MYANMA RAILWAYS
MINISTRY OF TRANSPORT AND COMMUNICATIONS
THE REPUBLIC OF THE UNION OF MYANMAR

PREPARATORY SURVEY
FOR
YANGON-MANDALAY RAILWAY
IMPROVEMENT PROJECT PHASE II

FINAL REPORT
(FOR DISCLOSURE)

SUMMARY

FEBRUARY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD.
PACIFIC CONSULTANTS CO., LTD.
TONICHI ENGINEERING CONSULTANTS, INC.
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(Exchange Rate: October 2017)

1 USD=110 JPY

1 USD=1,360MMK

1 MMK=0.0809 JPY

Preparatory Survey for Yangon-Mandalay Improvement Project Phase II

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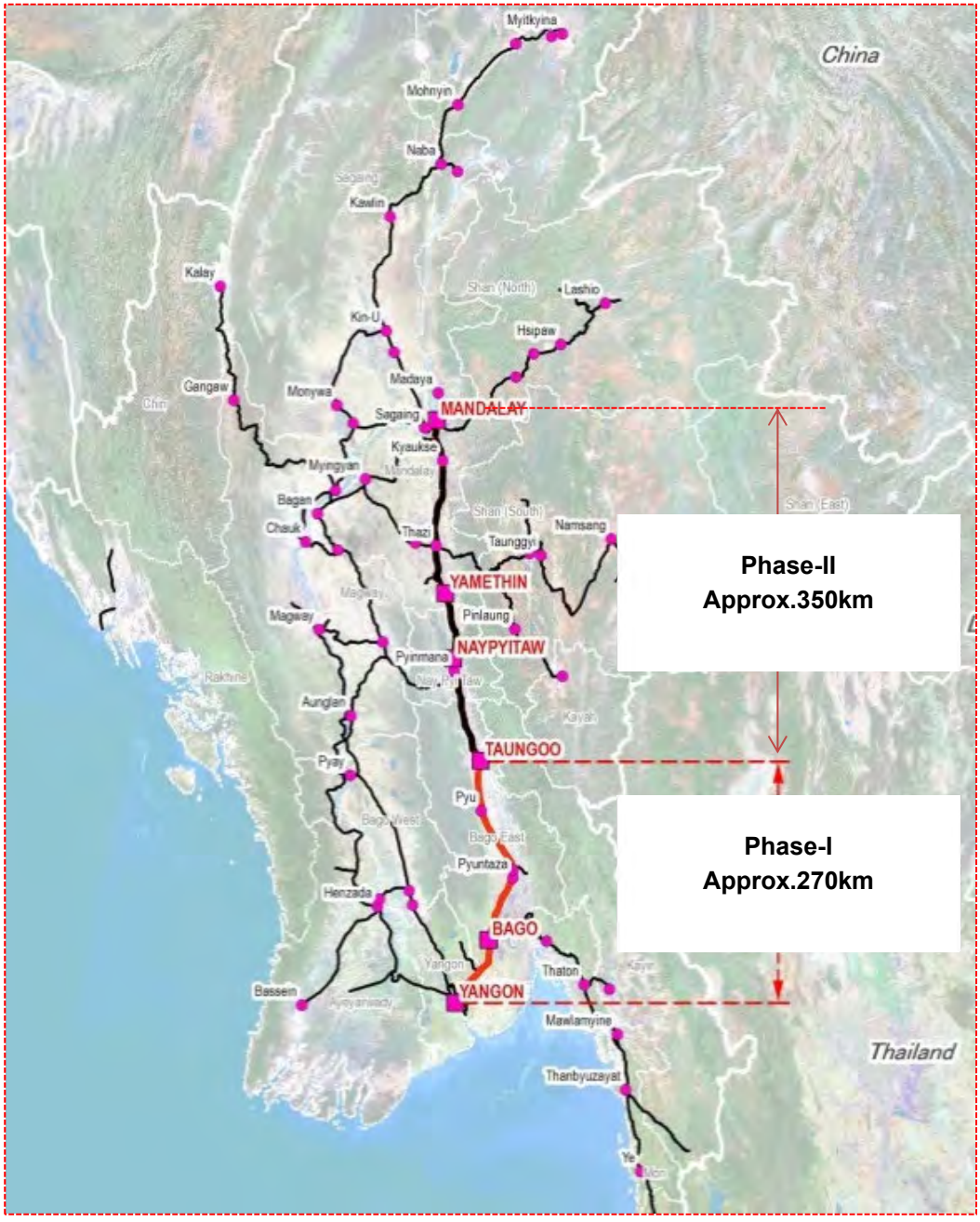

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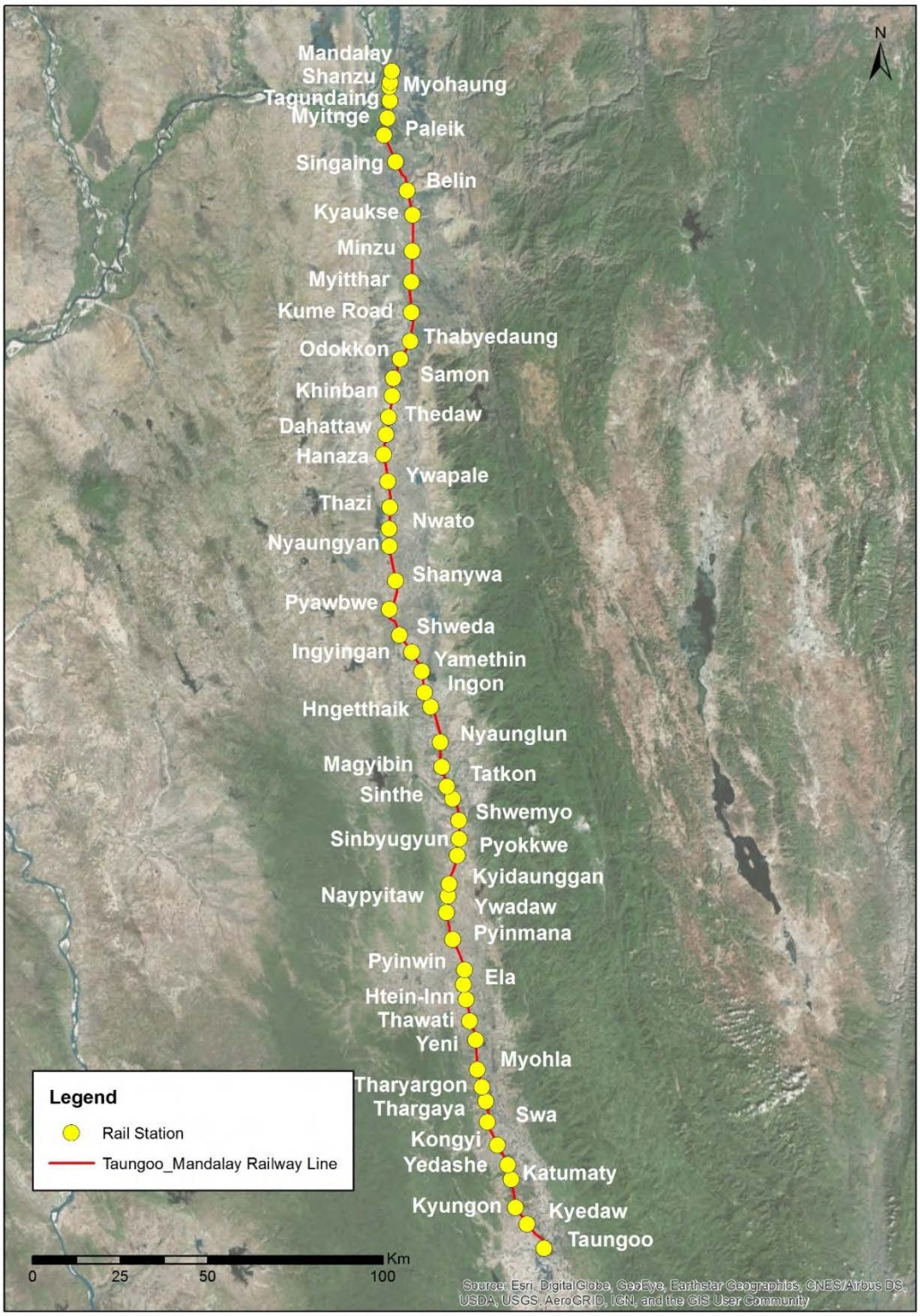


Source: JICA Study Team

Station Location Map of Yangon-Mandalay Railway

Abbreviations

No.	Abbreviation	English
1	AASHTO	American Association of State Highway and Transportation
2	AB	Absolute Block System
3	ABS	Automatic Block System
4	AC	Alternating Current
5	ADB	Asian Development Bank
6	AREMA	American Railway Engineering and Maintenance Way Association
7	ARP	Abbreviated Resettlement Plan
8	ASEAN	Association of South-East Asian Nations
9	ATC	Automatic Train Control
10	ATP	Automatic Train Protection
11	ATS-S	Automatic Train Stop using S-type transponder
12	AVR	Automatic Voltage Regulator
13	AW	Added Weight
14	BD	Basic Design
15	BOD	Biochemical Oxygen Demand
16	BOT	Build Operate Transfer
17	BS	British Standard
18	C/I	Converter-Inverter
19	CBR	California Bearing Ratio
20	CCTV	Closed-circuit Television
21	CI	Computerized Interlocking
22	CNV	Converter
23	COD	Chemical Oxygen Demand
24	CS	Construction Supervision
25	CSU	Continuous Speed Unit
26	CTF	Cable Termination Frame
27	CTS	Centralized Train Supervision
28	CVCF	Constant Voltage Constant Frequency
29	CWDM	Coarse Wavelength Division Multiplexing
30	CWR	Continuous Welded Rail
31	DB	Dispute Board
32	DC	Direct Current
33	DD	Detail Design
34	DEL	Diesel Electric Locomotive
35	DEMU	Diesel- Electric Multiple Unit
36	DHL	Diesel Hydraulic Locomotive
37	DL	Diesel Locomotive
38	DMH	Department of Meteorology and Hydrology, Myanmar
39	DMS	Detailed Measurement Survey
40	DMU	Diesel Multiple Unit
41	DRC	Diesel Rail Car

No.	Abbreviation	English
42	E&M	Electrical and Mechanical
43	ECC	Environmental Compliance Certificate
44	ECD	Environmental Conservation Department
45	EG	Emergency Generator
46	EI	Electronic Interlocking
47	EIA	Environmental Impact Assessment
48	EIT	End of intermediate transition curve
49	EMoP	Environmental Monitoring Plan
50	EMP	Environmental Management Plan
51	EMU	Electric Multiple Unit
52	EN	European Standard
53	ENG	Engine
54	ETC	End of Transition Curve
55	F/S	Feasibility Study
56	FC	Ferrule Connector
57	FC	Freight Car
58	FOB	Foot Over Bridge
59	FRP	Fiber-Reinforced Plastics
60	FWD	Falling Weight Deflectometer
61	GAD	General Administration Department
62	GC	General Conditions of Contract
63	GDP	Gross Domestic Product
64	GEN	Generator
65	GL	Ground Level
66	GM	General Manager
67	GOJ	Government of Japan
68	GOM	Government of Myanmar
69	GPS	Global Positioning System
70	HF	High Frequency
71	HID	High Intensity Discharge Lamp
72	ICB	International Competitive Bidding
73	IEC	International Electrotechnical Commission
74	IMF	International Monetary Fund
75	INV	Inverter
76	IP	Internet Protocol
77	ISO/IEC JTC 1	ISO/IEC Joint Technical Committee 1
78	ITU-R	International Telecommunication Union – Radio Communication Standardization Sector
79	ITU-T	International Telecommunication Union – Telecommunication Standardization Sector
80	JBIC	Japan Bank for International Cooperation
81	JETRO	Japan External Trade Organization
82	JICA	Japan International Cooperation Agency

No.	Abbreviation	English
83	JIS	Japanese Industrial Standards
84	L3SW	Layer 3 Switch
85	LC	Level Crossing
86	LED	Light Emitting Diode
87	LO	Lubricating Oil
88	MD	Managing Director
89	MDB	Multilateral Development Bank
90	MEPE	Myanmar Electric Power Enterprise
91	METI	Ministry of Economy, Trade and Industry
92	MGS	Myanmar Geosciences Society
93	MIMU	Myanmar Information Management Unit
94	ML	Main Line
95	MLIT	Ministry of Land, Infrastructure, Transport and Tourism, Japan
96	MM	Main Motor
97	MMI	Man Machine Interface
98	MNBC	Myanmar National Building Codes
99	MOALI	Ministry of Agriculture, Livestock and Irrigation
100	MOC	Ministry of Construction
101	MONREC	Ministry of Natural Resource and Environmental Conservation
102	MOTC	Ministry of Transportation and Communications
103	MR	Myanma Railways
104	MYT	Myanmar's National Transport Master Plan
105	NMS	Network Managed System
106	NTP	Notice to Proceed
107	O&M	Operation & Maintenance
108	OCC	Operation Control Center
109	OCC Project	The Project for Installation of Operation Control Centre System and Safety Equipment
110	ODA	Official Development Assistance
111	OECD	Organization for Economic Co-operation and Development
112	OFC	Optical Fiber Cable
113	OTC	Overhead Traveling Crane
114	OTDR	Optical Time Domain Reflectometer
115	P/Q	Pre-Qualification
116	PAPs	Project Affected Persons
117	PAUs	Project Affected Units
118	PC	Prestressed Concrete
119	PMU	Project Management Unit
120	PPP	Public-Private Partnership
121	PVC	Poly Vinyl Chloride
122	PWM	Pulse Width Modulation
123	QA and QC Plan	Quality Assurance and Quality Control Plan
124	RBE	Rail Bus Engine

No.	Abbreviation	English
125	RC	Reinforced Concrete
126	Rf	Rectifier
127	RH	Relay Hut
128	RI	Relay Interlocking
129	ROB	Road Over Bridge
130	ROW	Right of Way
131	SBD	Standard Bidding Documents
132	SC	Scissors crossing
133	SDR	Social Discount Rate
134	SIL	Safety Integrity Level
135	SL	Survey Center line
136	SM	Single Mode
137	SPAD	Signal Passed At Danger
138	SPT	Standard Penetration Test
139	SSI	Solid State Interlocking
140	STEP	Special Terms for Economic Partnership
141	STM	Synchronous Transfer Mode
142	SW	Switch
143	T/C	Technical Committee
144	TA	Tender Assistance
145	TAC	Technical Advisory Committee
146	TID	Train Information Display
147	TM	Traction Motor
148	TN	Turnout
149	T-N	Total Nitrogen
150	T-P	Total Phosphorus
151	UHF	Ultra High Frequency
152	VAT	Value Added Tax
153	VR	Variable Resistance
154	YCDC	Yangon City Development Committee
155	YCR	Yangon Circular Railway
156	YCR-F/S	Feasibility Study of the Yangon Circular Railway Line Upgrading Project
157	YCR-MR/BD	Supporting Consulting Services for the Yangon Circular Railway Upgrading Project (for MR Works)
158	YCR-RS/BD	Basic Design Study of the Yangon Circular Railway Line Upgrading Project
159	YESC	Yangon Electricity Supply Corporation
160	YM	Yangon-Mandalay Railway
161	YM-D/D (1)	Detailed Design for Yangon-Mandalay Railway Improvement Project Phase I
162	YUTRA	Comprehensive Urban Transport Master Plan of the Greater Yangon

Station Name (Phase I)

NO	STATION NAME	KILOPOST	MILEAGE
1	Yangon	0	0
2	Pazundaung	1.61	1
3	Mahlwagon	4.02	2.5
4	Thin gan gyun	7.24	4.5
5	Toegyaungkalay	11.67	7.25
6	Ywathagyi	20.52	12.75
7	Laydaungkan	25.75	16
8	Darbain	36.15	22.46
9	Tongyi	48.68	30.25
10	Kyauktan	55.12	34.25
11	Tawa	61.56	38.25
12	Payathonzu	68.4	42.5
13	Bago	74.83	46.5
14	Shwele	83.24	51.72
15	Payagyi	91.73	57
16	Pyinbongyi	104.12	64.7
17	Kadok	114.26	71
18	Paungdawthi	121.91	75.75
19	Eimshaylayse	126	78.75
20	Daiku	130.76	81.25
21	Pyuntaza	141.22	87.75
22	Nyaung le bin	149.27	97.47
23	Tawwi	156.86	97.47
24	Pein za lok	163.75	101.75
25	Tha tegon	170.59	106
26	Kyauktaga	175.02	108.75
27	Penwegon	183.87	114.25
28	Taw gywe in	191.51	119

NO	STATION NAME	KILOPOST	MILEAGE
29	Kanyutk win	199.08	123.7
30	Nyaung bintha	206.8	128.5
31	Pyu	216.05	134.25
32	Zeya wadi	222.49	138.25
33	Nyaungchidauk	230.54	143.25
34	Kywebwe	240.19	149.25
35	Banbwegon	245.83	152.75
36	Oktwin	254.68	158.25
37	Thaung dai gon	260.31	161.75
38	Taungoo	267.15	166

Station Name (Phase II)

NO	STATION NAME	KILOPOST	MILEAGE
38	TAUNGOO	267.15	166
39	KYEDAW	276.5	171-3/4
40	KYUNGON	282.5	175-1/2
41	KAYTUMADI	290.5	180-1/2
42	YEDASHE	295	183-1/4
43	KONGYI	301.5	187
44	SWA	308.5	191-1/2
45	THAGAYA	314.5	195-1/2
46	THARYARGON	318.5	197-23/24
47	MYOHLA	324	201-1/4
48	YENI	332.5	206-1/2
49	THAWATI	338	210
50	HTEININN	344.5	214
51	ELA	349	216-3/4
52	PYIWIN	353.5	219-1/4
53	PYINMANA	362	225
54	YWADAW	370	230
55	NAYPYITAW	370	232
56	KYIDAUNGGKAN	378.5	235-1/4
57	PYOKKWE	387	240-1/2
58	SINBYUGYUN	392	243-1/2
59	SHWEMYO	397	246-3/4
60	SINTHE	404	251
61	TATKON	407.5	253-1/2
62	MAGYIBIN	414	257-1/2
63	NYAUNGLUN	420.5	261-1/2
64	HNGETTHAIK	431	268
65	INGON	435.5	270-3/4

NO	STATION NAME	KILOPOST	MILEAGE
66	YAMETHIN (YMA)	441.5	274-1/2
67	INGYINGAN	448	278-1/2
68	SHWEDA	454	282-1/2
69	PYAWBWE	462.5	287-1/2
70	SHANYWA	471	292-3/4
71	NYAUNGYAN	481	299-1/4
72	NWATO	486	302-1/4
73	THAZI	492.5	306
74	YWAPALE	499.5	310-1/2
75	HANZA	507.5	315-1/2
76	DAHATTAW	512	318-1/4
77	THEDAW	517	322-1/4
78	KHINBAN	523.5	325-3/4
79	SAMON	530	329
80	ODOKKON	534.5	332-1/2
81	THABYEDAUNG	541	336-1/4
82	KUME ROAD	549.5	341-1/2
83	MYITTHA	558.5	347
84	MINZU	567	352-1/2
85	KYAUKSE	578	359-1/4
86	BELIN	585	363-1/2
87	SINGAING	594	369
88	PALEIK	602	374-1/4
89	MYITNGE	607	377-3/4
90	TAGUNDAING	611.5	380-1/2
91	MYOHAUNG	616	382-3/4
92	SHANZU	617.5	384
93	MANDALAY	620.5	385-1/2

Chapter 1 Introduction

1.1 Background of the Project

The Yangon-Mandalay Railway covers 620 km (2015) of the about 6,072 km railway network operated by Myanma Railways (MR), connecting Yangon, the country's former capital and largest city, Naypyitaw, the new capital, and Mandalay, the second largest city.

Source: JICA Study Team

Photo 1.1.1 Long-distance trains

The Line is a double-track/non-electrified route with a total of 96 stations (including cargo stations). In 2007, with the double-tracking of the last single-track section between Kyaukse and Mandalay, the line became double-track end to end. With a new station opened in Naypyitaw in 2009, the line is becoming the most important railway of Myanmar, connecting three major cities.

The Yangon, Bago, and Mandalay areas connected by this Yangon-Mandalay Railway are home to 19.55 million people (2014), 37% of Myanmar's total population, making it the most important line of MR's railway network.

Despite the increase in demand for transportation of passengers and cargo by Yangon-Mandalay Railway, safe and stable train operation is getting more and more difficult, due to the lack of proper maintenance of railway facilities over decades, poorly maintained and deformed rails causing train accidents, and aged, decrepit bridges not allowing the engineer to gain speed and run at a decent speed. For those reasons, the leading role in land transportation is now taken by truckers. In particular, for passenger transportation, while an expressway bus takes only 11 to 12 hours to connect Yangon and Mandalay, the train takes as long as 14 hours or so.

To promote the economic development of Myanmar in the future, proper sharing of transportation needs by rail is indispensable. At the Myanmar Development Cooperation Forum held in January 2013, the Ministry of Railways and Transportation (MORT) gave top priority to the project to improve and modernize the railway connecting Yangon and Mandalay. In response, JICA carried out the Preparatory Study for the Development of a National Transportation and Traffic Program (Master Plan). The Myanmar government requested JICA to conduct a feasibility study (FS) for a project to improve and modernize the Yangon-Mandalay Railway, which is implemented accordingly.

The feasibility study concluded that the government should give top priority to a project to improve and modernize the arterial railway from the viewpoints of national economy and fiscal revenues. Accordingly, an ODA loan agreement for the Phase I project was concluded in September 2014 in order to renew and modernize the transportation facilities and equipment along the Yangon-Taungoo section of the Yangon- Mandalay railway. Regarding the Phase I project currently under way, the detailed design study has already been completed, and MR is currently procuring contractors

The Yangon-Mandalay Railway Improvement Project is in line with what both the Japanese government and Myanmar government aim at, i.e., "the support of infrastructure development necessary for sustainable economic growth", one of the priority areas in Japan's Policy for Economic Cooperation to Myanmar (April 2012) and the rapid development of basic economic infrastructure, as one of the major objectives of the "Economic Policy" (July 2016) of the National League for Democracy (NLD), which recently came to power in the country.

The Study was triggered by a request from the Minister of Transport and Communications of Myanmar to early complete the renovation of the Yangon-Mandalay Railway as a whole, defining the improvement of the Taungoo-Mandalay section as a Phase II project and prompting it as a study necessary for the examination of the Yangon-Mandalay Railway Improvement Project Phase II (the Project).

1.2 Purpose of the Project

The objectives of this project are to rehabilitate deteriorated infrastructures and relevant facilities of the existing railway between Yangon city and Mandalay city and modernize them to increase the safety and speed of train operation, to reduce transportation cost, and to increase passenger and freight transportation, which will all contribute to the national economic development and the betterment of quality of life of the residents. The proposed technical targets of this project are to achieve the maximum train running speed of 100 km/h safely and to provide the train operation service of less than 8 hours for the section from Yangon to Mandalay.

Outline of the Project is shown below:

1) Civil Works including track works, civil structures and station buildings
2) Upgrade of signalling and telecommunication system
3) Introduction of new rolling stocks (DEMU)
4) Improvement of Freight Facilities
5) Improvement of Passenger Service Equipment including Automatic Ticket Bending Machine

1.3 Purpose of the Study

The purpose of the Study is to conduct studies and collect data such the purpose, outline, project cost, implementation schedule, implementation methods (procurement and construction), project implementation system, operation and management systems, environmental and social considerations, etc. for the review to implement the Project as a Japanese yen loan project.

1.4 Study Area

The subject of the Study is the 350 km section between Taungoo and Mandalay to be launched as the Yangon-Mandalay Railway Phase II project.

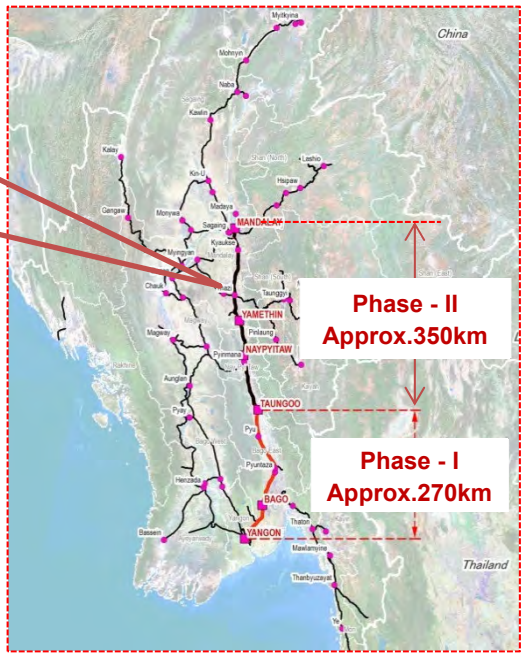
The outline of this section is as shown below:

< Outline of the Taungoo-Mandalay section >

- Distance: Approximately 350 km
- Number of stations: 56 stations
- Number of bridges: about 1,200
- Electrification method: non-electrified
- Number of lines: Double line

Source: JICA Study Team

Photo 1.4.1 Mandalay Station



Source: JICA Study Team

Figure 1.4.1 Location Map

1.5 Study Tasks

Tasks to be addressed in the study Tasks are as shown in Table 1.5.1.

Table 1.5.1 Study Tasks

No.	Study Tasks
[1]	Explain and Discuss the Inception Report to/with MR
[2]	Review and Update Existing Materials, Study Results, and Demand Forecasts
[2-1]	Review and Update Consistency with Existing Materials and Study Results
[2-2]	Review and Update Operation and Maintenance Plan
[2-3]	Review and Update Demand Forecasts
[2-4]	Examine Service Levels
[2-5]	Review the Project Plan for the Yangon-Mandalay Railway Improvement Project, Phase I
[3]	Study Natural Conditions; Study the Conditions of Existing Equipment and Facilities
[4]	Draft a Project Plan
[4-1]	Review the Route Plan
[4-2]	Develop a Civil Work and Facility Plan
[4-3]	Develop a Building and Equipment Plan
[4-4]	Develop Alignments and Track Layout Plan
[4-5]	Develop an Train Operation Plan
[4-6]	Develop a Rolling Stock Plan
[4-7]	Develop a Depot Plan
[4-8]	Develop a Freight Facilities and Container Transport Plan
[4-9]	Develop a Signalling and Telecommunication Plan
[4-10]	Develop an Electrical and Mechanical Plan
[4-11]	Develop a Station Development and Terminal Development Plan; Develop a Transport Nodes Improvement Plan
[4-12]	Develop a Project Plan
[4-13]	Develop a Financial Plan
[5]	Draft and Discuss an Interim Report I
[6]	Design the Project and Estimate the Cost for the Scope of Cooperation
[6-1]	Develop an Outline Design
[6-2]	Estimate the Project Cost
[7]	Develop a Project Implementation Plan for the Cooperation Scope
[7-1]	Examine the Procurement Plan and Method
[7-2]	Develop a Project Implementation Schedule
[7-3]	Review the Traffic Management Plan and the Safety Management Plan During the Construction Period
[7-4]	Review the Financial Plan
[7-5]	Develop a Project Implementation Plan
[7-6]	Examine the Scope of the Loan Assistance Project
[7-7]	Identify Points to be noted in developing the Project Work Plan
[7-8]	Examine Measures to Reduce the Project Cost and Shorten the Project Period
[8]	Review the Project Implementation System
[9]	Consider Environmental and Social Impact

No.	Study Tasks
[9-1]	Forecast and Evaluate Major Environmental and Social Impact; Develop Mitigation Measures; Draft Monitoring Plans
[9-2]	Help MR Develop Land Acquisition and Resettlement Action Plans
[10]	Evaluate the Effects of the Project
[10-1]	Verify the Effects of the Project Quantitatively
[10-2]	Verify the Effects Of the Project Qualitatively
[11]	Draft an Interim Report II and Discuss it with MR
[12]	Develop Visual Presentation Materials for the Project
[13]	Identify Points to be noted In carrying out the Project
[13-1]	Identify Points to be noted about the Unit and System to Manage and Maintain the Project
[13-2]	Identify Points to be noted and Develop Recommendations about the System to manage and maintain the Project
[13-3]	Streamline the Decision Making Process
[14]	Assist JICA in organizing relevant Seminars
[15]	Draft a Conclusion and Recommendations
[16]	Draft a Final Report and Discuss it with MR
[17]	Finalize a Final Report

Source: JST

Chapter 2 Review and Update Demand Forecast

2.1 Review of Demand Forecast in previous study

2.1.1 Demand Forecasting Result

Passenger and freight transport demand was estimated as follows in the YM(1)-F/S. The estimated passenger volume in 2023 and 2030 is 82,000 and 155,000 per day, respectively. The estimated cargo volume in 2023 and 2030 is 17,100 and 42,200 ton per day.

Table 2.1.1 Estimated Passenger Demand in YM(1)-F/S

(Unit: thousand passenger)

Year	Daily Boarding Passenger	Maximum Daily Sectional Passenger	Maximum Section
2023	82	43.5	Laydauntkan – Dabain
2030	155	80.0	Laydauntkan – Dabain

Source: YM(1)-F/S

Table 2.1.2 Estimated Cargo Demand in YM(1)-F/S

(Unit: thousand Ton)

Year	Daily Handling Cargo	Maximum Daily Sectional Cargo	Maximum Section
2023	17.1	17.1	Yangon - Taungoo
2030	42.2	42.4	Yangon - Taungoo

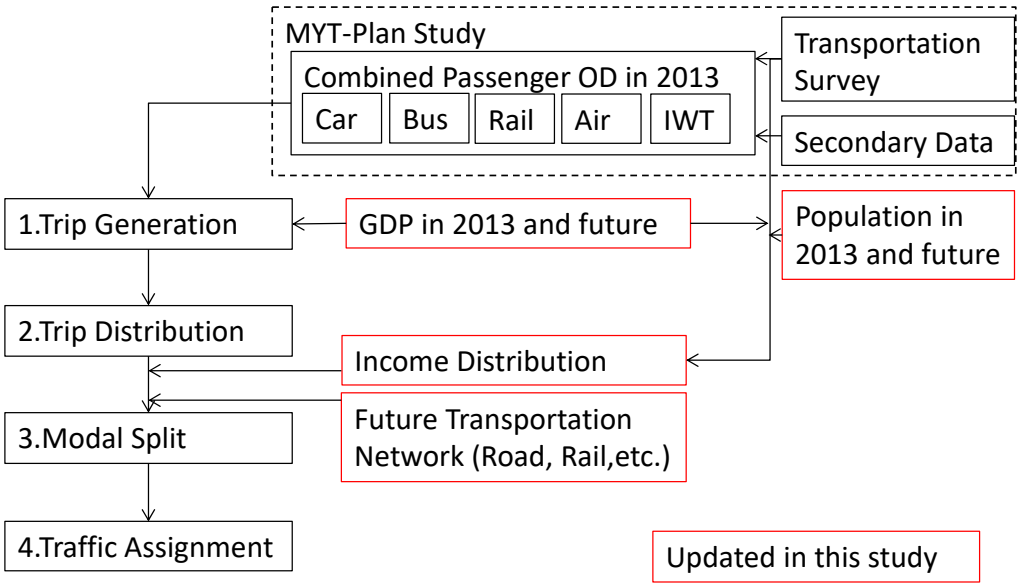
Source: YM(1)-F/S

2.2 Update of Demand Forecast

2.2.1 Methodology

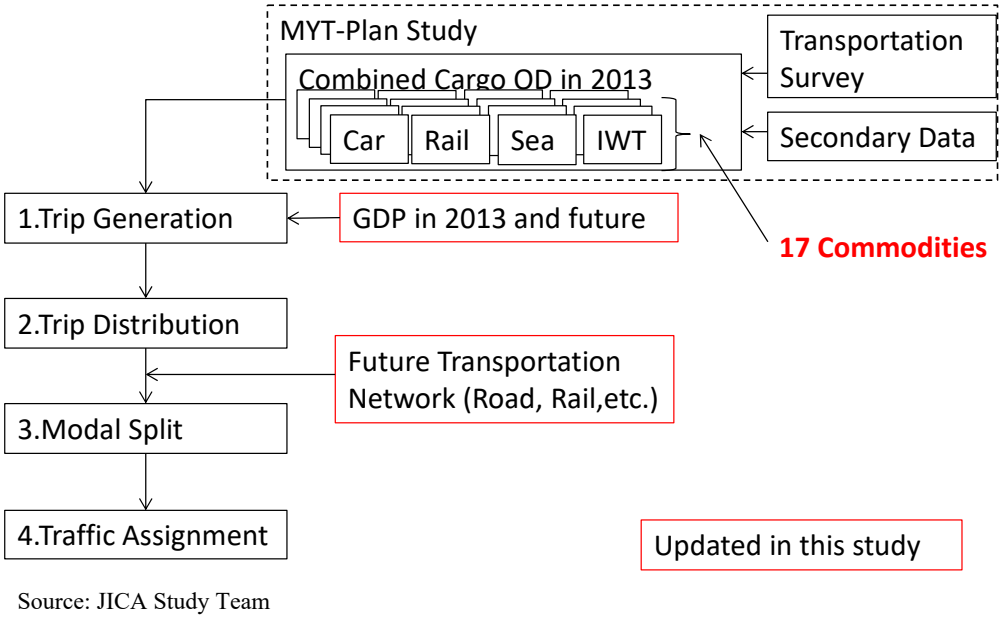
Four-step demand forecast model on passenger and cargo which was developed in MYT-Plan is adapted in this study. Considering the changes of precondition after the previous study, socio-economic frame and transportation network plan are reviewed in this study. Following contents are updated;

- Population: Population Census 2014,
- GDRP: latest economic indicators,
- Highway development plan: truck ban policy for expressway , toll price, and
- Railway development plan: fuel cargo PPP project, dry port projects.



Source: JICA Study Team

Figure 2.2.1 Work Flow for Passenger Demand Forecast



Source: JICA Study Team

Figure 2.2.2 Work Flow for Cargo Demand Forecast

2.2.2 Update of Passenger Demand Forecast

(1) Passenger Demand Forecast

Following table shows the estimated future passenger share by transportation mode along the Yangon-Mandalay Railway for with/without Yangon-Mandalay railway improvement. With the improvement of Yangon-Mandalay railway, it is estimated that the share of railway increases from 13% to 15 % in 2030. It is estimate that total passenger volume in Yangon-Mandalay railway in 2023 and 2030 is 80,700 and 132,400 person per day.

Table 2.2.1 Passenger Modal Share along Yangon-Mandalay Railway (Without Case)

(Unit: thousand Persons/day)

PAX	Air	Car	IWT	Rail	Bus	Total
2013	1.6	53.9	2.1	22.5	83.3	163.3
2023	18.6	173.6	0.6	65.4	180.6	438.7
2030	51.8	366.3	1.2	111.0	357.2	887.5
Share	Air	Car	IWT	Rail	Bus	Total
2013	1.0%	33.0%	1.3%	13.8%	51.0%	100%
2023	4.2%	39.6%	0.1%	14.9%	41.2%	100%
2030	5.8%	41.3%	0.1%	12.5%	40.2%	100%

Source: JICA Study Team

Table 2.2.2 Passenger Modal Share along Yangon-Mandalay Railway (With Case)

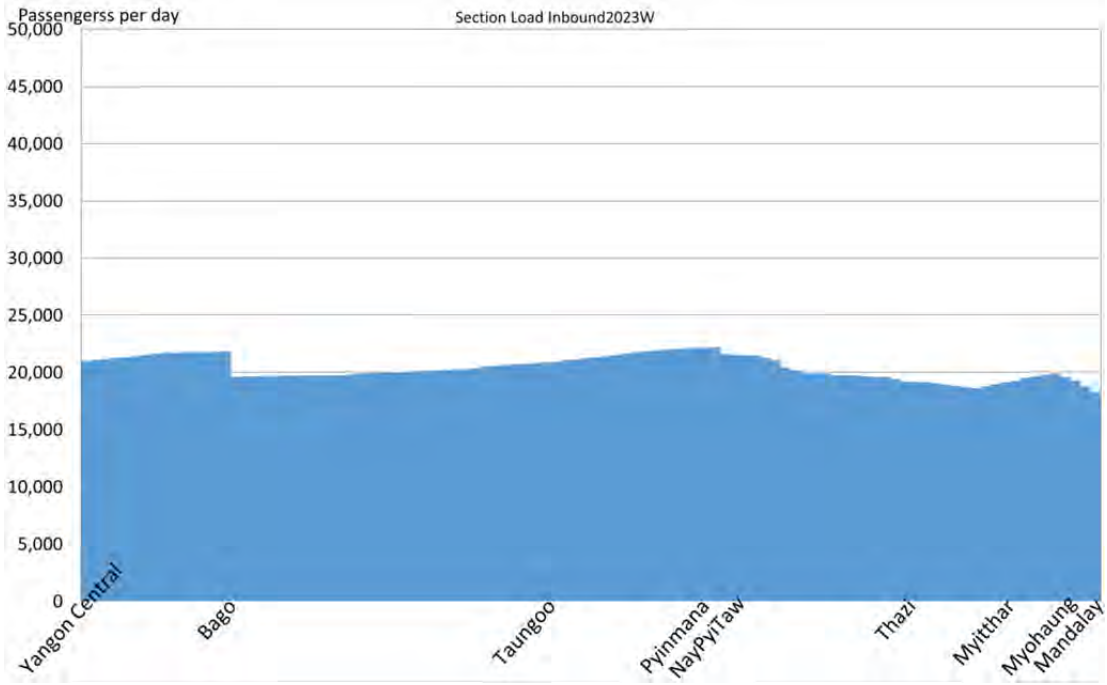
(Unit: thousand Persons/day)

PAX	Air	Car	IWT	Rail	Bus	Total
2023	17.2	169.2	0.7	80.7	171.0	438.7
2030	49.5	357.7	1.3	132.4	346.6	887.5
Share	Air	Car	IWT	Rail	Bus	Total
2023	3.9%	38.6%	0.2%	18.4%	39.0%	100%
2030	5.6%	40.3%	0.1%	14.9%	39.1%	100%

Source: JICA Study Team

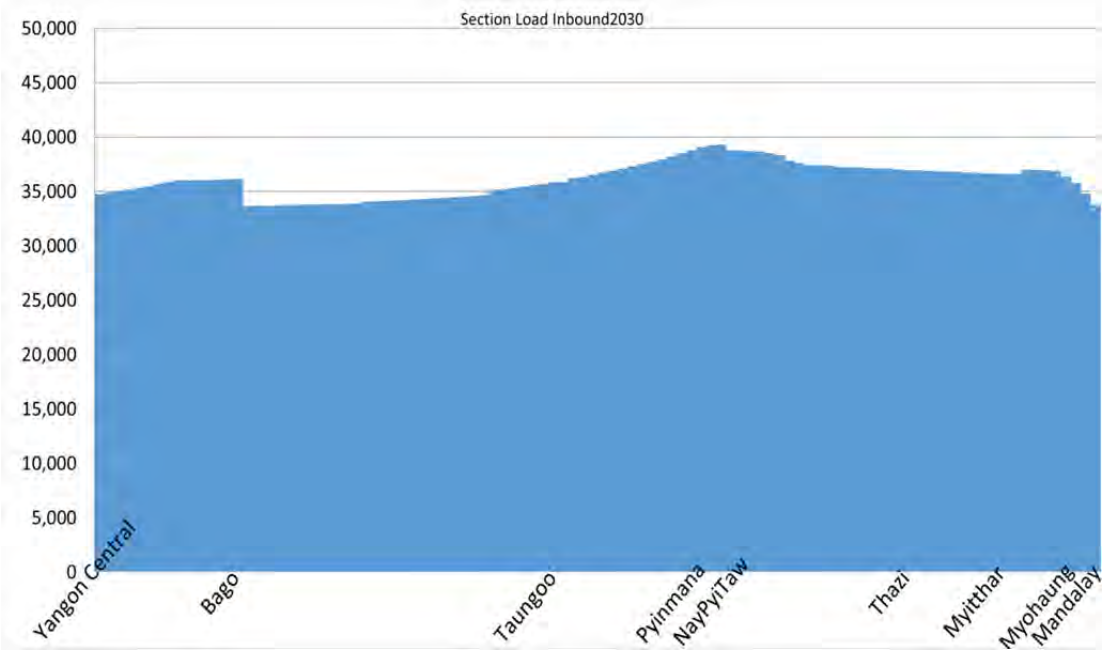
(2) Passenger Demand Forecast for Yangon-Mandalay Railway Line

Maximum sectional traffic volume in 2023 is 22,000, in 2030 is 39,300 passengers per one-way per day.



Source: JICA Study Team

Figure 2.2.3 Maximum sectional traffic volume in 2023



Source: JICA Study Team

Figure 2.2.4 Maximum sectional traffic volume in 2030

2.2.3 Update of Cargo Demand Forecast

(1) Cargo Demand Forecast

Following table shows the result of estimated cargo share by transportation mode along the Yangon-Mandalay Railway for with/without Yangon-Mandalay railway improvement. With the improvement of Yangon-Mandalay railway, it is estimated that the share of railway increases from 5% to 11 % in 2030.

Table 2.2.3 Cargo Modal Share along Yangon-Mandalay Railway (Without Case)

(Unit: thousand ton/day)

Cargo Volume	Truck	Rail	IWT	Total
2013	79.2	5.4	5.5	90.1
2023	146.3	9.7	30.7	186.7
2030	294.5	17.2	68.2	379.9
Share	Truck	Rail	IWT	Total
2013	89.7%	6.0%	6.1%	100%
2023	78.4%	5.2%	16.4%	100%
2030	77.5%	4.5%	18.0%	100%

Source: JICA Study Team

Table 2.2.4 Cargo Modal Share along Yangon-Mandalay Railway (With Case)

(Unit: thousand ton/day)

Cargo Volume	Truck	Rail	IWT	Total
2023	135.1	20.9	30.7	186.7
2030	271.5	40.7	67.7	379.9
Share	Truck	Rail	IWT	Total
2023	72.4%	11.2%	16.4%	100%
2030	71.5%	10.7%	17.8%	100%

Source: JICA Study Team

(2) Cargo Demand Forecast for Yangon-Mandalay Railway Line

Based on the above mentioned freight demand forecast model, station to station cargo volume was estimated as follows. In the assignment process, it is assumed that bulk cargo and general cargo will be handled at Myohaung station and Myinge area in Mandalay area, respectively.

It is estimate that total cargo volume in Yangon-Mandalay railway in 2025 and 2030 is 30,000 and 41,000 ton per day, respectively.

Table 2.2.5 Station to Station Cargo Volume in 2025 (Outbound)

(Unit: ton/day)

Commodity		Yangon					Total
		Myohaung	Myinge	Thazi	Pyinmana	Taungoo	
1	Live Animal & Animal Products	0	0	0	0	0	0
2	Fish and Aquatic Products	0	0	0	0	0	0
3	Vegetable and Fruits	0	0	0	0	0	0
4	Grain and Grain Products	153	0	2	0	1	157
5	Other Agricultural Products (ex. Plantation Product)	0	199	0	1	1	201
6	Foodstuff, Beverage and Animal Food	0	1,068	137	93	23	1,321
7	Petroleum, Oil and Gas	5,177	0	0	0	0	5,177
8	Coal, Ore, Stone and Sand	18	0	3	6	0	26
9	Cement, Construction Material (incl. steel - frame)	5,672	0	186	21	65	5,944
10	Fertilizer (incl. Urea)	0	43	0	0	0	43
11	Garment, Textiles and fabric	0	54	0	0	0	54
12	Wood and Wood Products	0	120	0	0	0	120
13	Paper and Printed Matter	0	137	0	0	0	138
14	Metal and Metal Products (excl. construction material)	435	0	2	0	0	437
15	Industrial Material, Chemicals	0	866	28	34	4	931
16	Household articles, miscellaneous	0	142	2	4	3	151
17	Machinery and Parts, Transportation	0	80	1	6	1	88
Total		11,455	2,708	360	167	99	14,788

Source: JICA Study Team

Table 2.2.6 Station to Station Cargo Volume in 2025 (Inbound)

(Unit: ton/day)

Commodity		Myohaung	Myinge	Thazi	Pyinmana	Taungoo	Total
		Yangon					
1	Live Animal & Animal Products	0	0	0	0	0	0
2	Fish and Aquatic Products	0	0	0	0	0	0
3	Vegetable and Fruits	0	0	0	0	0	0
4	Grain and Grain Products	138	0	2	10	8	158
5	Other Agricultural Products (ex. Plantation Product)	0	444	0	1	2	447
6	Foodstuff, Beverage and Animal Food	0	442	24	47	27	540
7	Petroleum, Oil and Gas	564	0	0	0	0	564
8	Coal, Ore, Stone and Sand	151	0	0	9	83	244
9	Cement, Construction Material (incl. steel - frame)	231	0	27	54	24	336
10	Fertilizer (incl. Urea)	0	59	0	0	0	59
11	Garment, Textiles and fabric	0	75	2	0	0	76
12	Wood and Wood Products	0	2,375	11	4	577	2,967
13	Paper and Printed Matter	0	24	0	0	0	24
14	Metal and Metal Products (excl. construction material)	58	0	0	0	0	58
15	Industrial Material, Chemicals	0	880	3	5	2	890
16	Household articles, miscellaneous	0	68	0	1	3	72
17	Machinery and Parts, Transportation	0	18	0	0	0	18
Total		1,142	4,384	70	131	726	6,452

Source: JICA Study Team

Table 2.2.7 Station to Station Cargo Volume in 2030 (Outbound)

(Unit: ton/day)

Commodity		Yangon					Total
		Myohaung	Myinge	Thazi	Pyinmana	Taungoo	
1	Live Animal & Animal Products	0	0	0	0	0	0
2	Fish and Aquatic Products	0	0	0	0	0	0
3	Vegetable and Fruits	0	0	0	0	0	0
4	Grain and Grain Products	249	0	4	1	0	254
5	Other Agricultural Products (ex. Plantation Product)	0	358	0	1	0	359
6	Foodstuff, Beverage and Animal Food	0	1,863	247	120	19	2,249
7	Petroleum, Oil and Gas	10,183	0	0	0	0	10,183
8	Coal, Ore, Stone and Sand	54	0	4	12	0	69
9	Cement, Construction Material (incl. steel - frame)	13,183	0	246	26	29	13,484
10	Fertilizer (incl. Urea)	0	68	0	0	0	68
11	Garment, Textiles and fabric	0	90	0	0	0	91
12	Wood and Wood Products	0	155	0	0	0	155
13	Paper and Printed Matter	0	180	1	0	0	181
14	Metal and Metal Products (excl. construction material)	765	0	3	1	0	768
15	Industrial Material, Chemicals	0	1,319	52	16	0	1,387
16	Household articles, miscellaneous	0	268	2	5	2	278
17	Machinery and Parts, Transportation	0	121	2	6	1	129
Total		24,433	4,422	561	188	52	29,656

Source: JICA Study Team

Table 2.2.8 Station to Station Cargo Volume in 2030 (Inbound)

(Unit: ton/day)

2030		Myohaung	Myinge	Thazi	Pyinmana	Taungoo	Total
		Yangon					
1	Live Animal & Animal Products	0	0	0	0	0	0
2	Fish and Aquatic Products	0	0	0	0	0	0
3	Vegetable and Fruits	0	0	0	0	0	0
4	Grain and Grain Products	305		4	12	4	326
5	Other Agricultural Products (ex. Plantation Product)	0	977	0	1	0	979
6	Foodstuff, Beverage and Animal Food	0	710	31	55	19	815
7	Petroleum, Oil and Gas	2,618	0	0	0	0	2,618
8	Coal, Ore, Stone and Sand	416	0	1	18	169	605
9	Cement, Construction Material (incl. steel - frame)	293	0	76	6	7	381
10	Fertilizer (incl. Urea)	0	54	0	0	0	54
11	Garment, Textiles and fabric	0	84	3	0	0	87
12	Wood and Wood Products	0	3,724	11	3	158	3,896
13	Paper and Printed Matter	0	40	0	0	0	40
14	Metal and Metal Products (excl. construction material)	107	0	0	0	0	107
15	Industrial Material, Chemicals	0	1,542	2	2	1	1,546
16	Household articles, miscellaneous	0	118	0	0	2	121
17	Machinery and Parts, Transportation	0	32	0	0	0	32
Total		3,739	7,280	128	98	361	11,606

Source: JICA Study Team

Chapter 3 Natural Condition

3.1 Climate

3.1.1 Meteorokogical & Hydrological Date Collection

(1) Meteorological Data collection

1) Climate

Myanmar's Climate can be described as tropical monsoon climate. It is characterized by strong monsoon influences, has a considerable amount of sunshine, a high rate of rainfall, and high humidity that makes it sometimes feel quite uncomfortable.

2) Temperature (2006-2016)

The temperature and rainfall have been analyzed from 2006 to 2016 to understand the meteorological conditions of the project area and its surroundings along the Taungoo-Mandalay railway.

Table 3.1.1 The Highest And Lowest Temperature (°C) In 7-Stations During (2006 To 2016)

Station Name	Month (max)	Highest Temp (avg) (°C)	Month (min)	Lowest Temp (avg) (°C)
Taungoo	Mar-May	40.0-44.0	Dec-Feb	10.0-12.5
Pyinmana	Mar-May	41.0-44.5	Dec-Feb	9.0-13.0
Tatkon	Mar-May	40.0-44.2	Dec-Feb	9.0-15.0
Yamethin	Mar-May	40.0-45.0	Dec-Feb	6.0-11.0
Meiktila	Mar-May	41.0-44.0	Dec-Feb	10.0-12.8
Kyaukse	Mar-May	40.5-43.2	Dec-Feb	8.4-10.0
Mandalay	Mar-May	42.2-45.0	Dec-Feb	10.5-12.3

Source: DMH

3) Rainfall (2006-2016)

Rainfall data is shown in the Table 3.1.2.

Table 3.1.2 The Highest And Lowest Rainfall (mm) In 7-Stations During (2006 To 2016)

Station Name	Month/year	Highest Rainfall (mm)	Month/year	Lowest Rainfall (mm)
Taungoo	Aug-09	859.0	May-09	1.0
Pyinmana	Sep-11	370.0	Jun-09	1.0
Tatkon	Apr-08	319.0	Jul-06	1.0
Yamethin	Sep-06	316.0	Aug-10	1.0
Meiktila	Oct-10	296.0	Oct-12	1.0
Kyaukse	Sep-13	326.0	May-14	1.0
Mandalay	Sep-06	450.0	1-Jul-17	1.0

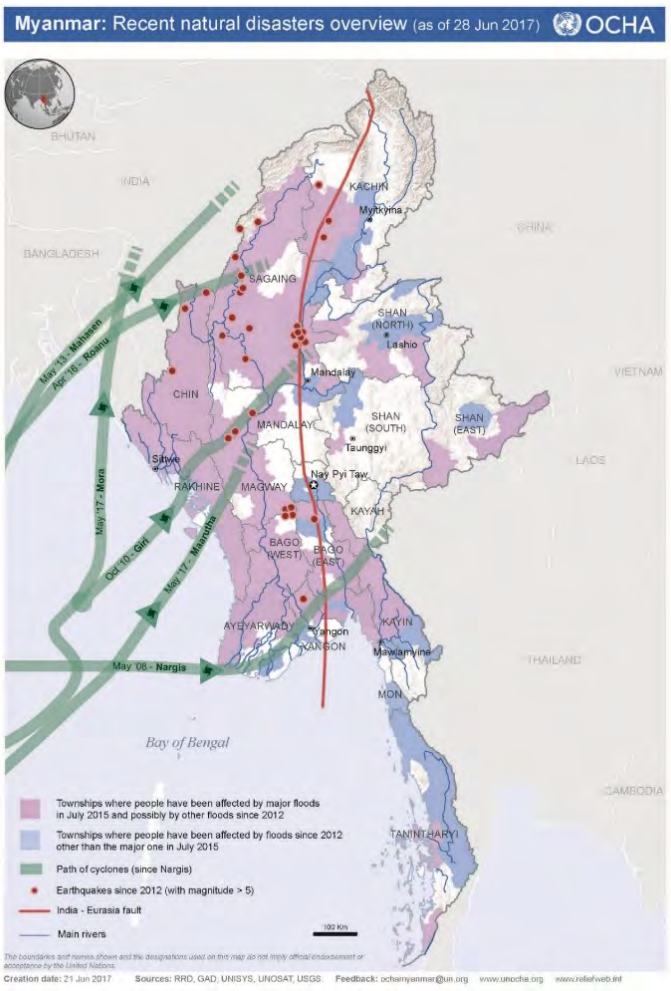
Source: DMH

4) Cyclone

(a) Historical Records of Cyclone Paths & Cyclone Intensity (2006-2016)

Cyclones are one of the most critical meteorological disasters, and considered the most significant natural disasters that take place in Myanmar. As shown in the following Figures, many cyclones have passed through Myanmar. Cyclone paths generally follow a southwest-to-northeast trajectory.

The following descriptions are the historical records of cyclones paths and intensity which has crossed Myanmar coast, and quoted from DMH and Wikipedia. Another source about the Cyclones Map was collected from the OCHA. The Map was updating in 2017 for the natural disasters overview as shown in the following Figure.



Source: DMH

Figure 3.1.1 Cyclone Track of MYANMAR (Since Nargis)

5) Flooding (Station between Taungoo and Mandalay) (2006-2016)

Flooding is another major natural disaster that takes place frequently in Myanmar during the rainy/monsoon season. As explained above, the corridor between Taungoo and Mandalay has commonly faced flooding problems and train operation has occasionally been disturbed.

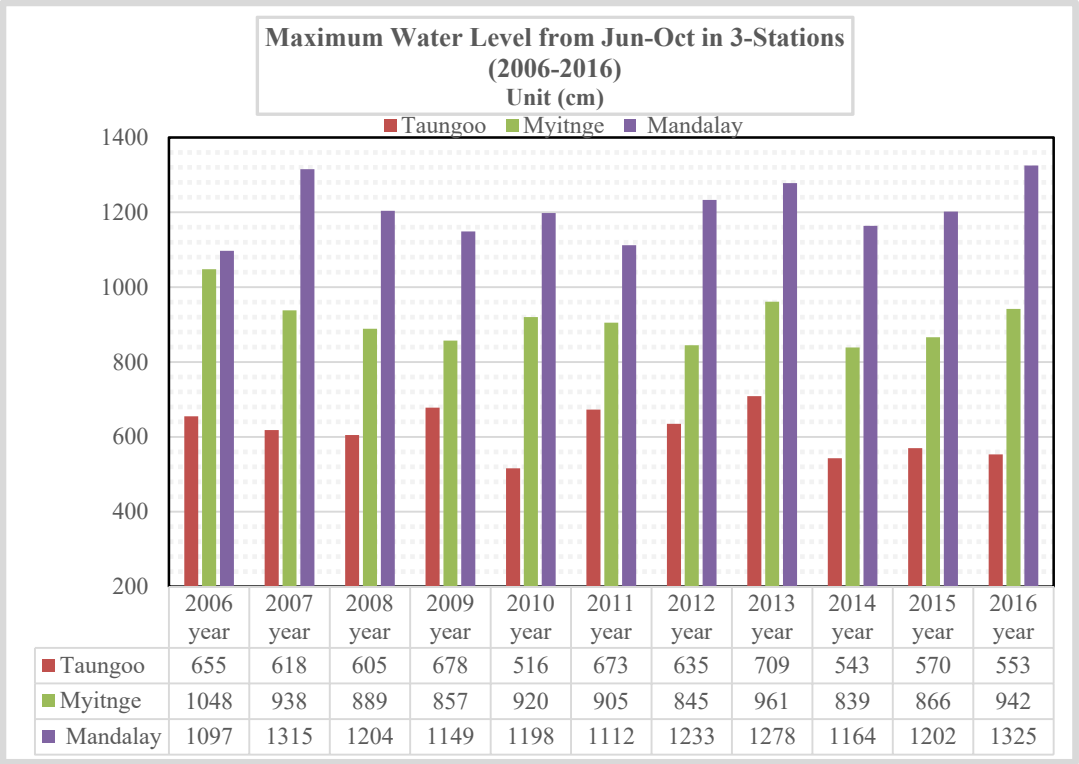
(a) Water Level and Rainfall during Flooding

There are three stations for the data collection of water level along the Taungoo-Mandalay stationas.

Table 3.1.3 Historical Record of Water Level

Station :	Taungoo	Myitnge	Mandalay
River :	Sittoung	Dokehtawady	Ayeyarwady
Danger Level (cm) :	**600 cm**	**870 cm**	**1260 cm**
Maximum WL During 2006 to 2016	709 cm(2013)	1048 cm(2006)	1325 cm(2016)

Source: DMH Data



	2006 year	2007 year	2008 year	2009 year	2010 year	2011 year	2012 year	2013 year	2014 year	2015 year	2016 year
Taungoo	655	618	605	678	516	673	635	709	543	570	553
Myitnge	1048	938	889	857	920	905	845	961	839	866	942
Mandalay	1097	1315	1204	1149	1198	1112	1233	1278	1164	1202	1325

Source: DMH

Figure 3.1.2 Maximum Water Level in 3 stations

3.2 Earthquake

3.2.1 Background and Earthquake Zone of Myanmar

The majority of the earthquakes in Myanmar are mainly confined to three zones as follows (Hazard profile of Myanmar 2009):

1) The zone along the western fault belt of Myanmar that has mostly intermediate focus earthquakes. The earthquake frequency is much higher in the northern part.

2) The zone along the Sagaing fault, including the offshore part with shallow focus earthquakes. The earthquake frequency is much higher in the three segments (from south to north), Bago – Taungoo, Sagaing- Tagaung, and Myitkyina- Putao.

3) The zone in the north eastern part of Myanmar which is continuous to the earthquake belt in southern Yunnan.

3.2.2 Records of Earthquakes in Myanmar

The seismic records show that there have been at least sixteen major earthquakes with Richter magnitude (RM) ≥ 7.0 within the territory of Myanmar in the past 170 years. The frequency with respect of time may be summarized in Table 3.2.1.

Table 3.2.1 Summary of Earthquakes in Myanmar over Time

Richter Magnitude	Frequency	Time Range	Data Source
8.0	1	1839 – 2008	Historical record and NEIC
7 – 7.9		1839 – 2008	Historical record and NEIC
6 – 6.9	47	1950 – 2012	ANSS Catalogue
5 – 5.9	700	1950 – 2008	ANSS Catalogue

Source: Seismic Sources in Myanmar, a report by Myanmar Earthquake Committee, June 2011

(1) Significant Earthquakes in Myanmar

Figure 3.2.1 below shows the map of the epicentre distribution of the most significant earthquakes that occurred in and around Myanmar from the 18th Century until recently.

Source: Wang, Y, 2013, Earthquake Geology of Myanmar, 2013, Californmia Institute of Technology

Figure 3.2.1 Historical Earthquake in Myanmar from the 18th Century until recently

3.3 Geology and Geotechnical Conditions of Project Area

3.3.1 Classification of soil layer

The soil layers are classified in accordance with their physical properties and/or their relative density. Generally nine different layers observed from BH-01 to BH-20 are described from top to bottom as follows.

1) Filled Soil
2) CLAY-I
3) Silty SAND-I
4) CLAY-II
5) Silty SAND-II
6) CLAY-III
7) Silty SAND-III
8) CLAY-IV
9) Silty SAND-IV

3.3.2 Field Investigation

(1) Location of Boring Points

The locations of investigated points were designated by client. The plan map showing geotechnical investigated points are indicated in Figure 3.3.1. Moreover, elevation of all boring points was referred from Google earth.

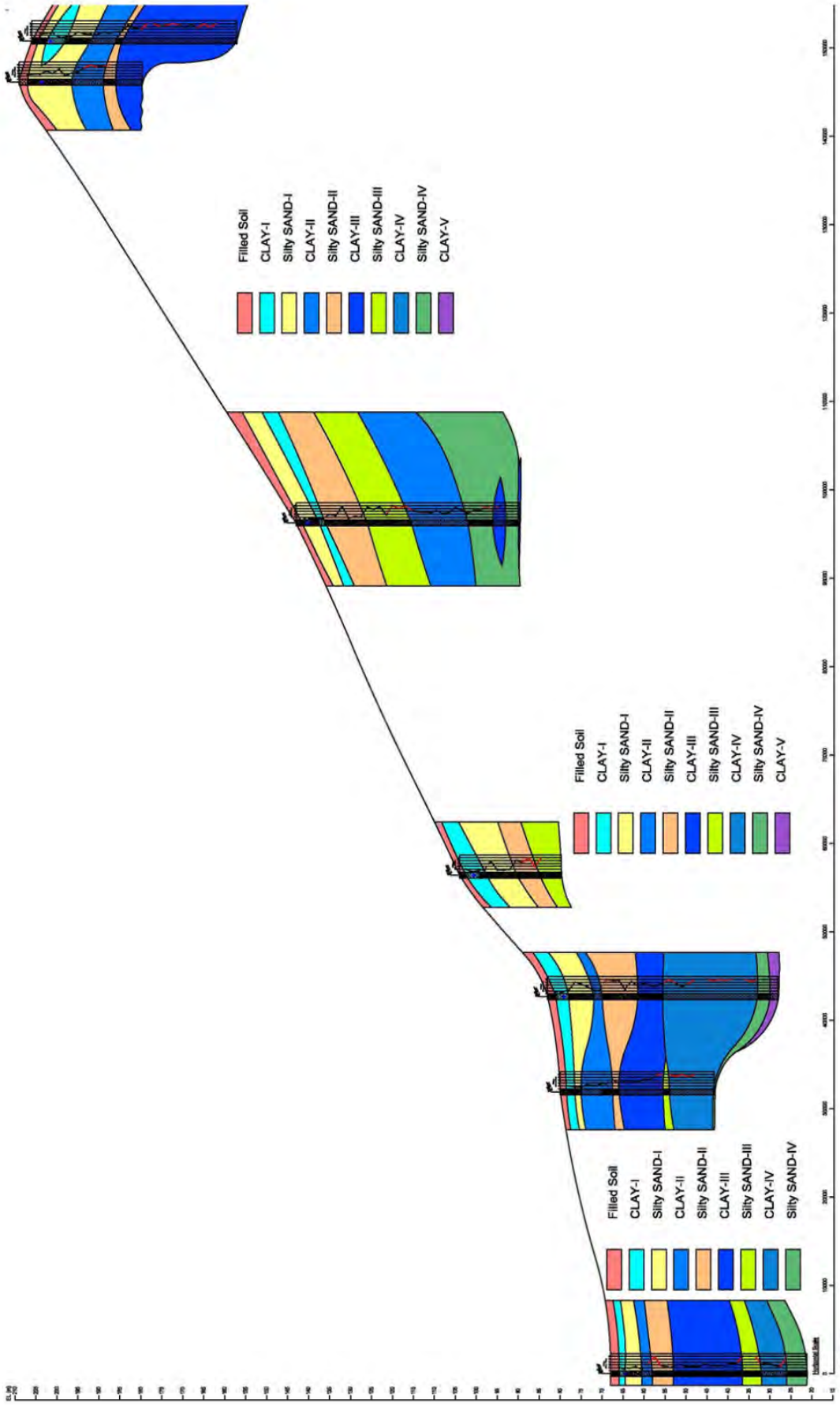


Figure 3.3.1 (a) Soil profile through the project area

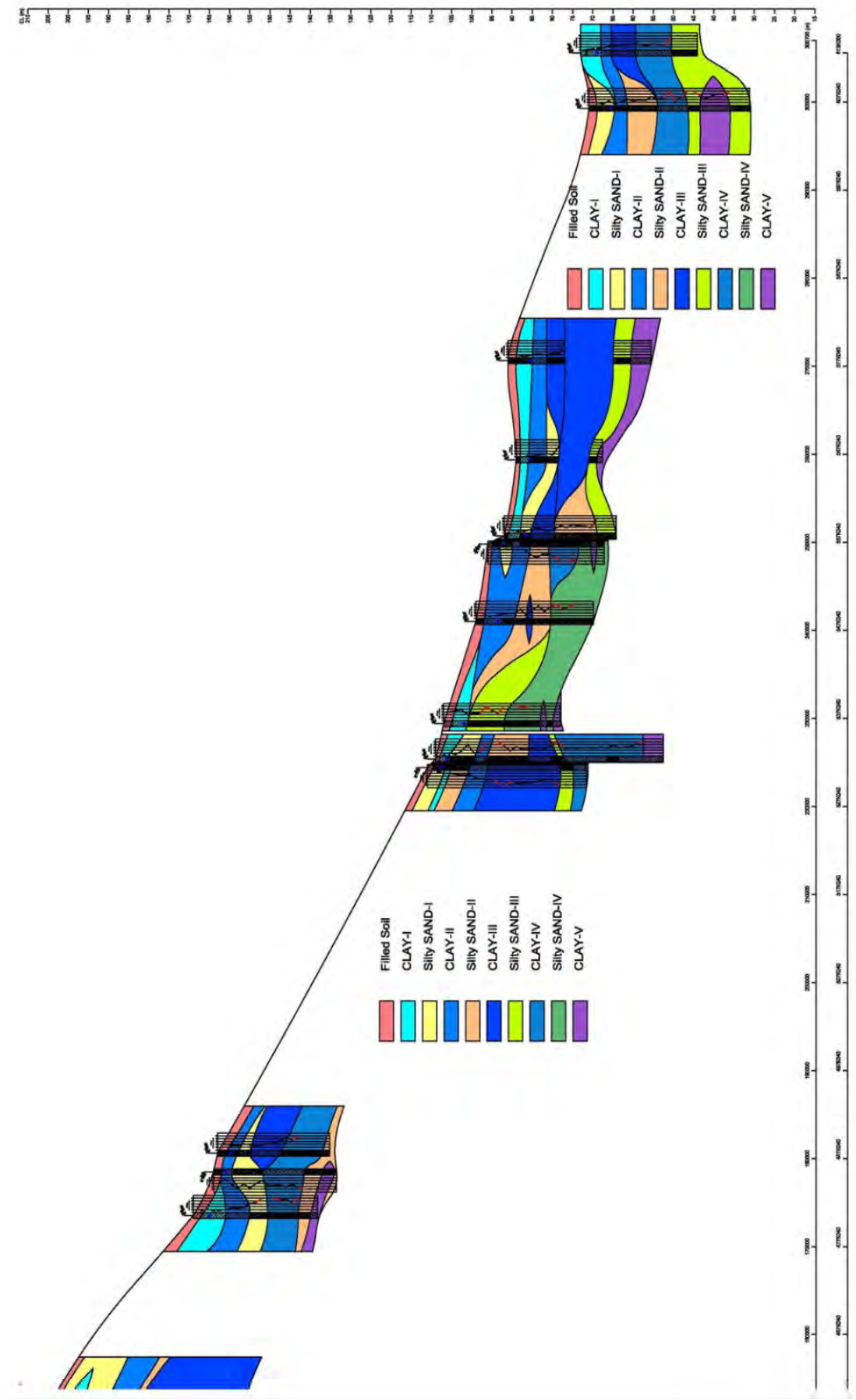


Figure 3.3.1 (b) Soil profile through the project area

Chapter 4 Railway System Parameters and Outline of Design Conditions

4.1 General

The purpose of rehabilitation and modernization for the existing railway facilities from Tangoo station to Mandalay are,

(1) Increasing passenger and freight transport capacity between Yangon-Mandalay to cope with increase traffic demand;

(2) Increasing the train operation speed;

(3) Reducing travel time;

(4) Increasing safety, reliability and punctuality of train operation and;

(5) Enhancing the national economic growth such as industries, trade, and commercial etc

The Railway Improvement Plan is as shown in table below.

Table 4.1.1 Railway Improvement Plan for the Project

No	Parameter	Existing Line (2017)	Improved Main Line (2023)	Remarks
1	Gauge: Double Tracks	1,000mm	1,000mm	
2	Length (km)	353km	353km	
3	Traction Power	Non-electrified	Non-electrified	
4	Axle Load for DEMU	less than 12.5ton	less than 20ton	
5	Construction Gauge / Rolling Stock Gauge			
	Construction Gauge			
a.	Height	3,810mm	4,300mm	
b.	Width	3,810mm	3,810mm	
	Rolling Stock gauge			
c.	Height	3,505mm	4,100mm	
d.	Width	2,818mm	3,000mm	
6	Horizontal curvature			
a.	Minimum radius	300m	Design Criteria 500m Design minimum value 300m	

No	Parameter	Existing Line (2017)	Improved Main Line (2023)	Remarks
7	Vertical alignment			
a.	Maximum gradient	6‰	10‰ Desirable 6‰	
8	Number of Stations	55	50	including Halt Station
9	Traffic Volume (Passenger-km/day)	2,089,247 (Estimated value in 2013)	10,190,618	Yangon-Mandalay whole section
10	Daily Ridership (No. of Passenger)	22,500 (Estimated value in 2013)	80,700	
11	Total number of Train per day	28	104	Trains on YM Line Only (Trains going to/from branch lines are excluded)
a.	Express Train	5 round trips	35 round trips	
b.	Local Train (including Mail trains)	5 round trips		
12	Speed			
a.	Maximum	48 - 69 kph	100 kph (DEMU)	
b.	Schedule	44 kph	77.5 kph or more	
13	Rolling Stock (Passenger Train)			
a.	Train composition and No. of Car	1 DEL + 14 coaches (max)	6 cars + 6 cars	
14	Safety System			
a.	Type of Signalling	Relay Interlocking Mechanical Interlocking	Relay Interlocking Electronic Interlocking	
b.	Train Control System	Absolute Block System	Absolute Block System Automatic Block System	
c.	Level Crossing	Manual Operated Level Crossing (97 crossings)	Automatic Level Crossing (79) Manual Level Crossing (17)	
15	Telecommunication	UHF, HF, OFC	UHF is improved	HF and OFC: out of scope
16	Station Platform			
a.	Minimum Length	***m	250m	for Express DEMU 12cars
b.	Height of platform above rail level	app. 150mm		
17	Maintenance facilities			
a.	Depot	Pyinmana, Naypyitaw, Thazi, Mandalay	Naypiytaw, Myouhan	Existing: for locomotive Improved: for DEMU
b.	Workshop	Myitnge	Ywathagyi (Phase 1)	
18	Power Supply	Limited to some stations only	All stations	

No	Parameter	Existing Line (2017)	Improved Main Line (2023)	Remarks
19	Track			
a.	Rail	BS75lbs(37kg/m)	50N (BS75lbs for stabling)	
b.	Sleeper	PC	PC	
c.	Ballast thickness	20cm	25cm	
d.	Fastening	e-Clip	FD or e-Clip	
e.	Rail joint	Fishplate	Welding and Fishplate	
20	Civil			
a.	Drainage	Partially installed	Basically Installed	
b.	Railway Bridge	Amount of Bridge No.is 71	Re-construction new bridge and/or box culvert	
21	Safety Fence	Partially installed	Partially installed	by MR component
22	Station Transfer Bridge Height			
a.	Pyinmana Station	Approx. 4,600mm > 3,810mm	Approx. 4,600mm > 4,300mm	
b.	Naypyitaw Station	Approx. 4,500mm > 3,810mm	Approx. 4,500mm > 4,300mm	
c.	Thazi Station	Approx. 4,400mm > 3,810mm	Approx. 4,400mm > 4,300mm	
23	ROB	5ROB	5ROB	

Source: JICA Study Team

The basic concept of technical utilisation in Japanese railway improvement projects is assumed as below.

a) Energy saving (Cost reduction and mechanisation of maintenance)

b) Lifelong duration of structures

c) Sustainable Operation & Maintenance

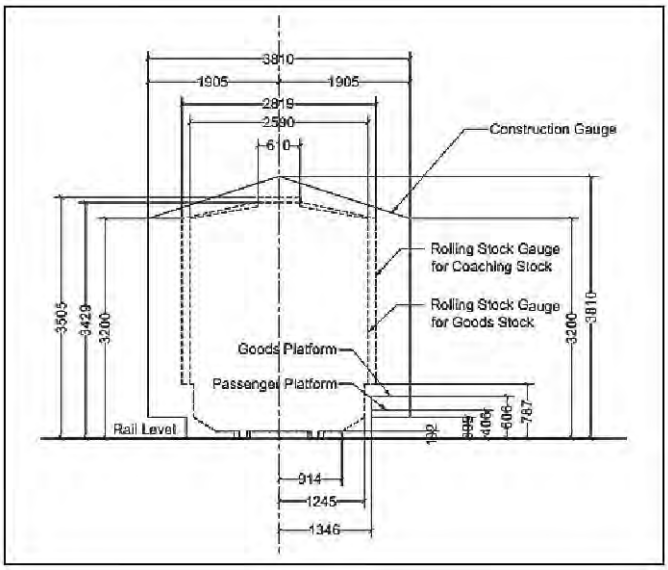
d) Renewal of facilities and improvement of function

The JICA Study Team proposes the utilisation of technology which saves the initial cost, enables sustainable operation & maintenance by local engineers, and ensures the renewal of facilities and improvement of function in the future.

4.2 Rolling Stock Gauge and Construction Gauge

4.2.1 Current MR Rolling Stock Gauge and Construction Gauge

The current MR rolling stock gauge and construction gauge is shown below in Figure 4.2.1



Source: MR

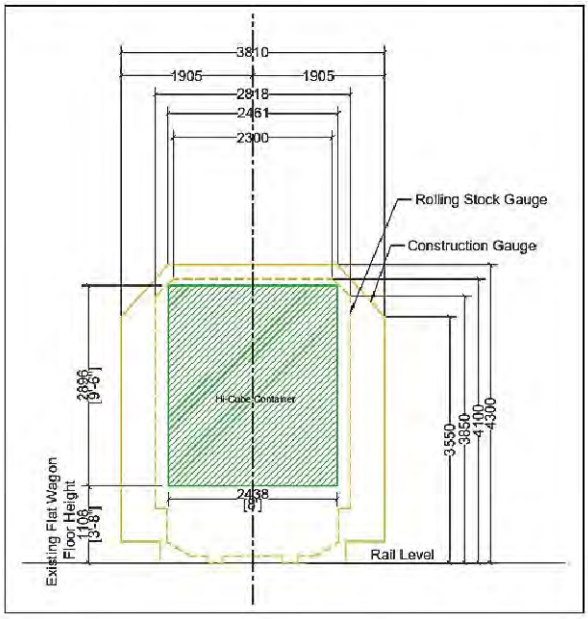
Figure 4.2.1 Current MR Rolling Stock Gauge and Construction Gauge

MR has two rolling stock gauges: for coaching stock and goods stock. Rolling stock gauges for coaching stock is wider and higher than for goods stock, however, the lower portion (close to platform) of both rolling stock gauges is the same. Both construction gauges are not different.

4.2.2 Proposed Construction Gauge and Rolling Stock Gauge for Yangon-Mandalay Railway Phase I

As mentioned in the previous section, it is necessary to expand the construction gauge and the rolling stock gauge should be expanded. Therefore, the JICA Study Team proposes a new construction gauge and rolling stock gauge for the Yangon Mandalay Railway Improvement Project Phase I, considering ASEAN connectivity and expansion of transportation capacity. The concept of the new rolling stock gauge is given below:

- Width of rolling stock gauge: 3,000mm, enveloping other countries' rolling stock gauge and based on Japanese rolling stock gauge because MR may use a lot of second hand Japanese rolling stock even after rehabilitation,
- Height of rolling stock gauge: 4,100mm, enveloping other countries' construction gauge, considering transportation of Hi-cube containers using the exiting flat wagons and based on Japanese rolling stock gauge (Refer to Figure 4.2.2).



Source: JICA Study Team

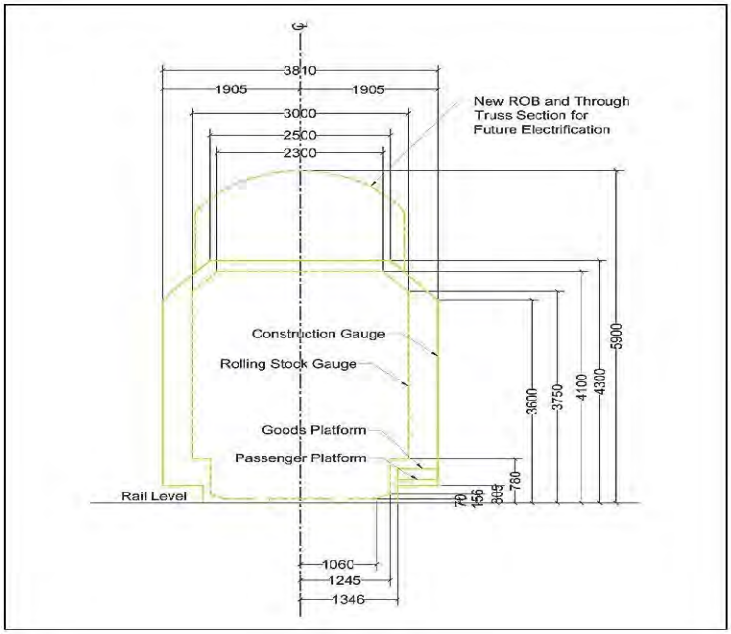
Figure 4.2.2 Proposed Rolling Stock Gauge considering Hi-Cube Container

And, clearance between rolling stock gauge and construction gauge should be at least 200mm at the top and 300mm at the sides, considering car body shaking and safety for train passengers.

Therefore, the concept of the new construction gauge is shown below:

- Width of Construction Gauge: 3,810mm, maintaining existing MR's construction gauge in order to avoid impact on the existing structures/facilities close to the track,
- Distance from rail center to Construction Gauge at Platform: 1,346mm, maintaining existing MR's construction gauge in order to avoid demolition of the existing platforms,
- Height of Construction Gauge: 4,300mm (5,900mm at the new ROB and through truss bridge sections, considering electrification in the future),
- Height of Construction Gauge at Platform: 406mm for passenger platform and 606mm for goods platform, maintaining the existing MR's Construction Gauge in order to avoid modification of existing platforms1.

The proposed construction gauge and rolling stock gauge is shown below in Figure 4.2.3.



Source: JICA Study Team

Figure 4.2.3 Proposed Construction Gauge and Rolling Stock Gauge

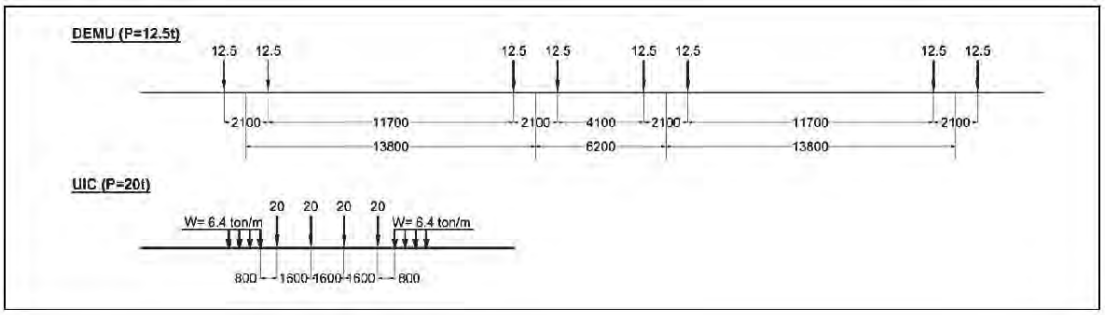
4.3 Axel Load of Train

4.3.1 Proposed MR Axel Load of Train for Yangon-Mandalay Railway

Considering introduction of new DEMU and ASEAN connectivity, the JICA Study Team proposes the following axle loads:

- New DEMU: 12.5 t Axle load
- UIC standard: 200 kN Axle Load, considering ASEAN connectivity

The proposed axle load of train is shown below in Figure 4.3.1.



Source: JICA Study Team

Figure 4.3.1 Proposed Axle Load of Train

UIC 200kN axle load shall be applied to design the new bridge, track and civil structures.

Chapter 5 Railway Project Plan

5.1 Train Operation

(1) Future Plan of Train Operation

1) Maximum Speed

The maximum speed of the line will be set 100km/h for the whole main line.

2) Speed Restriction

As the section between Taungoo and Mandalay is flat, there will be no speed restriction by slope. In case the speed restriction by curve is inevitable due to topographical conditions, the track layout should be taken care of in such a way that the curve will not affect the travel time as much as possible.

3) Speed Restriction in Stations

For each station, necessary measures including the interlocking of signals and points and safety sidings should be taken so that trains can pass the station without reducing its speed. However, in the large scale of stations, namely Pyinmana Station, Thazi Station and Mandalay Station, to set safety sidings will shorten the effective length of lines and thus the JICA Study Team proposes not to set safety sidings in these stations and to remain the speed restriction as it is.

4) Block System and Block Stations

The Absolute Block System will be adopted between Taungoo and Mandalay as it is today. The current method “Paper Line Clear” shall not be used but the train driver shall secure the block to the next station by the Proceed aspect of the Starter signal.

Among the 7 halt stations, the 5 stations where almost no passengers use are expected to be abolished so that the travel time on that block section will be shorter and the line capacity will not become smaller.

Shanzu Station is also expected to remain a station for passengers. Considering that the distance between Myohaung Station and Mandalay Station is rather short, the JICA Study Team proposes that the Automatic Block System be installed between Myohaung Station and Mandalay Station instead of the Absolute Block System and that Shanzu Station remain as a halt station as it is. This

modification is expected to require less cost compared with the case that Shanzu Station becomes a block station, while the line capacity is almost the same for the two cases.

5) Level Crossing

To keep the safety for the 100 km/h operation, the level crossings inside stations and those located between the Distant signal and the Outer signal are expected to be equipped with level crossing safety equipment as is the same as the design in Detailed Design for Yangon-Mandalay Railway Improvement Project Phase I (YM-D/D(1)). Even for the level crossings between stations, the JICA Study Team will consider to install the level crossing safety equipment on them if power supply is available.

6) Shunting in a Station

Current lay bye lines are expected to be abolished in principle.

7) Automatic Train Protection System

As is the same as Phase 1, the signals where train driver's human errors might cause serious accidents are expected to be equipped with the Automatic Train Protection System. The specifications should be the same as those of Phase 1 so that the on-board equipment installed in Phase 1 is able to be used for the Phase 2 section.

8) Traffic Management

While the OCC Project will install the Operation Control Center System for the section between Yangon Central Station and Pyuntaza Station, the rest of the whole section of Yangon Mandalay Line, including the Phase 1 section between Nyaung le bin Station and Taungoo Station, is expected to be covered by an Operation Control Center System.

As the current radio telecommunication system is improved in this project, train drivers, level crossing gatemen and maintenance staff are expected to communicate with station masters and OCC through a portable radio device in order to contribute to the safety and stable train operation.

9) Passenger Transport

As was planned in Phase 1, a plenty of DEMU cars are to be installed for express trains of Yangon Mandalay Line and also some local type of DEMU cars are to be installed for local trains between Yangon Central Station and Bago Station.

10) Freight Transport

Regarding the freight transport, container transport is expected to increase in the future. However, MR has launched a Public Private Partnership (PPP) project for container transport with industrial and domestic transport companies. In this regard, the container transport is out of scope of this project. However, the track layout of the related stations should be designed in such a way that

container trains will be able to go into and go out of the dry port by the PPP project. Under the PPP project, new dry ports are being constructed at Myitnge Station.

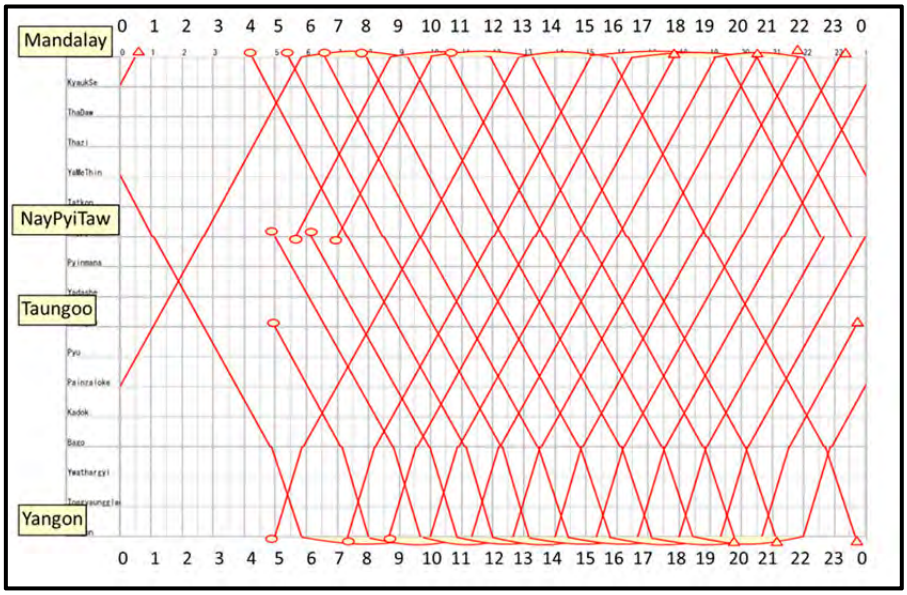
Besides, the development of Myohaung Goods Yard will be an important issue of this project since, a new DEMU depot is expected to be developed in the current goods area by rearranging the facilities in this area.

For other stations, the JICA Study Team will propose the station track layout while considering the current loading and unloading works in the stations.

(2) Number of DEMU Cars to be procured

Regarding the DEMU to be procured in this project, the JICA Study Team proposes to use the same transport plan and thus the same number of DEMU cars proposed in YM-D/D(1) in terms of Express DEMU. Regarding the Local DEMU between Yangon and Bago, it was decided not to procure the rolling stock after the discussion with MR.

Figure 5.1.1 shows an example of the express DEMU operation at the commencement of Phase 2 as the result of YM-D/D(1).



Source: JICA Study Team

Figure 5.1.1 Example of Express DEMU Operation (Proposal by JICA Study Team)

Table 5.1.1 shows the number of vehicles to be required and to be procured in Phase 2.

Table 5.1.1 Number of Vehicles to be Required and Procured in Phase 2 (Proposal by JICA Study Team)

	Number of Vehicles Required	Number of Vehicles Procured in Phase 2
Express DEMU	DEMU (6 cars＋6 cars) × 17 trainsets = 204 cars	180 cars

Source: JICA Study Team

Based on this result, the JICA Study Team discussed with MR regarding the number of rolling stock to be procured and, as is mentioned later, it was concluded that 180 DEMU cars are to be procured.

(3) Draft Station Track Layout

It is necessary to decide the station track layout considering the two points below, while following the various rules of MR.

- Line Capacity

  When there are various types of trains with different speed, there need stations where a fast train passes a slow train. On the other hand, if there are many stations with such a function, expensive facilities including turnouts and complex interlocking systems are required and thus the total project cost will be higher.

- Works at Stations including Shunting Works

  Current loading and unloading works of freight trains including ballast transport and other types of works at each station should be taken into consideration. Also, MR's future plans for freight transport should be considered, if any.

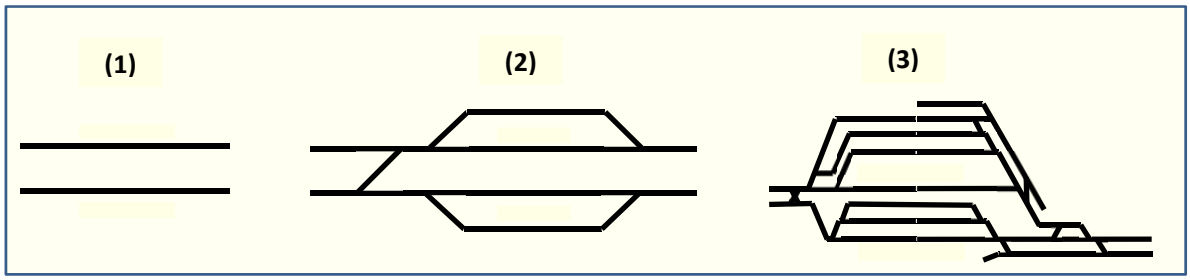
The JICA Study Team visited all the stations to make a survey with the support by MR in this study and developed the draft track layout plan of each station. The outline of the plan is summarized as follows.

The track layouts could be classified into the following three types.

(1) Up and Down main lines only

(2) Up and Down main lines with a few loop lines

(3) Up and Down main lines with lots of loop lines and/or stabling lines



Source: JICA Study Team

Figure 5.1.2 Station Track Layout Classification

For 49 stations, excluding 5 block stations to be abolished and 1 non-block station to be remained from the 55 stations in Phase 2, Table 5.1.2 shows the number of stations of each type of track layout.

Table 5.1.2 Breakdown of Draft Station Track Layouts

Type	No. of Stations	Station Name
(1)	15	-
(2)	28	-
(3)	6	Pyinmana, Naypyitaw, Thazi, Myitnge, Myohaung, Mandalay
Total	49	

Source: JICA Study Team

5.2 Track Alignment

(1) Design Standard for Track Alignment

Table 5.2.1 Design Standard for Track Alignment

Item		Standard	Remarks
Maximum Design Speed	Limited Express	100 km/h	There are DEMU and passenger trains as Limited Express.
	Local, Freight train	70 km/h	
Gauge		1000 mm	
Rail	Main Line, Passing Track	JIS50N	
	Siding, Depot	BS75	
Rolling Stock Gauge		W3000 mm×H4100 mm	
Construction Gauge		W3810 mm×H4300 mm	
Minimum Curve Radius	Main Line	500 m	Exceptional case: Absolute minimum of 160 m at the station
	Along Platform	400 m	Straight in principle
	Depot	100 m	
Transition Curve	Shape	Cubic Parabola	
	Length	L1=400*Cm L2=8.536*Cm*V (7.469*Cm*V) L3=9.603*Cd*V (7.469*Cd*V) Where, Cm : Applied Cant (m) Cd : Cant Deficiency (m) V : Train Speed (km/h)	( ) ; Exceptional case
Maximum Gradient	Main Line	10‰	Desirable 6‰
	Station, Depot, Stabling track	2.5‰ Exceptional case 5‰	Desirable 0‰
Distance between Track Centers (Main Line)		4.42 m	Existing condition
Turnout	Main Line	1:12, 1:10	
	Depot	1:8	

Source: JICA Study Team

(2) Recommendation for Track Alignment

1) Items of Curve Improvement

In this survey, horizontal alignment improvement is examined about the following items.

- Improvement of curve radius for 100km/h operation of DEMU
- Extension of transition curve length for 100km/h operation of DEMU
- Improvement of horizontal alignment before and after bridge, related to bridge relocation plan

The improvement of curve radius and the extension of transition curve length for the 100-km/h operation of DEMU is the target, and 100-km/h operation of the limited express passenger train is not the target of improvement. The improvement of curve radius is to make the curve with radius less than 500m to radius 500m or more, 38 locations in the Up Line and 34 locations in the Down Line are the targets for study. As for the extension of the transition curve length, all the curves are the targets for study, i.e., 159 locations in the Up Line and 167 locations in the Down Line.

As for study of the curve improvement plan, the efficient and realistic plan is examined without land acquisitions and big impact on environmental social consideration. Therefore, in cases where new land acquisition is needed when curve radius is improved to 500m or more, it will be improved to the curve radius as large as possible to fit within ROW.

In addition, the horizontal alignment improvement in this survey targets the main line, and the improvement of station yard is not included.

2) Study Results of Horizontal Alignment Improvement

As the result of the horizontal alignment improvement, as shown in Table 5.2.2, the number of curves with the radius less than 500m is 7 for the Up Line and 6 for the Down Line. The number of curves after improvement decreases because there are places where two adjacent curves are integrated into one curve.

Table 5.2.2 Number of Curves after Alignment Improvement

	Current Conditions		After Improvement	
	Up Line	Down Line	Up Line	Down Line
All Curves	159	167	156	160
800m≦R	83	84	100	109
500m≦R＜800m	38	49	49	45
R＜500m	38	34	7	6

Source: JICA Study Team

3) Curve with Speed Limit

Although enlargement of curve radius and extension of transition curve length are examined in this survey so that 100-km/h operation of DEMU is achieved, there are cases where it is impossible to improve the curves sufficiently due to the topographical reason along the railway and two close curves. As for such a curve, speed limit is set unavoidably, and the efficient and realistic plan is examined without land acquisitions and big impact on environmental social consideration.

The curves with speed limit for DEMU are shown in Table 5.2.3.

Table 5.2.3 Curves with Speed Limit for DEMU

No.	Current Condition	Improvement Plan	Limit Speed (DEMU)
i	U-IP.1 R=349.28m D-IP.1 R=349.28m	R=349.28m, TCL=60m R=349.28m, TCL=60m	75km/h
ii	D-IP.22 R=750m	R=750m, TCL=25m	70km/h
iii	U-IP.26 R=317.53m D-IP.29 R=317.53m	R=350m, TCL=80m R=330m, TCL=65m	85km/h 75km/h
iv	D-IP.98 R=500m	R=1100m, TCL=35m	90km/h
v	D-IP.99 R=500m	R=1100m, TCL=35m	90km/h
vi	D-IP.103 R=582.14m	R=620m, TCL=30m	70km/h
vii	U-IP.124 R=1000m D-IP.131 R=1000m	R=1000m, TCL=15m R=1000m, TCL=15m	70km/h
viii	U-IP.136 R=436.6m	R=436.6m, TCL=70m	90km/h
ix	U-IP.160 R=436.6m D-IP.173 R=436.6m	R=436.6m, TCL=40m R=436.6m, TCL=40m	70km/h
x	U-IP.161 R=582.14m D-IP.174 R=582.14m	R=582.14m, TCL=30m R=582.14m, TCL=30m	70km/h
xi	U-IP.175 R=349.28m D-IP.188 R=300m	R=349.28m, TCL=10m R=300m, TCL=70m	40km/h 75km/h

Source: JICA Study Team

4) Improvement of horizontal alignment before and after bridge, related to bridge relocation plan

In this survey, as for the alignment near the bridge, the alignment improvement plans are studied assuming that the bridge is in the current position. However, in the bridge improvement plan, improvement policies for all the bridges are studied, and the bridge relocation position is proposed for 27 bridges shown in Table 5.2.4. In this survey, as a reference, the alignment improvement plan is studied for all 27 bridges before and after the bridge in accordance with the bridge relocation position.

In the bridge improvement plan, site survey and soundness survey will be conducted for all existing bridges at the detailed design stage, and improvements such as relocation and repair will be finally judged.

Table 5.2.4 List of Bridges to be relocated

Bridge No.	Bridge Length	Bridge No.	Bridge Length
No.306	106.07m	No.684	48.77m
No.351	54.86m	No.691	UP 105.16m, DN 85.34m
No.373	76.20m	No.692	30.48m
No.393	UP 115.82m, DN 126.19m	No.699	UP 52.58m, DN 60.96m
No.453	UP 121.92m, DN 105.16m	No.718	30.48m
No.519	34.14m	No.719	UP 91.44m, DN 95.10m
No.527	48.77m	No.730	UP 30.48m, DN 24.38m
No.529	UP 30.48m, DN 24.38m	No.739	30.48m
No.574	60.96m	No.748	70.10m
No.581	UP 34.90m, DN 36.58m	No.788	24.38m
No.585	30.48m	No.796	18.29m
No.586	36.58m	No.826	207.26m
No.588	UP 36.58m, DN 48.77m	No.830	97.54m
No.683	70.10m	-	-

Source: JICA Study Team

5.3 Track and Roadbed

(1) The recommendations to solve the problems mentioned above and to secure 100km/h train operation are as follows.

- The rail of main line and sub-main line should be changed to JIS 50N rail basically.
- PC sleepers fit for JIS 50N rail should be also replaced current sleepers.
- The turnouts of main line and sub-main line should be changed to # 12 turnouts basically.
- The track maintenance systems should be improved.
- Continuous welded rail (CWR) should be installed for reliable 100km/h train running and improvement of passenger's riding comfort.
- The sub-ballasts should be improved.
- The ballast should be fulfilled in necessary sections. The current status of the quality of ballast should be investigated, and on finding poor quality, the ballast should be changed to MR standard.
- About the railroad crossing, the rubber pad should be installed between main line rail and guardrail. It is proved in Japan railways that the earth, sand and garbage between rails pop out by the repulsion of the rubber on the pushing of wheel flange of train.
- FD clip should be installed in the sections of frequent occurrence of the theft of rail fastening devices.

(2) Recommendation for Improvement of Track and Roadbed

The key factors of the track structure was decided basically same as Yangon-Mandalay Railway improvement project phase-I.

1) Specification and Definition

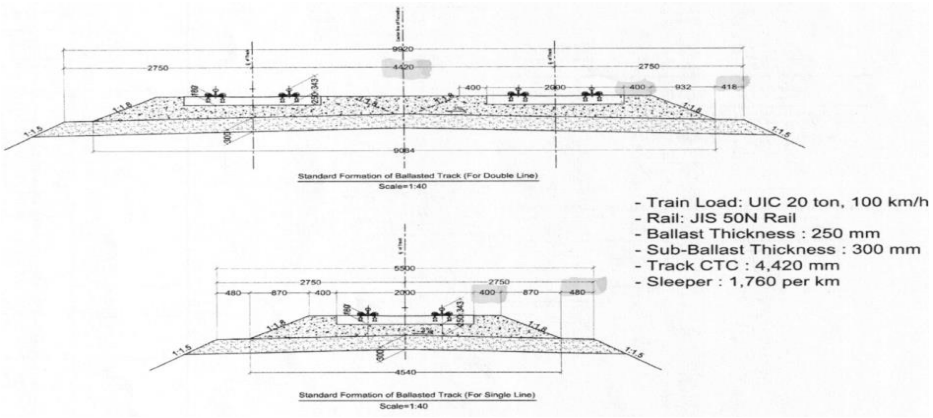
Table 5.3.1 Specification and Definition

Track	Item	Specification and Definition
Track Gauge	Whole line	1,000mm: meter gauge.
Train lord	Whole line	UIC train lord (P=20ton)
Rail	Main line Secondary line and others	JIS 50N Rail : Continuous welded Rail in possible max lengths. BS 75 lbs : Supplied by MR from its rail in storage.
Fastening	Round-bar clip type FD clip type	Supplied by MR, as MR manufactures or buys it. Supplied by MR, after MR buys it.
Ballast	Materials Sectional form	Supplied by MR, as MR buys them. Secure more than 400mm from the end of the sleeper to the shoulder of the ballast, and the incline of the ballast is less than 1:1,8.
PC sleeper	Load of UIC Concrete strength	Axel load 20 tons. Supplied by MR, as MR manufactures them. More than 500kg/cm^2 (50N/mm^2)
Turnout and so on	Main line Side line and others	In No.12 or No.10 high-speed turnout, the train speed at the straight line side is limited to 100 km/h. In the case of No.8, the speed is limited to 90 km/h. No.8 turnout is used and the speed in the yard is 25 km/h. (But in the case of UIC train lord (P=20tons), the speed is limited to 10 km/h.)

Source: JICA Study Team

2) Basic Track Section

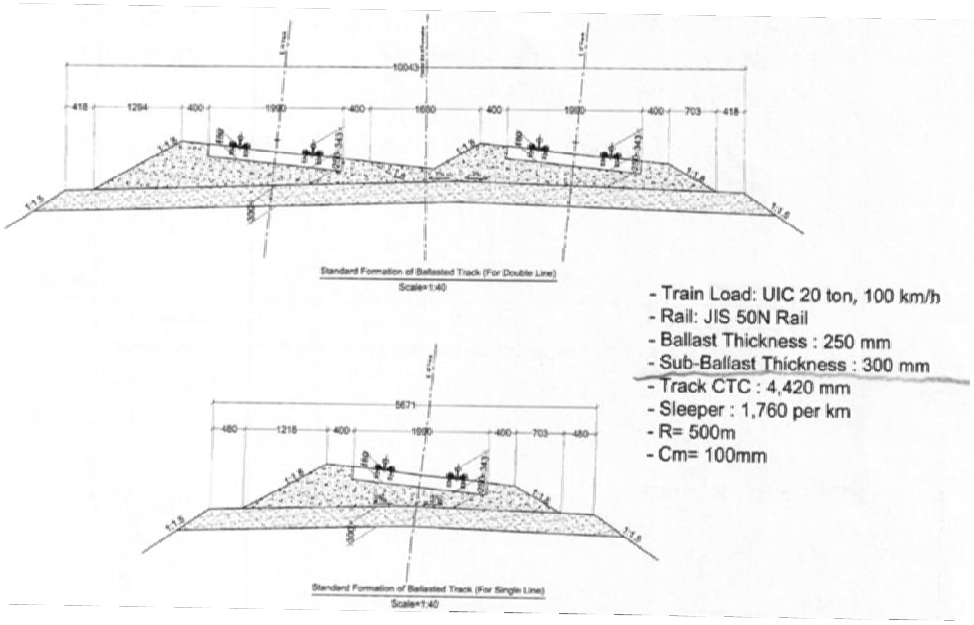
(a) Straight Section



Source: JICA Study Team

Figure 5.3.1 Standard Track Section in Straight Line]

(b) Curve Section



Source: JICA Study Team

Figure 5.3.2 Standard Track Section in Curve Line

5.4 Earth Work

It is important that the required standard cross section, soundness of embankment, stability of ground, etc. against expected train load are secured for the earth structure. In this study, the road bed (sub-ballast) of the earth structure has been completely changed from the FS study (2013: maximum axle load of 17 ton) mainly due to the new maximum axle load of 20 ton (UIC Loading: thickness became 30 cm) that is the target of International Train Operation of AEC (ASEAN Economic Community), and has been the request from the Myanmar Government and MR (Myanma Railways), including securing of the soundness of the embankment, stability of the ground, etc. of the railway facilities in YM Project-Phese 1.

5.4.1 Current Conditions of Earth Work

(1) Existing Embankment Conditions

Embankment age affects strength and stability. Normally for the embankment, the older, the better, while for cut slopes, the older, the worse in strength and stability.

The following Figure 5.4.1 shows existing conditions of Embankment at some locations.

1) Embankment Conditions

(a) Settlement due to soft ground (Mile 82)

(b) Settlement due to soft ground (Mile 146)

(c) Settlement due to erosion by stream (Mile 243)

(d) Settlement due to unstable embankment (Mile 336)

Source: JICA Study Team

Figure 5.4.1 Existing Conditions of Embankment

The following Figure 5.4.2 and Figure 5.4.3 show lack of fill in the embankment and stone pitching to prevent erosion respectively.

Source: JICA Study Team

Figure 5.4.2 Lack of fill in the embankment (Mile 44)

Source: JICA Study Team

Figure 5.4.3 Stone pitching to prevent erosion (Mile 357)

(2) Problems for Safe & High Speed Operation

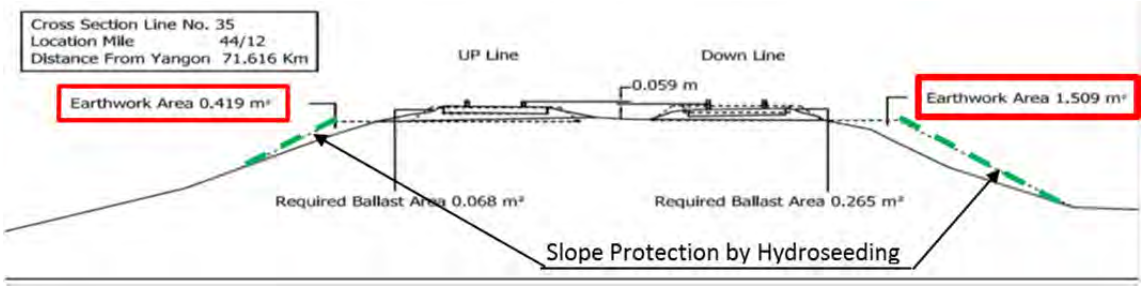
1) Lack of Fill

The first problem is the lack of fill compared to the standard formation, which was agreed between MR and the Study Team.

5.4.2 Recommendation for Earth Work

(1) Earthworks to the Standard Formation

For safe and high-speed railway operation, firstly, embankment dimensions should be kept at least to the standard formation which has been agreed between MR and the JICA Study Team as indicated in Chapter 4. These earthworks, including trimming slope and backfilling, should be carried out prior to other rehabilitation measures, such as stone pitching and preventive pile installation. Also, selected suitable material should be utilized for the backfilling. After completion of backfilling work, slope protection should be provided.



Source: JICA Study Team

Figure 5.4.4 Additional Embankment Work at Mile 44

5.5 Railway Bridges

(1) Current Conditions of Existing Bridges

The existing bridge structures determined to be at risk of either imminent or future problems are described from the perspective of current conditions and problems. The determinations presented in this report are made on the basis of the results of hearings held with Myanma Railways concerned personnel and confirmations through actual visual inspections of aging and time-related deterioration of bridge structures in this site survey.

The structural types listed below are the principal bridge structures that exist along the Taungoo - Mandalay Main Line.

[Superstructure Types]

- Steel Deck Plate Girder
- Steel Through Plate Girder

- Steel Through Truss Girder
- Reinforced Concrete Girder
- Prestressed Concrete Girder

[Substructure Types]

- Brick Pier
- Reinforced Concrete Pier
- Concrete-filled Steel Tubular Pier
- Brick Abutment
- Brick - Wing Wall / Retaining Wall

(2) Improvement Plans of Railway Bridges

Based on the thoughts and ways of the Phase I Stage, for about 70 railway bridges checked by visual inspection in this site survey and other bridges judged by existing documents and past experience, the improvement plans of each bridge have been classified. As a result of a comprehensive judgement, all existing bridges shall be targeted for replacement at the Phase II Stage. The basic policies for each existing structural type are also described below briefly.

1) Steel Through Truss Girders

Although the final judgement will be made based on a further site survey, the portal bracings and the upper lateral bracings of most truss girders are thought not to meet the construction gauge (4,300 mm) in this project. Also, for the truss girders designed using the H.M. live load (an axial load of 17t), it is difficult to assure the continual safety in terms of large-scale improvements and conversions, and to reduce cost, hence, all truss girder bridges shall be replaced as a basic policy.

2) Steel Deck Plate Girders

For the steel deck plate girders designed using the H.M. live load (an axial load of 17t), if the soundness of the superstructures and substructures seems to be comparatively in good condition, maintenance and repair measures can be considered. However, since the existing bridges are much deteriorated, all steel plate girder bridges shall be replaced as a basic policy. In case, the span lengths are relatively short and the cross-section conditions are judged as a channel, box culverts and hume pipes shall be applied considering the future safety (incl. the high-speed running performance), workability and economic performance (incl. the maintenance).

3) Concrete Girders (Unreinforced Substructures)

Despite the steel deck plate girders were replaced with the concrete girders having heavy weight, the old existing brick abutments and piers are being used continuously with no reinforcement. In

case the span lengths are relatively short and the cross-section conditions are judged as a channel, box culverts and hume pipes shall be applied considering the future safety (incl. the high-speed running performance), workability and economic performance (incl. the maintenance).

4) Concrete-Girders (Constructed after 2000)

During the double tracking projects after 2000, some bridges were constructed (e.g. Bridge No.453, No.691). For these bridges, although MR intends to take countermeasures against the settlements of piers due to the low bearing capacity and the damages of piles due to the scour and shoddy workmanship, all bridges shall be targeted for replacement from the point of view that Japan cannot hold responsibility for the safety and reliability for future. JST has obtained the approval for the replacement policy of bridges from MR at the official TAC meeting.

The bridge renewal plans as shown below are based on the concept of Phase I Stage.

i) Box culverts are applied over waterways categorized as channels where the actual bridge length is less than 30 m. The box culverts are planned to be constructed between existing abutments.

ii) Girder bridges are used over waterways categorized as rivers, or over waterways categorized as channels where the actual bridge length is 30 m or more.

iii) For existing bridges with short lengths under 3m, precast Hume pipes or its equivalent shall be used in construction.

5.6 R.O.B

In this site survey, all R.O.Bs between Taungoo Station and Mandalay Station have been checked by visual inspection, and clearances from the rail level to the bottom of road bridges have been measured by laser instruments. As a result of the inspection, it was found that all R.O.Bs meet the standard of the current construction gauge and hence, are not targeted for the improvement and renewal in this project.

5.7 Ancillary Civil Structures (Level Crossing, Fence, etc.)

This section describes the ancillary civil structures such as level crossings, trespass prevention fences, etc.

There are more than 200 official level crossings between Taungoo and Mandalay. Considering the safety for both train operation and road traffic, it is desirable that all official level crossings shall be improved in accordance with its level crossing features such as road traffic volume..

Also, in the current situation in which the train operation speed is not fast, many inhabitants and farmers with livestock enter onto the track freely and walk on the track. Entering into the track will

not be safe due to the increase in train operation speed after the Project. Therefore, the installation of trespass preventing fences will be one issue for safe operation.

5.7.1 Current Conditions of Ancillary Civil Structures

(1) Level Crossings

The number of level crossings (LC) between Taungoo and Mandalay are shown below in Table 5.7.1.

Table 5.7.1 Number of Existing Level Crossings between Taungoo and Mandalay

Type	Nos.
Manned	98
Unmanned	111
Total	209

Source: MR

In addition to the above, there are many illegal (unofficial) level crossings. These level crossings have been naturally formed by inhabitants crossing of the track repeatedly.

1) Manned Level Crossings

The manned level crossings have gates and a gate man closes those gates by hand when trains are passing. Some manned level crossings have a level crossing sign with warning lights

Asphalt or concrete pavement covers the tracks between the guide rails and the outside of the rails. However, there are some holes in the pavement, and these cause obstructions to the smooth flow of road traffic. Also, soil and refuse between and around the tracks before and after level crossings have been compacted by pedestrians. These situations make it difficult to maintain the track.

In addition, when a train approaches a level crossing, the gates are closed by a gate man, however, many motor bikes and people enter the level crossing through the gap in the gate or the fence along the track. The gate man frequently allows it.

Figure 5.7.1 below shows Manned Level Crossings.

(a) Pyinmana LC (225 mile 5-6/24)

(b) Shinte LC (251 mile 4-5/24)

Source: JICA Study Team

Figure 5.7.1 Manned Level Crossings

2) Unmanned Level Crossings

Unmanned level crossings have a level crossing sign without warning lights and no gate.

Figure 5.7.2 below shows Unmanned Level Crossings.

(a) Pyinmana LC (226 mile 11-12/24)

(b) Pyinmana LC (226 mile 11-12/24)

Source: JICA Study Team

Figure 5.7.2 Unmanned Level Crossings

(2) Trespass Prevention Fence

In most of the section between Taungoo and Mandalay, trespass prevention fences are not provided. Therefore, many inhabitants and farmers with livestock enter into the track area freely and walk on the track.

At some stations, fences are set between tracks to prevent passengers from crossing the tracks in order to get to the other platform. Those stations have foot bridges for passengers going to other platforms; however, the pedestrians cross the tracks at the gaps or the end of fences without using the foot bridges.

The brick wall type and chain link type fence used by MR are shown below Figure 5.7.3:

(a) Brick Wall Type Fence

(b) Chain Link Type Fence

Source: JICA Study Team

Figure 5.7.3 Brick Wall Type and Chain Link Type Fence

The tracks are used as passages for local inhabitants and livestock in many places. Currently, the train speed of 30 to 40km/h is slow enough for them to escape. If train speed is increased to 100km/h, there will not be enough time to escape from trains and serious train accidents, such as train derailment, may occur.

In order to avoid such situations, fences to prevent people and livestock from entering into the track ROW should be required.

5.7.2 Recommendation for Ancillary Civil Structures

(1) Level Crossing

Level crossings are planned at places where the frequency of maintenance is higher than at other places, because these are affected by loading, impact and vibration from not only trains but also road traffic. However, the current level crossings are paved over the track structure, such as concrete sleepers and ballast. These situations make it difficult to maintain any damaged or irregular track and, it will hinder safe and high-speed train operation.

Therefore, the level crossing structures shall be modified to allow quick maintenance and so it does not affect the road or rail traffic significantly. Also, access roads to level crossings shall be modified so that road traffic passes smoothly across the level crossings.

When modifying level crossings, basically road width shall be the same as at the present. However, it will be necessary to confirm the compatibility with road planning (urban planning) and to discuss the plans with the relevant road authorities

(2) Trespass Prevention Fence

Since the construction cost is high, MR will construct fences along the main line using its own budget.

(3) Distance Posts

Currently, many countries use the “Kilometre” as the distance unit because it is an international standard. And, “Kilometrage” can indicate accurate locations using one meter units.

The JICA Study Team recommends installing “Kilometre” posts, but still retaining the existing “Mileage” posts. Therefore, we propose to use both the “Kilometrage” system and the “Mileage” system because MR needs a transition period from the old to new systems. The kilometrage posts will be located on the side opposite the mile posts in order to avoid mistaking “Kilometrage” for “Mileage”. And, those locations are where it is easy for drivers on the trains to make visual recognition on the track.

5.8 Signal House and OCC Building

(1) Current condition signal houses and OCC buildings

JST investigated the signal house, OCC building, and the communication equipment huts in the phase 2 section. Signal house is two or three stories by reinforced concrete structure, all buildings have water leakage from roof and wall peeling off, and aging is intense. The OCC room is in the station building in the Naypyitaw station and Mandalay station where the station buildings was rebuilt and in a comfortable environment. There are buildings of communication equipment huts at each station, but damage such as roofs and ceiling is remarkable. Also, many air conditioning facilities in equipment huts is not functioning.

(2) Improvement plan of signal houses and OCC buildings

Along with updating of the signal system, it is necessary to construct a signal house building newly. However, only Naypyidaw Station, existing renovation will be done and used. JST agreed with MR not demolition the existing signal house of each station. The size of the signal house will be three types of 1 story, 2 stories, 3 stories; details need to be coordinated with the signal system experts. For the construction of the signal house, there is a possibility that relocation such as water tanks and warehouses etc.

MR requested to install the OCC room of Taungoo, Thazi and Mandalay in the new signal house. Part of MR Head office will be renovated for general OCC room. The OCC room of the Taungoo and Thazi Station should be study about install inside the station building at the detailed design stage. Because there will be rebuild buildings.

There was a request from MR to install communication equipment in the newly built signal house. For this reason, the current communication equipment huts will not renovation and demolition.

For the level crossing is set up, the huts is installed to protect the level crossing equipment.

5.9 Railway Station

(1) Current conditions of station buildings

JST investigated the current conditions of station buildings in 55 stations, divided according to the size and structure of the station building, and compiled the current situation of aging. And JST compiled the current condition and usage for the rooms and facilities in the station building. As a result of this investigation, there were cracks and breaks in the main structure of 20 stations, and JST reported to MR.

(2) Recommendation for improvement plan of station

Based on the field survey, JST set the following four subjects for improvement and made proposals for each maintenance item to MR.

- Comfort
- Safety
- Gender Free
- Barrier Free

The maintenance items are as follows.

- Civil Structures in Stations (Passenger Platform, Level Crossing, Storm Water Drainage System)
- Slope for Wheelchair
- Warning tile
- Information Guide board
- Lighting system
- Station toilet and shower
- Air conditioning system
- Nap room

(3) Renovation of station building

The repair of the station building was designated from MR to 7 stations of Taungoo, Yedashe, Pyinmana, Yemethin, Thazi, Kyaukse and Myohaung station. As a repair policy, consider the proposed maintenance items and establish the following main facilities.

- Concourse
- Free passage

- Gate
- Ticket Counter
- Lift equipment (Elevator, Escalator, Slope, etc.)
- The stairs
- Toilet for Passenger
- Information board
- Platform (Warning tile, Lighting system)
- Station operation facility (Staff room, Nap room, Equipment rooms)

And based on the passenger demand forecast, set the size of the station and decide the construction site in consultation with the MR. JST is agreeing does not demolition the existing station with MR. Therefore; it must be designed considering existing stations.

JST confirmed that cuts of the platform roof to the construction gauge, is 7 stations to be build. About the necessity of the platform roof cutting due to the construction gauge, deciding of the track level and surveying are necessary.

5.10 Rolling Stock

(1) Preconditions

For the rolling stock plan, preconditions are as follows:

- The infrastructure of the Phase II section of this project will be improved on the same conditions as those of YM-D/D (1),
- The rolling stock of the proposed express type will be operated on the whole line of YM,
- The rolling stock of the proposed local type is to be operated in the local section between Yangon and Bago, and
- The specifications of the rolling stock proposed in this project is to be the same as those of YM-D/D(1), taking the train operation plan of DEMU into consideration.

Considering the train operation plan, the rolling stock proposed in Phase II shall have the same rolling stock specifications as those of YM-D/D (1). In proposing the above items, the JICA Study Team will proceed by the following steps.

In the discussion with MR, it was concluded that MR would procure only the express type of DEMU and that the local type of DEMU would not be procured.

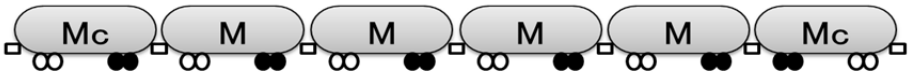
(2) Recommended Plan for Rolling Stock

Four trainsets of the express type have already been proposed in Phase I. Since the rolling stock

planned in this project will be also operated in common with the rolling stock in Phase I which is now under contract negotiation, it is required that its specifications be the same as those of the rolling stock proposed in YM-D/D (1). This will make it possible that train operation will be able to be planned without considering the rolling stock procured in Phase I and that in Phase II. In this section, the JICA Study Team describes the recommended specifications of the rolling stock.

- Trainset and Capacity

  The trainset consists of 6 cars. Two classes of Ordinary class and Upper class are set up, and the two Upper cars are to be sandwiched at the center of the trainset (Figure 5.10.1).

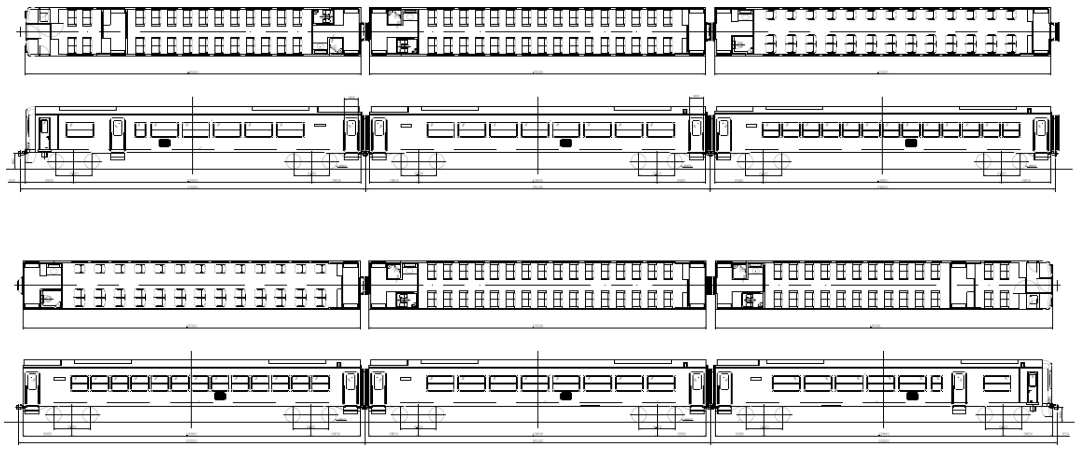


Mc: Motor Car with driver cab
M : Motor Car
○ : Non-motor axle
● : Motor axle
□ : Automatic coupler

Source: JICA Study Team

Figure 5.10.1 Train Configuration

The seat arrangement is shown in Figure 5.10.2 and the passenger capacity is shown in Table 5.10.1.



Source: JICA Study Team

Figure 5.10.2 Seat Arrangement of the Proposed Express Type

Table 5.10.1 Passenger Capacity of Proposed Express Type Rolling Stock

Model	Mc	M	M	M	M	Mc	total
class	O	O	U	U	O	O	-
Capacity	52	64	39	39	64	52	310

* O: Ordinary car, U: Upper car

Source: JICA Study Team

Table 5.10.2 shows the main specifications of the rolling stock. Regarding the radio equipment, it is proposed that the equipment is to be installed in the driver's cab as MR requests, while the rolling stock procured in YM-D/D(1) is not equipped and thus train crews are expected to carry it.

Table 5.10.2 Main Specifications of the Express Type

No	Item	YM-D/D(1) Express type			This case
		Ordinary Class		Upper Class	The same model as YM-D/D (1)
		Motor car with cab (Mc)	Motor car (M)	Motor car (Ms)	
1	Car length	20,000 mm (including couplers)			Left side
2	Car width	2,800 mm			Left side
3	Roof height	3,600 mm			Left side
4	Maximum design speed	110 km/h			Left side
5	Maximum Acceleration	2.0 km/h/s			Left side
6	Maximum deceleration	3.5 km/h/s			Left side
7	Axle load	12.5 t			Left side
8	Drive system	Diesel engine + Generator + Traction motor			Left side
9	Seat	Walkover seat	Walkover seat	Rotating reclining seat	Left side
10	Capacity	52	64	39	Left side
11	Radio equipment	Portable type	None	None	Equipped type

Source: JICA Study Team

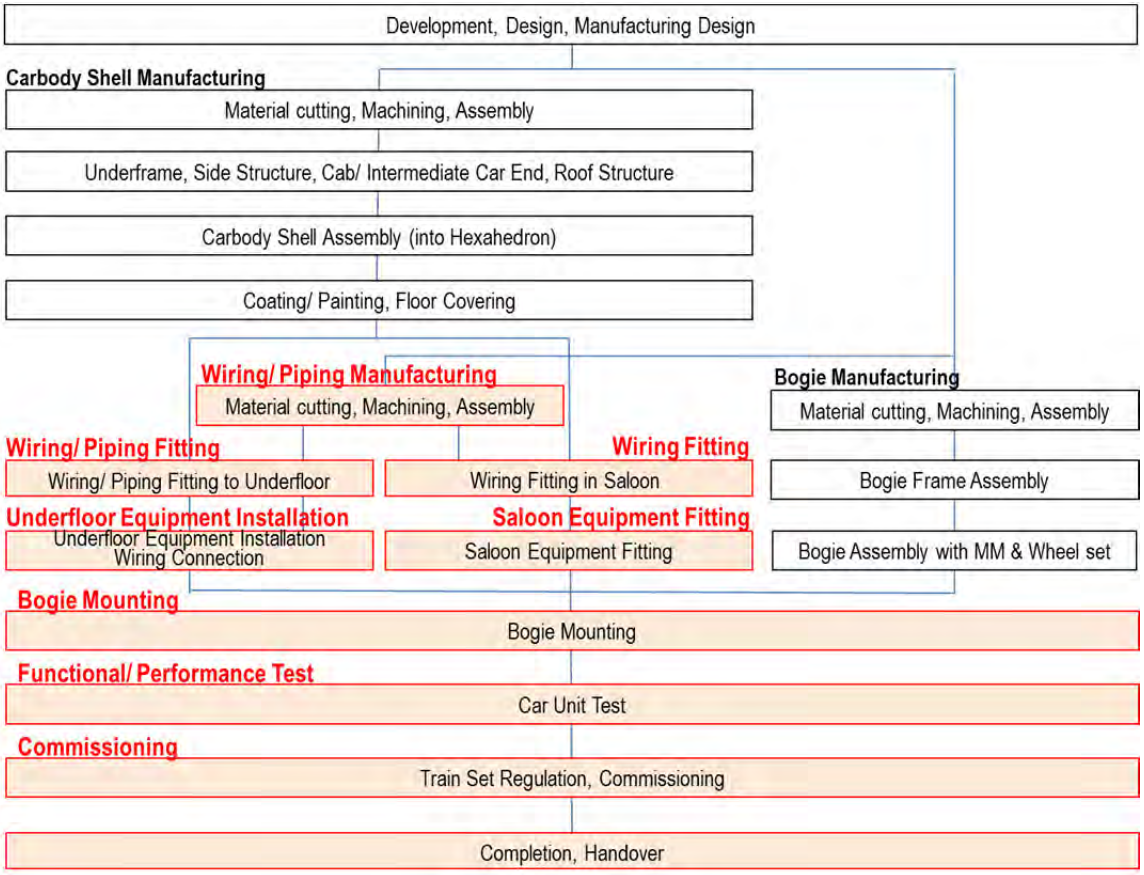
(3) Local Assembly

Regarding the local manufacturing of rolling stock, in "Basic Design Study of the Yangon Circular Railway Line Upgrading Project (YCR-RS/BD)" by JICA, MR requested to study for the local assembly work (part of assembly processes included in the local manufacturing). In that study, the scope of works and the location for the assembly in Myanmar were studied, and its cost was estimated.

On the other hand, this preparatory survey started without a local assembly plan, but the study for local assembly was added to the original study because MR strongly requested the local assembly where MR themselves will assemble for some cars to be purchased in case MR would purchase lots of DEMU cars.

1) Scope of Works

The scope of works is the same as that of JICA YCR-RS/BD.



Source: JICA Study Team

Figure 5.10.3 Reconfirmed and Determined Scope of Works (Cells with Orange Hatching)

2) Location

The location for the local assembly is New Naypyitaw Locomotive Factory, same as "Basic Design Study of the Yangon Circular Railway Line Upgrading Project" by JICA.

3) Facility

Facilities are expected to be installed as additional facilities before the implementation of the local assembly works as shown in Table 5.10.3.

Table 5.10.3 Additional Facilities List to be Expected

Shop	Facility	
	Name (Specification)	Quantity
General Assembly Workshop, Steel Frame Workshop	Movable lifting table for heavy weight (5t)	1
	Working platform	8
	Temporary bogie	2
Weighing room	Portable wheel load measuring equipment	1

Source: JICA Study Team

4) Work Schedule

Work schedule was planned based on the experiences of the JICA Study Team and rolling stock manufacturer, while considering that this will be the first project for MR and thus adequate training and supervising should be required.

5) Overall Schedule

The JICA Study Team studied the local assembly for three cases, 30 cars, 60 cars and 90 cars. and the period necessary for the technology transfer education.

(4) Procurement Schedule for Rolling Stock

After it was decided not to implement the local assembly, there was a discussion regarding the rolling stock procurement and it was concluded that MR would procure 180 Express DEMU cars. And then, the hearing survey of the manufacturing capacity to several Japanese manufacturers during this project period was conducted. As a result of this survey, it was found that it takes 36 months for handover of the 1st trainset from Notice to Proceed, and required interval time for handover after the handover of the 1st trainset is 1 month/trainset (6 cars). Therefore, the rolling stock procurement schedule will be completer by May ,2025.

However, MR insisted that the procurement be completed by December 2024. Japan side finally accepted MR's proposal with ealy procurement of rolling stock.

5.11 Depot

Ywathagyi Depot/Workshop that will be constructed in Yangon-Mandalay Railway Improvement Project Phase I has all required functions when maintenances are conducted. However, it is necessary that "inspection", "repair", and "preparation" for rolling stock maintenance shall be planned under the condition that other depots are used because the operation section on Yangon-Mandalay Railway (YM) is the long distance. The required inspection capability in this project calculated under conditions (operation plan, target of rolling stock, number of rolling stock, maintenance period, required time for maintenance, and work condition) is shown in Table 5.11.1.

Table 5.11.1 Required Inspection Capability of Depot in Phase I

Type	Number	Kilometric performance	Type of Inspection	Required capacity
YM Express DEMU	34	950 km/day	Monthly Inspection	1.133 train-sets/day
			Daily Inspection	16.581 train-sets/day
			Wheel re-profiling	0.533 train-sets/day

Source: JICA Study Team

From the above calculation, each depot plan with assumption of YM operation is shown in Table 5.11.2.

Table 5.11.2 Recommendation of Depot Equipment Plan

Facility	Ywathagyi	Taungoo	Naypyitaw	Mandalay
Inspection track for Light repair	3	0	0	3 (only Daily Inspection)
Inspection track for Unscheduled repair	1	0	0	1
Track for Wheel re-profiling	1	0	0	0
Tack for Preparation	2	0	2	2
Track for fueling	2	0	2	2
Track for supplying water	2	0	2	2

Source: JICA Study Team

(1) Ywathagyi Depot/Workshop

Ywathagyi Depot/Workshop is one of the bases for train operation because this depot is near Yangon Station that is the terminal station of YM. Therefore, it is recommended that all required facilities be installed.

(2) Taungoo Area

According to the operation plan, only one train (2 train-sets) will be stabled in Taungoo area. However, new facilities should not be installed, due to specifications of the train considering long distance operation. Therefore, it is recommended that new facilities not be installed in Taungoo area.

(3) Naypyitaw Area

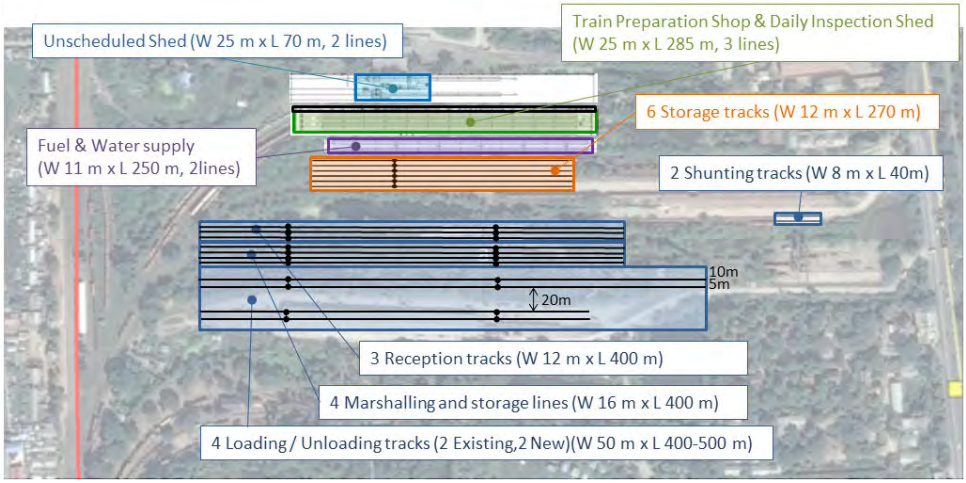
It is recommended that the depot be prepared for DEMU operation as a base because many trains will be stabled. However, from the viewpoint of reducing the project cost, facilities for inspection and repairing should be concentrated at Ywathagyi or Mandalay area, and facilities for required work before train operation should be installed at Naypyitaw. Moreover, to reduce the construction cost, Naypyitaw Depot for DEMU will be established by utilizing the existing Depot. Facilities will be constructed or installed based on Table 5.11.2. The plan of Naypyitaw Depot for DEMU is shown in Figure 5.11.1.

Source: Google Earth, JICA Study Team

Figure 5.11.1 Image of Naypyitaw Depot for DEMU

(4) Mandalay Area

The new depot in Mandalay area is an important base, as well as Ywathagyi Depot/Workshop because Mandalay Station is the terminal station of YM. However, the depot in Mandalay area shall have the role to assist Ywathagyi Depot/Workshop because all facilities will be installed at Ywathagyi Depot/Workshop in Phase I. On the other hand, this new depot will be established by redeveloping the facilities for not only rolling stock maintenance but also freight trains at Myohaung Station. The existing depot at Myohaung Station will be integrated into New Mandalay Depot because the existing depot will be redeveloped in order to create the space for new facilities. The plan of New Mandalay Depot is shown in Figure 5.11.2.



Source: Google Earth, JICA Study Team

Figure 5.11.2 Image of New Mandalay Depot

In this plan, it is necessary to develop the construction plan not to affect MR's operation because existing facilities in Myohaung Freight Station will be removed.

5.12 SIGNALLING

(1) Improvement Plan

1) Basic Policy

The signalling system required in Phase II should work for more than 20 years with proper maintenance after the completion of this project. Common specifications will be adopted for the easiness of the maintenance based on MR's request.

The signal equipment room is to be constructed by the architecture contractor. The civil contractor is expected to install the earth retaining for signalling equipment concurrently.

In Phase I, the level crossings to be equipped with safety equipment where those located near stations, including the section between Distant signal and Outer signal. The same policy is adopted in Phase II. Also, based on MR's request, the level crossings located between stations but with heavy road traffic, such as the crossings with Yangon Mandalay National Highway, are expected to be equipped with the safety equipment.

2) Shortening of Construction Period

Station track alignment is designed based on the train operation plan. If two small stations are designed with same alignment in designing such station track alignment, as a relay interlocking device will be installed for such small stations, it is possible to design, manufacture and test the signalling system of these two stations in the same method, and thus the overall construction period can be shorten. On the contrary, even if the station track alignment of one station is different from the other station slightly, design, manufacture and testing will be different, which will make the construction period longer. To design the same station track alignment with same routes will enable the design, manufacturing and testing period to be shorter, as far as it does not interfere with the future train operation.

3) Improvement Plan for Each Subsystem

(a) Interlocking System

As is mentioned above, the criteria to choose an electronic interlocking or a relay interlocking device is the number of signal routes of the station. The switches and indicators for the block system are supposed to be allocated on the interlocking control panel.

An electronic interlocking device will be installed at important stations with many number of signal routes. The electronic interlocking device shall be designed and manufactured based on the fail-safe principle. The interlocking control panel will be installed at each station as the station master controls the signal route at each station. The interlocking system is classified into electronic interlocking and relay interlocking based on the number of signal routes by the same criteria in Phase I as follows:

- Large station (31 routes or more): Electronic interlocking system
- Small station (30 routes or less): Relay interlocking system

The electronic interlocking system called Solid State Interlocking (SSI) made by Ansaldo India has been working for five years in Naypyitaw Station. However, it will be more advantageous for consideration of difficulty, such as replacement of point machines accompanying the conversion of 50N rail, increasing the electric power supply system and modification for an interface with other equipment, and cost of modification the signaling system of Naypyitaw station in the future.

(b) Block System

i) Absolute Block System (AB)

Since only one train allows to be occupied between stations on Yangon Mandalay Line, the Absolute Block System (hereinafter AB) which secures the block automatically between stations will be installed. The AB secures the block between stations while the block devices installed at both stations of the block section cooperate with each other. The AB should secure the safety of the block section by interlocking with the Starter signal.

ii) Automatic Block System (ABS)

Shanzu Station is the halt station between Myohaung Station and Mandalay Station, which does not have a block function. Appling the Automatic Block system (hereinafter ABS) for this section, this scheme does not require operation staff at Shanzu Station. Also as the distance of the ABS is not so long, this scheme is advantageous in terms of the project cost. For these reasons, to install the ABS on this section is examined.

(c) Signals

Wayside signals will be installed for the whole section of Yangon Mandalay Line. The wayside signal is used on the existing line and it is not necessary to change the system even under the condition of 100 km/h operation. The color light signal and the line light signal are adopted for main signals.

For the signalling system of Yangon Mandalay Line, the wayside signalling system based on the General Rules for Myanma Railways (first January 1948) will be adopted. The wayside signal will be of color light type with 2 or 3 aspects. The shunting signal will be of line light type, which is basically installed for each route. In case of setting one common signal for plural routes, a route indicator will be appended to the signal.

The signal lamp will be the LED type lamp. The failure of the lamp can be detected, and each lamp should be changeable one by one.

(d) Point Machine

In this project, rails will be replaced for high speed operation as well as turnouts. The point machines in the interlocking area will also be replaced to an electric point machine or a lever with electric lock. The electric point machine for the main line will be equipped with locking detection mechanism.

(e) Train Detection System (Track Circuit)

The train detection system is a very important system as it is the bases of the signalling system such as block and interlocking. There are some types of train detection method. DC track circuit is a suitable system for Yangon Mandalay Line as the system is easy to construct an uninterruptible system by battery backup, considering the electric power situation. Current track circuits are mainly the DC track circuit and there is no technical problem for the maintenance of the DC track circuit.

(f) Automatic Train Protection System

This project will contribute the increase in train frequency and train speed. High speed operation will make the damage by train accidents such as collision accidents much more serious. Therefore, an Automatic Train Protection (ATP) system will be introduced. The DEMU procured in this project will be equipped with the ATP on-board system. The current locomotives owned by MR will also be equipped with the ATP on-board system in Phase I.

The priority of the place that the ATP is installed depends on passenger's safety. In this sense, Outer signals and Starter signals are the most prioritized. Shunting signals will not be equipped with the ATP except those where human errors will cause the collision accident with a train on the main line.

Regarding onboard equipment, MR requested it for 30 locomotives. In Phase I, it was decided that onboard equipment for 50 locomotives will be procured in Contract Package 105. As the bidding procedure of this package will be expected in 2018, the onboard equipment for 30 locomotives is to be added to this package in Phase I.

(g) Power Supply System

Regarding the current situation of power supply, power interruption frequently occurs in Yangon, Naypyitaw and Mandalay. In terms of the quality, the voltage of the supplied electricity is usually below 200V at the terminal of consumer. The power supply system for signalling is expected to be installed for the purpose of supplying stable electric power in such a current electric power situation, even for the stations where electric power supply is not supplied from the commercial electric power company today.

The electric power to the telecommunication, level crossing and TMS will be provided from the signal power distribution board through the circuit breaker switch on the board.

(h) Cable and Transmission Line

The cable for information and the power supply line will be installed between the signal equipment room and signal devices in the station yard. Cables are also required to be installed between two adjacent stations and the signal devices installed between stations. The current signalling cables are directly buried under the ground. Such a buried type of cable has poor construction workability and poor flex resistance. Therefore, in the large scale of station where huge amounts of cables are required, it is recommended to lay the cable of the main line in the trough or duct considering the construction convenience.

(i) Level Crossing Safety System

The level crossing is the place where the possibility of train accidents is the highest in train operation. Therefore, it is important to secure the safety both for the railway side and for the road traffic side by installing safety equipment including warning devices and closing gates to road traffic in order to give warning of the train approaching to pedestrians and car drivers. Since MR's current operation work at the level crossing relies on human attentiveness, it is most likely that the number of level crossing accidents will increase when the frequency and speed of trains increase after the completion of this project. Therefore, the countermeasures of improving the safety level of level crossings should be studied.

MR requested that the level crossing between stations with heavy road traffic be equipped with level crossing safety equipment. In case such a level crossing can receive electric power, the automation by the level crossing safety equipment will be examined.

In Phase I, the level crossing gate operation was designed in such a way that the gateman is to close the gate by pushing the control switch. However, after pedestrians and car drivers recognize the 100 km/h train operation and become aware of the safety at the level crossing, it will be convenient and safer that closing the gate is controlled automatically. For this reason, the selection switch to select the automatic gate closing and the manual gate closing will be installed.

i) Level Crossings with Safety Equipment

The level crossing safety equipment will be installed at the following level crossings.

- Level crossings in the station yard (maned and un-maned)
- Intermediate level crossings between Distant signal and Outer signal (managed by Civil Department)
- Intermediate level crossing between stations which has heavy road traffic (managed by Civil Department)

ii) List of Level Crossings to be renewed

Table 5.12.1 shows the list of the level crossings to be renewed.

There are 102 level crossings officially managed by MR between Taungoo and Mandalay, while 3 level crossings near Taungoo Station which will be improved in Phase I are excluded. As Table 5.12.1 shows, 79 level crossings out of 102 are to be equipped with the level crossing safety equipment. Regarding the 23 rest level crossings, as the traffic volume on the road is small; gatemen will close and open the gates without such safety equipment as they do at present, taking the cost of the system into consideration.

Table 5.12.1 List of Level Crossing to be Renewed

Division (5)
List Of Level Crossing For Internal Area Of Division (5)

Power Distribution by POWER / SIGNAL

Measured by Map only

NSBI : Not Special But Important

No	St.No	Station from	Station to	Mileage from	Mileage to	Gateman	Department	Class	Distance from SMO (m)	Width (m)	Length (m)
1		TAUNGOO	KYEDAW	166/22	23	MAN	CIVIL	SPECIAL		7	~
2				167/9	10	MAN	CIVIL	SPECIAL		9	~
3	39	KYEDAW		171/13	14	from ST	OPERATING		110	6	33
4	40	KYUNGON		175/6	7	from ST	OPERATING		272	6	15.5
	41	KAYTUMADI		–	–	–	–	–			
5	42	YEDASHE		182/21	22	from ST	OPERATING		451	5	14
6				183/9	10	MAN	OPERATING		262	7	17.5
7		YEDASHE	KONGYI	184/13	14	MAN	CIVIL	NSBI		23.5	
8	43	KONGYI		186/22	23	from ST	OPERATING		349	4.5	11
9	44	SWA		191/5	6	from ST	OPERATING		322	4	19
10	45	THARGAYA		195/15	16	from ST	OPERATING		280	4	12.5
	46	THARYARGON		–	–	–	–	–			
11	47	MYOHLA		201/8	9	from ST	OPERATING		272	11.5	18
12	48	YENI		206/2	3	from ST	OPERATING		436	6	16
13				206/14	15	from ST	OPERATING		358	6	14
14	49	TAWUTI		209/3	4	MAN	CIVIL		1200	9	12
15				210/2	3	from ST	OPERATING		243	7	19.5
16		TAWUTI	HTEININN	210/23	24	MAN	CIVIL	NSBI		9	17.5
	50	HTEININN		–	–	–	–	–			
17		HTEININN	ELA	214/20	21	MAN	CIVIL	SPECIAL		22.5	23
18	51	ELA		216/7	8	from ST	OPERATING		292	5	13.5
	52	PYAYWUN		–	–	–	–	–			
19				224/16	17	MAN	OPERATING		596	9	22
20				225/5	6	MAN	OPERATING		346	10	18.5
21	53	PYINMANA		225/8		MAN	OPERATING		516	10	16.5
22				225/9	10	MAN	OPERATING		576	7	18
23				225/22	23	MAN	CIVIL		1450	17	16
24		PYINMANA	YWADAW	227/2	3	MAN	CIVIL	SPECIAL		74.5	12
25		PYINMANA	YWADAW	228/18	19	MAN	CIVIL	NSBI		48	15.5
26	54	YWADAW		229/18	19	from ST	OPERATING		334	4	10.5
27	55	NAYPYITAW		233/21	22	MAN	OPERATING		1650	7	13
28	56	KYIDAUNGKAN		234/23	24	from ST			281	8	24
29				235/7	8	from ST	OPERATING		259	4	17
30		KYIDAUNGKAN	PYOKKWE	236/17	18	MAN	CIVIL	SPECIAL		26	13
31	57	PYOKKWE		240/2	3	from ST	OPERATING		356	8	12.5
	58	SINBYUGYUN		–	–	–	–	–			
	59	SHWEMYO		–	–	–	–	–			
32	60	SINTHE		250/24	251/1	from ST			89	5	20
33				251/16	17	MAN	CIVIL		1150	10	10
34				253/2	3	from ST	OPERATING		366	6	11
35	61	TATKON		253/11	12	from ST	OPERATING		267	5	26
36				253/21	22	MAN	CIVIL		928	6	14
	62	MAGYIBIN		–	–	–	–	–			
37		MAGYIBIN	NYAUNGLUN	259/12	13	MAN	CIVIL	NSBI		12	37
38	63	NYAUNGLUN		(261/3)	(4)	from ST	OPERATING		276	4	15
39				261/14		from ST	OPERATING		430	5	15
40	64	HNGETTHAIK		267/15	16	from ST	OPERATING		395	10	21
	65	INGON		–	–	–	–	–			
41	66	YAMETHIN		274/14	15	from ST	OPERATING		380	8	15
42				274/17	18	from ST	OPERATING		607	7	15.5
43				275/4	5	MAN	CIVIL		1310	6	22
44		YAMETHIN	INGYINKAN	276/21	22	MAN	CIVIL	NSBI		13	46
	67	INGYINKAN		–	–	–	–	–			
	68	SHWEDA		–	–	–	–	–			
45		SHWEDA	PYAWBWE	284/11	12	MAN	CIVIL	NSBI		14	63
46	69	PYAWBWE		287/12	13	from ST	OPERATING		268	14	17
	70	SHANYWA		–	–	–	–	–			

Division (4)
List of Level Crossing For Internal Area Of Division (4)

Power Distribution by POWER / SIGNAL

Measured by Map only

NSBI : Not Special But Important

No	St.No	Station		Mileage		Gateman	Department	Class	Distance from SMO	Width	Length
		from	to	from	to				(m)	(m)	(m)
47	71	NYAUNGYAN		299/4	5	from ST	OPERATING		262	4	18
	72	NWATO		–	–	–	–	–			
48	73	THAZI		305/12	13	MAN	OPERATING		485	15	27.5

Division (3)
List of Level Crossing For Internal Area Of Division (3)

Power Distribution by POWER / SIGNAL

Measured by Map only

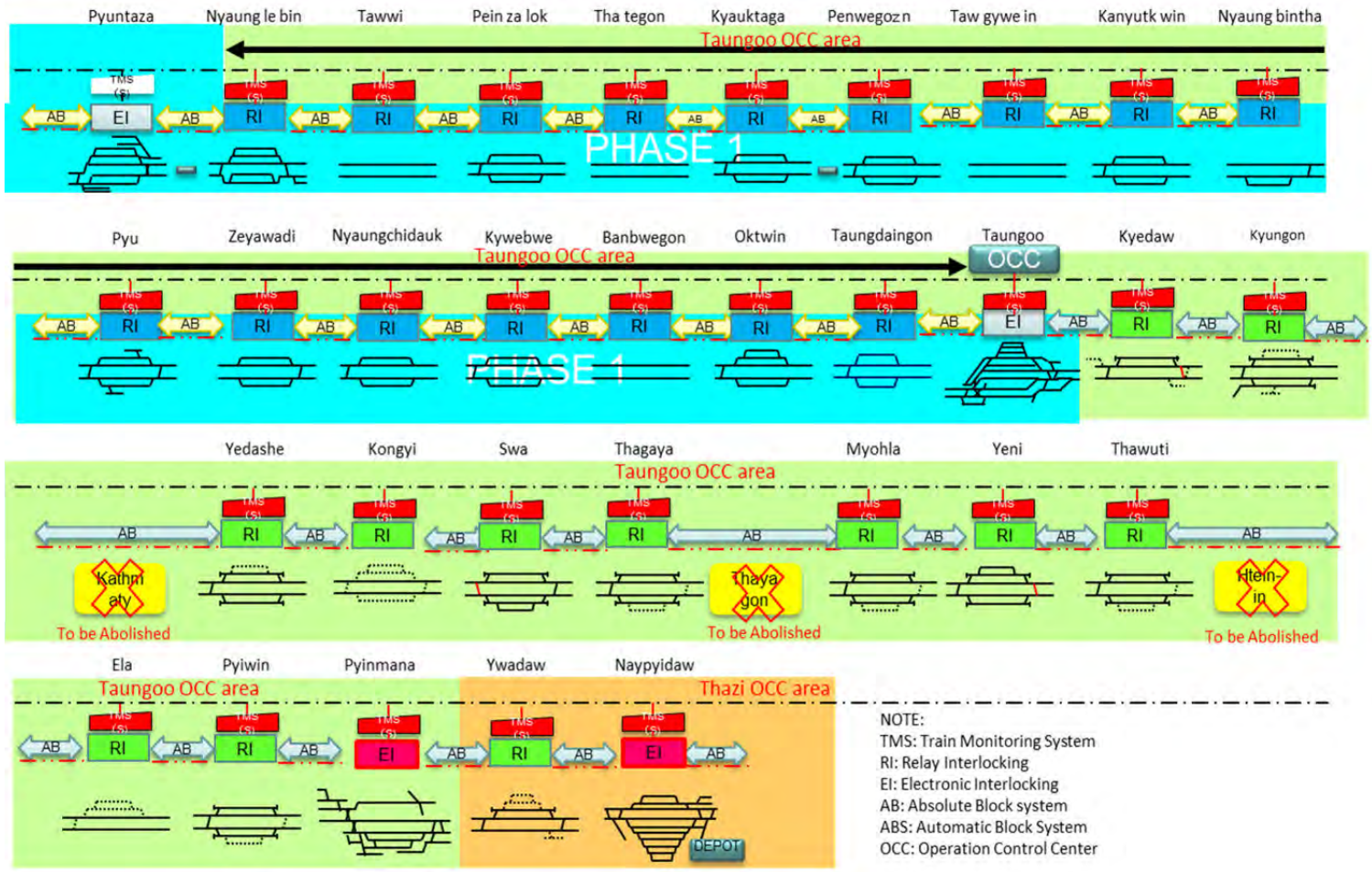
NSBI : Not Special But Important

No	St.No	Station		Mileage		Gateman	Department	Class	Distance from SMO	Width	Length
		from	to	from	to				(m)	(m)	(m)
49	75	HANZA		315/11	12	from ST	Operating		289	4	20
	76	DAHATTAW		–	–	–	–	–			
50	77	THEDAW		322/6	7	from ST	Operating		344	8	26
51	78	KHINBAN		325/24	326/1	UNMAN			423	5	15
52				326/7	8	UNMAN			865	5	15
53	79	SAMON		328/18	19	from ST	Operating		282	4	13
	80	ODOKKON		–	–	–	–	–			
54	81	THABYETAUNG		336/10	11	from ST	Operating		248	4	13
55	82	KUMELAN		341/7	8	from ST	Operating		256	20	14.5
56	83	MYITTHAR		346/10	11	from ST	Civil		970	4	13.5
57				346/18	19	from ST	Operating		309	7	13
58	84	MINZU		352/3	4	from ST	Operating		348	5	13
59	85	KYAUKSE		358/8	9	Man	Civil		1030	10	12
60				358/21	22	from ST	Operating		284	11	14
61				359/4	5	from ST	Operating		153	16	27
62				359/17	18	Man	Civil		1100	10	14.5
63	86	BELIN		363/2	3	from ST	Operating		319	4	12
64	87	SINGAING		368/10	11	Man	Civil		781	10	13
65				368/20	21	from ST	Operating		265	4	12
66		SINGAING	PALEIK	371/14	15	Man	Civil	NSBI		10.5	18
67	88	PALEIK		374/3	4	from ST	Operating		356	14	25
68	89	MYITNGE		376/7	8	Man	Civil		1230	21	16
69				376/20	21	from ST	Operating		426	4	13
70				377/20	21	from ST			1130	4	12
71	90	TAGUNDAING		379/13	14	Man	Civil		998	10	16
72				380/18	19	Man	Civil		888	36	12
73		TAGUNDAING	MYOHAUNG	381/3	4	Man	Civil	NSBI		9	12
	91	MYOHAUNG		–	–	–	–	–			
74	92	SHANZU		383/18	19	Man	Civil	Special	25	10	12
75		SHANZU	MANDALAY	384/10	11	Man	Civil	Special	339	15	16
76				384/13	14	Man	Civil	Special	164	15	13
77				384/15	16	Man	Civil	Special	–	20	11
78				384/17	18	Man	Civil	Special	180	14	12
79				384/21	22	Man	Civil	Special	364	14	13
	93	MANDALAY		–	–	–	–	–			

Source: JICA Study Team

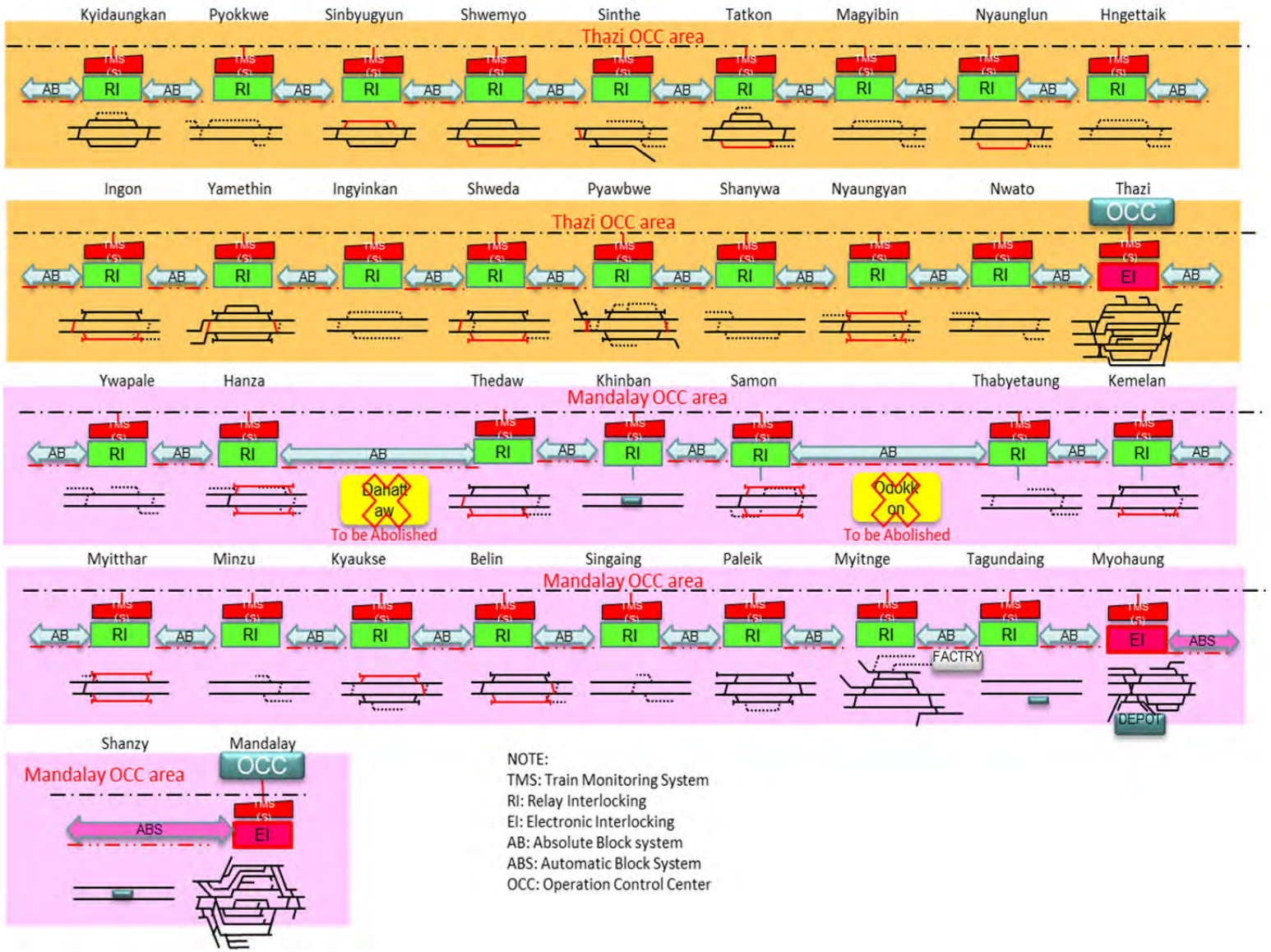
4) Diagram for Improvement Plan of the Signalling System

The improvement plan of the signaling system in Phase II section is shown in Figure 5.12.1 (excluding Phase I section between Pyuntaza and Taungoo) and Figure 5.12.2.



Source: JICA Study Team

Figure 5.12.1 Improvement Plan for Signalling System between Pyuntaza and Naypyitaw



Source: JICA Study Team

Figure 5.12.2 Improvement Plan for Signalling System between Kyidaungkan and Mandalay

5.13 Telecommunication

(1) Scope of Project

1) The area of this project is from Pyuntaza Station to Mandalay Station.

2) The scope of this project is the improvement of radio telecommunication system. The improvement of the existing main OFC telecommunication line, transmission system (SDH system, STM-1,4, etc.), the OFC phone system, power supply equipment for the existing transmission equipment and the High Frequency (HF) radio telecommunication system are outside of this project.

3) The Optical Fiber Cable (OFC) and its related equipment are not included in this project.

(2) Improvement Plan of Radio Telecommunication System

1) System Configuration

The JICA Study Team proposes the new radio telecommunication system for MR. It uses the existing UHF radio frequency band (450MHz band). The OCC and repeater station radio system is connected with the existing OFC line through the IP interface device in the existing telecommunication equipment room. The existing radio equipment is expected to be replaced with new radio equipment and the potable type device is to be installed for the train driver. It will be possible to communicate between OCC and the train driver and between the station master and the train driver directly. The specifications will be basically the same as those in Phase I.

The structure of the new radio telecommunication (UHF) system is shown in Figure 5.13.1 .

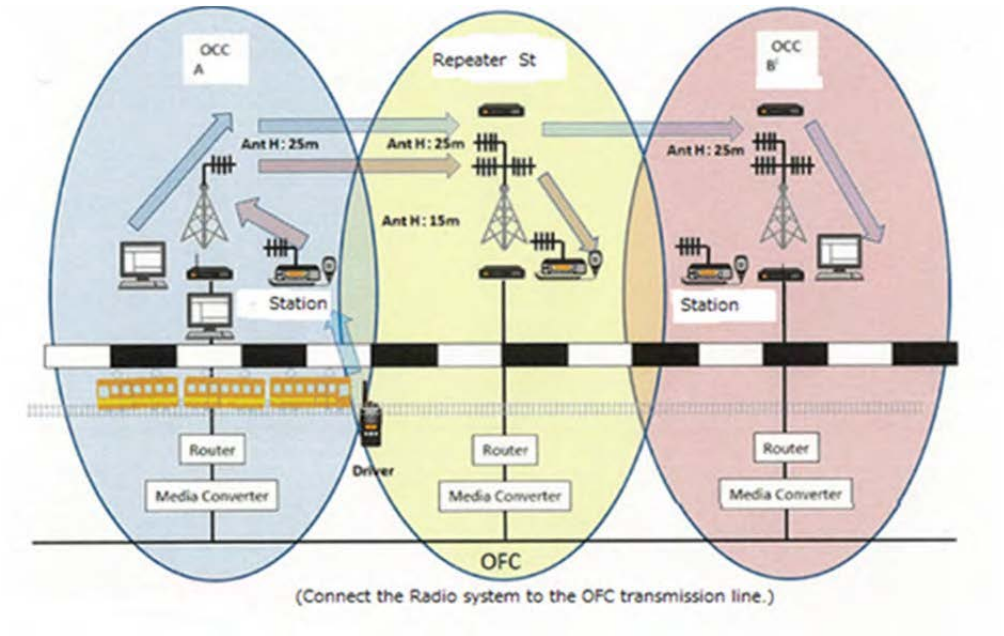


Figure 5.13.1 View of Radio Telecommunication System

2) Available Communication

a) Communication between OCC and OCC

b) Communication between OCC and station master

c) Communication between OCC and train driver

d) Communication between Station master and station master

e) Communication between station master and level crossing gateman

f) Communication between station master and maintenance man.

g) Communication between maintenance man and maintenance man

5.14 Train Monitoring System

(1) Basic Policy

This preparatory survey covers the section of 353.3 km from Taungoo Station to Mandalay Station. The supervising area of Mandalay Operation Control Center (OCC) is from Ywapale Station to Mandalay Station. The supervising area of Thazi OCC covers from Ywadaw Station to Thazi Station and that of Taungoo OCC covers from Nyaung le bin Station to Pyinmana Station. Regarding the Train Monitoring System (hereinafter TMS), the section to be provided in Phase II is from Nyaung le bin Station to Mandalay Station, corresponding to the supervising area of these three existing OCCs.

This signalling system is supposed to work for more than 20 years with proper maintenance after the completion of this project. Common specification policy should be adopted for the overall section to take easy maintenance based on the request of MR.

(2) Basic Function

The information of train detection, signal, switch, etc. is outputted to the TMS I/F from the interlocking system using relay contact at each station. The relay information from the TMS station device is transmitted to the TMS server in the OCC through the data transmission line using optical fiber cable. The train number is inputted from the TMS terminal at OCC and this train number shifts with the train movement. Train operation information in the TMS management area will be displayed on a large display in the OCC room. The train operation information will also be displayed on the Train Information Display (TID) in the station master room or the signal control room. The dispatch telephone which enables OCC staff to talk with each station will be installed. TMS has train diagram management function i.e. which creates the planned train diagram (train time table database) and records the actual train operation record. The train diagram creation function of TMS is expected to prepare train time table data for the whole Yangon-Mandalay Line. The device which exchanges the TMS information with adjacent OCC

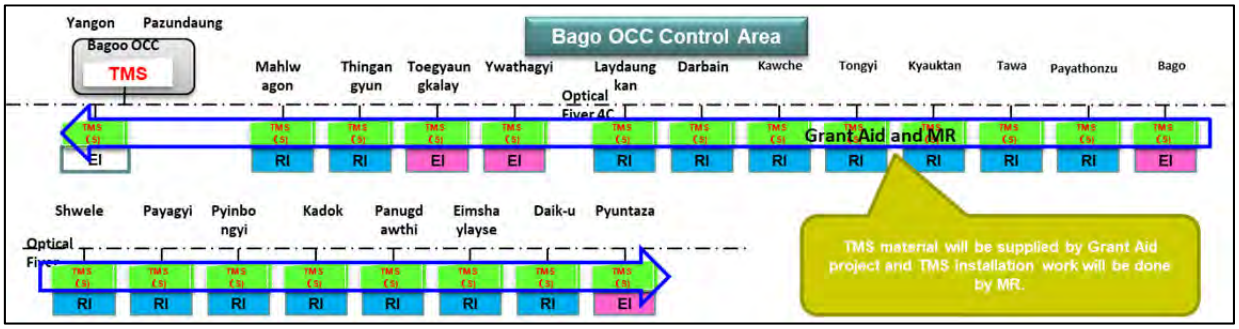
including train description number, train departing information from the adjacent station, etc. is supposed to be installed at the OCC boarder station of Pyuntaza.

(3) Improvement Plan

Yangon-Mandalay Line is managed by four OCCs and one general OCC shown as below.

- Bago OCC (Yangon Station to Pyuntaza Station)
- Taungoo OCC (Nyaung le bin Station to Pyinmana Station)
- Thazi OCC (Ywadaw Station to Thazi Station)
- Mandalay OCC (Ywapale Station to Mandalay Station)
- Naypyitaw General OCC managing the whole Yangon-Mandalay Line

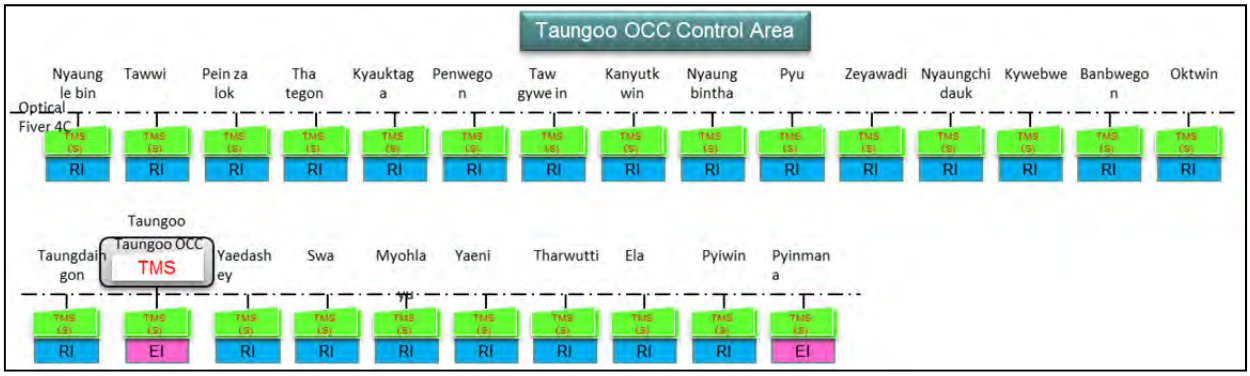
Taungoo OCC supervision area where new TMS system is to be installed consists of two sections; one is the section between Kyedaw Station and Pyinmana Station where new interlocking systems are expected to be installed in Phase II project, and the other is the section between Nyaung le bin Station and Taungoo Station where renovation is to be carried out in the Phase I project.



Source: JICA Study Team

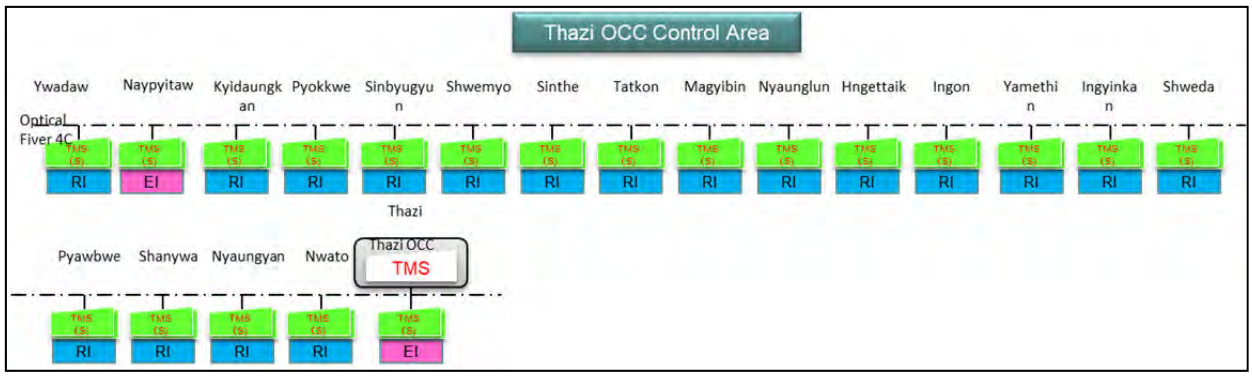
Figure 5.14.1 OCC Control Area (a) Bago OCC

Train Monitoring System for Taungoo OCC, Thazi OCC and Mandalay OCC is to be newly installed in Phase II. The configuration of TMS for each OCC is shown in the following figures.



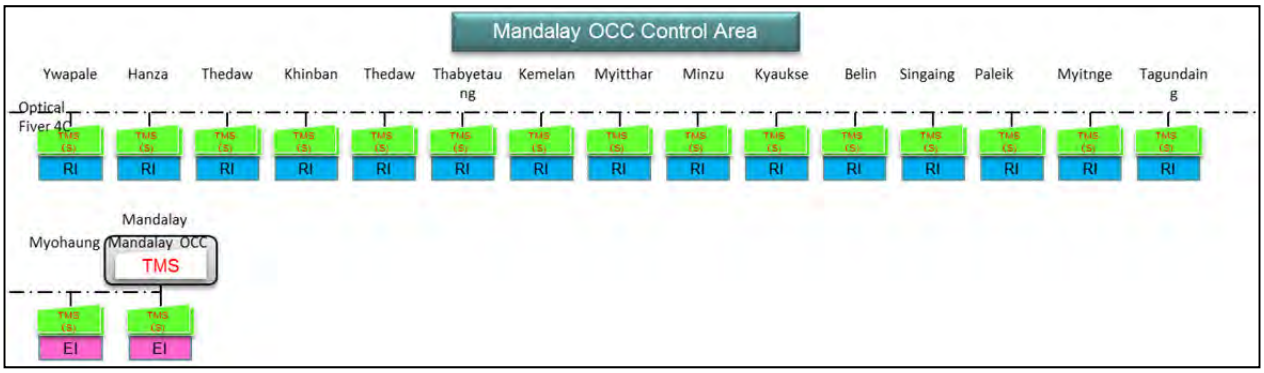
Source: JICA Study Team

Figure 5.14.2 OCC Control Area (b) Taungoo OCC



Source: JICA Study Team

Figure 5.14.3 OCC Control Area (c) Thazi OCC



Source: JICA Study Team

Figure 5.14.4 OCC Control Area (d) Mandalay OCC

TMS monitors the train operation of the supervising area of the exiting OCC. TMS consists of the station equipment in each station and the central equipment and displays in each OCC.

(4) Renovation Plan for Signalling System

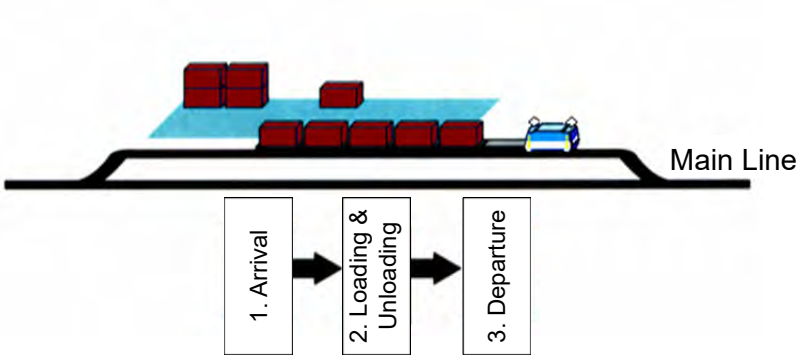
The renovation plan for the signalling system including TMS is mentioned in the Signaling System section.

5.15 Railway Freight Transport Plan

This survey focuses on how to plan railway freight transportation between Yangon (including Thilawa district) and Mandalay, therefore, the JICA Study Team proposes a recommendation on the railway freight transportation base plan between Taungoo and Mandalay.

(1) Express Freight Train between Yangon and Mandalay

The JICA Study Team recommends increasing the express freight trains between the Yangon area and Myohaung Station stopping at the main stations on the way (Bago Station, Taungoo Station, a station in Naypyitaw district, and Thazi Station), and without shunting freight wagons to handle cargos at each station, thus to operate the express freight trains by train unit which stop only at main stations (hereinafter called "express freight trains"). At each station on the way, the facilities with arrival and departure functions are to be developed on the cargo handling track.



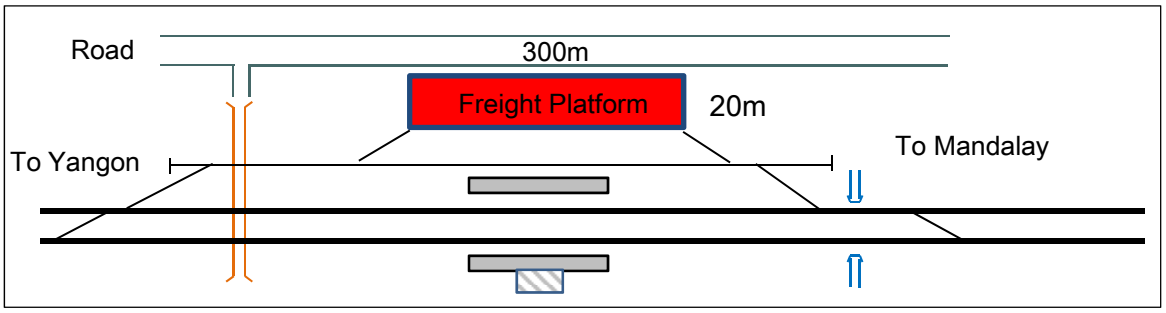
Source: JICA Study Team

Figure 5.15.1 Example of Arrival and Departure Track with Cargo Handling (Japan)

1) Naypyitaw District (Ywadaw Station)

In the Naypyitaw district, although there is not much demand for railway freight transport at present, along with the development of infrastructure by national policy, it is anticipated that demand for construction materials (aggregate for concrete, reinforcing bars, road construction materials, etc) will increase.

The space between the high standard roads on the west side of the station is suitable for a cargo handling platform. Cargo handling is made possible by constructing a cargo handling platform (300m long by 20m width) using the most outside stabling line as a loop line and also by preparing an access road between the tracks.



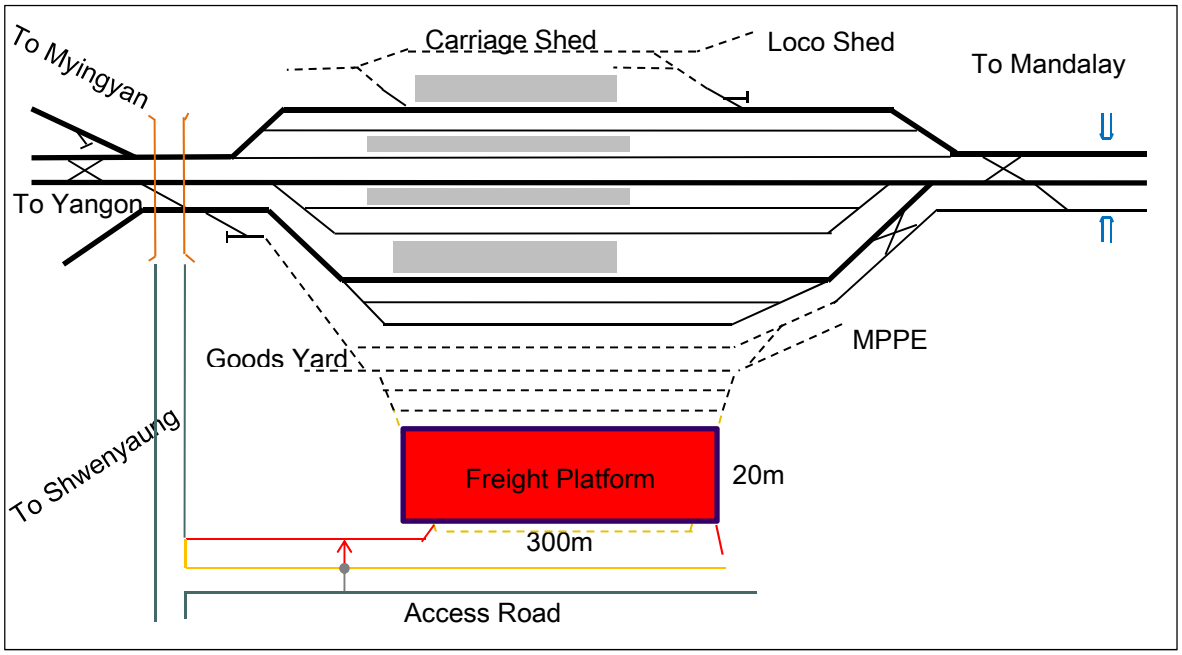
Source: JICA Study Team

Figure 5.15.2 Ywadaw Station Development Plan

2) Thazi Station

The surrounding area is agricultural land where farm products such as dairy products and fruits are produced. It is expected that transportation time will be shortened by shifting the railway to Yangon, a large consuming area, and also low temperature transport can be introduced by introducing refrigerated containers, etc.

By renovation of the station, that is, by removing 5 stabling lines on the east side of the station (securing the fuel transport terminal, shunting function into branch lines section and the storage function of wagons which are waiting for inspection in the train depot) and by construction of a cargo handling platform, it becomes possible to greatly increase the cargo handling volume. For large vehicles to enter and for handling future containers, it is necessary to improve the surrounding environment such as by widening the current 4m wide roads. As for this, further discussion with MR should be continued.



Source: JICA Study Team

Figure 5.15.3 Thazi Station Development Plan

3) Mandalay District (Myohaung Station)

Myohaung Station is a railway transport hub for general cargos in the Mandalay area, and it is also a relay point for freights to Myitkyina and China. Regarding the development of cargo handling facilities as described below, in order to conduct this development, the DEMU depot development plan is necessary and also the coordination with the Central Business District (CBD) plan around Myohaung Station is required.

- Loading/unloading track: 4 lines (track length: 400m to 500m)

  The 1st Area and the 2nd Area (military cargo handled in the third area is excluded) is to be consolidated. Currently, the high platform floor (2 cargo handling lines) in the 1st Area is left unchanged.

  A new flat platform (two loading/unloading lines) is to be constructed on the northern side, and the space between the existing platform and new platform is to be paved. In addition, these two loading/unloading lines are provided with reception function (departure and arrival).

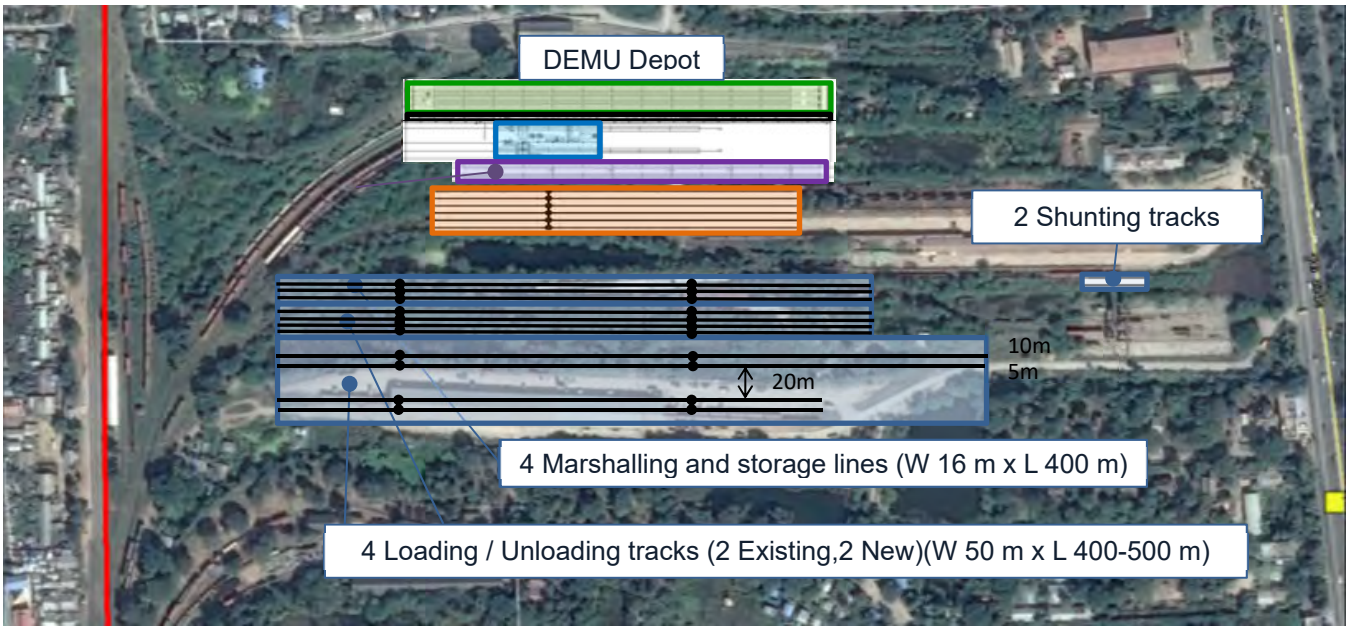
- Marshalling and storage tracks: 4 lines (track length 400m)

  For the purpose of the inspection of trains, these lines also have a tentative trains storage function for the section to the DEMU depot.

  These lines have a tentative trains storage function for relay trains heading from the southern part of Yangon to the northern part of Myitkyina

- Reception tracks: 3 lines (track length 400m)

  This line has car arrival and departure functions.



Source: JICA Study Team

Figure 5.15.4 Myohaung Station Development Plan

(2) Direct (non-stop) Oil Train

In preparation for the future demand for petroleum products, in conjunction with the current transportation by water on the Myitnge River (Tributary of the Ayeyarwardy River), it is recommendable to operate a direct, non-stop, oil specific train from Thilawa Port by developing a petroleum terminal in the Mandalay area. However, since there is no concrete plan for the development of a petroleum terminal at this time, in this project, special consideration will not be given to the arrangement of lines in the station and others.

(3) International Marine Container Trains

Currently, at the dry port development site in Myitnge Station, ground levelling is being carried out with the aim of opening in April, 2018. In the meantime, from August, 2017, KLN and RGL started the provisional operation of container trains between Yangon (Wadan Station) and Paleik Station.

In this project, the track layout and the signalling system of Myitnge Station will be planned in this project in such a way that effective train operation will be possible in this station for the shunting to/from the workshop nearby and the dry ports.

5.16 Power Supply

In this project, new power supply systems will be installed to supply necessary power for the railway improvement and modernization work of Yangon Mandalay Line.

Phase II work will be planned as follows;

- Improving the power supply systems for the signal and telecommunication equipment between Taungoo and Mandalay, and
- Installing the power supply systems for the new depot near Naypyitaw Station and the freight yard in Myohaung Station.

(1) Summary

- Receiving high voltage power as the voltage is relatively stable.
- In order to suppress voltage fluctuation at the location of the loads, using a three-phase four-wire transformer equipped with On Load Tap Changer (OLTC). An OLTC adjusts the voltage by automatically changing the winding ratio of the transformer. However, the capacity of the load is small at a level crossing. Therefore, an automatic voltage regulator (AVR) is to be used for a transformer not equipped with OLTC (for convenience, referred to as non-on-road tap changer: NLTC).
- For blackout and intense voltage drop, installing emergency generator (EG) as a backup system.
- In the jurisdiction of ESE and MESC, the transformer with capacity less than 1,000 kVA will be basically connected to the 11 kV transmission line. However, if there is no 11 kV transmission line near the load, a 33 kVA power receiving device shall be installed at the location.
- In Myanmar, power supply facilities of Power Suppliers are now being improved day by day. In the survey of power supply, not only current facilities but also the plan of improvement of Power Supplier's facilities in the near future should be confirmed.
- A product called SAC cable (Spaced Aerial Cable: SAC) is planned for the overhead transmission line from a power source to a load.
- The station will receive power from the distribution board installed in the signal equipment room. As for the telecommunication equipment, two (2) lines in the distribution board are planned to be provided, one is for the telecommunication equipment room and the other is for the station office.
- The level crossings between stations are planned to receive power from the commercial power and the generator like 50 stations. The lighting and the outlet for charging the transceiver will be installed in the gateman hut.
- In case of Pyinmana, Naypyitaw and Thazi station, the existing incoming transmission line from the Power Supplier shall be improved because the line capacity is not insufficient.
- For the signalling equipment from Myohaung Station to Mandalay Station, the Automatic Block System is planned to be installed. Since the distance between these stations is as

short as 5 km, a substation or HT lines like Phase I are not planned to be installed. Separate high voltage transformers are planned to be installed for supplying power to the signal equipment.

(2) Relevant Power Suppliers and Connecting Points to the Grids

- The power supply for the section between Taungoo and Mandalay is expected by the two power companies, Electricity Supply Enterprise (ESE) and Mandalay Electricity Supply Corporation (MESC). Under each public corporation there is a branch office. These companies have divisions in their organization chart. Township Engineers or Town Engineers are located in each division to manage power supply. Table 5.16.1 shows the detail information.
- For the detailed design and construction for this project, the coordination with such power suppliers will be quite important.

Table 5.16.1 Related Power Suppliers

No.	Corporation	Division	Township Engineer	Number of locations
1-1	ESE	Bago	Taungoo	3
1-2			Kaytumadi	1
1-3			Yedashe	3
1-4			Swa	1
1-5			Thargaya	1
1-6			Myolha	1
1-7			Yeni	1
2-1		Naypyitaw	Tawuti	2
2-2			Ela	3
2-3			Pyinmana	1
2-4			Pobbathiri	8
2-5			Tatkon	6
3-1	MESC	Mandalay	Yamethin	6
3-2			Pyawbwe	3
3-3			Thazi	5
3-4			Wantwin	3
3-5			Kume	2
3-6			Myitthar	1
3-7			Kyause	2
3-8			Singaing	2
3-9			Paleik	2
3-10			Amarapura	2
3-11			Pyikyi Takun	1
3-12			Chan Mya Tharse	2
3-13			Ma Har Aung Myay	1
3-14			Chan Aye Thazan	1

5.17 Station and Terminal Development Plan

(1) Planning

It is recognized that an improvement plan of convenience for railway passenger is important for increasing a number of it in the Project. It includes a development in front of a station and intermodal facilities among railway network and buses at major stations. According to "Urban Development Plan for Mandalay 2040" in "Proposal of Urban Development Plan for Regional Cities - Mandalay, Pathein and Mawlamyine-", "New CBD Development Project" is planned beside Myohaung station. The Station is expected as an entrance of the Project area. So, two stations as Mandalay station and Myohaung station, are assumed as having a potential for station and terminal development in the Survey which are expected a lot of passengers. Issues in current situation are pointed out mainly from a viewpoint of Barrier-Free, an improvement policy is proposed from a viewpoint of Transit Oriented Development or TOD and Universal Design. A plan for Myohaung station is proposed as expected in the Project, but a policy for Mandalay station is proposed as long term project without the Project.

In the Study focusing on bus, which influences a size of intermodal facilities and access road. A demarcation among other facilities as Mandalay station and existing bus terminals and trunk road network are assumed. Alternative plans of location of rail over foot bridge or an access road are prepared, and a plan of On Bridge Station and a station plaza/ access road in eastern side is proposed

- Approx. 10,500 m^2
- Bus berth; 2 cars
- Others; taxi, private car, bicycle

5.18 Passenger Service

(1) Current Conditions of Passenger Service

Until now, mainly two projects have been implemented for passenger service in Myanma Railways (MR). Through these projects and ongoing technical cooperation projects, the JICA Study Team analysed the present condition of passenger service in MR.

(2) Recommendation for Improvement Plan of Passenger Service

1) Required Level of Passenger Service

The JICA Study Team focused on Ticket Reservation System and Passenger Information System.

2) Ticket Reservation System (TRS)

The Ticket Reservation System is essential for modern railway, especially to maximize of the effect of this project.

(a) Proposal for Ticket Reservation System of MR

The system should be composed like a Japanese bus reservation system, and consumer use facilities and network like tablets should be used for cost reduction.

Also fare calculation and connecting fares cause of complicating the system in Japan. These factors should be simplified. For this purpose, the system will be specialized to issue, change, and refund the reservation tickets.

Proposed specifications are as follows:

- Operating Hours: 24 hours
- Numbers of trains: 13 Express trains per a day for each direction, total 26 trains per day
- Number of stations to install the system: 7 or 9
- Seats per train:
  Ordinary class 232 seats, Upper class 78 seats, total 310 seats (6 cars train set)
  Ordinary class 464 seats, Upper class 156 seats, total 620 seats (combined to 12 cars)
- Advance sale: 1 month in advance for general passenger/3 months in advance for group travel
- Number of system terminals: 2 terminals per station
- Location of server: In Japan or in Myanmar
- Terminal: PCs or tablets (for consumer use)
- Access line: Wired or wireless (LTE) consumer Internet access lines (Capable for future extension)
- Internet Reservation

According to the specifications above, the system will provide the reservation or the cancellation of the reservation seats of total 26 trains, from/to 7 or 9 stations. Seat selection from the seat map will be also available.

A ticketing printer of the system will issue the tickets between 2 stations among the 7 or 9 stations. As the current ticket of MR, fare ticket and reserved seat ticket will be combined. The fare will be charged per a train, and change/refund the ticket will be available.

Since the IC cards and two-dimensional bar code tickets have become widespread, magnetic coded tickets will not be handled. But unique two-dimensional bar code will be printed on each ticket. By reading the barcode by the system, change or cancellation of the seat will be easily handled. Bar code will be also useful for ticket inspection in the future. Both Myanmar and English are available to operate the system and issue the tickets.

(b) Internet Reservation System

It is preferable that customers can purchase the train ticket outside the station, via smartphone or PC. In this sense, Internet Reservation System is recommendable, and will be included in the scope of this project.

A payment subsystem should be installed as a part of the reservation system.

The system should be extendable to these functions also in the future: automatic ticket vending machine and spread the system to nationwide MR lines.

3) Passenger Information System (PIS)

At Yangon Station and Mandalay Station which are extremely important terminal stations from the viewpoint of passenger service, JST would propose to develop the system that provides train departure and arrival information as well as station information in real time.

Supposed specifications are as follows:

- At the concourse: show 6 trains (train type, train number, departure time, destination, platform track number, and remarks)
- At the platform: show 2 trains (train type, number, departure time, destination, platform track number and remarks)
- Station information such as train service status and advertisement will be also scrolled.
- The system should be stand-alone, therefore no connections with interlocking devices or TMS. Take all the control from the terminal of station office.
- Basically, Liquid Crystal Display (LCD) for indoor use, LED for outdoor use to install.

These facilities will be installed in

- Yangon Station: 2 for long distance trains in concourse, 2 for suburban trains in concourse, 4 for platform.
- Mandalay Station: 2 in concourse and 3 in platform.

Daily operation of the system shall be specified by MR.

An operator enters train information into the system. Then, when one train leaves the station, station staff will be able to display the information of the next train easily.

5.19 Construction Basic Plan

(1) Existing Conditions

ICA study team has conducted site survey about access , existing condition along the rail way between Tangoo station and Mandalay station.

By the considering with that survey result, Study of construction schedule outline, Construction basic plan has been made.

The followings are showing existing conditions of between Tangoo station and Mandalay station.

- the most sections are embankment section, and cut section are small.
- Away from main track road.
- Weeds and trees are clustered up to near railway or even in railway area.
- the volume of ballast is insufficient in most sections, and the sides of PC sleepers are exposed.
- the width of embankment body that supports the track is insufficient.
- the existing road access to and along railway are not suitable for the construction road.

(2) Study of the outline of construction schedule

The construction work in double track section will be carried out on single track operation section in this project, and its length will be around 30km.

JICA study team has studied and explained MR the outline of construction schedule as model case where between Nyaungyan station and Dahattaw station section which is 30km in length.

(3) General Construction Basic Plan

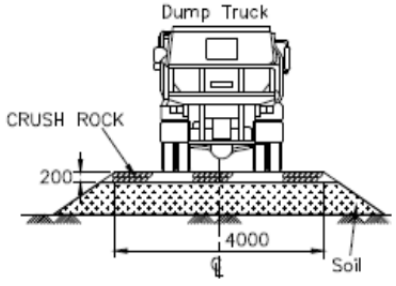
Based on study of the outline of the construction schedule and site survey, JICA study team carried out a temporary road plan for construction and a construction depot plan.

1) Temporary Road for Construction

Since it is necessary to transport a large amount of equipment/material at the same time, temporary road for Construction shall be required.

The JICA study team has planned that location and necessary length and calculated its cost. And then Jica study team has explained it to MR.

The following sketches are showing the typical sketch of temporary road for construction、



Source: JICA Study Team

Figure 5.16.1 Typical Sketch of Temporary Road

Temporary Road Length is shown in Table 5.19.1.

Table 5.16.1 Temporary Road Length (by each section)

Section	Length (km)	Remark
CP101	25.81	One side only
CP102	19.29	One side only
CP103	79.60	One side only
CP104	28.79	One side only
Total	153.49	

Chapter 6 Examine measures to reduce the project cost and shorten the project period

6.1 The comparison between Organized Mechanization Standard Method and Large-Scale Mechanization Method

Table 6.1.1 Comprehensive Summary of the Comparison between Organized Mechanization Standard Method and Large-Scale Mechanization Method

Comparison Items	Organized Mechanization Standard Method	Large-Scale Mechanization Method
Possibility of Shortening Working Period ➢ Working Speed ➢ Working Period (for 350 km) (including civil works) *The working speed of track works is limited to the working speed of civil works.	330 m/day 30 months (2 years 6 months)	800 m/day 24 months (2 years)
Cost	4.62 billion Yen	5.77 billion Yen
Possibility of Participation of Japanese Companies. ➢ Professional Engineer ➢ Constructor, Firm	Acceptable Acceptable	Acceptable (Professional engineer is necessary to stay at working site.) Acceptable
Application of the Machines to Other Projects after the Works of this Project.	Possible to be used all the machines in other projects, including MTT.	➢ It is possible to use MTT and Track Laying Machine for Mandalay~Myitkyina (700km) project. ➢ It may be possible to use Ballast & Roadbed Renewal Machine Mandalay~Myitkyina (700km) project. Detail discussion with MR is necessary.
Maintenance of Machines.	MTT experience has been Accumulated in MR.	➢ MTT experience has been Accumulated in MR. ➢ For the operation of Roadbed & Ballast Renewal Machines and Track Renewal Machines, expert engineer is necessary to stay at site.
Matters to be studied	It is necessary to study how to shorten the working period of both track works and civil works. Especially civil works are the crucial key for shortening total working period, as it precedes track works.	➢ The engineering design and production period of Roadbed & Ballast Renewal Machines is said to be 2~2.5 years. The negotiation with manufacturer to shorten the period is necessary. ➢ The Roadbed & Ballast Renewal Machines have been used mainly in Europe, and the experience of the machines is limited in other areas.

Comparison Items	Organized Mechanization Standard Method	Large-Scale Mechanization Method
		➢ It is necessary to confirm at the manufacturer if it is possible to make Roadbed & Ballast Renewal Machines in MR conditions, which are axel load, gauge and construction gauge, etc. ➢ It is necessary to study the frequency of machine troubles and the cost of repair. ➢ Price negotiation.

Source: JICA Study Team

6.2 Conclusion and Issues

Large- Scale Mechanization Method takes 2 to 2.5 years for designing and manufacturing. Therefore, it is so much difficult to use Large-Scale Mechanization Method with targeting in short period of 3.5 years.

So, Phase II construction work will be conducted by the standard mechanization method which introduces a part of machineries.

Issues to be studied are that careful attention should be paid especially designing and manufacturing period on the machines of Large-Scale Mechanization Method. And also, if the method is expected to be given priority, shortening of the period of the engineering design and the manufacturing the machines should be negotiated closely with the manufacturer from the beginning.

Furthermore, prior investigation should be payed whether this kind of method is a common or not in Japan, Asia or other areas.

Chapter 7 Operation and Maintenance

7.1 Institutional Arrangement for Operation and Maintenance (O&M)

7.1.1 General

The required time of limited express trains in YM will be shortened from 15 hr to 8 hr. The scheduled speed of the train will be from 40 km/hr to 78 km/hr and the maximum speed will be 100 km/hr. Similarly, the maximum speed of the freight trains will become up to 70 km/hr. To speed up train operations, the number of train operations in YM will increase. Particularly, in order to keep a safe and comfortable train operation, the maintenance and management of tracks and rolling stocks should be an important aspect.

7.1.2 Organization

(1) Operation and Administration of Railway in Myanmar

The organizational set up of MR is based on departmental system headed by the Managing Director. Its system consists of six major departments, namely: Operating; Mechanical and Electrical Engineering; Civil Engineering; commercial; planning and Administration; and Finance. The other supporting departments are: Supply; Medical; and Inspection. The railway operation system is divided into 11 divisions which are further grouped into two local organizations (Upper Region and Lower Region).

(2) Maintenance of Rolling Stock

Maintenance of the rolling stocks is conducted at the three main workshops, i.e., INSEI, YWATAUNG, and MYITNGE. A general manager is stationed at INSEI. INSEI is a major workshop near Yangon, equipped with large-scale inspection and repair facilities for locomotives. INSEI workshop carries out the overhaul of diesel locomotive. YWATAUNG workshop is a major diesel locomotive workshop near Mandalay, equipped with a railway technical training center. MYITNGE workshop is a major construction and repairing workshop for the carriages and wagons near Mandalay.

(3) Role of Division

For the O&M of YM, there are five divisions, i.e., 11, 4, 5, 6, and 7. Same as the head office, the organization of each division constitutes the Operating, Mechanical & Electrical Engineering,

Civil Engineering, Commercial, Planning & Administration, and Finance. Track and civil engineers account for the majority of staff of the divisions. Civil engineering facilities include tracks, bridges, and embankment structures, among others, and track works is the important issue in terms of the maintenance of civil engineering facilities.

(4) O&M Organization for the Future Civil Engineering Facilities

In order to secure the train operation safety, MR should completely change its maintenance plan from breakdown maintenance to periodic maintenance. For this purpose, the new O&M plan requires the introduction of the track inspection car to inspect track irregularity and extraction in advance of the section of track irregularity that requires repair. The O&M organizational set up of the future civil engineering facilities is based on the current organization of MR for the following reasons:

- Division 7 of Yangon and Division 11 of Mandalay are located at the regions of big cities, while divisions 4, 5, and 6 are established at the regional central city. O&M of MR is divided into a total of five divisions, and has been operating so far.
- The scope and responsibilities of the manager at each division are clear and it is easy to respond to the increased maintenance works of facilities after the improvement.

7.1.3 Operation

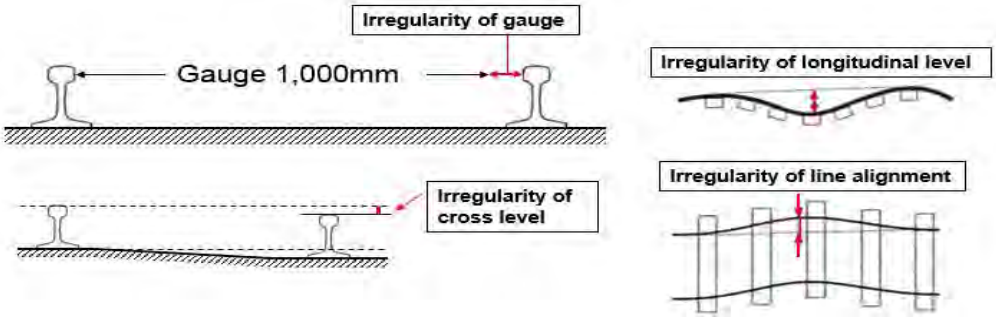
The train operation needs to ensure safety, comfort, and punctuality. For this purpose, O&M of railway facilities is an important issue. It is especially needed for O&M of rolling stocks and tracks. The O&M of track works shall be described in this section.

(1) Service criterion and safety criterion for track irregularity

Service criterion is a management standard to keep a comfortable riding condition while safety criterion is a safety control standard.

1) Service criterion of track irregularity

The following Figure 7.1.1 shows service criterion where the train maximum speed is 100 km/hr.



Source: JICA Study Team

Figure 7.1.1 Track Irregularity

Table 7.1.1 Example of Service Criteria for Track Irregularity

(Unit: mm)

Type of Track Irregularity	Measurement Car	Static Measurement
Gauge	+10, -5	+6, -4
Cross level	11	7
Longitudinal level	13	7
Alignment	13	7

Source: JICA Study Team

2) Safety criterion for track irregularity

Safety criterion is a standard to ensure safety for train operation, and this criterion is used as a standard value to repair track irregularity ahead of time. Table 7.1.2 shows an example of safety criteria that should be assumed in repairing track irregularity by track works within 14 days.

Table 7.1.2 Example of Safety Criteria for Track Irregularity

(Unit* mm)

Type of Track Irregularity	Measurement Car	Static Measurement
Gauge	+20	+14
Cross level	—	—
Longitudinal level	23	15
Alignment	23	15
Twist	23	18

Source: JICA Study Team

7.1.4 Maintenance

(1) Operation plan of track inspection car

Track irregularity is necessary to be kept below the service criteria of track irregularity. The track inspection car can carry out measurement at approximately 50 km/hr. Considering the maximum speed of train operation and growth of track irregularity, the appropriate measurement frequency by track inspection car is once or twice a year.

(2) Realignment of track works by Multiple Tie Tamping Machine (MTT)

MTT continuously tamps the ballast tracks. the number of working days for the annual actual performance record is 150 to 180 days/yr. In case of the tamping works during the rainy reason cause “mud pumping of ballast tracks”, the working days of YM will be assumed at 130 days/yr in consideration of rainy season; and the quantity of work per hour is 400 m.

(3) Frequency of tamping works by MTT and Number of required MTT

The tamping works by MTT should maintain the condition of tracks below the service criteria of track irregularity. The frequency of tamping works for YM should consider the condition of track which is soil roadbed as well as the maximum speed, the frequency of tamping works by MTT

should be assumed to be once every three years as a minimum value. Although 6 MTTs are scheduled to be procured at YM projects Phase I and Phase II. In future track maintenance and repair after the improvement make possible to use, one MTT in 5 Divisions, so thus the tampering frequency by MTT can be shortened to 3 years or less.

(4) Maintenance of turnout and other equipment

Except the measurement of track irregularity by track inspection car and tamping works by MTT, the maintenance works of the track will continue the maintenance of rails, rail joints, fastening devices, turnout and expansion joint of continuous welded rail. The adoption of continuous welded rail reduces the number of rail joints. A different maintenance is required to prevent buckling of continuous welded rail. Also, the replacement work of continuous welded rail will accompany the welding work of rail, the removal and laying of continuous welded rails, and the setting temperature of continuous welded rail.

Chapter 8 Environmental and Social Considerations

8.1 Environmental Impact Assessment

8.1.1 Introduction

(1) Environmental Approval for the Project (YGN-MDL section, phase 1 and 2 sections)

An Environmental Impact Assessment (EIA) on the Yangon-Mandalay Railway Improvement Project was carried out in 2013 and 2014 as part of the feasibility study (F/S) of the project covering the approximately 620 km section between Yangon and Mandalay. The study was implemented by the Ministry of Rail Transportation (MORT)[1] in coordination with the Department of Transport (DOT) situated under the Ministry of Transport (MOT)[2] and in collaboration with other concerned government agencies and the Japan International Cooperation Agency (JICA) F/S Team. The EIA report was produced as a result of the study and submitted to the Environmental Conservation Department (ECD) located under the Ministry of Environmental Conservation and Forestry (MOECAF)[3] on September 9, 2014. The ministry reviewed the report and issued with minor provisions an approval letter to MORT on October 28, 2014.

Based on the F/S, a detailed design (D/D) study on the first phase of the project was carried out from 2014 to 2016 by Myanma Railways (MR) situated under the then MORT (now MOTC) with support from JICA. Focus of the first phase of the project was the approximately 270 km section between Yangon and Taungoo. In the course of the study, the JICA D/D Team confirmed with ECD on March 24, 2015 that the approval of ECD/MOECAF on the EIA report was valid for the first phase of the project. The D/D study was completed successfully in June 2016.

Following the project's first phase, the preparatory survey for the second phase of the project commenced in March 2017 covering the remaining section of approximately 350 km between Taungoo and Mandalay. At this time, a new legislation called the Environmental Impact Assessment (EIA) Procedure (2015), which stipulates the EIA processes to be followed in Myanmar, had been put in place. In view of this situation, the JICA Study Team confirmed with ECD in March and May, 2017 whether the approval letter issued in October could be considered applicable to the second phase of the project. ECD told the Team that the approval letter was valid for the first phase of the project but the ongoing

[1] The ministry is now the Ministry of Transportation and Communication (MOTC).
[2] The ministry is now the Ministry of Transportation and Communication (MOTC).
[3] The ministry is now the Ministry of Natural Resources and Environmental Conservation (MONREC).

study for the second phase of the project, including the environmental work, needs to be carried out in accordance with the existing EIA Procedure (2015) and an EIA report should be submitted to ECD/MONREC in seek for a separate approval. Accordingly, MR with support from the JICA Study Team has commenced with the environmental work of the project in compliance with the EIA Procedure (2015), other relevant laws and regulations in Myanmar and with the JICA Guidelines for Environmental and Social Considerations (2010).

(2) Environmental Approval Process in Myanmar and Current State

Under the EIA Procedure (2015), project proponents in Myanmar need to obtain a notification, confirmation or approval from ECD/MONREC in three or four stages of the environmental study depending on the type of economic activities the projects are classified under. Three stages are required for 'initial environment examination (IEE) Type Projects' and four stages are required for 'EIA Type Projects'. The stages at which ECD/MONREC's approval are required for IEE Type Projects and EIA Type Projects, as well as the time stipulated in the EIA Procedure (2015) for ECD/MONREC's approval of them, are shown in Figure 8.1.1.

Stages	IEE Type Project (time for approval)	EIA Type Project (time for approval)
Screening	Project proponent submits to ECD a project proposal and ECD notifies the project proponent whether the project is an IEE Type Project, an EIA Type Project or a project that requires neither of them (15 working days)	
Notification of Consultant	Project proponent notifies ECD the consultant that will undertake IEE/EIA and ECD approves/disapproves it (7 working days)	
Scoping	N/A	Project proponent submits to ECD a scoping report and ECD approves/disapproves it (15 working days)
IEE/EIA Approval	Project proponent submits to ECD an IEE report and MONREC approves/disapproves it (60 working days)	Project proponent submits to ECD an EIA report and MONREC approves/disapproves it (90 working days)

Source: JICA Study Team

Figure 8.1.1 Approval Process and Time for IEE and EIA Type Projects

As of September, 2017, ECD/MONREC's approval of the first two stages (i.e. screening and notification of consultant) has been completed (cf. a letter of notification has been issued from MONREC to MOTC dated July 17, 2017) and the scoping report has been submitted from MOTC to MONERC by a letter dated August 17, 2017. According to the law, ECD should have returned their comments on the report by around September 5 but it has not reached MR or MOTC to date. In fact, the EIA report has already been prepared but ECD told JICA Study Team that EIA report

cannot be submitted to ECD/MONREC until ECD has completed their review on the scoping report. MR and JICA Study Team are waiting for ECD's review so that they could be reflected and the EIA report submitted to ECD/MONREC.

8.1.2 Results of Environmental Impact Assessment

(1) Legal Framework for Environmental and Social Considerations

Major environmental laws and regulations in Myanmar that are of relevance to the project are shown below.

1) Constitution of the Republic of the Union of Myanmar (2008)

The Constitution of the Republic of the Union of Myanmar was ratified and promulgated by the national referendum held in May, 2011. Some provisions that relate to land management and environmental conservation are summarized as below:

a) The Union is the ultimate owner of all land and natural resources in the area (Section 37);
b) The Union shall permit citiziens right of private property, right of inheritance, right of private initiative and patent in accord with the law (Section 37); and
c) Every citizen has the duty to assist the Union in preserving and safeguarding the cultural heritage, conserving the environment, striving for the development of human resources, and protecting and preserving public property (Section 390).

2) Environmental Impact Assessment Procedure (2015)

The objectives of the EIA Procedure (2015) are to provide a common framework for EIA reporting and to ensure that the EIA reporting is in line with legal requirements, good practices and professional standards. Concrete steps to be followed in conducting an EIA are stipulated in the EIA Procedure (2015). Some information that is to be taken into account is presented below:

a) All development projects in Myanmar are subject to an environmental screening process through which projects will be judged to determine if they require any environmental review and, if so, at which level (i.e. IEE or EIA);
b) EIA includes an environmental management plan and a social impact assessment report;
c) EIA includes an environmental and social baseline data of the study area as well as the changes that will occur during and after project implementation;
d) Public participation is essential for an Initial Environmental Examination (IEE) and an EIA;
e) Project alternatives are to be analyzed and measures defined that will minimize negative environmental, social and health impacts and maximize benefits to affected communities;

f) Environmental, social, health management and monitoring plans are required to be proposed to ensure that the requests from the government and the communities of the project proponent are implemented;

g) EIA Review Committee is formed to give recommendations to the Minister of MONREC from an environmental point of view on whether to approve the EIA report or not. The Minister makes the final decision based on this recommendation;

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

i) Involuntary resettlement is carried out under the responsibility of a respective regional governments and hence will not be included in the EIA Procedure (2015);

j) According to categorization of economic activities for assessment purposes (which is described in Annex A of EIA Procedures), Railways and Tramways (including construction and maintenance of rail infrastructure and operation of rolling stock) of more than 5 km in length as well as locomotives and other railway rolling material manufacturing, repairing and assembling whose capacity is more than 100 vehicles/a is categorized as EIA projects as shown in Table 8.1.1.

Table 8.1.1 IEE and EIA Project List for Railway-related Projects

No.	Type of Economic Activity	Criteria for IEE Type Economic Activities	Criteria for EIA Type Economic Activities
Metal, Machinery and Electronics			
90	Locomotives and Other Railway Rolling Material Manufacturing, Repairing and Assembling	-	≥ 100 vehicles/a
Transportation			
123	Railways and Tramways (construction and maintenance of rail infrastructure and operation of rolling stock)	Length < 5 km	Length ≥ 5 km

Source: Environmental Impact Assessment Procedure (2015)

3) National Environmental Quality (Emission) Guidelines (2015)

The objective of these national guidelines is to provide the basis for regulation and control of noise and vibration, air emissions, liquid discharges from various sources. According to these guidelines, all projects subject to the EIA Procedure (2015) have to comply with and refer to applicable national guidelines/standards or international standards adopted by MONERC. In addition, project proponents shall be responsible for the monitoring of their compliance with general and applicable industryspecific guidelines as specified in the environmental management plan (EMP) and environmental compliance certificate (ECC).

In addition, the project proponent is responsible for monitoring the environmental quality based on developed EMP as specified in the following sections:

a) As specified in the EIA Procedure (2015), projects shall engage in continuous, proactive and comprehensive self-monitoring of the project and comply with applicable guidelines and standards. For purposes of these guidelines, projects shall be responsible for the monitoring of their compliance with general and applicable industry-specific guidelines as specified in the project EMP and ECC (Section 12); and

b) Air emission, noise, odor, and liquid/effluent discharges will be sampled and measured at points of compliance as specified in the project EMP and ECC (Section 13)

4) Land Acquisition Act (1894)

Under the Land Acquisition Act (1894), the government holds rights to take over the land provided that compensation is made to the original land owner. No private ownership over land is permitted and all land must be leased from the Union State.

5) Farmland Rules (2012)

In accordance with Farmland Rules (2012), Township Farmland Management Committee shall calculate the amount of grievance and compensation to be given by the State or the Public and submit the statement of their amount to the Central Farmland Management Committee as follows:

a) Grievance for Crops and Buildings

   i. Three times of local current market price based on the yield per acre for paddy and other crops grown;

   ii. Three times of local current market price for perennial crop currently grown; and

   iii. Two times of local current market price for facilities and other activities aimed at improving the farm land

b) Compensation for Land

   i. Local current market price of the farm land in case it was requisitioned for non-profit construction works or other uses related to state security or the long-term interest of the State; and

   ii. In case of land requisition for profitable business activities that are for the long-term interest of the state, in order to avoid the loss of the person who has the right to work on the farm land, the agreed amount of compensation (or) the amount of money not less than the local current market price decided by the Compensation Committee under the Central Farmland Management Committee

It also states that when farmlands are converted into different forms of land based on the interest of the State or Public, the State or Public needs to make compensation to the farmers without delay.

6) International Binding Commitments

There are a number of conventions and treaties to which Myanmar is a signatory. In addition, this project is required to conform to the JICA Guidelines for Environmental and Social Considerations (2010/JICA Environmental Guidelines). While there exists some discrepancies between the laws and regulations in Myanmar and that of JICA Environmental Guidelines in terms of preparation of the resettlement action plan (RAP) and abbreviated resettlement action plan (ARAP), information disclosure and ways to provide compensation and support to the project-affected persons (PAPs), this project will be carried out in accordance with the JICA Environmental Guidelines and hence there will be no gap between them.

(2) Environmental and Social Baseline Condition

1) Social Environment

(a) Population and Demography

Mandalay region is the second most populous region in Myanmar with 6,442,000 inhabitants. The average population density is 424 persons per square mile. It is formed with seven districts, 30 townships and 2,320 wards and village-tracts. Mandalay with a population of over 650,000 is the capital city of Mandalay region. Bago region, on the other hand, occupies an area of 15,214 square miles. The total population is 5,014,000 and the average population density is over 300 per square mile. Bago region is made up of Bago, Pyay, Thayawady and Taungoo Districts which comprises of 28 townships with 1,619 wards and village-tracts.

Along the section between Taungoo and Mandalay on the Yangon - Mandaly Railway Line, local communities live in 18 townships – Pyigyi Takon, Chan Mya Thazi, Amara Pura, Sint Gaing, Kyaukse, Myit Thar, Wundwin, Thazi, Pyaw Bwe, Yamethin, Naypyitaw-Tetkone, Naypyitaw-Pyinmana, Naypyitaw-Lewe, Pobbathiri, Yedashe, Oktwin, Taungoo and Swa.

(b) Religion and Races

Mandalay and Bago are ethnically diverse cities. The primary religions practiced in Mandalay and Bago are Buddhism, Islam, and Hinduism. According to township data from the GAD at the township level, the majority of 18 townships located along the Mandalay - Bago section of the railway line are Buddhist.

(c) Economic Status

Economic activities in the 18 townships located along the Yangon-Mandalay Railway Line were examined according to the information provided by respective township GAD offices. Agriculture, livestock breeding and small-scale shop businesses take place especially in villages while small-

to large-scale businesses take place in urban and sub-urban areas. The townships in the project area can be said to be generally economically better off partly because they exist along the highway that connects Yangon and Mandalay.

(d) Educational Status

With regards to the educational status of 18 townships along the project area as per township information, it can be seen that Pyigyidagun has the largest number of illiterate (monastic) group of people with 6,474 people representing 20.22% of the population. The lowest rate of illiterate group is found in Thazi with only 0.22%. The number of university students in Amarapura Township is the highest among the 18 townships presumably because of the existence of Mandalay Yadanabon University.

According to the 'Environmental Impact Assessment for the Rehabilitation and Modernization of Yangon-Mandalay Railway Project (2014)', 4% of the people living along the railway line are illiterate, 28.5% have completed basic primary education (grade 1-5), 37.5% have completed middle school education (grade 6-9), 18.5% have completed high school education (grade 10-11), 1.5% are university students (undergraduates) and 10% possess a bachelor degree.

(e) Socio-economic Characteristics of the Project-affected Persons

A census survey was carried out by JICA study team from May to July, 2017. As part of the survey, the team interviewed all 24 project-affected household heads. No project-affected household was found to spend more than they earn. With regards to ethnicity and religion they believe in, all except for one household was Myanmar following Buddhism.

2) Natural Environment

(a) Topographic and Geological Conditions

The topography in Myanmar can be divided roughly into three types: the Western Hills Region; the Central Valley Region; and the Eastern Hill Region. The project area is included in the central valley region. The central valley region consists of the broadest valley of Ayeyawady. There also lies the low range of Bago Yoma that slopes down from north to south.

(b) Soil Type

There are several soil types in Bago and Mandalay regions. Along the railway line of Bago region, the soil types of meadow and meadow alluvial soils and alluvial soils are found. In Mandalay region, the soil types are mostly meadow and meadow alluvial soils, yellow brown dry forest soil, Indaing soils and compact soils.

(c) Climate

i) Bago Region

The southern part of Bago region enjoys a tropical monsoon climate and the northern part belongs to a tropical savannah climate. The average temperature in Bago, Taungoo and Pyay in April, the hottest month of the year, is around 31 to 32 °C. The average temperature in Bago in January, the coolest month, is 23.9 degrees Celsius. The average annual rainfall in the town of Myitkyo is 3,362 mm. The average rainfall in Pyay, which receives less rain than other towns, is 1,155 mm.

ii) Mandalay Region

There are various kinds of climate in Mandalay Division. The climate in the eastern plateau is warm and wet. An average temperature in the region is between 21 °C and 24 °C in April. The average temperature in the coldest months is 15.6 °C. The lowest temperature sometimes reaches the freezing point. The annual rainfall is 100 mm in Mogot and about 60 mm in Pyin Oo Lwin.

The southern part has a Savannah climate and the remaining regions are arid-like. Average temperature in the plains is 31°C and the highest day-time temperature is 43.3 °C. In winter, the average temperature drops to 21°C and the lowest temperature is around 18 °C. The average monthly rainfall is 131 mm in Mandalay.

(d) Natural Disasters

Myanmar is a country exposed to a number of natural hazards such as floods, cylones, storm surge, earthquakes, landslides, fires, and tsunamis. Over the decades, Myanmar has experienced a number of cyclones, floods, earthquakes, and landslides. Most parts of the country, especially the coastal regions, are mostly affected by the hazards. The townships located along the project area were mainly affected by flood and fire but some areas have been affected by storms as per township information of GAD.

(e) Land Use

The main land use along the railway line is agriculture (i.e. farm, horticulture, etc). Some of the crops seasonally grown are rice, wheat, various kinds of beans, cotton, sesame, sugarcane, onion, maize, chilli, and so on. Reserved forests, industrial land, protected area, vacant land and others are also found but they are not part of the project area.

(f) Protected Areas

Protected areas in Myanmar are described depending on regions and states. The project area is included in Mandalay and Bago regions. Shwe-U-Daung Wildlife Sanctuary, Pyin-O-Lwin Bird Sanctuary, Popa Mountain Park and Minsontaung Wildlife Sanctuary are located in Mandalay region and Moeyongyi Wetland Bird Sanctuary is in Bago region. Although they are located in Mandalay and Bago regions, they are not near or within the project area.

(g) Flora

A total number of 44 flora species were recorded in Taungoo, Nay Pyi Taw depot site and Myohaung depot site. The habitat of identified species consists of seven types, including tree, small tree, shrub, herb, climber, creeper and aquatic species. The recorded species were checked with the IUCN Red List of Threatened Species 2016 Version 3.1. All species were classified as neither threatened nor near threatened species.

(h) Fauna

As a result of an ecosystem survey, it was found that none of the fauna species in the study area are listed on the IUCN Red List category of endangered species for Myanmar (www.iucnredlist.org). In Taungoo, 17 species of birds and 22 species of butterflies were recorded. In Nay Pyi Taw depot site, 19 species of birds, 19 species of butterflies and 10 species of dragonflies were recorded. A total number of 17 species of birds, 19 species of butterflies and 10 species of dragonflies were recorded in Myohaung depot development site. The list of fauna species is presented in the following tables.

3) Ambient Environmental Quality

(a) Air Quality

A summary of the result is shown in Table 8.1.2 below. It can be seen that the level of concentration for SO_2 was in excess of the NEQ Guideline values at A-1 (i.e. Taungoo) and that of ozone was higher at A-2 (i.e. Pyinmana) and A-3 (i.e. Chan Mya Tha Zi).

Table 8.1.2 Results of Ambient Air Quality Measurement

Parameter	Location (μg/m^3)			NEQ Guildlilne Values (μg/m^3)	Averaging Period
	A-1	A-2	A-3		
PM_{10}	30.00	40.81	21.13	50.00	24hrs
$PM_{2.5}$	18.06	17.47	10.96	25.00	24hrs
NO_2	125.70	96.16	134.12	200.00	1hrs
SO_2	48.93	6.70	13.52	20.00	24hrs
Ozone	90.90	108.50	152.43	100.00	8hrs

*Measurement values that exceed the NEQ Guideline values are shown in a red square.

Source: JICA Study Team

(b) Water Quality

Table 8.1.3 shows the results of water quality measurement carried out at W-1 (i.e. channel near the planned depot development site in Nay Pyi Taw), W-2 (i.e. downsteream of Bridge No. 393 in Nga Lite stream, Pyinmana), W-3 (i.e. downsteream of Bridge No. 748 in Zaw Gyi river, Kyauk Se) and W-4 (i.e. downsteream of Bridge No. 826 in Myit Nge river, Amarapura). The observed

values were compared against the NEQ Guidelines. The results showed that all parameters were within the guildline value except for total suspended solid that showed a value of 67 mg/l at W-2.

Table 8.1.3 Results of Water Quality Measurement

No.	Parameter	Location				NEQ Guideline Values	Unit	Name of Laboratory
		W-1	W-2	W-3	W-4			
1	BOD	8	22	10	8	30	mg/l	ISO TECH
2	COD	32	64	32	32	125	mg/l	ISO TECH
3	Oil & Grease	<5	<5	<5	<5	10	mg/l	SGS
4	pH	7.6	7.7	7.8	7.9	6-9	Standard Unit	ISO TECH
5	Total Coliform	12	22	16	10	400	100ml	ISO TECH
6	Total Nitrogen	<1	<1	<1	<1	10	mg/l	SGS
7	Total Phosphorus	0.019	0.012	<0.01	<0.01	2	mg/l	SGS
8	Total Suspended Solids	38	67	44	27	50	mg/l	ISO TECH

*Measurement values that exceed the NEQ Guideline values are shown in a red square.

Source: JICA Study Team

(c) Noise and Vibration Level

i) Noise Level

Noise level near railway tracks depends on the single exposure level and frequency of train passes. When a train passes by, the parameter equivalent sound level (L_{eq}), which is the receiver's cumulative noise exposure from all events over a specified period of time, is derived. It is an hourly measure that accounts for the moment-to-moment fluctuation. The level of noise measured at the three locations (i.e. A-1, A-2 and A-3) are presented in Table 8.1.4.

Table 8.1.4 Results of Noise Level Measurement

Point	Period	L_{Aeq} (dB)	NEQ Guideline Values (dB)	Number of Trains Passed
A-1	Daytime (7:00-22:00)	59.7	55	9
	Night-time (22:00-7:00)	55.5	45	5
A-2	Daytime (7:00-22:00)	46.3	55	19
	Night-time (22:00-7:00)	53.7	45	5
A-3	Daytime (7:00-22:00)	54.5	55	14
	Night-time (22:00-7:00)	60.7	45	0

*Measurement values that exceed the NEQ Guideline values are shown in a red square.

Source: JICA Study Team

ii) Vibration Level

The resulting average value of vibration level at the three receptor locations is summarized in the following table.

Table 8.1.5 Results of Vibration Level Measurement

Point	Vibration Level (dB)			Guideline Values (Japan)*		Remarks
	X-axis	Y-axis	Z-axis	Day Time	Night Time	
A-1	30.1	32.4	34.4	65 dB	60 dB	8 hour average
A-2	30.8	31.5	33.2			
A-3	26.6	21.0	23.6			

* Guideline values that apply to areas where silence is needed to preserve a good living environment and to residential areas.

Source: JICA Study Team

(3) Assessment of Environmental Impacts

The potential environmental and social impacts which are expected to take place during planning, construction, operation, decommission and closure and post-closure stages of the project are presented along with the results of scoping. Predictions of the impacts were conducted based on the results of scoping, analysis of the project components and the baseline data including field survey results. It should be noted that the evaluation has been made based on a condition that no countermeasure has been put in place.

(4) Environmental Management Plan

A summary of the proposed environmental mitigation measures of the project, cost and implementation structure are presented and that of the environmental monitoring plan, cost and implementation structure proposed to be carried out under the project are presented.

(5) Implementation Structure

Carrying out environmental management for the project involves a number of participants each with different responsibilities, and interests. In particular, MR, supported by MOTC and the line government agencies, has the primary responsibility to ensure that the people and the natural environment are adequately protected from the negative impacts generated from the project and they adequately and rightfully benefit from the positive impact. The following figure presents the main players and their roles and responsibilities in the construction stange and operation and maintenance stages of the project.

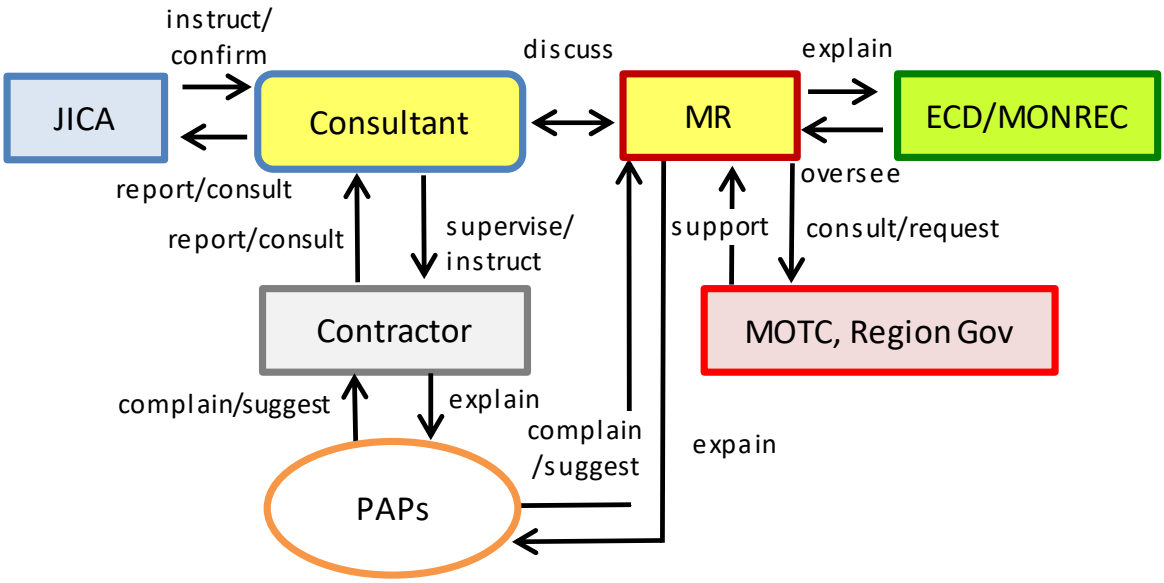


Figure 8.1.2 Implementation Structure (construction stage)

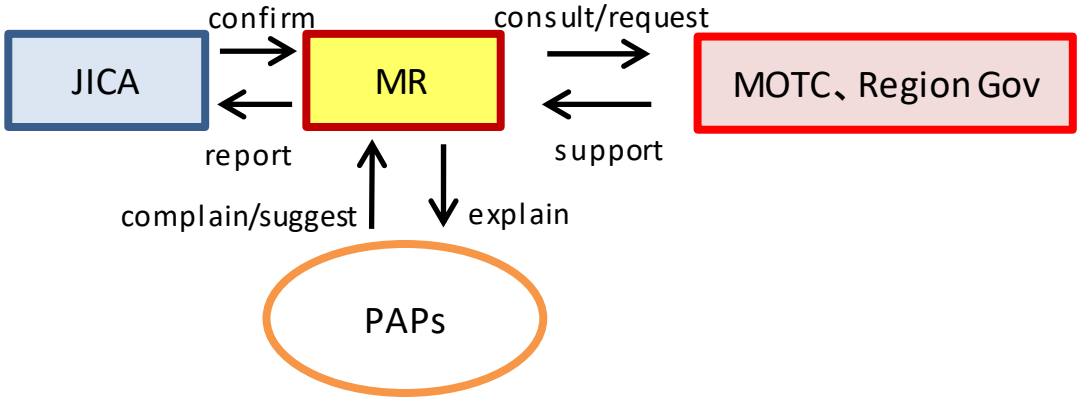


Figure 8.1.3 Implementation Structure (operation stage)

(6) Stakeholder Consultation

1) Requirements under EIA Procedure (2015)

In accordance with the EIA Procedure (2015), information on the project was made public in the following three stages under this project. In addition, MR plans to disclose the EIA report soon after submitting the report to ECD/MONREC.

1. Information disclosure on the project upon commencement of the EIA
2. Stakeholder meeting at the scoping stage
3. Stakeholder meeting upon preparation of the EIA report (draft)

Stakeholder meetings were held in four places at both the scoping stage (i.e. June, 2017) and upon preparation of the draft EIA report (i.e. September, 2017). The meetings attracted attendance from a wide range of stakeholders including the local people, relevant government organizations including ECD/MONREC and regional governments, private company and the media.

According to the agenda, MR introduced the project to the floor by explaining: the purpose of the stakeholder meeting; project background was including current state of the railway line; project objective and proponent; project location; project component; project schedule; and contact person using a power point presentation.

The EIA consultant then explained: the process of EIA; environmental type of the project; environmental baseline condition; project alternatives; terms of reference and results of the EIA survey including socio-economic characteristics of the PAPs; environmental impact assessment; mitigation measures; and monitoring plan.

In the question and answers session, MR and the EIA consultant gave an answer to each question raised from the floor which ranged from: environmental impact; information disclosure; resettlement; compensation; grievance redress mechanism; safety measures; project period; and project components. An outline of the stakeholder meetings is presented below.

Table 8.1.6 Summary of Stakeholder Meetings at the Scoping Stage

Date and Time	Venue	Number of Participants						
		Government Officials	Parliament Members	Local People	Media	Private Company	EIA Consultant	Total
Jun 5, 2017 (10am-12pm)	Thazi City Hall, Thazi, Mandalay Region	34	3	28	2	-	7	74
Jun 6, 2017 (10am-12pm)	Zaytawin Dhamma Hall, Myit Nge, Mandalay Region	28	-	14	8	-	7	57
Jun 15, 2017 (9am-11am)	Pyinmana Station (VIP Hall), Nay Pyi Taw Council Region	37	2	27	2	5	7	80
Jun 16, 2017 (3pm-5pm)	Taungoo Railway Station, Bago Region	41	6	13	2	6	7	75
Total		140	11	82	14	11	28	286

Source: JICA Study Team

Table 8.1.7 Summary of Stakeholder Meetings at the draft EIA Reporting Stage

Date and Time	Venue	Number of Participants						
		Government Officials	Parliament Members	Local People	Media	Private Company	EIA Consultant	Total
Sep 6, 2017 (9am-11am)	Thazi City Hall, Thazi, Mandalay Region	36	3	21	2	-	7	69
Sep 7, 2017 (9am-11am)	Zaytawin Dhamma Hall, Myit Nge, Mandalay Region	18	-	17	7	2	7	51
Sep 11, 2017 (9am-11am)	Mingalar Kan Taw Hall, Pyinmana, Nay Pyi Taw Council Region	16	4	15	-	-	7	42
Sep 12, 2017 (9am-11am)	Kay Tu Yadanar Hall, Taungoo, Bago Region	49	1	20	-	-	7	77
Total		119	8	73	9	2	28	239

Source: JICA Study Team

8.2 Abbreviated Resettlement Action Plan

(1) Summary of Possible Affected Persons and Units

Summary of possible affected persons is shown in the following Table. A-RAP Study (i.e. census, asset and socio-economic study, etc.) has been conducted for the Project which is expected to involve the acquisition of private land and involuntary resettlement.

Table 8.2.1 Summary of affected households

	No	HH Code	Religion/State	District	Township	Condition
Bridge Renovation	1	Bdg.379 - 01	Nay Pyi Taw	Dekkhina	Lewe	Affected 1 house, 1 temporary shed and 1 temporary hut
	2	Bdg.393 - 01	Nay Pyi Taw	Dekkhina	Pyinmana	Affected 1 temporary shed
	3	Bdg.393 - 02	Nay Pyi Taw	Dekkhina	Pyinmana	Affected 1 house and 1 temporary shed
	4	Bdg.417 - 01	Nay Pyi Taw	Ottara	Pobbha Thiri	Affected 1 temporary shed
	5	Bdg.683 - 01	Mandalay	Meikhtila	Wundwin	Affected 1 plot of YA land
	6	Bdg.683 - 02	Mandalay	Meikhtila	Wundwin	Affected 1 plot of farmland
	7	Bdg.748 - 01	Mandalay	Kyaukse	Kyaukse	Affected 1 temporary hut
Depot Improvement	1	Dep.MH 01	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 temporary shed and 1 house
	2	Dep.MH 02	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house
	3	Dep.MH 03	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house and 2 temporary huts
	4	Dep.MH 04	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house
	5	Dep.MH 05	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house
	6	Dep.MH 06	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house
	7	Dep.MH 07	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house
	8	Dep.MH 08	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house and 1 temporary shed
	9	Dep.MH 09	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 house and 1 temporary hut
	10	Dep.MH 10	Mandalay	Mandalay	Chan Mya Tharzi	Affected 2 houses
	11	Dep.MH 11	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 temporary hut
	12	Dep.MH 12	Mandalay	Mandalay	Chan Mya Tharzi	Affected 1 temporary hut
Alignment Improvement	1	U-IP.182 - 01	Mandalay	Mandalay	Pyi Gyi Tagon	Affected Brick Wall, about 60 metres in length, owned by Hindu Monastery
	2	D-IP.182 - 01	Mandalay	Kyaukse	Paleik	Affected 1 house
	3	D-IP.182 - 02	Mandalay	Kyaukse	Paleik	Affected 1 house
	4	D-IP.173 - 01	Mandalay	Kyaukse	Singaing	Affected 1 MR Staff's house
	5	U-IP.1 - 01	Bago	Taungoo	Taungoo	Affected Public access road to Monastery, about 68 metres in length, funded by Buddhist Monastery

Source: JICA Study Team

(2) Project Affected Persons and Project Affected Units

Following Table shows the number of PAUs and PAPs. There are 24 households (103 peoples) for 3 sectors in total for Phase 2 project.

Table 8.2.2 PAUs and PAPs (all)

Sectors	Affected HHs	Project Affected Persons	PAUs			Remark
			No. of Affected Units	No. of land plots	Total Land Area (m^2)	
Bridge Renovation	7	41	8	2	951.57	-
Myohaung Depot Improvement	12	53	18	-	405.58	-
Alignment and Track Improvement	5	9	5	-	875.67	Including Brick Wall and access road
TOTAL (Phase2)	**24**	**103**	**31**	**2**	**2,232.82**	
Phase 1	4	24	4			
TOTAL (Phase1+2)	28	127				

Source: JICA Study Team

Among 24 households (103 persons) for 3 sectors, the amount of households and affected people who need to be resettled is as following table. All lands locate within the Right of Way (ROW) and it is expected that all PAPs who need to be resettled are living illegally. The corresponding number of Project Affected Persons (PAPs) is enumerated by the census survey from May - July 2017 by JICA Study Team.

Table 8.2.3 Expected HH and PAPs who need to be resettled

Sector	No. affected HHs	No. affected Persons
Bridge Renovation	3	22
Myohaung Depot Improvement	12	53
Alignment and Track Improvement	3	7
TOTAL	**18**	**82**

Source: JICA Study Team

(3) Eligibility Cut-Off Date

A cut-off date is set to identify and differentiate genuine eligible PAPs from non-eligible people, thereby reducing possible conflict. For this project, the cut-off date has been set on **20th July, 2017** which represents to the time of completion of all socio-economic surveys for the improvement of 3 sectors. The period of social survey for 3 sectors (Bridge renovation, Myohaung depot improvement, and alignment and track improvement) is as follow.

- Bridge Renovation Areas: from May 17-18 and July 10-12 2017(4 days)
- Myohaung Depot Improvement Area: from June 1-2, 2017. (2 days)
- Alignment and Track Improvement Areas: from June 20 – 23, 2017 (4 days)

The Process of declaration of Cut-off date is issuance the letter with the list of affected peoples from MR Headquarter to General Manager of Upper and Lower MR at first. Then Upper and Lower MR office have sent that letter to all GAD offices and some stations that are expected some impacts. That letter is stick on the board at each station.

(4) Livelihood Restoration Program (Proposed)

The affected people in this project can be generally categorized into three types of group according to their loss of premises:

a) the people in consequence of loss of structural units such as living assets,

b) the people in consequence of loss of agricultural lands, and

c) the people in consequence of loss of religious structures.

Considering the type or degree of affect to their loss of premises, the proposed programs for livelihood restoration are as follows;

- Providing cash
- Providing vocational trainings
- Providing in finding job opportunity in/around the project area

(5) Concerned Organizations

Anticipated major organizations concerned with implementation of the A-RAP are shown in following table.

Table 8.2.4 Concerned Organizations with the Implementation of the A-RAP

Organization	Role	Responsibilities and Duties
MOTC (Ministry of Transport and Communications)	Role as the line Ministry of MR (Myanma Railways)	Approval of removing Structures and Resettlement in the project
MR (Myanma Railways)	Role as the project proponent	1) Identifying data regarding removing structures and resettlement 2) Forming and managing CFC (Compensation Fixation Committee) 3) Close communication with PAPs, GAD, State/Regional Government etc. 4) Negotiation, payment and making agreements with PAPs for process and cost of respective compensation and resettlement assistance 5) Adequate Response for grievance from PAPs with on-going interaction 6) Support of livelihood of PAPs during transition period 7) Internal monitoring of A-RAP implementation
Other organizations - Department of Agricultural Land Management and Statistics (DALMS), - Department of Human Settlement and Housing Development (DHSHD), NGOs, etc.	Support and consultation for MR	Support and consultation for MR

Note: Organizations making up the CFC will be concerned in addition to those shown above.

Source: JICA Study Team

(6) Monitoring System

It is necessary that project proponent (MR) together with State/Regional Governments, and their ministries (MOPF – PD/FERD and MOTC), establish special task force teams in order to monitor the resettlement activities. Those teams shall be a single window to respond to problems with regard to the resettlement activities of the project, and is expected to report the progress of the resettlement activities to the project proponents and concerned authorities such as State/Regional Governments. NGOs can also be involved as the third party in the monitoring activities as per necessary. A flow chart for proposed monitoring system is illustrated in Figure 8.2.1

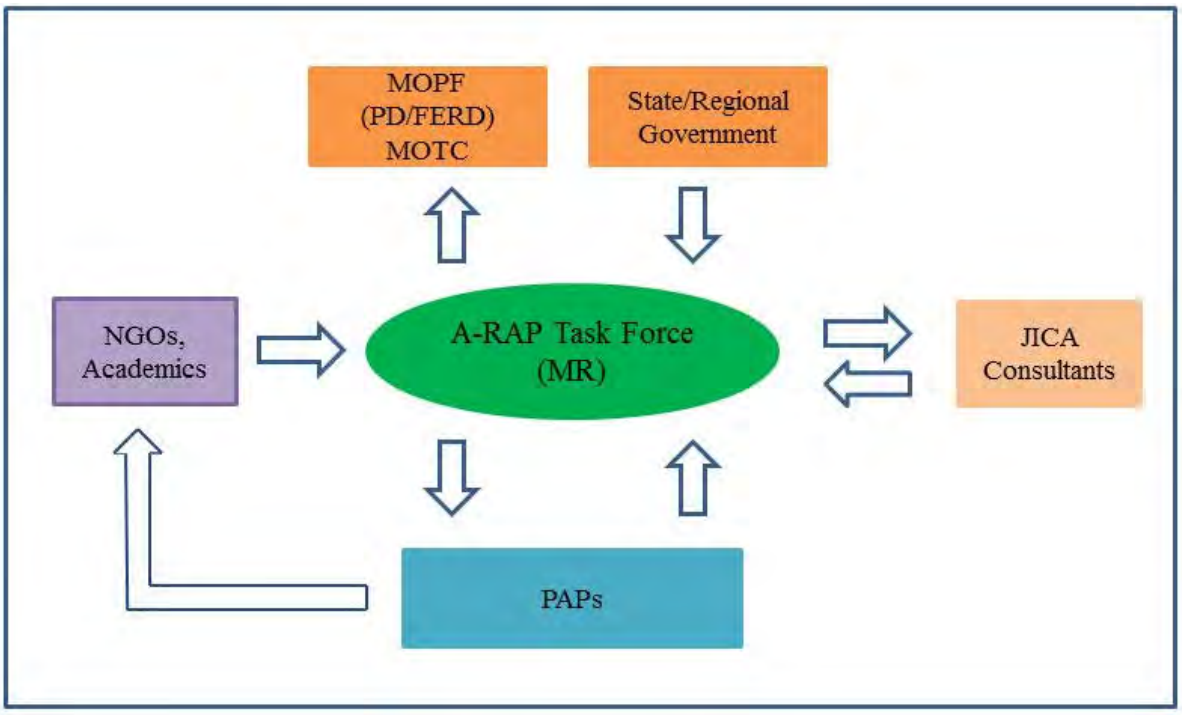


Figure 8.2.1 A-RAP Monitoring System

(7) Cost and Budget

The estimated RAP implementation budget for the project is MMK 34,125,840 and summarized in Table 8.2.5. MR will be responsible for providing adequate funds for land acquisition and resettlement related to the project. It is important to note that these figures need to update during updating of the RAP in the detailed engineering stage.

Table 8.2.5 A-RAP Implementation Budget

Activities/Cost Item	Estimated Budget		Note
	MMK	USD	
Bridge Renovation			
Compensation	1,415,000	1,040	
Business loss	2,480,000	1,824	353,500* 7 HHs
Livelihood assistance	2,480,000	1,824	353,500*7 HHs
Moving assistance	350,000	257	50,000*7 HHs
Public consultation	300,000	221	100,000*3 times
Monitoring	400,000	294	100,000*4 years
Subtotal	7,425,000	5,460	
Contingency (+8%)	594,000		
Grand Total	**8,019,000**		
Activities	Estimated Budget		Note
	MMK	USD	
Myohaung Depot Improvement			
Compensation	4,339,000	3,190	
Business loss	4,242,000	3,119	353,500* 12 HHs
Livelihood assistance	4,242,000	3,119	353,500* 12 HHs
Moving assistance	600,000	441	50,000*12 HHs
Public consultation	300,000	221	100,000*3 times
Monitoring	400,000	294	100,000*4 years
Subtotal	14,123,000	10,385	
Contingency (+8%)	1,129,840		
Grand Total	**15,252,840**		
Activities	Estimated Budget		Note
	MMK	USD	
Alignment and Track Improvement			
Compensation	7,836,000	5,762	
Business loss	707,000	520	353,500* 2 HHs
Livelihood assistance	707,000	520	353,500* 2 HHs
Moving assistance	100,000	74	50,000* 2 HHs
Public consultation	300,000	221	100,000*3 times
Monitoring	400,000	294	100,000*4 years
Subtotal	10,050,000	7,390	
Contingency (+8%)	804,000		
Grand Total	**10,854,000**		
TOTAL	**34,125,840**	**25,093**	

Note1: 1USD = 1,360 MMK

Note2: Unit price of business loss and livelihood assistance (353,500 MMK) was based on the highest monthly income reported by PAPs during the interview surveys.

(8) Terms of Reference (TOR) for Consulting Service

During the Detail Design stage, in parallel with Bridge Renovation plan, Myohaung Depot Improvement plan, Alignment Improvement plan and other additional plan will be finalized, so it is necessary to update this A-RAP too. Expected TOR for update this A-RAP is as follows;

1) Preparation for final A-RAP

a) Support the implementing institutions to implement socialization.

b) Implement the socioeconomic survey and asset survey on all PAPs who are living in the target areas.

c) In order to finalize the compensation rate and transfer cost, implement the replacement cost survey of various types of assets such as houses and lands.

d) Update an implementation schedule, grievance redressing mechanism, monitoring and evaluation of A-RAP.

e) Finalize the A-RAP. Also the summary is translated into Myanmar language.

f) Disclose the information of the draft and final version of A-RAP.

2) Update Socio-Economic Survey (SES) and Inventory of Loss (IOL)

Update the socioeconomic survey. Items are as follows.

a) Information of householder: name, gender, age, livelihood means, occupation, income, education background and ethnic group.

b) Information of family living together: number, livelihood means, occupation, number of school children, literacy rate and gender.

c) Data on affected houses: ethnic group, gender of householder, family size, main income and secondary income, elderly, disabled person and poor etc.

d) Legal position of affected land and building, period as owner.

e) Request for compensation, life rebuilding from PAPs.

In addition, implements the survey of the Inventory of Loss (IOL). The data obtained by this IOL is used to finalize the level of compensation and qualified eligibility. The information to be collected is as follows.

a) Area of affected buildings and its type

b) Types, areas and numbers of affected crops and trees

c) Area of affected lands and its type (for access road or if necessary)

d) Other losses (e.g. Temporary loss of income, loss of merchant income, etc.)

e) Types and areas of affected public facilities.

3) Replacement cost survey

Update the result of replacement cost survey at the same time of SES and IOL. The information to be collected is as follows;

a) Replacement cost of house, shed and hut

The replacement cost of house, shed and hut includes materials (market price) for rebuilding, transportation cost of materials, wage of the worker, required registration fee and tax, etc. Price calculation is based on the following two points.

- Unit price determined by government (GAD/DALMS)
- Unit price of recent market price

b) Price of lands

Price of lands is the sums of market price or land price of the neighborhood and preparation costs of similar land, required registration fee and tax, etc.

Chapter 9 Project Implementation Plan

This chapter is described following items.

First item is described contract package and its contract category.

Second item is described about whole implementation schedule and also each implementation schedule of each package.

9.1 Contract package

9.1.1 Plan of Construction Contract

Construction Projects utilize different kinds of contractual engagements. Two of the most widely used contract categories were reviewed and studied for Yangon–Mandalay Railway Line improvement Project phase II.

(1) Contract using rated items: Bill of Quantities (BOQ);

(2) Lump Sum Design and Build Contract.

Phase II Project will be adopted as same contract category as phase I.

9.1.2 Contract Package

Contract Package is disclosed.

(1) Civil and Signal Package Section

Implementation Schedule is disclosed.

Chapter 10 Cost Estimation

10.1 Pre-condition of Cost Estimation

10.1.1 General Conditions

(a) Exchange Rate

(1) JPY/USD USD 1 = JPY 110

(2) LC/USD USD 1 = MMK 1,360

(3) JPY/MMK MMK 1 = JPY 0.0809

(b) Price Escalation

FC: 1.7% LC: 7.0%

(c) Physical Contingency

Construction: 5.0% Consultant: 5.0%

(d) Base Year for Cost Estimation:

2017/10

(e) Schedule

Start: 2017/01 End: 2035/03

10.1.2 Others

(a) Rate of Tax

VAT: 5.0% Import Tax: 10.0%

(b) Rate of Administration Cost

5.0%

(c) Rate of Interest during Construction

Construction: 0.01% Consultant: 0.01%

(d) Rate of Front End Fee

0.0%

10.2 Cost Estimation by Package

Cost Estimation by package is disclosed.

10.3 Cost Estimation in Each Work Item and Package

Cost estimation in each Item and Package is disclosed.

10.4 Cost Estimation in Total

Total Cost Estimation in Phase II is disclosed.

Chapter 11 Project Evaluation

11.1 Basic Assumptions

(1) Inauguration Year

In 2023, the railway transport services will be renewed from Yangon to Mandalay after completion of Phase-II project. However fiscal accounting is assumed to start from 2024.

(2) Project Life

The project life for the economic analysis is assumed 30 years after phase-II project same as the phase-I project

(3) With/Without Comparison

For the economic evaluation, cost and benefit analysis is apdoted. The central thesis of cost-benefit analysis is with/without comparison principle that cost and benefit is estimated by both with project case and without project case respectively. In this study, followings cases are assumed:

- Without case : without Phase-II project
- With case : with Phase-II project

(4) Prices

For conversion of economic price between foreighn currencies in project cost calculation, following currency exchange rate sets are adopted as same as the cost estimation task in this study.

US$1.0 = JPY104.68

MMK1.0 = JPY 0.083

US$1.0 = MMK 1,261

(5) Operation and Effect Indicator

Operation and Effect Indicators in phase II is shown in the table 11.1.1.

Table 11.1.1 Estimated operation and ffect indicators in Phase II

Indicators	Present value	Target value
	2017 (actual)	2026
Train Operation Ration (%)	76.6	85
Passenger Transportation (Man*km/day)*	2,089,247	10,190,618
Fright Transportation (Ton*km/day)*	922,486	2,386,800
Number of running trains /day	27.5	104
Passenger Transportation (Train*km/day)*	7,815	38,125
Passenger Transportation (train*km/day)*	13,525,493	8,824
Passenger Revenue(Kyat/day)	13,525,493	310,123,288
Freight Revenue (Kyat/day)	91,560,700	245,049,315
Time required between TaungOo and Mandalay(Passenger Express Train)(hour)	8h01m	4h49m
Time required between Tanug Oo-Mandalay(Freight Train)(hour)	11h24m	6h40m

Note* Yangon to Mandalay

Source: JICA Study Team

11.2 Project Costs

(1) Financial Project Cost

Financial Project Cost is disclosed.

(2) Economic project cost

Economic Project Cost is disclosed.

11.3 Economic Analysis

(1) Expected benefit

- Savings of travel time and cost are generated among railway passengers and freight shippers as a result of improved train speed and other relevant services.
- Operation cost savings for other transport modes including air transport, buses, private transport and inland water transport, due to the transport volume reduction as a result of traffic diversion to railway .
- Travel time and cost saving for existing traffic users not diverted by project due to easing of traffic condition resulted from traffic reduction by project.

(2) Cost benefit analysis result

Based on the initial condition assumed for cost and benefit, cost benefit analysis was carried out. Table below shows its briefing of eveluation.

Table 11.3.1 Economic Analysis Result

Indicator	Value
EIRR	16.66 %
B/C (adopting 10% as a discount rate)	2.49
NPV (Million MMK discounted by 10%)	3,177,233

Source:JICA Study Team

11.4 Financial Analysis

(1) Revenue Estimation

To estimate fare revenue for the Yangon-Mandalay railway, fare system is assumed as a basic condition, just same as demand forecast process.

According to demand forecast, following fare structures are taken into consideration:

- Passenger fare : average 30 MMK/km[*1]
- Freight fare : 26.3 MMK/km for general cargo[*2]
  39.4 MMK/km for petroleum cargo[*2]

(2) Estimated revenue

Based on the demand forecast, gross passengers fare revenue and freight revenue are estimated. Future railway revenue will increase until year 2030, however fare revenue amont is assumed to maintain same level after 2030 because of railway capacity.

Railway revenue estimation result is shown below

Table 11.4.1 Estimated Revenue

(Unit: million MMK/year)

	2023	2030
Passengers fare revenue	49,892	350,048
Freight fare revenue	35,123	319,596

Note: Ramp-up effect is assumed in the beginning three years

(3) Base case result

Based on the cost stream data and revenue stream data, the financial cash flow analysis was conducted. Its result is shown below

Table 11.4.2 Financial Analysis Result

Indicator	Value
FIRR	13.37%
NPV(million MMK at discounted rate of 10%	1,984,846

Source: JICA study team

11.5 Economic potential increased by Y_M railway corridor development

Due to the track rehabilitation and upgrading for Y_M railway corridor to improve its railway operation capacity / quality, i.e. high train speed with safety, stable train operation schedule and attractive transport services for both passengers and rail freight. Following project outcome are expected:

- As its direct effect, both travel time and transport fare reduction are expected
- At the same time, these change leads area-wide impact on inter-regional transport network condition.
- These factor materialize the improvement of accessibility in regional network condition.
- The accessibility improvement has a long term effect of providing the development opportunity to the land along the railway line.

Chapter 12 Conclusion and Recommendation

12.1 Conclusion

Yangon - Mandalay Railway Improvement Project was planned to be implemented by dividing into three phases in the Feasibility Study in November 2013, because the total length of the line was approximately 620km long. By the strong request of the completion of the whole project by the end of 2023 from the Myanmar Government, JICA considered to combine the remaining two phases into one project as Phase II, in which the total section is approximately 353km from Taungoo to Mandalay.

As the result of the feasibility study, it was found out that to complete the project in three years and a half is feasible. However, there is a problem in terms of the project schedule that contractors might not be able to prepare manpower necessary for the construction works, as the last one year of Phase I and the first year of the construction works of Phase II are overlapped. On the other hand, as the construction works proceed in Phase I, it is expected that construction staff will get the ability for their works. In this regard, it will be necessary to pay attention to the works by the Phase I Contractors after Year 2018 when the construction works start in Phase I, especially for civil and signalling works.

For Phase II, it is necessary to divide the whole section into four (4) contract packages to shorten the project schedule, considering the 353km length.

This project is considered an important project from the viewpoint of the economic and financial analysis. At the result of the economic analysis, this project has the EIRR of 16.7%, and from the financial analysis, it has 13.4%. Therefore, it can be said that this project has a high investment effect.

In terms of environmental category, this project is in Category B by the JICA Guideline. Most of the project implementation can be conducted in utilization of the Right of Way of MR. Therefore; people affected by resettlement could be reduced as much as possible. And also, this project is a renovation project with little environmental impact.

This project is placed a meaningful project as Japanese ODA project, which is utilized by high quality materials and technologies from Japan such as 1) Introducton of 50N rail and related materials and also technologies for high speed and safety operation, 2) Introduction of ATP (ATS-S) which is utilized high reliability and long years in Japan, and also it is compatible with the imported

Japanese used DMUs and 3) Introduction of Radio Telecommunication System using UHF radio frequency which technology is widely used in Japan.

12.2 Recommendation and Consideration for the Project

12.2.1 Consideration at the Detailed Design Stage

(1) Timing on the Bidding Documents Preparation

Contract Package is disclosed.

(2) Utilization of Phase I Bidding Document and Review of Clarification

In the discussion with MR during the Preparatory Survey in Phase II, the JICA Study Team confirmed that the design criteria of Phase II should be the same as those of Phase I. Therefore, it is necessary to utilize the bidding documents of Phase I as much as possible on the preparation of the bidding documents. This will contribute to shorten the basic design period and also the detailed design period.

It is most important to review the clarifications by the bidders in Phase I and to reflect them to the bidding documents as well as the detailed design. To review the clarifications carefully and to prepare the bidding documents should be started as early as possible.

(3) Reconfirmation of Supplying PC Sleepers and Ballast by MR

Supplying PC sleepers and ballast by MR will absolutely affect the schedule of Phase II construction works. Therefore, it is necessary to reconfirm this issue with MR in the detailed design stage.

For supplying PC sleepers, MR must produce them at their factories and transport all sleepers to the sites on appropriate time designated by the contractors. In this sense, the close communication and coordination regarding the schedules between MR and the contactors will be the most important.

Regarding the demarcation for the ballast supply, during the Phase II Preparatory Survey, it has been confirmed that MR will prepare ballast at query sites and the contractors will transport it to their sites by them. In this regard, the risks in schedule delay will be reduced for the contractors. However, MR should note that MR has to secure the supply of enough budgets for ballast.

Both two items should be reconfirmed at the detailed design stage.

(4) Establishment of PMU

PMU, Project Implementation Unit, is the most important organisation to implement the project smoothly in any of the Yen Loan projects. Establishment of PMU has been agreed between MR and JICA at the M/D of the appraisal in October 2017.

Especially, as MR has been involved in many large scale projects at the same time, such as Yangon-Mandalay Railway Improvement Project Phase I, Yangon Circular Railway Line Upgrading Project and OCC Project, etc. In order to implement each project smoothly, it is important to set up the PMU for each project and secure enough number of qualified project staff.

As Yangon-Mandalay Railway Improvement Project Phase II is scheduled to commence the tender announcement as early as possible, it is necessary to designate the Project Director (PD) and assign the person in charge of the Phase II Project by MR as soon as possible for the smooth implementation.

a) Major Role of PMU

- For the smooth implementation of the project, the PMU has important tasks which include making bidding plans and disbursement plans to get approval from JICA in advance. Also it is necessary to report the progress of the project to the Ministry of Transport and Communications (MOTC), Ministry of Planning and Finance (MOPF) and JICA.
- Proper preparation for the project must comply with the current regulations for Japanese ODA loans (resettlement of inhabitants, environmental impact assessment and social impact assessment).
- Performing bidding, contracting and monitoring for the project and disbursement in accordance with the Myanmar law and JICA's rules is required.
- The coordination of the related ministries and the social and environmental considerations as is mentioned in c) and d) will be major tasks.

b) Organization of PMU

- The organizational structure of the PMU usually consists of administrative, planning, procurement (bidding), finance and technical sections with an adequate number of staff with adequate qualifications.
- The PMU Director must be professional with leadership capability and experiences for the project management.
- The responsibility and power of the PMU should be separated from the usual MR operation.

For the smooth implementation of the project, MR should establish the PMU and report it to MOTC and JICA as soon as possible.

c) Discussions with other Authorities

In some cases, the project requires approval from other authorities for various issues including roads, rivers, electric power supply, environment, taxation and others.

MR shall take the responsibility to implement necessary coordination with the related ministries

and other authorities. The details shall be discussed with the contractors after their mobilization. It is also recommended that MR explain the outline of the project to the related ministries and authorities before the tendering.

d) Fulfilment of Environmental Requirements

MR is required to fulfil the following environmental requirements as shown in Table 12.2.1.

Table 12.2.1 Environmental Requirements

Environmental Items	Requirements
Involuntary resettlement due to replacement of bridge	Completion of resettlement and compensation process based on the compensation policy, procedures and schedule set forth in the ARAP
Land clearance due to depot in Myohaung and Naypyitaw	Completion of relocation well be held in Oct. 2019 before the beginning of the tendering process and coordination with concerned authorities in order to facilitate the process
Environmental Management Plan	Preparation and finalization of the Environmental Management Plan based on the Report on Environmental and Social Considerations prepared by the JICA study team

(5) Optical Fiber Cable (OFC)

There are two types of OFC along Yangon-Mandalay Railway (YM), the buried OFC owned by MR and the overhead OFC owned by a Chinese enterprise. As the buried OFC is in a poor condition, the JICA Study Team developed the design on the assumption that the new overhead OFC is to be used for the system. In order for MR to use the overhead OFC, it is necessary to finalize the contract with the Chinese enterprise and to connect the OFC to each station along the line. It is recommended that MR conclude the contract, connect the OFC to each station and confirm that the OFC is available.

Also, as it is planned to use cranes for piling and the transport of materials in bridge construction works along the line, it is assumed that some parts of the overhead OFC have to be moved for such civil works. In order not to affect such civil works by the delay of the contract, MR is required to conclude the contract as soon as possible.

During the construction period, as such movement of the OFC at bridges will be required for the whole line, the Contractor shall be careful not to cut the OFC. In the detailed design stage, the Consultant should follow up the situation for the contact with the Chinese enterprise in the detailed design stage.

(6) Preparation of Asset Management and Implementation Plan

The number of replacement of bridges will be more than 2000 for PC Gurders and Box Culverts. Also track facilities, signal facilities, TMS and rolling stock will be newly installed in the Yangon-Mandalay Improvement Project. Those new facilities and equipment should be listed and managed by the Asset Management System, and spare parts should be also managed by MR properly.

The establishment and organizational management of the Asset Management System should be designed at the detailed design stage.

(7) Coordination with Other Projects

As there are several projects ongoing for YM, it will be important to coordinate with such projects in the detailed design. Besides the ODA projects by the Japanese Government such as OCC Project and Yangon-Mandalay Railway Improvement Project Phase I, the PPP developing dry ports in Myitnge is related with the track layout of the station and thus the consultant for the detailed design is required to obtain the information of the PPP while MR should provide enough information to the consultant accordingly.

12.2.2 Consideration items in the Implemantation Stage

(1) ATP installation on Existing Locomotives

Between Yangon and Mandalay, not only the new DEMUs but also the existing locomotives and coaches will be operated by MR even after the completion of the project, nearly 30% by the new DEMUs and nearly 70% by the existing MR's rolling stock.

The conditions of the existing locomotives and coaches are poor for safe operation including brake systems, and, if the situations do not change, these cars will disturb the safe and stable train operation on YM in the future. MR is required to keep these cars in good conditions so that they can run safely.

For further improvement for safety, it is necessary to install an ATP onboard device on the existing locomotives which are expected to be operated on YM. These ATP onboard devices are supposed to be supplied by the CP105 Contractor of Phase I and be installed by MR.

The consultant for YM-CMC of Phase I is supposed to supervise the installation work of ATP to provide technical advices and instructions to MR. It is recommended that MR check that all the locomotives operated on YM be equipped with an ATP onboard device.

(2) DEMU Operation between Taungoo and Naypyitaw

Although the section between Yangon and Taungoo will be rehabilitated in Phase I, MR is planning to operate the new DEMU up to Naypyitaw. This is reasonable from the viewpoints of travel demand and demonstration to Myanmar people, compared with the operation between Yangon and Taungoo.

In this case, the new DEMU will run on the track with bad conditions between Taungoo and Naypyitaw. The Contractor of CP104, Rolling Stock Procurement, will require MR to use the new trains on the improved track. The consultant for YM-CMC is supposed to coordinate with MR and conduct the analysis of track conditions between Taungoo and Naypyitaw. If necessary, the consultant is expected to provide advices to MR regarding the track maintenance for the section

and the appropriate operation rules including train operation speed.

MR has to understand that the rolling stock supplier designs and manufactures the rolling stock assuming that it is operated on the improved track between Yangon and Taungoo and that, if MR operates the new DEMU on the track with bad conditions which has not been improved and some trouble or malfunction occurs, the Contractor will claim that the cause of such trouble or malfunction is the operation on the bad track between Taungoo and Naypyitaw. In this case, the Contractor may not remedy the defective works even during the Defect Notification Period depending on the cause of the malfunction or trouble. MR should notice that MR will not be able to get remedial works for the defect or damage by the Contractor if the cause cannot be clarified.

(3) Human Resource Development of MR, Railway School Project

MR is an enormous organization with more than 20,000 staff. As MR is to be modernized through this Project in terms of facilities and equipment, it is necessary to educate and develop MR staff to meet such a modern railway system.

MOTC owns the Central Institute of Transport and Communications in Meiktela. While Yangon Mandalay Railway Improvement Project proceeds, it is important to develop MR staff so that they can operate and manage the modern railway of YM, and the institute in Meiktela should be the basement for the education.

It is recommended that a technical cooperation project be set up in parallel with the Yangon-Mandalay Railway Improvement Project where MR can train and educate their staff of civil engineering, track, electricity, signal, train operation, machinery, passenger service and so on, so that MR can operate the railway in terms of technical skills and railway management without the subsidy from the Government.

Details for this project should be discussed with JICA and MR at the detailed design stage.

(4) Request to MR from the Aspect of Bridge Engineering

To pave a shortcut to the modernization and rehabilitation project, MR is requested to take actions as mentioned below. The actions will provide basic existing information at the initial stage of this project and contribute significantly to the quick and appropriate implementation of the project.

(a) Updating and Adding the List of Bridge Structures

There is already a bridge list but its information is defective or insufficient and does not include many newly built PC bridges. Therefore, the information should be updated and added.

(b) Arranging Past Inspection Records about Bridge Structures

Although the inspection methods and recording techniques are insufficient for the appropriate health diagnoses of bridge structures, MR conducts periodic inspection on main bridge structures. Therefore, MR is considered to have basic reference materials. Such past records and information

should be collected and arranged as useful reference materials for future.

(c) Arranging Past Inspection Records about Bridge Structures

The design documents (design drawings and calculation reports) for the PC bridges including substructures designed and constructed recently should be obtained by MR immediately, because these basic reference materials will be necessary to understand the design conditions about the axle load and design speed of train and the like, also to evaluate future health diagnoses. In addition, it was considered that the qualities of materials like concrete and construction management at the time of construction of these PC bridges were inadequate. From now on, attention should be focused on the perspective of not only ensuring of temporary bearing force but also ensuring of long-life durability.

(d) Establishing Systems for Supporting Technique Acquisition in the Field of Bridge Engineering

At the initial stage of the project, it becomes necessary to establish maintenance systems and manuals for inspecting, repairing, and reinforcing various bridge structures and also to establish information management systems and inspection standards. At the same time, organizations should be created to smoothly execute a series of operations from inspection to the planning and implementation of repairs, reinforcement, and renewal based on the inspection data. Where possible, preparations for the series of operations should be advanced (for example, conception of an educational organization for railway civil engineers and institution-building of an incentive system).

(5) Maintenance of Equipment

Maintenance of the equipment and devices installed in this project is absolutely important in order to keep their functions after the commercial operation starts. While the Contractors are supposed to provide enough and proper education and training to MR staff, MR will be required to secure the budget for the maintenance as well as enough maintenance staff and proper organization for the maintenance.

Chapter 13 Public Relations

13.1 PR materials prepared by JICA Study Team

There are several materials are considered as PR of Yangon Mandalay Railway Improvement Project.Following PR materials are made in Japanese, English, Myanmar.

- PR Video: 5minutes version.
- Book which Japanese monthly magazine will be translated into Myanmar.:5,000
- Leaflet:A4 size brochure(14,000 in Myanmr, 13,000 in English, 3,000 in Japanese)

13.2 Making Visual Presentation Material

In order to aim to increase demand of Yangon – Mandalay Railway which will be asserted against buses and cars, public relations visual presentation of improved railway transport service will be made in the Study.

JST shot a movie for comparison of before and after the improvement project at Mandalay station, Myohaung Depot, Thazi Station, Naypyitaw Station and Yangon Station. JST will made scenarios and materials for the public relations presentation as referenced in Table 13.2.1 after the decided major improvement items.

Table 13.2.1 Public Relations items of visual presentation material

Items	Contents
Increasing train operation	Movie which is able to feel the speed felt of the train after improvement will be prepared by using CG and map. The movie is made as it can be seen how much time was shortened between Yangon Station and Naypyitaw Station by the project
Station yard and station development	The station yard will be improved in order to be more convenient for kids and pregnant women, and to be age-friendly by becoming barrier-free. Also, it will become easier to transit to buses and taxis.
Introduce of new DEMU	New DEMU has performance of comfortable riding and clear toilets and priority sheets.
Introduce of ticket vending machine and ticket reservation system	Easily buying ticket on-line system will be introduced by using PC and smartphone
Improvement safety awareness	The movie will facilitate public awareness in order to decrease railway accidents due to increased train speed

Source: JICA Study Team