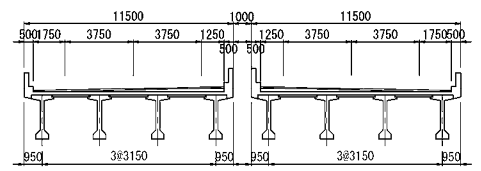
Source: JICA Study Team

(2) Bridge Cross Section

As the result of a comparative study, "Integrated Type" is recommended by the following aspects:

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

Table S 7.2.6 Study Result and Comparison Table for Bridge Cross Section for Approach Bridge

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

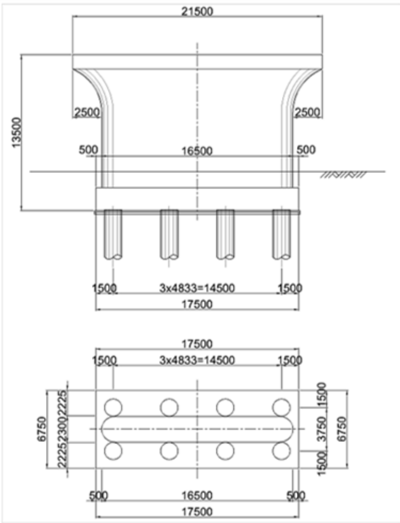
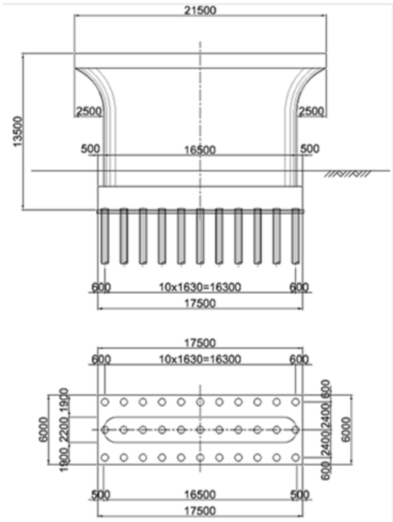
Source: JICA Study Team

(3) Foundation Type and Pile Diameter

A comparative study on foundation type for the approach bridge was carried out as given in Table S 7.2.7. Since there is an advantage for the construction cost in the Cast-in Place Concrete Pile, thus, the Cast-in Place Concrete Pile type is recommended.

In order to select the most economical and shortest construction period, the pile diameter for the above selected foundation type was studied. A comparison table is shown in Table S 7.2.8. As the result of the study, a diameter of 1500mm is recommended since this type is the most economical and gives the shortest construction period.

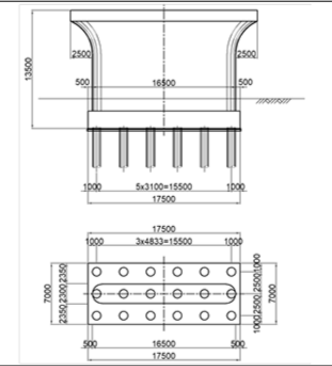
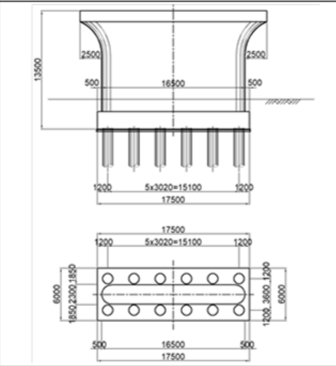
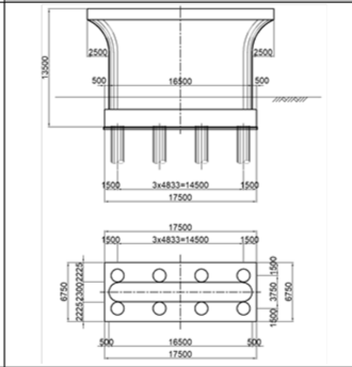
Table S 7.2.7 Comparative Study of Foundation Type for Approach Bridge

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

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

Source: JICA Study Team

Table S 7.2.8 Comparison of Pile Diameter for Cast-in-Place Concrete Pile

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

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

Source: JICA Study Team

7.3 Preliminary Design for Bank Protection and Scour Protection

7.3.1 Countermeasures for Future Erosion and Scour at the Right Bank

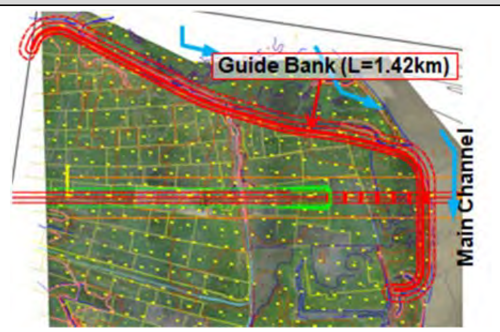
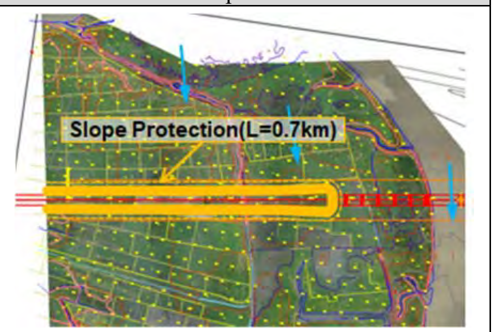
To avoid critical land erosion and scouring on the right bank side of the proposed bridge, 2 alternatives sere considered as shown in Table S 7.3.1.

Alternative 2 is more economical but has a risk for erosion at the riverbank and serious scour at the piers.

On the other hand, Alternative 1 is recommended since it is economically reasonable if considering that the erosion at the riverbank can be controlled and it is the best way to ensure stability of river morphology in the future.

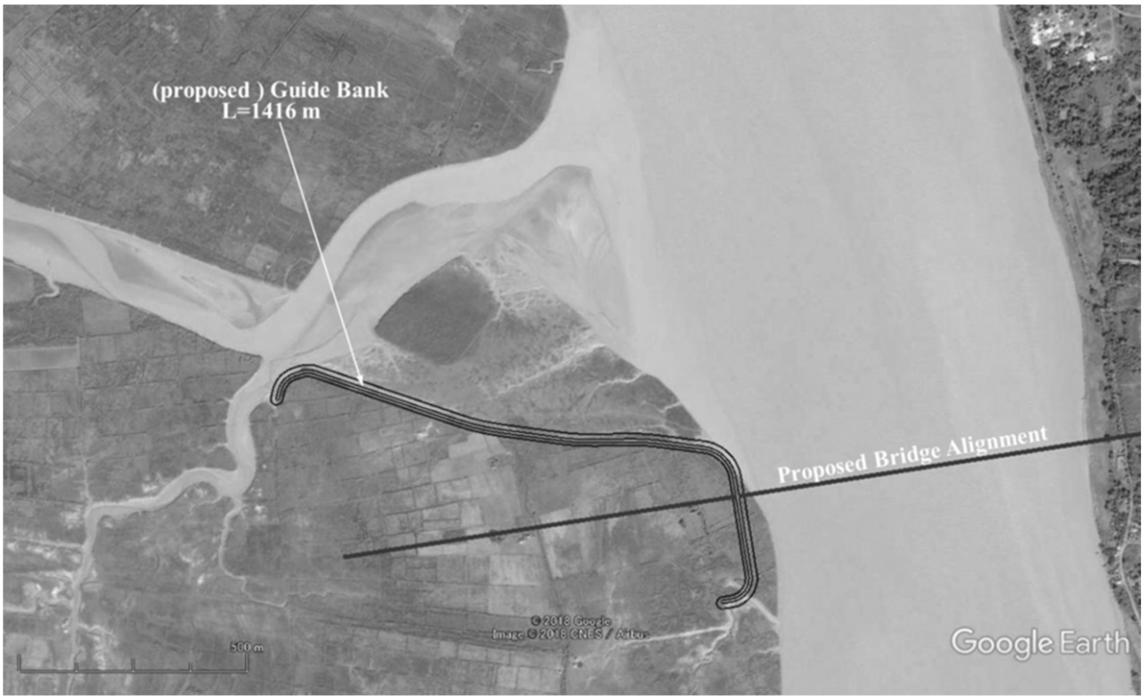
The plan view and typical cross section of the selected countermeasure are given in Figure S 7.3.1 and Figure S 7.3.2 respectively. The guide bank with a length of approximately 1.42km is installed to cover the range of the New Sittaung Bridge including its approach road.

Table S 7.3.1 Bank Protection Comparison Table for Right Bank

Evaluation Item	Alt-1 Guide Bank	Alt-2 Slope Protection
Schematic View		

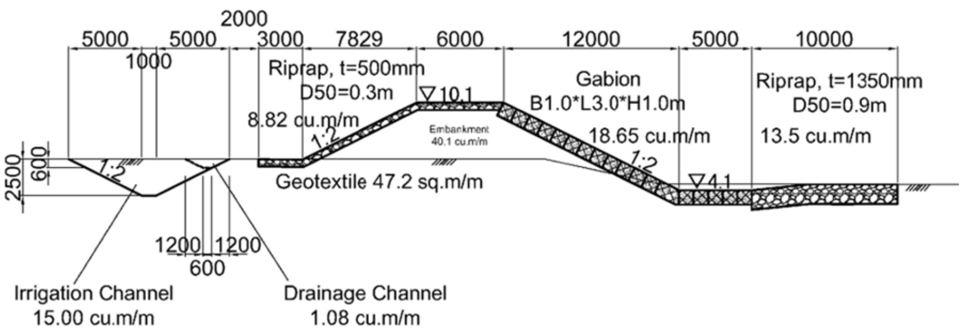
Basic Concept	Riverbank erosion and scour on land are not allowed in the bridge design		Riverbank erosion and scour are allowed in the bridge design	
Effectiveness Against Erosion	The existing river channel and bridge foundations can be protected from the erosion/scour by the guide bank	○	Erosion/scour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

Source: JICA Study Team



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

Figure S 7.3.1 Proposed Guide Bank at Right Bank



Source: JICA Study Team

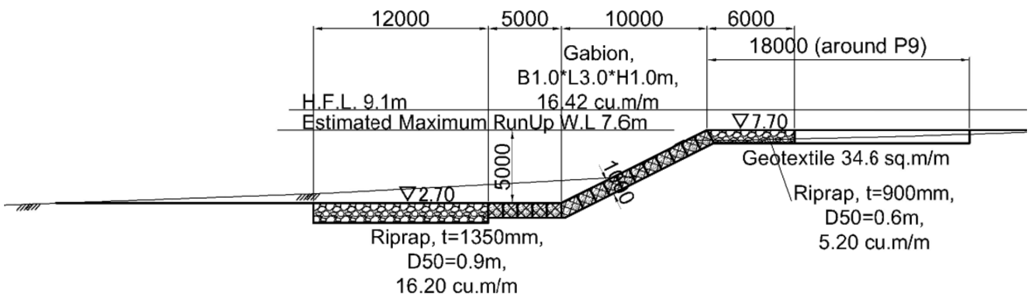
Figure S 7.3.2 Typical Cross Section of Guide Bank for Right Bank

7.3.2 Countermeasures for Future Erosion and Scour at the Left Bank

The main river flow attacks the left bank nearby the proposed bridge. Although the left bank side is a natural levee with sufficient height and stability, the revetment is desirable to be applied to avoid the further riverbank erosion. The revetment with approximately 330 meter in length is proposed to be installed along the current riverbank line as shown in Figure S 7.3.3 .

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

Figure S 7.3.3 Proposed Guide Bank at Left Bank



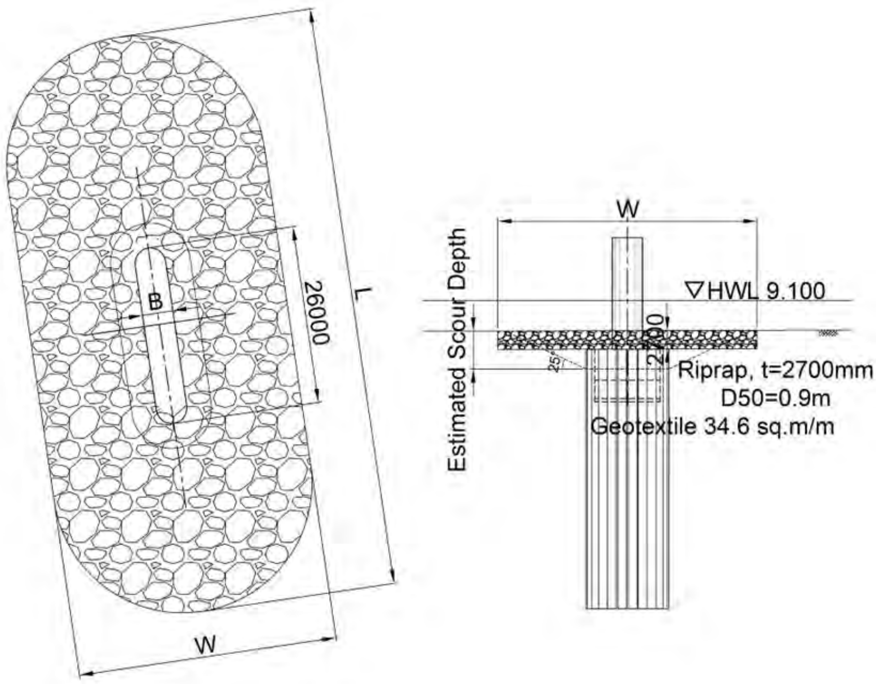
Source: JICA Study Team

Figure S 7.3.4 Typical Section of Revetment for Left Bank

7.3.3 Scour Protection

The typical plan and cross-section of the scour protection works around piers in river is shown in Figure S 7.3.5. The riprap is to be installed within the zone of influence of each pier scour, and the minimum thickness is three times of the median riprap size (3xD50). The zone of influence of each pier scour is estimated by the angle of repose of riverbed materials (25°) in the water. The protection range at each pier is shown in Table S

7.3.2. The mean diameter of riprap is calculated as 0.9 m by the rearranged Isbash equation.



Source: JICA Study Team

Figure S 7.3.5 Typical Plan / Section of Bridge Pier Protection for Scouring

Table S 7.3.2 Extent of Bridge Pier Protection

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

Source: JICA Study Team

8. CONSTRUCTION PLANNING OF NEW SITTAUNG BRIDGE

8.1 Project Outline

The major components for civil work are summarized in Table S 8.1.1.

Table S 8.1.1 Summary of Major Civil Works

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

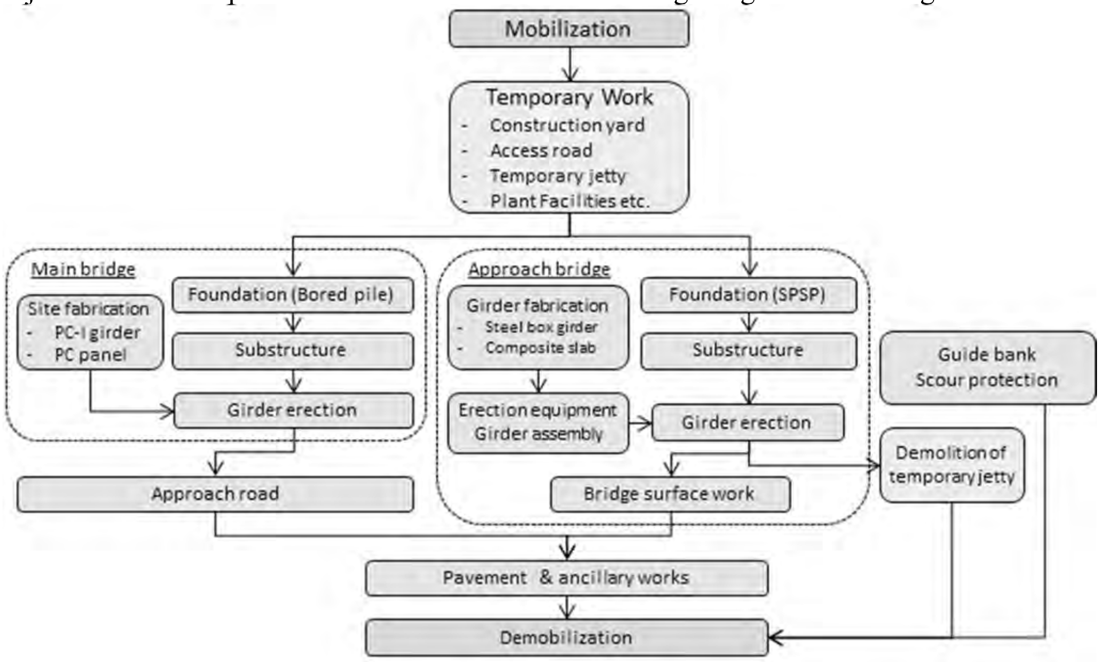
*Construction limit between JICA portion and ADB portion should be adjusted during detailed design

Source: JICA Study Team

8.2 Construction Methodology

8.2.1 Overall Construction Sequence

The major construction sequence for the construction of New Sittaung Bridge is shown in Figure S 8.2.1.



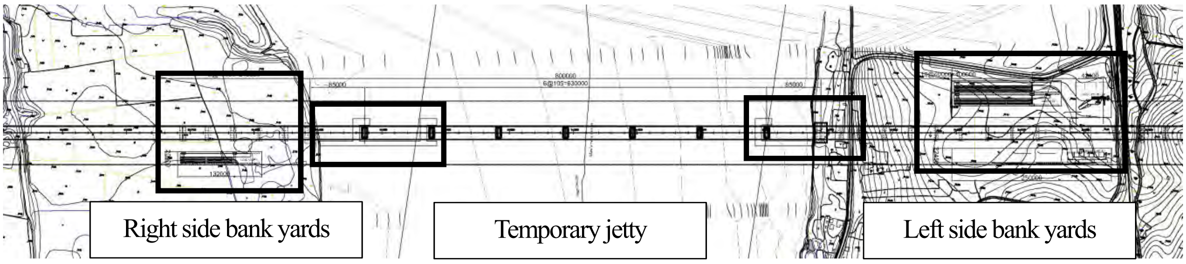
Source: JICA Study Team

Figure S 8.2.1 Overall Construction Sequence

8.2.2 Temporary Work

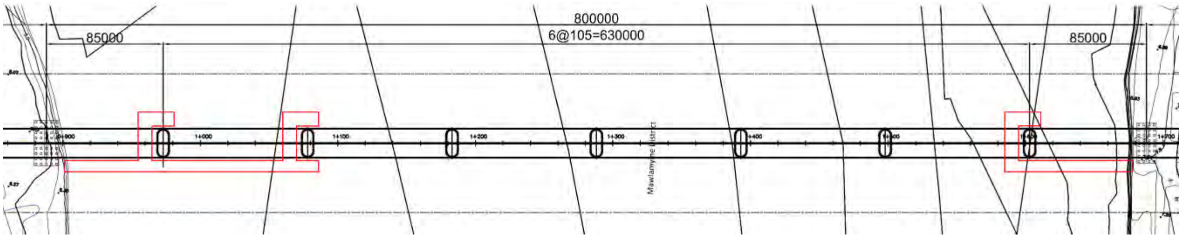
(1) Construction Yards and Temporary Jetty

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



Source: JICA Study Team

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



Source: JICA Study Team

Figure S 8.2.3 Enlarged View of Temporary Jetty (Reference only)

(2) Access Roads

The access roads to the construction site are expected to be developed as shown in Figure S 8.2.4.

Source: Prepared by JICA Study Team based on Google Earth

Figure S 8.2.4 Enlarged View of Temporary Jetty (Reference only)

8.2.3 Bridge Foundation Work

(1) Steel Pipe Sheet Pile (SPSP)

Considering the river condition, foundation work shall be conducted on a "temporary jetty" in the shallow area; in the deep area it shall be conducted by "barge" as shown in Figure S 8.2.5.

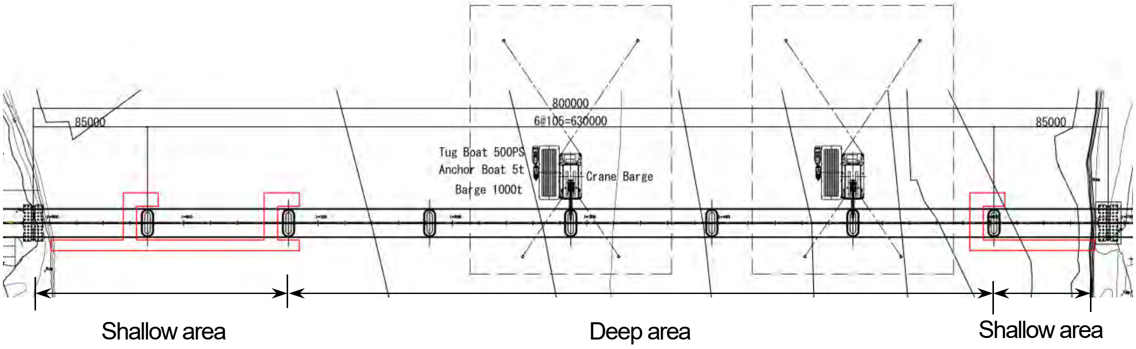
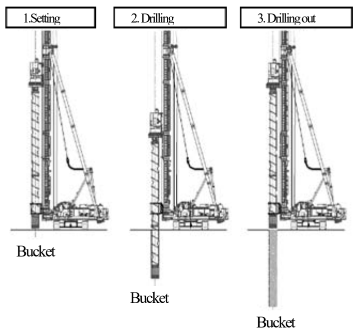
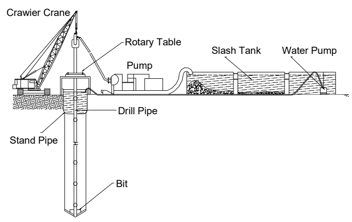
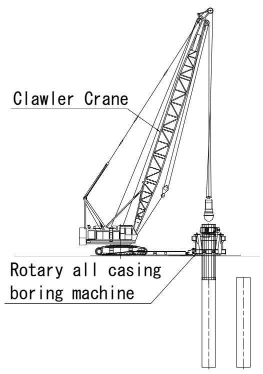


Figure S 8.2.5 Typical Layout of Temporary Jetty and Barges during SPSP Construction

(2) Cast-in-place RC Pile

Considering the applicable pile length as well as economical efficiency, the Reverse Circulation Drilling Method is recommended among the applicable alternatives.

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

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

Source: JICA Study Team

8.2.4 Substructure Work

(1) Piers in River

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

(2) Substructures on Land

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

The main substructure elements are divided into the footing, column, and pier head. Ready mix concrete can be locally sourced and casted using a concrete pump. Wooden formwork was adopted for the footing and abutment construction, since those elements are composed of plane surfaces. For the pier columns and pier head, metallic formwork shall be adopted to guarantee the constructability and surface quality of the curved/variable sections of those elements.

8.2.5 Superstructure Works

(1) Erection Method of Steel Narrow Box Girder

Two alternatives are nominated for the erection method of steel narrow box girders, one is "by launching girder erection method" and the other is "by truck crane with bent method". As the result of a comparative study, the former is selected for the erection method of a steel narrow box girder bridge since the latter needs higher construction cost and a longer construction period due to the additional temporary bridge/jetty which is necessary for girder erection by truck cranes.

(2) Erection of PC-I Composite Girder

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

8.3 Procurement Plan

8.3.1 Procurement Plan for Major Materials and Source of Materials

Cement, aggregate, PC-I girder and PC board and a temporary jetty can be procured domestically in Myanmar. A factory produced steel box-girder and steel deck slab for the main bridge and bearings and expansion joints will be procured from Japan or 3rd countries.

Table S 8.3.1 Procurement Plan for Main Materials

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

Source: JICA Study Team

8.3.2 Procurement Plan for Major Equipment

The main equipment for construction of the bridge and road are shown in Table S 8.3.2Table S 8.3.2 .

Table S 8.3.2 Procurement Plan for Main Equipment

Equipment	Specification	Country to be Procured
Dump Truck	10t	Local
Dump Truck	2t	Local
Track Crane	4.9t	Local
Track Crane	16t	Local
Track Crane	200t	Local
Rough Terrain Crane	16t	Local
Rough Terrain Crane	25t	Local
Rough Terrain Crane	50t	Local
Crawler Crane	40~45t	Local
Crawler Crane	50~55t	Local
Crawler Crane	60~65t	Local
Crawler Crane	100t	Local
Clamshell	Bucket Struck Capacity $0.8m^3$	Local
Back Hoe	Bucket heaped Capacity $0.8m^3$	Local
Back Hoe	Bucket heaped Capacity $0.45m^3$	Local
Bulldozer	21t	Local
Bulldozer	15t	Local
Motor Grader	Blade Length 3.1m	Local
Road Roller	10~12t	Local
Tire Roller	8~20t	Local
Vibration Roller	8~10t	Local
Vibration Roller	Combined Type 3~4t	Local
Tamper	60~80kg	Local
Asphalt Finisher	1.7~3.1m	Local
Concrete Pumping Truck	$90\sim110m^3/h$	Local
Vibratory Hammer	60kW	Local or Foreign
Push-out Devices		Japan
Bent		Local or Foreign
Crawler Pile Driver		Japan
Generator	250kVA, 300kVA	Local

Source: JICA Study Team

8.4 Construction Schedule

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

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

Table S 8.4.1 Alternatives for Comparative Study on Construction Schedule

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

Source: JICA Study Team

As the result of a comparative study as shown in Table S 8.4.2, considering a request by MOC that the completion date of civil works should be as early as possible, "Alternative-2" is a recommended option although the option requires bid higher construction cost (approx. +3%) due to additional cost for labor's overtime works.

Table S 8.4.2 Comparative Study on Construction Schedule

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

Source: JICA Study Team

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

9. OPERATION AND MAINTENCE PLAN

9.1 Operation and Maintenance Plan

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

9.1.1 Inspection Plan

The types and frequency of the inspection work are planned as shown in Table S 9.1.1.

Table S 9.1.1 Types and Frequency of Inspection Works

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

Source: JICA Study Team

9.1.2 Maintenance Plan

The maintenance plan for the New Sittaung Bridge is planned as Table S 9.1.2.

Table S 9.1.2 Major Maintenance Required Items of New Shittaung Bridge

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

Source: JICA Study Team

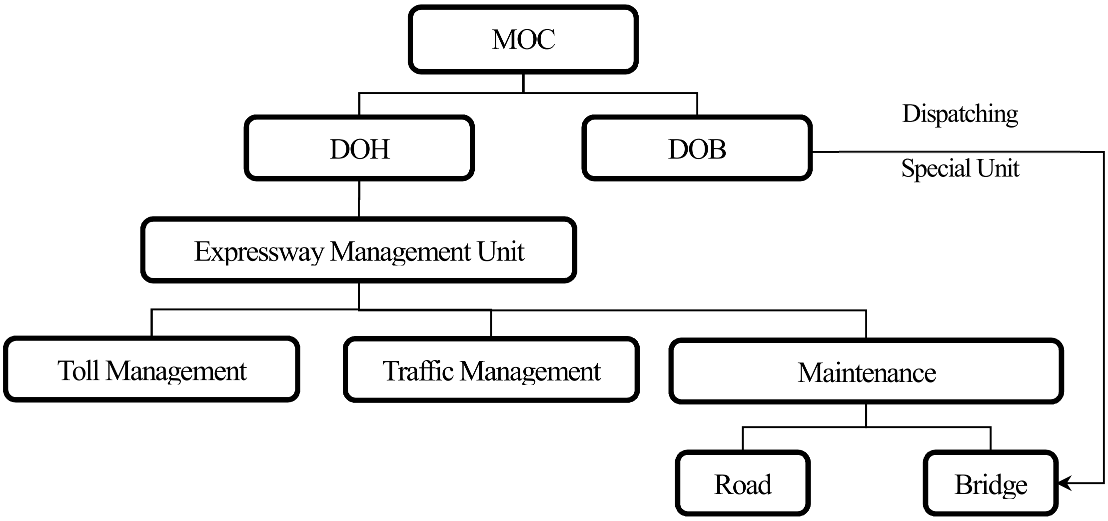
9.1.3 Expressway Facility Plan

For the toll collection and the traffic management works of the project expressway, the expressway facility plan provided by ADB is reviewed by the JICA Study Team.

9.2 Operation and Maintenance Structure

9.2.1 Overall Organizational Structure

The management unit will be established and operated and maintained immediately under the executing agency of this project.



Source: JICA Study Team

Figure S 9.2.1 Overall Organizational Structure for Operation and Maintenance (Draft)

(1) Structure of Toll Collection Management Work

1) **Toll Plaza Operation Work**

The required number of toll collection staff at each toll plaza is shown in Table S 9.2.1.

Table S 9.2.1 Number of Toll Collection Staff (Reference)

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

Source: JICA Study Team

2) **Toll Management Work**

The required number of toll management staff at each toll plaza is shown in Table S 9.2.2.

Table S 9.2.2 Number of Toll Management Staff (Reference)

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

Source: JICA Study Team

3) Weight Measurement Work

The required number of weight measurement staff at each toll plaza is shown in Table S 9.2.3.

Table S 9.2.3 Number of Weight Measurement Staff (Reference)

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

Source: JICA Study Team

(2) Structure of Traffic Management Work

1) Monitoring Work

The monitoring staff will be responsible for monitoring around the toll plaza and on the main line using CCTV monitors, monitoring facility malfunctions, coordinating communication in the abnormal event, sending out SNS of traffic conditions, etc. and 2 staff members will be assigned to the monitoring room at each toll plaza. The required number of monitoring staff members at each toll plaza is shown in Table S 9.2.4.

Table S 9.2.4 Number of Monitoring Staff (Reference)

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

Source: JICA Study Team

2) Traffic Management Work

The traffic management staff will be responsible for traffic patrols, response to accidents, inspection of traffic management patrol cars, etc., and 2 staff members will be assigned to each traffic management vehicle placed at the management center of each toll plaza. The required number of traffic management staff at each toll plaza is shown in Table S 9.2.5.

Table S 9.2.5 Number of Traffic Management Staff (Reference)

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

Source: JICA Study Team

(3) Structure of Maintenance Management Work

1) Daily Maintenance Work (Road Maintenance)

The inspection and maintenance staff will be responsible for the maintenance patrol, the primary response in the event of an abnormality on the main line, inspection of the maintenance patrol car, etc. Two inspection and maintenance staff members will be assigned to each maintenance management vehicle placed at the management center of the 2 tollgates. The required number of inspection and maintenance staff at each toll plaza is shown in Table S 9.2.6.

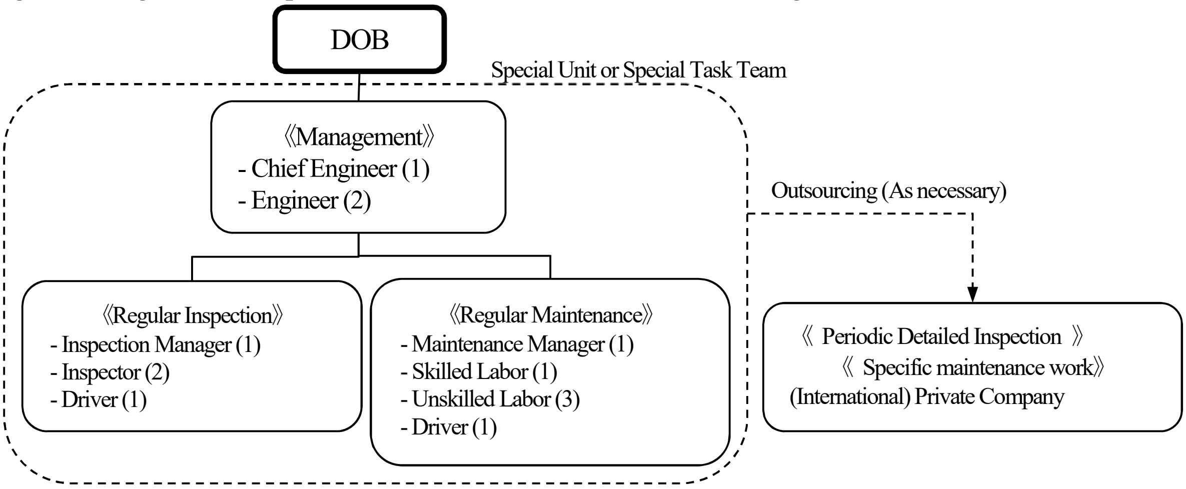
Table S 9.2.6 Number of Inspection and Maintenance Staff (Reference)

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

Source: JICA Study Team

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

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



Source: JICA Study Team

Figure S 9.2.2 Implementation Structure for Bridge Inspection and Maintenance (Reference)

9.3 Operation and Maintenance Cost

The approximate operation and maintenance cost required for the project road is calculated based on the ADB-calculated cost and the contents of the operation and maintenance management plan proposed in the previous sections.

Table S 9.3.1 shows the operation and maintenance costs required for 20 years from the completion of this project, including daily operation and maintenance.

Table S 9.3.1 Operation and Maintenance Costs for This Project Road (20 Years)

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

Source: JICA Study Team

9.4 Future Implementation Body for Expressway Operation

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

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

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

As the result of a comparative study, although the future operation method of expressways needs to be discussed with MOC considering the process of the reformation of MOC under which a SOE might be established, Alternative-1 : Expressway Enterprise model is recommended for the time being by the following reasons.

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

9.5 Necessity of Upgrading of the Thuwunna CTC

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

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

To cope with the above issues and a movement that MOC plans to a new department which will be responsible for all research and laboratory functions, and training functions provided by CTC and 4 Research Laboratories under DOH, DOB, DOBi and DRRD, this Project aims to strengthen the functions of the Thuwunna RLTC by reconstructing the Training Facility and Research Laboratories, Hostels and procuring the necessary training and laboratory equipment for these facilities. Thereby proper implementation body for proper and sustainable O&M of the project expressway is expected to be developed through advanced technical trainings to MOC's engineers.

10. OUTLINE OF PRELIMINARY DESIGN FOR UPGRADING OF THUWUNNA RLTC

10.1 Project Contents for Upgrading Thuwunna RLTC

The summary of work scopes for building works and procurement of equipment necessary for upgrading the Thuwunna RLTC are shown in Table S 10.1.1 and Table S 10.1.2.

Table S 10.1.1 Summary of the Facilities

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

Source: JICA Study Team

Table S 10.1.2 Main Equipment Items

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

Source: JICA Study Team

10.2 Overall Design Policy

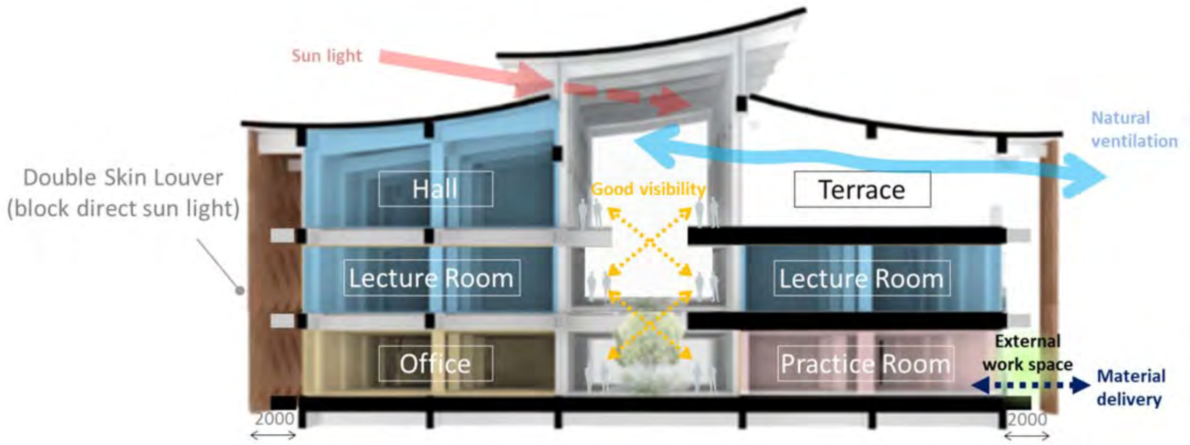
The Thuwunna RLTC, which is planned to be built under this Project, is a center that integrates the current CTC, DOH Laboratory, DOB Laboratory, DoBi Laboratory, and DRRD Laboratory. It aims to centralize the currently scattered facilities and take the following factors into account: (1) functionality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

- As a training and laboratory facility responsible for human resource development and quality control in the field of construction in Myanmar, the facility is planned to further enhance research and human resource development.
- MOC is in the process of strengthening the organization of CTC. In this project, the minimum necessary facilities and equipment shall be designed that can be respond to the new organization.
- To establish a proper facility which contributes to construction-related technology development and quality control as well as facilitate research and development, the facility shall be designed in consideration of the possibility of building expansion in the future.
- Laboratories shall be designed to provide exhibition facilities and libraries to allow more diverse training and for easy access of trainees to acquire more knowledge.
- The Research Laboratory shall be aimed to provide quality control under the ASEAN, and facilities and provision of equipment shall be planned to adapt to ASTM standards. Since there is a possibility to restructure the laboratories in the future, flexibility of the building plan to respond to layout changes will be taken into consideration.
- In regard to the equipment, sharing and unified management of common equipment will be considered.
- In order to reduce the burden of maintenance and management in the future, the design shall be prepared in consideration of securing natural lighting and ventilation, ease of maintenance, and reduction of utility costs. In addition, the concept of green building design shall be adopted, and the facility itself shall be an example in which the trainees can learn from.
- To be a suitable environment as training center and research laboratory, the design shall be prepared following the current trends (i.e. universal design, green building, etc.).

10.3 Major Design Outputs

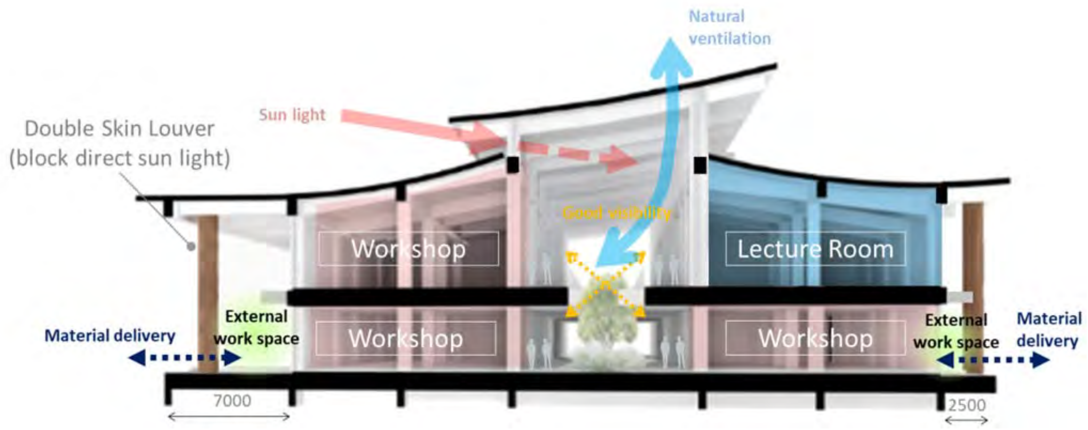
10.3.1 Architectural Plan

The floor plan was designed based on the layout plan and function or standard calculation for each necessary room. The building design concept diagrams are shown in Figure S 10.3.1 to Figure S 10.3.4.



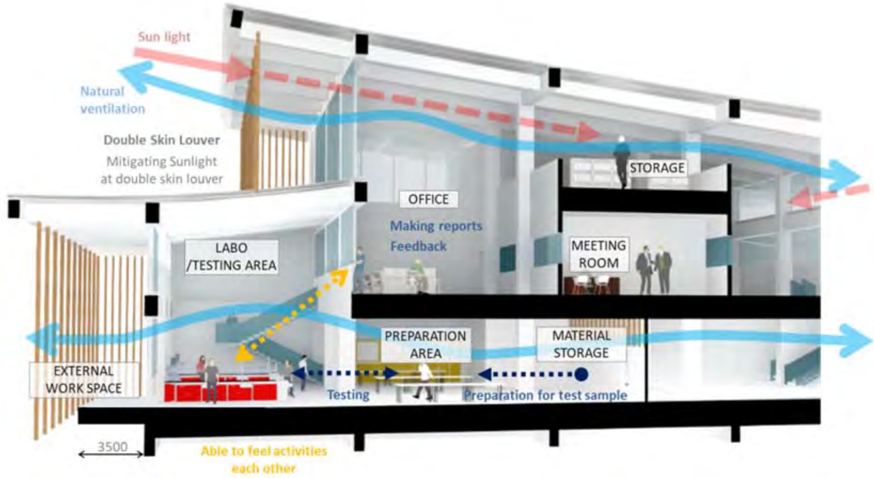
Source: JICA Study Team

Figure S 10.3.1 Building Design Concept Diagram (Section) of MOC Training Center



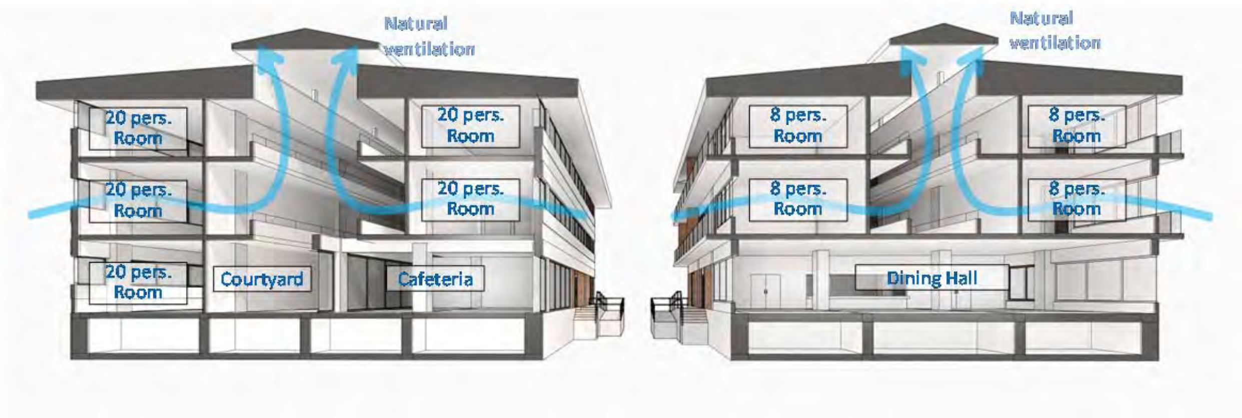
Source: JICA Study Team

Figure S 10.3.2 Building Design Concept Diagram (Section) of Vocational Training Center



Source: JICA Study Team

Figure S 10.3.3 Building Design Concept Diagram (Section) of Research Laboratory



Source: JICA Study Team

Figure S 10.3.4 Building Design Concept Diagram (Section) of Hostels

10.3.2 Equipment Plan

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

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

As a result of examination by the Study Team, the following equipment listed in Table S 10.3.1 is expected to be procured under this Project.

Table S 10.3.1 List of the Equipment

Item No.	Description	Quantity	Use
Thuwunna CTC			
1-1	Cutting machine for brick	10	Practical Training
1-2	Bending machine for rebar	8	Practical Training
1-3	Cutting machine for rebar	8	Practical Training
1-4	Tying machine for rebar	8	Practical Training
1-5	Total station	10	Practical Training
1-6	Theodolite	10	Practical Training
1-7	Level	10	Practical Training
1-8	Concrete mixer	5	Practical Training
1-9	Los Angeles abrasion machine	1	Practical Training
1-10	Concrete compression machine	1	Practical Training
1-11	Desktop computer	10	Lecturing
1-12	Laptop computer	10	Lecturing
1-13	Printer color	10	Lecturing
1-14	Copier medium	10	Lecturing
1-15	Projector	10	Lecturing
1-16	Plate Compactor	10	Practical Training
1-17	Recessed screens	10	Practical Training
DOB (Soil Testing)			
2-1	Double Tube Core Barrel Complete Assembly	5	Quality Control
2-2	Consolidation Test Apparatus	2	Quality Control
2-3	Oven	1	Quality Control
DOB (Concrete Testing)			
2-4	Flow Table Test (Flow of hydraulic cement Mortars and cement pastes) Apparatus	1	Quality Control
2-5	Turbidimeter Test Apparatus with accessories	1	Quality Control
2-6	Soundness Test (Autoclave) Apparatus with accessories	1	Quality Control
2-7	Compressive Strength Test	1	Quality Control
DOBi (Concrete Testing)			
3-1	Mortar Mixer	3	Quality Control
3-2	Automatic Blaine Fineness Apparatus	1	Quality Control
3-3	Electronic Analytical balance	3	Quality Control
3-4	Curing Bench	1	Quality Control
3-5	Flow Tables Machine	2	Quality Control
3-6	Concrete curing specimen tank	2	Quality Control
3-7	S.I.T (Sonic Integrity Test)	1	Quality Control

Item No.	Description	Quantity	Use
3-8	Ultrasonic Pulse Velocity Tester	1	Quality Control
3-9	Pulse Echo Foundation Tester	1	Quality Control
3-10	Flat Jacks	1	Quality Control
3-11	Laboratory Ovens	1	Quality Control
3-12	Electromagnetic Sieves Shaker	1	Quality Control
3-13	Rotary Automatic scales	3	Quality Control
3-14	Water Stills	2	Quality Control
3-15	Pulse Echo Foundation Tester	1	Quality Control
3-16	Cross Hole Ultrasonic Monitor	1	Quality Control
3-17	Compression Machine 3000 KN	2	Quality Control
DOBi (Soil Testing)			
3-18	Direct Shear Test Apparatus C/W All Accessories	1	Quality Control
3-19	Horizontal Sample Ejector	1	Quality Control
3-20	Moist Cabinet	1	Quality Control
DOBi (Steel Testing)			
3-21	Universal Tensile Testing Machine (1000 kN)	1	Quality Control
3-22	Cold Bend Testing Machine	1	Quality Control
3-23	Floor-standing Optical Emission Spectrometers	1	Quality Control
DOBi (Office Equipment)			
3-24	Copier	5	Data Processing
3-25	Computer (Laptop)	11	Data Processing
3-26	Printer (A3)	5	Data Processing
3-27	Computer (desktop)w/ desk	3	Data Processing
DOH (Bitumen Testing (Lab-1))			
4-1	Gyratory Compactor	1	Quality Control
4-2	Laboratory Saw	1	Quality Control
4-3	Universal Core Drill for AC	1	Quality Control
4-4	Standard Rotational Viscometer	1	Quality Control
4-5	Oven (0-120^{o} C)	1	Quality Control
4-6	Automatic Asphalt Extraction Apparatus	1	Quality Control
4-7	Draft Chamber	3	Quality Control
4-8	Electromagnetic Sieves shaker	1	Quality Control
DOH (Fine and Coarse Aggregates Testing (Lab-2))			
4-9	Los Angeles Machine	1	Quality Control
4-10	Pilot Compact-line	1	Quality Control
4-11	Electromagnetic Sieve Shaker	1	Quality Control
DOH (Cement Testing (Lab-2))			
4-12	High Pressure Cement Autoclave	1	Quality Control
4-13	Automatic Digital mortar Mixer	1	Quality Control
4-14	Temperature and Humidity Controlled Cabinet	1	Quality Control
DOH (Concrete Testing (Lab-2))			
4-15	Pan-type Mixer with accessories	1	Quality Control
DOH (Soil Testing (Lab-3))			
4-16	Los-Angeles Abrasion Test	1	Quality Control
4-17	Triaxial Compression Test	1	Quality Control
DRRD (Soil Testing)			
5-1	CBR Apparatus	3	Quality Control
5-2	Direct Shear Test Equipment	1	Quality Control
5-3	Moisture Tester	2	Quality Control
5-4	Consolidation Test Equipment	1	Quality Control
5-5	Oven 100 Litters	1	Quality Control
DRRD (Aggregates Testing)			
5-6	Compressive Testing Machine	3	Quality Control
5-7	Los Angeles Abrasion testing machine	1	Quality Control

Item No.	Description	Quantity	Use
DRRD (Field Survey/Testing)			
5-8	Total Station	2	Survey/Testing
5-9	Level	1	Survey/Testing
5-10	SIT (Sonic Integrity Testing)	1	Survey/Testing
5-11	Theodolite	1	Survey/Testing
Furniture			
6-1	Experiment Table-1	27	Working and Testing
6-2	Experiment Table -2	19	Working and Testing
6-3	Experiment Table-3	38	Working and Testing
6-4	Experiment Table-4	32	Working and Testing
6-5	Experiment Table-5	21	Working and Testing
6-6	Lab Sink-1	42	Working and Testing
6-7	Lab Sink-2	21	Working and Testing

Source: JICA Study Team

11. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

11.1 Overview of the EIA

Overview of a series of mandatory environmental and social consideration activities for the project in accordance with Myanmar's environmental laws and JICA Guidelines for Environmental and Social Considerations (2010) is indicated in this chapter.

The prepared draft EIA was submitted from the Ministry of Construction (MOC) to the Environmental Conservation Department (ECD) under the Ministry of Natural Resources and Environmental Conservation (MONREC) in January 2019, and it will be approved before the commencement of civil works.

11.2 Summary of the Project Features

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

Table S 11.2.1 Summary of the Project

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

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

Source: JICA Study Team

11.3 Summary of the EIA

11.3.1 Screening of the EIA

The length of New Sittaung Bridge (JICA Section) exceeds 2km and the length of the new Bypass section (ADB Section) exceeds 50km, thus both projects have been requested to conduct EIA by the ECD.

Table S 11.3.1 IEE and EIA Mandatory List

Project Type	Criteria	
	IEE	EIA
126. Bridges, River Bridges and Viaducts (new	Length≥0.2km but <2km	Length≥2km

Project Type	Criteria	
	IEE	EIA
construction)		
127. Bridges, River Bridges and Viaducts (upgrading)	Length≥300m	All activities where the Ministry requires that the project shall undergo EIA
129. Expressways and Highways (ASEAN Highway Standard; new construction or widening)	**Length≥2km but <50km**	**Length≥50km**
130. Other Roads (state, region, urban; new construction or widening)	Length≥50km but <100km	Length≥100km
131. Road Improvement (upgrading from seasonal to all weather surface, widening of shoulders)	Length≥50km	All activities where the Ministry requires that the project shall undergo EIA

Source: EIA Procedure Law 2015 (ANNEX 1/Categorization of Economic Activities for Assessment Purposes)

The Project is classified as “Category B” as the project does not fall under the large-scale project in the roads, railways, and bridges sector, the project is not likely to cause significant adverse impacts on the environment and society, and the Project is not applicable to any of the sensitive characteristics nor located in or near sensitive areas according to the JICA Guidelines for Environment and Social Considerations (April 2010). However, the indivisible project (the ADB section of the EWEC project) is recognized as “Category A” as the large scale involuntary resettlement is expected. Therefore, the environmental and social aspects should be carefully considered to the extent considered reasonable based on the JICA Guidelines.

11.3.2 Summary of Baseline Survey, Forecasts and Mitigation Measures

A series of baseline surveys regarding pollution items (air, water quality, noise and vibration), fauna-flora and social items (involuntary resettlement, local economy) based on a result of scoping analysis are necessary. A summary of baseline the surveys, forecasts and necessary mitigation measures are shown below;

(1) Natural Environment

In the project area, there aren’t any law-based natural conservation areas, national parks and international treaty designated places. However, there are Key Biodiversity Areas (KBA) which is proposed by international NGOs in the project area. However, the registered Ramsar Site named Gulf of Mottama is located approximately 5.5km away from the planned bridge location. Thus, on-site and literature surveys have been conducted, and then review and evaluation has been done by the wildlife specialists in Myanmar and Japan.

During construction, operation of construction machines and land alternation will impact fauna species and such species may avoid the construction area. With regard to considerable species, some species on IUCN Red-list have been recorded during the baseline survey. However, these species are evaluated as escape species or non-native species in the project area, thus it is evaluated that the Project does not give serious impacts on these observed species.

With regards to birds, any considerable species such as Spoon-billed Sandpiper have not been observed in the project area during migratory season.

After construction, it has been analyzed that the existence of pillars in the river does not seriously impact the hydrological situation of the Sittaung River. It means the tidal flat which is an important habitat for fauna-flora species is not impacted by the Project.

Although fauna species may avoid the project area after opening of the project road due to traffic and its noise temporarily, such fauna species should come back to the project area gradually. However, implementation of some mitigation measures such as turbid water prevention during construction and setting up LED along the bridge shall be done for the minimization of impacts.

Additionally, not only the project area, but also a part of Ramsar area will be surveyed on fauna – flora including considerable species and fishes (adult, larval, juvenile), noise and distribution of mudflat twice in the dry and rainy season a year during the detailed design and construction phase. Appropriate mitigation measures will be considered when such considerable species are recorded or some adverse impacts by the Project are suspected during the Special Ecosystem Monitoring.

(2) Pollution Items

Most of the items on air, water quality, soil and noise meet Myanmar's standard level and international standards except PM10, BOD and SS.

During construction, operation of construction machines and construction activities may give adverse impacts on dust, turbid water, noise and vibration in the project area. However residential houses and sensitive receptors such as hospitals and schools are not located near the project area, and it is confirmed that the impact level at the point 300m away from construction area is negligible based on the quantitative forecasts.

After construction, although air quality, noise and vibration level will exceed the current level, forecasted level meets standard or negligible impact. Additionally, mitigation measures during and after construction are prepared, thus it is not likely to give any serious impacts.

(3) Social Environment Items

The land use of the project area is mainly paddy fields and rubber plantations, and residential areas are limited in the project area. Thus, those who are mainly affected by the Project are farmers.

As the result of resettlement and land acquisition surveys, 21 displaced persons and approximately 26 ha affected land have been recorded. (See details in Chapter 12 Resettlement Action Plan)

During the surveys and meetings regarding resettlement and land acquisition, the MOC has explained the degree of impacts and basic compensation policy to those affected by the Project and has formulated a basic consensus regarding implementation of the Project and the basic compensation policy without any objections.

On the other hand, since a restricted area of 400m width in the Sittaung River has been established from the view of safety management during construction, some adverse impacts on fishing grounds has been expected. However, there aren't any law-based fishing grounds in the project area, hence, the fishermen can move and continue fishing activities during construction. The fishermen can move up and down stream through a navigation channel.

After construction, there aren't any restricted areas set up in the project area, thus it is not likely to give adverse impacts for the fishermen.

11.3.3 Grievance Redress Mechanism

It is forecasted that the adverse impacts on the natural and social environment are not serious, however, prompt responses are necessary when an unexpected situation occurs. Thus, a Grievance Redress Mechanism (GRM) for EIA and land acquisition will be established during and after construction. The members of Grievance Redress Committee (GRC) will be composed of representatives of each relevant organizations and communities such as DOB, DOH, GAD, village tract, women association, etc. It is recommended that female members to be included to GRC from the view of gender equality and adoption of opinions from women. It is also noted that GRM procedures will have to be disclosed and discussed with various stakeholders of the communities around the project area including PAPs of RAP and fishermen to the extent possible in order to ensure that they recognize the GRM, and to agree and understand the process.

11.4 Environmental Management Plan

During construction, monitoring and interviews shall be done at same points of the baseline survey, and necessary action shall be taken when the monitored values are exceeding the baseline data and/or standard values.

The implementation of mitigation measures and monitoring shall be done by the Contractor. The Contractor shall submit a monthly environmental monitoring report to PMU after reviewing by the supervision consultant. MOC submits the report to ECD, local governments and other relevant organizations.

With regard to the ecosystem, the Project does not give serious impacts on KBA nor Ramsar Site, continuous special ecosystem monitoring shall be carried out during detailed design, construction and after construction, and necessary actions shall be taken when unexpected impacts are caused. The detailed plan for the ecosystem special monitoring will be discussed among some wildlife specialists in Japan and/or Myanmar and local natural NGOs, and then established and carried out.

11.5 Local Stakeholder Meeting

Local stakeholder meetings in the Bago Region and Mon State have been conducted at the scoping and draft EIA preparation stage in accordance with EIA procedure 2015 and JICA Guidelines. As the result of meetings, basic consensus for implementation of the Project have been formulated.

11.6 Schedule regarding EIA Approval

It is expected that the EIA report will be processed and approved by ECD as early as possible by the commencement of civil works. And then the approved EIA, written in Burmese, will be disclosed to the public.

The environmental management plan (EMP) in a part of EIA and resettlement action plan (RAP) will be updated based on the result of detailed design, and then land acquisition and compensation will be implemented by MOC and local government before tendering.

11.7 Other Necessary Permission

Approximately 0.15 million m^3 borrow and 0.21 million m3 crushed stone is required for the construction of the New Sittaung Bridge. All necessary volume will be secured from the existing borrow pits and quarry sites near project site.

However, the Contractor shall obtain appropriate permission(s) from local government and ECD in accordance with relevant Myanmar laws and JICA Guidelines when the Contractor develops new borrow pits and quarry sites.

12. RESETTLEMENT ACTION PLAN (RAP)

12.1 Project Description and Necessity of RAP

The Project is composed of the construction of approximately 61.4km of new bypass road from Kyaikto to Bago, the construction of approximately 2.5km of New Sittaung Bridge and the upgrading of Thuwunna RLTC. The feasibility study for the New Sittaung Bridge and the Thuwunna RLTC were conducted by JICA and the feasibility study for new bypass road section was separately conducted by the Asian Development Bank (ADB).

Table S 12.1.1 Project Outline and Main Component

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

The component of the Project of New Sittaung Bridge section consists of the bridge part and the guidebank and revetment. The outline of the project components are shown in Table S 12.1.2. Accompanied by the implementation of the Project, some land acquisition, impact to private assets and resettlements are expected. Thus, RAP for the Project is prepared.

On the other hand, (2) Upgrading of the Thuwunna RLTC expects to be implemented on the land owned by MOC. In addition, any other residences, buildings and agricultural crops are not expected to be affected, therefore RAP is not necessary to be prepared for the Thuwunna RLTC.

Table S 12.1.2 Project Outline and Main Component

Component	Structure Specification	Location
1. Main Bridge with Approach Bridge and Approach Road	Main Bridge: L=800m, W=22.0 m, Right of Way (ROW)=100m	East Bank: Kyaito Township, Thaton District, Mon State West Bank: Waw Township, Bago District, Bago Region
	Approach Bridge: L=240m (right), L=960m (left) , W=22.0 m, ROW=100m	
	Approach Road: L = 248m (right), L = 252m (left), W=23.5 m, ROW=100m	
2. Guidebank and Revetment	Guidebank Length L = app. 1.5km, (West side bank)	Guidebank: Waw Township, Bago District, Bago Region
	Revetment Length = app. 0.3km (East side bank)	Revetment : Kyaito Township, Thaton District, Mon State

Source: JICA Study Team

12.2 Policy and Legal Framework

The RAP of the Project is prepared based on the relevant laws and regulations of the Government of

Myanmar and other international polices and guidelines for environmental social considerations developed by relevant international donor and organizations. The following list shows the major laws and legislations followed.

- ✓ Constitution of the Republic of the Union of Myanmar (2008)
- ✓ Land Acquisition Act (1894)
- ✓ Farmland Law (2012)
- ✓ Farmland Rules (2012)
- ✓ JICA Guidelines on Environmental and Social Considerations (2010)
- ✓ World Bank Environmental and Social Safeguard Policies, Operational Policy on Involuntary Resettlement (WB OP 4.12) (2001)
- ✓ Asian Development Bank Safeguard Policy Statement (ADB SPS) (2009)

12.3 Project Entitlement

The cut-off date (COD) is usually set in order to determine eligibility for entitled assistance and to avoid influx of population into the project area. The COD for this project was declared on 1 January 2018 by MOC. The announcement was officially posted on the bulletin board of the township administration of Kyaikto Township of Mon State and Waw Township of Bago Region for informing the public. In addition, PAPs were reminded verbally several times during socialization meetings and interview surveys.

The entitlement of the Project was prepared in Entitlement Matrix based on the impact identified through the RAP surveys. The Entitlement Matrix mainly shows the eligibility conditions and the main compensation measures proposed to PAPs according to the type of impact.

Major items subjected to compensation are land, structure, crops and trees, business and employment. Some other criteria are also considered to be subjected to the assistance such as vulnerability and severity of the impact. The method of compensation and assistance is mainly in cash but it is noted that Income Restoration Program (IRP) will also be provided to some of the eligible PAPs. The IRP intends to provide technical assistance for agriculture and livestock, vocational training for creating new job opportunities and vocational training for project related work. The contents of the compensation and valuation of compensation rate follows the no-worse off policy and replacement principle of JICA guideline, WB policy and ADB SPS.

12.4 Scope of Land Acquisition and Resettlement Impacts

Surveys regarding inventory data of loss land and assets of each household, land use and socioeconomic condition of PAPs were conducted based on the design prepared by the Project. The results of the impact are summarized in Table S 12.4.1.

Table S 12.4.1 Summary of Project Impact

No.	Items	Quantity
1	Project Affected Households (PAHs) and Project Affected Persons (PAPs)	
1.1	Total PAHs and PAPs	20 PAHs/ 106 PAPs
1.2	Relocation Households	4 PAHs/ 24 PAPs
1.3	Households losing 10% or more of their productive land and/or income source	16 PAHs/ 87 PAPs
1.4	Vulnerable households	4 PAHs/ 17 PAPs
2	Lands to be Acquired under Proposed Alignment	
2.1	Affected Private Lands	62.53acres (253,050m^2)
3	Affected structures	
3.1	Main structures	4 structures
3.2	Secondary structures	8 structures
4	Crops and trees	
4.1	Crops (Paddy)	2,625 Basket
4.2	Crops (Peas and Beans)	457 Basket
4.2	Trees	15,439 trees

Source: JICA Study Team

12.5 Implementation Framework

Although the responsible organization for this RAP is the Department of Bridge (DoB) is the project proponent of the Project, implementation of the RAP will be conducted by the Resettlement Implementation Committee (RIC). The RIC is composed of relevant organizations such as the Department of Highways (DoH), the Ministry of Agriculture, Livestock and Irrigation (MOALI) and the Ministry of Home Affairs (MOHA), Ministry of Social Welfare, Relief and Resettlement (MSWRR), local authority at township level and village level. The RIC take responsibility from the re-valuation of the compensation rate and finalization of the RAP budget to the implementation of RAP, namely notification and negotiation of the compensation contents with PAPs and payment of the compensation and assistance to PAPs.

12.6 Grievance Redress Mechanism

Before and during implementation the Project, there may be some complaints and conflicts related to land acquisition, resettlement and other EIA issues. To ensure all such grievances and complaints are resolved in a timely and satisfactory manner, a grievance redress mechanism (GRM) will be established for the Project. The members of the Grievance Redress Committee (GRC) will be composed of representatives of each relevant organization and community such as DOB, DOH, GAD, village tract, women association, etc. It is recommended that female members to be included to GRC from the view of gender equality and adoption of opinions from women. It is also noted that GRM procedures will have to be disclosed and discussed with various stakeholders of the communities around the project area including PAPs of RAP and fishermen to the extent possible in order to ensure that they recognize the GRM, and to agree and understand the process.

12.7 Monitoring Activity

Monitoring activity normally consists of internal and external monitoring. The main purpose of the monitoring activity is to ensure that all PAPs who lost their respective houses, land or other livelihood assets have been provided with sufficient compensation and assistance according to the policies and procedures which is described in RAP.

The internal monitoring is to be undertaken by DoB with support from resettlement specialists/consultants with the assistance from RIC to ensure the resettlement activities are proceeded as planned without critical issues and resettlement objectives are met. On the other hand, external monitoring is to be carried out by an independent local/international External Monitoring Agent (EMA) to assess and provide an independent view on the achievement of the RAP.

12.8 Cost and Financing for RAP Implementation

The estimated RAP implementation budget for the Project is 2,216,242,379 MMK (equivalent to 1,477,495 USD). The amount consists of compensation costs for each affected item such as land, structures, crops, trees and business and employment, various assistance including severely affected assistance and vulnerable assistance and, cost for an income restoration program and other RAP implementation costs such as the cost for an external monitoring agency and IRP service provider. DoB (MOC) is responsible for providing adequate funds for land acquisition and resettlement related to the Project. It is important to note that these figures will be updated during the updating of the RAP in the detailed design stage.

12.9 Information Disclosure, Consultation and Participation

Concerning the Project in FS stage, 3 public consultation (socialization) meetings were held in concerned villages with PAPs. The first 2 took place prior to the preparation of RAP and the third after data collection and preparation of Draft RAP. The first 2 meetings aimed at informing the PAPs about the project outline, the expected adverse impacts such as loss of property and displacement, legislation and guidelines to be followed, the activities, process of RAP survey and declaration of Cut-off date and to exchange opinions with local stakeholders. The third meeting shared the survey result, compensation policy and entitlements and RAP procedure and future schedule, and was open to exchanging opinions. There are a total of 142 participants consisting of local people, government members and the JICA Study Team. Of those participants, 74 were local people. During the meetings, some questions and opinions were raised from local participants, but there were no objection or critical issues. Therefore, it is understood as basic consensus for implementation of the project has been formulated.

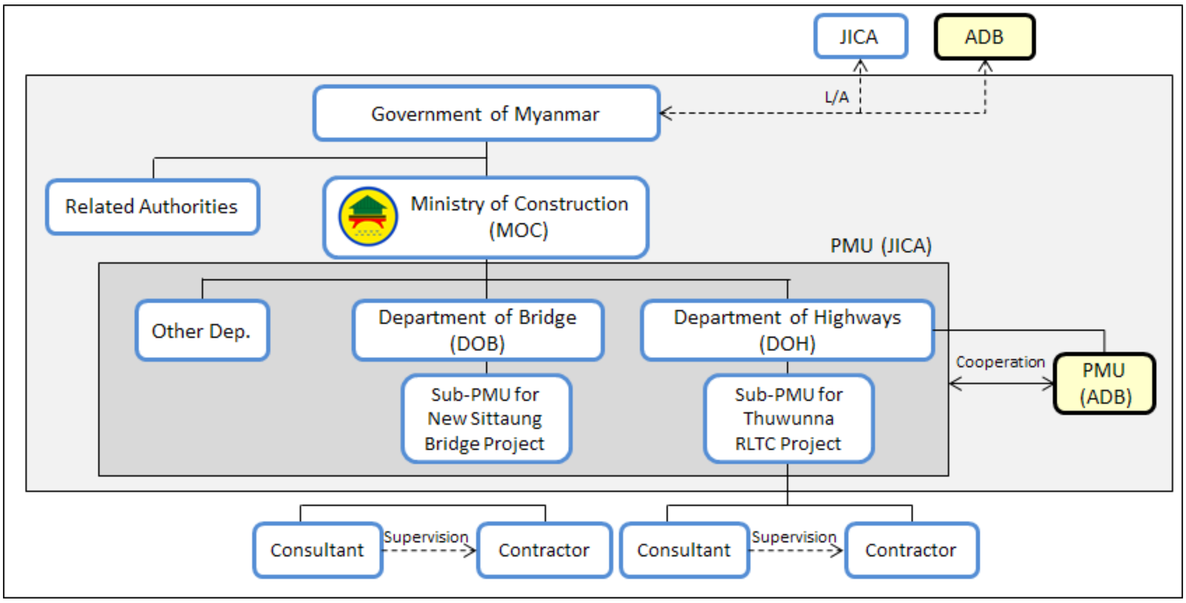
12.10 Implementation Schedule

The RAP for the Project is approved by DoB, MOC during FS stage and it will be updated in the detailed design stage expected to be started in 2021. After the Updated RAP (URAP) is approved by DoB, MOC, the RIC will re-valuate the RAP budget and notify and negotiate the compensation amount with PAPs. This step is expected to be around 2022. After DoB secures the budget from the Ministry of Finance & Planning (MOPF), the compensation to PAPs will be started. The payment of the compensation and resettlement of PAPs should be completed before construction activities estimated to be starting in 2023.

13. PROJECT IMPLEMENTATION PLAN

13.1 Implementation Organization

The project implementation organization will be organized so that the MOC can implement the Project smoothly and effectively as well as coordinate with project stakeholders. Since the upgrading of the Thuwunna RLTC shall be also implemented under this Project which will be mainly under the charge of DOH, the Executing Agency shall be MOC to manage both sub-projects (New Sittaung Bridge and Thuwunna RLTC). It is recommended that a Project Management Unit (PMU) be established under MOC before the commencement of the detailed design stage as illustrated in Figure S 13.1.1.



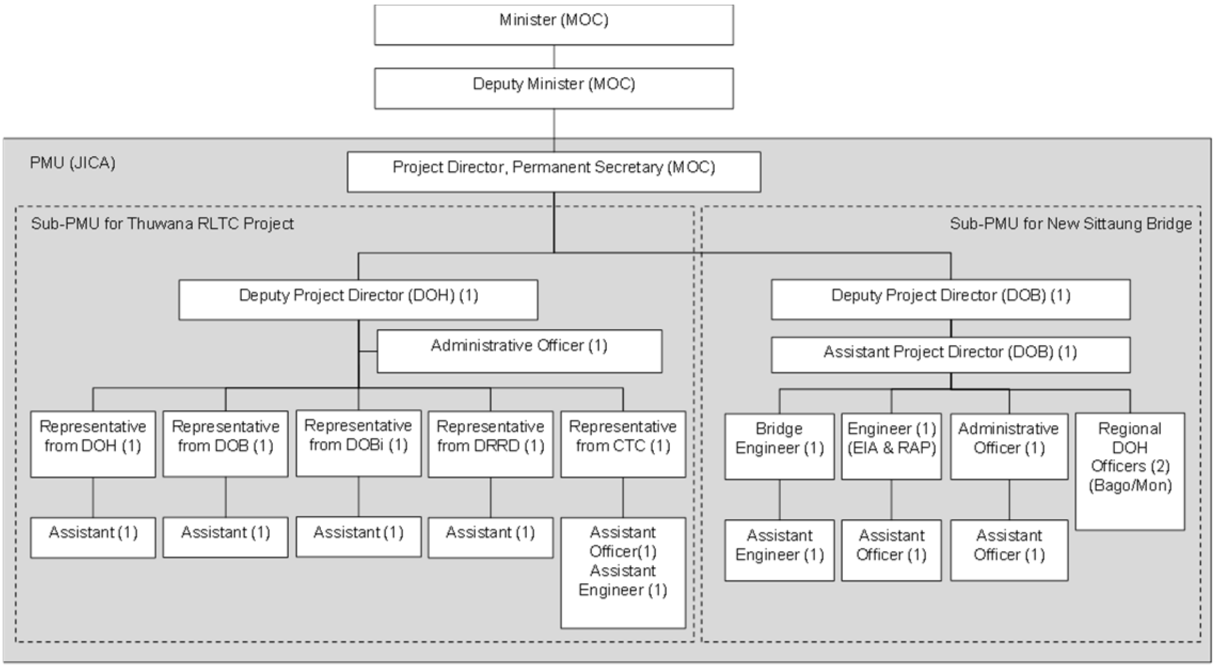
Source: JICA Study Team

Figure S 13.1.1 Proposed Implementation Organization Structure

The aim of the establishment of PMU is to implement the Project smoothly and effectively as well as maintain smooth and timely coordination with project stakeholders to fulfill the responsibilities listed below. Thus, the PMU should be organized by the internal staff of MOC as proposed in Figure S 13.1.2.

【Key Responsibilities of PMU】

- Financial management
- Contract administration
- Procurement of Consultants and Contractors
- Pre-construction work comprised of detailed design, land acquisition, relocation/resettlement, acquisition of environmental approval
- Construction Management (traffic safety management, supervision, progress monitoring etc.)
- Coordination with relevant authorities and projects
- Project Evaluation



Source: JICA Study Team

Figure S 13.1.2 Proposed Organization Structure of PMU

13.2 Implementation Schedule

The project implementation schedule is established based on the assumptions listed in Table 13.2.1. The project implementation schedule is shown in Figure S 13.2.1.

Table 13.2.1 Assumptions for Implementation Schedule

Item	Assumption
Confidential	

Source: JICA Study Team

Confidential

Source: JICA Study Team

Figure S 13.2.1 Project Implementation Schedule

14. PROJECT COST ESTIMATE

14.1 Condition of Cost Estimate

The conditions of the cost estimate are as follows:

Confidential

Table S 14.1.1 Proposed Contract Package

Package No.	Package Component	Procurement Method
Confidential		

Source: JICA Study Team

14.2 Result of Cost Estimate

The total project cost is shown in Table S 14.2.1 and Table S 14.2.2.

Table S 14.2.1 Project Cost (JPY Version)

Confidential

Source: JICA Study Team

Table S 14.2.2 Project Cost (USD Version)

Confidential

Source: JICA Study Team

15. ECONOMIC AND FINANCIAL ANALYSIS

15.1 Economic Analysis

15.1.1 Preconditions

Economic Internal Rate of Return (EIRR) and Cost-Benefit Ratio (B/C) are adopted as evaluation indicators to evaluate the effectiveness of the Bago-Kyaikto Expressway project including New Sittaung Bridge from the viewpoint of Myanmar's national economy. These indicators are calculated using annual cash inflow (economic benefit) and cash outflow (economic cost) with the discounted cash flow method. Table S 15.1.1 shows the preconditions of the economic analysis.

Table S 15.1.1 Preconditions for The Economic Analysis

Project period	27 years in total
Exchange rate	1 USD ＝ 109 1 USD ＝ 1,500 MKK
With project case, Without project case	"With project" is defined as the case with Bago-Kyaikto Expressway project where JICA finances the New Sittaung Bridge and ADB finances the road section and "without project" is defined as the case without the projects
Social discount rate	Set to be 12%.

Source: JICA Study Team

15.1.2 Economic Benefit

Reduction of Vehicle Operating Cost (VOC) and travel time saving are considered as the economic benefits of the projects.

Reduction of vehicle operating cost is calculated by multiplying the difference in travel distance between "without project" and "with project" cases by the VOC unit. Travel time saving is calculated by multiplying the difference in travel time by vehicle category between "without project" and "with project" cases by the time value per hour and by the number of passengers by vehicle category. The time value per hour is calculated by using GDP and population data.

15.1.3 Economic Cost

Investment cost consists of construction, consulting service, land acquisition and administration cost. Taxes, price escalation, and interest during construction are eliminated from the investment cost. O&M cost consists of routine maintenance, toll system and periodic maintenance for the project.

15.1.4 EIRR and Cost-Benefit Ratio

The annual cashflow of the project is calculated by taking the difference between economic benefit and economic cost. Economic Internal Rates of Return (EIRR) of the projects is 24.6% and cost-benefit ratio is 3.78. The EIRR exceeds 12%, a benchmark of social discount rate in developing countries which is commonly used. Therefore, the projects are feasible from the point of national economic development.

Results of the sensitivity analysis show that both a 20% increase in investment and O&M costs and a 20% decrease in economic benefit keep the EIRR relatively high (around 22%). The projects can be said to be viable from the viewpoint of the national economy.

15.2 Financial Analysis

This section verifies the financial feasibility of the project cashflow using Financial Internal Rate of Return (FIRR) and analyzes how likely the revenue from tolling can cover the initial investment and O&M expenses. While ADB's financial analysis is based on the nominal price, financial analysis by JICA study team in this section uses the real price.

15.2.1 Revenue from tolling

The project is expected to generate the revenue from collecting tolls. JICA study team used three types of Toll Strategy (TS1, TS2, and TS3) from ADB's "Feasibility Study Bago-Kyaikto Expressway" to verify the financial feasibility of the Project. Since the ADB's Tolling Strategies assume inflation, JICA study team excluded price rise of the tolling due to inflation for financial analysis in the real term when calculating the revenue.

15.2.2 Expenses

Investment expense consists of construction, consulting service, land acquisition and administration cost and tax. Price escalation and interest during construction are eliminated from the investment expense. O&M cost consists of routine maintenance, toll system and periodic maintenance for the project.

15.2.3 Results of the Financial Analysis

Table 15.2.1 shows the results of a summary of the financial analysis. FIRRs for TS1, TS2 and TS3[1] are -10.2%, -7.8% and -2.6% respectively meaning in either case, revenue from tolling alone cannot cover all the investment and O&M expenses. In every case, revenue can cover annual O&M expenses. After financing O&M expenses, revenues from TS1, TS2 and TS3 can cover 19.5%, 30.1% and 66.8% of investment expense respectively.

Table 15.2.1 Summary of Financial Analysis

Unit: million Japanese yen

Toll Strategy	Total Revenue	Total CAPEX	Total OPEX	FIRR	Cover ratio of CAPEX
TS1	37,703	[redacted]	22,854	-10.2%	19.5%
TS2	45,785			-7.8%	30.1%
TS3	73,828			-2.6%	66.8%

Source: JICA Study Team

[1] TS1 is "business as usual" case, TS2 is ADB's median toll rate in 2018 and TS3 is 150% price increase of TS1 respectively.

16. OPERATION AND EFFECT INDICATORS

16.1 Proposed Operation and Effect Indicators for New Sittaung Bridge

Like other road/bridge improvement projects in Myanmar and other countries funded by JICA, the traffic volume and travel time are set as operation and effect indicators for the Project, respectively.

- Operation Indicator: Annual average daily traffic (PCU/day), and
- Effect Indicator: Average travel time (hours per vehicle), average travel speed (km/h) and conversion factor (V/C).

The operation and effect indicators are prepared showing present performances in 2017 and targets in 2028, 2035 and 2045. The proposed operation and effect indicators for New Sittaung Bridge for each tolling scenario.

Table S 16.1.1 Proposed Operation and Effect Indicators for the Project (TS1)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	33,377	19,880	43,849	61,738	54,358	85,049
Average travel time (hour)	2.27	2.12	0.80	2.48	1.02	2.85	1.27
Average travel speed (km/h)	41.3	44.3	83.7	37.8	65.2	33.0	52.4
Congestion factor (V/C)*2	0.91	1.08	0.25	1.42	0.77	1.77	1.06

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

Table S 16.1.2 Proposed Operation and Effect Indicators for the Project (TS2)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	33,288	19,998	42,207	64,463	53,421	80,117
Average travel time (hour)	2.27	2.12	0.80	2.42	1.05	2.84	1.21
Average travel speed (km/h)	41.3	44.4	83.1	38.8	63.7	33.0	55.1
Congestion factor (V/C)*2	0.91	1.08	0.25	1.37	0.81	1.74	1.00

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

Table S 16.1.3 Proposed Operation and Effect Indicators of the Project (TS3)

Year	2017	2028		2035		2045	
Route (existing/new)	existing	existing	new	existing	new	existing	new
Traffic volume (PCU/day)*1	15,579	35,752	17,604	49,385	56,661	55,218	80,723
Average travel time (hour)	2.27	2.20	0.78	2.68	0.98	2.91	1.21
Average travel speed (km/h)	41.3	42.6	85.3	35.0	68.1	32,2	55.2
Congestion factor (V/C)*2	0.91	1.16	0.22	1.60	0.71	1.79	1.01

Note: *1 The weighted mean value by the section length (Bago South Interchange - Kyaikto Interchange).
*2 V/C means Traffic Volume (V) divided by Traffic Capacity (C).

Source: JICA Study Team

In addition to the above indicators, Table S 16.1.4, Table S 16.1.5 and Table S 16.1.6 show future number of passengers and cargo volume by vehicle category for the New Sittaung Bridge in 2028, 2035 and 2045 respectively, as supplemental indicators.

Table S 16.1.4 Supplemental Operation and Effect Indicators for the Project (TS1)

Item	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	12,755	4,217	7,086	1,832	2,548	3,949	32,386
		new	6,055	2,018	2,048	449	33,738	35,301	79,610
	2035	existing	14,950	4,560	9,002	2,366	5,195	6,342	42,415
		new	20,184	6,727	12,992	2,250	65,408	51,018	158,579
	2045	existing	15,705	4,432	9,112	2,136	22,061	14,517	67,963
		new	29,232	9,548	19,256	4,950	81,176	44,061	188,223
Cargo volume (thousand tons / day)*1	2017	existing	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	48,380	17,010	26,879	7,165	-	-	99,523
		new	22,968	8,184	7,769	1,756	-	-	40,677
	2035	existing	56,708	18,493	34,144	9,254	-	-	118,600
		new	76,560	27,280	49,280	8,800	-	-	161,920
	2045	existing	59,571	17,974	34,563	8,353	-	-	120,461
		new	110,880	38,720	73,040	19,360	-	-	242,000
Traffic volume (cargo vehicles) (veh. /day)	2017	existing	1,723	266	826	373	-	-	3,187
	2028	existing	5,498	1,943	3,054	814	-	-	11,309
		new	2610	930	883	200	-	-	4,622
	2035	existing	6,444	2,102	3,880	1,052	-	-	13,477
		new	8700	3,100	5,600	1000	-	-	18,400
	2045	existing	6,769	2,043	3,928	949	-	-	13,689
		new	12,600	4,400	8,300	2,200	-	-	27,500

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.
Source: JICA Study Team

Table S 16.1.5 Supplemental Operation and Effect Indicators for the Project (TS2)

Item	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	13,418	4,143	5,901	1,589	2,737	4,378	32,165
		new	5,150	2,018	2,582	497	32,380	34,812	77,439
	2035	existing	17,703	4,544	5,216	1,545	6,888	8,650	44,547
		new	17,168	6,727	16,704	3,150	63,656	48,699	156,104
	2045	existing	22,228	3,189	6,287	2,151	19,409	12,163	65,428
		new	21,112	10,633	20,648	3,600	82,344	44,061	182,398
Cargo volume (thousand tons / day)*1	2017	exiting	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	50,896	16,800	22,383	6,213	-	-	96,292
		new	19,536	8,184	9,794	1,942	-	-	39,456
	2035	existing	67,149	18,427	19,786	6,043	-	-	111,406
		new	65,120	27,280	63,360	12,320	-	-	168,080
	2045	existing	84,314	12,932	23,848	8,4123	-	-	129,507

		new	80,080	43,120	78,320	14,080	-	-	215,600
Traffic volume (cargo vehicles) (veh. /day)	2017	exiting	1,723	266	826	373	-	-	3,187
	2028	existing	5,784	1,909	2,544	706	-	-	10,942
		new	2220	930	1,113	221	-	-	4,483
	2035	existing	7,631	2,094	2,248	687	-	-	12,660
		new	7400	3,100	7,200	1400	-	-	19,100
	2045	existing	9,581	1,470	2,710	956	-	-	14,717
		new	9,100	4,900	8,900	1,600	-	-	24,500

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.
Source: JICA Study Team

Table S 16.1.6 Supplemental Operation and Effect Indicators for the Project (TS3)

Item	Year	Route	2 axles trucks	3 axles trucks	4 axles trucks	Trailers	Passenger cars	Buses	Total
Number of passengers (person/day)	2017	exiting	3,997	577	1,915	839	11,721	13,056	32,105
	2028	existing	14,518	4,511	7,870	1,955	3,293	4,677	36,824
		new	3,550	1,628	3,828	675	33,118	34,260	77,058
	2035	existing	23,020	5,711	9,190	2,353	5,125	6,261	51,660
		new	11,832	5,425	12,760	2,250	68,620	55,656	156,543
	2045	existing	18,327	5,630	11,224	2,917	7,855	6,482	52,434
		new	24,592	8,246	15,544	2,700	96,944	53,337	201,363
Cargo volume (thousand tons / day)*1	2017	exiting	15,162	2,340	7,265	3,281	-	-	28,049
	2028	existing	55,068	18,294	29,851	7,645	-	-	110,858
		new	13,464	6,600	14,520	2,640	-	-	37,224
	2035	existing	87,317	23,162	34,859	9,201	-	-	154,538
		new	44,880	22,000	48,400	8,800	-	-	124,080
	2045	existing	69,515	22,832	42,574	11,408	-	-	146,329
		new	93,280	33,440	58,960	10,560	-	-	196,240
Traffic volume (cargo vehicles) (veh. /day)	2017	exiting	1,723	266	826	373	-	-	3,187
	2028	existing	6,258	2,079	3,392	869	-	-	12,597
		new	1530	750	1,650	300	-	-	4,230
	2035	existing	9,922	2,632	3,961	1,046	-	-	17,561
		new	5100	2,500	5,500	1000	-	-	14,100
	2045	existing	7,899	2,595	4,838	1,296	-	-	16,628
		new	10,600	3,800	6,700	1,200	-	-	22,300

Note: *1 The average loading volume of trucks of 8.8 tons in the Pre F/S is used.
Source: JICA Study Team

16.2 Proposed Operation and Effect Indicators for Thuwunna RLTC

Upgrading of Thuwunna RLTC includes two components with different goal values. Hence, it is necessary to set optimal indicators for each goal.

The 1st component – or the redevelopment of training facilities for MOC staff and skilled labor– is expected to contribute towards improving skills and knowledge of various types of human resources in the construction sector in Myanmar. Provision of training will upgrade the skills of MOC staff, including both administrative officers and engineers responsible for construction administration. Vocational training will be provided to skilled workers in a variety of construction fields to meet the required skill level among ASEAN countries.

The 2nd component – or the redevelopment of the Research Laboratories – is expected to upgrade the quality control function of MOC to meet ASEAN standards. The proposed operation and effect indicators for RLTC is summarized in the following table.

Table S 16.2.1 Proposed Operation and Effect Indicators for Thuwunna RLTC

Operation and Effect Indicators (Draft)	Baseline Value (2019)*1	Target Value(2029)	Available means of data and Monitoring methodology
1. Quantitative Indicators			
1-1. Prospective number of MOC staff trained at the Training Center per year	1,061 pers.(2017/18)	2,000 pers.	Collect data from the Center
1-2. Prospective Number of MOC Staff Training Courses	21 courses	30 courses	Ditto
1-3. Prospective number of workers trained at the Training Center per year	Training : 150pers Assessment Course : 160pers	Training : 1,440 pers (30 pers x 16 courses x 3 times) Assessment Course :960 pers (20 pers x 16 courses x 3times)	Ditto
1-4. Prospective number of Vocational Training Courses	Training : 5types Assessment Course : 8 types	Training : 16 types (level I) Assessment Course :16 types	Ditto
1-5. Laboratory test	Laboratories provide BS base test.	All laboratories provide test responding to ASEAN standards.	Ditto
1-6. Quality assurance of Laboratory	Only one laboratory has been applied to ISO.	All laboratories becomes ISO certified laboratories	Ditto
2. Qualitative Indicators			
2-1. Type of training provided in the RLTC	More administration courses are provided, rather than planning and technical courses.	More courses will be provided for planning, project management, and quality assurances.	Collect data from the Center
2-2. Satisfaction degree with training contents by MOC staff	Generally, trainees are satisfied with training contents.	Trainees are satisfied with the training contents, facility and equipment.	Collect data through Q&A to participants
2-3. Evaluation by construction companies		Construction companies are satisfied with level of skilled workers who own the certificate issued by the RLTC	Collect data through Q&A at the target construction companies
2-4. Quality of constructions in the country		Contractors are satisfied with the quality of test provided at RLTC	Collect data through Q&A at the target construction companies

Note*1: Baseline value and target value to be arranged through the discussion with the authority of Myanmar side.
Source: JICA Study Team

17. CONCLUSIONS AND RECOMMENDATIONS

17.1 Conclusions

The conclusions of this Survey are as follows:

- It is concluded that the Project is technically and economically feasible and is acceptable from the viewpoints of environmental and social considerations.
- The location of the New Sittaung Bridge was carefully set considering the site geometry (especially pertaining to past shifts in the riverbank), economic efficiency and minimizing adverse impacts to both the environment and the resettlement of people. The final alignment avoids the Mottama Ramsar Site but needs to pass the Important Bird Area (IBA) and Key Biodiversity Area (KBA). Thus, the Special Ecosystem Monitoring Plan is prepared in order to assess influence on the IBA/KBA areas by the Project during the implementation stage.
- It is justified that 22m width with the emergency bays for both side of bridges shall be applied to New Sittaung Bridge in order to harmonize with a possible future upgrading to the "Primary" class stipulated in the ASEAN Highway Standards as well as the demand for a reduction of the initial construction cost, although the initial operation would be as "Class-I" road with access control.
- The structural types for the New Sittaung Bridge were carefully studied and it is designed with the following points:

  The main bridge has 800m in length and the superstructure type is steel narrow box girder supported by oval-shape RC piers and Steel Pipe Sheet Pile (SPSP) foundations.

  The approach bridge is a total of 1,200m in length and the superstructure type is PC-I composite girder supported by RC piers/abutments and cast-in-situ RC piles.
- DOB is an eligible implementation agency for the construction of New Sittaung Bridge as they have enough experience with international projects on a similar scale, although technical assistance is necessary to further develop the technical capacity.
- It is necessary that upgrading of the Thuwunna RLTC is implemented under this Project in order to enhance technical capacity of MOC and develop human resources so that a proper implementation body for proper and sustainable O&M of the project expressway is expected to be developed through advanced technical trainings to MOC's engineers in the Thuwunna RLTC.

17.2 Recommendations

- It is recommended that a Project Management Unit should be established with enough staff proposed in Chapter 13 before commencement of the detailed design.
- It is necessary for MOC to get an environmental clearance certificate as early as possible otherwise the

Project will be delayed.

- To maximize the effectiveness of the Project and harmonization between ADB and JICA, the following coordination should be taken through periodical coordination meetings and other opportunities during implementation of the Project;

Table S 17.2.1 Necessary Coordination with ADB during Implementaion Stage

Item	Timing	Details
Design	Detailed Design	− Design criteria − Road configuration − Vertical alignment at the construction boundaries − Effective planning of access roads to the construction sites
EIA	The entire implementation	− Countermeasures when considerable species are identified during environmental monitoring activities − Sharing the updated environmental management plan (EMP) − Sharing environmental monitoring results continuously including special ecosystem monitoring
RAP	The entire implementation	− Eligibility, entitlement and price for compensation − Institutional frameworks such as members of the RIC − Harmonized establishment of Grievance Redress Mechanism (GRM)
Implementation Schedule	Detailed Design	− Opening date
Operation and Maintenance	Before opening	− Initial implementation body and development plan − Toll policy (rate, location of toll plaza etc.)

Source: JICA Study Team

- To make the Thuwunna RLTC more effective, functioned, developed and sustainable, the followings are recommended;
  - In order to provide more comprehensive and effective training to MOC staff, it is necessary to identify the clear image of MOC personnel and establish a strategic HR training plan, in order to properly respond to and prepare for the reformation of MOC;
  - In order to establish the functional role of the Thuwunna RLTC's Laboratory as the only public laboratory for the construction sector in Myanmar, institutional aspects such as an accreditation system, quality control system, etc. are necessary. These accreditation system and quality control system will help to develop business model of the RLTC for sustainable operation. (including fee charging system and autonomous budget management system);
  - In order to establish a quality management system for testing operation, it is important to obtain the ISO certification in not only building field but also other fields as well to improve confidence in the MOC laboratory;
  - Reorganization and integration of the laboratories by type of tests, for more efficient operation and management of the laboratories; and
  - In the future, it is important to enhance research work on construction methods and materials that match Myanmar's climate and available materials. Space for future expansion is proposed in the site plan.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Concrete
ADB	Asian Development Bank
AEC	ASEAN Economic Community
AIDS	Acquired Immune Deficiency Syndrome
AJTP	ASEAN-Japan Transport Partnership
ARND-MP	Master Plan for Arterial Road Network Development in Myanmar
ASEAN	Association of South‐East Asian Nations
ASTM	American Society for Testing and Materials
B/C	Cost Benefit Analysis
BANCA	Biodiversity and Nature Conservation Association
BCF	Border Control Facilities
BETC	Bridge Engineering Training Centre
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BOD	Biochemical Oxygen Demand
BOT	Build Operate-and-Transfer
BS	British Standards
CBD	Central Business District
CBR	California Bearing Ratio
CCTV	Closed-Circuit Television
CDM	Clean Development Mechanism
COD	Cut Off Date
COI	Corridor of Impact
CSC	Construction Supervision Consultant
CSP	Country Partnership Strategy
D/D	Detailed Design
DALMS	Department of Agricultural Land Management and Statistics
DEM	Digital Elevation Model
DFL	Design Flood Level
DICA	Directorate of Investment and Company Administration
DMH	Department of Meteorology and Hydrology
DMS	Detailed Measurement Survey
DOA	Department of Agriculture
DOB	Department of Bridge
DOBi	Department of Building
DOH	Department of Highways
DOUHD	Department of Urban and Housing Development
DRRD	Department of Rural Road Development
DTM	Digital Terrain Model
DWIR	Directorate of Water Resources and Improvement of River Systems
EC	Environmental Consultant
ECC	Environmental Compliance Certificate

ECD	Environmental Conservation Department
EDCF	Economic Development Cooperation Fund
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EL	Elevation Level
EMA	External Monitoring Agency
EMP	Environmental Management Plan
EO	Exterior Orientation
EPC	Engineering Procuring and Construction
ER	Expressway Route
ESIA	Environmental and Social Impact Assessment
ETC	Electric Toll Collection
EWEC	East-West Economic Corridor
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
FDI	Foreign Direct Investment
FHWA	Federal Highway Administration
FL	Factor of safety against Liquefaction
GAD	General Administration Department
GAP	Gender Action Plan
GCP	Ground Control Point
GDP	Gross Domestic Product
GEBCO	General Bathymetric Chart of the Oceans
GEV	Generalized Extreme Value
GHGs	Greenhouse Gases
GIS	Geographic Information System
GL	Ground Level
GMS	Greater Mekong Subregion
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRC	Grievance Redress Committee
GRDP	Gross Regional Domestic Product
GRM	Grievance Redress Mechanism
GRO	Grievance Redress Officer
HEC	Hydraulic Engineering Circular
HEC-RAS	Hydrologic Engineering Center - River Analysis System
HHWL	Historical High Water Level
HIV	Human Immunodeficiency Virus
IBA	Important Birds Area
IC	Interchange
ID	Irrigation Department
IDF	Intensity Duration Frequency
IEE	Initial Environmental Examination
IFC	International Finance Cooperation
IRP	Income Restoration Program
IMA	Internal Monitoring Agent
IMF	International Monetary Fund

ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITV	Industrial Television
IUCN	International Union for Conservation of Nature
JAMA	Japan Automobile Manufacturers Association, Inc.
JCT	Junction
JICA	Japan International Cooperation Agency
JICA GL	JICA Guideline
JRA	Japan Road Association
JSHB	Japanese Specifications of Highway Bridges
JST	JICA Study Team
JUTPI	JOBODETABEK Urban Transportation Policy Integration
KBA	Key Biodiversity Area
KOICA	Korea International Cooperation Agency
LB	Left Bank
LDC	Least Developing Countries
LED	Light Emitting Diode
LL	Liquid Limit
LRFD	Load and Resistance Factor Design
MACCS	Myanmar Automated Cargo Clearance System
MIDV	Myanmar's Industrial Development Vision
MIMU	Myanmar Information Management Unit
MMSIS	The Myanmar Information System
MMUTIS	Metro Manila Urban Transportation Integration Study
MNBC	Myanmar National Building Code
MOAI	Ministry of Agriculture and Irrigation
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOC	Ministry of Construction
MOHA	Ministry of Home Affairs
MONREC	The Ministry of Natural Resources and Environmental Conservation
MOT	Ministry of Transport
MOU	Memorandum of Understanding
MP	Master Plan
MPA	Myanmar Port Authority
MR	Ministry Railways
MSL	Mean Sea Level
MSWRR	Ministry of Social Welfare, Relief and Resettlement
MYT-Plan	Myanmar's National Transport Master Plan
NASA	National Aeronautics and Space Administration
NCDP	National Comprehensive Development Plan
NEDA	Neighboring Countries Economic Development Cooperation Agency
NGO	Non-Governmental Organization
NH	National Highway
NITI	National Institution for Transforming India
NSEC	North-South Economic Corridor
NSSA	National Skill Standards Authority

O&M	Operation and Maintenance
OBOR	One Belt and One Road
OD	Origin / Destination
ODA	Official Development Assistance
OJT	On-the-Job Training
PAHs	Project Affected Households
PAPs	Project Affected Persons
PC	Prestressed Concrete
PCC	Project Construction Contractor
PCU	Passenger Car Unit
PFI	Private Finance Initiative
PHC	Prestressed High-strength Concrete
PI	Plastic Index
PL	Plastic Limit
PMC	Project Management Consultant
PMU	Project Management Unit
PPP	Public Private Partnership
PPTA	Project Preparatory Technical Assistance
PQ	Pre-Qualification
PW	Public Works
RAP	Resettlement Action Plan
RB	Right Bank
RC	Reinforced Concrete
RCS	Replacement Cost Survey
RFID	Radio-frequency identification
RIC	Resettlement Implementation Committee
RLTC	Research Laboratory and Training Center
ROW	Right of Way
RR	Ring Road
SAH	Severely Affected Households
SEZ	Special Economic Zone
SHM	Stakeholder Meeting
SLRD	Settlement and Land Records Department
SN	Structural Number
SOI	Survey of India
SPS	Safeguard Policy Statement
SPSP	Steel Pipe Sheet Pile
SPT	Standard Penetration Test
SPV	Special Purpose Vehicle
SRTM	Shuttle Radar Topographic Mission
SS	Suspended Solids
STDs	Sexually Transmitted Diseases
SUDP	Strategic Urban Development Plan of the Greater Yangon
T/C	Technical Committee
TA	Technical Assistance
TAZ	Traffic Analysis Zone

TBC	Trimble Business Center
TICA	Thailand International Cooperation Agency
TIN	Triangulated Irregular Network
TKK	Tamu-Kyigone-Kalewa
TM	Thematic Mapper
TOR	Terms of References
TSP	Total Suspended Particulate
UAV	Unmanned Aerial Vehicle
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNHABITAT	United Nations Human Settlements Programme
UNHCR	The office of the United Nations High Commissioner for Refugees
UPS	Uninterruptible Power System
UPV	Ultrasonic Pulse Velocity
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
UU	Unconsolidated Undrained
VAH	Vulnerable Affected Households
VAT	Value Added Tax
VOC	Vehicle Operating Cost
VMS	Variable Message Signboard
WB	World Bank
WB OP	World Bank's Operational Policy
WG	Working Group
WL	Water Level
Y-M	Yangon-Mandalay
YCDC	Yangon City Development Committee
YIRR	Yangon Inner Ring Road
YORR	Yangon Outer Ring Road
YUTRA	The Project for Comprehensive Urban Transport Plan of the Greater Yangon

CHAPTER 1 INTRODUCTION

1.1 Background of the Project

The Republic of the Union of Myanmar (hereinafter referred to as "Myanmar") has had continuing high economic growth with the shift to democratization (March 2011). There is active trade with neighboring ASEAN countries in the background. Trade between the countries are expected to further expand in the future, but the current maritime transport via the Malay Peninsula is very inefficient. As an alternative mean of the marine transport, it is expected that the East-West Economic Corridor (hereinafter referred to as "EWEC") connecting ASEAN countries by land will be developed soon. The other countries' section of the EWEC has been improved with international standards that can correspond to international logistics. On the other hand, there are many bottleneck sections in Myanmar that impede smooth land transportation, such as weight limitation due to aging bridges, incorrect alignment and profiles such as steep and sharp curves, passage through dense urban areas, etc. Therefore, the government of Myanmar has put the development of the route as a high priority, and has promoted improvement through the support of international organizations and the Thai government.

As a result, from the Thai border to the Thaton and Mawlamyine section, it has been improved to a two-lane paved road corresponding to international standards, thereby domestic and international logistics are expected to be activated. Meanwhile, issues such as traffic congestion and deterioration of safety are beginning to surface. Especially, the traffic congestion is predicted to occur due to the mixture of regional traffic and transit traffic because the existing road passes through the urban area from Bago to Kyaikto section about 100 km from Thaton to Yangon. Therefore, in order to separate regional traffic and transit traffic to ensure safety, it is necessary to build an alternative highway that can divert the traffic from urban areas in the section.

Moreover, in response to logistics promotion in line with the country's economic growth, a lot of roads and bridges have been constructed recently in Myanmar and results in lack of technical capacity and human resources. Thus, MOC needs to strengthen technical training programs which will improve the technical and project management skills of engineers in MOC. To reflect to this, enhancement of the Thuwunnna Central Training Center (hereafter referred to as "Thuwunna CTC")'s function and Research Laboratories' quality control function are strongly required. However it was recognized that advanced trainings and quality inspections cannot be provided sufficiently in the existing Thuwunna CTC and laboratories due to its aging and insufficient facilities. Hence, the upgrading of the CTC and Research Laboratories' facilities is strongly required for providing the necessary advanced trainings and quality inspections for sustainable operation, maintenance and management of highways and bridges including this Project road.

Under these circumstances, the Japan International Cooperation Agency (hereinafter referred to as

"JICA") decided to implement a Feasibility Study (F/S) necessary for the development of the new road between Bago and Kyaikto and upgrading the existing training center including laboratories for quality inspections of construction materials, in cooperation with the Asian Development Bank (hereafter referred to as "ADB"). The JICA's Study (hereafter referred to as "the Study") is concerned for the "Construction of the New Sittaung Bridge" and "Upgrading of the Thuwunnna Research Laboratory and Training Center" (hereinafter referred to as "the Project") and ADB's Study is concerned for the construction of the road section from Bago to Kyaikto section.

1.2 Outline of the EWEC Project

The objective of the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) (hereinafter referred to as "the EWEC Project") is the development of a new arterial road of about 63.9km connecting Bago and Kyaikto including the construction of New Sittaung Bridge and the upgrading of the Thuwunna Research Laboratory and Training Center (hereafter referred to as "Thuwunna RLTC"). And the subject of the Study is for the New Sittaung Bridge section of about 2.5km total length as well as upgrading of the Thuwunna RLTC, in which JICA's loan is studied. The outline of the EWEC Project is shown in Table 1.2.1.

Table 1.2.1 Outline of the EWEC Project

Project Name	East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section)
Project Purpose	To improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to activate the domestic and international trade of Myanmar.
Project Outline	Study object of JICA's loan ・Construction of the New Sittaung Bridge (total length of 2.5km) ・Upgrading of the Thuwunna Research Laboratory and Training Center Study object of ADB's loan ・Construction of new arterial road except for the New Sittaung Bridge (total length of 61.4km)
Project Area	Mon State, Bago Region and Yangon Region of Myanmar
Related Government Agency	Ministry of Construction(MOC), Department of Bridge (DOB) and Department of Highways (DOH)

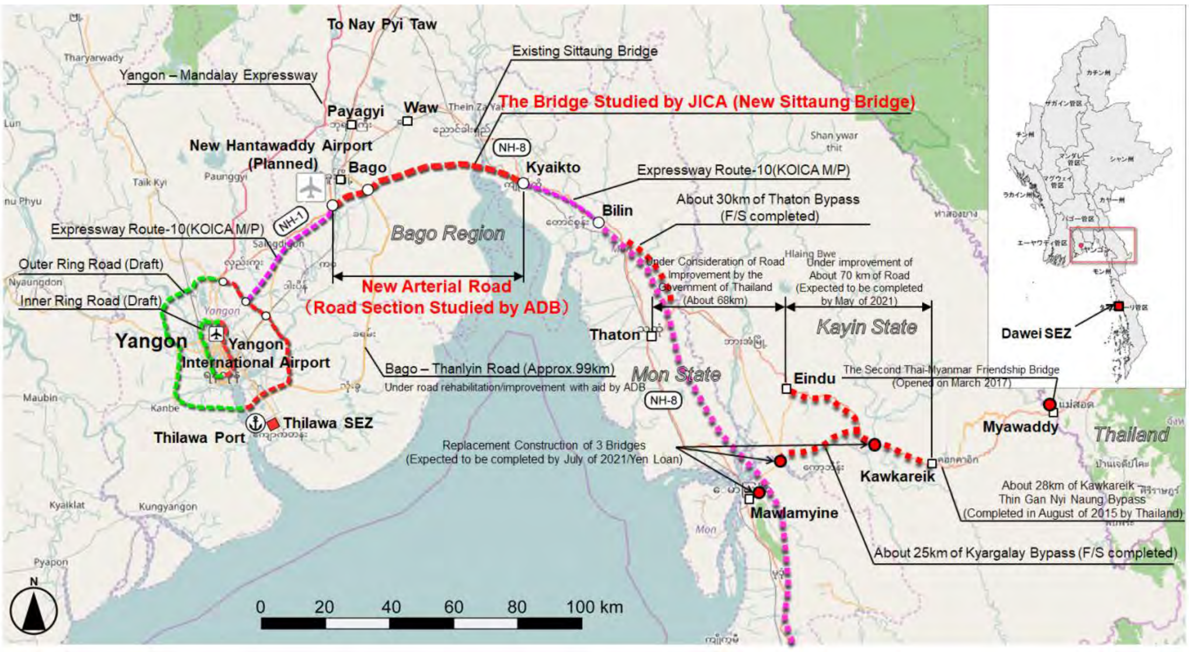
Source: JICA Study Team

1.3 Objective of the Study

The objective of the Study is to conduct a necessary survey, such as objectives, outline, project cost, implementation schedule, implementation method (procurement, construction), project implementation organization, operation and maintenance system, environmental and social considerations, etc., for the examination for implementation of construction of the New Sittaung Bridge and upgrading of the Thuwunna RLTC under the EWEC Project as Japan's loan cooperation.

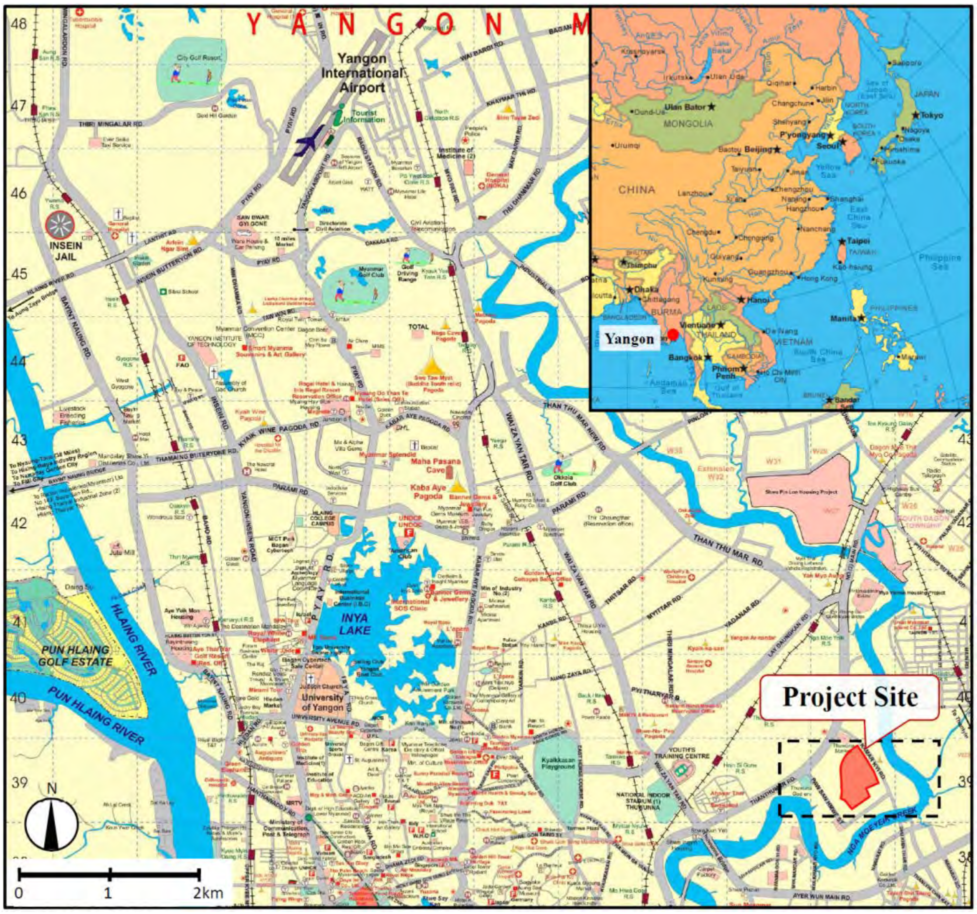
1.4 Study Area

The details of the EWEC Project area are shown in Figure 1.4.1 and Figure 1.4.2.



Source: JICA Study Team

Figure 1.4.1 Project Location Map (New Sittaung Bridge)

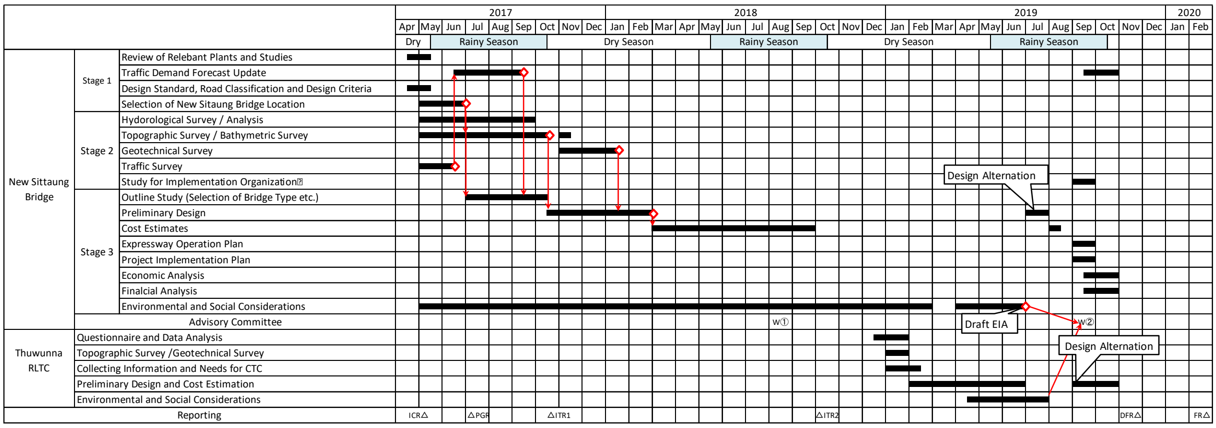


Source: JICA Study Team

Figure 1.4.2 Project Location Map (Thuwunna RLTC)

1.5 Study Schedule

The work schedule of the Study is shown in Figure 1.5.1.



Source: JICA Study Team

Figure 1.5.1 Work Schedule of the Study

CHAPTER 2 GENERAL APPRECIATION AND PURPOSE OF THE PROJECT

2.1 Socio-Economic Conditions of the Project Area

2.1.1 Population and GDP

In Myanmar, a nation-wide census was conducted in 2014 after 31 years of the previous census. According to the census result, the total population in Myanmar is 51.49 million as of 2014.

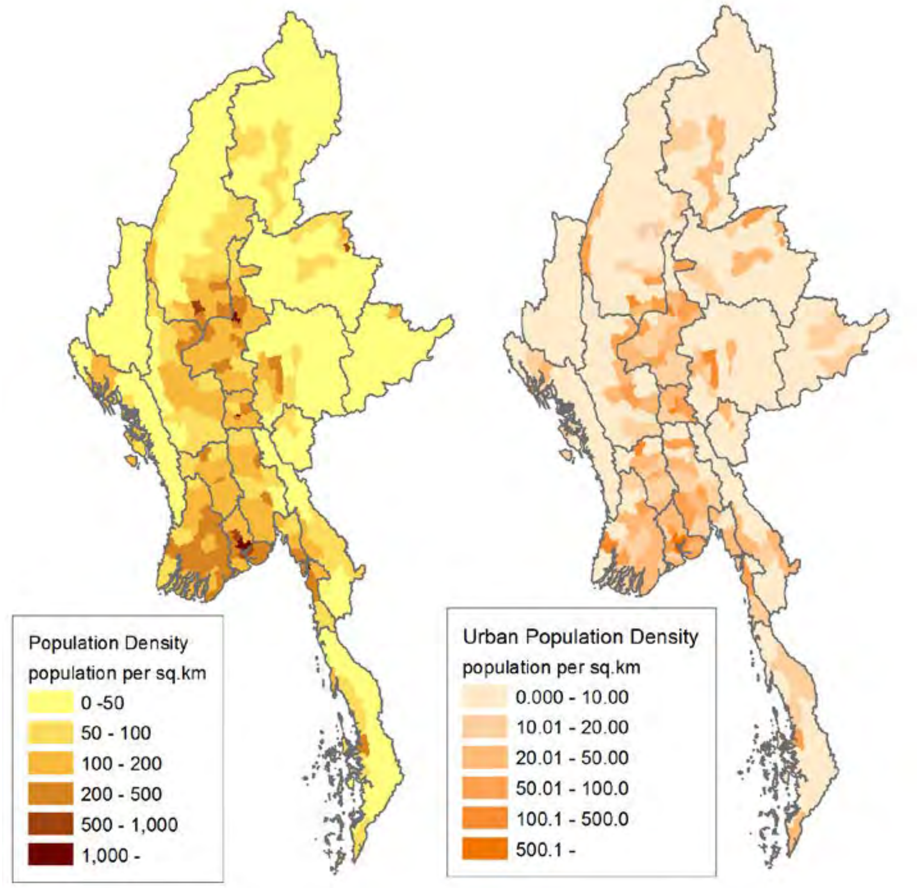
Table 2.1.1 shows population, area and population density by regions and states. The project area (Bago Region and Mon State) accounts for 13.4% and 7.6% in terms of population and area respectively. Population density in the project area, the mean density of Bago Region and Mon State, is 133.9 people/km^2 which is almost twice compared with the national average of 76.1 people/km^2.

Table 2.1.1 Population, Area and Population Density by Regions and States

Regions/States	Population (1,000 persons) 2014	Area (km2)	Population Density (people/km2)
Kachin State	1,689	89,042	19.0
Kayah State	287	11,732	24.4
Kayin State	1,574	30,383	51.8
Chin State	479	36,019	13.3
Sagaing Region	5,325	93,702	56.8
Tanintharyi Region	1,408	43,345	32.5
Bago Region	4,867	39,404	123.5
Magway Region	3,917	44,821	87.4
Mandalay Region	6,166	30,888	199.6
Mon State	2,054	12,297	167.1
Rakhine State	3,189	36,778	86.7
Yangon Region	7,361	10,277	716.3
Shan State	5,824	155,801	37.4
Ayeyarwady Region	6,185	35,032	176.5
Nay Pyi Taw Union Territory	1,160	7,057	164.4
Total	51,486	676,577	76.1

Source: 2014 Population and Housing Census of Myanmar

As shown in the following figure, high-density population townships are mainly located along the Ayeyarwady River and the National Highway-1 (NH-1) between Yangon and Mandalay. Urbanized area judging from urban population density of township is observed in major cities such as Yangon, Mandalay, Nay Pyi Taw and along the NH-1.

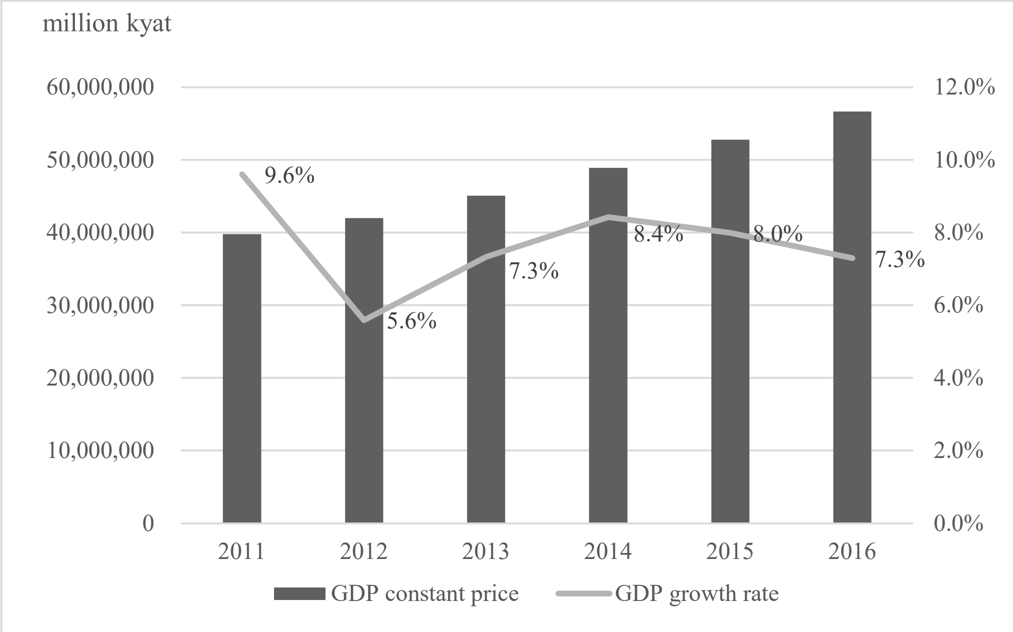


Source: 2014 Population and Housing Census of Myanmar

Figure 2.1.1 Population Density in 2014

Figure 2.1.2 indicates the real GDP and GDP growth rate in Myanmar from 2011 to 2017. The GDP growth rate has been steady for the last several years, recording 8.4% in 2013/2014, 8.0% in 2014/2015, and 7.0% in 2015/2016. GDP growth rate in 2016/2017 was 5.9%. Projections from IMF suggest that Myanmar will maintain its steady economic growth in the near future. It shows that the estimated GDP growth rate in 2017/2018 is 6.8% while that in 2018/2019 and 2019/2020 will be 6.4% and 6.6% respectively[1].

[1] Myanmar : 2016 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for Myanmar, IMF, February 2017



Source: 2016 Myanmar Statistical Yearbook, Ministry of National Planning and Economic Development

Figure 2.1.2 Real GDP and GDP Growth Rate

Table 2.1.2 shows Gross Regional Domestic Product (GRDP) in each region and state in 2017. The Study used the share of GRDP in each region and state in 2012 which was estimated in "Preparatory Survey for the Project for Strengthening Connectivity of International Highway in Mekong Region" (hereinafter referred to as Pre-F/S). GRDP in 2017 is corrected in accordance with available statistical data in 2017.

Proportion of GRDP in the project area is 13.0%. It is the second largest share next to Yangon Region of 21.9%.

Table 2.1.2 GRDP in 2017

Unit: billion Kyat

Region/State	2017	Share
Kachin State	1,398	2.3%
Kayah State	219	0.4%
Kayin State	1,057	1.8%
Chin State	196	0.3%
Sagaing Region	7,020	11.7%
Tanintharyi Region	2,140	3.6%
Bago Region	5,132	8.6%
Magway Region	5,902	9.9%
Mandalay Region	6,609	11.1%
Mon State	2,629	4.4%
Rakhine State	2,365	4.0%
Yangon Region	13,120	21.9%
Shan State	4,299	7.2%
Ayeyarwady Region	6,965	11.6%
Nay Pyi Taw Union Territory	740	1.2%
Total	59,793	100%

Source: Pre-F/S

Note: Total GDP data is from 2017 Myanmar Statistical Yearbook, Ministry of National Planning and Economic Development.

2.1.2 Industry and Trade

(1) Industry

Agriculture is the largest economic sector in Myanmar. In addition, manufacturing, energy and mining, and infrastructure are industries which lead the economy.

According to a report by UNDP, the largest number of businesses is in the manufacturing sector, of which more than half of businesses are the food, beverage and tobacco subsectors[2]. When looking at the distribution of businesses by region/state, the highest number of businesses is found in the Yangon Region. Mon State and Bago Region are the seventh and eighth largest region/state in terms of the number of businesses. In Mon State, a relatively large number of manufacturing businesses (including mining and construction) can be found while the distribution of the economic sector in Bago Region is more equal.

In Myanmar, 18 or 19 industrial zones are currently operated and 7 or 8 new industrial zones are under development or planned as shown in the following table and figure. In terms of project area, Bago Industrial Park (i-Land Park) has been developed by a Singaporean company and soft opened in February 2016. Bago Industrial park is located along the Yangon-Mandalay Expressway and 10km west of Payargyi, and it will be a 160ha industrial complex including commercial district, apartment, bank, hospital and exhibition/event halls.

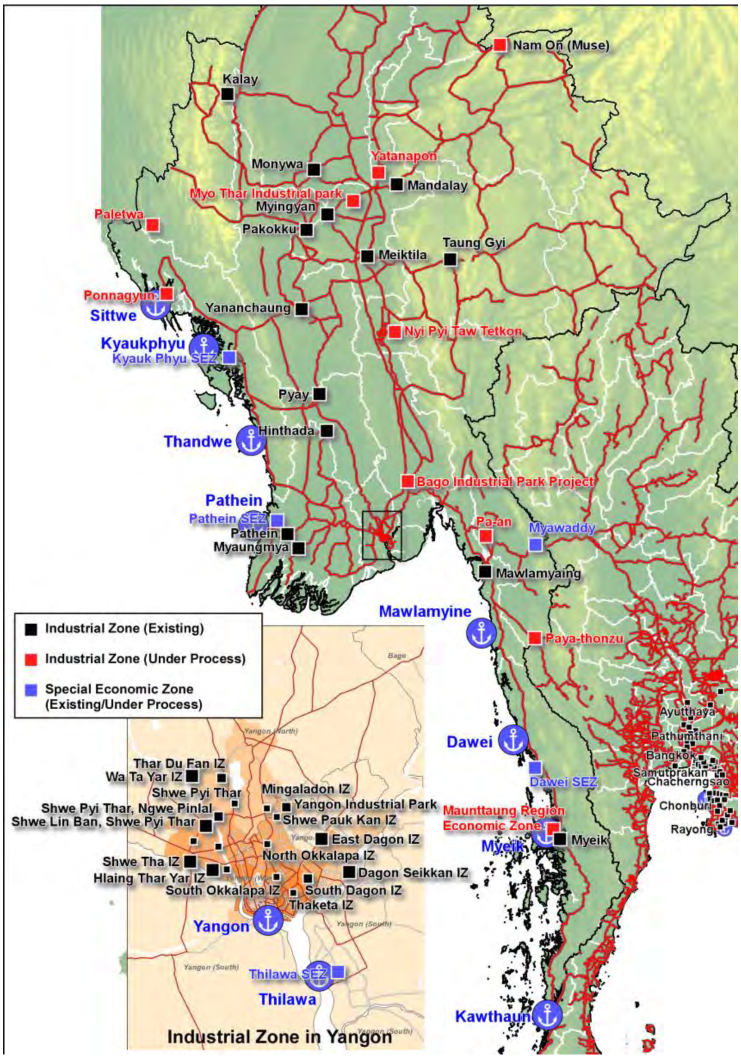
Table 2.1.3 Existing and New Industrial Zone and Registered Industry in Myanmar

Name of Industrial Zone	State/ Region	Year of Opening	No. of Companies operated	Total Area (ha)	Workers per firm (2009-10)	Year of Established
Existing						
East Yangon Industrial Zone (10 zones)	Yangon	1992	3204	1295.1	38.6	1996
West Yangon Industrial Zone	Yangon	Unknown	659	Unknown	38.6	1996
South Yangon Industrial Zone (2 zones)	Yangon	1996	3	350.2	38.6	1996
North Yangon Industrial Zone (12 zones)	Yangon	1990	1093	3634.7	38.6	1996
Hinthada Industrial Zone	Ayeyarwady	1995	9	34.9	6.9	1995
Myaungmya Industrial Zone	Ayeyarwady	1995	9	23.5	6.9	1995
Pathein Industrial Zone	Ayeyarwady	1993	51	43	6.9	1999
Pyay Industrial Zone	Bago	1992	143	48.9	6.5	1995
Pakokku Industrial Zone	Magway	1998	274	153.3	5	1996
Yaenangyaung Industrial Zone (Yananchaung)	Magway	1998	90	69.5	5	1995
Mandalay Industrial Zone	Mandalay	1990	1379	501.5	9.7	1995
Meiktila Industrial Zone	Mandalay	1997	290	156	9.7	1995
Myingyan Industrial Zone	Mandalay	1995	265	66.2	9.7	1995
Mawlamyine Industrial Zone	Mon	1995	83	69.2	5.2	1995
Monywa Industrial Zone	Sagaing	1999	632	147.8	6.9	1995
Kalay Industrial Zone	Sagaing	2004	76	67.7	6.9	2004
Ayetharyar Industrial Zone (Taunggyi)	Shan	1995	932	365	4.3	1995
Myeik Industrial Zone	Tanintharyi	1999	8	128.9	131.6	1995
Hpa-An Industrial Zone	Kayin					-

[2] Myanmar Business Survey 2015 Data report, Central Statistical Organization and UNDP Myanmar, 2016
Note: Agriculture, finance and telecommunication sectors as well as state-owned and family-run businesses are not included in the survey.

New						
Bago Industrial Park	Bago					
Myawaddy	Kayin					
Tetkon	Nay Pyi Taw					
Yadanarpon	Mandalay					
Myo Thar	Mandalay					
Pkayar Thone Su	Mon					
Nant On	Shan					
Ponnagyun	Rakhine					

Source: Ministry of Industry, 2013



Source: Ministry of Industry (2013) and "Project for Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA) (JICA, 2014)"

Figure 2.1.3 Industrial Zones in Myanmar

(2) Trade

Table 2.1.4 shows Myanmar's export amount with major partners from 2013 to 2015. China is the largest export partner and Thailand follows. According to the data from Central Statistical Organization in Myanmar, the total export amount from 2013 to 2015 is 11,204 million USD, 12,523 million USD, 11,136 million USD respectively. However, the sum of export amount in Table 2.1.4, or the sum of export amount of eight countries surpasses figures reported by the Myanmar government. Therefore, it is noted that the table below doesn't show the total export amount.

Table 2.1.5 shows export items and its volume and amount with Thailand in 2014 and 2015. Mineral products including oil and gas are the largest export items in terms of both volume and amount. Among the border points with Thailand, Mae Sot is along the EWEC. The export amount in Mae Sot is 3,519 million THB and 4,073 million THB in 2014 and 2015 respectively[3]. This is equivalent to 107 million USD and 124 million USD.

Table 2.1.4 Major Export Partners of Myanmar

Unit: million USD

	2013	2014	2015
China	2,857	15,601	5,301
Thailand	4,033	3,917	3,557
India	1,366	1,393	1,016
Japan	759	861	864
South Korea	488	580	506
Malaysia	198	167	176
Singapore	179	159	123
Vietnam	124	135	56

Note: Export amounts above are reported from each trade partner
Source: UN Comtrade

Table 2.1.5 Export Volume and Amount with Thailand

Export Items (HS section classification)	2014		2015	
	Volume (ton)	Amount (1,000 USD)	Volume (ton)	Amount (1,000 USD)
Live animals, animal products	31,822	93,715	45,931	83,811
Vegetable products	76,158	62,674	71,683	53,610
Animal or vegetable fats or oil	7	4	8	2
Prepared foodstuffs	11,376	7,281	19,677	12,576
Mineral products	8,775,315	3,594,610	10,037,378	3,301,534
Chemical products	2,472	15,911	2,765	14,157
Plastics and rubber	28	10	1,706	672
Raw hides and skins, leather	261	693	655	743
Wood and wood articles	133,793	80,120	103,696	22,527
Pulp of wood and paper	940	244	4,588	633
Textile and textile articles	297	4,029	489	6,496
Footwear and headgears	26	541	26	762
Stone, cement, ceramic products	56	46	1,037	106
Precious stones and metals	1	1,968	0	1,888
Base metals and articles	7,420	32,283	8,675	33,145
Machinery and mechanical appliances	1,123	13,400	390	8,167
Vehicles and transport equipment	303	1,931	282	2,115
Photographic and clocks	15	3,898	30	12,726
Miscellaneous manufactured articles	833	3,237	222	920
Total	9,042,247	3,916,593	10,299,237	3,556,589

Source: UN Comtrade

Table 2.1.6 indicates Myanmar's import amount with major partners from 2013 to 2015. China is the largest import partner every year and Thailand is the second largest import partner. According to the data from the Central Statistical Organization in Myanmar, the total import amount from 2013 to 2015 is 13,759 million USD, 16,632 million USD, 16,577 million USD.

Table 2.1.7 shows import volume and amount with Thailand in 2014 and 2015. According to the statistics from

[3] Mae Sot Custom House Custom Department website

the Mae Sot Custom Department, import volume in Mae Sot is 55,957 million THB and 64,240 million THB in 2014 and 2015.

Table 2.1.6 Major Import Partners of Myanmar

Unit: million USD

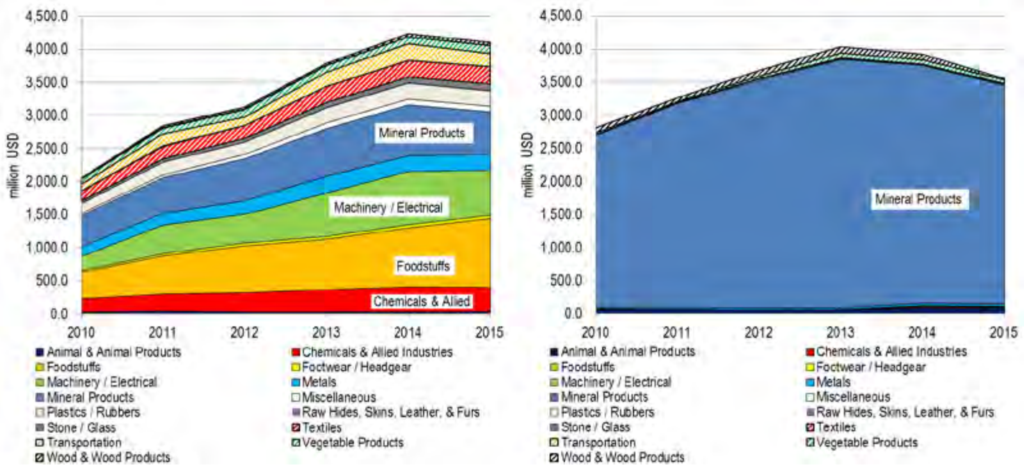
Country	2013	2014	2015
China	7,339	9,368	9,430
Thailand	3,789	4,239	4,108
Singapore	2,245	2,395	2,455
Japan	1,057	1,189	1,065
India	743	869	860
Malaysia	717	805	787
South Korea	705	801	660
Vietnam	230	345	376

Source: UN Comtrade
Note: Import amounts above are reported from each trade partner

Table 2.1.7 Import Volume and Amount with Thailand

Import Items (HS section classification)	2014		2015	
	Volume (ton)	Amount (1,000 USD)	Volume (ton)	Amount (1,000 USD)
Live animals, animal products	14,202	27,619	18,236	29,517
Vegetable products	44,073	51,924	64,571	74,177
Animal or vegetable fats or oil	47,174	55,609	45,218	43,448
Prepared foodstuffs	812,990	891,986	1,613,439	1,038,289
Mineral products	3,663,624	770,974	4,103,100	644,021
Chemical products	245,747	380,512	259,084	372,582
Plastics and rubber	93,077	238,325	112,426	227,350
Raw hides and skins, leather	200	7,463	182	6,067
Wood and wood articles	14,525	13,639	13,702	11,585
Pulp of wood and paper	35,015	33,563	51,389	37,431
Textile and textile articles	44,614	187,184	47,346	257,501
Footwear and headgears	3,023	47,274	3,038	48,430
Stone, cement, ceramic products	257,066	88,682	265,447	86,581
Precious stones and metals	11	1,360	7	24,867
Base metals and articles	133,153	237,406	143,024	237,385
Machinery and mechanical appliances	55,727	804,788	34,913	683,475
Vehicles and transport equipment	19,700	247,988	23,731	200,102
Photographic and clocks	192	28,398	377	24,247
Miscellaneous manufactured articles	5,690	58,314	7,683	61,136
Total	5,489,802	4,173,009	6,806,912	4,108,191

Source: UN Comtrade



Source: UN Comtrade

Figure 2.1.4 Import (left) from Thailand and Export (right) to Thailand

(3) Foreign Direct Investment

Foreign Direct Investment (hereinafter referred to as "FDI") approval trends in Myanmar have been changing year by year although the total FDI amount has been increasing every year since 2011/12, but it has been decreasing since 2016/17. Oil & gas is the sector that received the largest FDI amount in 2014/15 and 2015/16 with 3.2 billion USD and 4.8 billion USD. Transport & communication and manufacturing received the largest FDI amount with 3.1 billion USD and 1.8 billion USD in 2016/17 and 2017/18 respectively. During the last few years, manufacturing, transport & communication, hotel & tourism and real estate sectors are constantly receiving FDI although its amount fluctuates by year.

Table 2.1.8 Foreign Direct Investment by Sector

Unit: million USD

Sector	2012/13	2013/14	2014/15	2015/16	2017/18
Agriculture	9.7	20.3	39.7	7.2	134.5
Livestock & fisheries	5.6	96.0	26.9	8.3	27.7
Mining	15.3	32.7	6.3	28.9	1.3
Manufacturing	400.7	1,827.0	1,502.0	1,065.0	1,769.2
Power	364.2	46.5	40.1	360.1	405.8
Oil & gas	309.2	0.0	3,220.3	4,817.8	0.0
Construction	0.0	0.0	0.0	0.0	0.0
Transport & communication		1,190.2	1,679.3	1,931.0	901.6
Hotel & tourism	300.0	435.2	357.9	288.4	176.8
Real estate	0.0	440.6	780.7	728.7	1,262.0
Industrial estate	0.0	0.0	0.0	10.0	34.0
Other services	14.8	18.5	357.3	236.0	1,005.3
Total	1,419.5	4,107.1	8,010.5	9,481.3	5,718.1

Source: Directorate of Investment and Company Administration (DICA)

With regard to investing countries, Singapore invested the most in terms of amount during the last four years. Investment from other countries fluctuates year by year. China was the second largest in 2017/18 by investing 14 billion USD or 24.4% of total FDI amount. In 2016/17, Vietnam was the second largest (14.6% of total FDI amount) and that in 2015/16 was China (35.1%).

Table 2.1.9 Foreign Direct Investment by Major Countries

Unit: million USD

	2014/15	2015/16	2016/17	2017/18
China	511.4	3,323.9	482.6	1,395.2
Hong Kong	625.6	224.7	213.7	252.0
India	208.9	224.2	0.0	11.0
Japan	85.7	219.8	60.4	384.1
Malaysia	6.7	257.2	21.4	21.9
Singapore	4,297.2	4,246.9	3,820.8	2,164.0
Thailand	165.7	236.2	423.6	123.9
Netherland	302.4	438.0	5.0	534.0
UK	850.8	75.3	54.3	211.2
			1,386.2	20.9

Source: Directorate of Investment and Company Administration (DICA)

2.2 Trend of Assistance by Japanese Government and Other Donors

2.2.1 Assistance by Japanese Government

(1) Overview

Japanese financial cooperation to Myanmar was initiated when the "Japan-Burma Peace Treaty and Agreement on Reparations and Economic Cooperation" was signed in 1954. However, the financial cooperation, except humanitarian aids, had been basically suspended under the governance by the military in 1988 to 2011.

In March 2011, the new administration of Myanmar was formed and the democratic reforms toward national reconciliation have been facilitated. Given this democratic movement, the government of Japan reviewed and changed its economic cooperation policy to Myanmar in April 2012 and has extended its economic cooperation in the following fields:

Policy-1: Improvement of people's livelihoods (including assistance for ethnic minorities and poverty groups as well as agricultural and rural development)

Policy-2: Capacity building development of systems to sustain economic and society Developing human resources and institutions (including assistance for promotion of democratization)

Policy-3: Developing economic infrastructure

Under these cooperation policies, Japan has been providing ODA to Myanmar continuously. The amount of ODA provided in recent years is summarized in Table 2.2.1.

Table 2.2.1 Amount of Japan's ODA to Myanmar by Fiscal Year

(Gross disbursements, 100 million Yen)

Fiscal Year	Loan Aid	Grant Aid	Technical Cooperation
2011	-	45.13	21.23
2012	1,988.81	277.36	42.00
2013	510.52	199.76	67.14
2014	983.44	181.89	75.18
2015	1,257.38	176.05	89.09
2016	1,358.08	156.44	98.12
2017	1,170.40	135.07	92.00
Accumulated Total	11,298.35	3,038.94	880.06

Source: Ministry of Foreign Affairs of Japan

(2) Japan's ODA Projects related to Road Sector

Cooperation to the road sector is one of the biggest contributions to Myanmar. Outlines of Japan's ODA projects for the road sector in Myanmar by JICA are summarized below:

1) Project for Improvement of Road Construction and Maintenance Equipment in Kayin State

Project Cost / Type of Aid	759 million Yen / Grant Aid
Project Area	Kayin State
Status	Completed / 2012-2014
Project Objectives	The purpose of the project is to contribute to economic development and to promote the return and resettlement of the international and internal displaced people in Kayin State by providing construction equipment for road maintenance. The project is expected to improve logistics, activate industries in Kayin State, improve living standards of the people living along the roads, facilitate transportation of returnees as well as materials for maintenance of accepting villages, and promote return of international and internal displaced people and regional development.
Project Components	- To provide the construction equipments necessary for construction of roads and bridges under the Kayin State planned route. - To provide equipment ledger management devices to manage the procured equipment efficiently

2) Project for Improvement of Road Technology in Disaster Affected Area

Project Cost / Type of Aid	Unknown / Technical Cooperation
Project Area	Ayeyarwady Region
Status	Completed / 2012-2015
Project Objectives	The project objective is to enhance the capacity of MOC (the former Public Works) for road construction adaptive to the delta areas of Ayeyarwady Region.
Project Components	Road length constructed by the technology introduced from the pilot project is extended longer than 2.6 km. Also, the enhancement of skill and knowledge of the engineer for road design and construction is aimed for more than 30 staff members by introducing road technology standards and manuals for designing and construction works.

3) Regional Development Project for Poverty Reduction Phase I

Project Cost / Type of Aid	17,000 million Yen / Loan Aid
Project Area	Whole in Myanmar
Status	On-going / 2012- August 2019
Project Objectives	This project is expected to improve the livelihoods of local residents, and thus contribute to development and poverty reduction in local areas, by constructing and rehabilitating life-supporting infrastructure (roads, electricity, and water supply), which is highly beneficial to the poor and urgently required, in seven Regions and seven States in the whole of Myanmar.
Project Components	The project consists of 64 subprojects which aim to improve life-supporting infrastructures as follows. - 16 subprojects of road and bridge construction - Total 25 electric power supply subprojects (electricity supply network repair and extension, repair for substation and transformer and small hydroelectric power plant rehabilitation) - 23 water supply subprojects (improvement and expansion of rural city water supply pipes and maintenance of water purification facilities)

4) Project for Improvement of Road Construction and Maintenance Equipment in Rakhine Sate

Project Cost / Type of Aid	738 million Yen / Grant Aid
Project Area	Rakhine State
Status	Completed / 2014-2016
Project Objectives	The project is to improve road construction equipment to further road improvements in Rakhine State, which lags in development, with the objectives of stimulating socioeconomic activity and improving the lives of residents in the state.
Project Components	Provision of 57 road construction and maintenance equipment to be utilized in the

	construction of Toungup, Ma-Ei and An Road Section (approximately 140 km)

5) Infrastructure Development Project in Thilawa Area Phase II

Project Cost / Type of Aid	4,613 million Yen / Loan Aid
Project Area	Yangon Region (Thilawa)
Status	On-going / 2015-
Project Objectives	This project is to promote the inflow of foreign investment in the Thilawa SEZ by improving and widening the access road between Yangon and the Thilawa SEZ and achieving a smooth traffic flow, thereby contributing to job creation and the economic development of Myanmar.
Project Components	- Road widening and improvement (8.7 km) - Underground distribution cables and communication cables installation

6) Project for Construction of New Thaketa Bridge

Project Cost / Type of Aid	4,216 million Yen / Grant Aid
Project Area	Yangon Region (Thaketa)
Status	Completed / 2014-2018
Project Objectives	In order to improve traffic capacity and congestion at Taketa Bridge, the project is to replace the existing Taketa Bridge located in Yangon City. It aims to contribute to the efficiency of logistics and passenger transportation in the trunk road network connecting the east and southeast in Yangon.
Project Components	- To construct three span continuous extra-dozed bridge (bridge length:253m) and PC box girder bridge (bridge length:33m) and connecting roads

7) East-West Economic Corridor Improvement Project

Project Cost / Type of Aid	33,869 million Yen / Loan Aid
Project Area	Mon State, Kyain State
Status	On-going / 2015-
Project Objectives	By replacing three bridges that hinder the smooth flow traffic along the GMS East-West Economic Corridor to Mawlamyine and Myawaddy on the Thai border, this project will address the rising need for transportation in that interval, make domestic and international goods distribution more efficient, and thereby stimulate trade with other countries in the Mekong region and promoting direct investment in Myanmar.
Project Components	- To replace the following bridges: 1) Gyaing Kawkareik Bridge (bridge length: 850m, approach bridge: 900m) 2) Attaran Bridge (bridge length: 900m, approach bridge: 1000m) 3) Gyaing Zathabyin Bridges (bridge length: 800m, approach bridge: 900m) The outline of the replaced bridges is illustrated in Table 2.6.2.

8) Project for Improvement of Road Construction and Maintenance Equipment in Kachin State and Chin State

Project Cost / Type of Aid	2,740 million Yen / Grant Aid
Project Area	Kachin State, Chin State
Status	Completed / 2015-2017
Project Objectives	This project aimed to improve the equipment for road construction and maintenance in Kachin and Chin State, which are some of the most undeveloped regions in Myanmar and are slower than other states and regions in developing roads.
Project Components	The following sections were selected as target road in the project: - Kachin state: Nansiaung – Namiti (Approximately 141km) on the Shwebo – Myitkyina Road - Chin state: Falam area – Hakha (Approximately 109km) on the Kalay – Hakha Road

9) Project for Capacity Development of Road and Bridge Technology

Project Cost / Type of Aid	Unknown / Technical Cooperation
Project Area	Whole of Myanmar
Status	Completed / 2016-2019
Project Objectives	The project aims to support (i) improvement of road standards and classification and (ii) improvement of management ability of Public Works of the Ministry of Construction.
Project Components	- Reviewing current road and bridge standards - Understanding current technical capabilities in road and bridge construction and

	maintenance, and analysis and suggestion for latest technologies necessary for the project - Implementation of training programs and its monitoring

10) Project for Construction of Bago River Bridge

Project Cost / Type of Aid	31,051 million Yen / Loan Aid
Project Area	Yangon Region (Thaketa and Thanlyin)
Status	On-going / 2016-
Project Objectives	The objective of the project is to meet the increasing traffic demand between Yangon City and Thanlyin Township, especially the Thilawa SEZ, by constructing a bridge over the Bago River and making the traffic and logistics network efficient, thereby promoting foreign direct investment in the Thilawa SEZ and economic development in Myanmar.
Project Components	- Construction of Bago River Bridge (total length: approx.2km) including on-ramp bridge which consists of; 1) PC box girder (5@50m in Thanlyin, 6@50m in Thaketa) 2) Steel box girder with steel deck (2@76.5m+104m in Thanlyin, 6@112m+104m in Thaketa) 3) Steel cable stayed bridge (112m+224m+112m) 4) PC-i girder ((4@28.8m) - Construction of Flyover Bridge (total length: 602m)

11) Regional Development Project for Poverty Reduction Phase II

Project Cost / Type of Aid	23,979 million Yen / Loan Aid
Project Area	Kayin State, Sagaing Region, Bago Region, Magway Region, Shan State, Ayeyarwady Region
Status	On-going / 2017-
Project Objectives	The objective of the project is to improve access to basic social infrastructure in regional areas through the rehabilitation, construction and installation of roads, bridges, power and water supply facilities nationwide, thereby contributing to the poverty reduction and socioeconomic development of Myanmar.
Project Components	The project consists of 61 subprojects which aim to improve life-supporting infrastructures as follows. - 7 subprojects in the road and bridge sector (asphalt pavement, concrete pavement and rehabilitation of small bridges accompanying roads etc.) - 32 subprojects in the power supply (on-grid) sector (rehabilitation and expansion for small and medium-sized electricity distribution network, and rehabilitation for substations and transformer etc.) - 22 subprojects in the water supply sector (maintenance and expansion of local urban water supply pipes, and improvement of water purification facilities, etc.)

2.2.2 Assistance on Road Sector by Other Donors

(1) ADB

Myanmar joined ADB in 1973, but most of the operations were put on hold in 1988, when the country entered a period of economic and political isolation. In 2012, ADB reengaged with Myanmar, and set a Country Partnership Strategy (CSP). It aims to support the Myanmar government in laying the foundations for sustainable and inclusive economic development, and job creation for poverty reduction focusing on:

- Improving access and connectivity to connect rural and urban areas and markets, and to link Myanmar with the regional and global marketplace
- Strengthening human capital to promote a skilled workforce and increased employment, and enable the poor and disadvantaged to benefit from economic growth
- Promoting structural and institutional reform to support the modernization of the economy

Based on the strategies, ADB has implemented the following financial support and technical cooperation as of 2018.

Table 2.2.2 Amount of ADB Finacial Assistance to Myanmar by Fiscal Year

Unit: million USD

Fiscal Year	Loan Aid	Grant Aid	Technical Cooperation
2013	635.50	-	6.79
2014	230.00	4.00	12.40
2015	432.20	10.00	7.05
2016	270.49	10.00	11.62
2017	319.79	-	21.45
2018	614.1	22.00	9.25
Total	2,502.08	46.00	68.56

Source: Asian Development Bank

Outline of ADB projects for road sector in Myanmar are summarized below.

Table 2.2.3 ADB Projects in Road Sector (Myanmar)

Project Name	Organization	Project Area	Length (km)	Width (m)	Status	Project Cost (mil.USD)	Remark
Maubin-Phyapon Road Rehabilitation Project	ADB	Ayeyarwady	54.5	6.7	On-going	80.0	Loan
Greater Mekong Subregion East–West Economic Corridor Eindu to Kawkareik Road Improvement Project	ADB	Kayin	64.7	10.0	On-going	120.0	Loan
Greater Mekong Subregion Highway Modernization Project	ADB	Bago Ayeyarwady Yangon	280	7.0	On-going	340.0	Loan
Rural Roads and Access Project	ADB	Ayeyarwaddy and Magway	152.0	5.0	On-going	51.2	Loan Grant

Source: Asian Development Bank

(2) Korea

KOICA published "The Republic of Korea's Country Partnership Strategy for the Republic of the Union of Myanmar 2016-2020" and stated that cooperation policy of road transport area will be the following support plans.

- Support efforts to develop public transport systems (e.g. urban railways) and residential infrastructure in major cities to balance growth in urban areas and settle problems of urbanization
- Promote regional connectivity and distribution network to enhance national connectivity in Myanmar by repairing railways and building bridges

The annual amount of financial assistance from KOICA is shown in Table 2.2.4.

Table 2.2.4 Amount of KOICA Finacial Assistance to Myanmar by Fiscal Year

Unit: USD

Fiscal Year	Project Type Cooperation	Development Consulting	Volunteer	KOICA Fellowship Program	Public-Private Partnership
2011	2,899,482	-	813,962	918,171	347,255
2012	1,466,644	-	1,025,974	1,020,585	2,043,786
2013	5,251,625	1,658,901	1,736,866	908,979	1,698,325
2014	8,493,766	5,244,714	4,579,513	1,307,028	1,757,185
2015	3,658,329	5,658,807	4,681,392	1,703,417	1,800,693
2016	7,869,666	10,550,690	5,403,590	1,606,972	76,016
2017	11,688,978	4,411,504	4,375,665	1,894,048	500,358
Total	41,328,490	27,524,616	22,616,963	9,359,200	8,223,617

Source: KOICA

The Korean projects for the road sector in Myanmar are summarized below.

Table 2.2.5 Korean Projects in Road Sector (Myanmar)

Project Name	Organization	Project Area	Length (km)	Width (m)	Status	Project Cost (mil.USD)	Remark
Myanmar - Korea Friendship (Dala) Bridge Project	Korea EDCF	Yangon	1.87	20.9	On-going	168.2	Loan

Source: Information from MOC

(3) India

The Indian government has provided financial and technical assistance to road connectivity with Southeast Asia as well as Pacific Countries under the "Act East Policy". Especially the physical link between North India and Myanmar is a priority in the policy to develop the gateway to the Southeast Asia.

The Indian projects for the road sector in Myanmar are summarized below.

Table 2.2.6 India Projects in Road Sector (Myanmar)

Project Name	Organization	Project Area	Length (km)	Width (m)	Status	Project Cost (mil.USD)	Remark
Rid-Tiddim Road	India	Chin	52.1	7.0	On-going	60.0	Grant
Kaladan(Paletwa-Set pyitpyin-Zoyinvi)	India	Chin	62.0	6.7	On-going	287.0	Grant
Upgrading the 69 Bridges on India-Myanmar Friendship Road (Tamu – Kalewa section)	India	Sagaing	69 bridges on 149.7 km	7.0	On-going	12.0 bil. RS	Grant
Upgrade of India–Myanmar–Thailand Trilateral Highway (Kalewa-Yargyi section)	India	Sagaing	120.74 km	2- Lane ROW = 70 m (Design) ROW = 46 m (Existing) Carriageway = 2x3.5 m Earthen shoulder 2x(1~2)m	On-going		Grant

Source: JICA Study Team based on Arterial Road Network Development Master Plan (KOICA) and information from MOC

(4) Thailand

The Thailand government has provided technical and financial assistance to neighboring countries within the ASEAN region under one of its foreign policies, namely, "Promoting Thailand's Role and Expanding Opportunities in the ASEAN Communities" which is expected to be achieved by Thailand's sufficient contribution to the establishment of the ASEAN Economic Community (AEC). For this purpose, investment on the development of SEZs, border checkpoints including border checkpoint facilities at Mae Sot and the road network in Myanmar has been intensively promoted in order to establish an effective transportation and logistics network and ensure the connectivity of ASEAN markets. The Thai projects for the road sector in Myanmar is summarized below.

Table 2.2.7 Thailand Projects in Road Sector (Myanmar)

Project Name	Organization	Project Area	Length (km)	Width (m)	Status	Project Cost	Remark
Construction of Myawaddy-Thingannyinaung Section	Thailand	Kayin	17.2	10.0	Completed	100 million Thai Bath	Grant
Construction of Thingannyinaung-Kawkareik Road	Thailand	Kayin	28.2	10.0	Completed	100 million Thai Bath	Grant
Three Pagoda Pass	NEDA	Mon Kayin	Approximately 12 km	Variable	Completion of Pre F.S	483 mil. THB	
Second Thai-Myanmar Friendship Bridge	Thailand	Kayin	0.78	17.2	Completed	3,900 mil.THB	Grant

Source: JICA Study Team based on Arterial Road Network Development Master Plan (KOICA) and information from MOC

(5) China

In 2013, China and Myanmar developed comprehensive strategic cooperative partnership and foreign investment, however the specific cooperation and / or assistant policy on road sector in Myanmar is unknown.

The Chinese projects for the road sector in Myanmar are summarized below.

Table 2.2.8 Road Projects by China (as of 2015)

Project Name	Organization	Project Area	Length (km)	Width (m)	Status	Project Cost (mil. USD)	Remark
Loilem - Kengtung Road	China(EXIM)	Shan	221.5	6.7	Proposed	359.0	Concessional Loan
Thanphyuzayet - Kawthaung Road	China(EXIM)	Mon & Thanintharyi	994.0	6.7	Proposed	150.0	Concessional Loan
Yangon – Mandalay Expressway	China(EXIM)	Yangon & Mandalay	593.5	15.2	Proposed	150.0	Concessional Loan
Lido Road (Namti-Tanine)	China	Kachin	86.5	3.7	Proposed	N.A.	Grant
Upgrading the Kengtung - Mongla Road	China	Shan	90.1	6.7	Proposed	N.A.	Grant

Source: Arterial Road Network Development Master Plan (KOICA)

2.3 Road Network in Myanmar

2.3.1 Introduction

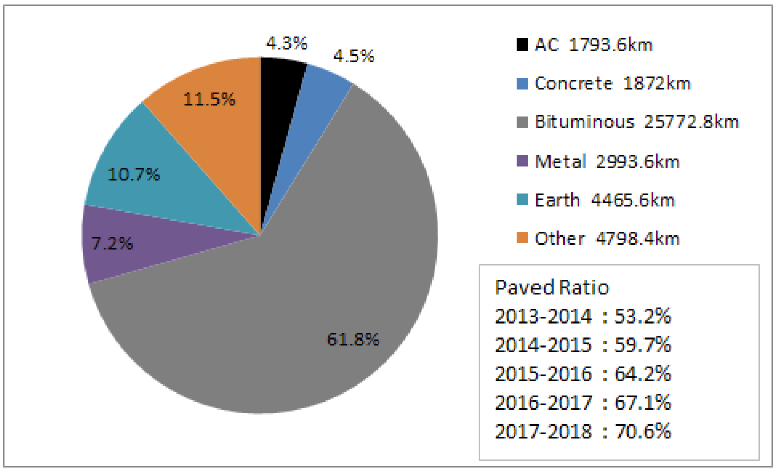
(1) Road Condition in Myanmar

The total length of roads in Myanmar is approximately 142,400 km and MOC manages about 42,100km (29.5% of total). Road length by road class in Myanmar is summarized in Table 2.3.1, and classification by surface type of road under control of MOC is shown in Figure 2.3.1. Paved ratio is about 71% of the total and it has been improving year by year.

Table 2.3.1 Road Length by Road Class in Myanmar (as of September 2018)

Road Class	Length (km)	Percent (%)	Responsible Authority
Expressways	586	0.4	MOC
Class-II and Class III Roads	29,123	20.4	MOC
Below Class III Roads	12,391	8.7	MOC
Major city roads and other roads	22,280	15.6	City Development Committees
Village and boundary area roads	78,057	54.9	Ministry of Livestock, Fisheries, and Rural Development
Total	142,437	100	

Source: MOC



Source: Myanmar Data Book (2018)

Figure 2.3.1 Classification by Surface Type of Road Under the Control of MOC

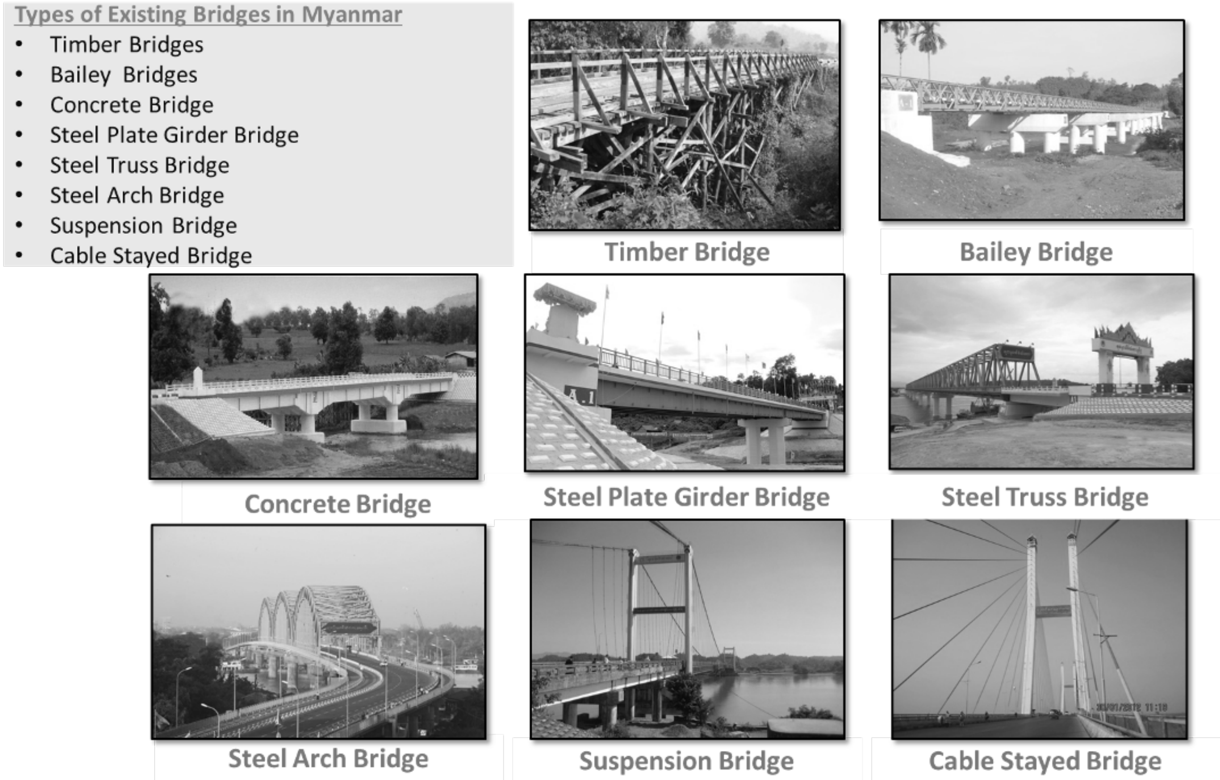
(2) Bridge Condition in Myanmar

There are 514 bridges in Myanmar of which the length is over 54m (as of 2016). Many bridges in Myanmar are designed, constructed and maintained by MOC directly, while some roads are being maintained under BOT scheme.

Financial and technical support for bridge construction in Myanmar began with “Bridge Engineering Training Center Project” (BETC Project) by JICA, which was implemented from 1969 to 1975. This project contributed a lot for the capacity development of MOC’s staff and increased the number of bridge engineers in Myanmar. During the period of economic sanctions on Myanmar, several bridges, including the portable Bailey bridges, were constructed with the support of China and India.

MOC has constructed many bridges by themselves. The type of existing bridges constructed by MOC is summarized in Figure 2.3.2. Several types of bridge including suspension bridge and cable stayed bridge can be designed and constructed by MOC. It can be considered that Japan's technical cooperation such as BETC Project has significantly contributed to bridge construction in Myanmar.

Some existing bridges have critical problems, such as deterioration, because of their aging and insufficient structural capacity, and have become bottlenecks in the road network.



Source: MOC

Figure 2.3.2 Types of Existing Bridges Constructed by MOC

Bridges of which the length are over 1,000 feet and constructed after 1988 till the end of March 2018 are listed in Table 2.3.2.

Table 2.3.2 Bridge List (Length over 1,000 feet and constructed after 1988 till the end of March 2018)

No.	Name	State or Division	Length (feet)	Type of Bridge	Completed Date
1	Ngawon Bridge	Ayeyarwady, Yegyi	1,164	Cable Stay + box girder	12.9.1991
2	Thanlyin	Yangon, Thanlyin	7,056	Steel Truss	31.7.1993
3	Bayintnaung	Yangon, Mayangone	1,641	Steel Truss	23.7.1994
4	Myaungmya	Ayeyarwady, Myaungmya	1,270	Bailey	18.9.1996
5	Newtamin (Salin)	Magway	1,200	Bailey	31.3.1997
6	Thanlwin (Hpa-An)	Kayin, Hpa-An	2,252	Steel Truss	3.8.1997
7	Nawaday	Bago, Pyi	4,183	Steel Truss	18.9.1997
8	Laputta (Pinlallay)	Ayeyarwady, Myaungmya	1,300	Bailey	3.1.1998
9	Maubin	Ayeyarwady, Maubin	2,362	Steel Truss	10.2.1998
10	Attaran	Mon, Mawlamyine	1,420	Cable Stay	26.3.1998
11	Mone Chaung	Magway, Pwint Phyu	1,300	Bailey	15.4.1998
12	Balaminhtin	Kachin, Myitkyina	2,688	Steel Truss	14.11.1998
13	Gyaing (Zarthapyin)	Kayin, Hp-Aan	2,900	Cable suspension	24.3.1999
14	Myitmakha	Bago, Lapatan	1,520	PC	3.5.1999
15	Gyaing (Kawkaraik)	Kayin, Kawkaraik	1,200	Baily suspension	22.5.1999
16	Yaw Chaung	Rakhine, Myaypon	1,100	Bailey	14.7.1999
17	Sinphyushin	Sagaing, Chaungoo	4,957	Steel Truss	18.9.1999
18	Bo Myat Htun	Ayeyarwady, Nyaungdon	8,544	Steel Truss	15.11.1999
19	Yarmaung	Rakhine, MyaukOo	1,300	Bailey	15.12.1999

20	Kispanady	Rakhine, Kyauktaw	2,513	Steel Truss	2.1.2000
21	Min Chaung	Rakhine, Sittwe	2,003	Steel Truss	5.2.2000
22	Hlaing River	Yangon, Mhawbi	1,940	RCC	26.3.2000
23	Maharbadula	Yangon, Pazuntaung	3,643	Cable Stay	12.7.2000
24	Aungzaya	Yangon, Insein	3,786	Cable Stay	25.8.2000
25	Bawlel river (Yaypawthaung)	Yangon, Htantabin	1,940	RCC	17.11.2000
26	Taninthari	Taninthari, Taninthari	1,360	Bailey	12.11.2000
27	Hlaing river	Yangon, Shwepyithar	3,415	Steel Truss	2.1.2001
28	Gonnyintan	Ayeyarwady, Kyaiklat	1,940	RCC	9.2.2001
29	Anawyathar	Magway, Chauk	5,192	Steel Truss	4.4.2001
30	Shwelaung	Ayeyarwady (Shwelaung)	1,900	Bailey	21.3.2002
31	Ayeyarwady (Magway)	Magway, Magway	8,989	Steel truss (tension)+RCC	24.11.2002
32	Wakema	Ayeyarwady, Wakema	3,020	Bailey+RCC	5.1.2003
33	Sittaung (Shwekyin – Maduak)	Bago, Shwekyin	1,500	PCC+RCC	11.2.2003
34	Shweli	Sagaing, Katha	2,330	PCC+RCC	9.3.2003
35	Daydaye	Ayeyarwady, Daydaye	4,088.3	PCC+RCC	23.3.2003
36	Chindwin (Monywa)	Sagaing, Monywa	4,730.2	Steel Truss + RCC	7.4.2003
37	Darka	Ayeyarwady, Darka	1,400	RCC	6.7.2003
38	Kwalku-Kyaukphya	Taninthari, Myeik	3,612	Steel Truss + RCC	26.10.2003
39	Myitthar (Kalewa)	Sagaing, Kalewa	1,320	Cable suspension	12.6.2004
40	Lonetawpauk	Rakhine, Yanbyal	1,154.5	Steel Truss	25.10.2004
41	Pathein	Ayeyarwady, Pathein	2,140	Cable Suspension	22.11.2004
42	Thanlwin (Mawlamyine)	Mon, Mawlamyine	11,575	Steel Truss, PCC+ RCC	5.2.2005
43	Panhlaing	Yangon, Hlaingtharyar	1,940	PCC+RCC	22.10.2005
44	Manpawady (Myinkaseik)	Ayeyarwady, Myaungmya	1,260	Bailey+RCC	25.5.2006
45	Minkyaung Chaung	Rakhine, Yanbyal	2,704.2	Steel Truss	17.4.2006
46	Twante	Yangon, Twante	3,750	Cable Stay+RCC	25.5.2006
47	No.1 Pauk Bridge (Ohntaw) Expansion	Magway, Pauk	1,380	Bailey	30.6.2006
48	No.2 Pauk Bridge (Yepyar) Expansion	Magway, Pauk	1,390	Bailey	31.7.2006
49	Pyapon	Ayeyarwady, Pyapon	3,931.7	Steel Truss+Steel, Girder+RCC	20.3.2007
50	Paikyon	Kayin, Hlaingbwe	1,170	Bailey+wood	1.6.2007
51	Dagon	Yangon, new Dagon City	4,540	PCC+RCC	27.10.2007
52	Ooru	Sagaing, Homemalin	1,090	PCC+RCC	9.2.2008
53	Ayeyarwady (Yadanarpon)	Mandalay, Amarapura	5,614	Steel Truss	11.4.2008
54	Bwetkyi	Magway, Aunglan	1,770	PCC+RCC	2.5.2008
55	Sittaung (Mokepalin)	Mon, Kyaikto	2,392.7	Steel truss+Steel Grider+RCC	12.7.2008
56	Ngawun (In City)	Ayeyarwady, Ingapu	2,835	Steel Truss+PCC	21.3.2009
57	Yarzudaing No.1	Ayeyarwady, Mawlamyine kyun	1,956	PCC+RCC	22.8.2010
58	Myaukyamar chaung	Sagaing, Yinmarpin	1,280	Bailey	18.9.2010
59	Lainli	Shan, Pinlaung	1,760	Cable stay	5.11.2010
60	Daung nay Chaung	Magway, Magway	1,785	PCC	5.2.2011
61	Ayeyarwady (Nyaungdon)	Ayeyarwady, Nyaungdon	10,814	Steel Truss+PCC+RCC	27.11.2011
62	Ayeyarwady (Pakokku)	Magway, Pakokku	13,537	Steel Truss + RCC	31.12.2011
63	Ayeyarwady (SinKhan)	Kachin, Bamaw	4,630	Steel Truss+RCC+Borepile	4.2.2012

64	Chaungbyalkyi	Ayeyarwady, Bogalay	1,040	Bailey + RCC	8.4.2013
65	Ayeyarwady (Malon)	Magway, Malon	5,839	Steel Truss + RCC	11.5.2013
66	Minton Chaung (Yadanarpon)	Magway, Amarapura	1,080	Steel Truss + RCC	16.6.2013
67	Thatkal Chaung	Ayeyarwady, Ngaputaw	1,820	Steel Truss + RCC	7.7.2013
68	Yadanartheinga	Sagaing, Shwebo	2,480	Steel Truss +RCC	24.7.2013
69	Seikkyikhanangto	Yangon	1,680	Bailey +RCC	27.11.2013
70	Bayintnaung	Yangon	4,140.53	Steel Girder	9.11.2014
71	No.2 Pauk (Yepyar)	Magway	3,140	RCC	22.11.2014
72	Bogalay	Ayeyarwady, Bogalay	4,005	Steel Girder + RCC	27.12.2014
73	Sonyal	Rakhine	1,216	Steel Girder +RCC	1.5.2014
74	Thanlwin (Pharsaung)	Kayah	1,260	Steel Girder + RCC	31.4.2015
75	Myanmar – Lao Friendship bridge	Shan	22,693	Steel Girder + RCC	9.5.2015
76	Ayeyarwady (Hteegyaint)	Sagaing	7,730	Steel Girder + RCC	22.10.2015
77	Mumyint (Karbo)	Sagaing	1,260	RCC	28.2.2016
78	Yewar chaung	Sagaing	1,440	RCC	13.3.2016
79	Sittaung River Bridge (Htantabin)	Bago	1,200	RCC	22.3.2016
80	Chindwin Brige (Kalewa)	Kalewa	2805	Steel Truss	2.4.2017
81	Bogyoke Aung San Bridge (Bilu Kyun)	Bilu Kyun	5203.4	Steel Truss	9.5.2017
82	Tawan Bridge	Kachin (Tanai)	1260	RCC	31.8.2016
83	Taw Phyar Chaung Bridge	Rakhine (Ponar Kyun)	1200	Plate Girder	21.5.2017
84	Chindwin Bridge (Khandi)	Saging (Khandi)	2656	Steel Truss	8.4.2018
85	Chi Chaung Bridge	Magway (Saw)	1000	P.C Girder	14.3.2018

Source: MOC

Bridges on major rivers in Myanmar are listed in Table 2.3.3.

Table 2.3.3 Bridges on Major Rivers

No	Name	Span (feet)	Type of Bridge
River Ayeyarwady			
1	Innwa Bridge (Sagaing)	3,960	Steel Truss
2	Nawaday Bridge	4,183	Steel Truss
3	Maubin Bridge	2,362	Steel Truss+ RCC
4	Bala Min Htin Bridge	2,688	Steel Truss
5	Bo Myat Htun Bridge	8,544	Steel Truss
6	Anawrahtar Bridge	5,192	Steel Truss
7	Ayeyarwady Bridge (Magway)	8,989	Steel Truss+ PC+RCC
8	Dadaye Bridge	4,088	Steel Truss+ RC
9	Ayeyarwady Bridge (Yadanarpon)	5,641	Steel Truss
10	Ayeyarwady Bridge (Nyaungdon)	10,814	Steel Truss
11	Ayeyarwady Bridge (Pakokku)	13,537	Steel Truss
12	Ayeyarwady Bridge (Sinkhan)	4,630	Steel Truss+ PC+RCC
13	Ayeyarwady Bridge (Malon)	5,839	Steel Truss+RCC+Borepile
14	Yadanartheinkha Bridge	2,480	Steel Truss+RCC+Borepile
15	Ayeyarwady Bridge (Hteegyaint)	7,730	Steel Truss+RCC
River Sittaung			
16	Sittaung Bridge (Theinzayat)	2,320	Steel Truss
17	Sittaung Bridge	680	CH Steel Girder

	(Taungoo-Mawchi-Loikaw)		
18	Sittaung Bridge (Shwe Gying-Madauk)	1,500	PC+RCC
19	Sittaung Bridge (Mokepalin)	2,393	Steel Truss+ Plate Girder + RC
20	Sittaung Bridge (Natthankwin)	720	Steel Truss
River Thanlwin			
21	Kwan Lone Bridge	789	Steel Suspension
22	Tar Kaw Bridge	780	Steel Truss
23	Thanlwin Bridge (Tarkawatt)	600	Bailey
24	Thanlwin Bridge (Hpa-An)	2,252	Steel Truss
25	Thanlwin Bridge (Tarsan)	900	Suspension
26	Thanlwin Bridge (Mawlamyine)	11,575	Steel Truss+ PC+RCC
27	Thanlwin Bridge (Tarpar)	600	Steel Suspension
28	Thanlwin Bridge (Pharsaung)	1,260	Steel Truss + RCC
29	Bogyoke Aung San Bridge (Bilu Kyun)	5203.4	Steel Truss
River Chindwin			
30	Shinphyushin Bridge	4,957	Steel Truss
31	Chindwin Bridge (Monywa)	4,730	Steel Truss
32	Chindwin Bridge (Kalewa)	2805	Steel Truss
33	Chindwin Bridge (Khandi)	2656	Steel Truss

No	Name	Span (feet)	Type of Bridge
River Ayeyarwady			
1	Innwa Bridge (Sagaing)	3,960	Steel Truss
2	Nawaday Bridge	4,183	Steel Truss
3	Maubin Bridge	2,362	Steel Truss+ RCC
4	Bala Min Htin Bridge	2,688	Steel Truss
5	Bo Myat Htun Bridge	8,544	Steel Truss
6	Anawrahtar Bridge	5,192	Steel Truss
7	Ayeyarwady Bridge (Magway)	8,989	Steel Truss+ PC+RCC
8	Dadaye Bridge	4,088	Steel Truss+ RC
9	Ayeyarwady Bridge (Yadanarpon)	5,641	Steel Truss
10	Ayeyarwady Bridge (Nyaungdon)	10,814	Steel Truss
11	Ayeyarwady Bridge (Pakokku)	13,537	Steel Truss
12	Ayeyarwady Bridge (Sinkhan)	4,630	Steel Truss+ PC+RCC
13	Ayeyarwady Bridge (Malon)	5,839	Steel Truss+RCC+Borepile
14	Yadanartheinkha Bridge	2,480	Steel Truss+RCC+Borepile
15	Ayeyarwady Bridge (Hteegyaint)	7,730	Steel Truss+RCC
River Sittaung			
16	Sittaung Bridge (Theinzayat)	2,320	Steel Truss
17	Sittaung Bridge (Taungoo-Mawchi-Loikaw)	680	CH Steel Girder
18	Sittaung Bridge (Shwe Gying-Madauk)	1,500	PC+RCC
19	Sittaung Bridge (Mokepalin)	2,393	Steel Truss+ Plate Girder + RC
20	Sittaung Bridge (Natthankwin)	720	Steel Truss
River Thanlwin			
21	Kwan Lone Bridge	789	Steel Suspension
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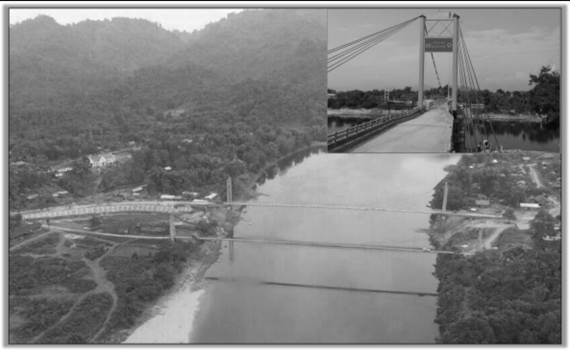
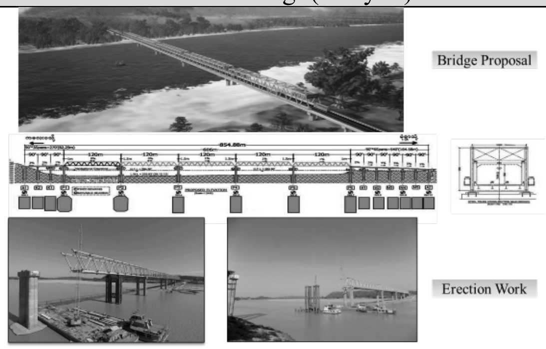
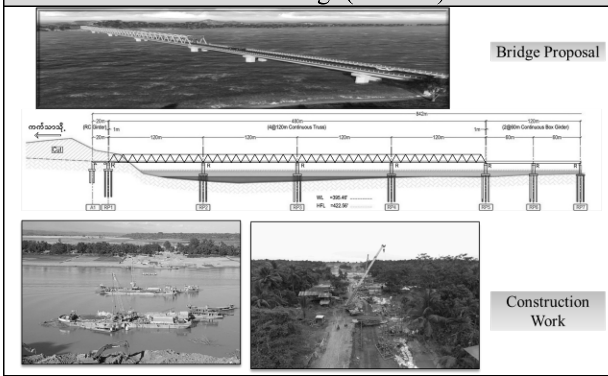
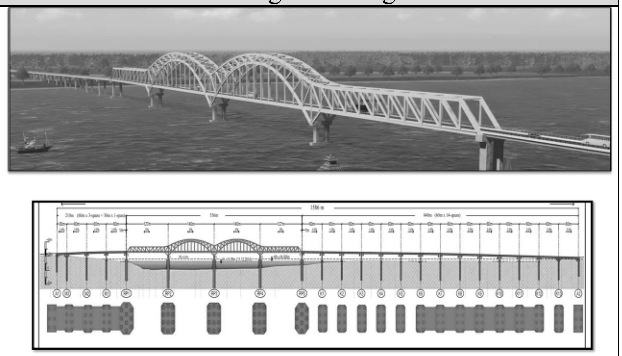
24	Thanlwin Bridge (Hpa-An)	2,252	Steel Truss
25	Thanlwin Bridge (Tarsan)	900	Suspension
26	Thanlwin Bridge (Mawlamyine)	11,575	Steel Truss+ PC+RCC
27	Thanlwin Bridge (Tarpar)	600	Steel Suspension
28	Thanlwin Bridge (Pharsaung)	1,260	Steel Truss + RCC
29	Bogyoke Aung San Bridge (Bilu Kyun)	5203.4	Steel Truss
River Chindwin			
30	Shinphyushin Bridge	4,957	Steel Truss

31	Chindwin Bridge (Monywa)	4,730	Steel Truss
32	Chindwin Bridge (Kalewa)	2805	Steel Truss
33	Chindwin Bridge (Khandi)	2656	Steel Truss

Source: Note Book 2019, MOC

Outline of major bridges constructed in 2016 and 2017 is summarized in Table 2.3.4.

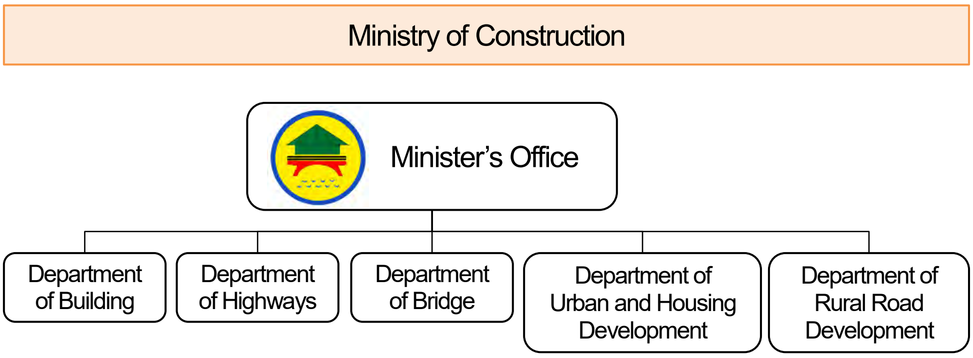
Table 2.3.4 Outline of Major Bridges Constructed in 2016 and 2017

Machanbaw Bridge in Kachin Region	Chindwin Bridge (Kalaywa)
	
Chindwin Bridge (Homalin)	Chaung Sone Bridge
	

Source: JICA Study Team based on information from MOC

(3) MOC's Organization

Current organization chart of MOC is shown in Figure 2.3.3. There are five departments, Department of Building (DOBi), Department of Highways (DOH), Department of Bridge (DOB), Department of Urban and Housing Development (DOUHD) and Department of Rural Road Development (DRRD) under the Minister's Office. DOH takes the responsibility for the planning, construction and maintenance of major roads, such as Expressway and National Highways, while DRRD takes the responsibility for the development of rural roads which connect villages to the main roads, and DOB takes responsibility for bridge planning, construction and maintenance.

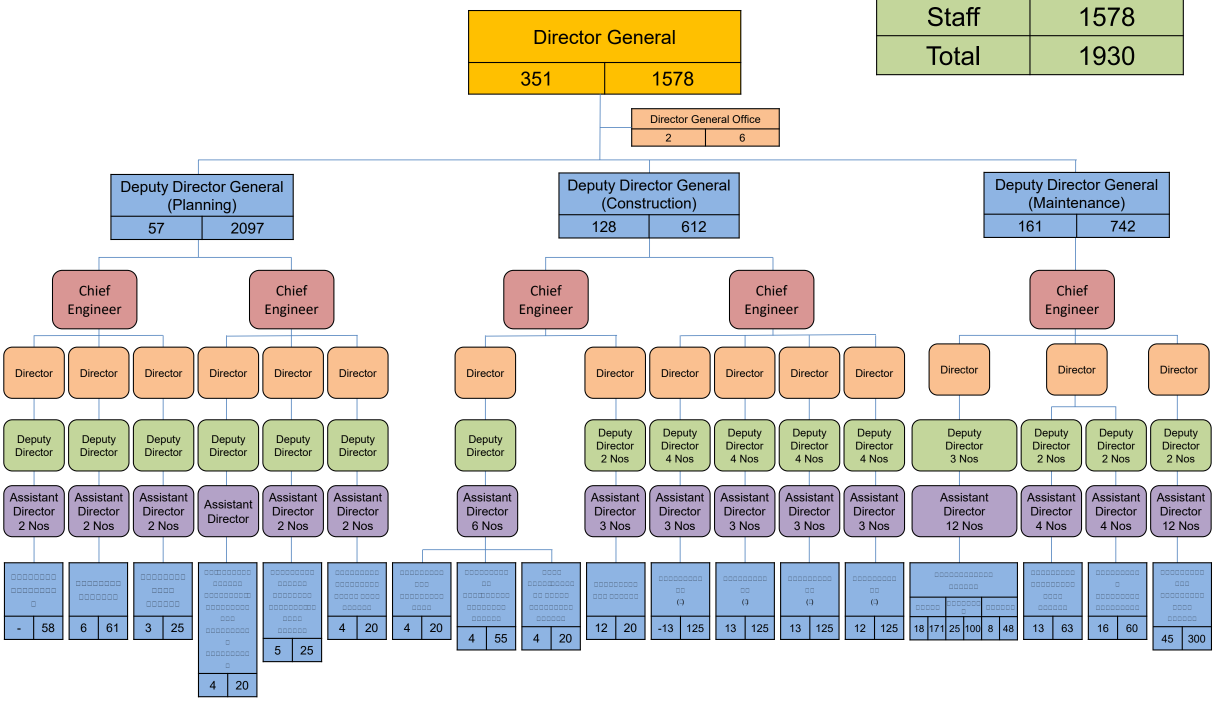


Source: MOC

Figure 2.3.3 MOC's Organization Chart

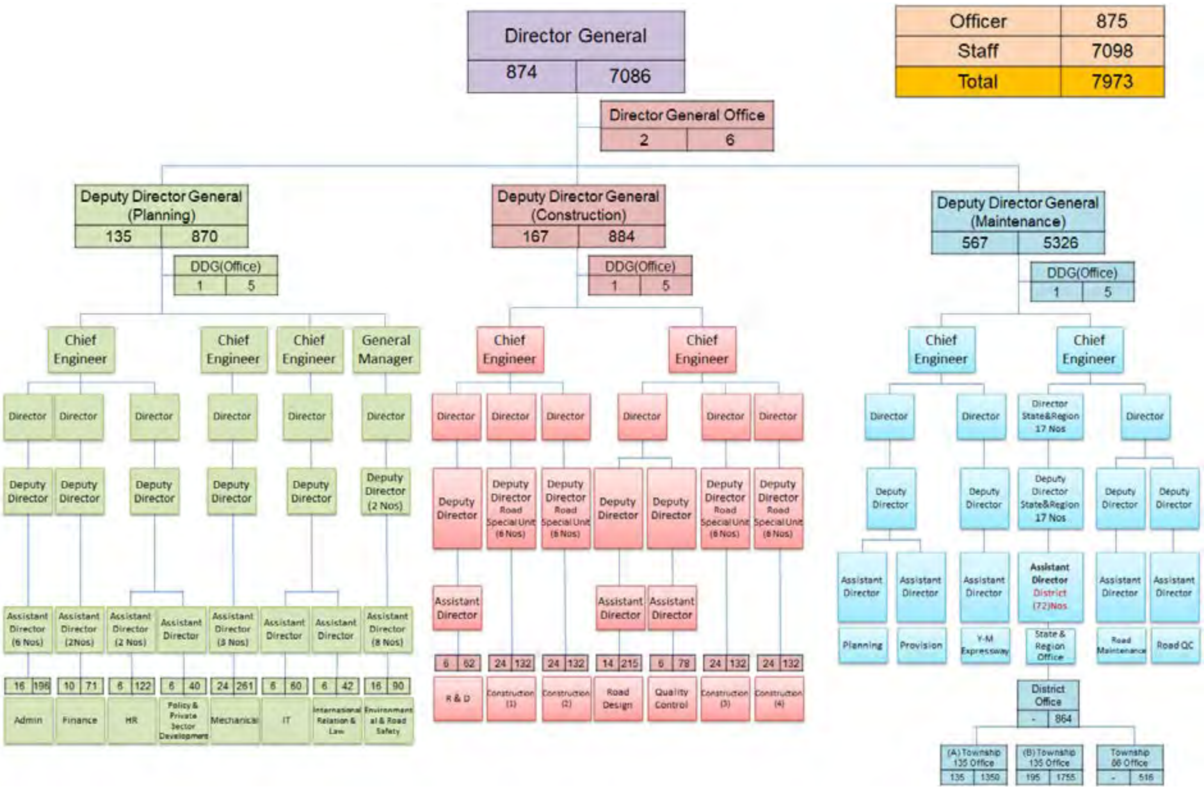
The current organization chart of DOB of MOC is shown in Figure 2.3.4 and that of DOH is shown in Figure 2.3.5. As for the number of DOH staff, around 8,000 personnel are working under the Director General. In addition to organization in the headquarters, MOC has Special Units for both roads and bridges all over the country, which consists of 24 units for roads and 20 units (including 4 construction units) for bridges as shown in Table 2.3.5. Actual site works for both construction and maintenance are implemented by Special Units. Therefore, MOC is working closely between the headquarters and Special Units. Moreover, the construction and maintenance of bridges with more than 50 feet in length (approx. 15 meters) is conventionally undertaken by Special Units under DOB, and on the other hand, construction and maintenance of bridges with 50 feet or less in length is undertaken by Special Units or local offices under DOH.

Officer	352
Staff	1578
Total	1930



Source: MOC

Figure 2.3.4 DOB's Organization Chart



Source: MOC

Figure 2.3.5 DOH's Organization Chart

Table 2.3.5 List of Special Unit

Road Special Unit		Bridge Special Unit	
Unit	State and city	Unit	State and city
Special Unit – 1	Kachin, Putao	Construction Unit –1	Mandalay, Mandalay
Special Unit – 2	Kachin, Myitkyina	Construction Unit –2	Mandalay, Nyaung Oo
Special Unit – 3	Shan, Kyaington	Construction Unit –3	Yangon, Yangon
Special Unit – 4	Shan, Shwenyaung	Construction Unit –4	Yangon, Yangon
Special Unit – 5	Shan, Loilam	Special Unit –1	Kachin, Myitkyina
Special Unit – 6	Shan, Lashio	Special Unit –2	Sagaing, Monywa
Special Unit – 7	Sagaing, Kalewa	Special Unit –3	Magway, Pakokku
Special Unit – 8	Sagaing, Phaungpyin	Special Unit –4	Mandalay, Mandalay
Special Unit – 9	Mandalay, Meikhtilar	Special Unit –5	Magway, Seikphyu
Special Unit – 10	Chin, Hakha	Special Unit –6	Nay Pyi Taw, Nay Pyi Taw
Special Unit – 11	Magway, Minbu	Special Unit –7	Rakhine, Kyauktaw
Special Unit – 12	Sagaing, Gangaw	Special Unit –8	Rakhine, Minpya
Special Unit – 13	Naypyidaw, Pyinmanar	Special Unit –9	Bago, Bago
Special Unit – 14	Yangon, Yangon	Special Unit –10	Yangon, Hlagu
Special Unit – 15	Taunggo, Bago	Special Unit –11	Yangon, Yangon
Special Unit – 16	Rakhine, Ann	Special Unit –12	Shan, Loilam
Special Unit – 17	Rakhine, Sittwe	Special Unit –13	Taninthari, Myeik
Special Unit – 18	Rakhine, Taunggok	Special Unit –14	Taninthari, Mawlamyine
Special Unit – 19	Mon, Mawlamyine	Special Unit –15	Ayeyarwady, Pyapon
Special Unit – 20	Ayeyarwady, Yegyi	Special Unit –16	Ayeyarwady, Bogalay
Special Unit – 21	Ayeyarwady, Nyaungdon	Total: 24 units for road 20 units for bridge	
Special Unit – 22	Kayin, Hpa-An		
Special Unit – 23	Taninthari, Dawei		
Special Unit – 24	Taninthari, Myeik		

Source: MOC

(4) Budget for Roads and Bridges

Budget for the construction and maintenance of the roads and bridges in Myanmar is allocated by the government based on the national annual budgetary plan. The annual budget of both DOH and DOB is shown in Table 2.3.6 and Table 2.3.7.

Table 2.3.6 Budget amount for road and bridge

Unit: million Kyat

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

Source: JICA Study Team based on information from MOC

Table 2.3.7 Actual Budget of DOB (Million Kyat)

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

Source: DOB, MOC

DOH and DOB prepare the budget proposal for the next fiscal year and submit it to the Minister's office. MOC organizes proposals from each department and submit the budget request to the Ministry of Planning and Finance usually in November. After review by the Ministry of Planning and Finance, the Parliament gives approval to MOC in February next year and amount of budget allocation is decided.

As for the road and bridge maintenance budget, site engineers in each Special Unit confirm site conditions and report to the Headquarters. Staff in the Headquarters decides the quantity for construction and maintenance based on the reports from site offices and prepares the budget proposal. In the maintenance budget, "Routine maintenance", "Periodic Maintenance", "Special Maintenance", "Disaster Restoration" and "Maintenance for Yangon-Mandalay Expressway" are included. For the decision of the maintenance budget amount for the next year, the actual budget amount for the previous year is taken into account.

(5) Involvement of Private Sector (BOT)

Road improvement by private sector (Build-Operate-Transfer: BOT) is widely executed in Myanmar. Most of the road and bridge construction has been implemented directly by MOC, so there are few cases of BOT. After the transition to democracy in March 2011, BOT road construction is under way and it is necessary to pay close attention to future trends. Currently, the Yangon - Mandalay

Expressway is under the direct control of MOC.

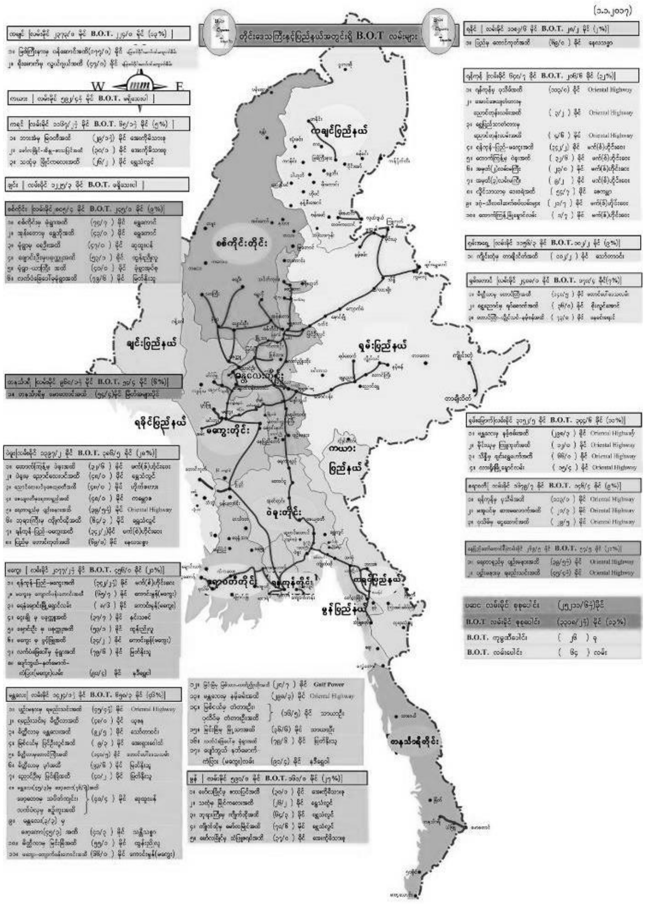
BOT projects in Myanmar are listed in Table 2.3.8 and a map of BOT road network is shown in Figure 2.3.6.

Table 2.3.8 List of BOT Projects in Myanmar (as of 2018)

Company Name	Road Name, Road Section	Road Length (km)
Asia World	1. Mandaly-Lashio-Muse-NantKham road 2. Maiyu-Kyukot road 3. Theinni-Kwan Lone-Chinshwehaw road 4. Yangon-Bago-Meikhtilar-Mandalay (Yaytarshay-Pyinmanar) 5. Yangon-Bago-Meikhtilar-Mandalay (Pyinmanar-Yamethin) 6. Myitnge-Htonebo-Pyinoolwin 7. Pathein-Ngwesaung 8. Yangon-Pathein 9. From Approach road of Aungzayya bridge to Nyaungdone junction 10. From Shwepyithar bridge to Nyaungdone junction 11. Maubin-Sarmalauk	1. 480 2. 193.12 3. 106.21 4. 63.8 5. 73 6. 15 7. 47.5 8. 181.8 9. 5.2 10. 7.2 11. 34.3 Total – 1207.13
Thawtarwin Consrtuction	1. Kyaingtone-Tachileik 2. Yangon-Bago-Meikhtilar (Meikhtilar-Mandalay)	1. 164.5 2. 141.6 Total – 306
Yuzana Construction	1. Yangon-Bago-Meikhtilar-Mandalay (Yemethin-Meikhtilar) 2. Myitkyina-Sadon-Kanpiketii (Winemaw-Kanpiketii) 3. Kawthaung-Bokpyin (50mile from Kawthaung) 4. Myeik-Tanintharyi 5. Tanintharyi-Thalphyu 6. Thalphyu-Maungdaw	1. 77 2. 123.9 3. 80.5 4. 80.5 5. 51.5 6. 58 Total – 471.5
Aye Ko family Constuction	1. Hpa-An-Kawkareik-Myawaddy 2. Mawlamyine-Eindu-Zarthapyin 3. Mawlamyine-Mudon-Thanphyuzayat	1. 45 2. 72.5 3. 59.5 Total – 177
Lido Highway	Myitkyina-Pansauk-Lido (Myitkyina – Nantmatee – Tanine)	Total – 139
PaHtama Shwenangar Construction	Pahote(Moekaung)-KarMine-Lawa-LoneKhin-PharKant	Total – 105
Naymin Yaung	Taunggyi-Loilem-NantSam	Total – 117.5
Shwethanlwin Highway	1. Yangon-Myeik (Phayargyi – Kyaikto =56/3) (Mokepalin approach road = 8/0) 2. Thaton-Hpa-An (Thaton-Myinekalay) 3. Yangon – Myeik (Kyaikto-Thaton-Mawlamyine) 4. Yangon-Bago-Meikhtilar-Mandalay(Bago-Nyaunglebin)	1. 103 2. 42 3. 115 4. 77.2 Total – 337
Max Myanmar	1. Yangon-Pyi-Mandalay(Yangon-Pyi-Magway) 2. No.4 road (6/0 to 12/4) 3. Yangon-Bago-Meikhtilar-Mandalay (Htaukkyant-Bago) 4. No.2 road (Thingangyun-Zayatkwin) 5. No.3 road 6. No.7 road 7. Htaukkyant Bypass 8. Bago-Thanatpin-Khayan-Thongwa-Thanlyin (Dagon bridge-Thilawa industry zone) (Thanlyin-Kyauktan) Thanlyin – Thilawa port) (Thanlyin – Thilawa-Lower Pardagyi) (Pardagyi – Thilawa)	1. 537 2. 10 3. 52 4. 23 5. 14.5 6. 19.3 7. 2.6 8. 168 Total – 826.4
NayLa Thitsar Construction	1. Pyi – Taunggok 2. Taunggok – Thandwe – Ngapali – Mazin - Lonethar	1. 164 2. 91 Total – 255
Kyauksein Myay Construction	Mandalay – Lashio – Bamaw – Myitkyina (Bamaw – Myitkyina)	Total – 188

Suhtupan Construction	1. Mandalay – Phawtaw (45/3 to 76/4), Phawtaw – Thabeikkyin (10/7), Latpanhla – Sintku (5/4) 2. Katha – Indaw, Naba – Nantsiaung 3. Monywa - Yayoo	1. 76.4 2. 64 3. 75.6 Total – 216
Taungpawdaytha Construction	Meikhtilar – Taunggyi – Kyaing Tong – Tachileik (Meikhtilar – Taungyi)	Total – 226
Kaungmon Construction	1. Yangon – Pyi – Mandalay (Magway – Yaynanchaung – Gwaycho – Kyaukpadaung) 2. Magway – Minbu – Pwintphyu	1. 106 2. 54.7 Total – 160.7
Myatnoethu Construction	1. Meikhtilar – Kyaukpadaung – Nyaung Oo – Bagan 2. Bagan – Nyaung Oo – Myinchan (Nyaung Oo – Myinchan)	1. 150 2. 64 Total – 215
Shwetaung Development	1. Mandalay – Sagaing – Monywa – Yayoo (Sagaing – Monywa), (Myinmu bypass) 2. Mandalay – Sagaing – Shwebo (Ohntaw – Shwebo)	1. 117 2. 69 Total – 186
Monywa Group Construction	Monywa – Yargyi	Total – 40/0

Source: MOC



[BOT Length by State]

Source: JICA Study Team based on information from MOC

Figure 2.3.6 Map of BOT Road Network

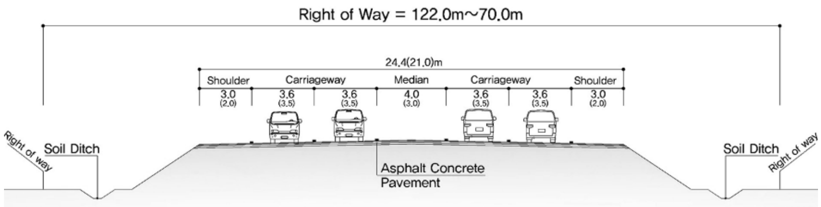
2.3.2 National Highways

(1) Expressway

The total length of Expressway in Myanmar is currently 586km and there is only one route, Yangon-Mandalay Expressway, which has four-carriageway and can serve as a high-speed arterial road for the northern and southern direction of the country. An outline of the Yangon – Mandalay Expressway is summarized in Figure 2.3.7.

[Scope of each section]

S.N	Section	Construction Period	Length (km)	Opened to Public
1	Yangon-Nay Pyi Taw	10/2005-3/2009	390	25/3/2009
2	Nay Pyi Taw-Sagaing	7/2008-12/2010	177	29/12/2010
3	Sagaing- Tadaoo-Tagonedine	1/2011-12/2011	22	23/12/2011
	Total Length		586	



[Typical Cross section]

[Map of Expressway] [Current condition]

Source: JICA Study Team based on information from MOC

Figure 2.3.7 Outline of Yangon – Mandalay Expressway

(2) National Highway

Currently, the National Highway Network with a total length of about 20,000km covers the whole country and it is controlled under the jurisdiction of MOC. Some highways are maintained by private companies under BOT contract as shown in Table 2.3.8, such as National Highway No.8 between Bago and Thaton section by Shwe Than Lwin Highway Co., Ltd. As for the BOT sections, the road surface is kept in a relatively good condition.

On the other hand, National Highways in rural areas are mainly maintained by MOC directly and the road conditions are comparatively poor compared with highways in urban areas maintained under BOT contract.

Issues related to the existing National Highways are as listed below:

- Widening of roads to cope with increase of traffic volume
- Improvement to all-weather type roads

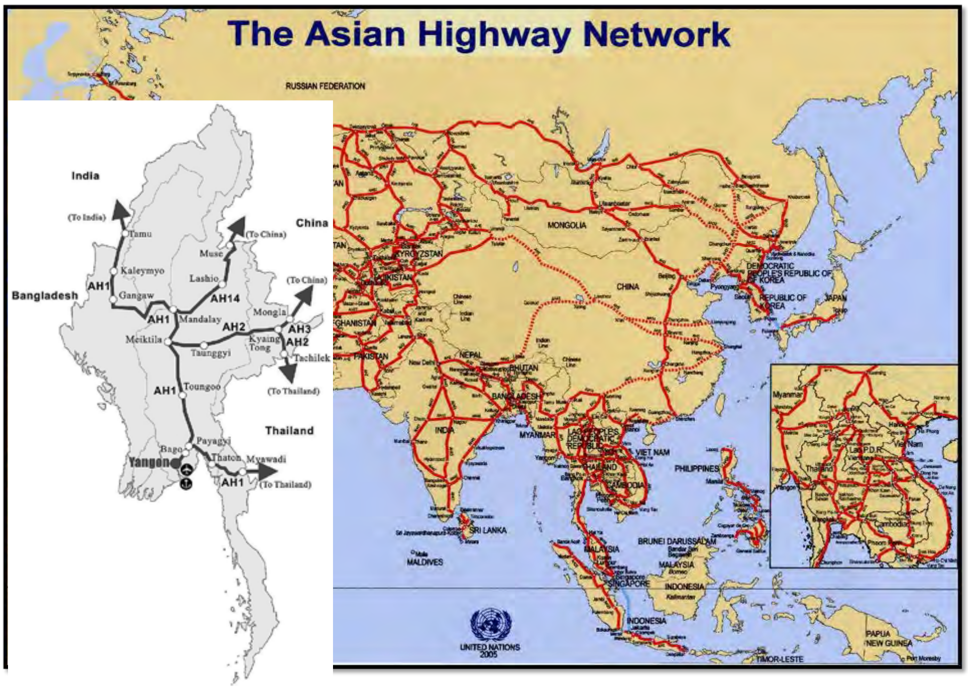
- Development of the paved shoulder to improve road safety
- Reconstruction of deteriorated bridges which is a bottleneck on the highway
- Development of the bypass route to divert around the urban area
- Promotion of pedestrian – vehicle separation by installing sidewalks
- Safety enhancement by installing the traffic safety facilities, such as road markings and traffic signs, and by providing the superelevation
- Unification and improvement of standards and standards for roads and bridges
- Intensification of regulation against entry in the road site (ROW)
- Reduction of the traffic accidents

In the 30-Year Plan by MOC, it is planned that the main National Highways will be 24 feet-wide 2 lanes roads and all bridges on the highway will be permanent bridges having the width of the corresponding roads.

2.3.3 International Highways

(1) Asian Highways

Asian Highways is the international highway network initially established by UNESCAP in 1959, with its approximately 141,000km length of road networks covering 32 countries. In Myanmar, there are four Asian Highways with a total length of 3,003km. AH1 (Myawaddy-Yangon-Mandalay-Tamu: 1,650km), AH2 (Tachileik-Meikhtilar-Tamu: 807km), AH3 (Mongla-Kyaing Tong: 93km) and AH14 (Muse-Mandalay: 453km) are linking to neighboring countries such as Thailand, China and India. The Asian Highways Network and outline of each Highway are summarized in Figure 2.3.8 and Table 2.3.9. New Sittaung Bridge is planned on a bypass route which is a part of AH1 as well as the GMS East-West Economic Corridor.



Source: MOC

Figure 2.3.8 Map of Asian Highways Network

Table 2.3.9 Current Status of Asian Highways in Myanmar

Sr. No.	ASIAN Highway Route No.	National Highway Route No.	City/Town Name at Starting Point	City/Town Name at Ending Point	Sub-Total Length (Km)	Total Length (Km)	Road Class	Expected Completion Year of Construction	AADT (2011)	Budget Needed for Road Construction (million US$)	Remark
1	AH-1		Tamu	Mandalay	610	1656	3,below3	2014-15	423		1208 km of these routes
			Mandalay	Meiktila	167		1,3		2713		have been upgraded
			Meiktila	Yangon	540		1,3		2050		to class3 level
			Yangon	Bago	80		1,3		2697		
			Bago	Payagyi	16		3		1896		
			Payagyi	Thaton	144		3		1487		
			Thaton	Myawadi	195		3, below3		792		
2	AH-2		Meiktila	Loilem	276	807	2,3 below 3	2014-15	527		350 km of these routes
			Loilem	Kyaingtong	367		below3		44		have been upgraded
			Kyaingtong	Tachileik	164		3		195		to class3 level
3	AH-3		Mongla	Kyaingtong	93	93	3	2012	100		93 km of these routes
											have been upgraded
											to class3 level
4	AH-14		Mandalay	Thibaw	245	453	1,3	N/A	2378		453 km of these routes
			Thibaw	Muse	208		3		1828		have been upgraded
											to class3 level

Source: MOC

(2) ASEAN Highways

ASEAN Highways comprise of 23 routes with a total length of about 38,400km and are under development for the purpose of the establishment of efficient, integrated, safe and environmentally sustainable regional land transport corridors linking all ASEAN countries. There are 7 routes in Myanmar designated as parts of the ASEAN Highway Network. 4 routes are the same as the Asian Highways and there are 3 other routes, AH111 (Thibaw-Loilem), AH112 (Thaton-Dawei-Khongloy) and AH123 (Dawei-Maesamee Pass). ASEAN Highways link Myanmar to China, India, and Thailand, and are playing important roles as major international road networks in the country.

Current Status of the ASEAN Highways in Myanmar

Sr. No.	ASEAN Highway Route No.	National Highway Route No.	City/Town Name at Starting Point	City/Town Name at Ending Point	Sub-Total Length (Km)	Total Length (Km)	Road Class	Expected Completion Year of Construction	AADT (2011)	Budget Needed for Road Construction (million US$)	Remark
1	AH-1		Tamu	Mandalay	610	1656	3,below3	2014-15	423		1208 km of these routes
			Mandalay	Meiktila	167		1,3		2713		have been upgraded
			Meiktila	Yangon	540		1,3		2050		to class3 level
			Yangon	Bago	80		1,3		2697		
			Bago	Payagyi	16		3		1896		
			Payagyi	Thaton	144		3		1487		
			Thaton	Myawadi	195		3, below3		792		
2	AH-2		Meiktila	Loilem	276	807	2,3 below 3	2014-15	527		350 km of these routes
			Loilem	Kyaingtong	367		below3		44		have been upgraded
			Kyaingtong	Tachileik	164		3		195		to class3 level
3	AH-3		Mongla	Kyaingtong	93	93	3	2012	100		93 km of these routes
											have been upgraded
											to class3 level
4	AH-14		Mandalay	Thibaw	245	453	1,3	N/A	2378		453 km of these routes
			Thibaw	Muse	208		3		1828		have been upgraded
											to class3 level
5	AH-111		Thibaw	Loilem	239		below 3	N/A	275		
6	AH-112		Thaton	Mawlamyine	66		3		872		103 km of these routes
			Mawlamyine	Thanbyuzayat	64	1145	2, below 3	2015	740		have been upgraded
			Thanbyuzayat	Ye	91		below 3		161		to class3 level
			Ye	Dawei	155		below 3		116		
			Dawei	Lehnya	449		below 3		154		
			Lehnya	Khamaukgyi	206		below 3		26		
			Lehnya	Khongloy	60		-		0		For Future proposed
											aligment
7	AH-123		Dawei	Maesamee Pass	141	141	-	2015	36		constructed by ITD &
											Max Myanmar Co.,
											corridor of Dawei Deep
											Seaport Project

Source: MOC

Figure 2.3.9 Current Status of Asian Highways in Myanmar

(3) GMS Economic Corridor

The Greater Mekong Subregion (hereinafter referred to as "GMS") is a natural economic area bound together by the Mekong River, covering 2.6 million km^2 and with population of around 326 million. The GMS countries, Cambodia, China, Lao PDR, Myanmar, Thailand and Vietnam, have actively participated in a comprehensive program of economic cooperation, which is called as the "GMS Program", with the support of ADB and other development partners since 1992. The GMS Program is being implemented not only to improve freight transportation and facilitate trade in the region but also for the development of the transportation network across the Mekong sub region.

The GMS Economic Corridor originally consists of nine corridors, and five corridors (North-South Economic Corridor, East-West Economic Corridor, Southern Economic Corridor, Northern Economic Corridor and Western Economic Corridor) out of the nine corridors passing through Myanmar as shown in Figure 2.3.10. As for the GMS EWEC having 1,481km in total length, the road surface condition is in good condition at most of the sections due to improvement work. For example, the ADB-funded GMS Highway Expansion Project 1, co-financed by the Thai Government, has upgraded a 178 km section of the EWEC in Thailand; specifically, a 105km section of Highway No.12 running from Phitsanulok to Lom Sak was completed in Nov 2015. Also, a JICA Grant Aid project for upgrading 58 km of road in Savannakhet Province of Lao PDR was completed in March 2015. In Myanmar, the construction of a 28km length of bypass between Kawkareik and Myawaddy, funded by the Thai Government, was completed in August 2015, providing a new route to go around the Dawna mountain range. In addition, the road improvement between Eindu and Kawkareik is planned to be completed in May 2021 with aid by ADB and the existing bottleneck bridges are expected to be replaced with new bridges by July 2021, with aid from JICA. However, the remaining sections of the EWEC in Myanmar still need substantial improvement if they are to become part of a fully functioning transport corridor.

Moreover, according to the foregoing discussion among the GMS countries in 2016, some proposals for realignment and/or extension have been identified as shown in Figure 2.3.11. As for the East-West Economic Corridor, an extension at the west end to Yangon-Thilawa using the Myawaddy-Kawkareik-Eindu-Hpa-An-Thaton-Kyaikto-Payagyi-Bago-Yangon-Thilawa route, with a possible extension to Pathein[4].

Under the above circumstances, New Sittaung Bridge is planned on a bypass route of the GMS EWEC as well as AH1. The GMS EWEC connects the regional hubs such as Bago and Mawlamyine, with Yangon. Also, the linkages among the major land developments, such as Hanthawaddy New International Airport in Bago, SEZ and a deep sea port plan in Dawei, industrial park development plan in Mawlamyine, etc., are expected to enhance economic activities along the corridor which is the next priority after the north-south corridor between Yangon - Mandalay, because it is the second highest traffic demand.

4 The length from Myawaddy to Yangon is approximately 400km and to Pathein is approximately 600km.

Source: ADB

Figure 2.3.10 GMS Economic Corridor (2006-2015)

Source: Review of Configuration of the Greater Mekong Subregion Economic Corridors (ADB)

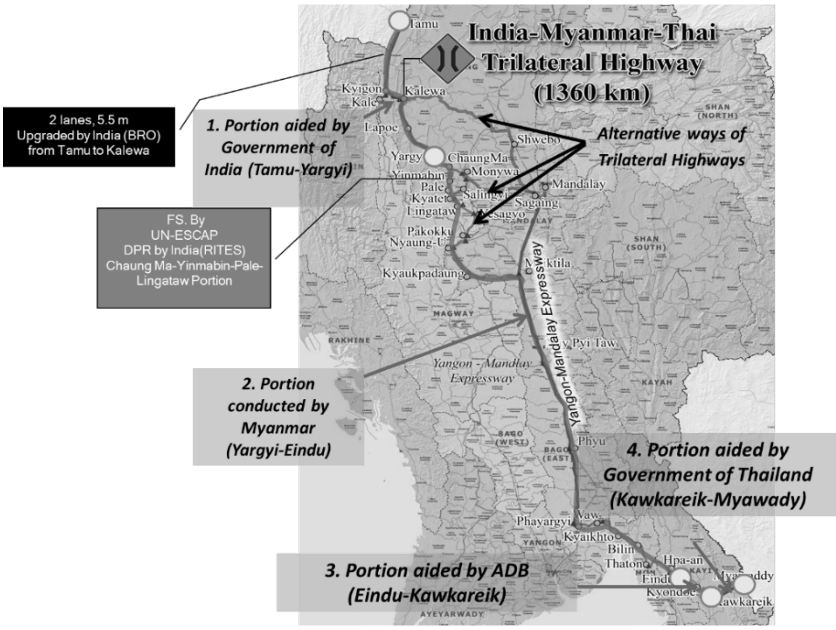
Figure 2.3.11 Proposed Realignment and/or Extension on the GMS Economic Corridors

2.3.4 Other Roads

(1) India-Myanmar-Thailand Trilateral Highway

The India–Myanmar–Thailand Trilateral Highway is under construction that will connect Moreh, India with Mae Sot, Thailand via Myanmar. The road is expected to boost trade and commerce in the ASEAN–India Free Trade Area, as well as with the rest of Southeast Asia. This highway includes the Yangon-Mandalay Expressway and the GMS EWEC in its route as shown in Figure 2.3.12. India has also proposed extending the highway to Cambodia, Laos and Vietnam by connecting the GMS EWEC.

As for the progress, Myanmar approved a proposal from the Thai Government permitting the latter to upgrade a 68km section of the road between Thaton in Mon State and Eindu in Kayin State in February 2017. The upgrade will be financed by Thailand at a cost of US$51 million. Under the project, the road will be widened and its surface will be improved. Myanmar also requested Thailand to assist in the development of other sections of the highway. In May 2017, India's NITI Aayog, which is a policy think-tank of Indian Government, proposed establishing a Special Purpose Vehicle (SPV) owned by all three countries to monitor and implement the project.



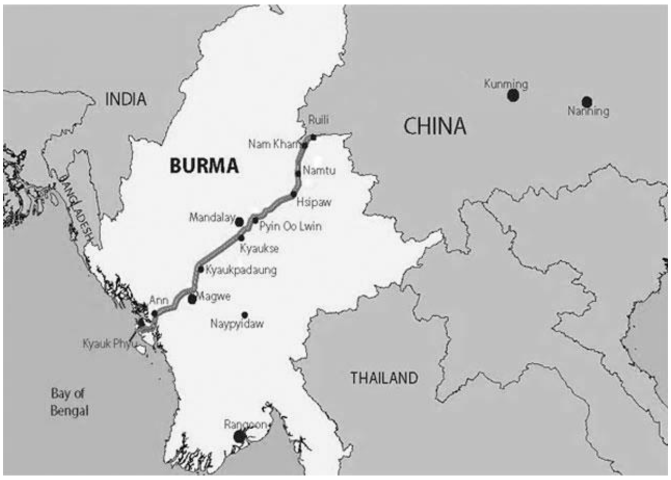
Source: MOC

Figure 2.3.12 MAP of India-Myanmar-Thailand Trilateral Highway

(2) Ruili - Kyaukpyu Corridor

Ruili-Kyaukpyu Corridor will connect Ruili, a border town in Yunnan province in China bordering Myanmar's Muse town, with Kyaukphyu, a town on the western coast of Myanmar with the Kyaukphyu Port. Together with the Hambantota Port in Sri Lanka, the Gwadar Port in Pakistan and Kyaukphyu Port form a triangular maritime route that encloses India, therefore, it is important for China to construct the corridor. These projects within the framework of the "One Belt and One Road" (OBOR) Initiative would change the economic landscapes of the landlocked Chinese provinces/autonomous regions. It will also be an accomplishment of the "Two-Ocean" strategy of China. If successfully implemented, these economic corridors and SEZs will boost China's reform and opening up policy. The Yunnan provincial authorities have been demanding to develop railway and road links to Myanmar's western coast. The oil and natural gas dual pipeline projects have strengthened the Chinese presence along the Rakhine coast. Ruili, a border town in Yunnan Province bordering Myanmar's Muse town, will see larger volumes of trade with the opening of the Ruili-Muse economic zone. This border economic zone will find greater vitality when the Kyaukphyu SEZ comes into operation. Myanmar and China talked about the Ruili-Kyaukphyu Corridor in August 2015 and

China intended to persuade Myanmar to establish the SEZ and the economic corridor for Yunnan Province to become a hub of regional trade and financial services.



Source: Website http://www.ramree.com/2014/03/01/chinas-2-billion-loan-road-project-refused-by-burma/

Figure 2.3.13 Map of Ruili-Kyaukpyu Corridor

2.4 Road Transportation in Myanmar

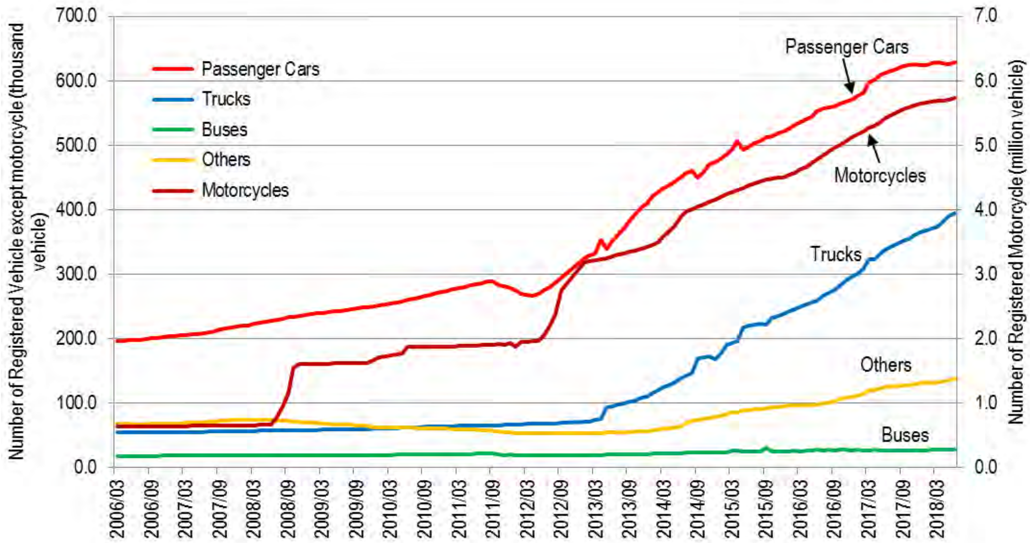
2.4.1 Number of Motor Vehicles

Import of motor vehicles in Myanmar had been restricted by the control of import permission since 1997 because of a shortage of foreign currency reserve. Thereafter, the restriction of the import of completed vehicles was removed gradually from September 2011 to July 2012. As the result, imported and registered vehicles have increased rapidly since 2012 as shown in the following table and figure. As of March in 2018, 5.9 million motorcycles, 628,000 passenger cars, 374,000 trucks and 28,000 buses are registered in Myanmar.

Table 2.4.1 Registered Motor Vehicles and Annual Growth Rate

	Passenger Cars		Trucks		Buses		Motorcycles		Others		Total	
FY 2017/18	628,054	5%	374,287	16%	28,010	5%	5,690,773	8%	132,871	11%	6,853,995	8%
FY 2016/17	596,549	11%	322,533	29%	26,801	3%	5,271,105	14%	120,014	23%	6,337,002	14%
FY 2015/16	536,471	8%	250,529	29%	25,937	-3%	4,631,007	8%	97,316	13%	5,541,260	9%
FY 2014/15	494,657	14%	193,559	55%	26,746	21%	4,276,696	19%	86,041	40%	5,077,699	20%
FY 2013/14	434,169	31%	124,597	67%	22,151	12%	3,595,474	12%	61,291	13%	4,237,682	15%
FY 2012/13	331,468	24%	74,546	10%	19,812	1%	3,219,213	65%	54,070	1%	3,699,109	56%
FY 2011/12	267,561	-4%	67,750	4%	19,579	-7%	1,955,505	4%	53,352	-11%	2,363,747	2%
FY 2010/11	279,066	10%	64,888	6%	20,944	6%	1,883,958	8%	59,665	-5%	2,308,521	8%
FY 2009/10	254,797	6%	61,132	4%	19,807	1%	1,749,083	8%	62,585	-8%	2,147,404	7%
FY 2008/09	239,895	8%	58,857	3%	19,683	2%	1,612,423	145%	68,102	-9%	1,998,960	94%
FY 2007/08	222,661	8%	57,211	3%	19,291	2%	658,997	2%	74,682	7%	1,032,842	4%
FY 2006/07	206,020	5%	55,382	1%	18,857	5%	646,872	1%	69,625	2%	996,756	2%
FY 2005/06	196,314	-	54,801	-	18,038	-	641,777	-	68,358	-	979,288	-

Source: The Myanmar Statistical Information Service (MMSIS)



Source: The Myanmar Information System (MMSIS)

Figure 2.4.1 Registered Motor Vehicles by Type

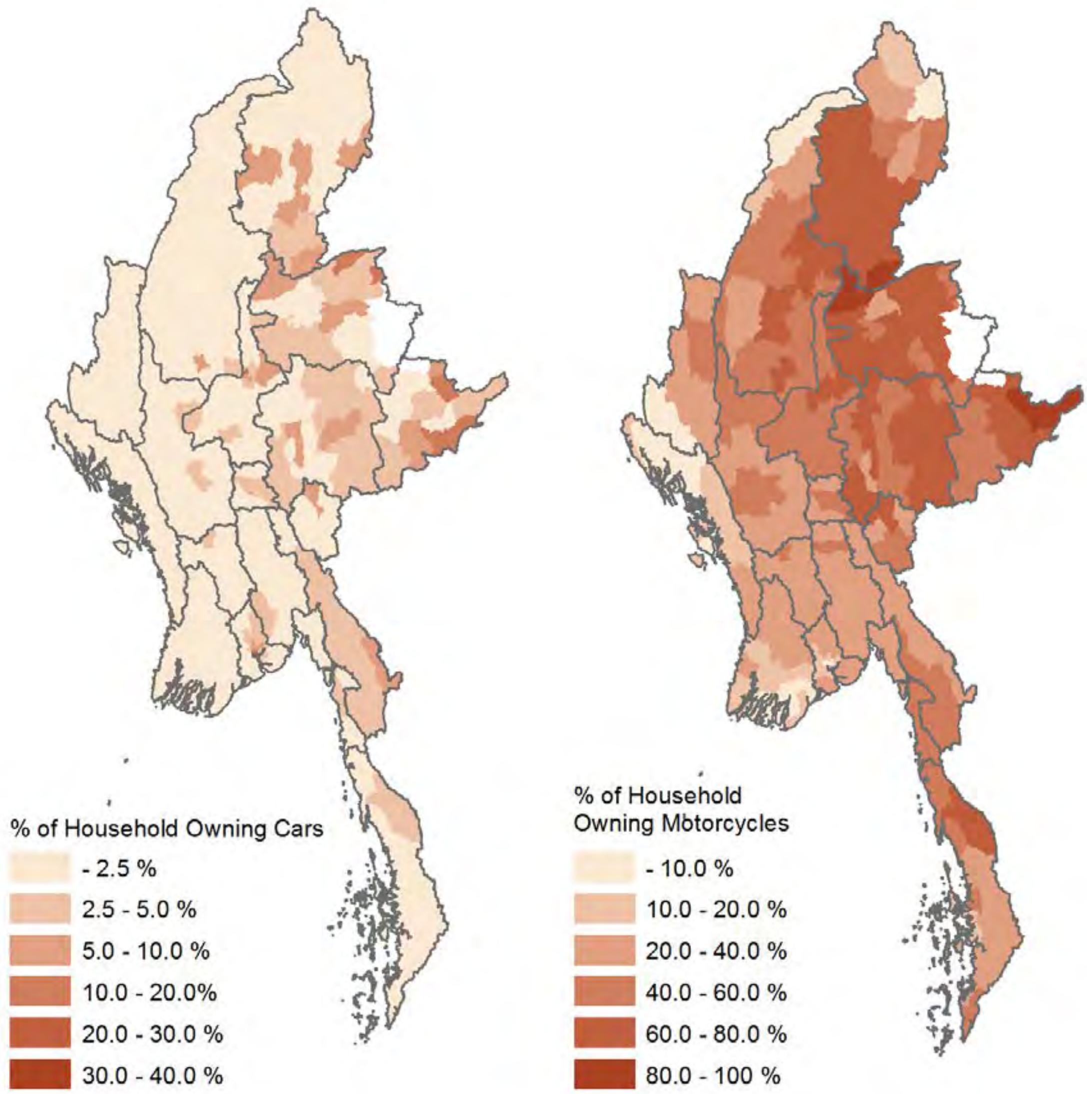
As of 2014, however, the vehicle ownership ratio in Myanmar is still low, only 3.1% of households own cars (including trucks and vans), and 38.7% of households own motorcycles (including mopeds).

Table 2.4.2 Percentage of Households Owning Vehicles in 2014

State/Region	Number of Households ('000)	% of households owning Car/Truck/Van	% of households owning Motorcycle/Moped
Kachin	269	4.1%	70.1%
Kayah	57	3.3%	60.1%
Kayin	308	4.0%	41.5%
Chin	91	0.8%	28.1%
Sagaing	1,097	1.7%	55.8%
Tanintharyi	283	1.7%	41.8%
Bago	1,143	1.2%	34.3%
Magway	920	1.4%	38.8%
Mandalay	1,323	4.4%	58.2%
Mon	423	2.6%	42.0%
Rakhine	460	0.5%	11.9%
Yangon	1,583	7.8%	13.6%
Shan	1,170	4.5%	63.6%
Ayeyarwady	1,489	0.6%	18.6%
Nay Pyi Taw	262	3.2%	41.9%
Total	10,878	3.1%	38.7%

Source: The 2014 Myanmar Population and Housing Census

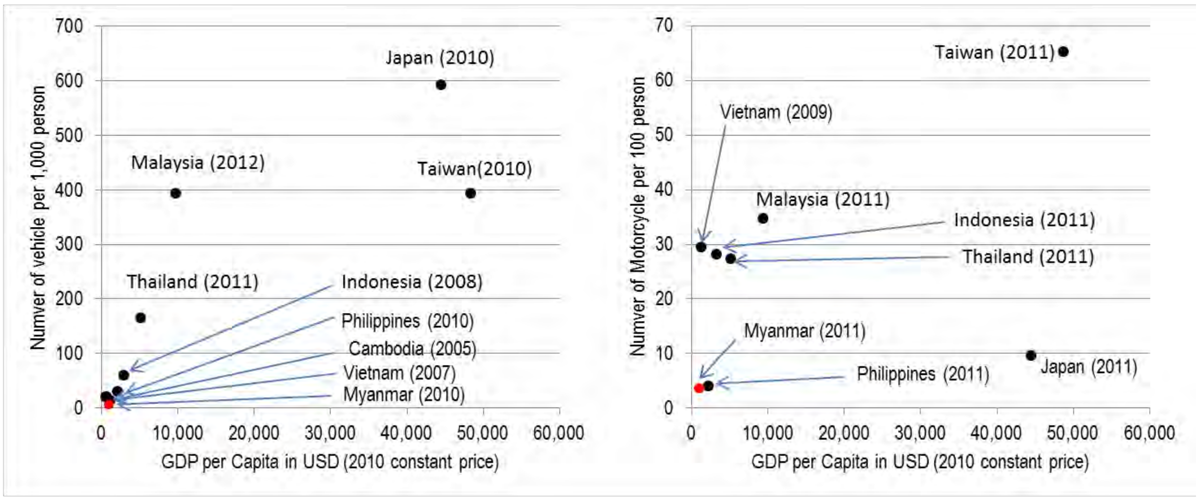
The following figures show the spatial distribution of household owning motor vehicles based on the 2014 Census. Generally, the higher percentage of household owning cars (including trucks and vans) is observed in large cities such as Yangon and Mandalay, and at major cross-borders with Thailand and China.



Source: The 2014 Myanmar Population and Housing Census

Figure 2.4.2 Percent of Household Owning Motor Vehicles

The vehicle ownership ratio of Myanmar is lower than the other ASEAN countries, therefore, the number of motor vehicles is expected to increase in accordance with economic growth in Myanmar. As with the increase of the number of vehicles, private vehicle trips are also expected to increase instead of trips by public transport.

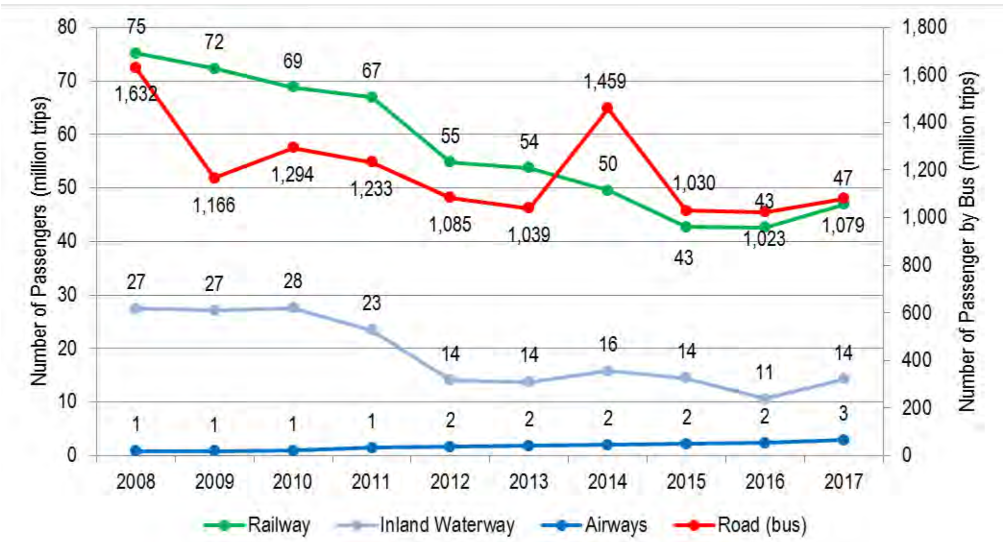


Source: World Bank, Japan Automobile Manufacturers Association, Inc. (JAMA)

Figure 2.4.3 Number of Vehicles per Population in Asian Countries

2.4.2 Passenger and Freight Volume

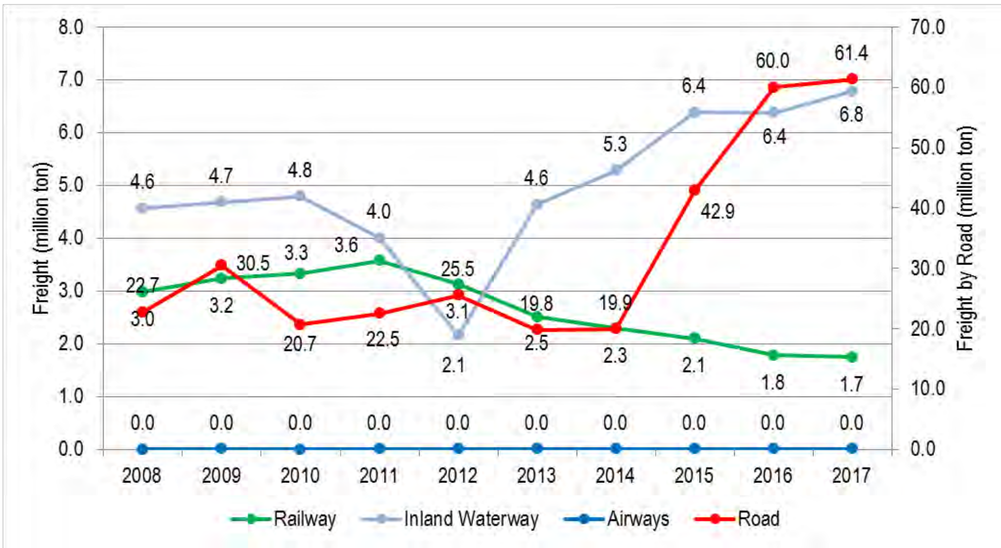
Person trips by public transport mode, as shown in following figure, have been decreasing since 2008, except for airways. The most popular public transport in Myanmar is public buses (94% as of 2017), followed by railway (4% as of 2017).



Source: ASEAN-Japan Transport Partnership (AJTP)
Note: Passenger of airways is only domestic flight passenger.

Figure 2.4.4 Number of Passengers by Transport Mode

As well as personal trips, freight volume is dominated by road transport such as trucks and trailers; 88% of freight is transported by road, 10% is inland water transport and 2% is railway as of 2017. Freight volume in Myanmar is expected to increase in accordance with economic growth and industrialization, therefore, freight by road transport is expected to increase. On the other hand, improvement of railway and inland water transport is expected to contribute to ecological logistic systems in Myanmar and alleviation of road congestion.



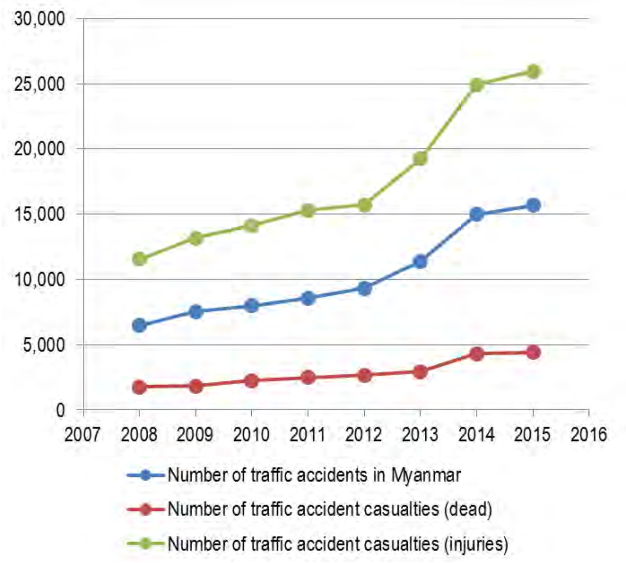
Source: ASEAN-Japan Transport Partnership (AJTP)

Note: Freight volume of airways is only domestic flight.

Figure 2.4.5 Freight Volume by Transport Mode

2.4.3 Road Traffic Accident

In accordance with growth of motor vehicles including private and public, road traffic accidents are also increasing. Traffic accidents in Myanmar have rapidly increased in 2013-2014. The impact is likely caused by the increase of registered vehicles because of the deregulation in 2011-2012.



Source: ASEAN-Japan Transport Partnership (AJTP), Population Division of the Department of Economic and Social Affairs of the United Nations

Figure 2.4.6 Road Traffic Accidents in Myanmar

2.5 Upper Plans and Related Development Plans

2.5.1 Master Plans

(1) National Comprehensive Development Plan (NCDP)

The Former President, Thein Sein, announced in January 2013 that a National Comprehensive Development Plan (NCDP) was being drawn up to describes the country's development vision and strategic goals. The 20-year plan was positioned as the second stage of the reform process of Myanmar, the first stage being political reform and national reconciliation undertaken between 2011 and 2012, and will comprise four five-year programs aimed at increasing economic development in Myanmar. To achieve long-term national goals, a specific strategy and program were assigned to MOC (PW at that time) according to the NCDP, in order to develop and improve the current road network to meet international standards. According to the ARND-MP by KOICA, the strategy and programs prepared by PW are summarized in Table 2.5.1.

Table 2.5.1 Strategy and Programs for NCDP Prepared by PW

Strategy	Rules, Regulations, and Acts must be developed according to the nation's spatial plan
Program	- Developing the Highway Code - Assessing the current standards and specifications in Myanmar and updating them according to international standards - Carrying out the development of road safety and road safety audits for proposed and completed projects - Operating training courses aimed at improving technology - Developing the national road network - Public Private Partnership (PPP) sector - Upgrading private sectors with BOT system

Source: JICA Study Team based on the Final Report of the ARND-MP (KOICA)

(2) 30-Year Road Development Plan (by MOC)

MOC has developed a 30-Year Road Development Plan that composed of six 5-year short-term plans and explains the strategy and implementation activities for the future development of the highway network in Myanmar. As for the third Five Year Plan to the sixth Five Year Plan (from 2011-2012 fiscal year to 2030-2031 fiscal year), general objectives are set as follows:

- To upgrade connecting roads to ASEAN countries standards, and
- To upgrade Union Highway connecting Divisions and States.

MOC concludes that all International Highways, such as Asian Highways, ASEAN Highways and GMS Economic Corridor, will be 48 feet-wide 4 lanes asphalt concrete roads, main Union Highways will be 24 feet-wide 2 lanes roads and other Union Highways will be 12 feet-wide bituminous roads after upgrading roads and bridges according to 30-Year Plan. In addition, all bridges will be permanent bridges having the width of corresponding roads.

The calculation of the value of road/bridge projects cost is made for each four short term Five-Year Plans from 2011-2012 fiscal year to 2030-2031 fiscal year of the 30-year plan as shown in Table 2.5.2. The fund for the planned projects will be acquired in the national budget, joining with PPP funding and loans/grants from foreign countries/donors.

Table 2.5.2 Value of Road/Bridge Projects Cost (from 2011-2012 Fiscal Year to 2030-2031 Fiscal Year)

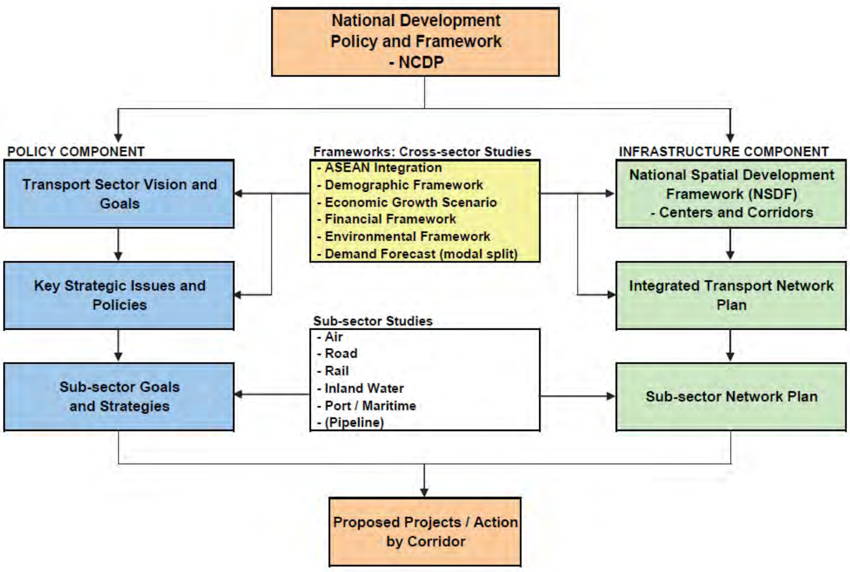
No	Fiscal Year	Value of Road projects (Kyat Million)	Value of Bridge projects (Kyat Million)	Total (Kyat Million)
1	Third five-year (from 2011-2012 to 2015-2016)	1,834,893.1920	1,345,972.8890	3,180,866.0810
2	Fourth five-year (from 2016-2017 to 2020-2021)	401,661.6240	147,024.3553	548,685.9793
3	Fifth five-year (from 2021-2022 to 2025-2026)	1,821,153.7990	577,096.9960	2,398,250.7950
4	Sixth five-year (from 2026-2027 to 2030-2031)	1,113,801.5210	71,494.2330	1,185,295.7540
	Total	5,171,510.1360	2,141,588.4733	7,313,098.6093

Source: 30-year Long Term Plan (MOC)

(3) Myanmar National Transport Master Plan (by JICA)

"Myanmar National Transport Master Plan (MYT-Plan)" is a Master Plan for the transportation sector in Myanmar prepared by JICA and approved by the Parliament in 2015. It was designed to provide guidance for a long-term investment program that would help the government achieve its economic growth targets by 2030. In addition, the MYT-Plan provides guidelines that are adaptable to other industrial sectors and to private investment, to assist with investment planning and decision making for a variety of transport sector projects.

The MYT-Plan has been prepared with the NCDP in mind and will be updated in conjunction with the achievement of national development objectives guided by the NCDP. Structure of the MYT-Plan is described in Figure 2.5.1.



Source: MYT-Plan

Figure 2.5.1 Structure of the MYT-Plan

In the MYT-Plan, 10 development corridors that connect strategic activity hubs were identified based on whether corridors embodied important city and economic activities, such as industrial zones, agro-industrial centers, strategic transport networks, international and national networks and major nodes for all transport modes. National spatial development framework and development corridors are described in Figure 2.5.2. Four priority corridors, Central North-South Corridor, East-West Corridor, Mandalay-Tamu Corridor and Western North-South Corridor, are proposed for urgent investment.

Construction of the New Sittaung Bridge is considered as a part of development of the East-West Corridor which is prioritized in the MYT-Plan. Development of the East-West Corridor is well synchronized in conformity with the development strategy of the MYT-Plan; "improvement of connectivity between Yangon and Thailand (land freight transport)", "contribution to the industrial development for the coastal regions extended between Yangon and Mawlamyine", "New connectivity with new transport hub (Hanthawaddy International Airport, etc.)", "provision of safe and reliable transport network/services focused on cargo".

A	Central North South Corridor
B	East West Corridor
C	Northern Corridor
D	Mandalay Tamu Corridor
E	Second East West Corridor
F	Main River Corridor (part of the Western North South Corridor)
G	East West Bridging Corridor
H	Delta Area Development Corridor
J	Southern Area Development Corridor
K	Western North South Corridor
L	Eastern North South Corridor

Priority Corridor

Source: Source: JICA Study Team based on the MYT-Plan

Figure 2.5.2 National Spatial Development Framework and Development Corridors

(4) Arterial Road Network Development Master Plan (by KOICA)

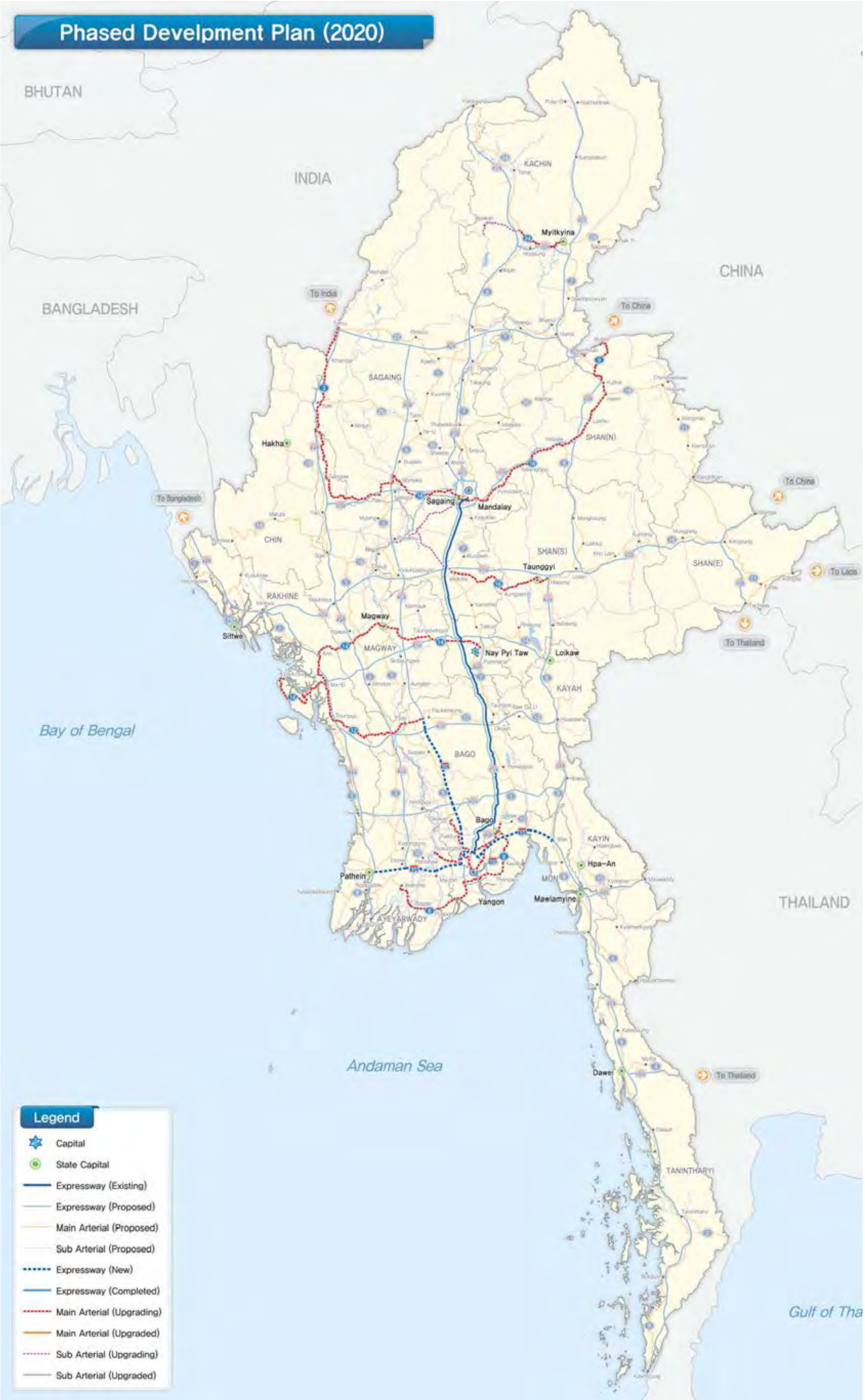
The objectives of the ARND-MP are as follows:

- To establish an optimum transport system to promote interregional social and economic activities,
- To establish a mid- and long-term plan to achieve efficient and systematic development of arterial road networks for supporting national economic growth, and
- To share Korea's experience and technology related to developing arterial road networks with Myanmar.

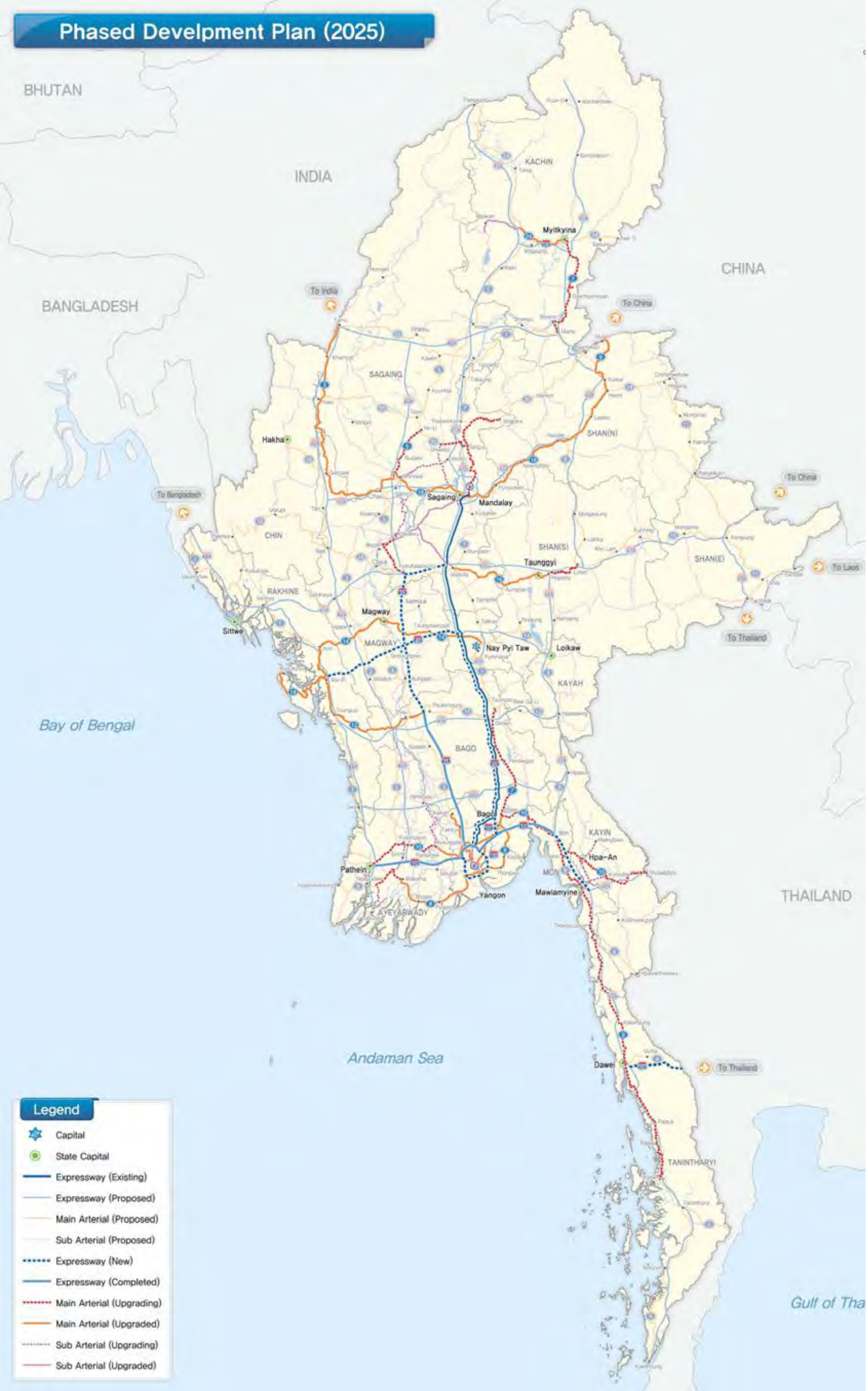
Rapid increase of population, which is expected to increase from 51.4 million in 2014 to 65.1 million in 2035, will cause a notable change of spatial structure within the country in the future. Traffic demand of both passengers and freight is expected to dramatically increase due to the increase of the country's GDP which will be nearly 5 times in the next 20 years. In the upper plans such as the NCDP, development strategies of arterial road networks were figured out under the framework for economic growth of the development corridors. In the ARND-MP, traffic demand forecast using 333 traffic analysis zones in the country was conducted. As the result, passenger traffic volume is expected to increase approximately 8 times from 3,009,484 trips per day in 2014 to 24,503,410 trips per day in 2040, while cargo traffic volume is expected to increase approximately 8.4 times from 122,620 vehicles per day in 2014 to 1,028,899 vehicles trips per day in 2040.

In the ARND-MP, the arterial road network development which is composed of the new 7x5 Expressway Network (East –West Direction 7 Roads, North- South Direction 5 Roads) to support economic growth, the 12×6 main arterial road network (East –West Direction 12 Roads, North- South Direction 6 Roads) to promote the region's economic development and regional integration, and the sub-arterial road network to enhance the efficiency of road networks by connecting main arterial roads is proposed. Phased arterial road network development plans are shown in Figure 2.5.3. It is planned that the arterial road length of 15,309km (44.5%) among the total length of 34,378km will be constructed or improved by 2035 and the remaining 19,069km (55.5%) will be after 2035. Main arterial and sub arterial roads will be mainly improved with 2 lanes (or 4 lanes). And the expressway network will be newly developed with 4 lanes (or 6 lanes) except for the existing Yangon-Mandalay Expressway.

Also, it is suggested that road design criteria which were provided in the ARND-MP and accepted by MOC in 2015 shall be applied in all the road construction or improvement projects in Myanmar. Furthermore, it is suggested that the road numbering system which were also provided in the ARND-MP and accepted by MOC shall be used for road users' guidance and road operation & maintenance. And a road inventory system for arterial road networks was also established in the ARND-MP and suggested to be upgraded and updated continuously.

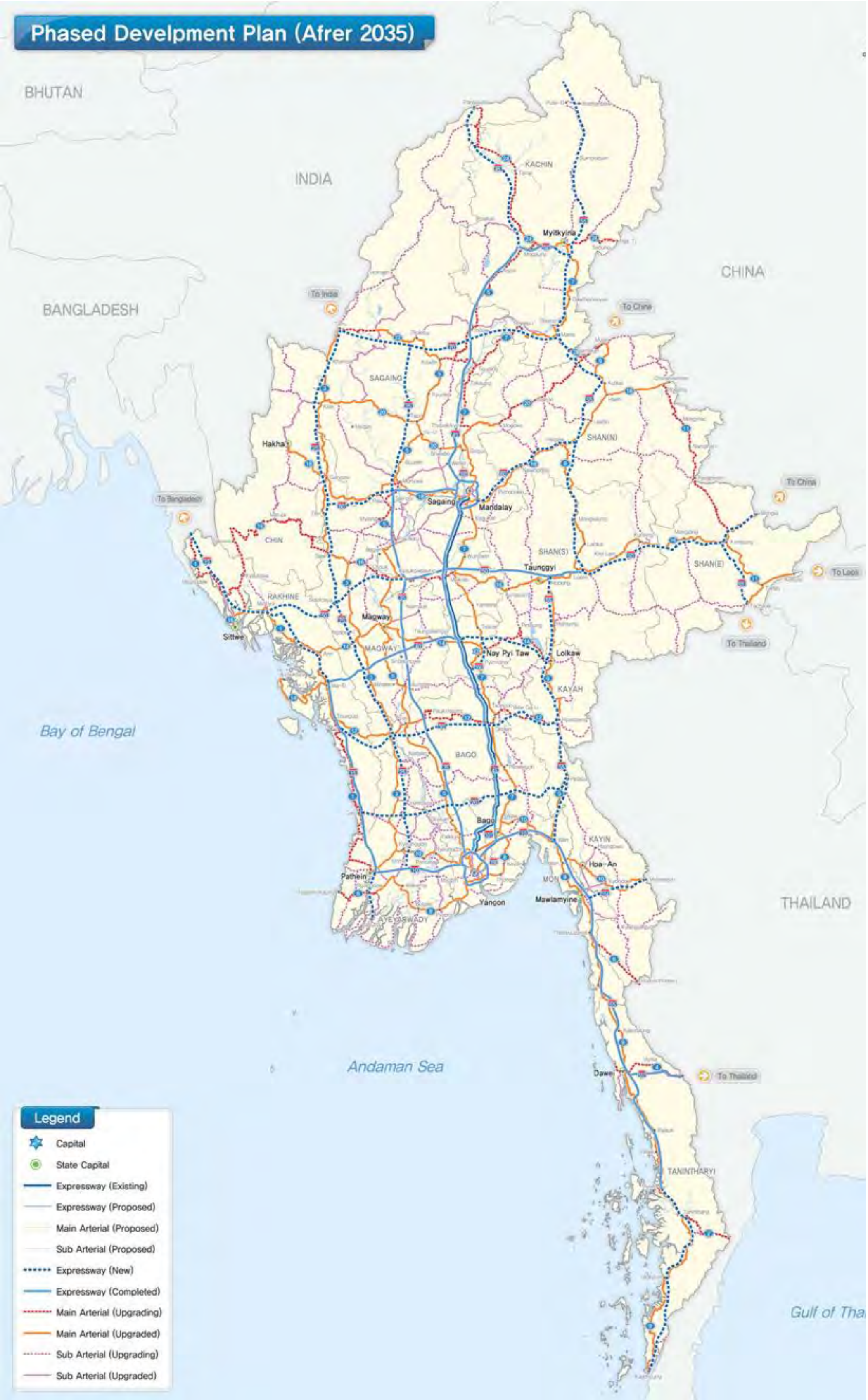


[Development Plan in Phase 1 (2016-2020)]



[Development Plan in Phase 2 (2021-2025)]

[Development Plan in Phase 3 (2026-2035)]



[Development Plan in Phase 4 (after 2035)]

Source: Source: ARND-MP (KOICA)

Figure 2.5.3 Development Plan (2016-2035 and after 2035)

Regarding the financial resources for the arterial road network development, it is suggested to be secured from the transport infrastructure special account, ODA funds and private funds under PPP schemes, based on internal funds. The costs of 41,437 million USD by 2035 for arterial road network development are estimated. The investment cost of each phase for arterial road network development is estimated as shown in Table 2.5.3.

Table 2.5.3 Phased Investment Costs

Road Class	Total		2016-2020		2021-2025		2026-2035		After2035	
	Length	Cost	Length	Cost	Length	Cost	Length	Cost	Length	Cost
Expressway	9,470 (597)	50,962 (1,172)	558	2,897	1,165 (364)	5,728 (871)	2,128 (233)	9,681 (301)	3,851 (597)	18,306 (1,172)
Main Arterial Road	13,225	27,642	2,794	5,809	2,062	3,455	4,173	9,043	9,029	18,307
Sub Arterial Road	11,683	25,462	347	525	694	1,091	1,388	3,208	2,429	4,824
Total	34,378	104,066	3,699	9,231	3,921	10,274	7,689	21,932	15,309	41,437

Note: ( ) stands for expansion of existing expressways
Source: ARND-MP (KOICA)

(5) Position and Relationship of each Master Plan

As mentioned the above, there are some national-level plans for arterial road development in Myanmar, such as the “30-Year Road Development Plan”, established by MOC in 2000, and the MYT-Plan supported by JICA in 2014. The 30-Year Road Development Plan is composed of six five-year plans and indicates the purpose and priorities of road projects. The MYT-Plan is a national transport plan that covers not only roads but also railways, civil aviation, maritime vessels, Inland water transport, and the arterial road system. The plan establishes major transport corridors and takes into consideration of arterial road network in Myanmar as a road sector based on the Corridor-Base Approach method. Therefore, the networks outside the major corridors are not included in MYT-Plan's scope.

The 30-year plan is currently being conducted as a long-term, national-level plan for road development in Myanmar and focuses on improving and upgrading existing roads. However, the country requires high-level roads, such as expressways, to drive its economic and social development. Furthermore, the plan is insufficient in terms of development targets and national spatial framework strategies, and does not have these comprehensive considerations.

For these reasons, the ARND-MP has been comprehensively and systematically developed by KOICA to support and finalize the 30-year road development plan and the MYT-Plan in a long-term approach.

2.5.2 Road Development Plans

(1) Five-Year Plan (MOC)

MOC has been developing a Five-Year Road and Bridge Development Plan for the 30-Year Long Term Plan. The first Five-Year Plan was carried out from 2001 to 2006, and the fourth Five-Year Plan is currently in progress. According to the ARND-MP, future road development plans are summarized in Table 2.5.4 and strategies for road and bridge improvement in Five-Year Plans are summarized in Table 2.5.5. In order to ensure enough funds for achieving these plans, MOC considers that investment from the private sector, as well as cooperation with bilateral and multilateral agencies, is highly valued.

Table 2.5.4 Road Development Plan

Name of Plan	Type of Project	Length (km)	Implementation Period
Third Five-Year Plan	International transport linkages	9,117	2011 - 2016
	Current implementation projects	7,214	
	Construction of new roads	1,694	
Fourth Five-Year Plan	Main implementation projects	4,461	2016 - 2021
Fifth Five-Year Plan	International transport linkages	9,608	2021 - 2026
Sixth Five-Year Plan	Main implementation projects	5,349	2026 - 2031

Source: JICA Study Team based on the Final Report of Arterial Road Network Development Master Plan (KOICA)

Table 2.5.5 Strategies for Road and Bridge Improvement in Five-Year Plans

No	Financial Year	Road/Bridge Project
1	Third Five-Year Plan	- International linking roads with ASEAN, Asian, Trilateral, BIMSTEC, and GMS highways to be improved from original width of four meters to seven-meter wide bituminous concrete road, and bridges to be constructed as seven-meter wide permanent concrete bridges. - Major union roads to be constructed as four-meter wide bituminous road, and bridges to be built as seven-meter wide permanent concrete bridges - New roads currently under construction to be constructed as four-meter wide bituminous roads, and bridges to be constructed as seven-meter wide permanent concrete bridges
2	Fourth Five-Year Plan	- International linking roads with ASEAN, Asian, Trilateral, BIMSTEC, and GMS highways to be constructed from original width of four meters to seven-meter wide bituminous concrete road, and bridges to be constructed as seven-meter wide permanent concrete bridges - Major union roads to be constructed as four-meter wide bituminous road, and bridges to be built as seven-meter wide permanent concrete bridges
3	Fifth Five-Year Plan	- International linking roads that already have a motorway width of seven meters to be widened to 14-meter, four-lane bituminous concrete roads, and bridges to be constructed as motorway-width permanent concrete bridges
4	Sixth Five-Year Plan	- Major union roads that are four-meters wide to be expanded to seven-meter wide, two-lane bituminous road roads, and bridges to be constructed as motorway-wide permanent concrete bridges

Source: ARND-MP (KOICA)

(2) MOC’s Road Development Policy

MOC's current vision, mission and strategy for road development are summarized below.

Table 2.5.6 MOC's Vision, Mission and Strategy for road development

Vision	Mission	Strategy
✧Road, bridges and building technology need to be advanced for the development of the entire people’s social and economic sector in Myanmar. ✧Road, bridges and urban areas have to be developed with the same balance in all states and regions. ✧Transportation cost which have the development of Myanmar GDP has to be reduced at least point and transportation period has to be reduced as much as possible by carrying out the development of road and bridges and removing the obstacles. ✧All the citizens have to stay at fair and good quality houses to promote their	✧In 2030, current roads which have the length of (42,121 km) have to be met at least as ASEAN class III (18ft width AC/ Concrete). ✧In 2030, all the bridges have to be met at least as two-lane which have a width of 24 feet RC/PC/Steel Bridge class. ✧In 2030, over 330 towns in Myanmar will be constructed by plotting as systematic urban planning and the	The project will be carried out by the following steps; 1. Implementation of the project by Government Budget. 2. Among these projects, some of the possible ones have to be carried out by Public Private Partnership (PPP) Program. 3. Implementation of the project by the Grant/ Loan with the help of international organization such as JICA, ADB, WB, KOICA and TICA. 4. Enacting road user tax law for the purpose of road/ bridge maintenance jobs. The ministry of construction have already drawn 30 years project plans which have 6

Vision	Mission	Strategy
livelihood. ✧International standard road network contributing towards regional connectivity with ASEAN and other neighboring countries as well as balanced and sustainable development of Myanmar. ✧Safe and sustainable building construction sector and construction administration. ✧Balanced and sustainable urban and regional system throughout the nation and Adequate housing with improved living standards for the people of Myanmar ✧To lead and guide the building construction sector towards safe and green development. ✧To upgrade the urban system contributing towards balanced and sustainable development of the nation.	accomplishment of a million units of housing that will be constructed by both the government and companies in those towns. ✧To meet the current road network of Myanmar to the international standards as in neighboring countries, and the aim to develop the Union road network in States and Regions for smooth transport.	phases of 5 years from 2001 to 2030. In 2011 at the period of the former government, the above project was concluded and amended into 20 years project plan which have 4 projects and each of the projects have 5 years of life. At the age of the current government, this project was redrawn into 3 5-year project plans in accordance with the Economic Publicity of the State by analyzing and negotiating with the fact of Parliament's pact, with the fact included in ARND-MP (support by Korea), with the fact included in MYT-Plan (support by Japan).

Source: JICA Study Team based on information from MOC

(3) Development Plan of Expressway

MOC has a development plan for Expressway and National Highways. Future Expressway Network is shown in Figure 2.5.4. 7 Expressways for East-West direction and 5 Expressways for North-South direction (7x5 Expressway Network) are planned to be developed in Myanmar. This Expressway Network was planned in the study of ARND-MP with considerations of followings;

- Creation of a high efficiency transportation network by connecting major cities
- Formation of an expressway network by connecting major and local cities
- Reinforcement of international socioeconomic relationships by connecting neighboring countries

The major passage points of the expressway network are summarized in Table 2.5.7. Project route of this study is also included as a part of the expressway network (East-west 1 axis).

Source: MOC

Figure 2.5.4 Development Plan of Expressway Network

Table 2.5.7 Major Passage Points of Expressway Network

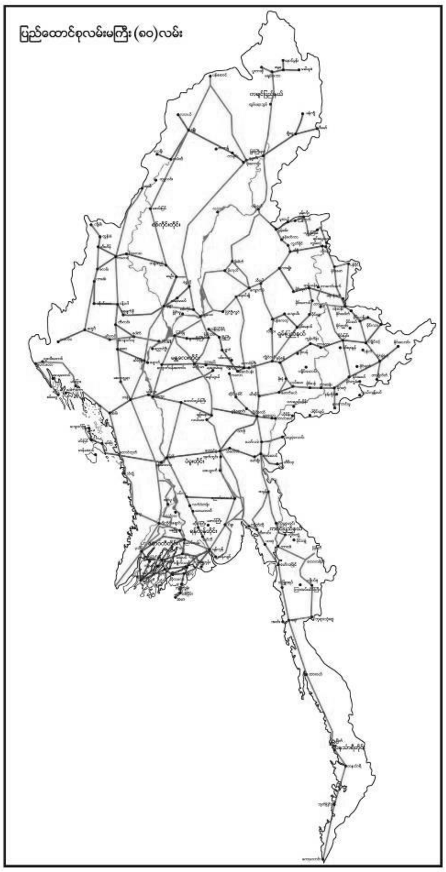
Classification	Major Passage Point
South-North: 1 axis	Labutta-Ngapudaw-Pathein(10)-Thabaung-Gwa(20)-Kyeintali-Thandwe-Toungup(30)-Ma-Ei(40)-Ann-Minbya(50)-Ponnagyun-Rathedaung-Buthidaung-Taungpyoletwea
South-North: 2 axis	Einme(10)–kyaunggon–Kyonpyaw–Lemyethna(20) – Ingapu – Kyangin – Padaung(30) –Mindon(40) – Ngape – Sidoktaya(50) – Saw – Kyaukhtu – Tilin(60) – Gangaw – Kale – Khampat –Tamu(70)
South-North: 3 axis	Yangon(Hmawbi(100))–Taikkyi–Okekan-Thayarwaddy(20)–Letpadan–Minhla–Okpho–Gyobingauk–Zigon–Nattalin–Paungde–Thegon(30)–Paukkhaung–Aunglan–Sinbaungwe(40)–Minhla–Magway–Natmauk–Kyaukpadaung(50)–Ngathayouk–Pakokku–Salingyi(60)–Budalin–Tabayin–Taze–Pinlebu(70)
South-North: 4 axis	Yangon(Htaukkyant(100)) – Hlegu – Bago(101) – Daik-U(20) - Penwegon – Phyu – Oktwin(30) – Taungoo – Yedashe – Lewe(200) - Nay Pyi Taw(- Oke Ta Ra Thi Ri(40)) – Meikhtilar (50) – Mandalay(Pyigyitagon) - Sagaing(300) – Wetlet – Myaung – Kyauk – Thabeikkyin - Takaung –Tigyaing - Indaw(70) – Mohnyin – Hopin – Kamaing – Tanai – Shinbwayyang – Nanyun - Pansaung
South-North: 5 axis	Kawthaung – Khamaukgyi – Karathuri – Bokpyin – Pyigyimandaing – Tanintharyi – Palaw – Palauk – Thayetchaung – Dawei(552) – Yebyu – Kaleinaung – Ye – Lamaing – Thanbyuzayat – Mudon – Kyaikmaraw - Mawlamyine(554) – Thaton – Bilin(10) – Hpapun(20) – Hpasawng(30) – Bawlakhe – Hpruso – Demoso - Loikaw(40) – Hsihseng – Taunggyi – Hopong(50) - Loilen(50) - Pinlon -Mongkaung – Hsipaw(60) - Lashio – Kutkai – Namhkan – Mansi(70) – Bhamo – Dawthponeyan –Waingmaw(556) - Injangyang – Sumprabum – Machanbaw – Putao
East-West: 1 axis	Pathein(15) – Einme(35) – Maubin – Yangon(Hlaingtharya(100)) - Yangon(Hlegu(100)) – Kawa – Bago(101) - Thanatpin – Kyaikto – Bilin(55)
East-West: 2 axis	Gwa(15) – Lemyerhna(25) – Hinthada – Thayarwaddy(35) – Daik-U(45) - Nyaunglebin – Pyuntasa – Madauk – Shwegyin – Hpapun(55)

East-West: 3 axis	Toungup(15)–Padaung(25)–Shwedaung–Thegon(35)–Oktwin (45)–Htantabin–Baw Ga Li–Hpasawng(55)
East-West: 4 axis	Ma-Ei(15) - Mindon(25) – Sinbaungwe(35) – Taungdwingyi – Nay Pyi Taw(- Oke Ta Ra Thi Ri(45))-Tatkon(200) - Pekon – Loikaw(55)
East-West: 5 axis	Minbya(15) – Sidoktaya(25) – Chauk - Kyaukpadaung(35) – Meiktila(45) – Thazi – Pindaya –Taunggyi – Hopong(55)-Loilen(55)-Nansang-Kho Lam - Kar Li – Mongping – Tontar –Kengtung(501) – Mongla
East-West: 6 axis	Tilin(25) – Pale – Salingyi(35) - Chaung-U – Myinmu – Ngazun – Sagaing(300) – Mandalay(Amarapura(300)) – Pyinoolwin – Nawnghkio – Kyaukme – Hsipaw(55)
East-West: 7 axis	Tamu(25) – Pinlebu(35) – Wuntho – Indaw(45) - Katha – Shwegu – Mansi(55)
Branch 552	Dawei(55) – To Thailand
Branch 554	Mawlamyine(55) – Kyondoe – Kawkareik – Myawaddy
Branch 556	Mogaung(45) - Waingmaw(55)
Branch 501	Tachileik - Kengtung(50)

Source: ARND-MP (KOICA)

(4) Development Plan of National Highways

MOC has also a development plan for National Highways. Future National Highway Network is shown in Figure 2.5.5. 36 highways for North-South direction and 49 highways for East-West direction are planned to be developed in Myanmar.



Source: MOC

Figure 2.5.5 Development Plan of National Highway Network

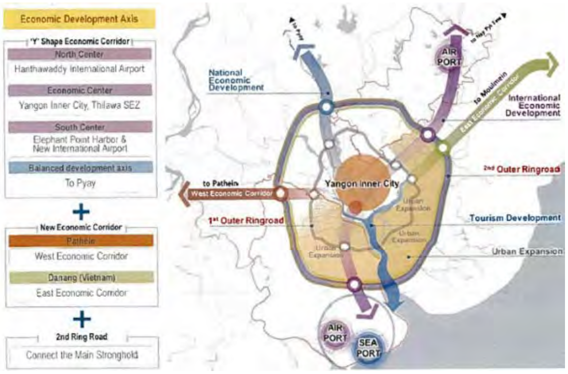
2.5.3 Other Related Development Plans

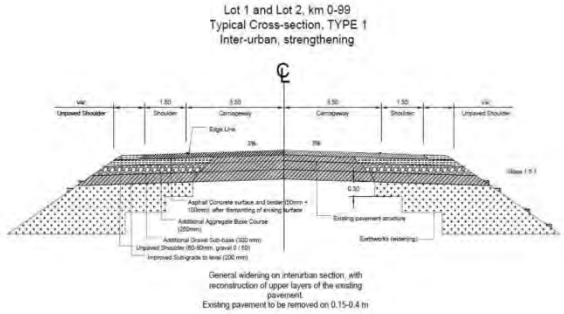
An outline of related development projects and relevance to this project are summarized in Table 2.5.8.

Consistency with other development projects should be secured through the review of on-going or completed surveys by JICA.

Table 2.5.8 Outline of Relevant Projects and Relevance to the Project

Project Name	Project Outline	Relevance and Points to be Considered in the Study
Thilawa SEZ Development Project	Development area is approximately 2400ha and zone A (Approx. 400ha) has been opened since August 2015. As of December 2016, 68 international/domestic firms have been registered. The other area is under development (construction).  Source: Pre-F/S	Traffic demand on the project road would be increased since future cargo volume to/from Thilawa SEZ is estimated to be 2.86 million ton per year. Progress and development schedule of relevant development projects shall be confirmed and reflected to traffic demand forecast in the Study.
Hanthawaddy International Airport Project	A new international airport (Hanthawaddy International Airport) is expected to be developed and opened in 2022 by a PPP (Public-Private-Partnership) project. Annual number of passengers is estimated to be approx. 11 million in 2025, and to be approx. 53 million in 2050.  Source: Pre-F/S	Direct impact by the new airport development to this project might be small. However, development demand should be considered in traffic demand for this project by development plans in the Bago Region.
Yangon Outer Ring Road Construction Project	In YUTRA, the outer ring road is divided into four sections and the eastern section is planned in the midterm plan (by 2025).  Source: SUDP	Considering the possibility that the project road connects to the eastern section of Yangon Outer Ring Road, a development scenario as high capacity road shall be studied in the Study.
Southern Economic Corridor Development Project (Dawei SEZ Development Project)	Development of a deep sea port and SEZ is delayed although the access road between Dawei SEZ and Thailand has been connected. Traffic demand from Thailand is estimated to be approximately five thousand vehicles per day at the opening of the seaport.	Case study on traffic demand forecast due to the developing scenario of the southern economic corridor shall be conducted.

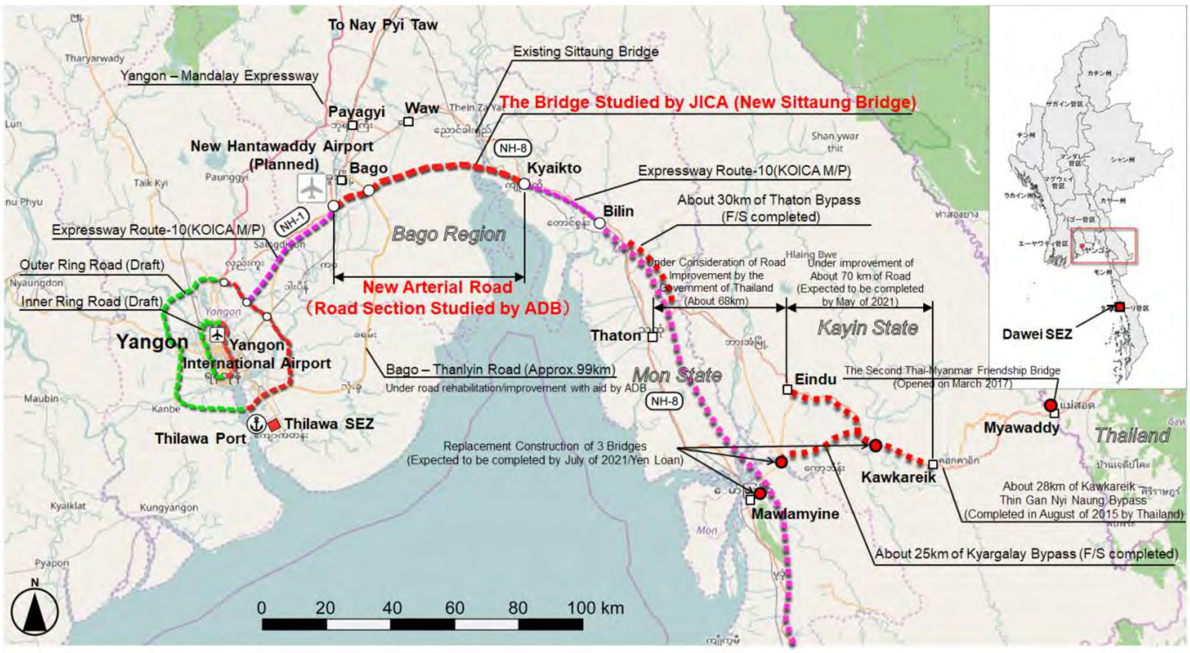
Project Name	Project Outline	Relevance and Points to be Considered in the Study
	 Source: Pre F/S For Southern Economic Corridor In Myanmar (JICA)	
Yangon-Hanthawaddy-Bago Corridor and Yangon South Western Regional Development in Myanmar (Korea)	The three development concepts ("Y-shaped Economic Corridor", "New Economic Corridor" and "Second outer ring road") have been formulated as economic development axis in Yangon urban area.  Source: Master Plans for Yangon-Hanthawaddy-Bago Corridor and Yangon South Western Regional Development in Myanmar	The project road is expected to be a part of "New Economic Corridor" connecting to Yangon Outer Ring Road as economic development axis for Yangon Urban Development Plan.
Greater Mekong Subregion Highway Modernization Project	The project is to conduct road rehabilitation/improvement along the Yangon-Pathein Highway and Bago-Thanlyin Highway with a total of about 280km, improve safety on Yangon-Mandalay expressway, and finance detailed technical preparation of a new highway project along GMS East -West Economic Corridor (EWEC) and GMS North-South Economic Corridor (NSEC). Under this project, the Bago-Thanlyin road (approx. 99km) is expected to be upgraded to 2-lanes asphalt paved road with 7m width as shown in the below figures.  Source: MOC	The Bago-Thanlyin road will be upgraded to 2lane asphalt paved road with 7m width. This should be considered for the traffic demand forecast in this F/S.

Project Name	Project Outline	Relevance and Points to be Considered in the Study
	 Source: MOC	

Source: JICA Study Team

2.6 Current Road Condition of the East West Economic Corridor

The following figure and table show the summary of the current road condition and ongoing/future road development of the EWEC. The Myanmar section on the EWEC connects Myawaddy, the border area with Thailand, to Yangon urban area with approximately 380km in total length.



Source: JICA Study Team

Figure 2.6.1 Current Road Network and Development Project along the EWEC

Table 2.6.1 Outline of Current Road Condition along the EWEC (Myanmar Section)

Road Section	Length	Lane	Pavement Type	O & M
Yangon*-Payagyi	68km	2 to 4	A/C	1) Yangon-Bago by BOT (Max Highway) 2) Bago-Payagyi by BOT(Shwe Than Lwin Highway)
Payagyi – Thaton	130km	2	A/C	BOT (Shwe Than Lwin Highway)
Thaton - Eindu	68km	2	Penetration Macadam	1) Thaton – Hpa-an by BOT (Shwe Than Lwin Highway) 2) Hpa-an-Eindu by (Aye Ko Family Construction)
Eindu - Kawkareik	70km	2	Penetration Macadam	MOC
Kawkareik-Myawaddy	42km	2 to 4	A/C	MOC

* From the entrance of Yangon-Mandalay Expressway
Source: JICA Study Team based on the information provided by MOC

(1) Yangon (Yangon-Mandalay Expressway Entrance) – Payagyi Section

This section is a part of the National Highway-1 stretching from Yangon to Mandalay and approximately 68km. Road maintenance and operation for this section is performed by private companies under BOT scheme as shown in the above table. The paved 2 to 4-lane road is kept in a relatively good condition, however heavy vehicles (large freight cargo) are travelling through the urban area such as Bago and Payagyi which is currently result in the chronic traffic congestion in the peak time.

Photo-1 Road Condition on Yangon – Bago Section

Photo-2 Road Condition at Bago

Photo-3 Road Condition on Bago–Payagyi Section

Source: JICA Study Team

Figure 2.6.2 Current Road Condition on Yangon – Payagyi Section

(2) Payagyi – Thaton Section

This section is a part of the National Highway No.8 connecting Myeik, the capital city in Thanintharyi Region, and Payagyi with approximately 130km in total length.

Shwe Than Lwin Highway Co., Ltd is currently involved in the operation and maintenance for the road section under the BOT contract. It is observed that the road surface in a two-lane asphalt pavement is kept in a relatively good condition. In recent days, the soft shoulder has been gradually changed to asphalt concrete that contributes to improvement of road safety (Photo-4). However, heavy vehicles (large freight cargo) (Photo-5 and 9) are travelling through the urban area which is a concern causing chronic congestion and degradation of road safety in the future.

Meanwhile, there are so many existing houses and commercial facilities on the roadside. Thus, a large number of resettlements is predicted when widening the road over the limited ROW. Particularly, Thaton, which has about 35 million people, which is the second highest population in the southeast region, is a confluence of major roads such as AH1 and AH112. It is therefore obvious for social issues to appear such as increased congestion and accidents along with the growth in traffic demand.

Photo-4 Road Condition on Payagyi – Waw

Photo-5 Road Condition at Waw

Photo-6 Road Condition on Waw- Kyaikto

Photo-7 Road Condition on Existing Sittaung Bridge

Photo-8 Road Condition at Kyaito

Photo-9 Road Condition at Thaton

Source: JICA Study Team

Figure 2.6.3 Current Road Condition on Payagyi – Thaton Section

(3) Thaton– Myawaddy Section

Thaton – Hpa-an and Hpa-an – Eindu sections are maintained by BOT (Shwe Than Lwin Highway Co., Ltd and Aye Ko Family Construction Co., Ltd respectively) and the other section is directly controlled by MOC. Currently, the road surface of a two-lane macadam paved road (soft shoulder) is kept in relatively good condition. In town areas, such as Eindu and Kawkareik, some roadside houses and local shops invade the road area over the boundary of ROW while other sections have been basically ensured. In August 2015, the bypass of Downa mountain range was completed by the support of the Thai government which was most the difficult mountainous section along the EWEC and required unavoidable one-sided traffic every other day. Moreover, the Second Thai-Myanmar Friendship Bridge was opened to traffic in March 2017 and the border control facilities is expected to be completed by Oct 2019. Now the complete two lanes paved road on the Downa mountain region and smoother border traffic allow mutual traffic flows and is expected to contribute to the further growth in land trade with Thailand (Photo14).

In addition, Gyang-Kawkareik Bridge, which is located on the west side of Kawkareik town (Photo-12), has insufficient structural capacity thus the operation of the bridge has been restricted with the weight limit of traffic up to 24t. Large vehicles with the gross weight of more than 24t is thereby forced to divert to the nearby temporary pontoon bridge for crossing the river (Photo-13). This bottleneck of bridges will be replaced by the support of Japan ODA until July 2021 as well as Gyaing Zathapyin Bridge and Atran Bridge along the route between Hpa-an and Mawlamyine as summarized in Table 2.6.2. Moreover, for the section between Eindu and Kawkareik, the road improvement project will be conducted until May 2021 by the financial support of ADB. By the completion of these projects, the section between Eindu - Kawkareik will be improved for completely asphalt paved roads.


Photo-10 Road Condition on Thaton – Eindu Section


Photo-11 Road Condition on Eindu – Kawkareik Section


Photo-12 Gyaing Kawkareik Bridge (Existing)


Photo-13 Pontoon Bridge


Photo-14 Kawkareik – Thin Gan Nyi Naung Bypass

Source: JICA Study Team

Figure 2.6.4 Current Road Condition on Thaton – Myawaddy Section

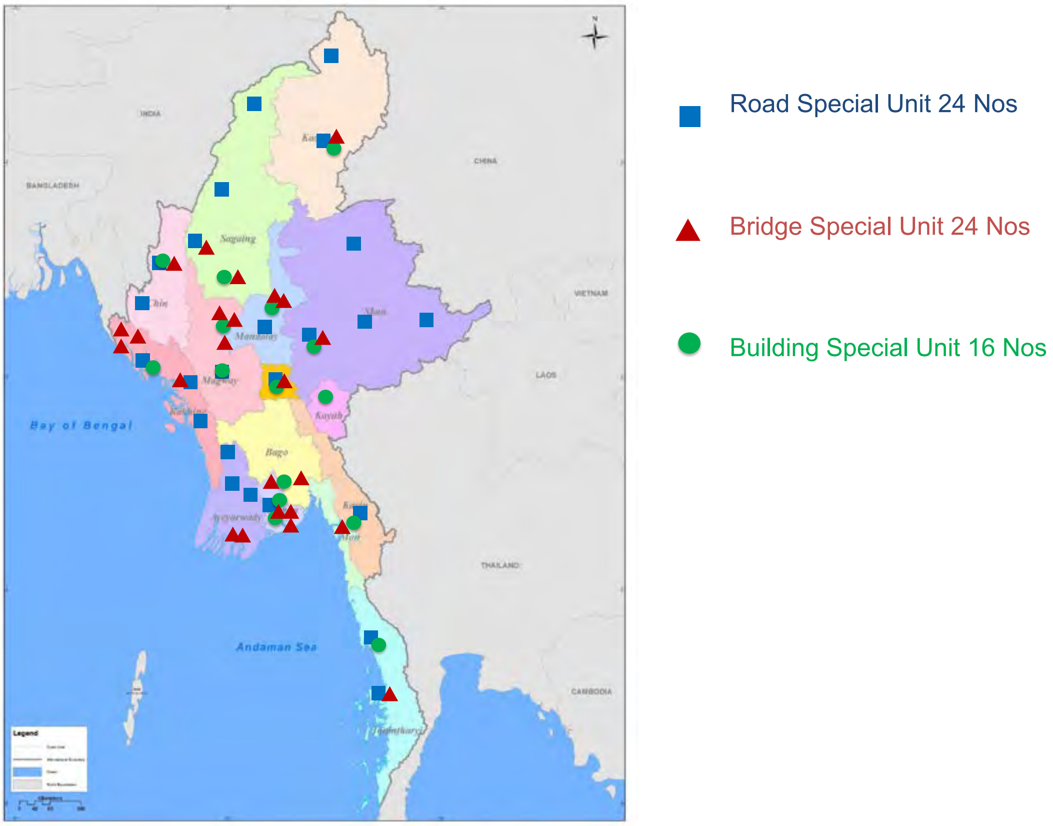
Table 2.6.2 Outline of Replacement of Three (3) Bridges along the EWEC

Bridges in the East-West Economic Corridor (EWEC) Project (Japan ODA Loan)	
	
Gyaing Kawkareik Bridge	
(1) **Bridge Type :** PC Extradosed Bridge with Corrugated Steel Plate Web (Main) + Steel-I Girder (Approach) (2) **Bridge Length :** L = 580m (3) **Main Span** : 180m	
Gyaing Zathapyin Bridge	
(1) **Bridge Type :** Steel Cable-Stayed Bridge (2) **Bridge Length :** L = 796m (3) **Main Span** : 470m	
Ataran Bridge	
(4) **Bridge Type :** Steel Cable-Stayed Bridge (Main) + PC Post Tensioned T-girder bridge (5) **Bridge Length :** L = 480m (6) **Main Span** : 200m	

Source: JICA Study Team based on information from MOC

2.7 Current Situation of Road and Bridge Operation and Maintenance

MOC operates and manages major roads in Myanmar, having approximately 42,100km in total length. As for bridges, DOB under MOC manages approximately 5,000 bridges in Myanmar. While some major highways are under operation and maintenance by BOT scheme as aforementioned, the Maintenance Section in both DOH and DOB is mainly in charge of O/M works of responsible roads and bridges in collaboration with the Road and Bridge Special Units which are distributed in the whole country as shown in Figure 2.7.1.



Source: MOC

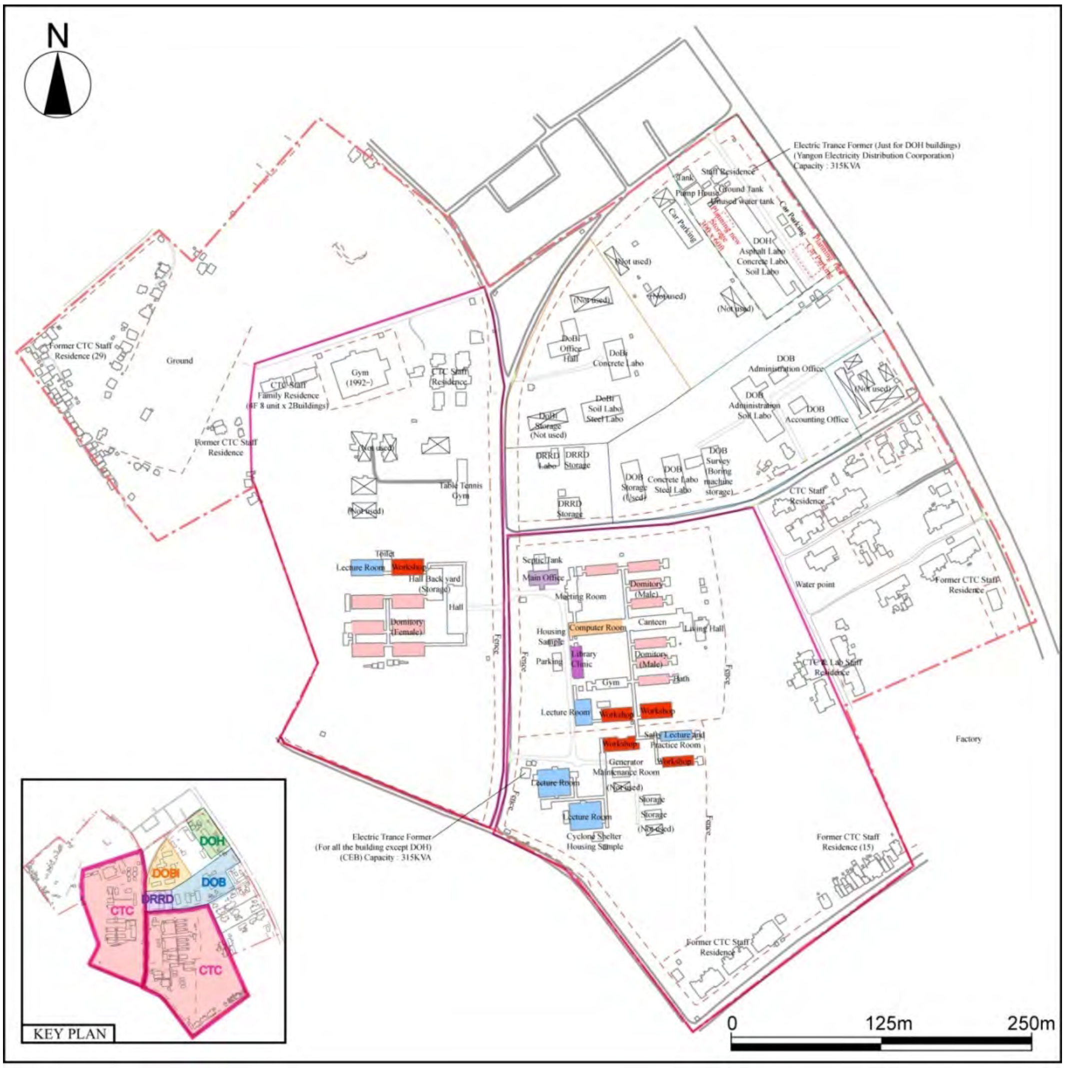
Figure 2.7.1 Location of Special Units

Recently, with technical and financial assistances by international agencies such as JICA and ADB as well as its significant economic growth, a lot of road and bridge constructions have been implemented, thus the number of roads and bridges responsible by MOC has increased drastically. Moreover, due to such technical assistance, the advanced technologies have been introduced to Myanmar, therefore higher level of technical capacity is required for proper and sustainable operation and maintenance of such infrastructures. Under such circumstances, it is recognized that technical capacity including quality control of construction/maintenance works and human resource development on operation and maintenance of roads and bridges is one of urgent tasks for MOC.

2.8 Current Situation of the Thuwunna CTC and Research Laboratories under MOC

As aforementioned, technical capacity development including quality control of construction/maintenance works and human resource development is one of priority tasks in MOC. Especially, the Thuwunna Central Training Center (CTC) and Research Laboratories have a major role of training engineers and skilled labors in MOC, and quality inspection activities especially for construction/maintenance materials.

The CTC and laboratories are located in the same compound in Thingangyun Township, the north east of the central area of Yangon. It includes the research laboratories of the Department of Highways (DOH), the Department of Bridge (DOB), the Department of Building (DOBi), the Department of Rural Road Development (DRRD), and the facilities of the Thuwunna Central Training Center (CTC) which are all under the MOC. The current building layout is shown in Figure 2.8.1. Although the details are given in Vol.2 of this Report but the current situation and issues of these facilities are described hereafter.



Source: MOC

Figure 2.8.1 Layout Drawing of Existing CTC Buildings and Laboratories

2.8.1 Current Situation of the Thuwunna CTC

The CTC was established in 1966 as a technical training center for the Ministry of Construction (MOC) staff, and has been conducting technical training for the MOC staff (both engineers and administrative staff), as well as vocational training and assessments for skilled labors.

As for technical training for the MOC staff, the CTC provides management training and basic construction skills training (i.e. road, bridge and building construction) for MOC officers and junior class as listed in Table 2.8.1.

Table 2.8.1 MOC Staff Technical Training Courses in CTC (2017-2018)

No	Name of Training	Time	Quantity	Week
1	Staff Officer (Finance) & Accountant Refresher Training Course	1	142	4
2	Junior Engineer (4) Civil Entry Training Course	3	114	6
3	Defense Services Technology Academy(Cadet)	1	20	2
4	Middle Rank officer Training Course for DD & AD	1	20	4
5	Building, Road and Bridge Quality Control Training Course	2	40	4
6	Junior Engineer (3) Civil Refresher Training Course	2	31	6
7	Road materials Quality Control Training Course Mini Lab	1	34	4
8	Workshop for Financial (Building)	1	39	1
9	Officer Training Course for Staff Officer (civil)	1	40	6
10	Clerical Training Course for superintendent & Branch Clark	1	19	2
11	Junior Engineer (1) Civil Refresher Training Course	1	44	4
12	Junior Engineer (2) Civil Refresher Training Course	2	59	4
13	Accountant (2) Refresher Training Course	1	66	4
14	Asphalt Concrete Road Construction Training Course	1	61	2
15	Housing Management Training Course	1	20	4
16	Road materials Quality Control Training Course (Assistant Reserve)	1	50	4
17	Clerical Training Course for UD & LD	1	40	4
18	Rural Roads & Bridge Construction Training Course	1	43	6
19	Rural Roads & Bridge Construction Training Course	1	49	4
20	Survey Course	1	80	6
21	Concrete Course	1	50	6

Source: CTC

On the other hand, the CTC conducts technical training and assessment of skilled laborers in accordance with the standards set by the National Skill Standards Authority (NSSA). There are 19 types of construction-related skills in the NSSA standards. The CTC has been conducting technical training and issuing training participation certificates for 5 construction worker types: (1) Concrete Worker, (2) Carpenter, (3) Bricklayer, (4) Tiler, and (5) Road Worker. The CTC performs skills assessments and issues the national certificate of occupational competency on 8 worker types: (1) Concrete Worker, (2) Carpenter, (3) Brick layer, (4) Painter, (5) Tiler, (6) Scaffolder, (7) Plumber, and (8) Bar Bender. In addition, the CTC carries out a one-day safety management classes for all training and assessments of any type of competency held in the facilities. In the future, the CTC hopes to provide technical trainings and assessment for a total of 16 out of 19 construction-related occupational competencies following the NSSA standards. The remaining 3 competencies will be covered by the Mechanical Training Centers in Mandalay and Yangon s as shown in Table 2.8.2.

Table 2.8.2 NSSA Construction-Related Occupational Competency, CTC Technical Training, Assessment and Future Plans

No	Field	Current Situation		Future Plan	
		Technical Training	Assessments	Technical Training	Assessments
1	Concrete	✔	✔	✔	✔
2	Carpenter	✔	✔	✔	✔
3	Brick Layer	✔	✔	✔	✔
4	Painter	Will be held soon	✔	✔	✔
5	Tiler	✔	✔	✔	✔
6	Steel Structure		✔	✔	✔
7	Scaffolder	Will be held soon	✔	✔	✔
8	Plumber		✔	✔	✔
9	Roofer			✔	✔
10	Care Taker			✔	✔
11	Landscape Gardener			✔	✔
12	Construction Machine Maintenance			(MTC)	(MTC)
13	Well Digger			✔	✔
14	Toll Collector			✔	✔
15	Bar Bender	Will be held soon	✔	✔	✔
16	Road Worker	✔		✔	✔
17	Plasterer			✔	✔
18	Hydraulic Excavator Operator			(MTC)	(MTC)
19	Forklift Operator			(MTC)	(MTC)
	19 types	5 types	8 types	16 types	16 types

Source: CTC

The CTC facilities are roughly divided into training buildings, trainee dormitories, office, common areas and staff residence. Technical training for MOC staff as well as technical training and assessment of skilled labors are all held in the same facilities on site. Because the location of the CTC facilities has a particularly high level of water, there are buildings which suffer from severe deterioration, where the walls are likely to come off from structural frames. Such buildings are currently used as warehouses where unused equipment items are piled up. The procedure to discard such unused equipment would take a quite long time, so even the equipment which had been broken for years had to be kept on site, i.e. in existing deteriorated buildings.

On site, there are two wells of approximately 200 m deep which are purified by the water treatment facilities provided on site. There are toilets and rainwater storage tanks made of concrete in several locations on site which are utilized during training and for daily use such as cleaning. The sewage on the site is not connected to the public sewerage system; thus, all sewerages are infiltrated after treatment in septic tanks. Although a request for drainage improvement has been sent to the Yangon City Development Committee (YCDC), YCDC representatives only came to conduct a field survey, and there has been no answer regarding the matter since then.

2.8.2 Research Laboratories

There are four laboratories in the site, which are the research laboratories of Department of Highways (DOH), the Department of Bridge (DOB), the Department of Building (DOBi), the Department of Rural Road Development (DRRD). These laboratories were constructed 1960s and 1970s and are currently under management of MOC. These laboratories has been constructed and developed to mainly conduct quality inspections of construction materials such as asphalt concrete, concrete, soil, rebar at the laboratories as well as at the constructions sites.

Some of laboratories are responsible for design works and supervision of construction works. The major roles and activities of the laboratories are summarized in Table 2.8.3.

Table 2.8.3 Major Roles and Activities of the Research Laboratories

Laboratory	Major Roles and Activities
DOH	− Strength testing of airport runway and road pavement surface as well as soil quality testing − Material testing of roads within jurisdiction (i.e. crushed stone, sand, bitumen, sealant, cement, concrete block) − Various designs of asphalt concrete and concrete − Implementation of cement stabilization treatment method, lime stabilization treatment method as well as cement and granular asphalt treatment method − Design of pavement and road retaining wall − Production of asphalt mix emulsion − Annual lectures on road materials and quality control in CTC training courses − Implementation of research projects regarding on site material utilization as well as road pavement and slope collapse repair − Collaboration with international technology groups for sustainable development in the road sector
DOB	− To conduct soil quality surveys and tests of bridges, retaining walls and buildings planned by the five departments of MOC − To establish a construction quality control team and conduct on-site concrete and material quality control, for bridge quality control; and − To conduct Non-Destructive Test (NDT), loading test, and cable tensile test on cable-stayed bridges. (All cable-stayed bridges are inspected once a year.)
DOBi	− Building of materials testing − Formation and dispatch of quality control teams − Quality inspection of concrete and rebar − Physical properties testing of building materials such as cement, crushed stone, bricks, and deformed rebar − Concrete mix design and concrete compressive strength test − Supervision and management of concrete quality control at construction sites − On-site inspection of deformed rebar structures according to the special specifications − On-site inspection of building materials according to the design and the special specifications − Concrete testing of existing buildings (non-destructive structure testing (UPV, Rebound) and destructive testing (core drill machine testing)) − Inspection of quantity and positioning of rebar and steel frames in existing buildings
DRRD	− Material testing and soil testing of aggregate, cement and concrete materials for the purpose of quality control of local paved roads

Source : JICA Study Team

The above roles and activities should expand and effectively functioned in order to cope with expanding needs for quality assurance, transition of testing method to ASTM standards from BS, needs for acquisition of ISO certifications and MOC's renovation policy to establish a new department called "Thuwunna Research Laboratory and Training Department" which will be responsible for all research and laboratory functions and training functions. However, in spite of such needs, the existing facilities and equipment suffer from significant deterioration due to its aging so that the functions are very limited. The current issues of each facility are summarized in the below table.

Table 2.8.4 Current Situation and Issues of the CTC and Laboratories

Facilities	Current Situation	Issues
Training Centers	• The area where CTC facilities are located is low on the entire site and has been damaged by flooding on the floor in the past. • There are many buildings with low ceilings because they are heavily damaged and have raised their own floors. • There are buildings which suffer from severe deterioration, where the walls are likely to come off from structural frames. • The building materials used in the training are	• Since the existing buildings have severely deteriorated and/or have become hazardous, there are some buildings that are no longer being used, immediate reconstruction is required. • In addition to drainage measures in the rainy season, measures for rising water levels such as floor level adjustment are required. • Additional lecture rooms and workshops are required to match the future plans of the training course that CTC is aiming for.

	placed outdoors, because the warehouse capacity is not enough.	• Appropriate warehouse space for building materials is required.
Research Laboratories	• Facilities are independent for each department. • Aged facilities are being used while renovating. But it is not planned based on laboratory activities. • There are no ventilation facilities considering safety in the asphalt research and testing laboratory etc. • The indoor environment as a laboratory is not sufficient. • Since the warehouse for testing samples is not planned, testing samples are placed and spread all over the floor or stacked at the corridor or outdoors.	• It is necessary to design the facility according to the activities of the laboratories. • It is necessary to improve the indoor environment as a laboratory. • Appropriate warehouse space for testing sample is required. • In order to ensure the quality of inspections, it is necessary to improve the facilities according to the test contents in order to acquire ISO certification aimed at by each department. • As test specification is transferred to ASTM, new equipment needs to be procured. • For efficient management of equipment, sharing of equipment between departments and integrated management are required. • It is necessary to improve the layout so that inspection work can be performed more efficiently by consolidating each type of inspection, in the future.
Trainee Dormitories (Hostels)	• Dormitories are limited to large rooms with a capacity of about 15 people with wooden bed frame in each building. • Some rooms have rain leaks, and heavy damage to the floor and joinery. • Only a limited number of rooms are equipped with fans.	• Improvement of living environment is essential. • Additional rooms are required to match the future plan of the number of the trainees that CTC is aiming for.

Source : JICA Study Team

2.9 Major Issues in the Vicinity of the Project

Major issues in the vicinity of the Project are as follows;

- It is forecasted that traffic demand on the East-West Corridor will increase drastically as shown in Table 2.9.1. For the section between Thaton and Myawaddy as a part of the GMS EWEC, it has specifically initiated road improvements corresponding to the future traffic demand by the support of international organizations such as JICA and ADB, however road improvement on the remaining sections of the East-West Corridor are not scheduled yet due to the conflict with the existing BOT contracts, difficulty in widening the existing road on the limited ROW (populated area) as well as lack of development budget. The section from Yangon to Thaton is expected to increase the traffic in merging the traffic from the southeastern part of the country and would be one of critical future bottlenecks.

Table 2.9.1 Traffic Demand Forecast along the EWEC in Pre F/S

Traffic Demand Forecast	2017 (PCU)	2025(PCU)	2035(PCU)	2045(PCU)
Y-M Exp. connect - Bago	17,200-23,800	29,700-44,300	45,600-87,900	53,500-92,400
Bago - Payagyi	20,900	30,100 - 52,700	51,500 - 123,700	73,200 - 151,900
Payagyi-Thaton	7,400-19,200	18,900-48,800	48,200-128,200	52,600-162,700
Thaton -Myawaddy	3,900-7,000	11,200-14,500	16,400 - 27,800	20,000-36,200

Source: JICA Study Team

- Moreover, deterioration in traffic environment caused by large freight vehicles passing through the populated area mixed together with regional traffic is concerned. The situation will worsen along with the expanding traffic volume in the future.
- It is highly required to ensure the redundancy (substitutability) of the road network. Redundancy is the means not only to reduce traffic congestion but also provide an alternative function to divert the traffic for alleviating/reducing the social disruption and economic loss in emergency events caused by natural disasters or serious accidents. The Yangon - Mandalay Expressway consists of the north-south corridor that has already provided an alternative route for the national road (Yangon - Mandalay road). However, the East–West Corridor has very few sections having alternative routes. Particularly, the section between Bago and Thaton where the traffic is highly concentrated is meaningfully required for redundancy on the East–West Corridor.
- In addition, in line with logistic promotion and remarkable economic growth in Myanmar, a lot of roads and bridges have been constructed recently and results in lack of technical capacity and human resources. Under such circumstances, for proper and sustainable road /bridge operation and maintenance including this project road, it is a challenge for MOC to enhance its technical capacity and develop human resources. To reflect to this, enhancement of the Thuwunnna Central Training Center (hereafter referred to as “Thuwunna CTC”)’s function and Research Laboratories’ quality control function are strongly required. However it was recognized that advanced trainings and quality inspections cannot be provided sufficiently in the existing Thuwunna CTC and laboratories due to its aging and insufficient facilities.

2.10 Purpose of the Project

The purpose of the Project is to improve the efficiency of international and domestic logistics by responding to the increasing traffic demand through developing a new road from Bago to Kyaikto section of the EWEC and strengthening the road operation and maintenance capacity of MOC, thereby contributing to the vitalization of Myanmar's trade.

CHAPTER 3 TRAFFIC DEMAND FORECAST

3.1 Methodology of Traffic Demand Forecast

The objectives of traffic demand forecast in the Study are to forecast future traffic volume in order to contribute bridge (and road) design and prepare indicators for the project evaluation such as economic evaluation.

Along the East-West Economic Corridor including New Sittaung Bridge and New Bago – Kyaikto road section, JICA conducted a Pre-F/S in 2016. Traffic demand forecast in the Pre-F/S was based on traffic demand forecast models prepared by "The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (JICA, 2014)". In the same year, JICA conducted the "Project for Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA)" in 2014 to formulate the urban transport master plan for the Greater Yangon and road network improvement including Outer and Inner Ring Road. The Outer Ring Road is expected to be an alternative route for heavy vehicles generated by the Thilawa Port and the Thilawa SEZ, therefore, it affects the traffic demand of the Thilawa – Bago Road and should be considered in the traffic demand forecast in the Study.

Traffic demand in the Study, therefore, should be built by merging the existing demand forecasts prepared by Pre-F/S and YUTRA. The following figure shows the work flow of traffic demand forecast in the Study.

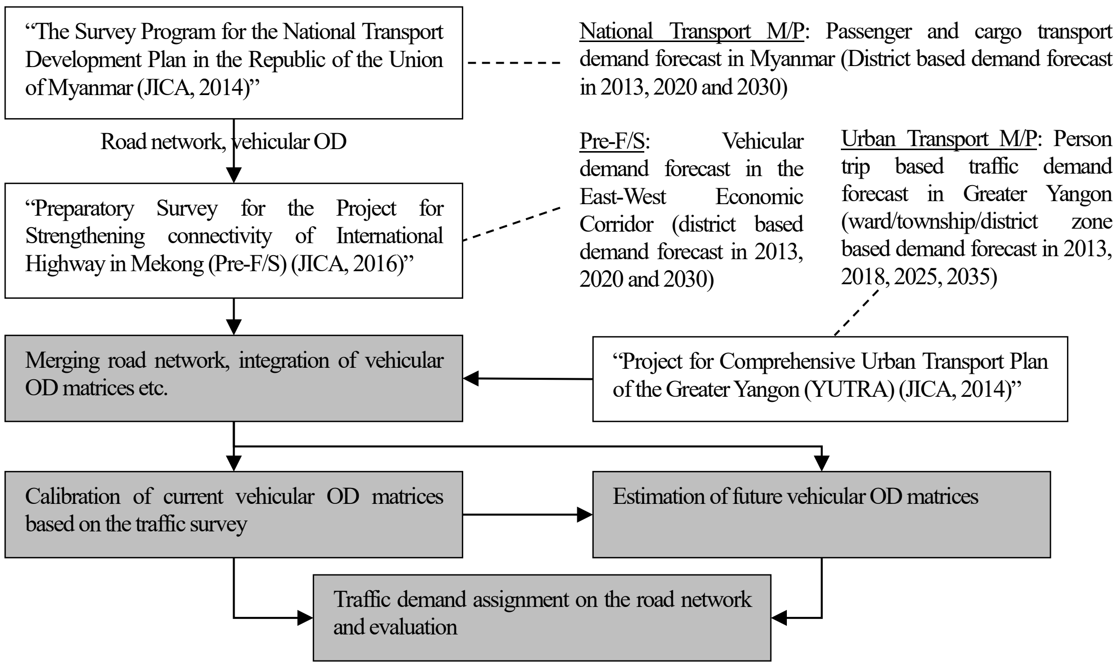


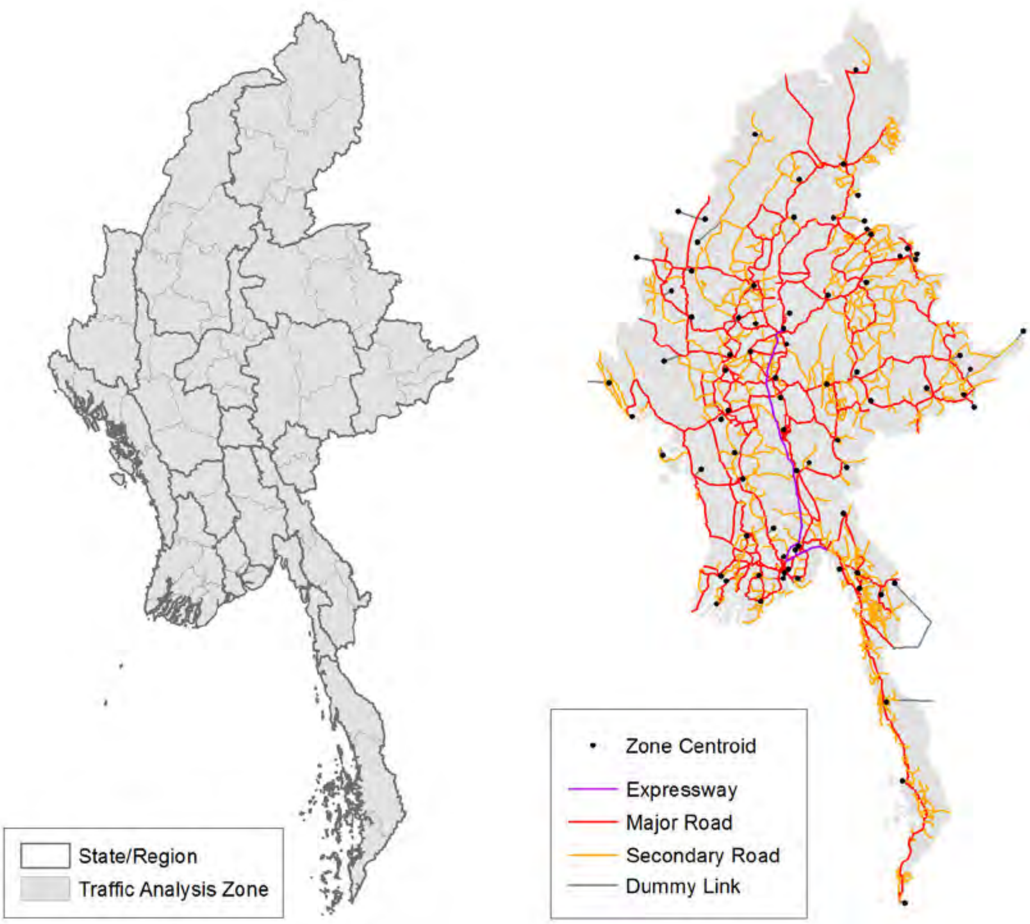
Figure 3.1.1 Methodology of Traffic Demand Forecast

Source: JICA Study Team

3.1.1 Review of Existing Traffic Demand Forecast

(1) Demand Forecast by Pre-F/S

Traffic demand forecast in the Pre-F/S was based on the existing demand forecast models prepared by "The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (JICA, 2014)", (hereafter, National Transport M/P). The objective of the National Transport M/P is for the preparation of comprehensive policies relevant to all modes of transport, as well as development strategies for specific modes such as road/road transport, rail, air, maritime and inland waterways, as well as the associated projects and activities that can help these modes achieve the Vision and its Objectives for economic growth target towards 2030 in Myanmar. The traffic demand forecast models in the National Transport M/P were built for the estimation of national level passenger and freight including roads, railways, inland waterways and airways. The present passenger/freight demand was estimated by using the existing statistics and results of traffic surveys such as roadside traffic count and OD interview survey, passenger/traffic count and OD interview survey at major transport terminals including railway stations, river ports and airports; therefore, short-distance trips such as intra-zonal trips were not included in the traffic demand in the National Transport M/P. Future passenger/freight demand forecast was based on zone parameters such as population, GRDP, household income composition and inter-zonal impedance by transport mode.



Source: JICA Study Team

Figure 3.1.2 Traffic Analysis Zone System and Road Network in Pre-F/S

In addition, the traffic demand forecast in Pre-F/S includes,

- Traffic generation of Hanthawaddy International Airport based on the "Preparatory Study on Development and Operation of Hanthawaddy international Airport (2015, JICA)".
- Traffic generation of industrial zones and SEZs prepared by the National Transport M/P. It is considered in the GRDP growth in demand forecast model.
- Modal shift of freight from marine transport to road transport between Myanmar and Thailand by road improvement of the East-West Economic Corridor, that is estimated by modal share model adopting generalized cost of land and sea transport.

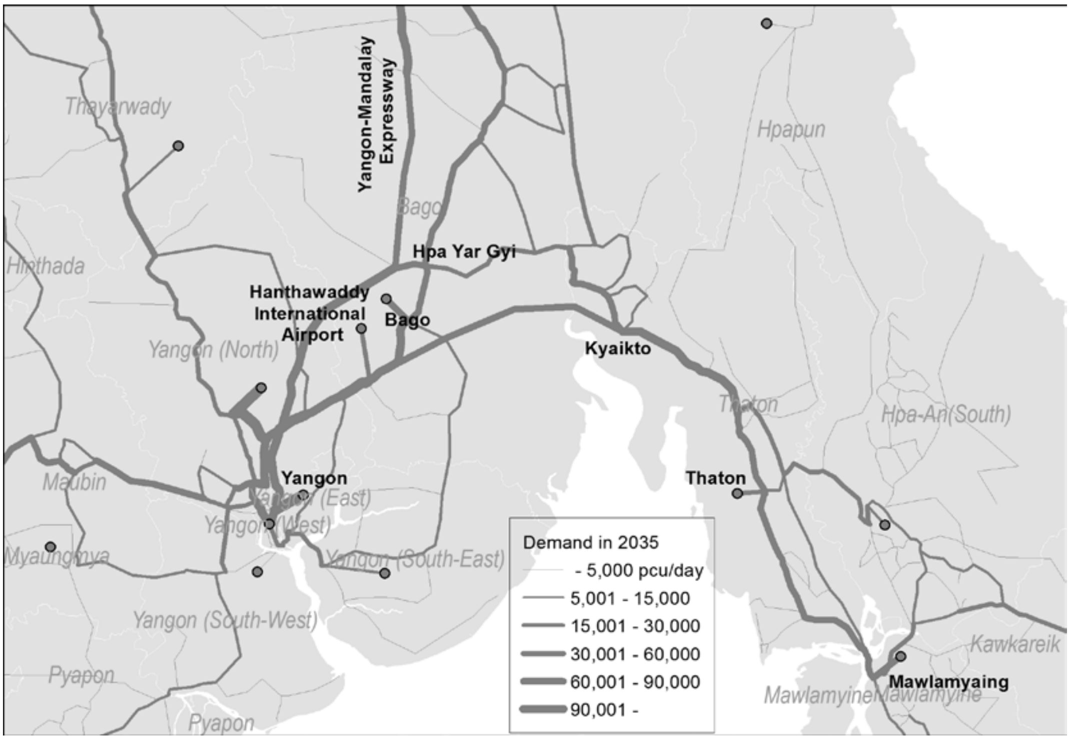
Existing and future traffic demand are forecasted by 6 vehicle types (car, bus, 2 axles truck, 3 axles truck, 4+axles truck and trailer) in the Study based on the demand forecast from the Pre-F/S. The demand forecast model in the Pre-F/S was based on boundary of the District (80 traffic analysis zones are defined in the entire Myanmar including Hanthawaddy Airport as a special zone and external zones such as China and Thailand), therefore, it is difficult to estimate accurate future traffic demand relevant to Yangon such as the Outer Ring Road because Yangon consists of 5 zones in the Pre-F/S.

As the results of traffic demand forecast by the Pre-F/S, future traffic demand of New Sittaung Bridge is forecasted 24.2 thousand PCU per day in 2025, and 63.5 thousand PCU per day in 2035 as shown in the following table.

Table 3.1.1 Future Traffic Demand Forecasted by Pre-F/S

Section	2025 (PCU/day)	2035 (PCU/day)
Hpa Yar Gyi - Kyaikto (existing road)	2,800-8,700	10,500-16,400
Bago – Hpa Yar Gyi (existing road)	13,800-25,500	54,400-77,500
Bago – Kyaikto (project road and bridge)	24,200	63,500
National Highway No.1	9,800-16,000	44,700-47,900
Hanthawaddy Airport Access (new elevated road on NH-1)	34,600-36,700	82,500-99,300

Source: Preparatory Survey for the Project for Strengthening connectivity of International Highway in Mekong (Pre-F/S) (JICA, 2016)

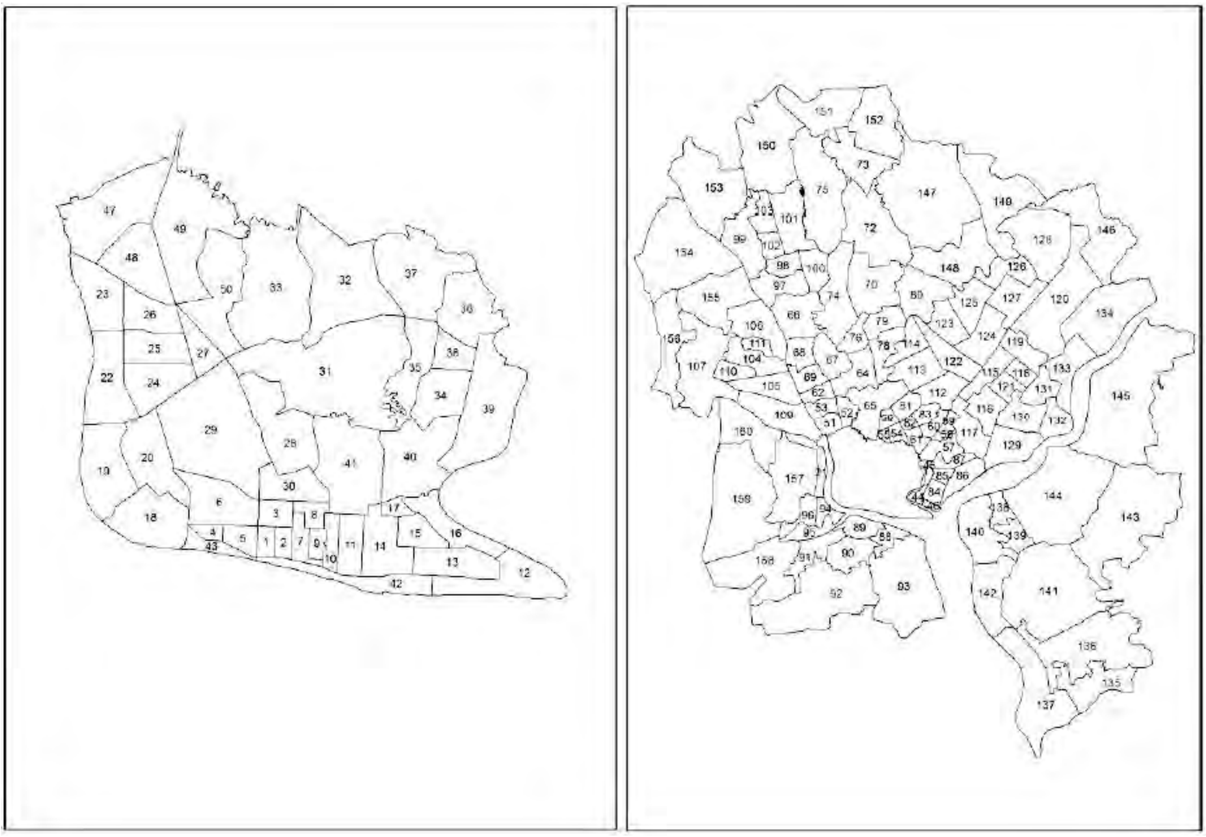


Source: JICA Study Team

Figure 3.1.3 Future Traffic Volume in 2035 Forecasted by the Pre-F/S

(2) Demand Forecast in YUTRA

YUTRA is the urban transport master plan and the objective of the traffic demand forecast is to contribute to the planning and evaluation of the transport project in the Greater Yangon such as the Inner and Outer Ring Road, railway and other urban public transport systems. Existing and future traffic demand, therefore, were estimated by 10 vehicle types (bicycle, motorcycle, car, taxi, bus, pick-up, 2 axles truck, 3+axles truck, truck trailer and other commercial vehicles) in accordance with urban transport policy and planning. The traffic analysis zone in YUTRA is 187 zones in total, however, Bago and other States/Regions are defined as integrated external zones.



Source: YUTRA

Figure 3.1.4 Traffic Analysis Zone System in YUTRA

3.1.2 Demand Forecast Models in the Study

The existing traffic demand forecast models prepared by relevant JICA Studies are summarized below.

Table 3.1.2 Summary of Existing Traffic Demand Forecast Models

	YUTRA (2014)	National Transport M/P (2014)	Pre-F/S (2016)
Study Area (for demand forecast model)	Greater Yangon including Yangon City and a part of adjacent six townships (Thalyin, Hmawbi, Helgu, Htantabin, Twantay and Kyauktan).	Entire Myanmar	
	In this Study, the road network and traffic demand for future demand forecast includes all of Myanmar.		
Traffic Analysis Zone (TAZ) System	187 zones (including special generator zones such as airport, bus terminals and truck terminal, and 27 external zones out of study area)	84 zone zones.	80 zones (incl. Hanthawaddy Airport and merged external zones in Thailand).
	In the Study Area, each township is divided into several TAZs.	Each TAZ is defined by one or more districts of each State/Region.	
	Bago and Mon are external zones respectively.	Bago and Mon are four and two TAZs based on district boundariea.	
	In this Study, a 128 zones system is adopted which consists of 43 zones in Yangon, 12 zones in Bago, 3 Mon State, 62 zones in other States and 8 external zone.		
Traffic demand at survey year	Based on the results of person trip survey and cordon/screen line survey, etc.	Based on the roadside and major facilities traffic count/interview survey.	Updating of road traffic demand (OD) prepared by M/P with roadside traffic count/interview survey.
Trip generation model	Person trip generation model by trip purpose with population, worker/student by resident/work place or school by car availability etc. as variables. Heavy goods vehicle is estimated by future GDP growth.	GDP elasticity.	Updating of road traffic demand (OD) prepared by M/P with updated present OD.
Trip distribution model	Gravity model by trip purpose and car availability.	Frater method (present pattern method).	ditto

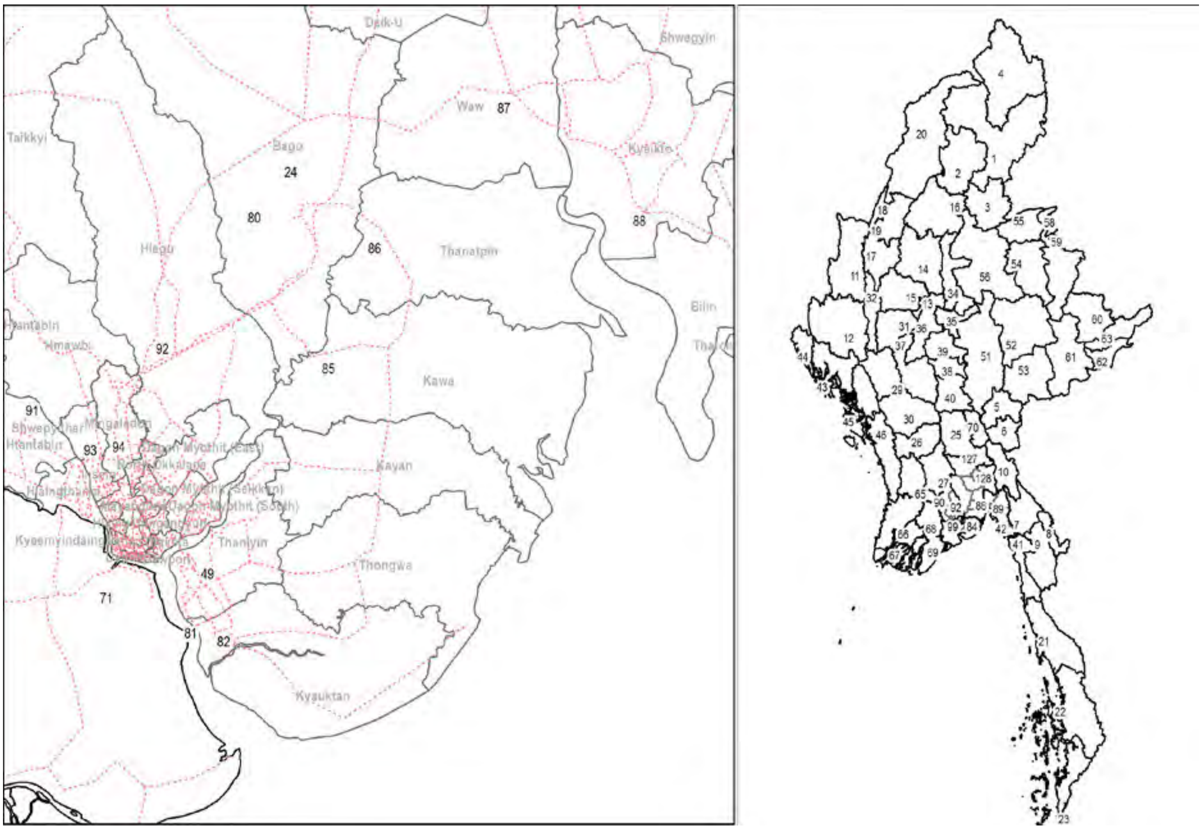
Modal split model	Aggregated logit split models for existing modes by car availability with inter-zonal travel cost and time as variables. .	Aggregated logit models with inter-zona generalized cost as variable.	ditto
Demand Forecast	In the Study, present and future traffic demand is estimated by integration and calibration of exiting road traffic demand forecasted by YUTRA and Pre-F/S without demand forecast models prepared by YUTRA and M/P.		

Source: JICA Study Team

To estimate present and future traffic demand in the Study, (i) present road transport ODs prepared by YUTRA and Pre-F/S are merged, (ii) merged OD is updated and calibrated by the results of traffic survey conducted in the Study, (iii) future traffic demand growth prepared by YUTRA and Pre-F/S are reviewed and, (iv) future traffic demand is forecasted and assigned on the road network.

(1) Traffic Analysis Zone

Traffic analysis zone systems between YUTRA and the Pre-F/S are quite different because of different of purposes of demand forecast and objectives of the studies. The traffic analysis zone system for the Study, therefore, consists of the township level zones in the Greater Yangon, Bago and Mon State along New Bago – Kyaikto Highway, and existing district level zones in other State/Region as the Pre-F/S. Based on the new zone system, OD prepared by YUTRA is merged by town ship level and OD prepared by the Pre-F/S is divided into township level in accordance with population by census relevant to Bago and Mon. The total number of TAZs is 128 including Yangon Airport, Hanthawaddy Airport, Thilawa Port, Yangon Port and eight external zones.



Source: JICA Study Team
Note: Figures on the map are Zone No. in Traffic Analysis Zone System Table.

Figure 3.1.5 Traffic Analysis Zone System

Table 3.1.3 Traffic Analysis Zone System

State	District	Township	Zone No.	State	District	Township	Zone No.
Kachin	Myitkyina		1	Ayeyarwady	Hinthada		65
Kachin	Mohnyin		2	Ayeyarwady	Myaungmya		66
Kachin	Bhamo		3	Ayeyarwady	Labutta		67
Kachin	Puta-O		4	Ayeyarwady	Maubin		68
Kayah	Loikaw		5	Ayeyarwady	Pyapon		69
Kayah	Bawlake		6	Kayin	Hpa-An		70
Kayin	Hpa-An		7	Yangon	Yangon (South-West)		71
Kayin	Myawaddy		8	External	India		72
Kayin	Kawkareik		9	External	India		73
Kayin	Hpapun		10	External	China		74
Chin	Falam		11	External	China		75
Chin	Mindat		12	External	China		76
Sagaing	Sagaing		13	External	China		77
Sagaing	Shwebo		14	External	China		78
Sagaing	Monywa		15	External	Thailand		79
Sagaing	Katha		16	Bago	Bago	Hanthawaddy IA	80
Sagaing	Kale		17	Yangon	Yangon (South)	Thilawa Port	81
Sagaing	Tamu		18	Yangon	Yangon (South)	Kyauktan	82
Sagaing	Mawlaik		19	Yangon	Yangon (South)	Thongwa	83
Sagaing	Hkamti		20	Yangon	Yangon (South)	Kayan	84
Tanintharyi	Dawei		21	Bago	Bago	Kawa	85
Tanintharyi	Myeik		22	Bago	Bago	Thanatpin	86
Tanintharyi	Kawthoung		23	Bago	Bago	Waw	87
Bago	Bago	Bago	24	Mon	Thaton	Kyaikto	88
Bago	Taungoo		25	Mon	Thaton	Bilin	89
Bago	Pyay		26	Yangon	Yangon (North)	Taikkyi	90
Bago	Thayarwady		27	Yangon	Yangon (North)	Htantabin	91
Magway	Magway		28	Yangon	Yangon (North)	Hlegu	92
Magway	Minbu		29	Yangon	Yangon (North)	Shwepyithar	93
Magway	Thayet		30	Yangon	Yangon (North)	Mingaladon	94
Magway	Pakokku		31	Yangon	Yangon (North)	Insein	95
Magway	Gangaw		32	Yangon	Yangon (North)	Hlaingtharya	96
Mandalay	Pyinoolwin		33	Yangon	Yangon (West)	Hlaing	97
Mandalay	Mandalay		34	Yangon	Yangon (West)	Mayangone	98
Mandalay	Kyaukse		35	Yangon	Yangon (West)	Kamaryut	99
Mandalay	Myingyan		36	Yangon	Yangon (West)	Kyeemyindaing	100
Mandalay	Nyaung-U		37	Yangon	Yangon (West)	Ahlone	101
Mandalay	Yamethin		38	Yangon	Yangon (West)	Yangon Port	102
Mandalay	Meiktila		39	Yangon	Yangon (West)	Dagon	103
Naypyitaw	Naypyitaw		40	Yangon	Yangon (West)	Bahan	104
Mawlamyine	Mawlamyine		41	Yangon	Yangon (East)	Yankin	105
Mawlamyine	Thaton		42	Yangon	Yangon (East)	Tamwe	106
Rakhine	Sittwe		43	Yangon	Yangon (East)	Dawbon	107
Rakhine	Maungdaw		44	Yangon	Yangon (East)	Mingalartaungnyunt	108
Rakhine	Kyaukpyu		45	Yangon	Yangon (West)	Seikkan	109
Rakhine	Thandwe		46	Yangon	Yangon (West)	Lanmadaw	110
Yangon	Yangon (North)	Hmawbi	47	Yangon	Yangon (West)	Latha	111
Yangon	Yangon (East)	Dagon Myothit (East)	48	Yangon	Yangon (West)	Pabedan	112
Yangon	Yangon (South)	Thanlyin	49	Yangon	Yangon (West)	Kyauktada	113
Yangon	Yangon (West)	Sanchaung	50	Yangon	Yangon (East)	Botahtaung	114
Shan	Taunggyi		51	Yangon	Yangon (East)	Pazundaung	115
Shan	Loilen		52	Yangon	Yangon (East)	Thaketa	116
Shan	Langkho		53	Yangon	Yangon (East)	Thingangyun	117
Shan	Lashio		54	Yangon	Yangon (East)	Dagon Myothit (Seikkan)	118
Shan	Muse		55	Yangon	Yangon (East)	Dagon Myothit (South)	119
Shan	Kyaukme		56	Yangon	Yangon (East)	Dagon Myothit (North)	120
Shan	Kunlong		57	Yangon	Yangon (East)	North Okkalapa	121
Shan	Laukkaing		58	Yangon	Yangon (North)	Yangon Airport	122
Shan	Hopang		59	Yangon	Yangon (East)	South Okkalapa	123
Shan	Kengtung		60	Mon	Thaton	Paung	124
Shan	Monghsat		61	Bago	Bago	Daik-U	125
Shan	Tachileik		62	Bago	Bago	Nyaunglebin	126
Shan	Monghpyak		63	Bago	Bago	Kyauktaga	127
Ayeyarwady	Pathein		64	Bago	Bago	Shwegyin	128

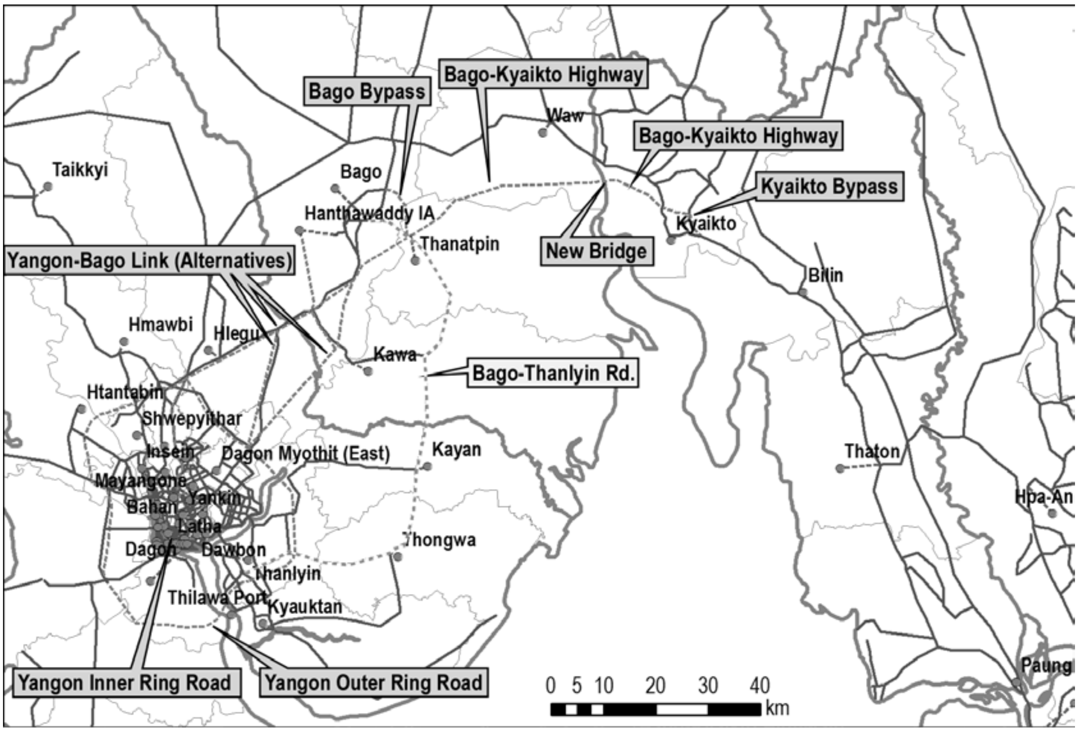
Source: JICA Study Team

Note: Because of zone division, traffic analysis zone is no particular order.

(2) Road Network and Attributes

Existing and future road network for traffic demand forecast is based on the road network prepared by the Pre-F/S which includes the New Sittaung Bridge, the New Bago – Kyaikto Highway Section and three alternative routes for access to the Outer Ring Road, Airport access to Hanthawaddy Airport, and Yangon Inner and Outer Ring Roads.

Future road network for traffic demand forecast is finalized by future road network plans prepared by ADB TA, and Bago Bypass, Kyaikuto Bypass, Bago - Thanlyin Road improvement and other improvement are considered in the future network.



Source: JICA Study Team

Figure 3.1.6 Road Network and Traffic Analysis Zone for Demand Forecast in the JICA Study

Condition of the road network for traffic assignment is defined based on the QV condition prepared by YUTRA as shown in following table.

Table 3.1.4 QV for Road Network

Area	Type	Lanes	Vmax (km/h)	Qmax (PCU/day)
CBD	Secondary	1	40	4,400
		2	40	15,200
	Major	1	45	9,000
		2	45	20,000
Township Inner RR	Secondary	1	45	11,600
		2	45	27,200
	Major	1	50	14,400
		2	50	33,600
Township Suburb	Secondary	1	50	16,600
		2	50	35,200
	Major	1	60	19,800
		2	60	42,000
Bridges (Yangon)		1	45	27,600

	2	80	60,000
Expressway Ramp	1	80	30,000
Expressway	1	100	40,000
	2	100	80,000

Source: YUTRA

(3) Other Traffic Generation

Traffic generation at Hanthawaddy Airport and the modal shift from maritime freight transport between Thailand are included in the demand forecast prepared by the Pre-F/S and it is included in the demand forecast in the Study.

In the existing JICA Study, "Preparatory Survey on Myanmar Hanthawaddy International Airport Project", future person trip made by airport passenger and airport staff is expected to be 125,000 trips per day in 2035 and 90% of person trip relevant to airport will be transported by passenger car and buses. Based on the estimation, future vehicular trip generation relevant to Hanthawaddy Airport is estimated by the Pre-F/S as shown in the following table. Future OD of generated trip at Airport is distributed in accordance with population of TAZs.

Table 3.1.5 Future Demand Relevant to Hanthawaddy Airport

Year	Person trips per day		Total PCU per day
	Buses	Passenger Cars	
2025	20,600	34,200	12,200
2035	43,100	72,700	25,800

Source: Pre-F/S

Note: Average vehicle occupancy of bus is 34 person per bus and 3.14 person per passenger cars based on National Transport M/P. PCU of bus is 2.0 and passenger car is 1.0.

Improvement of roads and bridges of the East-West Economic Corridor between Myanmar and Thailand through Myawaddy and Mae Sot will encourage cross-border trade between the two countries because of shortened travel time. In the Pre-F/S, by the improvement of NH-1 (Hpa Yar Gyi – Mawlamyine and Mawlamyine – Dawei) and an access road with Three Pagodas increases share of freight volume by road transport between Myanmar and Thailand. The expected diversion freight volume from marine transport to road transport estimated by the Pre-F/S is summarized below.

Table 3.1.6 Additional Freight Volume and Trucks by the Improvement of EWEC

	2030	2035
Freight volume shifted from marine transport to road (million ton / year)	3.8	6.6
Estimated additional heavy trucks (vehicle / day)	1,660	2,880

Source: Pre-F/S

Note: Volume of trucks is computed by average loading ton (8.8 ton per truck including empty truck) and working day (260 days per year).

In terms of other trip generation, such as industrial zones, was included as the factor of GRDP growth which is the growth factor of future traffic demand in YUTRA and National Transport M/P.

3.2 Traffic Survey

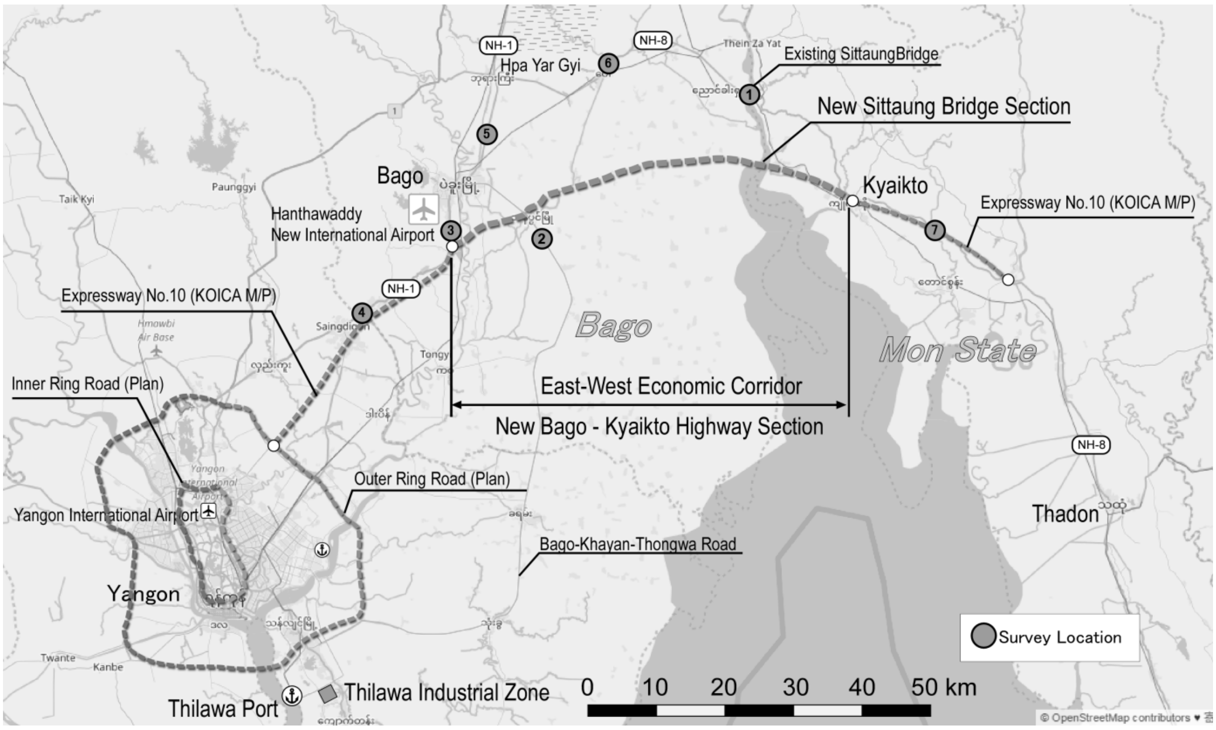
3.2.1 Outline of Traffic Survey

For the purpose of understanding current traffic condition and calibration of existing vehicular OD, a traffic survey consisting of a roadside driver interview survey and a traffic count survey were planned and carried out. Survey locations were decided to include river crossings and existing access road to New Bago – Kyaikto Highway. Survey contents and locations are summarized in the following table and figure.

Table 3.2.1 Traffic Survey Contents and Locations

No	Location	Traffic Count	Roadside Interview	Survey Day
1	Existing Sittaung Bridge	24 hours	10hours (7:30-17:30)	2 Weekdays
2	Bago-Kahyan-Thongwa Road	16 hours (5:30-21:30)	10hours (7:30-17:30)	2 Weekdays
3	NH-1 Bago South	24 hours	-	2 Weekdays
4	NH-1 Yangon-Bago	16 hours (5:30-21:30)	-	2 Weekdays
5	NH-1 Bago-Hpa Yar Gyi	16 hours (5:30-21:30)	-	2 Weekdays
6	NH-8 Hpa Yar Gyi – Sittaung Bridge	16 hours (5:30-21:30)	-	2 Weekdays
7	NH-8 Kyaikto East	16 hours (5:30-21:30)	-	2 Weekdays

Source: JICA Study Team



Source: JICA Study Team

Figure 3.2.1 Traffic Survey Location Map

Vehicle type of traffic count survey and roadside interview survey is classified into 11 types, namely, passenger cars including sedans and 4WD, pick-up trucks mainly used as public transport, vans mainly used as public transport, two-wheeled motorcycles, mini buses with 25-30 seats, large buses with 50 seats, 2 axles rigid trucks, 3 axles rigid truck, 4 and more axles rigid trucks, trailers and others such as agricultural tractors and three-wheeled vehicles.

Roadside interview survey items include origin and destination of trip, number of passengers and a willingness to pay relevant to travel time saving.

3.2.2 Results of Traffic Survey

(1) Traffic Count Survey

The results of traffic count survey are summarized in following table.

Table 3.2.2 Results of Traffic Count Survey

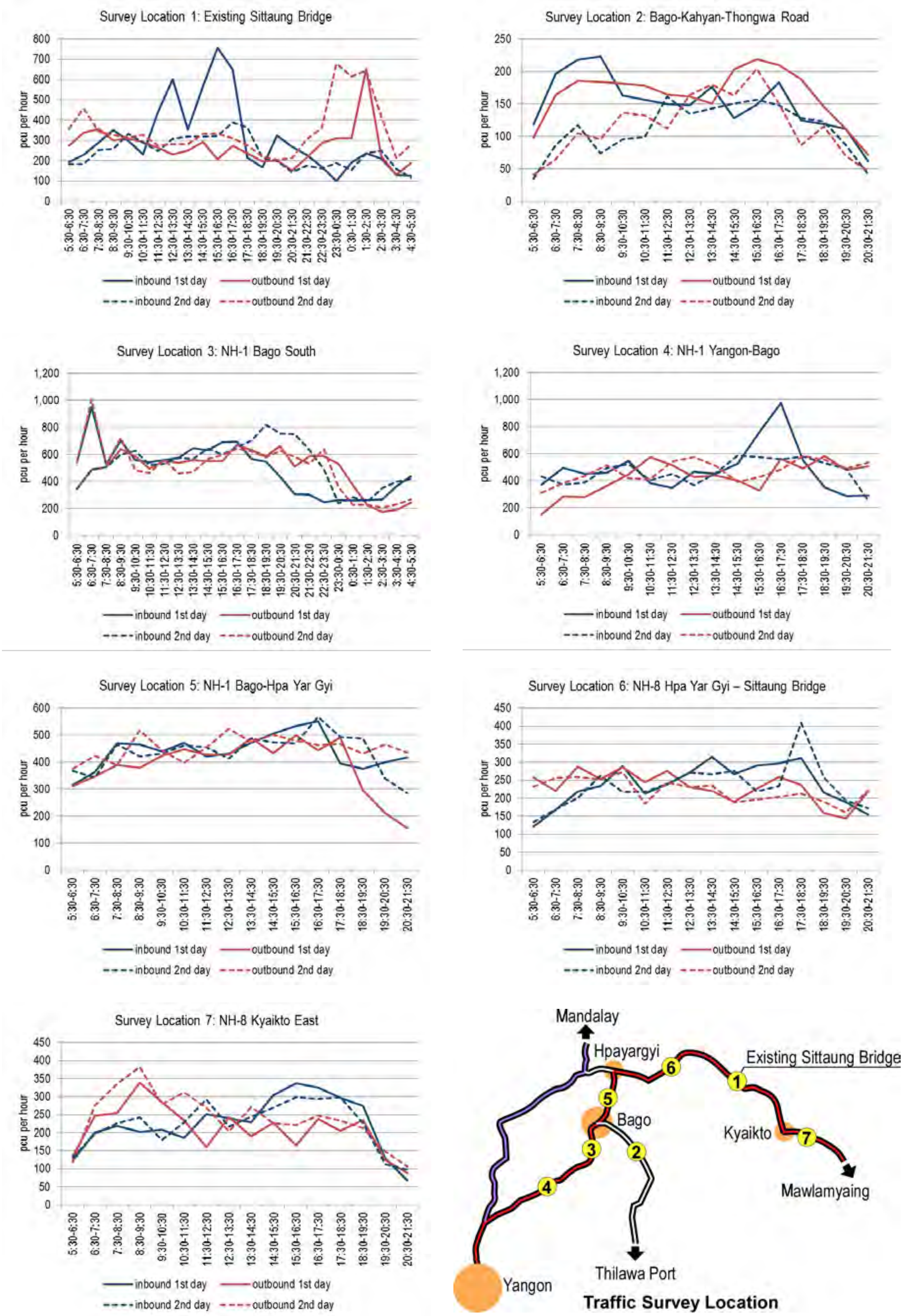
Survey Location	Direction	Date	Sedan	Pick-up	Van	Motor-cycle	Mini Bus	Large Bus	2axles Truck	3axles Truck	4+axl Truck	Trailer	Others	3 wheels
Loc.1 24 hours	inbound	8-May	1,489	353	326	1,219	51	432	1,241	114	601	162	9	35
		9-May	1,107	216	305	954	23	278	1,182	108	388	157	5	51
	outbound	8-May	1,223	199	352	1,140	32	295	1,241	157	503	170	8	50
		9-May	2,070	227	493	1,078	42	339	1,948	115	411	169	6	69
Loc.2 16 hours	inbound	15-May	237	211	41	3,035	12	47	497	2	28	5	23	281
		16-May	247	197	29	2,161	5	29	300	4	19	10	48	182
	outbound	15-May	225	203	38	3,663	17	31	500	4	35	13	16	301
		16-May	228	211	37	2,490	6	30	301	3	17	8	16	181
Loc.3 24 hours	inbound	11-May	1,550	1,409	312	4,206	433	520	1,519	138	764	540	10	180
		12-May	1,789	1,210	296	4,098	389	376	1,838	156	952	654	15	170
	outbound	11-May	1,697	872	247	3,728	405	451	1,573	125	974	597	14	189
		12-May	1,511	1,144	265	3,823	493	597	1,207	149	1,074	628	16	121
Loc.4 16 hours	inbound	17-May	1,458	1,027	159	1,786	369	258	899	73	474	355	14	60
		18-May	1,366	795	205	1,536	330	254	914	76	460	414	12	73
	outbound	17-May	1,108	708	190	1,286	371	276	741	66	529	354	4	47
		18-May	1,377	870	192	1,230	371	317	830	88	537	365	11	69
Loc.5 16 hours	inbound	17-May	820	722	107	2,713	66	204	915	149	551	437	6	169
		18-May	913	800	128	2,208	53	154	693	342	554	421	19	153
	outbound	17-May	901	903	156	2,335	48	150	594	286	380	306	9	178
		18-May	921	909	151	2,464	50	215	1,152	72	524	361	16	200
Loc.6 16 hours	inbound	17-May	773	384	187	1,544	6	133	629	86	175	70	9	66
		18-May	780	405	195	1,261	8	120	593	42	222	93	13	54
	outbound	17-May	677	433	179	1,564	12	163	519	51	221	82	5	78
		18-May	736	394	174	1,023	13	158	530	52	214	75	7	72
Loc.7 16 hours	inbound	8-May	717	457	522	1,712	7	164	356	57	86	73	20	46
		9-May	775	614	271	1,802	11	113	409	54	90	67	21	43
	outbound	8-May	795	285	215	1,698	14	130	524	42	93	70	27	60
		9-May	965	387	206	1,615	15	132	611	29	154	66	28	62

Source: JICA Study Team

Note: inbound and outbound are direction inbound for Yangon and outbound from Yangon respectively.

The following figures show a fluctuation of observed traffic volume by survey date and direction. Survey locations are basically located in rural areas except survey locations No.2 and No.7, therefore, hourly fluctuation caused by commuting trip is calm. At survey locations No.2 and No.7, hourly fluctuations by commuting trip relevant to Bago and Kyaikto were observed. Outbound traffic from Yangon at the existing Sittaung Bridge at midnight is remarkable, which is mainly caused by passenger cars and trucks.

The peak hour ratios of observed total traffic volume in passenger car unit (PCU) at 24 hours traffic count survey points, namely, No.1 the existing Sittaung Bridge and No.3 NH-1 Bago south are 6.3% and 5.8% respectively.



Source: JICA Study Team

Figure 3.2.2 Hourly Fluctuation of Observed Traffic Volume

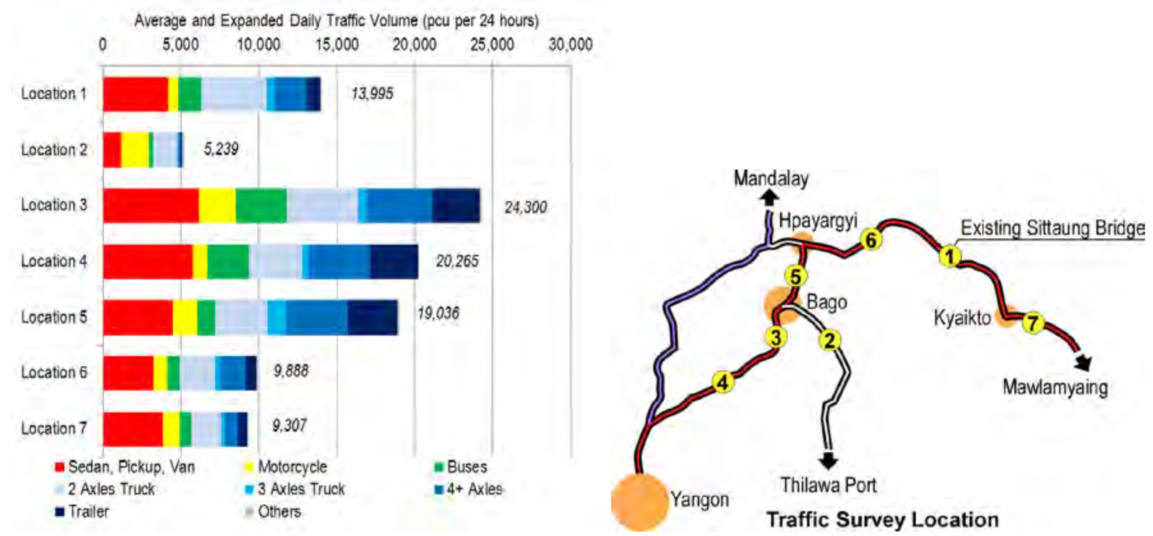
PCUs are defined based on the Pre-F/S as shown in the following table.

Table 3.2.3 Passenger Car Units

	Motorcycle (MC)	Sedan, Pick-up, Van	Mini Bus	Large Bus	2 Axles Truck	3 Axles Truck	4+ Axles Truck	Trailer	Others
PCU	0.3	1.0	1.5	2.0	1.5	2.0	2.25	2.5	0.3

Source: JICA Study Team

The following figure shows the daily traffic volume of total in both directions. Daily traffic volumes at survey locations with a 16 hours survey are expanded by expansion factor to expand the 16 hours traffic volume to 24 hours at survey locations No. 1 and No.3 by type of vehicle. Traffic volume at the existing Sitting Bridge is about 14,000 pcu per day in 2017.



Source: JICA Study Team

Note : Daily traffic volumes are total of both direction, average of two days of survey results, and expanded to 24 hours by survey results of location 1 and 3.

Figure 3.2.3 Processed Daily Traffic Volume

In the Pre-F/S, traffic count survey was conducted at the existing Sittaung Bridge for two days in February 2014. The following table shows the average daily traffic volume in the Pre-F/S and traffic survey in the Study. Traffic volume of 2 or 3 axles trucks has sharply increased almost four times and 59% per year since the Pre-F/S. Passenger cars such as sedans, pick-ups and vans have also sharply increased almost two times and 24% per year. Buses and heavy trucks including trucks with four and more axles and trailer are also increased by 17% and 15% per year respectively.

Table 3.2.4 Observed Daily Traffic Volume at Existing Sittaung Bridge

	Daily Traffic Volume (24 hours)					Total (vehicle)		Total (pcu)	
	Motor cycle (MC)	Sedan, Pick-up, Van	Buses	2-3 axles Truck	4+ axles, Trailer	Include MC	Exclude MC	Include MC	Exclude MC
Feb. 2014	1,907	2,184	455	758	837	6,141	4,234	6,492	5,920
May 2017	2,196	4,180	737	3,053	1,281	11,446	9,250	13,995	13,301
Growth (% p.a.)	4.8%	24.2%	17.4%	59.1%	15.2%	23.1%	29.8%	29.2%	31.0%

Source: JICA Study Team

(2) Roadside Interview Survey

The roadside interview survey is a sample survey at survey location No.1 existing Sittaung Bridge and survey location No.2 Bago-Kahyan-Thongwa Road. Number of samples and sample ratio are shown in following table.

Table 3.2.5 Number of Sample and Sample Ratio

	Location	Direction	Sedan	Pick-up	Van	Motor-cycle	Mini Bus	Large Bus	2Axles Truck	3+Axles Truck	Trailer	Others
Num. of Samples	Loc. 1	inbound	139	60	44	17	2	44	53	57	4	10
		outbound	176	86	38	19	5	37	66	27	19	5
	Loc. 2	inbound	99	60	18	1	5	13	170	14	2	54
		outbound	138	27	8	67	3	8	233	29	6	31
Daily Traffic Volume	Loc. 1	inbound	2,596	569	631	2,173	74	710	2,423	1,211	989	100
		outbound	3,293	426	845	2,218	74	634	3,189	1,186	914	133
	Loc. 2	inbound	598	475	93	5,514	19	103	1,072	90	47	579
		outbound	583	466	89	6,180	24	81	1,076	90	52	592
Sample Ratio	Loc. 1	inbound	5%	11%	7%	1%	3%	6%	2%	5%	0%	10%
		outbound	5%	20%	4%	1%	7%	6%	2%	2%	2%	4%
	Loc. 2	inbound	17%	13%	19%	0%	27%	13%	16%	16%	4%	9%
		outbound	24%	6%	9%	1%	12%	10%	22%	32%	12%	5%

Source: JICA Study Team

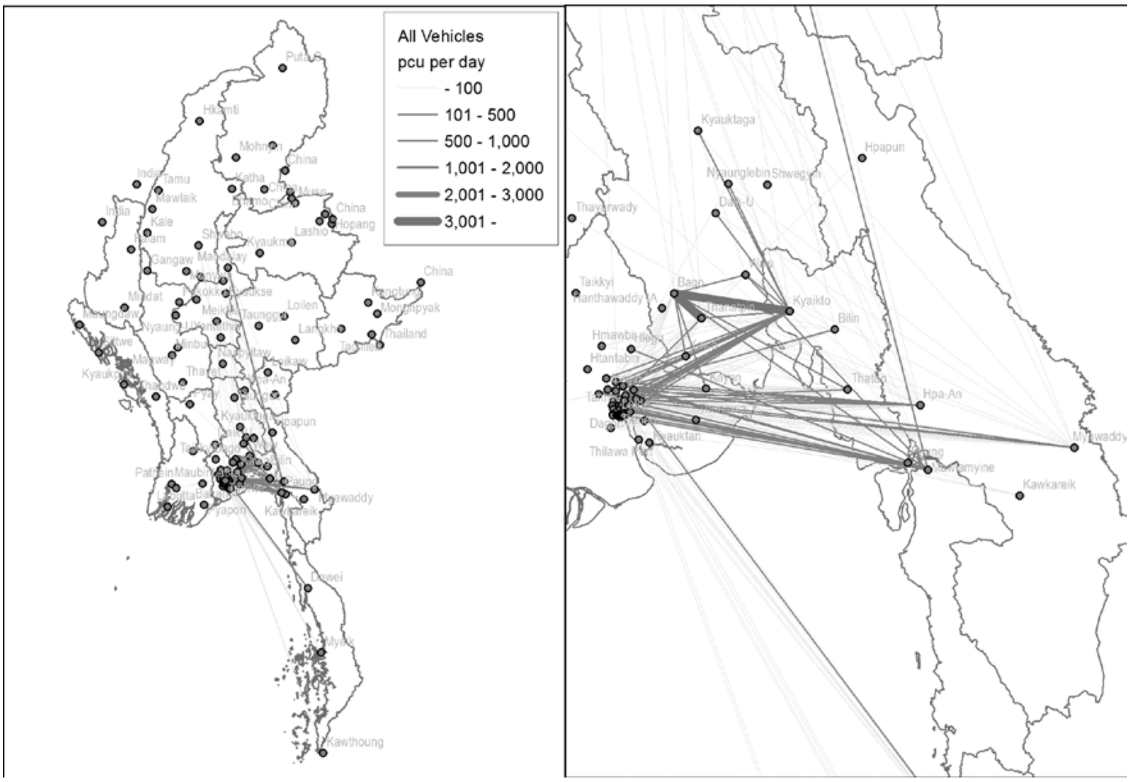
Based on results of the roadside interview survey, average vehicle occupancy is computed as shown in the following table. Vehicle occupancies of pick-ups, vans and 2 axles trucks are high because it includes passenger transport use.

Table 3.2.6 Average Vehicle Occupancy

Vehicle Type	Number of Sample (vehicle)	Total Number of Passenger	Ave. Occupancy (person per vehicle)
Sedan	552	1,865	3.4
Pick-up	233	1,861	8.0
Van	108	964	8.9
Motorcycle	104	217	2.1
Mini-Bus	15	337	22.5
Large-Bus	102	3,817	37.4
2Axles Truck	522	3,987	7.6
3Axles Truck	49	132	2.7
4+Axles Truck	78	179	2.3
Trailer	31	73	2.4
Others	26	58	2.2
3 Wheels	74	196	2.6

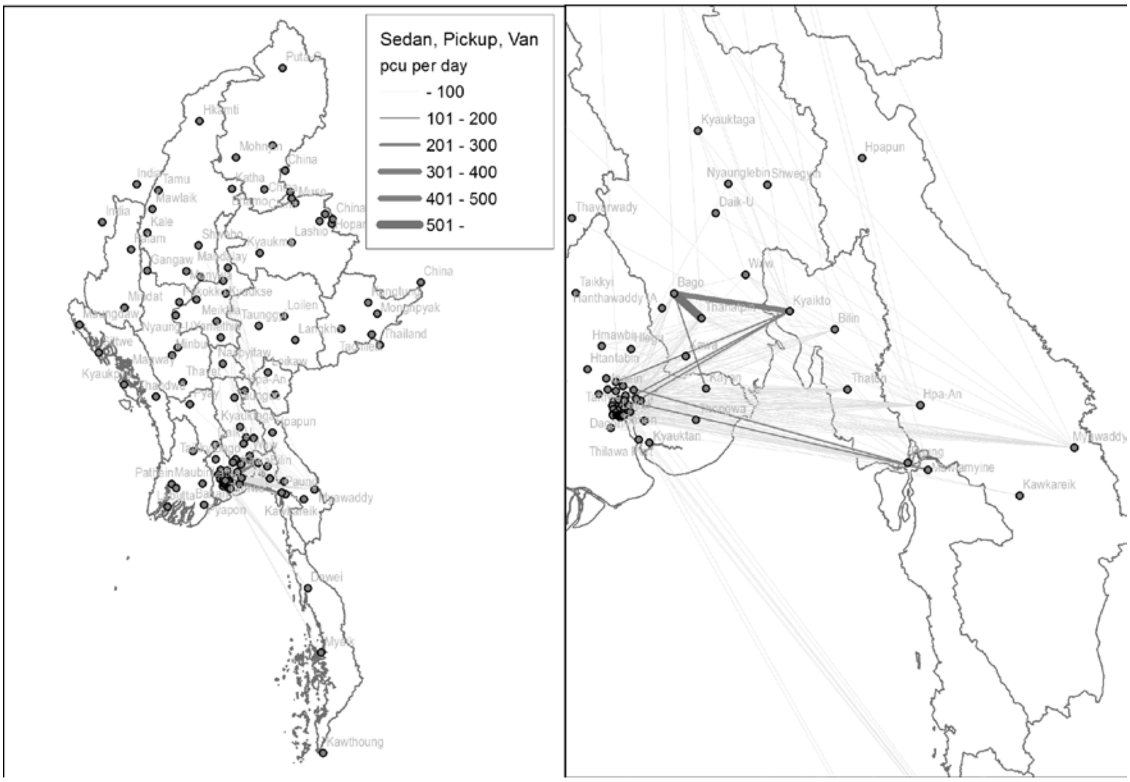
Source: JICA Study Team

Based on the results of the roadside interview survey, origin and destination of vehicular trip through the existing Sittaung Bridge and Bago-Kahyan-Thongwa Road is visualized as shown in the following figures. Passenger car trip is almost dominated by Bago – Kyaikto and Bago – Thanatpin. In terms buses, Yangon – Mawlamyine is remarkable. Truck trip through survey locations is mainly, Kyaikto – Yangon and Bago, Mawlamyine – Yangon.



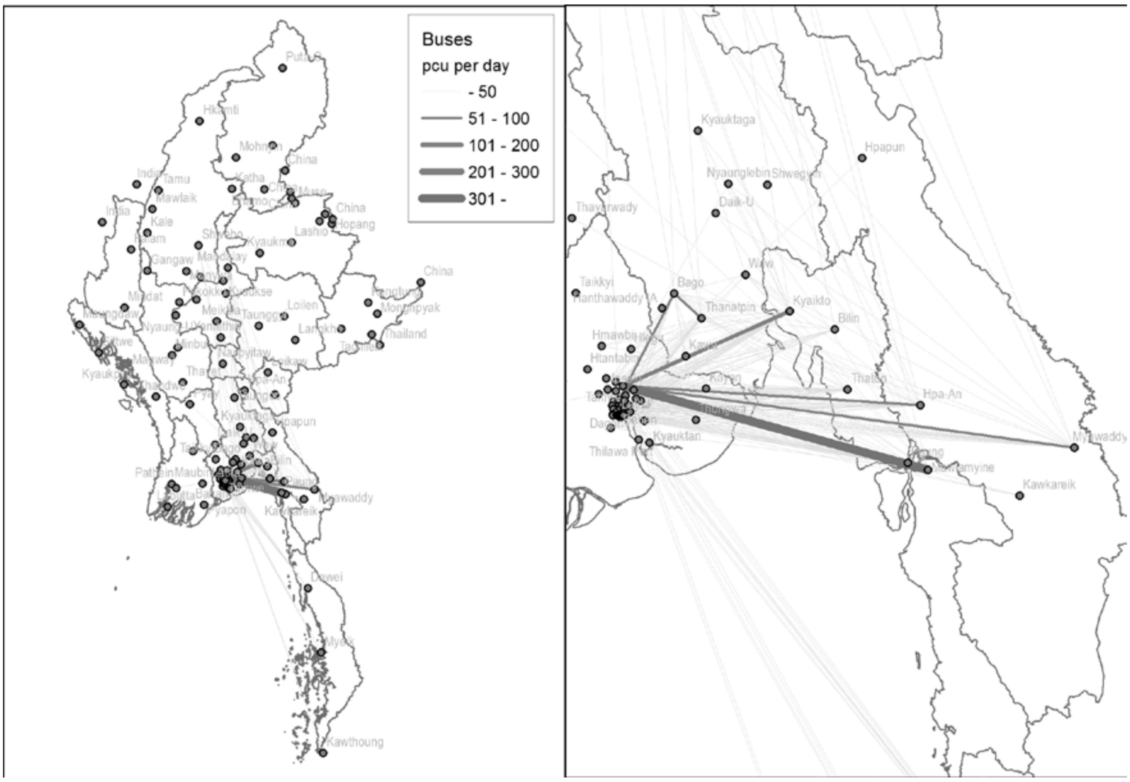
Source: JICA Study Team

Figure 3.2.4 Desire Line of All Vehicles



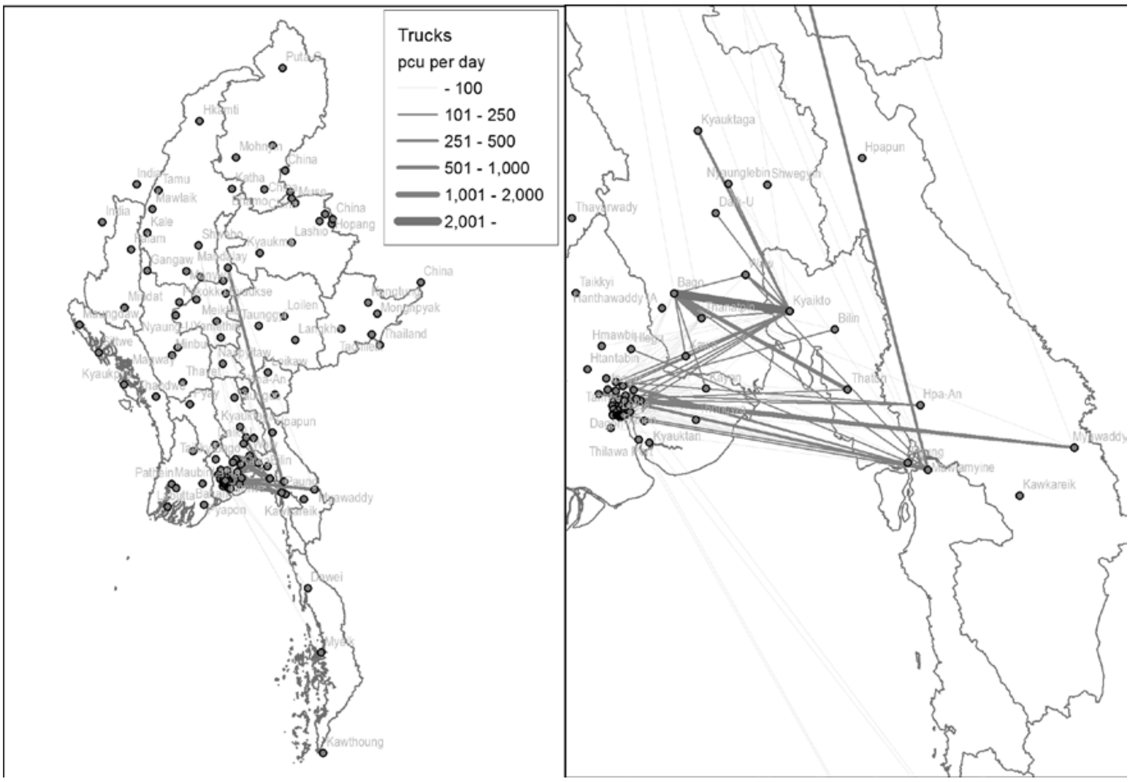
Source: JICA Study Team

Figure 3.2.5 Desire Line of Sedans, Pickups and Vans



Source: JICA Study Team

Figure 3.2.6 Desire Line of Buses

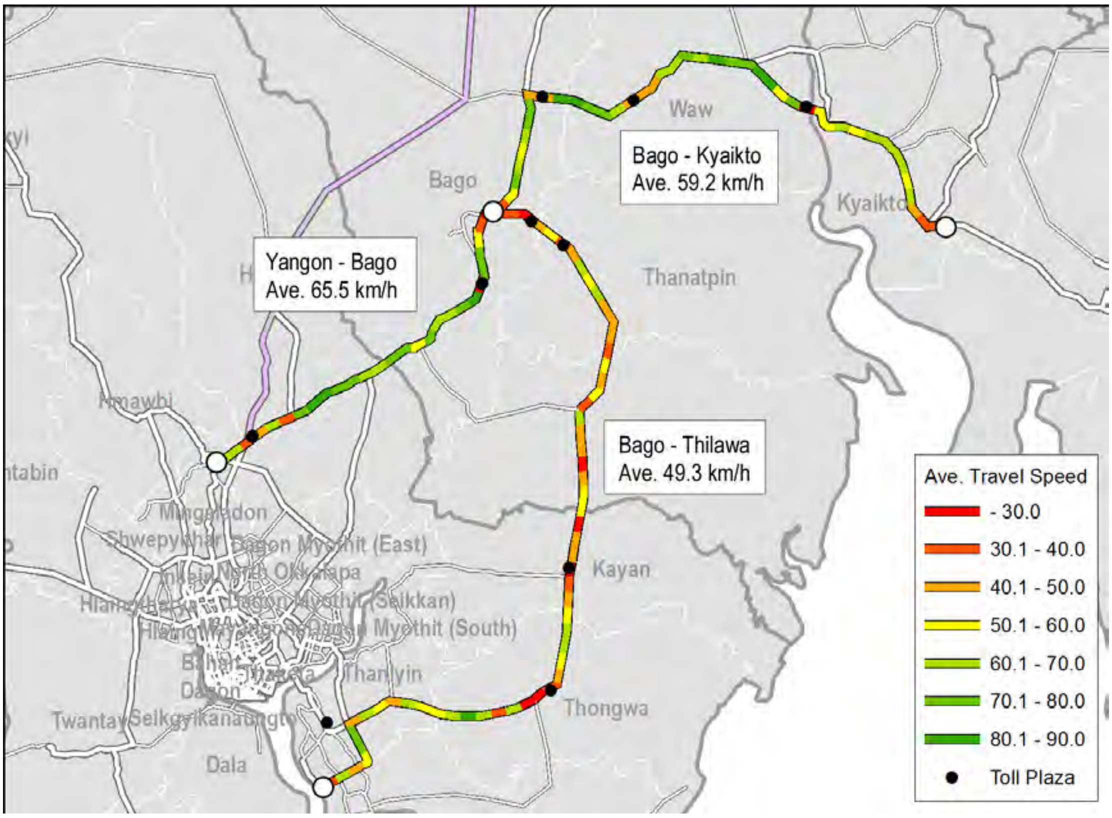


Source: JICA Study Team

Figure 3.2.7 Desire Line of Trucks

(3) Travel Speed

The following figure shows the average travel speed on 29th and 30th April 2017. Traffic flow conditions along the existing road is almost satisfactory, average travel speed between Yangon and Bago is 65.5km/h, Bago to Kyaikto is 59.2km/h. Average travel speed between Bago and Thilawa is 49.3km/h because of insufficient road width and narrow bridges.



Source: JICA Study Team

Figure 3.2.8 Average Travel Speed

3.3 Traffic Demand Forecast

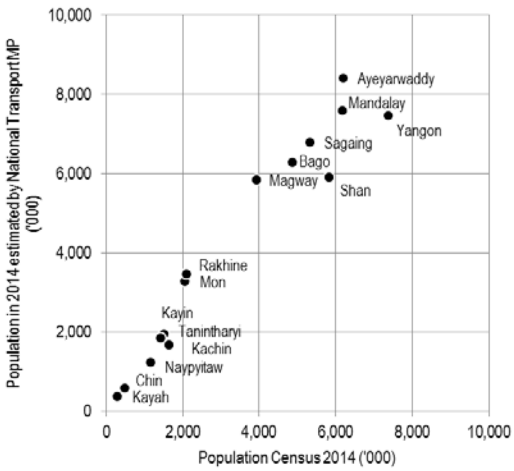
3.3.1 Socio-economic Framework

(1) Adjustment by Census Population

Traffic demand forecast by National Transport M/P and YUTRA were completed in 2013 before the Census 2014 in Myanmar, therefore, the socio-economic framework for the traffic demand forecast was estimated based on estimated population by the Population Department, Ministry of Immigration and Population (2012).

The following table and figure show population in 2014 by census and population framework defined by the National Transport M/P. In the National Transport M/P, population is overestimated as compared with the census population and the difference between census and estimation by M/P is different by State/Region.

State/Region	(a) Census	(b) Master Plan	(b)/(a)
Kachin State	1,643	1,685	102.6%
Kayah State	287	382	133.3%
Kayin State	1,504	1,941	129.1%
Chin State	479	588	122.8%
Sagaing Region	5,325	6,793	127.6%
Tanintharyi Region	1,408	1,841	130.7%
Bago Region	4,867	6,281	129.0%
Magway Region	3,917	5,852	149.4%
Mandalay Region	6,166	7,597	123.2%
Mon State	2,054	3,280	159.6%
Rakhine State	2,099	3,457	164.7%
Yangon Region	7,361	7,465	101.4%
Shan State	5,824	5,901	101.3%
Ayeyarwaddy Region	6,185	8,414	136.0%
Naypyitaw Council Territory	1,160	1,233	106.3%
Total	50,280	62,711	124.7%



Source: JICA Study Team

Figure 3.3.1 Population in 2014

The present traffic demand prepared by the Pre-F/S is estimated by the calibration of ODs of National Transport MP with the results of traffic survey, therefore, trip generation and distribution include the difference of population with Census population. Before merging with present ODs prepared by YUTRA, present ODs of the Pre-F/S is adjusted by difference of population between framework and Census 2014.

(2) Future Socio-Economic Framework

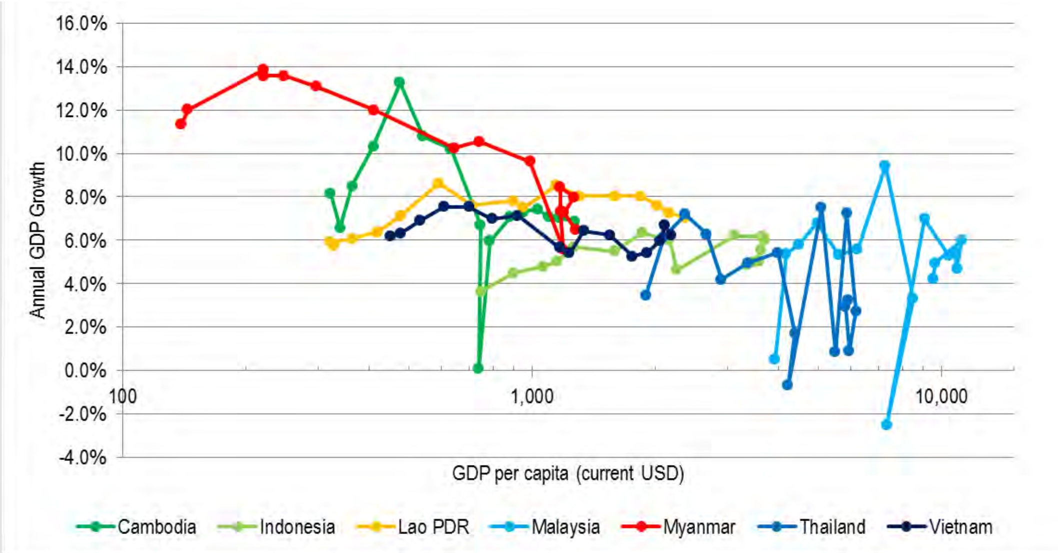
Economic development, not only population growth, will increase trip generation volume. Future GDP growth in Myanmar is forecasted by existing studies as shown in the following tables. For the purpose of future traffic demand forecast, the annual GDP growth in the future is forecasted at 7.2% and 7.0% by National Transport MP and YUTRA respectively.

Table 3.3.1 Forecasted GDP Growth Rate by Existing Studies

	Master Plan			YUTRA		
Scenarios	1) High	2) Medium	3) Low	1) High	2) Medium	3) Low
2015-2025	7.7	7.2	6.0	7.7	7.0	6.0
2025-2035	7.7	7.2	6.0	7.7	7.0	6.0

Source: The Survey Program for the National Transport Development Plan in the Republic of the Union of Myanmar (2014) , Project for Comprehensive Urban Transport Plan of the Greater Yangon (2014).

In general, annual GDP growth rate gradually declines in accordance with the economic development of a country. The following figure shows the relationship between GDP growth rate and per capita GDP of ASEAN countries in 2001-2016. In Myanmar, the annual GDP growth rate is in a slowdown in accordance with increase of per capita GDP.



Source: World Development Indicators 2017 (World Bank)

Figure 3.3.2 GDP Growth and GDP per Capita in ASEAN Countries (2001-2016)

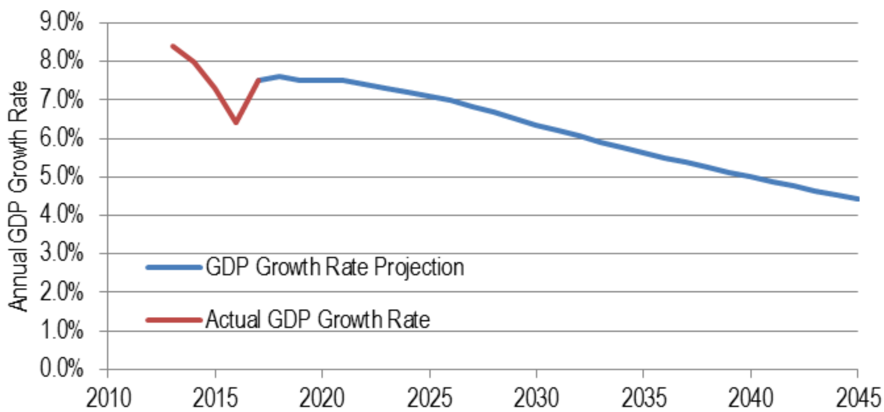
For forecasting long-term future economic growth in Myanmar, the following prediction by IMF is adopted in the Study. GDP growth rate in 2026 and 2036 are predicted at 7.0% and 5.5% respectively.

Table 3.3.2 Predicted GDP Growth Rate

Year	2013	2014	2015	2016	2017 f	2018 f	2019 f	2020 f	2021 f	2026 f	2036 f
Real GDP growth	8.4%	8.0%	7.3%	6.4%	7.5%	7.6%	7.5%	7.5%	7.5%	7.0%	5.5%

Source: IMF Country Report (Feb. 2017)
Note: GDP growth in year with "f" is assumption in baseline scenario.

Based on the prediction of future GDP growth prepared by IMF, the annual GDP growth in Myanmar is assumed as shown in the following figure.



Source: JICA Study Team

Figure 3.3.3 Future GDP Growth Rate

3.3.2 Traffic Demand Forecast

(1) Current Traffic Demand Estimation

The current traffic demand as of 2017 is computed by the following steps.

- Present ODs prepared by the Pre-F/S are adjusted by the population distribution of the Census 2014, and TAZs in Yangon, Bago and Mon State are divided to township zones in accordance with township population,
- Present ODs prepared by YUTRA is consolidated to township zones,
- Present ODs of Pre-F/S and YUTRA are merged,
- Based on the results of traffic surveys, the present merged ODs are calibrated, and
- Present ODs are assigned on the current road network.

For the traffic demand assignment on the road network, a time value is required for route choice. Based on the YUTRA and the Pre-F/S, time values of each vehicle type are defined as shown in the following table. The time value in 2017 is updated based on GDP deflator between 2013 and 2017 in Myanmar.

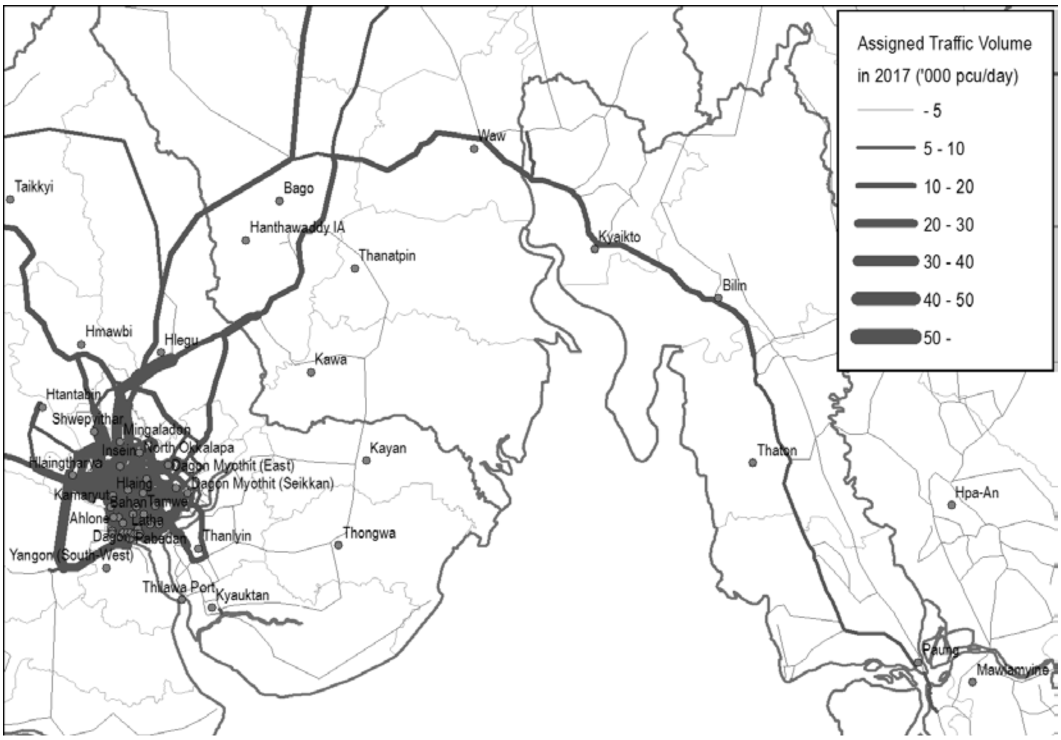
Table 3.3.3 Time Value

Unit : MMK/hour

Year	Passenger Cars (per passenger)	Bus (per passenger)	2 Axles Truck (per vehicle)	3 Axles Truck (per vehicle)	4 Axles Truck (per vehicle)	Trailer (per vehicle)
2013	1,313	660	176	337	513	811
2017	1,193	600	160	306	466	737

Source: JICA Study Team

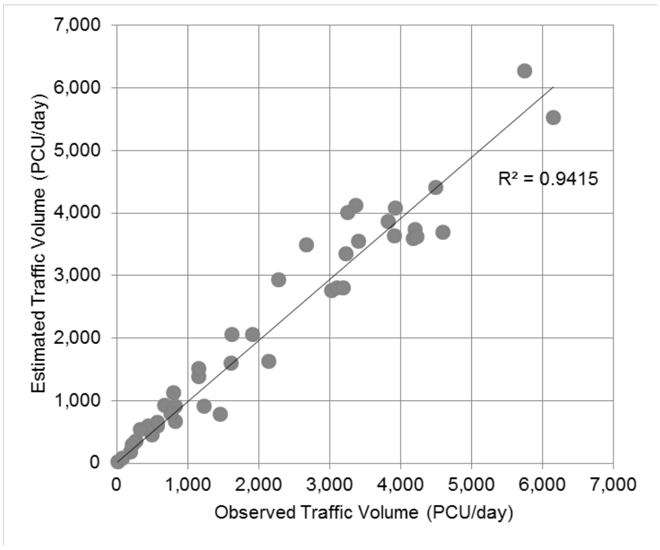
The estimated current traffic demand is assigned on the existing road network as shown in the following figure.



Source: JICA Study Team

Figure 3.3.4 Assigned Traffic Demand in 2017

The following figure shows the observed traffic volume by survey location and vehicle type, and estimated current traffic volume by traffic assignment using updated vehicular ODs and the current road network. The coefficient of determination of observed traffic volume and results of traffic assignment is 0.942, and the current traffic demand and road network are useful for further analysis.



Source: JICA Study Team

Figure 3.3.5 Observed and Estimated Traffic Volume in 2017

The following table shows the difference between the actual travel speed shown in Figure 3.2.8 and the current travel speed calculated by the traffic demand model. The travel speed by traffic demand model is the daily average speed in accordance with daily traffic volume, road capacity and volume-speed curve (QV curve), therefore, it is difficult to compare with actual travel speed.

At present, the survey routes shown in following table are not seriously congested except in urbanized areas such as the center of Bago, therefore, the modeled speed are approximate to free-flow speed and actual survey speed.

Table 3.3.4 Actual Travel Speed and Travel Speed by Model in 2017

Route	Dist (km)	Time (Hr)	Survey Speed	Model Speed	Diff (kmph)	Diff (%)
Bago - Thilawa	112	2.66	49.3	42.3	-7.0	17%
Yangon - Bago	53	0.80	65.5	66.2	0.7	-1%
Bago - Kyaikto	90	1.47	59.2	61.4	2.2	-4%

(2) Future Traffic Demand Forecast

Future demand forecast is based on following preconditions.

- Target years for demand forecast are 2025, 2035 and 2045.
- Future road network includes the New Sittaung Bridge and road section of New Bago – Kyaikto Highway, Yangon Inner and Outer Ring Road and Hanthawaddy Airport access.
- Existing road widening plan (four lanes between Bago and the existing Sittaung Bridge) is included in the future road network.

The future traffic demand is forecasted by the growth of future traffic demand forecasted in the Pre-F/S under the assumption of GDP growth 7.2% p.a. and the adjustment factor based on updated GDP growth assumption. Forecasted future traffic generation in all of Myanmar is shown in the following table.

Table 3.3.5 Forecasted Vehicle Trip Generation

Year	2 Axles Truck	3 Axles Truck	4+ Axles Truck	Trailer	Passenger Cars	Buses
2017	158	12	39	14	721	128
2025	316	24	78	29	1,532	213
2035	555	43	136	51	3,174	311
2045	838	64	205	76	5,650	390

Source: JICA Study Team
Note: ('000) vehicle trip per day in total.

Future traffic demand distributions are computed by present pattern method by existing OD pattern and future traffic generation based on the forecast by the Pre-F/S and YUTRA. Forecasted OD matrices are adjusted by the abovementioned vehicle trip generation. Additional trip generation such as traffic demand generated at Hanthawaddy Airport and cross-border traffic are added on as the special traffic demand.

Time value for target years are assumed by GDP deflator predicted by IMF Country Report. Forecasted time values are shown in the following table. In the traffic assignment, route choice is decided by the shortest path based on the generalized cost which is calculated by toll fare, travel time and time value.

Table 3.3.6 Time Value

Year	Passenger Cars (USD/hour)	Bus (USD/hour)	2 Axles Truck (vehicle)	3 Axles Truck (vehicle)	4 Axles Truck (vehicle)	Trailer (vehicle)
2017	3.29	17.97	0.21	0.41	0.62	0.98
2025	6.49	35.45	0.47	0.90	1.37	2.17
2035	13.33	72.81	1.10	2.11	3.21	5.07
2045	24.29	132.63	2.23	4.26	6.48	10.24

Source: JICA Study Team

In the "Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)", there are four (4) tolling scenarios are prepared and results of demand forecast are analyzed. Based on the results of ADB's study, following three (3) toll scenarios are applied to demand forecast in the study.

Table 3.3.7 Toll Strategy 1 (TS1)

		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	15.0	0.0061	0.0069	0.0085	0.0103
Toll Class 2	2-Axle Truck	69.0	0.0282	0.0320	0.0390	0.0475
Toll Class 3	3-Axle Truck	120.0	0.0490	0.0556	0.0677	0.0826
Toll Class 4	4 & 5 Axle Heavy truck	162.5	0.0663	0.0753	0.0917	0.1118
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	284.0	0.1159	0.1315	0.1603	0.1954
Toll Class 6	Median Bus and Large bus	45.5	0.0186	0.0211	0.0257	0.0313

Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

Table 3.3.8 Toll Strategy 2 (TS2)

TS2: ADB Median Toll Rates 2018		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	30.0	0.0122	0.0139	0.0169	0.0206
Toll Class 2	2-Axle Truck	100.0	0.0408	0.0463	0.0565	0.0688
Toll Class 3	3-Axle Truck	120.0	0.0490	0.0556	0.0677	0.0826
Toll Class 4	4 & 5 Axle Heavy truck	150.0	0.0612	0.0695	0.0847	0.1032
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	250.0	0.1020	0.1158	0.1411	0.1720
Toll Class 6	Median Bus and Large bus	75.0	0.0306	0.0347	0.0423	0.0516

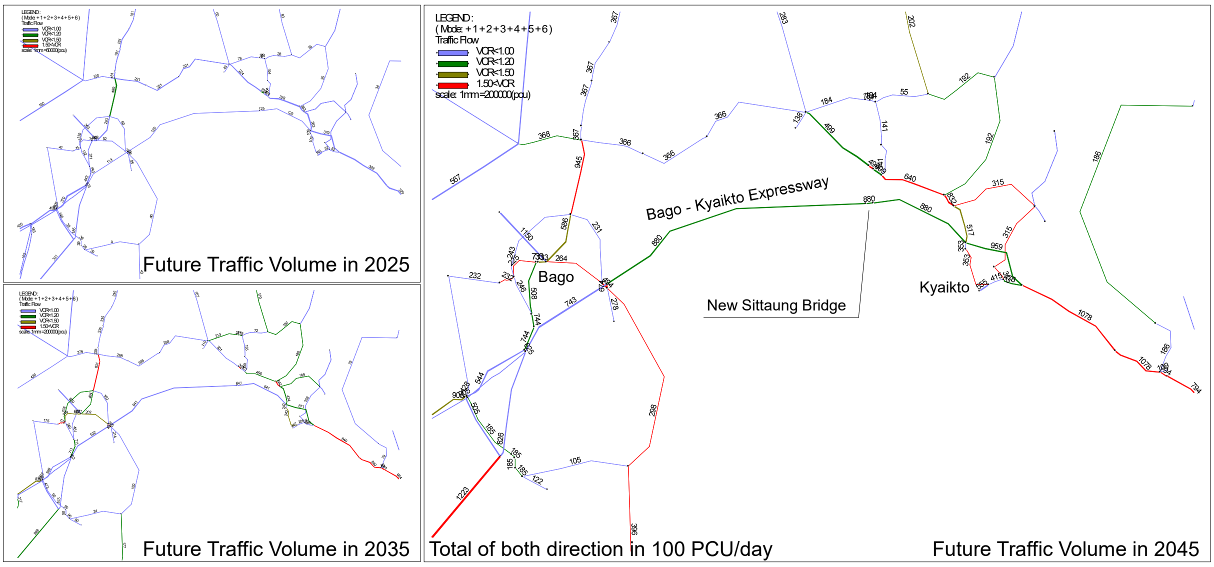
Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

Table 3.3.9 Toll Strategy 3 (TS3)

TS3 : 150% of TS-1		(Kyat/mile)	2018 (USD/km)	2025 (USD/km)	2035 (USD/km)	2045 (USD/km)
Toll Class 1	Car, Pickup, Van	22.5	0.0092	0.0104	0.0127	0.0155
Toll Class 2	2-Axle Truck	103.5	0.0679	0.0771	0.0940	0.1146
Toll Class 3	3-Axle Truck	180.0	0.1182	0.1341	0.1635	0.1993
Toll Class 4	4 & 5 Axle Heavy truck	243.8	0.1600	0.1816	0.2214	0.2699
Toll Class 5	Semi-Trailer truck 4 - 6 Axle	426.0	0.2797	0.3174	0.3869	0.4717
Toll Class 6	Median Bus and Large bus	68.3	0.0448	0.0509	0.0620	0.0756

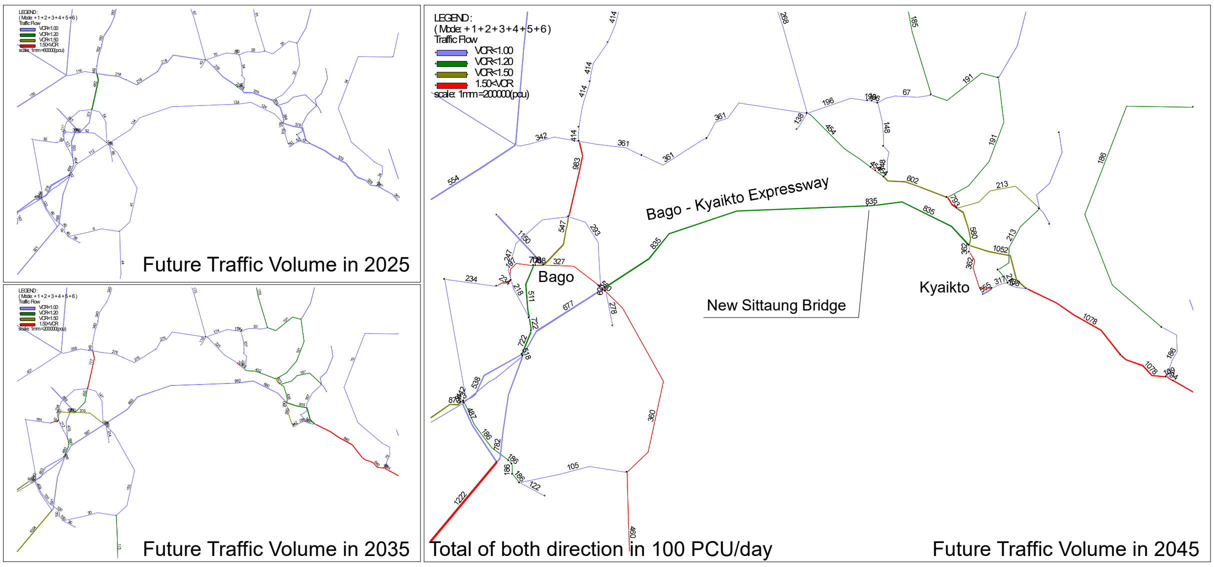
Source: Feasibility Study on Bago-Kyaikto Expressway (ADB, 2019)

The following figures show the results of traffic assignment for TS1, TS2 and TS3 respectively.



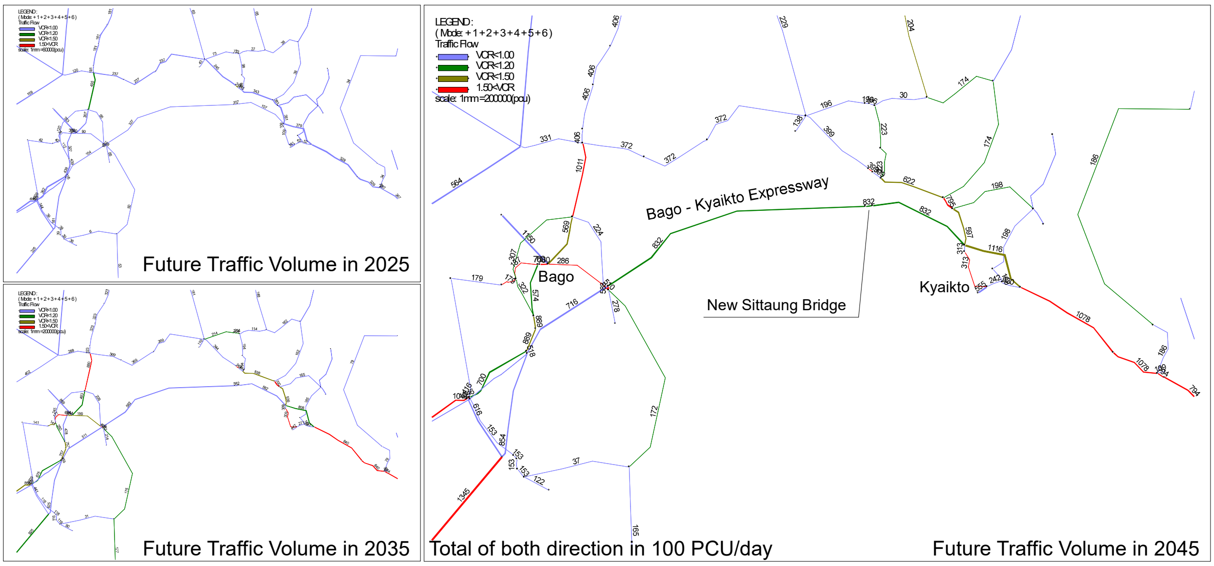
Source: JICA Study Team

Figure 3.3.6 Assigned Traffic Volume of TS1



Source: JICA Study Team

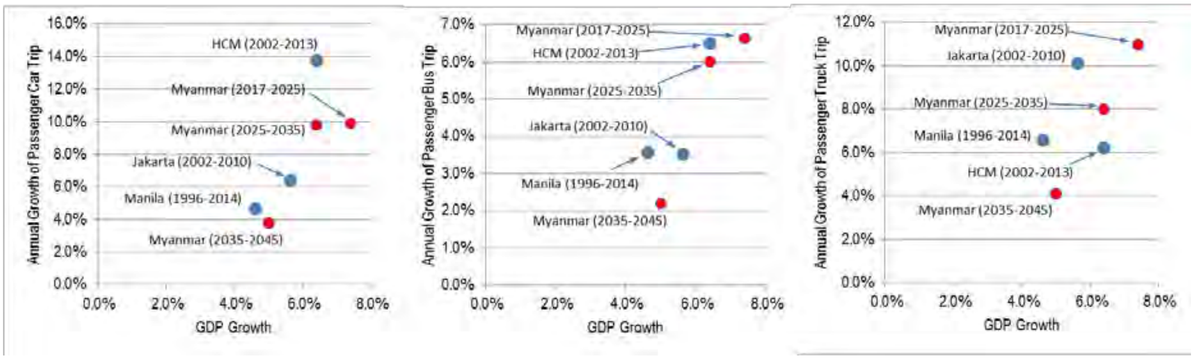
Figure 3.3.7 Assigned Traffic Volume of TS2



Source: JICA Study Team

Figure 3.3.8 Assigned Traffic Volume of TS3

The following figures show the relationship between annual GDP growth and annual traffic demand growth by mode in Myanmar, Ho Chi Minh, Jakarta (Jabodetabek) and Metro Manila. Traffic volumes in Ho Chi Minh, Jakarta and Manila are referred from the existing JICA studies (HOUTRANS and METROS in Ho Chi Minh, MMUTIS and MUCEP in Manila, SITRAMP and JUTPI in Jakarta). The relationship of forecasted GDP growth and forecasted traffic volumes in Myanmar are considered reasonable though the growth rate of traffic volume between 2035- 2045 is lower than other periods.



Source: JICA Study Team, The Study on Urban Transport Master Plan and Feasibility Study in Ho Chi Minh Metropolitan Area (HOUTRANS), Data Collection Survey on Railways in Major Cities in Vietnam (METROS), Metro Manila Urban Transportation Integration Study (MMUTIS) The Project for Capacity Development on Transportation Planning and Database Management in the Republic of Philippines (MUCEP), The Study on Integration Transportation Master Plan for JABODETABEK (SITRAMP) and JOBODETABEK Urban Transportation Policy Integration Project in the Republic of Indonesia (JUTPI).

Figure 3.3.9 Annual GDP and Traffic Demand Growth

As the results of traffic assignment, the future traffic volume of New Sittaung Bridge is forecasted as shown in the following tables. Future traffic volume in Toll Strategy 1 (TS1) for New Sittaung Bridge is forecasted to 88.8 thousand pcu/day in 2045, 83.5 thousand pcu/day in 2045 in TS2 and 83.2. thousand pcu/day in 2045 in TS3.

Table 3.3.10 Future Daily Traffic Volume of Existing and New Bridge in TS1

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	22,400	12,500	34,900	14.77%
2035	30,100	64,100	94,200	10.44%
2045	49,900	88,000	137,900	3.88%

Source: JICA Study Team

Table 3.3.11 Future Daily Traffic Volume of Existing and New Bridge in TS2

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	23,500	12,400	35,900	15.17%
2035	32,500	66,000	98,500	10.62%
2045	45,400	83,500	128,900	2.73%

Source: JICA Study Team

Table 3.3.12 Future Daily Traffic Volume of Existing and New Bridge in TS3

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total (pcu per day)	Growth % p.a.
2017	11,597		11,597	
2025	24,500	10,700	35,200	14.89%
2035	34,400	58,200	92,600	10.16%
2045	39,900	83,200	123,100	2.89%

Source: JICA Study Team

Table 3.3.13 Future Daily Traffic Volume New Sittaung Bridge in TS1

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Cars (veh/day)	Buses (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	400	100	8,700	1,300	10,500
2035	8700	3,100	5,600	1000	22,400	2,200	43,000
2045	12,600	4,400	8,300	2,200	27,800	1,900	57,200

Source: JICA Study Team

Table 3.3.14 Future Daily Traffic Volume New Sittaung Bridge in TS2

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Cars (veh/day)	Buses (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	500	100	8,300	1,300	10,200
2035	7400	3,100	7,200	1400	21,800	2,100	43,000
2045	9,100	4,900	8,900	1,600	28,200	1,900	54,600

Source: JICA Study Team

Table 3.3.15 Future Daily Traffic Volume New Sittaung Bridge in TS3

Year	2 Axles Truck (veh/day)	3 Axles Truck (veh/day)	4 Axles Truck (veh/day)	Trailer (veh/day)	Cars (veh/day)	Buses (veh/day)	Total (veh/day)
2017	-	-	-	-	-	-	-
2025	0	0	0	0	8,300	1,200	9,500
2035	5100	2,500	5,500	1000	23,500	2,400	40,000
2045	10,600	3,800	6,700	1,200	33,200	2,300	57,800

Source: JICA Study Team

As the results of future traffic demand forecast, project impacts such as reduction of vehicular travel distance and travel time are summarized in the below tables based on future traffic assignment of with and without project case.

Development of Bago-Kyaikto Highway including New Sittaung Bridge is able to reduce travel distance 277.6 thousand vehicle-km in 2025, 2,768.2 thousand vehicle-km in 2035 and 1,836.8 thousand vehicle-km per day in 2045 in the case of Toll Strategy 1. In the case of Toll Strategy 2, travel distance reduction is 304.3, 2,207.1 and 1,311.4 thousand vehicle-km per day respectively. In the case of Toll Strategy 3, travel distance reduction is 308.9, 1,920.5 and 1,891.8 thousand vehicle-km per day respectively.

And also, travel time saving is expected, 18.0 thousand vehicle-hours per day in 2025, 213.9 thousand vehicle-hours per day in 2035 and 285.1 thousand vehicle-hours per day in 2045 in TS1. In the case of TS2, travel time saving is 17.6, 206.7 and 239.3 thousand vehicle-hour per day respectively. In the case of TS3, travel time saving is 16.5, 195.2 and 279.8 thousand vehicle-hour per day respectively.

Table 3.3.16 Future Travel Distance Reducation by the Project in TS1

		('000) Vehicle-km						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	22,253.2	2,299.3	8,282.8	4,460.7	58,403.1	9,386.0	105,085.0
	Without Case	22,297.6	2,306.9	8,318.9	4,464.5	58,574.7	9,400.0	105,362.6
	Project Impact	44.4	7.5	36.2	3.8	171.6	14.1	277.6
2035	With Case	54,394.5	5,272.9	19,241.2	10,379.5	151,481.7	17,801.3	258,571.1
	Without Case	54,854.2	5,460.6	19,621.7	10,497.2	152,888.4	18,017.3	261,339.4
	Project Impact	459.7	187.7	380.5	117.7	1,406.7	216.0	2,768.2
2045	With Case	68,992.4	6,725.1	24,537.8	13,249.3	220,876.8	18,226.1	352,607.5
	Without Case	69,232.4	6,916.2	24,768.5	13,207.6	222,014.7	18,305.0	354,444.3
	Project Impact	239.9	191.1	230.7	-41.7	1,137.9	78.9	1,836.8

Source: JICA Study Team

Table 3.3.17 Future Travel Time Reducation by the Project in TS1

		('000) Vehicle-hour						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	579.3	57.6	197.2	104.9	1,393.1	201.9	2,534.1
	Without Case	582.7	58.4	199.4	105.3	1,402.9	203.3	2,552.0
	Project Impact	3.4	0.7	2.2	0.4	9.8	1.4	18.0
2035	With Case	1,969.4	178.7	620.0	328.7	5,312.7	548.4	8,958.0
	Without Case	2,023.8	195.1	652.0	337.9	5,402.9	560.1	9,171.9
	Project Impact	54.4	16.3	32.1	9.2	90.2	11.7	213.9
2045	With Case	2,813.0	255.4	887.9	472.6	8,886.0	646.7	13,961.6
	Without Case	2,886.3	279.7	926.5	478.4	9,018.0	657.8	14,246.7
	Project Impact	73.3	24.3	38.6	5.8	132.0	11.0	285.1

Source: JICA Study Team

Table 3.3.18 Future Travel Distance Reducation by the Project in TS2

		('000) Vehicle-km						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	22,233.8	2,294.2	8,285.1	4,458.2	58,056.8	9,382.7	104,710.9
	Without Case	22,271.1	2,303.9	8,318.7	4,465.3	58,255.7	9,400.5	105,015.2
	Project Impact	37.3	9.7	33.6	7.1	198.8	17.8	304.3
2035	With Case	54,443.6	5,267.1	19,173.9	10,348.0	150,820.1	17,855.9	257,908.5
	Without Case	54,777.2	5,441.6	19,590.4	10,468.7	151,807.6	18,030.1	260,115.6
	Project Impact	333.7	174.5	416.6	120.7	987.5	174.2	2,207.1
2045	With Case	69,085.0	6,719.3	24,468.3	13,242.7	220,986.8	18,294.0	352,796.0
	Without Case	69,085.1	6,887.9	24,758.0	13,244.3	221,808.3	18,323.7	354,107.4
	Project Impact	0.1	168.6	289.8	1.7	821.5	29.7	1,311.4

Source: JICA Study Team

Table 3.3.19 Future Travel Time Reducation by the Project in TS2

		('000) Vehicle-hour						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	580.4	57.0	197.1	104.8	1,390.6	201.9	2,531.7
	Without Case	582.8	57.7	199.1	105.2	1,401.2	203.3	2,549.3
	Project Impact	2.4	0.7	2.0	0.4	10.7	1.4	17.6
2035	With Case	1,981.0	178.4	614.5	326.4	5,300.0	546.1	8,946.4
	Without Case	2,033.8	194.1	648.9	335.8	5,384.3	556.3	9,153.1
	Project Impact	52.8	15.7	34.4	9.4	84.2	10.1	206.7
2045	With Case	2,830.7	257.2	886.7	473.8	8,890.6	649.1	13,988.1
	Without Case	2,883.8	277.4	921.5	477.5	9,008.8	658.4	14,227.4
	Project Impact	53.0	20.2	34.8	3.7	118.2	9.3	239.3

Source: JICA Study Team

Table 3.3.20 Future Travel Distance Reducation by the Project in TS3

		('000) Vehicle-km						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	22,272.6	2,291.8	8,292.7	4,465.3	58,127.3	9,337.0	104,786.7
	Without Case	22,283.7	2,298.1	8,313.6	4,470.6	58,376.5	9,353.2	105,095.7
	Project Impact	11.1	6.3	20.9	5.3	249.1	16.3	308.9
2035	With Case	54,458.6	5,289.8	19,248.9	10,374.5	151,630.2	17,841.0	258,843.0
	Without Case	54,766.8	5,435.1	19,558.0	10,463.5	152,552.5	17,987.6	260,763.5
	Project Impact	308.1	145.3	309.1	89.0	922.3	146.6	1,920.5
2045	With Case	68,634.9	6,627.7	24,216.6	13,053.5	220,832.2	18,149.3	351,514.2
	Without Case	68,933.3	6,808.4	24,494.4	13,084.8	221,808.4	18,276.7	353,406.0
	Project Impact	298.4	180.6	277.8	31.3	976.3	127.4	1,891.8

Source: JICA Study Team

Table 3.3.21 Future Travel Time Reducation by the Project in TS3

		('000) Vehicle-hour						
		2 axles truck	3 axles truck	4 axles truck	Trailers	Passenger Cars	Buses	Total
2025	With Case	582.2	57.4	199.1	105.5	1,387.7	201.3	2,533.2
	Without Case	584.0	58.0	200.4	105.9	1,398.8	202.8	2,549.7
	Project Impact	1.8	0.6	1.3	0.3	11.1	1.5	16.5
2035	With Case	2,017.6	184.0	631.4	333.4	5,341.5	550.1	9,058.0
	Without Case	2,064.9	198.4	661.9	342.3	5,425.0	560.7	9,253.2
	Project Impact	47.2	14.4	30.5	8.9	83.4	10.7	195.2
2045	With Case	2,820.0	256.7	887.2	470.0	8,804.7	642.4	13,881.0
	Without Case	2,889.8	275.9	923.8	478.1	8,940.2	653.1	14,160.8
	Project Impact	69.8	19.2	36.6	8.0	135.5	10.7	279.8

Source: JICA Study Team

CHAPTER 4 DEVELOPMENT POLICY OF NEW SITTAUNG BRIDGE

4.1 Road Classification

MOC has a plan that the Project Road, the East - West Economic Corridor Highway (New Bago – Kyaikto Section), is to be constructed as a highway (Non-access controlled road) at initial stage (Refer to Appendix 1). This MOC's plan is consistent with the plan proposed in the Pre-F/S.

On the other hands, the development of a new expressway (ER-10) which connects Pathein to Kyaikto via Bago was planned in the ARND-MP as stated above. The Project Road would be upgraded to an expressway (Access controlled road) as a part of the new expressway (ER-10) in the future.

Through the confirmation by an official letter (Refer to Appendix 1) and the discussion in the 1st Technical Committee (T/C) on 6th July 2017, MOC requested that the New Sittaung Bridge is to be constructed with a 4-lane asphalt paved road corresponding to the "expressway classification" for the following reasons:

- Required bridge width for the expressway is wider than that for the highway
- Once the bridge is constructed with narrower width for a highway, it is difficult to widen in the future.

Considering the above request by MOC, it was originally decided in the 1st T/C that the following geometric design standard and road classification is applied to the New Sittaung Bridge among applicable options as shown in Table 4.1.1 and Figure 4.1.1.

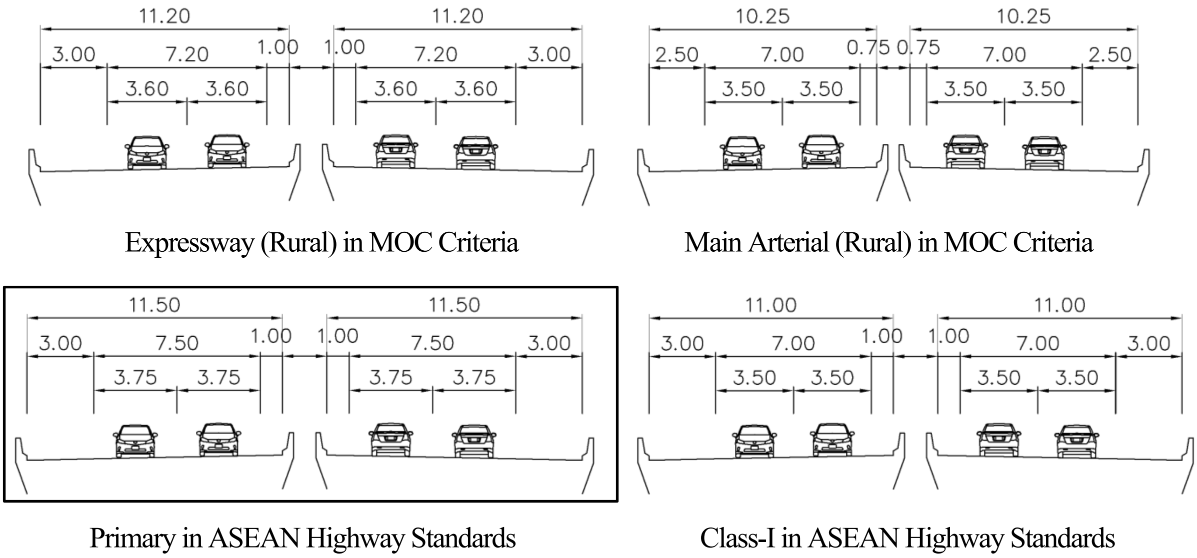
- Applied Geometric Design Standard: "ASEAN Highway Standards (9 Oct 2012)"
- Applied Road Classification: "Primary"

It was also confirmed in the 1st T/C that a sidewalk is not necessary for the New Sittaung Bridge because MOC is planning to utilize the New Sittaung Bridge only for automobiles.

Table 4.1.1 Cross Section Elements on MOC Road Design Criteria and ASEAN Highway Standards

Standard	MOC Road Design Criteria		ASEAN Highway Standards	
Classification	Expressway	Main Arterial	Primary	Class-I
Description	Access controlled	Non-access controlled	Access controlled	Non-access controlled
Design Speed (Level - Rolling)	120 - 100	100 - 80	120 - 100	110 - 80 (ASEAN)
Lane	3.60 (Rural) 3.50 (Urban)	3.50 (Rural) 3.25 (Urban)	3.75	3.5
Right Shoulder	3.00 (Rural) 2.00 (Urban)	2.50 (Rural) 2.00 (Urban)	3.00	3.00
Left Shoulder	1.00	0.75	-	-
Median	4.00 (Rural) 3.00 (Urban)	3.00 (Rural) 0.50 (Urban)	4.00	4.00

Source: MOC Road Design Criteria, ASEAN Highway Standards

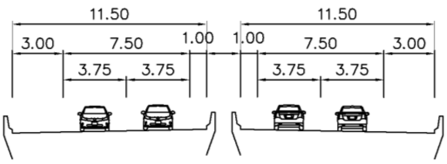
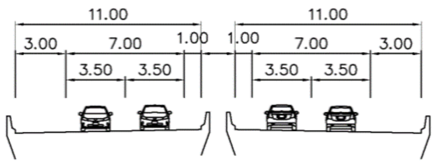


Source: JICA Study Team

Figure 4.1.1 Typical Cross Section on MOC Road Design Criteria and ASEAN Highway Standards

The above development policy has been justified by the below study result and approved in the 2nd T/C on 24th Oct 2017.

Table 4.1.2 Justification for Developing with Expressway Cross Section from the Initial Stage

Road Classification	Primary	Class-I
Access Control	Access Controlled	Non-access Controlled
Required Number of Lanes	4 lanes (or more)	4 lanes (or more)
Design Speed*1	100 to 120 km/h	80 to 110 km/h
Cross Section		
Construction Cost (Ratio) *2	1.00	0.96
Comments	-Most expensive -Sufficient bridge width without risk for future upgrade.	Bridge width cannot meet with the required width of Primary Road.

*1: For level terrain
*2: Construction cost is estimated for 2.33km of bridge based on the unit price prepared in JICA Pre-F/S
Source: JICA Study Team

4.2 Cross Section

4.2.1 Number of Lanes for the New Sittaung Bridge

(1) Future Traffic Volume

The number of lanes for the New Sittaung Bridge was determined based on the future traffic volume. The "TS-1" case gives the maximum future traffic volume among given three cases. The future traffic volume (PCU/day) in the year of 2025, 2035 and 2045 forecasted for TS-1 case is shown in Table 4.2.1.

Table 4.2.1 Future Traffic Volume of the Existing & New Sittaung Bridge

Unit: PCU/day

Year	Existing Sittaung Bridge	New Sittaung Bridge	Total	Growth % p.a.
2017	11,597	-	11,597	-
2025	22,400	12,500	34,900	13.1%
2035	30,100	64,100	94,200	10.7%
2045	49,900	88,000	137,900	4.0%

Source: JICA Study Team

(2) Required Number of Lanes

The required number of lanes for the New Sittaung Bridge is determined in accordance with ASEAN Highway Standards. According to ASEAN Highway Standards, traffic capacity for one lane is set as 1,800 PCU/hour. The required number of lanes of the New Sittaung Bridge for each year is shown in Table 4.2.2.

At the initial construction stage (2025), enough capacity can be provided by a 2-lane bridge (1 lane x 2 directions). However, the bridge should be upgraded to 4 lanes by 2035. ASEAN Highway Standards states that the road class including number of lanes should be determined based on the future traffic volume projected for 20 years after completion of road construction, namely Year 2045 for this project.

Table 4.2.2 Required Number of Lanes of the New Sittaung Bridge

Year	Traffic Volume (PCU/day)	Traffic Volume (PCU/hour) for Both Directions *1	Traffic Volume (PCU/hour) for One Direction *2	Traffic Capacity for One Lane (PCU/lane)	Required Number of Lanes for each Direction
2025	12,500	750	450	1,800	1
2035	64,100	3,486	2,092	1,800	2
2045	88,000	5,280	3,168	1,800	2

*1: Peak hour ratio (K value) is set as 6.0% based on the existing condition.
*2: Heavy directional ratio (D value) is seat as 0.60 based on ASEAN Highway Standards.
Source: JICA Study Team

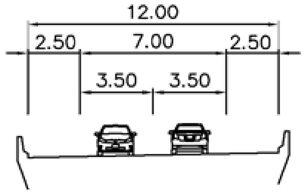
4.2.2 Cross Section to be Constructed at the Initial Stage

(1) Standard Cross Section

Standard cross sections for 2-lane and 4-lane bridge are shown below.

(a) 2-lane Bridge

According to ASEAN Highway Standards, 2-lane road is classified as Class II which is non-access control road with 80-100km/h of design speed. Cross Section for 2-lane bridge is shown in Figure 4.2.1.



Source: JICA Study Team

Figure 4.2.1 Cross Section for 2-lane Bridge

(b) 4-lane Bridge

As the ultimate stage development, a 4-lane bridge should be constructed with Primary classification as aforementioned. Cross Section for a 4-lane bridge is shown in Figure 4.2.2.

< Primary, 2 Separate Bridge> < Primary, 1 Bridge for Both Directions >

Source: JICA Study Team

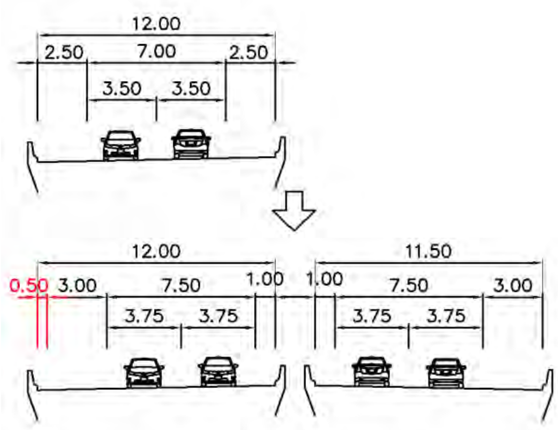
Figure 4.2.2 Cross Section for 4-lane Bridge

(2) Alternative Implementation Scheme

The following 2 alternatives were prepared as the implementation scheme for New Sittaung Bridge development.

Alternative 1

- Initial Stage (2025): Construction of a 2-lane bridge
- Ultimate Stage (by 2035): Construction of another 2-lane bridge.



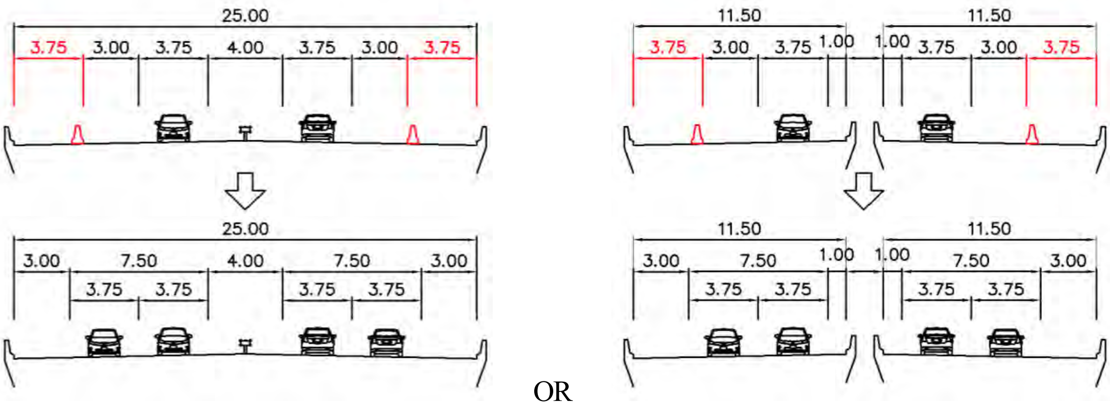
Source: JICA Study Team

Figure 4.2.3 Implementation Plan for New Sittaung Bridge Development (Alternative 1)

In Alternative 1, an additional 0.5m space outside of shoulder is required at the ultimate stage in order to provide the proper shoulder width at the initial stage.

Alternative 2

- Initial Stage (2025): Construction of a 4-lane bridge (or) 2 x 2-lane bridges
- Ultimate Stage (by 2035): Only operation change (No additional construction)



Source: JICA Study Team

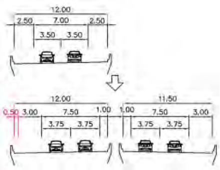
Figure 4.2.4 Implementation Plan for New Sittaung Bridge Development (Alternative 2)

In Alternative 2, an additional 3.75m space outside of shoulder is required at the initial stage in order to provide the proper shoulder width at the ultimate stage.

(3) Evaluation

The 2 alternatives were evaluated as shown in Table 4.2.3. As a result, Alternative 2, "Construction of a 4-lane bridge from the initial stage" was selected for the optimum implementation scheme for New Sittaung Bridge development.

Table 4.2.3 Evaluation on Implementation Scheme for New Sittaung Bridge Development

Alternative	Alternative 1		Alternative 2	
Cross Section				
Construction Cost (Ratio) *1	Initial: (1.00) Total: (1.00)	△	Initial: (1.92) Total: (0.86)	◎
Stage Construction	− The bridge needs to be upgraded to 4 lanes by 2035 (within 10 years after completion of the initial stage) to meet the increased traffic demand. − It is difficult to construct a new bridge beside the existing bridge.	△	− Stage construction is not required.	◎
Economy	− Lower initial cost − Higher total cost	△	− Higher initial cost − Lower total cost	◎
Evaluation	Less recommended − Lower initial cost, but another bridge needs to be constructed within 10 years.		**Recommended**	

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

*1: Construction cost is estimated for 2.33km of bridge based on the unit price prepared in Pre- F/S.

( ) shows the ratio between alternatives

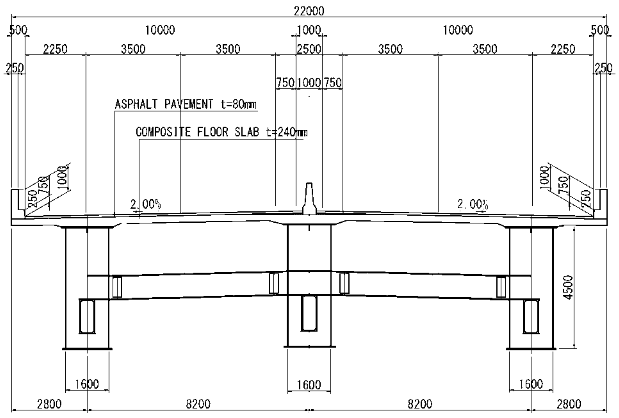
Note: Red-colored description means "advantage". Blue-colored description means "disadvantage".

Source: JICA Study Team

4.2.3 Revised Development Scenario for New Sittaung Bridge

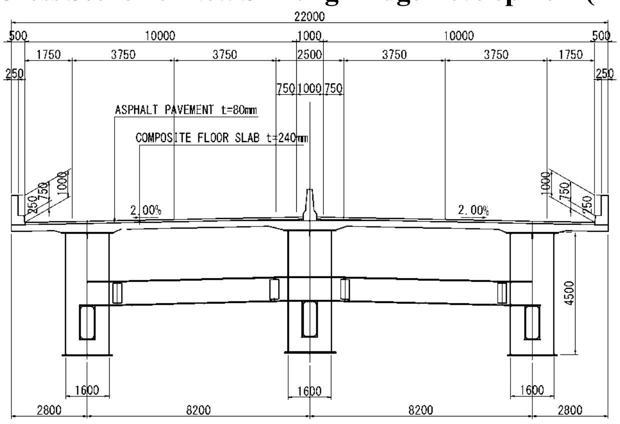
Based on the series of discussions with MOC, for the purpose of reducing initial construction cost, it was finally concluded on 27th August 2019 that both the sections of ADB and JICA could be applied with "Class-I" in the ASEAN Highway Standards with "access-controlled"[1], although New Kyaikto-Bago road would be upgraded to "Primary" class depending on the increase of traffic demand in the future.

In this context, for New Sittaung Bridge, it was concluded that the following cross section shall be adopted to harmonize to the future upgrading to the Primary class road, which has 22m width in total with the emergency parking bays for both sides of the main bridge and the approach bridge. The cross section component could not be fully the same with the Primary class of ASEAN Highway Standard, but it was justified that it could be reasonable for the operation of expressway in satisfying the requirements as the Primary class of ASEAN Highway referring to the practices of Japanese expressway standard[2].



Source: JICA Study Team

Figure 4.2.5 Typical Cross Section of New Sittaung Bridge Development (Initial Operation Stage)



Source: JICA Study Team

Figure 4.2.6 Typical Cross Section of New Sittaung Bridge Development (Future Operation Stage)

1 Class-I road stipulated in the ASEAN Highway Standards is usually operated without access-controlled but this Project road shall be operated with access-controlled according to MOC's policy.

2 In Japanese expressway design guidelines, 1.75m is specified as the minimum outer shoulder width which can be applied to "long-span bridges under the special conditions such as terrain constraints and financial constraints. In "Road Design Criteria in Myanmar, MOC, 2015", it is also specified that outer shoulder can be reduced up to 1.0m in expressway for bridges.

CHAPTER 5 LOCATION OF NEW SITTAUNG BRIDGE

5.1 Introduction

Sittaung River has a stretch of about 540km which covers about 34,000km2 of catchment basin. Sittaung River has unique characteristics with the occurrence of "Tidal Bore" which is generated by tidal waves at the specialized geography of river mouth. Also, the channel of Sittaung River has moved drastically in the past. Although the movement of the river channel has become slow in the last 30 years after the completion of some flood control facilities upstream, the local movement has been yet observed. Since the movement of the river channel affects the location of New Sittaung Bridge, care should be taken into the Study for a number of probable bridge sites and the decision should be based on which site is most likely to serve the bridge at a reasonable cost. The location of New Sittaung Bridge had been once proposed in the Pre-F/S. However, upon the review of hydrological conditions (tidal bore and the river channel movements) which have been newly acquired by the Study, the location of New Sittaung Bridge was reviewed. The review of bridge sites were conducted by narrowing down from the possible corridor to the eligible alignments along with the steps given below.

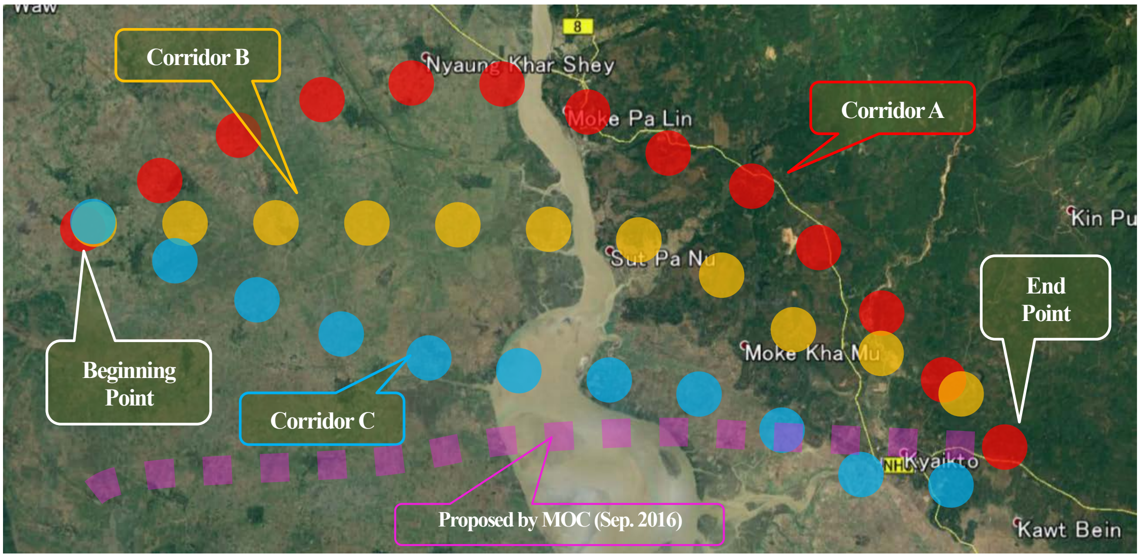
- ✓ First, the selection of a possible corridor between the area of Bago and Kyaikto (the candidate corridors which connect between Bago and Kyaikto were proposed by macroscopic view)
- ✓ Second, the selection of eligible alignment including the location of New Sittaung Bridge (the exact locations will be proposed within the selected possible corridor)

5.2 Corridors Selection prior to Alignment Setting for Bridge Site

5.2.1 Extraction of Candidate Corridors

Among the possible corridors passing through the project area studied in the Pre-F/S, three corridors were extracted as the possible candidates which are given in Figure 5.2.1.

- **Corridor "A",** which runs mostly along the existing National Highway No.8 and crossing the Sittaung River beside the existing Sittaung Bridge.
- **Corridor "B",** which covers the possible alignments proposed in the Pre-F/S running through Sut Pa Nu village and crossing the Sittaung River approximately 7km downstream from the existing Sittaung Bridge.
- **Corridor "C",** which is the shortest connection between Bago City and Kyaikto City and crossing the Sittaung River approximately 13km downstream from the existing Sittaung Bridge.



Source: JICA Study Team

Figure 5.2.1 Plan View for Alternatives of Corridor

It is noted that the route highlighted in purple color given in Figure 5.2.1 was proposed by MOC in September 2016. The proposed alignment by MOC was consequently turned down due to the unreasonable bridge length (too long) and the scoring impact by tidal bore which was already acknowledged by MOC during the Pre-F/S.

5.2.2 Comparative Study for the Selection of Eligible Corridor

The comparative study was conducted by multi-criteria analysis for the selection of eligible corridor for the East - West Economic Corridor Highway (New Bago – Kyaikto Section) that is shown in Table 5.2.1. Each of criteria below are given the classification (A to C) to measure the weight of performance for each candidate corridor under the comparative assessment as shown in Table 5.2.1.

(1) Riverbank Stability / Influence for Erosion:

- A: Relatively stable / minor erosion in the past
- B: Stable with countermeasures / Intermediate erosion in the past
- C: Unstable / Large erosion in the past

(2) Construction Cost

- A: Cheapest option
- B: More than 20% higher than the cheapest option
- C: More than 50% higher than the cheapest option

(3) Environmental Impact (Impact on Ramsar site and IBA/KBA)

- A: Corridor does not pass through Ramsar site and IBA/KBA
- B: Corridor passes through either Ramsar site or IBA/KBA
- C: Corridor passes through both of Ramsar site and IBA/KBA

*In order to avoid IBA/KBA, the corridor needs to bypass the existing road by running in a further north area of the road which runs near north edge of IBA/KBA. Since it significantly reduces the benefit of the new expressway construction project, such a corridor cannot be for the Project.

(4) Social Environmental Impact (Land Acquisition and Resettlement)

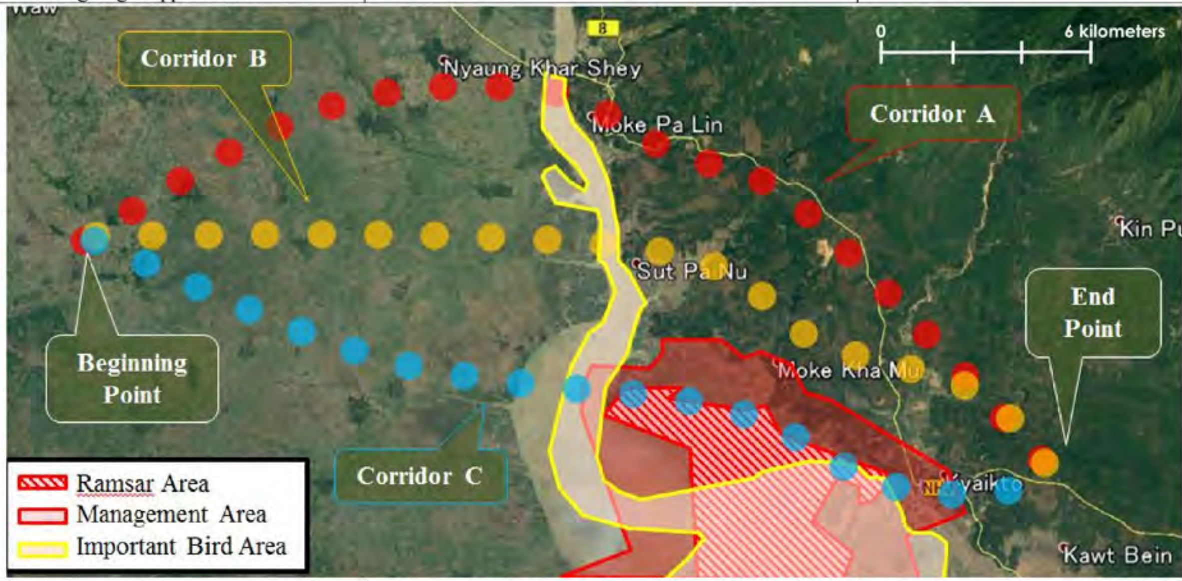
- A: Almost no residential area in/around the corridor
- B: Some residential areas in/around the corridor
- C: Many residential areas in/around the corridor

The evaluation was made by a scoring method based on the following formula. The alternative which has the highest score will be selected as an optimum candidate corridor among the alternatives.

<u>Score = Criteria (1) x Evaluation (A:20pt, B:10pt, C:0pt) + ……..+ Criteria (4) x Evaluation.</u>

In addition, the alternative corridor which has been ranked “C” evaluation will be disqualified (even for having single evaluation “C”), because it gives an essential factor to affect the performance of project road. As a result, Corridor “B” was recommended by acquiring the highest score of 60/80 points while other alternatives were disqualified. Corridor “A” was assessed to be relatively shown a lower performance due to unreasonable length of project road and given potentially high social impact for the large resettlement. Corridor “C” was assessed to be unreasonable bridge length crossing close to the river mouse and unstable riverbank due to direct influence of tidal bore while providing reasonable (short) road length.

Table 5.2.1 Comparison of the Corridor for New Bago – Kyaikto Highway

Alternative	Corridor A		Corridor B		Corridor C	
Summary	✓ Along the existing highway (NH8). ✓ New bridge beside the existing Sittaung Bridge. ✓ Road length: app. 45km ✓ Sittaung river crossing length: app. 650m		✓ Short road length.: app. 40km ✓ Short river crossing length: app. 750m		✓ Short road length: app. 40km ✓ Long river crossing length: app. 2.8km	
Alternative Corridors						
Riverbank stability / Influence for erosion	✓ "Relatively stable" but scoured by minor tidal wave	A	✓ "Relatively stable" but scored by minor tidal wave	A	✓ Unstable scored by tidal bore ✓ Large erosion at present	C
Construction cost (Ratio with lowest cost)	✓ "Reasonable" because of shorter bridge length but longer distance of road ✓ (1.03)	A	✓ "Reasonable" because of shorter bridge length. ✓ (1.00)	A	✓ "Very High" because of longer bridge length. ✓ (1.87)	C
Environmental Impact (Impact on Ramsar site and IBA/KBA)	✓ Corridor does not pass through Ramsar site, but it passes through IBA/ KBA partially	B	✓ Corridor does not pass through Ramsar site, but it passes through IBA/ KBA partially	B	✓ Corridor passing through Ramsar site and IBA/KBA	C
Social Environmental Impact (Land Acquisition and Resettlement)	✓ 13 residential areas in the corridor	C	✓ 5 residential areas in the corridor	B	✓ 2 residential areas in the corridor	A
Total assessment	Score = 50/80, (Disqualified)		**Recommended** Score = 60/80		Score = 20/80 (Disqualified)	

Source: JICA Study Team

5.3 Selection of Eligible Alignment

5.3.1 Alignment Setting in Suitable Corridor

Upon the results of the comparative study on the corridor selection, it was recommended to find an eligible alignment for the new bridge location within the range of Corridor "B". Several alternative alignments can be proposed taking into account the control points including the existing facilities (road, railway and irrigation facilities, etc.), local communities. The most eligible bridge site should be selected by the criteria considering the suitability of a bridge site crossing a river as below.

- Steady river flow without cross currents;
- Straight trail of the river;
- Narrow channel with firm banks;
- Suitable high banks above high flood level on each side;
- Rock or other hard soil conditions for slope and river bed;
- Absence of sharp curves in the approaches;
- Absence of expensive river training works;
- Avoidance of excessive underwater construction;
- Economical approaches danger of floods, free from obstacles, frequent drainage crossings, or place for troublesome in environment assessment, land acquisition and resettlement, etc.

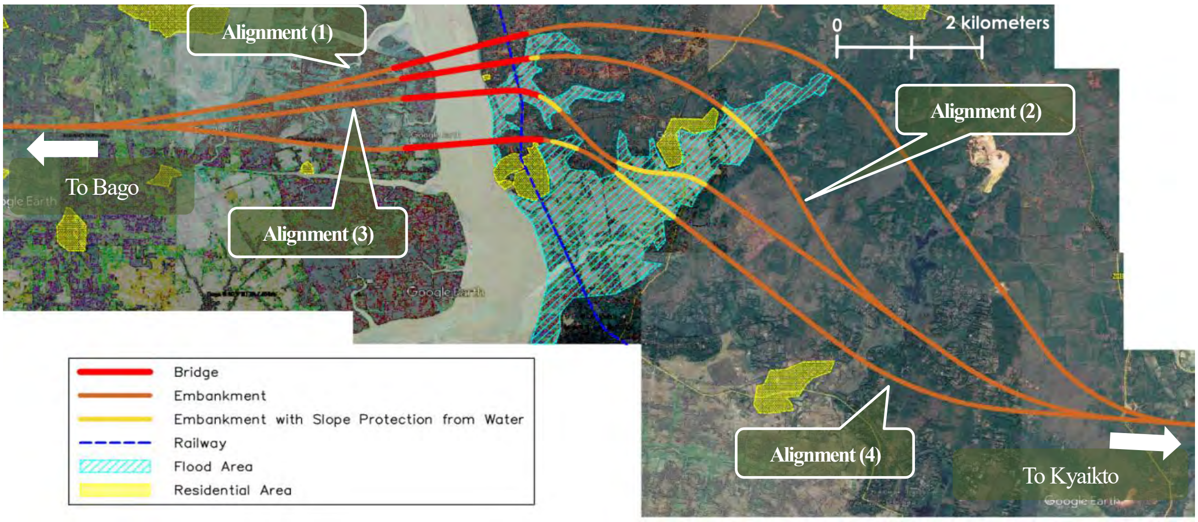
For selecting a suitable site for the New Sittaung Bridge, field reconnaissance was conducted by the JICA Study Team to get an impression of the landscape and to extract the possible types of structures for the bridge site. Four alternative sites were selected on the site which is likely to serve the need of the bridge with reasonable cost.

Within certain width of Corridor "B", four possible alternative alignments were proposed as given in Figure 5.3.1. The candidate alignments pass through the area from east to west. Right (west) riverbank is sedimentary flood terrain while left bank observed stiff hilly terrain and partially paddy field. The elevation of the paddy fields is rather low, thus, is normally flooded during rainy season.

Since there is no critical control point at the right bank side, the route selection was made in consideration of conditions of left bank side.

- **Alignment (1)**, which stretches most upstream side amongst the alternatives (700m apart from the Pre-F/S route), becomes longest route length but can avoid passing thru flood area on the left bank.
- **Alignment (2)**, which runs through secondly upstream side amongst the alternatives (400m upstream side from the Pre-F/S route), crosses the narrowest point of river width and passes thru a mostly hilly area except some flood areas on the left bank.

- **Alignment (3)**, which overlays the route proposed by the Pre-F/S.
- **Alignment (4)**, which runs through most of the downstream side amongst the alternatives (850 m apart from the Pre-F/S route), becomes shortest route length but passes thru some flood areas on the left bank.



Source: JICA Study Team

Figure 5.3.1 Plan View for Alternatives of Route

5.3.2 Comparative Study for the Suitable Bridge Site (Alignment)

The selection of alignments was conducted similarly to the selection method of a corridor based on the multi-criteria analysis. The weighting of evaluation criteria were slightly adjusted to suit for the selection of an eligible alignment as shown below.

(1) Riverbank Erosion (last 10 year's erosion progress ratio "m/year")

- A: Relatively Stable (less that 3m/year)
- B: Tolerable stable (less than 10m/ year)
- C: Unstable (more than 10m /year)

(2) Approach Road

- A: Does not run in flood area
- B: Runs in flood area for small part
- C: Runs in flood area for large part

(3) Construction Cost

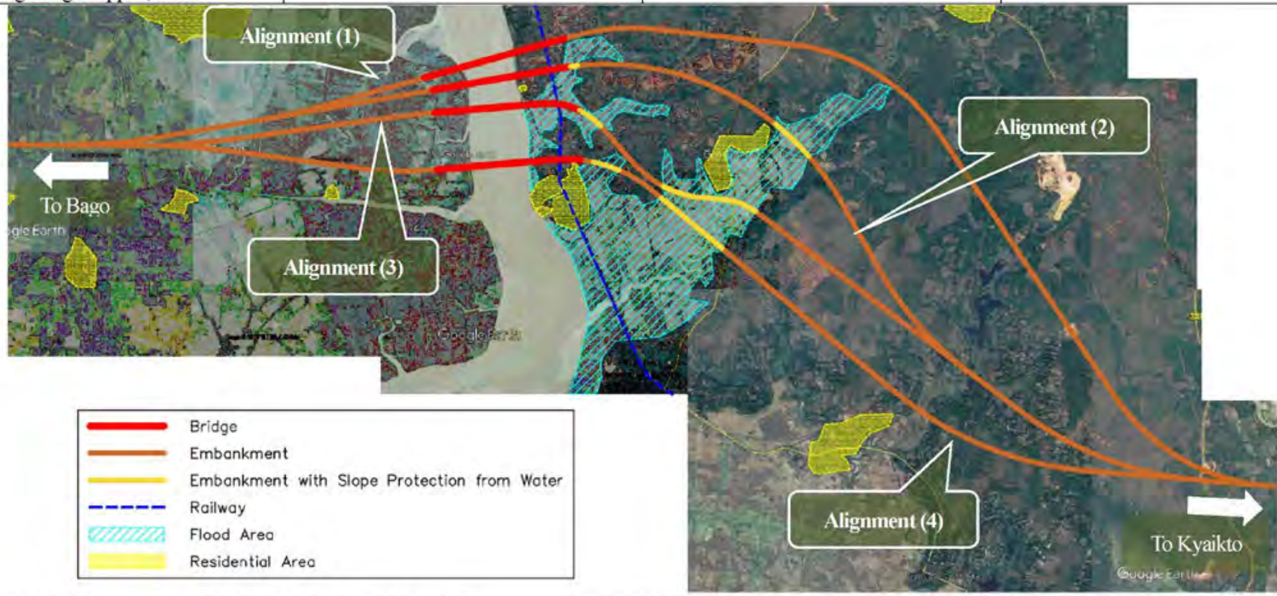
- A: Lowest / Reasonable (within 5% higher than lowest)
- B: Intermediate (More than 5% higher than lowest option)
- C: Unreasonable (More than 10% higher than lowest option)

(4) Land Acquisition and Compensation

- A: Less than 10 households affected
- B: Less than 50 households affected
- C: More than 50 households affected

The comparative study for alignment of the New Sittaung Bridge is shown in Table 5.3.1. As a result, it was recommend that Alignment (2) should be most eligible alignment for crossing the Sittaung River.

Table 5.3.1 Comparison of the Route for New Sittaung Bridge

Alternative	Alignment (1)		Alignment (2)		Alignment (3)		Alignment (4)	
Summary	✓ Avoiding flood area all along the alignment ✓ Road length: app. 22km ✓ River crossing length: app. 880m ✓ Bridge length: app. 2,200m		✓ Avoiding flood area at river crossing point ✓ Road length: around 22km ✓ River crossing length: app. 720m ✓ Bridge length: app. 2,100m		✓ Pre-F/S Alignment ✓ Road length: app. 21km ✓ River crossing length: app. 800m ✓ Bridge length: app. 2,200m		✓ Avoiding flood area at river crossing point ✓ Road length: app. 21km ✓ River crossing length: app. 870m ✓ Bridge length: app. 2,200m	
Sketch								
River Bank Erosion (10 years erosion ratio (m/year))	✓ Tolerable stable East (9.0m /year) West (2.1m/year)	B	✓ Relatively stable East (1.8m/year) West (4.8m/ year)	A	✓ Unstable East (0.5m/year) West (20.0m/year)	C	✓ Unstable East (0.6m/year) West (30.3 m/year)	C
Approach Road	✓ No flood area along the alignment.	A	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B	✓ Some flood area needs slope protection.	B
Construction Cost (Ratio)	✓ Intermediate (1.08)	B	✓ Lowest (1.00)	A	✓ Reasonable (1.03)	A	✓ Reasonable (1.06)	B
Land Acquisition and Compensation	✓ 17 households are affected.	B	✓ 26 households are affected.	B	✓ 20 households are affected.	B	✓ 29 households are affected.	B
Evaluation	Score = 50/80		**Recommended** Score = 60/80		Score = 40/80, (Disqualified)		Score = 30/80, (Disqualified)	

Source: JICA Study Team