5.5 Railway Bridges

5.5.1 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 (referred to as "MR") concerned personnel and confirmations through actual visual inspections of aging and time-related deterioration of bridge structures in this site survey.

The list of all existing bridges between Taungoo Station and Mandalay Station is shown in the attached Appendix5.5.1.

(1) Structural Types and Summaries of Existing Bridges

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

The superstructure types listed below are shown in Figure 5.5.1

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

The substructure types listed below are shown in Figure 5.5.2

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

Steel Deck Plate Girder

Steel Through Plate Girder

Steel Through Truss Girder

Reinforced Concrete Girder

Prestressed Concrete Girder

Source: JICA Study Team

Figure 5.5.1 Types of Superstructures

Brick Pier

Reinforced Concrete Pier

Concrete-filled Steel Tubular Pier

Brick Abutment

Brick - Wing Wall / Retaining Wall

Source: JICA Study Team

Figure 5.5.2 Types of Substructures

The salient features of the existing bridges are listed below.

- All bridges are managed by numbering from Yangon Station.
- The distances in miles of each bridge are measured from Yangon Station as the starting point (0 mile). It is to be noted that the left side of main line facing toward Mandalay Station from Yangon Station is termed as "Up Line".
- MR has a list of existing bridges. However, some bridges that were closed and rebuilt recently are not reflected in the list.
- Some bridges were built before the World War II, so they are at least 70 years old. Some of them were built more than 100 years ago. Consequently, for most of these bridges, these are no design and completion documents.
- Almost all the bridges have been basically designed for a 12.5t or a 17t axial load.

(2) Inspection of Existing Bridges

At the early stage of this study, in order to confirm the bridge conditions and environments around the bridges, the site survey of important bridges existing along the Taungoo – Mandalay Main Line was conducted. The important bridges were chosen mainly by the structural types and their lengths.

1) Summary of Inspection

This survey with MR staff was conducted as below.

- Duration of Survey: 26th Apr. 2017 to 28th Apr. 2017 (Total 3 days)
- Total Number of Bridges: 71 Bridges
- Selection Criteria: Selection criteria of target bridges as below.
  - Length: Longer than 40ft (Basically)
  - Number of spans: More than 3 spans (Basically)
- Method of Survey: Visual inspection (Using MR's inspection car)
- Main Purpose for the Survey：
  - To check condition of existing bridges (Incl. new ones)
  - To check classification of river and channel
  - To check level crossings near target bridges.
  - To check condition of existing R.O.Bs

2) Target Bridges

The lists of target bridges are indicated in Table 5.5.1 through Table 5.5.4.

Table 5.5.1 Target Bridges (1)

●: Same span as Up Line (UP)

Station Name & Bridge	Location Mileage (mile)		Location Kilometer (km)	Interval (km)	Up Line (UP)					Remarks	Down Line (DN)					Remarks
					Bridge Length			Total Length (m)	Axle Load Type		Bridge Length			Total Length (m)	Axle Load Type	
					Span	Length (feet)	Total (feet)				Span	Length (feet)	Total (feet)			
Taungoo	165	21	266.950													
270	167	7	269.230	0.536	2	40	80	24.38						●	HM	
279 A	171	16	276.271	1.006	1	47.5	47.5	14.48	-	CLOSED (F.O.B)						
Kyedaw	171	18	276.405	0.134												
281 A	175	10	282.306	1.207						CLOSED (F.O.B)						
Kyungon	175	12	282.440	0.134												
Kaytumadi	180	12	290.487	1.073												
291	181	14	292.230	0.672	3	10+10+10	30	9.14						●	ML	
Yedashe	183	6	294.912	0.536												
298	184	14	297.058	0.201	3	20	60	18.29						●	ML	
299	185	1	297.796	0.738	3	10	30	9.14						●	ML	
Kongyi	187	6	301.350	1.609												
301	187	10	301.618	0.268	1	40	40	12.19		PRESTRESSED CONC GIRDER				●	HM	SITTING SPAN
306	190	12	306.580	1.073	1 1 1 1	100 58 150 40	348	106.07	ML	Truss Girder	1 1 1 1	58 100 150 40	348	106.07		Truss Girder
Swa	191	12	308.189	0.671												
Thargaya	195	6	314.224	0.671												
Tharyargon	197	0	317.041	0.671												
320 A	197	3	317.242	0.201	3	20	60	18.29	ML					●		
325	199	17	321.399	1.140	2	20	60	18.29	ML					●		
Myohla	201	6	323.880	0.671												
329	201	21	324.886	0.672	1	60	60	18.29	ML	Through PL Girder				●		Through PL Girder
Yeni	206	12	332.330	0.536												
350	209	16	337.426	0.402	2	40	80	24.38	HM					●		
Tawuti	210	0	337.962	0.536												
351	210	9	338.566	0.604	1 1 1	40 100 40	180	54.86	HM HM	Through PL Girder				●		Through PL Girder
Hteininn	214	0	344.400	0.067												
Ela	216	18	348.825	0.939												
373	217	3	349.429	0.469	1 1 1	40 150 60	250	76.20	HM 	Truss Girder				●		Truss Girder
379	218	19	352.111	0.335	3	20	60	18.29	HM					●		
Pyaywun	219	4	352.715	0.604												
384	220	16	355.129	0.604	1 1	20 20	40	12.19	ML HM					●		
392	225	0	362.102	0.335		1				CLOSED (F.O.B)						
Pyinmana	225	0	362.102	0.000												
393	225	15	363.108	1.006	1 3 1	40 100 40	380	115.82	HM HM	Truss Girder	1 4 1	45.75 85 28.25	414	126.19		PC Girder

Source: JICA Study Team

Table 5.5.2 Target Bridges (2)

●: Same span as Up Line (UP)

Station Name & Bridge	Location Mileage (mile)		Location Kilometer (km)	Interval (km)	Up Line (UP)					Remarks	Down Line (DN)					Remarks
					Bridge Length			Total Length (m)	Axle Load Type		Bridge Length			Total Length (m)	Axle Load Type	
					Span	Length (feet)	Total (feet)				Span	Length (feet)	Total (feet)			
406	229	11	369.277	0.335	1	6	6	1.83		ARCH CULVERT				●		Plate Girder
Ywadaw	230	0	370.149	0.469												
Naypyitaw	233	0	374.977	0.469												
Kyidaungkan	235	6	378.598	1.408												
417	235	12	379.001	0.402	2	40	80	24.38		PC Girder				●	HM	
419	236	18	381.012	0.469	1	40	60	18.29	HM		1	?				PC Girder
					1	20			HM							
Pyokkwe	240	12	387.047	0.201												
433	240	24	387.852	0.335	2	40	80	24.38	HM					●		PC Girder
436	242	22	390.936	1.073	3	20	60	18.29	ML					●		RC Girder
Sinbyugyun	243	12	391.875	0.402												
Shwemyo	246	18	397.106	0.268												
453	250	10	403.007	1.073	4	100	400	121.92		Truss Girder	6	57.5	345	105.16		PC Girder
Sinthe	251	0	403.945	0.939												
Tatkon	253	12	407.969	1.073												
Magyibin	257	12	414.406	0.939												
477	260	10	419.100	0.201	2	40	80	24.38	HM					●		RC Girder
Nyaunglun	261	12	420.843	0.604												
485	263	21	424.666	0.738	1	40	40	12.19						●		PC Girder
497	267	1	429.762	0.872	2	40	80	24.38	HM					●		PC Girder
Hngetthaik	268	0	431.304	0.738												
501	268	17	432.444	0.201	3	2	6	1.83		ARCH CULVERT						RC Girder
Ingon	270	18	435.730	0.671												
Yamethin	274	12	441.765	0.939												
Ingyinkan	278	12	448.202	0.671												
519	281	8	452.762	1.475	1	34	112	34.14		PL Girder				●		PC Girder
					1	44										
					1	34										
Shweda	282	12	454.640	1.878												
523	282	21	455.243	0.201	4	20	80	24.38	ML					●		RC Girder
524	283	1	455.511	0.268	3	20	60	18.29	BL					●		RC Girder
527	284	4	457.322	0.134	4	40	160	48.77		PC Girder	8	20	160	48.77	ML	PL Girder
529	286	7	460.742	0.671	1	100	100	30.48		Truss Girder	2	40	80	24.38		PC Girder
Pyawbwa	287	12	462.686	1.006												
536	289	5	465.436	0.469	1	6	6	1.83		RAIL OPENING				●		
Shanywa	292	18	471.135	0.335												
573	297	24	479.585	0.469	3	20	60	18.29		RC Girder				●		

Source: JICA Study Team

Table 5.5.3 Target Bridges (3)

●: Same span as Up Line (UP)

Station Name & Bridge	Location Mileage (mile)		Location Kilometer (km)	Interval (km)	Up Line (UP)					Remarks	Down Line (DN)					Remarks
					Bridge Length			Total Length (m)	Axle Load Type		Bridge Length			Total Length (m)	Axle Load Type	
					Span	Length (feet)	Total (feet)				Span	Length (feet)	Total (feet)			
574	298	9	480.188	0.604	1 4 1	20 40 20	200	60.96		RC Girder PC Girder RC Girder	2 4	20 40	200	60.96	ML HM	PL Girder
Nyaungyan	299	6	481.596	0.201												
577	299	8	481.730	0.134	3	20	60	18.29		RC Girder				●	HM	
580	300	1	482.870	0.201	4	20	80	24.38		RC Girder				●	ML	
581	300	3	483.004	0.134	2	57.25	114.5	34.90		PC Girder	3	40	120	36.58	HM	PL Girder
585	301	9	485.016	0.402	2	50	100	30.48		PC Girder	5	20	100	30.48	HM/ML	
586	301	14	485.351	0.335	6	20	120	36.58		RC Girder				●	ML	PL Girder
Nwato	302	6	486.424	0.671												
588	302	16	487.095	0.671	3	40	120	36.58		PC Girder	4	40	160	48.77	HM	PL Girder
599	305	8	491.386	0.268	1 1 1	20 40 20	80	24.38		RC Girder PC Girder RC Girder				●	ML HM ML	
601 A	305	24	492.459	0.671	1	143	143	43.59		CLOSED (F.O.B)						
Thazi	306	0	492.459	0.000												
Ywapale	310	12	499.701	0.604												
622	311	18	501.713	0.201	2	40	80	24.38		PC Girder				●	ML	
Hanza	315	12	507.748	0.604												
Dahattaw	318	18	512.978	0.268												
Thedaw	322	6	518.611	0.671												
663	322	10	518.879	0.201	2 1	20 40	80	24.38	HM					●		PC Girder
Khinban	325	18	524.244	1.676												
677	326	18	525.853	1.006	2	40	80	24.38	HM	PL Girder				●		PC Girder
Samon	329	0	529.474	0.939												
683	329	21	530.882	0.268	4	57.5	230	70.10		PC Girder	2 1	40 150	230	70.10	HM	Truss Girder
684	330	11	531.821	0.939	4	40	160	48.77		PC Girder				●	HM	PL Girder
688	331	20	534.034	0.604	2	40	80	24.38		PC Girder				●	HM	
Odokkon	332	12	535.107	0.402												
691	332	23	535.844	0.738	6	57.5	345	105.16		PC Girder	7	40	280	85.34	HM	PL Girder
692	334	23	539.063	2.079	5	20	100	30.48		RC Girder	5	20	100	30.48	ML HM	
694	335	8	539.667	0.268	3	20	60	18.29		PC Girder				●	ML	
Thabyetaung	336	6	541.142	1.207												
699	340	1	547.244	1.475	3	57.5	172.5	52.58		PC Girder	5	40	200	60.96	HM	PL Girder
Kumelan	341	12	549.591	0.402												
707	342	12	551.200	0.201	2	40	80	24.38	HM					●		PC Girder

Source: JICA Study Team

Table 5.5.4 Target Bridges (4)

●: Same span as Up Line (UP)

Station Name & Bridge	Location Mileage (mile)		Location Kilometer (km)	Interval (km)	Up Line (UP) Bridge Length Span	Length ('eet)	Total (feet)	Total Length (m)	Axle Load Type	Remarks	Down Line (DN) Bridge Length Span	Length (feet)	Total (feet)	Total Length (m)	Axle Load Type	Remarks
718	345	11	555.961	0.335	1	100	100	30.48	HM	Truss Girder	1	20				RC Girder
											1	60	100	30.48		PC Girder
											1	20				RC Girder
719	346	2	556.967	1.006	2	150	300	91.44		Truss Girder	1	57				
											3	85	312	95.10		PC Girder
720	346	13	557.705	0.134	3	10	30	9.14	HM					●		RC Girder
Myitthar	347	0	558.442	0.604												
727	349	20	563.002	1.207	2	40	80	24.38	HM	I.R.S				●		PC Girder
730	351	10	565.550	0.469	1	100	100	30.48	HM	Truss Girder	1	20				RC Girder
											1	40	80	24.38		PC Girder
											1	20				RC Girder
Minzu	352	12	567.294	0.805												
739	355	13	572.189	1.006	5	20	100	30.48	HM	2 NOS 1924 1NO 1927 & 2NOS 1928				●		RC Girder
748	358	11	576.883	0.134	4	57.5	230	70.10		PC Girder	2	40			ML	
											1	150	230	70.10		Truss Girder
Kyaukse	359	6	578.157	0.335												
Belin	363	12	584.997	0.738												
788	365	22	588.886	0.402	2	40	80	24.38	HM	PL Girder				●		PL Girder
796	366	23	590.562	0.201	1	60	60	18.29	ML	Through PL Girder				●		Through PL Girder
Singaing	369	0	593.848	0.805												
822	374	1	601.962	0.872	1	45.5	45.5	13.87		CLOSED (F.O.B)						
Paleik	374	6	602.297	0.335												
826	376	2	605.247	1.676	4	150										Composite Steel
					2	40	680	207.26	HM	Truss Girder				●		Box Girder (JFE)
827	377	2	606.857	1.609	1	45.5	45.5	13.87		CLOSED (F.O.B)						
Myitnge	377	18	607.930	1.073												
R.O.B																
830	380	0	611.551	1.609	5	40	320	97.54	HM	CONT NO.3962 & 1924	8	40	320	97.54		PC Girder
					3	40			ML	CONT NOE 334 / 2891 OF 1945						
Tagundaing	380	12	612.355	0.335												
Myohaung	382	18	615.976	1.676												
R.O.B																
838 A	383	19	617.653	0.671	1	45.5	45.5	13.87		CLOSED (F.O.B)						
Shanzu	384	0	617.988	0.201												
R.O.B																
R.O.B																
843	385	3	619.799	1.341	1	45.5	45.5	13.87		CLOSED (F.O.B)						
R.O.B																
Mandalay	385	12	620.402	0.604												

Source: JICA Study Team

(3) Current Conditions and Problems of Superstructures

1) Steel Deck Plate Girders

(a) Unstable Shoe Structures

The stacked wooden sleepers set on abutments and piers, and part of shoes (sole plates) or girders set on them directly. These seem to be the countermeasures for lack of shoes and for adjustment of height based on the settlement etc. of abutments and piers. Also, these sleepers have not been secured to superstructures or substructures. Therefore, there is a risk of the horizontal displacement of these sleepers and the collapse of the girders. These conditions can be seen in almost all of steel deck plate girders [Figure 5.5.3].

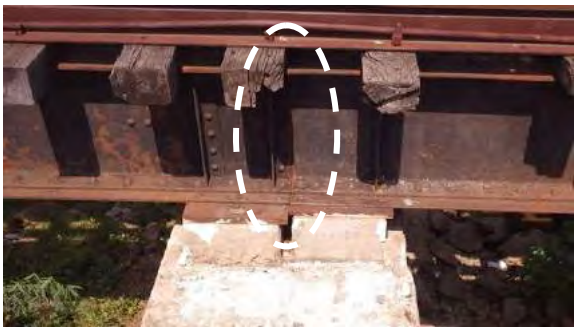
Source: JICA Study Team

Figure 5.5.3 Unstable Shoe Structures (Bridge No.325)

(b) Reduction of Joint Gaps

The girder ends clashing with next girder ends or abutments due to the horizontal motion can be seen in multiple locations [Figure 5.5.4 (a), (b)]. These conditions might cause further damages to the girders and abutments, and progression of deformation. In addition, there are a lot of countermeasures by setting wooden sleepers between girders to maintain joint gaps. [Figure 5.5.4 (c)].

(a) Bridge No.384



(b) Bridge No.577

(c) Bridge No.320A

Source: JICA Study Team

Figure 5.5.4 Reduction of Joint Gaps

(c) Deformation of Lateral Bracings under Tracks

There are several bridges with the local deformation of lateral bracings. From the long-term perspective, there is a risk that such bridges cannot keep the structural stability and integrity [Figure 5.5.5].

Source: JICA Study Team

Figure 5.5.5 Deformation of Lateral Bracings under Tracks (Bridge No.384)

(d) Corrosion due to Repeating Submergence

The trace of submergence judged based on the location of rust on the main girder's webs can be seen. These bridges are thought to submerge repeatedly when water levels rise during the rainy season [Figure 5.5.6].

Source: JICA Study Team

Figure 5.5.6 Corrosion due to Repeating Submergence (Bridge No.291)

(e) Girders Supported by Temporal Members

There are several girders supported by temporal members after the partial collapse of piers due to scour. These supports are composed of only stacked wooden sleepers or steel members. Therefore, there are at risk of the collapse and flowing when water levels rise during the rainy season [Figure 5.5.7].

(a) Bridge No.270

(b) Bridge No.739

Source: JICA Study Team

Figure 5.5.7 Girders Supported by Temporal Members

2) Steel Through Truss Girders

(a) Interference with Portal Bracings to Construction Gauge

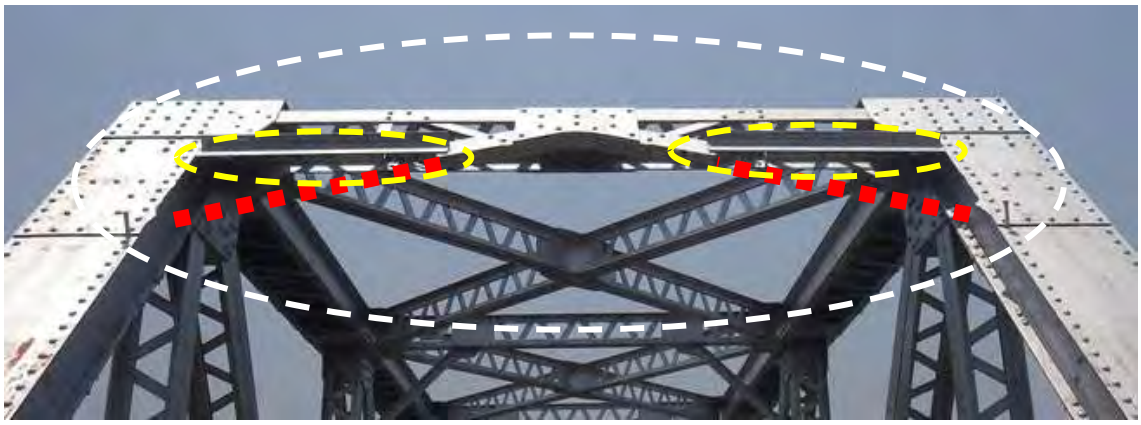
There are generally the portal bracings at each end of truss girders. These members are thought to be obstacles because they don't have enough clearance for the construction gauge of future cars including freight cars which would expect a high level of demand [Figure 5.5.8].

Source: JICA Study Team

Figure 5.5.8 Interference with Portal Bracings to Construction Gauge (Bridge No.373)

(b) Converted Portal Bracings

In some truss bridges, temporal members are attached after removing a part of original portal bracings (Red dashed lines). These are thought to be the countermeasures for preventing interference with the present construction gauge. However the temporal members (Yellow dashed circles) do not seem to have performance equivalent to original ones because of the section deficiency and the unsuitable joining method with a welding [Figure 5.5.9].



Source: JICA Study Team

Figure 5.5.9 Converted Portal Bracings (Bridge No.529)

(c) Unstable Temporary Supporting

The truss girder is temporarily supported by stacked wooden sleepers. It is really in unstable condition because there are no anchor bolts to restrict the horizontal movement [Figure 5.5.10].

Source: JICA Study Team

Figure 5.5.10 Poor of Bearings (Bridge No.718)

(d) Corrosion and Cross-section Reduction of Cross Beams under Tracks

In all the truss bridges, the cross beams under the tracks are corroding locally and progressing rapidly as a result of the effect of organic excrement from the passing trains. Many parts of the bridges have been either partially painted or covered with doubling plates by bolting and welding [Figure 5.5.11].

(a) Bridge No.453

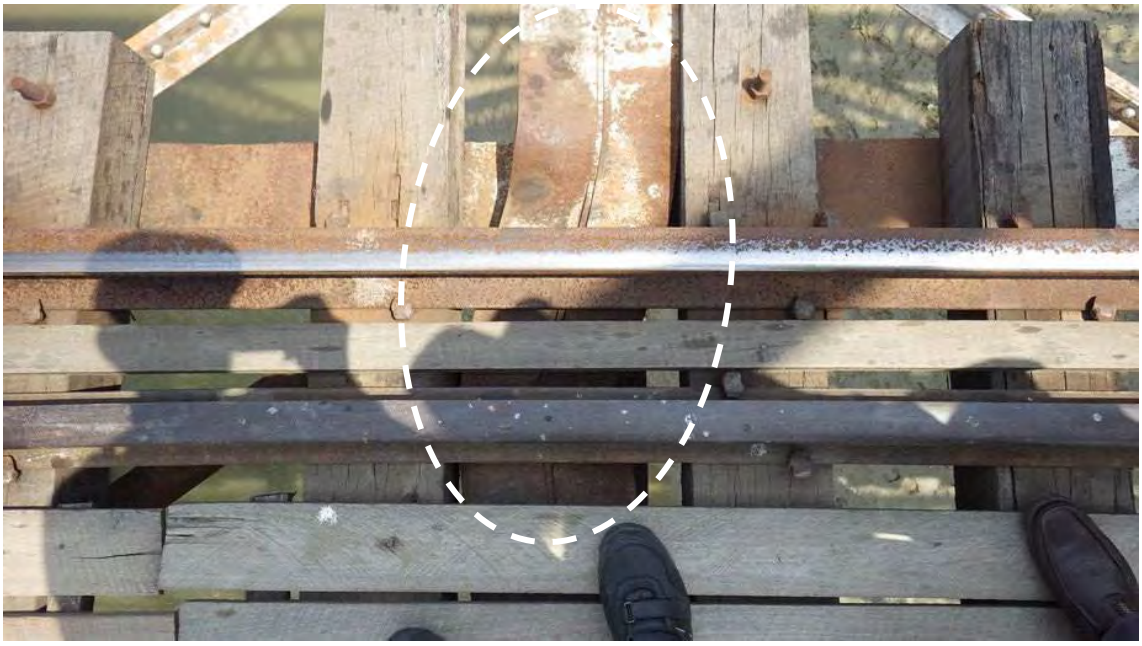
(b) Bridge No.730

Source: JICA Study Team

Figure 5.5.11 Corrosion and Cross-section Reduction of Cross Beams under Tracks

(e) Deformation of Cross Beams under Tracks

The deformation of the upper flanges of cross beams under the tracks can be seen. These deformations seem to be based on collisions of wheels by the derailment because the deformation points are close to rails and exist continuously in the direction of the railway [Figure 5.5.12].



Source: JICA Study Team

Figure 5.5.12 Deformation of Cross Beams under Tracks (Bridge No.373)

(f) Panel Points Filled with Concrete

The concrete filled in panel points at many truss girders have been deteriorated. They may accelerate the progression of steel corrosion caused by pooling of rain water in the deteriorated points [Figure 5.5.13].

Source: JICA Study Team

Figure 5.5.13 Panel Points Filled with Concrete (Bridge No.306)

a) Damages of Other Structural Members

For some bridges, there are several damages with local cross-sectional deficiency in the structural members. These damages seem to be the bullet holes during the war [Figure 5.5.14].

Source: JICA Study Team

Figure 5.5.14 Damage of other Structural Members (Bridge No.683)

3) Concrete Girders

(a) Durability Deterioration Caused by Material and Construction Faults

For the RC and PC girders, there are many evidences of the separation and exposure of materials such as aggregates or reinforcing bars and the pocks related to lack of compacting and so on. These problems are caused by the use of non-conforming materials and inadequate mix proportion, shoddy formworks under construction [Figure 5.5.15].

Source: JICA Study Team

Figure 5.5.15 Durability Deterioration Caused by Material and Construction Faults (Bridge No.270)

(b) Girder Surface Covered with Mortar

For the RC and PC girders (side surface of the girders), since many girders are covered with repair mortar, the initial defects and cracks due to shoddy workmanship can't be confirmed by a visual inspection [Figure 5.5.16].

Source: JICA Study Team

Figure 5.5.16 Girder Side Surface Covered with Repair Mortar (Bridge No.436)

(c) Spillage of Ballast from Joint Gaps between Girders

There are places where ballast spill out of the joint gaps between each girder. That is why the track structures might be unstable [Figure 5.5.17].

Source: JICA Study Team

Figure 5.5.17 Spillage of Ballast from Joint Gaps between Girders (Bridge No.586)

(4) Current Conditions and Problems of Substructures

1) Abutments and Piers

(a) Structural Instability Due to Aged Deterioration in Bodies of Substructures

For the aging brick abutments and piers, there are many damages such as fallen bricks, loose bricks, and body cracks [Figure 5.5.18 (a), (b)]. Besides this, many cracks at the boundaries of piers between the Up Line and Down Line can be seen [Figure 5.5.18 (c)].

(a) Bridge No.497

(b) Bridge No.306

(c) Bridge No.519

Source: JICA Study Team

Figure 5.5.18 Structural Instability Due to Aged Deterioration in Bodies of Substructures

(b) Structural Instability Due to Bearing Capacity Deficiency of Substructure Foundations

For the aging abutments and piers, there are cracks caused by the settlement and inclination due to the deficiency of bearing capacity [Figure 5.5.19].

(a) Bridge No.599

(b) Bridge No.677

(c) Bridge No.497

Source: JICA Study Team

Figure 5.5.19 Structural Instability Due to Bearing Capacity Deficiency of Substructure Foundations

(c) Surface Coating with Mortar

The body surface of several brick abutments and piers is covered with mortar [Figure 5.5.20].

Source: JICA Study Team

Figure 5.5.20 Surface Coating wtih Mortar (Bridge No.527)

(d) Scour around Pier Foundations Caused by Flowing Water

Exposure of the piles supporting the bridge piers can be seen which is caused by the scouring action. In these places, there is a possibility that the piers might settle and incline in the future [Figure 5.5.21]. However, some of the bridges already have anti-scour protection works [Figure 5.5.22].

Source: JICA Study

Figure 5.5.21 Scour around Pier Foundations Caused by Flowing Water (Bridge No.691)

Source: JICA Study Team

Figure 5.5.22 Anti-Scour Protection Works (Bridge No.699)

For the bridge No.588, although the soundness of anti-scour protection works were fine during 2013 survey, scour progression around these works could be confirmed during this survey [Figure 5.5.23].

(a) Bridge No.588 (2013) (b) Bridge No.588 (2017)

Source: JICA Study Team

Figure 5.5.23 Scour Progression (Bridge No.588)

(e) Damages of Pile Foundations

For the bridge No.719, piles that are exposed by scour are suffering damage [Figure 5.5.24]. These damages are thought to be caused by the eroding action especially in rainy season and the low-quality material and shoddy workmanship at the construction stage.

Source: JICA Study Team

Figure 5.5.24 Damages of Pile Foundations (Bridge No.719)

(f) Aged Deterioration of Piers with Concrete-filled Steel Tubular

For this type of the piers, deformations of several structural members due to the rust progression and local buckling can be seen [Figure 5.5.25].

(a) Bridge No.727 (b) Bridge No.788

Source: JICA Study Team

Figure 5.5.25 Aged Deterioration of Piers with Concrete-filled Steel Tubular

(g) Lack of Bearing Seats

For some of the RC piers, there is a possibility that the girders might collapse due to the lack of bearing seats when earthquakes occur [Figure 5.5.26].

(a) Bridge No.393 (b) Bridge No.453

Source: JICA Study Team

Figure 5.5.26 Lack of Bearing Seats

2) Wing and Retaining Walls

(a) Structural Instability due to Aged Deterioration in Wing and Retaining Walls

For the aging wing and retaining walls, there are many damages, such as fallen bricks, loose bricks, and body cracks [Figure 5.5.27 (a)]. And many cracks and gaps at the structural boundaries can be seen. Disintegration of joints can be observed in some walls. These structures do not have enough strength and horizontal bearing capacity [Figure 5.5.27 (b)].

(a) Bridge No.497 (b) Bridge No.574

Source: JICA Study Team

Figure 5.5.27 Structural Instability due to Aged Deterioration in Wing and Retaining Walls

(b) Spillage of Ballast and Embankment Materials

There are locations where the embankment materials and ballast have spilled out due to frequent heavy rain. These phenomena cause the roadbed loosening at the back side of the abutments and the strength reduction and settlement of the tracks [Figure 5.5.28].

(a) Bridge No.393 (b) Bridge No.719

Source: JICA Study Team

Figure 5.5.28 Spillage of Ballast and Embankment Materials

5.5.2 Improvement Plans of Railway Bridges

(1) Brief of Basic Policies

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.

(2) Basic Policies for Each Structural Type

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 high magnitude 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 [Figure 5.5.29]). 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 bridges constructed since 2000 are shown in Table 5.5.5.

(a) Bridge No.453 (b) Bridge No.691

Source: JICA Study Team

Figure 5.5.29 Concrete Girder Bridges (Constructed after 2000)

Table 5.5.5 List of Bridges Constructed since 2000

Bridge No.	UP or Down (DN)	Bridge No.	UP or Down (DN)
393	DN	684	UP
453	DN	691	UP
519	DN	692	UP
527	UP	699	UP
529	DN	718	DN
574	UP	719	DN
581	UP	727*	DN
585	UP	730	DN
586	UP	748	UP
588	UP	826	DN
677*	DN	830	DN
683	UP	---	---

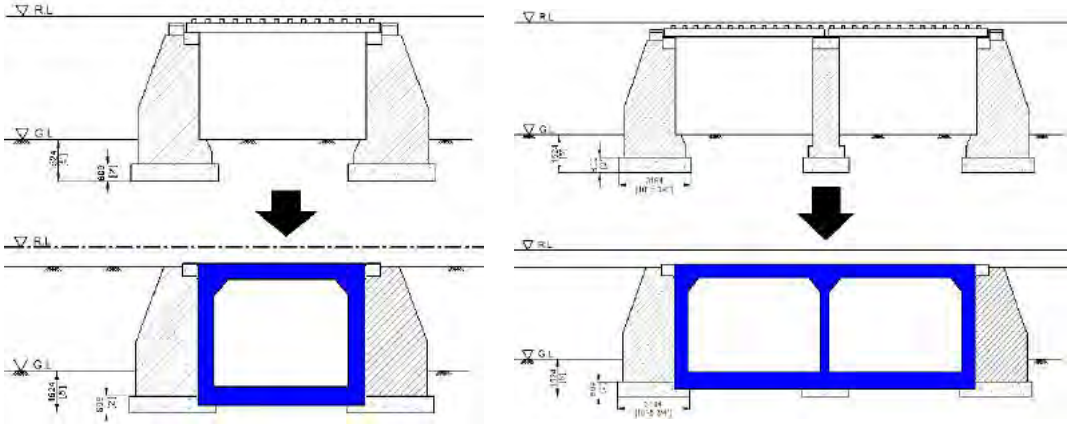
* Bridge Length is 30m or less.

Source: JICA Study Team

(3) Bridge Renewal Plans (Based on the concept of Phase1 Stage)

1) Box Culverts (Estimated 181 Locations)

Box culverts are applied over waterways categorized as channels where the actual bridge length is less than 30 m. The following figure shows the schematic examples of box culverts that are planned to be constructed between existing abutments.



(a) Simple Span (b) Multiple Span

Source: JICA Study Team

Figure 5.5.30 Box Culverts to be Constructed between Existing Abutments

Here, the characteristics and merits of box culverts are described below.

- Characteristics

  a) Box culverts shall be constructed between existing abutments.

  b) Existing abutments shall not be removed.

  c) Existing piers shall be removed except for the foundations. However, if the remaining foundations negatively affect newly built box culverts, those should be removed completely.

  d) Box culverts with more than one span shall be designed according to total bridge lengths.

  e) Upper surface level of the lower slab shall be the same as the riverbed surface level.

  f) Construction of box culverts shall be considered under single track operation. (Some of them might be considered under double track operation).

- Merits

  a) No need for piles (Rail piles are partially applied).

  b) No need for bearings.

  c) No need to remove existing abutments.

  d) Existing abutments contribute to function as buffers of the approach sections to the box culverts.

  e) Low cost, easy to construct in comparison with newly built girder bridges.

  f) No problems regarding structural strength or function in comparison with newly built girder bridges.

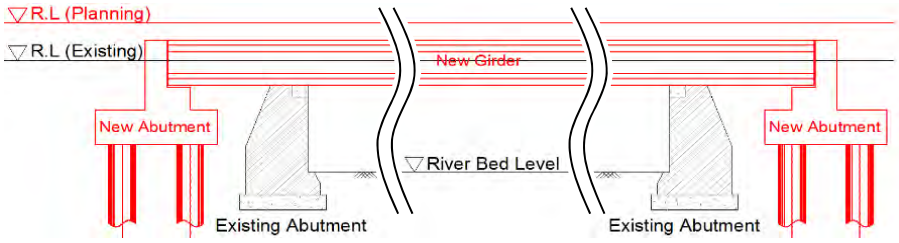
2) Girder Bridges (Estimated 27 Locations)

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. Here, the following 2 patterns can be considered for the construction forms of girder bridges.

(a) Type-1: New Abutments Built behind Existing Abutments

This type is applied in cases where the existing track spacing is not large, and there are existing obstacles or soft grounds around, with the aim of minimal change in the existing horizontal alignment, during construction under the single track operation.

■ Option 1

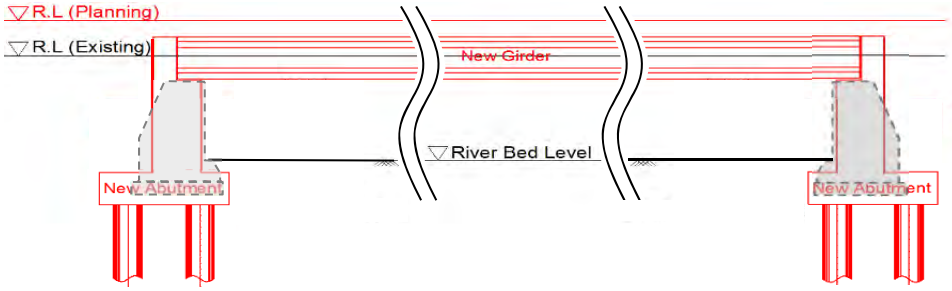


Source: JICA Study Team

Figure 5.5.31 Type-1: New Abutments Built behind Existing Abutments

(b) Type-2: New Abutments Built at Existing Abutments

This type is applied in cases where the existing track spacing is large, or there are no existing obstacles and soft grounds around, so as to continue the double track operation while constructing a new single track bridge one at a time, or a new double track bridge at the same time.

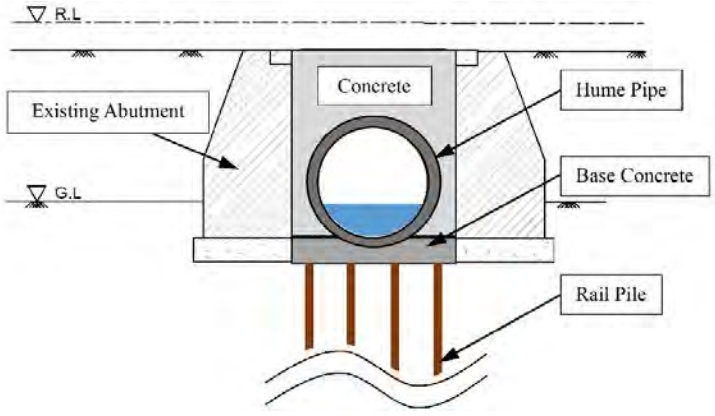


Source: JICA Study Team

Figure 5.5.32 Type-2: New Abutments Built at Existing Abutments

3) Precast Structures (Estimated 216 Locations)

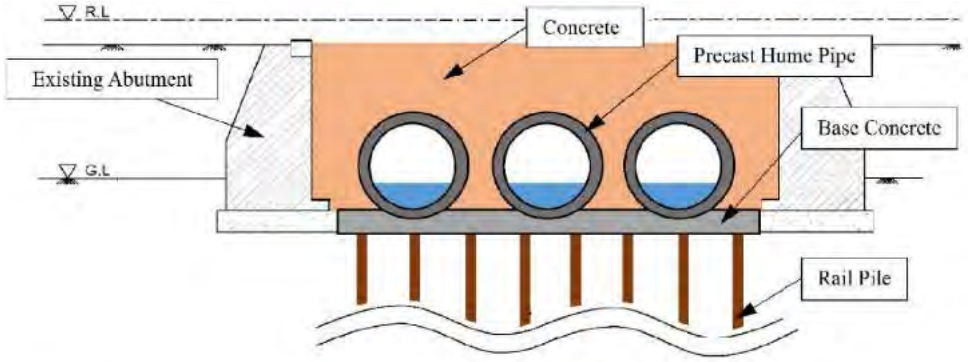
For existing bridges with short lengths under 3m, precast Hume pipes or its equivalent shall be used in construction.



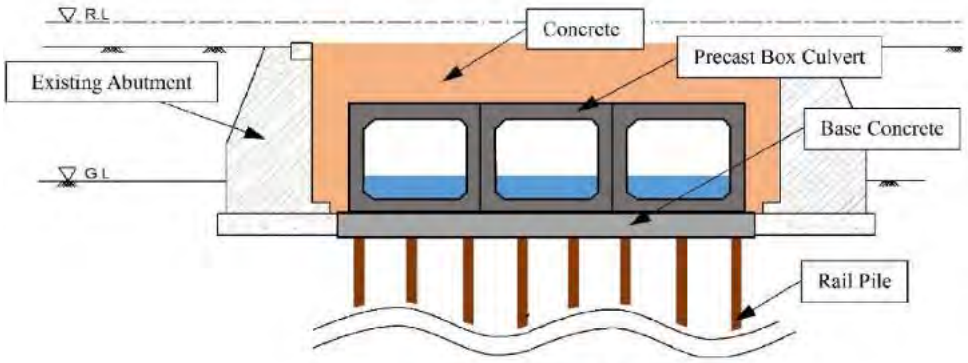
Source: JICA Study Team

Figure 5.5.33 Construction Using Precast Hume Pipe

Furthermore, in cases where the flow speed and discharge rate of rivers at relatively short span bridges despite the rainy season remain at a low level, not only cast-in-place box culverts, but also precast members arranged in parallel rows can be used as shown in Figure below. Therefore regarding these issues, it is needed to make adequate and concrete proposals with consideration for the merits of the cost and construction period at the Detailed Design stage.



(a) Parallel Precast Hume Pipe



(b) Parallel Precast Box Culvert

Source: JICA Study Team

Figure 5.5.34 Construction Applying Parallel Precast Members

5.6 R.O.B.

5.6.1 Current Conditions of Existing R.O.Bs

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.

The structural types and clearances of all existing R.O.Bs are as follows.

- R.O.B No.1 (Crossing of Yangon – Mandalay Expressway) [(a)]

  Structural Type: Composite Steel Deck Plate Girders

  Clearance: Approx. 5.1m

- R.O.B No.2 (Crossing of Land Thit Street) [(b)]

  Structural Type: Concrete Girders

  Clearance: Approx. 4.1m

- R.O.B No.3 (Crossing of Chan Mya Maria Street) [(c)]

  Structural Type: Concrete Girders

  Clearance: Approx. 3.9m

- R.O.B No.4 (Crossing of Yan Gyi Aung Street) [(d)]

  Structural Type: Concrete Girders

  Clearance: Approx. 4.0m

- R.O.B No.5 (Crossing at Mandalay Station) [(e)]

  Structural Type: Concrete Girders

  Clearance: Not measured

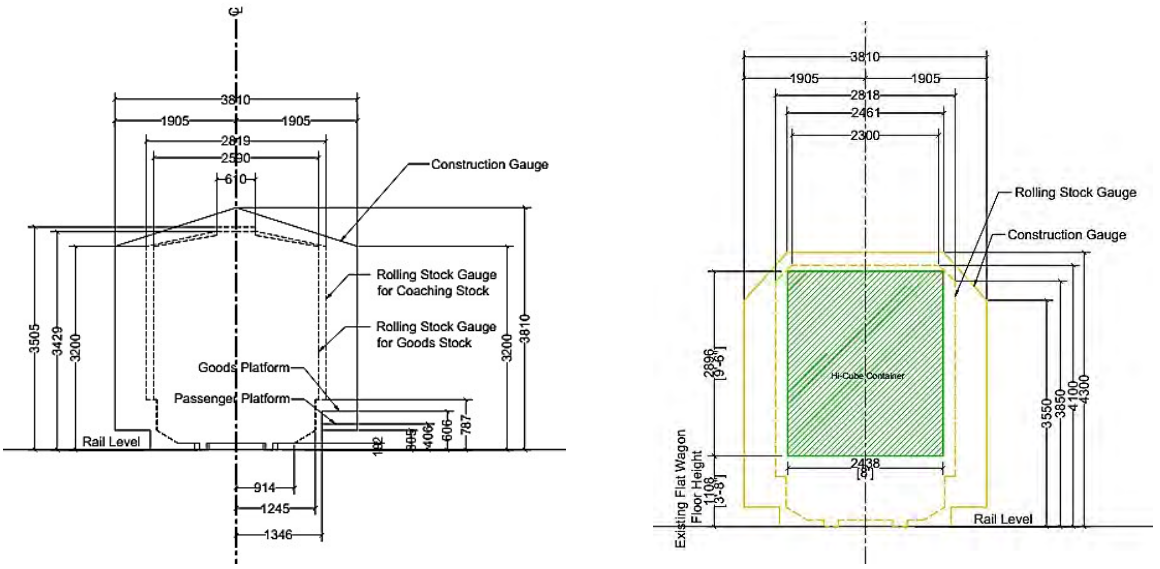
Source: JICA Study Team

Figure 5.6.1 R.O.Bs

5.6.2 Future Conditions of Existing R.O.Bs

All R.O.Bs meet the current construction gauge (3,810 mm). Of them, R.O.B No.1 located in the south area of Myohaung Station meets the future construction gauge (4,300 mm). Therefore, all R.O.Bs are not targeted for the improvement and renewal in this project.

The current and future construction gauges are shown in (a), (b).



(a) Current Construction Gauge (b) Future Construction Gauge (Same as Phase I)

Source: JICA Study Team

Figure 5.6.2 Construction Gauges

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.

In some of the unmanned level crossings, wooden sleepers are set between the rails. However, most unmanned level crossings are filled with gravel without guardrails. The soil and refuse between and around the tracks before and after the level crossing have been compacted by pedestrians the same as at the manned level crossings.

Many vertical alignments of the road are convex shape across the railway, and the visibility of the car driver and the train driver is inadequate.

Cars and motor bikes don't stop to determine the status of the safety of the level crossing.

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.

(3) Distance Post

MR uses the "Mile" as the distance unit from the starting station of its railway for structure and station locations, train operation, fare structure, and so on.

In the "Mileage" system, distances of less than one mile are indicated by a fraction, and locations of the structures, such as bridges, level crossings, and so on, are shown in 1/24 mile units and locations of the stations are shown in 1/4 mile units. Therefore, the locations of structures and stations are not very accurate.

The distance from Yangon is posted on the telecommunication poles every 1/24 mile (approximately 67m). The poles are 10m from the track.

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.

The main kilometrage posts are to be every 1km, the middle- kilometrage posts every 500m and the sub-kilometrage posts every 100m.

(4) Summary of Outline Design for Ancillary Civil Structures

MR has accepted the summary of outline design for ea

5.8 Signal House and OCC Building

5.8.1 Current Conditions of Signal House and OCC Building

(1) Signal House

Now there are four signal houses of Phase 2. It is Thazi Station, Pyinmana Station, Myohaung Station and Mandalay Station. The structures of the signal houses are foundations, columns, floors, etc., by reinforced concrete structures, and walls by brick. There are two floor types and three floor types. Thazi Station is at the same height as the F.O.B, Pyinmana Station, Myohaung Station, and Mandalay Station which are on the side of the track. These have been built more than 50 years ago, and leakage from the roof and the external walls are peeling off. Air conditioning facilities are not installed in these signal houses. Also, there is no toilet for staff. The signal house will be

built with the same specifications as Phase 1, so it is necessary to construct a signal house for these four stations.


Souce: JICA Study Team

Figure 5.8.1 Signal House

(2) OCC Building

There are three OCC Rooms. The OCC rooms are located in Taungoo Station, Naypyitaw Station, Thazi Station, and Mandalay Station. This room is located in the station building. The Station buildings of Naypyitaw and Mandalay have been rebuilt in recent years, and a comfortable environment is in place for the train operation control. However, the station buildings of Taungoo and Thazi are old and MR staffs are working for the train operation control in the station building without air conditioning facilities.

Souce: JICA Study Team

Figure 5.8.2 OCC Room

(3) Current conditions and improvements of communication equipment huts

There are buildings for the communication equipment huts at each station, but damage such as to roofs and ceilings is remarkable. Also, many air conditioning facilities in equipment huts are not functioning. In the field survey, there were cracks and breaks found in z columns and walls, and there are six communication equipment huts that need rebuilding. The current status of the communication equipment huts is shown in Table 5.8.1.

Table 5.8.1 The current status of the communication equipment huts

No.	Station Name	Condition of OFC Huts	No.	Station Name	Condition of OFC Huts
39	KYEDAW		67	INGYINKAN	
40	KYUNGON	Damage of eaves	68	SHWEDA	Damage of eaves
41	KAYTUMADI		69	PYAWBWE	Damage of eaves
42	YEDASHE		70	SHANYWA	Damage of eaves
43	KONGYI		71	NYAUNGYAN	Crack of column and wall
44	SWA		72	NWATO	rack of wall
45	THARGAYA	Damage of eaves	73	THAZI	Damage of eaves
46	THARYARGON		74	YWAPALE	Crack of column and wall
47	MYOHLA		75	HANZA	
48	YENI		76	DAHATTAW	
49	TAWUTI	Damage of eaves	77	THEDAW	
50	HTEININN		78	KHINBAN	
51	ELA		79	SAMON	
52	PYAYWUN	Damage of eaves	80	ODOKKON	
53	PYINMANA		81	THABYETAUNG	Crack of wall and damage of eaves
54	YWADAW		82	KUME LAN	Damage of eaves
55	NAYPYITAW		83	MYITTHAR	
56	KYIDAUNGKAN		84	MINZU	
57	PYOKKWE		85	KYAUKSE	
58	SINBYUGYUN		86	BELIN	
59	SHWEMYO		87	SINGAING	Damage of eaves
60	SINTHE		88	PALEIK	
61	TATKON		89	MYITNGE	
62	MAGYIBIN	Damage of eaves	90	TAGUNDAING	
63	NYAUNGLUN	Damage of ceiling	91	MYOHAUNG	
64	HNGETTHAIK	Damage of eaves	92	SHANZU	
65	INGON		93	MANDALAY	
66	YAMETHIN	Damage of eaves			

Source: JICA Study Team

Source: JICA Study Team

Figure 5.8.3 Extremely damaged communication equipment house

5.8.2 Phase 2 improvement policy and design policy

(1) Signal House

Along with updating of the signal system, it is necessary to construct a new signal house building. The signal house of each station is shown in Table 5.8.2. However, JST has been asked by MR to use the existing signal house of Naypyitaw Station. This signal house has to be repaired to a free access floor. And, JST agreed with MR at the 5th TAC meeting that it would not demolish the existing signal houses of the stations.

Table 5.8.2 The list of Signal House

No.	Station Name	Construction Building					Renovation (Free Accesfloor FL+300 etc.)		
		3 Story	2 Story	1 Story			1 Story		
		Signal Cabin Type3-A MSH	Signal Cabin Type2-A MSH	Signal Cabin Type1-B SSH	Signal Cabin Type1-A	Signal Power House	SSH	MSH	General OCC
		15m×6.5m ×3F = 292m^2	15m×6.5m ×2F = 195m^2	15m×6.5m ×1F = 97.5m^2	15m×6.5m ×1F = 97.5m^2	5m×7m× 1F = 35m^2	4m×10m = 40m^2	Station Building	MR Head Office
38	TAUNGOO								
39	KYEDAW				1				
40	KYUNGON				1				
41	KAYTUMADI								
42	YADASHE				1				
43	KONGYI				1				
44	SWA				1				
45	THARGAYA				1				
46	THARYARGON								
47	MYOHLA				1				
48	YENI				1				
49	TAWUTI				1				
50	HTEININN								
51	ELA				1				
52	PYAYWUN				1				
53	PYINMANA		1	1					
54	YWADAW				1				
55	NAYPYITAW					2	2	1	1
56	KYIDAUNGKAN				1				
57	PYOKKWE				1				
58	SINBYUGYUN				1				
59	SHWEMYO				1				
60	SINTHE				1				
61	TATKON				1				
62	MAGYIBIN				1				
63	NYAUNGLUN				1				
64	HNGETTHAIK				1				
65	INGON				1				
66	YAMETHIN				1				
67	INGYINKAN				1				
68	SHWEDA				1				
69	PYAWBWE				1				
70	SHANYWA				1				
71	NYAUNGYAN				1				
72	NWATO				1				

No.	Station Name	Construction Building					Renovation (Free Accesfloor FL+300 etc.)		
		3 Story	2 Story	1 Story			1 Story		
		Signal Cabin Type3-A MSH	Signal Cabin Type2-A MSH	Signal Cabin Type1-B SSH	Signal Cabin Type1-A	Signal Power House	SSH	MSH	General OCC
		15m×6.5m ×3F = 292m^2	15m×6.5m ×2F = 195m^2	15m×6.5m ×1F = 97.5m^2	15m×6.5m ×1F = 97.5m^2	5m×7m× 1F = 35m^2	4m×10m = 40m^2	Station Building	MR Head Office
73	THAZI	1		1					
74	YWAPALE				1				
75	HANZA				1				
76	DAHATTAW								
77	THEDAW				1				
78	KHINBAN				1				
79	SAMON				1				
80	ODOKKON								
81	THABYETAUNG				1				
82	KUME LAN				1				
83	MYITTHAR				1				
84	MINZU				1				
85	KYAUKSE				1				
86	BELIN				1				
87	SINGAING				1				
88	PALEIK				1				
89	MYITNGE				1				
90	TAGUNDAING				1				
91	MYOHAUNG		1	1					
92	SHANZU								
93	MANDALAY	1		1					

Source: JICA Study Team

The signal house of Phase 1 is classified from Type-1 to Type-3 according to building size and room layout. Phase 2 is in principle consistent with Phase 1 specifications. There are three types of buildings in Phase 2, and the total floor area will be a little extended in order to install electric facilities (Refer to table 5.8.2). Signal house design is recommended by applying a local construction method and local conventional materials in order for MR to make future maintenance work easier.

- Load considered in structural design

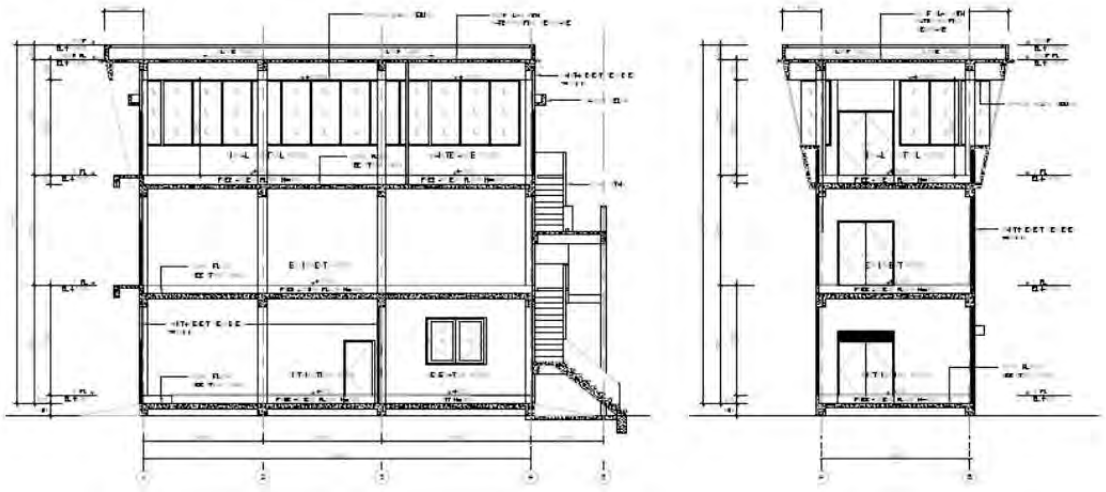
  Dead Loading, Floor live loading, Roof live loading, Wind loading, Seismic Loading

- Electrical facility design

  Power Supply, Lighting, Socket Outlet System

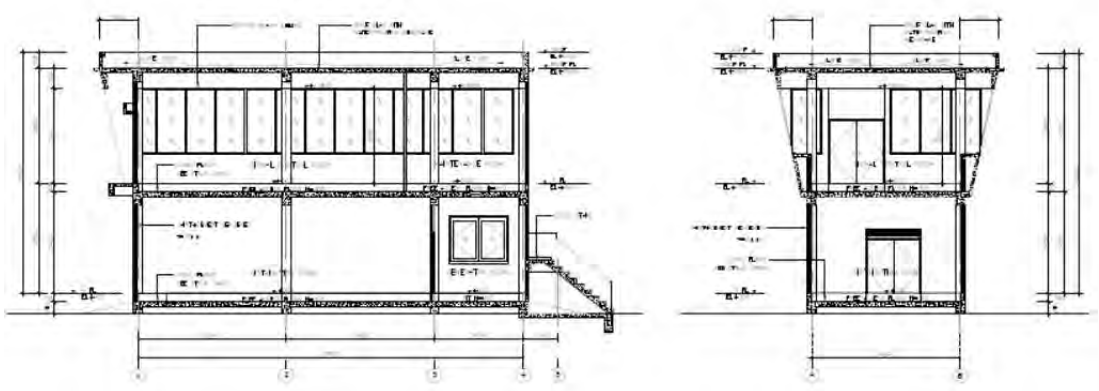
- Mechanical facility design

  Water Supply system, Drainage system, Sanitary Equipment, Air Conditioning System, Ventilation System, Fire Extinguishers Equipment



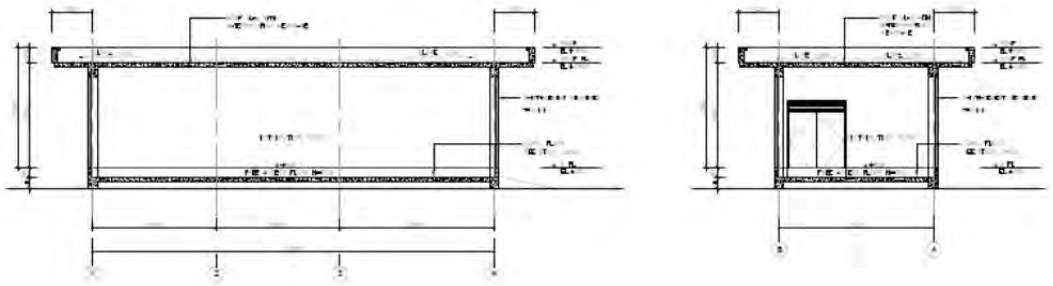
Source: JICA Study Team

Figure 5.8.4 OCC Signal Cabin Type3



Source: JICA Study Team

Figure 5.8.5 OCC Signal Cabin Type2



Source: JICA Study Team

Figure 5.8.6 OCC Signal Cabin Type1

The construction cost of the signal houses is as shown in Table 5.8.3. This cost includes architectural work, piling work, septickseptic tank, electrical work, air conditioning work, and plumbing work.

Table 5.8.3 the Cost of Signal Houses

(Unit : million)

Type of Signal Cabin	Cost (MMK)	Type of Signal Cabin	Cost (MMK)
Type3-A	133	Type1-B	53
Type2-A	100	Signal Power House	53
Type1-A	53	Renovation	53

Source: JICA Study Team

For the construction of the signal house, there is a possibility that relocation will be necessary for some items such as water tanks and warehouses etc. Therefore, the construction sites will be decided by consultation with MR in the detailed design stage.

(2) OCC Building

At the 3rd TAC meeting, it was requested by MR to install the OCC rooms of Taungoo, Thazi and Mandalay in a new signal house. The current OCC room of Neypyitaw will be renovated and used. And, part of MR Head office will be renovated to become a general OCC room. The OCC rooms of the Taungoo and Thazi Stations should be studied at the detailed design stage to determine if they could be installed inside the station buildings because there will be buildings rebuilt

(3) Communication Equipment Huts

At the 10th TAC meeting, there was a request from MR to install communication equipment in the newly built signal houses. For this reason, the current communication equipment huts will not be renovated and demolited.

(4) Machine Huts for Level Crossings

When the level crossings are set up huts will be installed to protect the level crossing equipment. The installation locations are as shown in Table 5.8.4.

Table 5.8.4 Location of machine huts for level crossings

No	Sta. No.	Station		Mileage		No.	Sta. No.	Station		Mileage	
		From	To	From	To			From	To	From	To
1		TAUNGOO	KYEDAW	166/22	23	41	66	YAMETHIN		274/14	15
2		TAUNGOO	KYEDAW	167/9	10	42				274/17	18
3	39	KYEDAW		171/13	14	43				275/4	5
4	40	KYUNGON		175/6	7	44		YAMETHIN	INGYINKAN	276/21	22
5	42	YEDASHE		182/21	22	45		SHWEDA	PYAWBWE	284/11	12
6				183/9	10	46	69	PYAWBWE		287/12	13
7		YEDASHE	KONGYI	184/13	14	47	71	NYAUNGYAN		299/4	5
8	43	KONGYI		186/22	23	48	73	THAZI		305/12	13
9	44	SWA		191/5	6	49	74	HANZA		315/11	12
10	45	THARGAYA		195/15	16	50	77	THEDAW		322/6	7
11	47	MYOHLA		201/8	9	51	78	KHINBAN		325/24	25
12	48	YENI		206/2	3	52				326/7	8
13				206/14	15	53	79	SAMON		328/18	19
14	49	TAWUTI		209/3	4	54	81	THABYETAUNG		336/10	11
15				210/2	3	55	82	KUME LAN		341/7	8
16		TAWUTI	ELA	210/23	24	56	83	MYITTHAR		346/10	11
17		HTEININN	ELA	214/20	21	57				346/18	19
18	51	ELA				58	84	MINZU		352/3	4
19	53	PYINMANA		224/16	17	59	85	KYAUKSE		358/8	9
20				225/5	6	60				358/21	2
21				225/8		61				359/4	5
22				225/9	10	62				359/17	18
23				225/22	23	63	86	BELIN		363/2	3
24		PYINMANA	YWADAW	227/2	3	64	87	SINGAING		368/10	11
25		PYINMANA	YWADAW	228/18	19	65				368/20	21
26	54	YWADAW		229/18	18	66		SINGAING	PALEIK	371/14	15
27	55	NAYPYITAW		233/21	22	67	88	PALEIK		374/3	4
28	56	KYIDAUNGKAN		234/23	24	68	89	MYITNGE		376/7	8
29				235/7	8	69				376/20	21
30		KYIDAUNGKAN	PYOKKWE	236/17	18	70				377/20	21
31	57	PYOKKWE		240/2	3	71	90	TAGUNDAING		379/13	14
32	60	SINTHE		250/24	25	72				380/18	19
33				251/16	17	73		TAGUNDAING	MYOHAUNG	381/3	4
34	61	TATKON		253/2	3	74	92	SHANZU	MANDALAY	383/18	19
35				253/11	12	75		SHANZU	MANDALAY	384/10	11
36				253/21	22	76		SHANZU	MANDALAY	384/13	14
37		MAGYIBIN	NYAUNGLUN	259/12	13	77		SHANZU	MANDALAY	384/15	16
38	63	NYAUNGLUN		261/3	4	78		SHANZU	MANDALAY	384/17	18
39				261/14		79		SHANZU	MANDALAY	384/21	22
40	64	HNGETTHAIK		267/15	16						

Source: JICA Study Team

The construction costs of machine huts are as shown in Table 5.8.5. This cost includes architectural work, pile construction, and embankment construction (1.5 m). Regarding construction costs, I agreed with Myanmar National Railway at the 10th TAC meeting. However, we will investigate for reduction in the detail design stage. At the 10th TAC meeting, JST agreed on the construction cost with MR, but JST will consider reducing the construction cost at the detailed design stage.

Table 5.8.5 Cost of machine huts for level crossings

(Unit : million)

Item	Cost (MMK)
Machine huts (10mx5m=50m^2)	26

Source: JICA Study Team

5.9 Railway Station

5.9.1 Survey of Station Building

(1) Brief of Survey

This survey was conducted as below.

- Duration of Survey: 15th May 2017 to 23th May 2017, 5th Jul. 2017 to 7th Jul. 2017(With MR)
- Survey Days: Total 10 days
- Total Number of research Stations: 55 stations
- Method of Survey: Visual inspection and interview with station staff
- Main Purpose for the Survey:
  - To check condition of existing station buildings and platform roofs.
  - To check condition of around the station and inside the station.
  - To check station facilities.
  - To check usage situation of station building.

(2) Target Stations

The lists of target stations are indicated in Table 5.9.1. And, details of the investigation station are shown in the Appendix 5.9.

Table 5.9.1 Summary of Station Type and Station Facilities

No	Sta. No.	Express Stop	Station Name	Main Structure A: Wooen B: Brick C: Concrete	Total Floor Area (m^2)	Length of Platformroof (m)	Remark
	38	○	TAUNGOO	B	1500	200	
1	39		KYEDAW	B	109		
2	40		KYUNGON	B	120		
	41		KAYTUMADI	B			To be abolished
3	42	○	YEDASHE	A	147	35	
4	43		KONGYI	B	120		
5	44	○	SWA	A	190	30	
6	45		THARGAYA	A	108		
	46		THARYARGON		19		To be abolished
7	47	○	MYOHLA	B	150	20	
8	48	○	YENI	A	120	35	
9	49	○	TAWUTI	A	126	25	
	50		HTEININN				To be abolished
10	51	○	ELA	A	96	35	
11	52		PYAYWUN	B	120		
12	53	○	PYINMANA	C	450	420	
13	54		YWADAW	A	78	50	
14	55	○	NAYPYITAW	C	2500		
15	56		KYIDAUNGKAN	A	120	25	
16	57		PYOKKWE	A	96	20	
17	58		SINBYUGYUN	B	120	20	
18	59		SHWEMYO	A	97	25	
19	60		SINTHE	A	150		
20	61	○	TATKON	A	169	70	
21	62		MAGYIBIN	B	120		
22	63		NYAUNGLUN	B	120		
23	64		HNGETTHAIK	A	120		
24	65		INGON	B	120		
25	66	○	YAMETHIN	C	280	85	
26	67		INGYINKAN	B	113		
27	68		SHWEDA	B	120		
28	69	○	PYAWBWE	C	200	85	
29	70		SHANYWA	B	118		
30	71	○	NYAUNGYAN	A	98	50	
31	72		NWATO	B	118		
32	73	○	THAZI	B	1350	275	
33	74		YWAPALE	B	111		
34	75		HANZA	B	230		
	76		DAHATTAW	C	12		To be abolished
35	77	○	THEDAW	A	126	70	
36	78		KHINBAN	B	118		
37	79		SAMON	B	118		
	80		ODOKKON	A	25		To be abolished

No	Sta. No.	Express Stop	Station Name	Main Structure A: Wooen B: Brick C: Concrete	Total Floor Area (m^2)	Length of Platformroof (m)	Remark
38	81		THABYETAUNG	B	115		
39	82		KUME LAN	B	230		
40	83	○	MYITTHAR	A	108	50	
41	84		MINZU	B	97		
42	85	○	KYAUKSE	B	174	80	
43	86		BELIN	B	118		
44	87		SINGAING	B	118		
45	88		PALEIK	A	97	30	
46	89		MYITNGE	A	126	50	
47	90		TAGUNDAING	B	117		
48	91	○	MYOHAUNG	A	120	50	
49	92		SHANZU	A	136	20	
50	93	○	MANDALAY	C	15000	280	

Source: JICA Study Team

5.9.2 Current Conditions of Station

There are 55 stations in Phase 2. In the operation plan of 5.1, which proposes to abolish five stations, there will be 50 stations in all.

[Kaytumadi, Tharyargon, Hteininn, Dahattaw, Odokkon]

Taungoo to Mandalay Line extended on 1st Mar, 1889 which was of British colonial origin.

Mandalay Station was renovated in 2001, Naypyitaw Station was renovated in 2009, but the Thazi Station building and many other station buildings were built at the time of opening. So that the exact age of building is unknown, and there are no drawings.

(1) The size of the station building

The scale of the station building can be categorized into three by the total floor area. The first one is a large-sized station building with a total floor area of 500 m^2 or more and many express stops. The second is a middle-sized station building with a total floor area of 100 m^2 or more. The third is a small station building with a total floor area of less than 100 m^2.

(2) Structure of the station building and specifications

As a result of visual inspection, the main structure of the station building can be categorized as wooden, brick and reinforced concrete structures.

1) Station building of wood structure

The wooden station building is made by the timber framework method, the column is 100 to 150 mm square and the beam is around 50 × 100 mm. The foundation is made by brick and reinforced concrete, the wall made by bricks or wood boards. Some station buildings have partly broken and

cracks in columns and foundations. These station buildings may collapse when the dead load and the seismic load is applied. Also, the roof is a tile roof or a corrugated steel sheet. The roofs of some station buildings have corroded rafters and cracks in roof tiles, and there is a danger of falling down due to wind or earthquake.

Figure 5.9.1 Thargaya Station

Figure 5.9.2 Nyaungyan Station

Source: JICA Study Team

Figure 5.9.3 Inconsistent settlement

Figure 5.9.4 Crack of foundation

2) Station building of brick structure

The station building of brick structure seems to have a foundation and columns made by bricks, beams, eaves and some roofs made by reinforced concrete. The roof is a trussing method and corrugated steel sheet. There are cracks and breaks in the columns, beams, walls and floors of many station buildings made by brick. It is considered that these are caused by differential settlements due to the effect of its own weight. It is unknown how much reinforcement steel and concrete are used for these main structures. A large breaking is about 3 to 5cm and there is a risk of collapse so that through the TAC meeting with MR (8th Jul, 2017), JST advised urgent surveys and repair of station buildings on the current situation.

At Thazi Station and other stations, which are said to have been built more than 100 years ago, steel beams are used for the structure of the building, which shows that it was built during the British colonial era.

Figure 5.9.5 Pyaywun Station

Figure 5.9.6 Steel structure of Tajee station

Figure 5.9.7 Ceiling collapse of Shanywa Station

Source: JICA Study Team

Figure 5.9.8 Crack of Ingyinkan Station

3) Station building of reinforced concrete structure

Built in recent years, the station buildings of Neypyitaw and Mandalay are reinforced concrete structures. The station building of Mandalay has a station in the lower part and a hotel in the upper part. It is a complex station building. Also in this station building, the peeling of concrete and floor tiles etc. are observed, and maintenance of the building is not done. Other station buildings of reinforced concrete structure also have cracks in the ceiling slabs and eaves. There is concern about the deterioration of the structure due to water leakage.

Source: JICA Study Team

Figure 5.9.9 Mandalay Station

Figure 5.9.10 Peeling of concrete

4) Architectural specification

The roofs of many station buildings are made by the trussing method and corrugated steel sheets and reinforced concrete. The doors and window sashes are made of wood. However, the doors and window sashes of the Naypyitaw and Mandalay Stations are made of aluminium. There are no screen doors and iron barred windows at all stations.

(3) Electrical facility of the station building

Many stations can secure electricity, but some stations don't have a village around them, so electricity can't be secured. These stations generate electricity using sunlight and generators.

1) Electric power system

The electric power system of the station building is used for lighting and socket outlets systems by the switchboard and wiring on a wall in the office.

2) Lighting system

Lighting equipment is installed in the office. Although it is also installed in the passenger waiting area and the platform roof, the amount is low. Also, many are not functioning. So that reason, the station building and the platform at night are dark.

3) Socket outlet system

Socket outlet equipment is installed at stations that can secure electric power.

Source: JICA Study Team

Figure 5.9.11 Lighting system of platform

Figure 5.9.12 Electric power system and socket outlet system

(4) Mechanical facility of the station building

1) Water Supply System

The express stop stations are installed with wells and pumps, and these are used for draining toilets and cleaning. Many other stations don't have wells, so the staff use the well of station dormitories for living water.

2) Drainage system

The sewage treatment of public toilets is filtered through a septic tank, and then discharged into a drainage or underground penetrating treatment.

3) Fire extinguishing facility

A fire extinguisher is installed in the station buildings, and initial fire extinguishing is possible at the time of fire.

4) Air conditioning system

There are no air conditioning facilities for station staff and passengers in the station buildings. However, air conditioning is set up in the OCC of Naypyitaw and Mandalay Stations.

Source: JICA Study Team

Figure 5.9.13 Well

Figure 5.9.14 Fire extinguishing facility

(5) The Rooms for Station

The rooms of a station building are as shown in Table 5.9.2. The rooms are a station staff office, ticket counter, and passenger waiting area. In the large-sized station building at the terminal station, there are also the office of railway police and OCC.

Table 5.9.2 The rooms for station

The size of the station building	Rooms in the station building
Large-sized station building	• Station office (the office of railway police) • Ticket counter • Passenger waiting area • Station staff dormitory
Middle-sized station building	• Station office • Ticket counter • Passenger waiting area
Small-sized station building	• Passenger waiting place

Source: JICA Study Team

Figure 5.9.15 Station office

Figure 5.9.16 Ticket Counter

(6) Station facilities

The station facilities are as shown in Table 5.9.3. There is a parking and a station plaza in front of the station of the express stop station (large-sized stations and some middle-sized stations). Also, there are many people who use express trains at the express stop station, so there are public toilets and station kiosks in the station building. Most of the stations have a dormitory for station staff nearby, and the staff lives with their families. There are wells and toilets in the dormitory, but passengers can't use it.

Table 5.9.3 Station facilities

The size of the station building	駅構外	駅構内
Express stop station	• Parking • Station plaza	• Public toilet • Station kiosk • Drinking pots
Other stations		• Drinking pots

Source: JICA Study Team

Figure 5.9.17 Public toilet

Figure 5.9.18 Station kiosk

(7) Other facilities

There are a total of two station name boards on both ends of the platform, which are written in English. The name board is also written by Burmese on the roof part of the station building. The timetable is written in Burmese only and mainly posted near the ticket counter. The room name board is posted in the office of the main station and the public toilet. However, there are no signs to guide it.

Source: JICA Study Team

Figure 5.9.19 Time table

Figure 5.9.20 Station name board

(8) Platform shed

There are platform sheds using rail materials at many stations. However, the material of the shelter is damaged. Also, there is a roof only on part of the platform. Therefore, at the time of strong sunshine and rainy weather, the passengers are in a situation in which they wait for the train under the platform shed. Also, because the shade is under the roof of the platform, a bench is installed and it is also used as a passenger waiting space. As in Phase 1, the construction gauge will be determined by the track alignment and rolling stock. Depending on the construction gauge, the platform roof is to be partially modified.

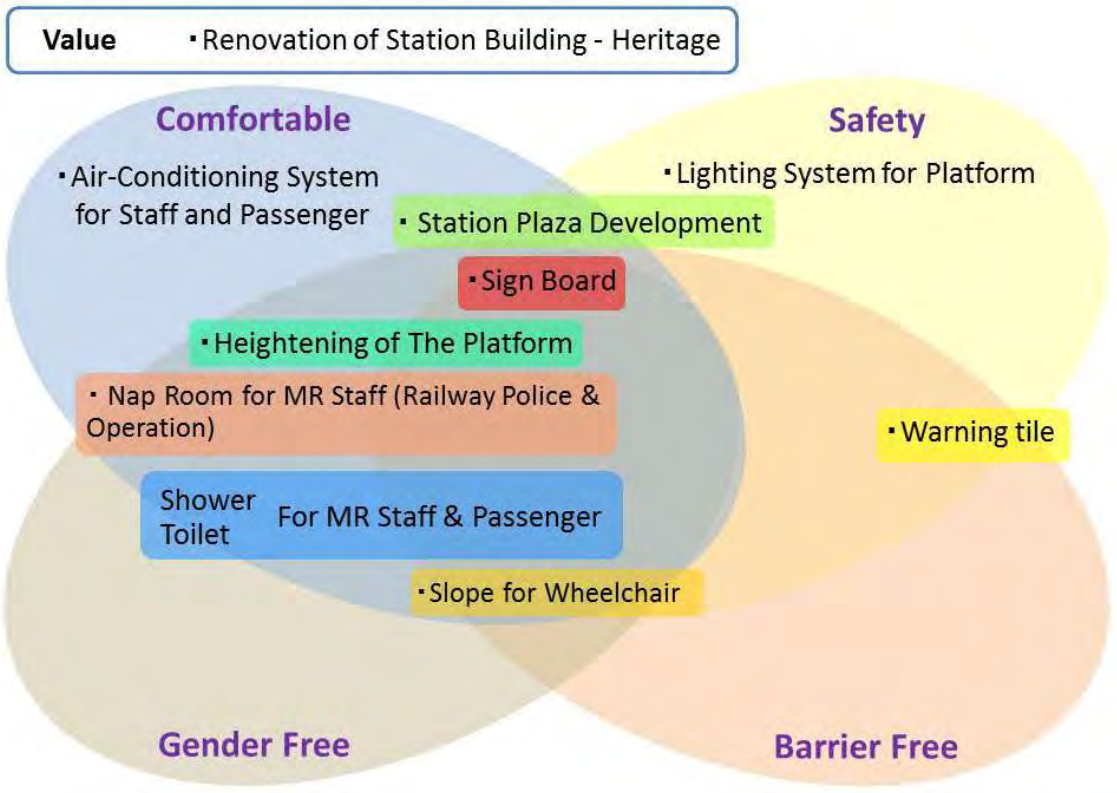
Source: JICA Study Team

Figure 5.9.21 Current Conditions of platform

5.9.3 Recommendation for Improvement Plan of Station

The station building is a railway transportation base for passengers and freight facilities. Therefore, it is expected that the demand for transportation will be greatly expanded by railway improvement and modernization projects. So that reason, JST set four subjects for improvement.

- Comfort
- Safety
- Gender Free
- Barrier Free



Source: JICA Study Team

Figure 5.9.22 Improved concept

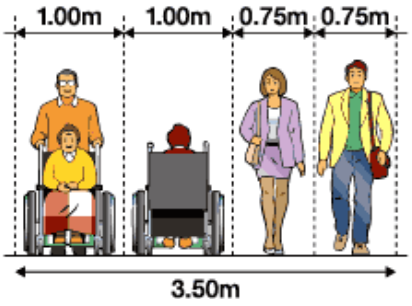
The station building must respond to the needs of diversified users including elderly people and disabled people. Also, considering the improvement of the workplace environment of station staff, JST proposed the following maintenance items to MR.

(1) Civil Structures in Stations (Passenger Platform, Level Crossing, Storm Water Drainage System)

MR has accepted the summary of outline design for Civil Structures in Stations shown in Appendix 5.9. This outline design concept is the same as that of YM Phase1.

(2) Slope for Wheelchair

There is no equipment considering the wheelchair in the station building. Mandalay Station has elevator and escalator facilities, but passengers can't use them because the escalator isn't functioning. Elevators aren't installed on all platforms. JST proposed installing a slope so that the wheelchair can access the train from outside. Also, the width accounts for wheelchairs should be taken into consideration, too.



Source: JICA Study Team

Figure 5.9.23 Pedestrian Width

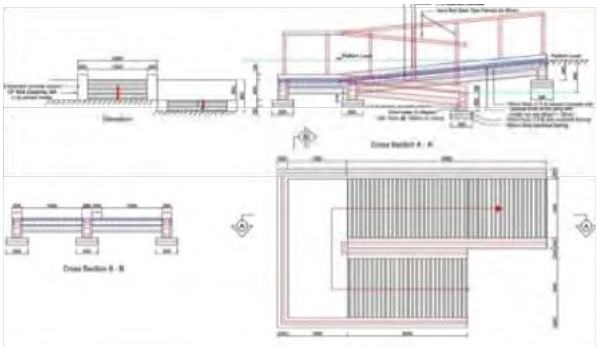
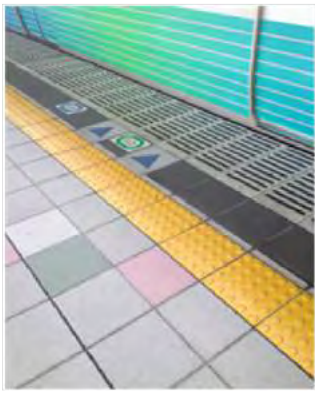


Figure 5.9.24 Slope for Wheelchair

(3) Warning tile

JST proposed installing a warning tile on the floor of the platform to prevent passenger accidents.



Source: JICA Study Team

Figure 5.9.25 Warning tile

(4) Information Guide board

JST proposed installing a guide display at the station to improve the convenience of passengers and provide information to foreigners.

Source: JICA Study Team

Figure 5.9.26 Guide Sign

Source: JICA Study Team

Figure 5.9.27 Station name board and information guide board

(5) Lighting system

Currently, platforms are very dangerous at night because there is very little lighting equipment. So that reason, JST proposed installing lighting poles on the platforms to avoid danger when getting on and off the train and passing through the station.

Source: JICA Study Team

Figure 5.9.28 Solar lighting pole

Figure 5.9.29 Station Toilet

(6) Station toilet and shower

There is a public toilet at the main station. One use is 100 MMK and a shower is also installed. These public toilets are cleaned and used. However, due to the lack of maintenance management, they are becoming old. There are few stations where toilets are installed, which is very inconvenient for passengers. JST proposed the installation of public toilets and showers.

(7) Air conditioning system

There are no air conditioning facilities for station staff and passengers in the station building. In high temperature and humid climate, station staff is working for train service operations. Passengers are also waiting for the train at the shade platform or the bench in the station building. In order to ensure the comfort of station staff and passengers, JST proposed installing an air conditioner in the station building.

(8) Nap room

JST proposed installing a nap room for station staff. Because the train runs even in the middle of the night and female staffs are also working it must be designed to permit secure use by both genders. Safe train operation can be done by ensuring a healthy working environment.

5.9.4 Renovation of station building

(1) Station building

1) Selection of station building

According to the site survey of JST, twenty stations with cracks and breaks in the main structure could be confirmed. Some stations are in a critical condition and possibility of collapse. JST confirmed this condition with the MR side in a joint survey and reported the situation at the 4th and 5th TAC meetings. But the repair of the station building was designated by MR for 7 stations, Taungoo, Yedashe, Pyinmana, Yemethin, Thazi, Kyaukse and Myohaung stations.

Source: JICA Study Team

Figure 5.9.30 Station building in critical condition

2) Station facilities

Main facilities in the station are shown below. Installation status varies depending on each station.

- Concourse
- Free passage
- Gate (Refer 5.18 Passenger service)
- Ticket Counter (Refer 5.18 Passenger service)
- Lift equipment (Elevator, Escalator, Slope, etc.)
- The stairs
- Toilet for Passenger
- Information board
- Platform (Warning tile, Lighting system)
- Station operation facilities (Staff room, Nap room, Equipment rooms)

3) Passenger Demand Forecast

According to the 2.2.4 Update of Passenger Demand Forecast, estimated passengers demand at each station is as shown in Table 5.9.4.

Table 5.9.4 Estimated Passengers Demand

(Unit: Passenger)

Station Name	Passenger/Day	Station Name	Passenger/Day
Taungoo	136	Thazi	3280
Yedashe	442	Kyaukse	5950
Pyinmana	3562	Myohaung	3452
Yamethin	1018		

4) Construction cost of station building

The construction costs of the station buildings are as shown in Table 5.9.5. Construction cost of the station building includes architectural work, piling work, electrical work, air conditioning work, and plumbing work. And, 10% of construction cost is calculated as landscape construction cost. The existing Station building will not be demolished, because JST agreed this with MR at the 5th TAC meeting. The size of the station building to be constructed takes into consideration the current station building, demand forecast, station development and so on. And, the construction site will be decided in consultation with the MR in the detailed design stage.

Table 5.9.5 Construction cost of station building

Station Name	Total Floor Area (m^2)	Cost of Station Building (million MMK)	Cost of Landscape (million MMK)	Station Name	Total Floor Area (m^2)	Cost of Station Building (million MMK)	Cost of Landscape (million MMK)
Taungoo	1500	900	90	Thazi	1500	900	90
Yedashe	300	180	18	Kyaukse	700	420	42
Pyinmana	700	420	42	Myohaung	1700	1020	102
Yamethin	300	180	18				

Wheelchair slope, warning tile, signboard, lighting system, station toilets, air conditioning systems and nap room will be installed at each of the seven new stations. JST agreed to this with MR at the 10th TAC Meeting. Each construction cost is shown in Table 5.9.6.

Table 5.9.6 Construction cost of station building

(Unit : 1 Station)

Item	Cost (million MMK)	Item	Cost (million MMK)
Slope for wheelchair	10.4	Public Toilet (Tube Well, Septic Tank)	28
Warning Tile	19.1	Air Conditioning	1.41
Sign Board	17.31	Nap Room	15.27
Solar Ligthing	1.115		

(2) Platform shed

About the necessity of the platform roof cutting due to the construction gauge, deciding of the track level and surveying are necessary. These are to be decided in the detailed design stage. At the 10th TAC meeting, JST confirmed that it may be necessary to trim the platform roofs to the construction gauge in the 7 stations that are to be built.

Source: JICA Study Team

Figure 5.9.31 Improvement of platform shed

5.10 Rolling Stock

The Phase II of this project is to rehabilitate the section between Taungoo and Mandalay of the Yangon - Mandalay Railway (YM), and together with the Yangon - Mandalay Railway Improvement Project Phase 1, the improvement of the passenger service in YM will be completed.

In the Basic Design Study of the Yangon Circular Railway line Upgrading Project (YCR-RS/BD), DEMU has the same basic specifications (rolling stock size and rolling stock performance) as those of the DEMU used in YM.

In consideration of the DEMU planned for the Yangon - Mandalay Railway Improvement Project Phase 1 and the Yangon Circular Railway Improvement Project, and the operation plan after the entire section renovation, the rolling stock plan for the whole project will be formulated.

In the next detailed design study of this project, if the same basic specifications as those of the Detailed Design for Yangon - Mandalay Railway Improvement Project Phase 1 (YM-D/D (1)) are adopted, to shorten the time required for the procurement of the rolling stock in this project might be possible.

Therefore, the JICA Study Team proposes the DEMU with the same basic specifications as that of YM-D/D (1).

The above is summarized 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.
- Considering the operation plan, the rolling stock proposed in Phase II shall have the same rolling stock specifications as those of YM-D/D (1).

Regarding the rolling stock of the local type to be planned in this project, to comply with the same specifications as those of the express type will reduce the number of items to be newly designed in the detailed design study. However, as boarding time is expected to be shorter compared with the limited express trains, the JICA Study Team proposes in-car equipment and seat arrangement considering the flow of passengers. In addition, the JICA Study Team proposes the adequate number of cars of the trainset so that it will be possible to cope with large fluctuations of the number of passengers.

Specifically, the following items are considered.

- Basic specifications of rolling stock
- Room facilities including toilets, air conditioning, deck (steps)
- In-car seat layout, capacity
- Basic formulation of the trainset

In proposing the above items, the JICA Study Team will proceed by the following steps.

(1) Investigation of the current situation of onboard passengers and rolling stock owned by Myanmar Railways (MR)

(2) Proposal of rolling stock for express trains and rolling stock for local trains based on (1)

Although the JICA Study Team had been studying based on this step above, it was concluded by agreement between the Minister and JICA that MR would procure 180 cars for express trains and that the local train vehicles would not be procured.

5.10.1 Present Conditions of MR Rolling Stock

In order to confirm the rolling stock possessed by MR, the JICA Study Team conducted a survey in Pyinmana Depot, Mandalay Locomotive Depot, and Mandalay Station. In addition, in order to check the usage of the rolling stock, the JICA Study Team conducted a survey in a train stopping at Mandalay Station and in a train operated from Naypyitaw Station to Mandalay Station. In this section, the results of the investigation are described.

(1) Investigation of Room Facilities of Rolling Stock

1) RBE 2526 Rolling Stock (Former Tenryu Hamanako Railway: LE-20 Type)

This rolling stock is a car with cabs at both ends used for Pakokku Line with 2 rows of box seat and a combination of long seats at both ends. There is a large space in the long seat part often used for luggage storage of the peddler. According to MR, many cars have been remodeled for this purpose.

- Car Body
  - ✓ Car length 15,500mm
  - ✓ Car width 2,700mm
  - ✓ Roof height 3,550mm
- Interior
  - ✓ Capacity 100 passengers
  - ✓ Box seat (moquette paste)
    Seat pitch: 1,540 mm, Width: 985 mm, Depth: 540 mm

(a) Box Seat (Center of the Car)

(b) Long Seat (near Entrance Door) No. 1

(c) Long Seat (near Entrance Door) No. 2

Source: JICA Study Team

Figure 5.10.1 RBE 2526 Car Seat Layout

2) RBE 3045 Rolling Stock (Former JR Tokai's Kiha 40 Type)

This car is the rolling stock that used to be operated on Takayama Line of JR Tokai until June 2015. Long seats for three passengers are arranged on the deck of both ends and box seats are on

other areas. A toilet with a sewage storage tank is equipped, but it was remodeled with a pipe bypassing the tank, so that sewage goes directly outside.

- Car Body
  - ✓ Car length 20,800 mm
  - ✓ Car width 2,900 mm
  - ✓ Roof height 4,055 mm
- Interior
  - ✓ Capacity 74 passengers
  - ✓ Box seat (moquette paste)
    Seat pitch: 1,470 mm, Width: 1,025 mm, Depth: 540 mm
- Toilet in one end deck section

(a) Exterior of RBE

(b) Interior

(c) Car Side View

(d) Sewage Storage Tank

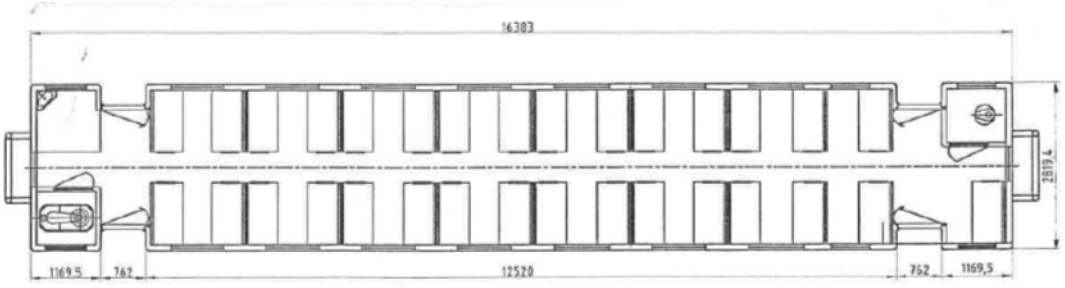
Source: JICA Study Team

Figure 5.10.2 RBE 3045 Rolling Stock Situation

3) 12272 No. Coaches

This rolling stock is a passenger car used in local areas and is a standard rolling stock of MR.

- It is an Ordinary class passenger car manufactured by Myitnge Carriage and Wagon Workshop.
- Car Body
  - ✓ Car length 16,383 mm
  - ✓ Car width 2,820 mm
  - ✓ Roof height 3,403 mm
- Interior
  - ✓ Capacity 62 passengers
  - ✓ Box seat (boarded)
    Seat pitch: 1,560 mm, Width: 1,040 mm, Depth: 440 mm
- A Western-style toilet and an Eastern style toilet on the deck section at both ends



Source: MR

Figure 5.10.3 12272 Passenger Car Drawing (Seat Arrangement)

(a) Interior

(b) Box Seat (Boarded)

(c) Western-style Toilet

(d) Eastern-style Toilet

Source: JICA Study Team

Figure 5.10.4 12272 Passenger Car Seating in the Car

4) Locomotives and Passenger Cars Made in China

- Locomotive (DF 2000 type)

  The JICA Study Team investigated the locomotives made in China at Pyinmana Depot.

  - ✓ Manufacturing CSR SIFANG CO. LTD.
  - ✓ Price USD 1,165,216 (according to the plate in driver's cab)
  - ✓ Engine output 2,000 HP
  - ✓ Maximum design speed 100 km/h
  - ✓ Axle load 12.5 ton
  - ✓ Car Body
    - Car length 16, 360 mm
    - Car width 2,750 mm
    - Roof height 3,480 mm

(a) Exterior of Locomotive (b) Locomotive Cab

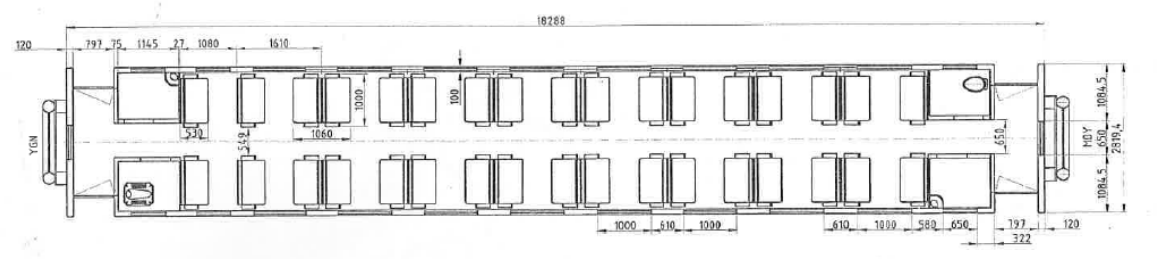
Source: JICA Study Team

Figure 5.10.5 DF 2000 Type Locomotive (Made in China)

- Passenger Car (14000 type)

  A daily service train, 6 Down train, consists of a locomotive made in China and passenger cars made in China. the JICA Study Team made a survey at Mandalay Station for the inside of the train.

  - ✓ 14-car train: Ordinary class (one is a guard luggage car), 3 cars of Upper class
  - ✓ Car Body
    - Car length 18,088mm
    - Car width 2,820mm
    - Roof height 3,403mm
  - ✓ Interior
    - Ordinary class: FRP box sheet (68 passengers)
      Pitch: 1,600 mm, Width: 1,000 mm, Depth: 530 mm
    - Upper class: Third row seat of revolving reclining seats (24 passengers)
  - ✓ A Western-style toilet and a washroom at one end and an Eastern style toilet and a washroom at the other end of each car
  - ✓ LED lighting, indirect lighting in Upper class
  - ✓ Conical rubber support bogie equipped with air spring
  - ✓ No air conditioning unit



Source: MR

Figure 5.10.6 Chinese Made Car (Ordinary Class) Drawing (Seat Arrangement)

(a) Inside of Ordinary Class

(b) Inside of Upper Class

(c) Western-style Toilet

(d) Eastern-style Toilet

(e) Air Spring Bogie

Source: JICA Study Team

Figure 5.10.7 State of Passenger Car Made in China

(2) Usage Situation Survey at the Daytime

1) Passenger Car Made in China (6 Down Train)

The survey was conducted at Mandalay Station to investigate in-car conditions before 6 Down train left. (5.10.8)

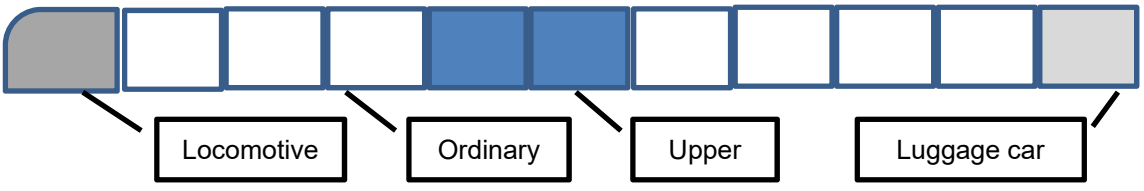
- As there is no air conditioner, windows use open for both classes. Electric fans were used.
- There were less carry-on luggages compared with 11 UP trains in 2) below.

- The bogie is equipped with an air spring. Generally speaking, an air spring improves riding comfort, but this survey was only from the appearance at the station and thus riding comfort was not checked.

2) Passenger Car Manufactured by Myitnge Carriage and Wagon Workshop (11 UP Train)

The JICA Study Team Investigate from Naypyitaw to Mandalay. As shown in Figure 5.10.8, the first locomotive is organized to tow a total of 10 passenger cars, seven ordinary classes, two upper classes and a luggage car at the end. Train set capacity 500 people.

- Locomotive made in China (same model as above)
  - ✓ The oil level gauge and the water meter are unusable (about 1 year of business use)
  - ✓ As Myanmar's domestic maximum speed is 70 km/h. There is no operation experience at 100 km/h.
- Passenger car made by Myitnge Carriage and Wagon Workshop.
  - ✓ In both classes the windows and doors are open and using fans.
  - ✓ The cars of both classes were full of passengers sitting or lying down so that it was difficult for them to walk on the deck section. Some passengers stood on the deck.
  - ✓ The cars of both classes have toilets at both ends. There is a washroom opposite side of the toilet. However, it was difficult to use the washroom as it was occupied by sitting passengers or luggage placed.
  - ✓ The lighting fixtures were LED and the inside room was bright enough for reading a book.
  - ✓ As there was no announcement device, passengers could not understand the current traveling section and situations of the train.
  - ✓ Every time the train stopped at a station, passengers came to the train crossing the track and got onboard with their belongings.
  - ✓ At stations, merchants came to the side of the train and sold goods. Passengers continued paying money to them even after the train started moving.
  - ✓ The riding comfort was bad. Vertical, horizontal and longitudinal shake was huge for all over the line.



Source: JICA Study Team

Figure 5.10.8 Trainset of 11 UP Train

(a) In the Room of the Ordinary Class

(b) Locomotive to Pull

(c) In the Room of the Upper Class

(d) Status of Departure

Source: JICA Study Team

Figure 5.10.9 Train Ride Survey

5.10.2 Recommended Plan for Rolling Stock

In this section, based on the results of YM-D/D (1) and the results of the survey, the JICA Study Team recommends a plan of the express type of rolling stock in this section. As for the local type of rolling stock, which was expected to be introduced in YM-D/D (1), although it was decided that this type would not be introduced in this project, the results of the study in this F/S are described as a reference in this section, considering the possibility of future introduction.

(1) Express Type of Rolling Stock

Four trainsets of the express type have already been proposed in YM-D/D (1). 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

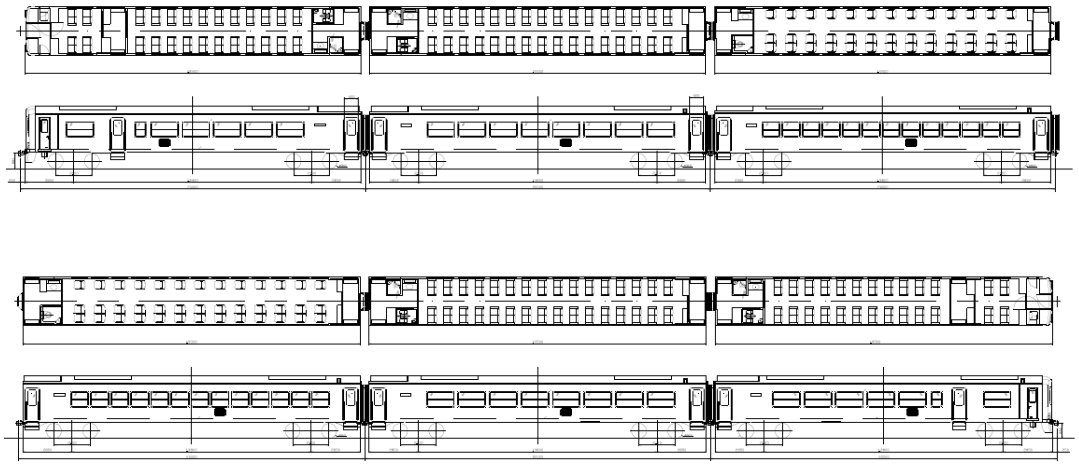
  The trainset consists of 6 cars. Two classes of Ordinary class and Upper class are set up, and the two Upper cars are to be sandwiched at the center of the trainset (Figure 5.10.10).

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

Source: JICA Study Team

Figure 5.10.10 Train Configuration

The seat arrangement is shown in Figure 5.10.11 and the passenger capacity is shown in Table 5.10.1.



Source: JICA Study Team

Figure 5.10.11 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

(2) Local Type of Rolling Stock

The local type rolling stock is different from the DEMU proposed in YM-D/D(1) and YCR-RS/BD in terms of the purpose of service. However, from the view point of maintenance, it is required that its specifications be commonalized with the specifications of the DEMU proposed in YM-D/D(1) and YCR-RS/BD. As is mentioned at the beginning of this section, the local type of rolling stock will not be introduced. Here, the general specifications are described as a reference, which were based on the specifications of the Express DEMU considering the train operation on Yangon Mandalay Line.

With regard to the seat arrangement, considering the baggage of the passenger, long seats are allocated for space securing in the vicinity of the entrance and exit and box seats are arranged for passengers using for a relatively long time at the central part of the car.

Regarding the number of trainsets according to the current operation, a locomotive with 5 or 6 passenger cars is operated on the Yangon Circular Railway Line. The RBE which was used in Japan is operated as a 5-car train. Therefore, the JICA Study Team proposes a plan to make a 6-car trainset for the local type of rolling stock. In addition, since it is a local train with huge passenger flow, the JICA Study Team proposes a 2-car unit or a 3-car unit as a trainset in order to cope with the increase and decrease of passengers per train.

Table 5.10.3 Outline Specification of Rolling Stock of Local Type

No	Item	Express type (Ordinary Class)		Local type	
		Motor car with cab (Mc)	Motor car (M)	Motor car with cab (Mc)	Motor car (M)
1	Car length	20,000 mm (Including couplers)			
2	Car width	2,800 mm			
3	Roof height	3,600 mm			
4	Maximum design speed	110 km/h			
5	Maximum Acceleration	2.0 km/h/s			
6	Maximum deceleration	3.5 km/h/s			
7	Axle load	12.5 t			
8	Drive system	Diesel engine + Generator + Traction motor			
9	Seat	Walkover seat		Box seat, Long seat	
10	Capacity	52	64	92	92

Source: JICA Study Team

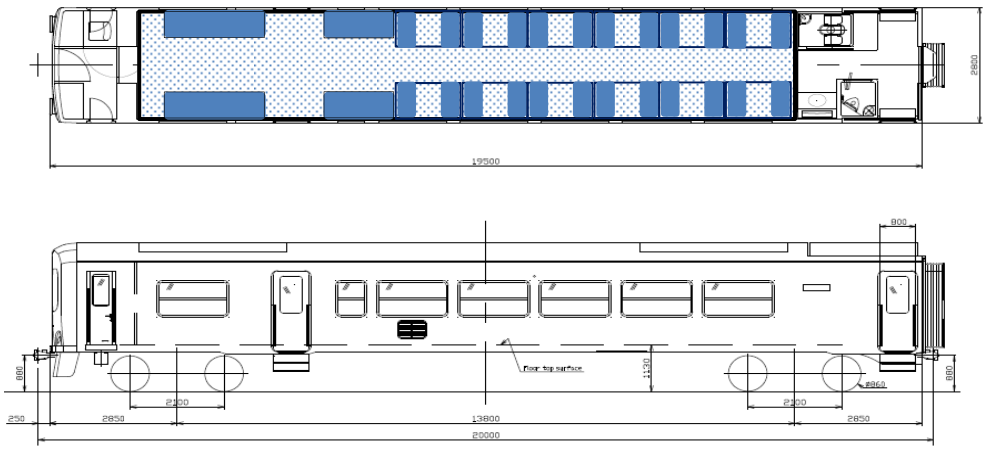
- Seat Arrangement Proposal

(1) Motor Car with Cab (Mc)

Based on the first car of the express type, only seat arrangement is modified. Box seats and long seats are arranged instead of walkover cross seats of the express type.

Long seats are allocated for luggage around the deck at both ends.

Capacity: Seat 64, Standing 28, Total 92 passengers



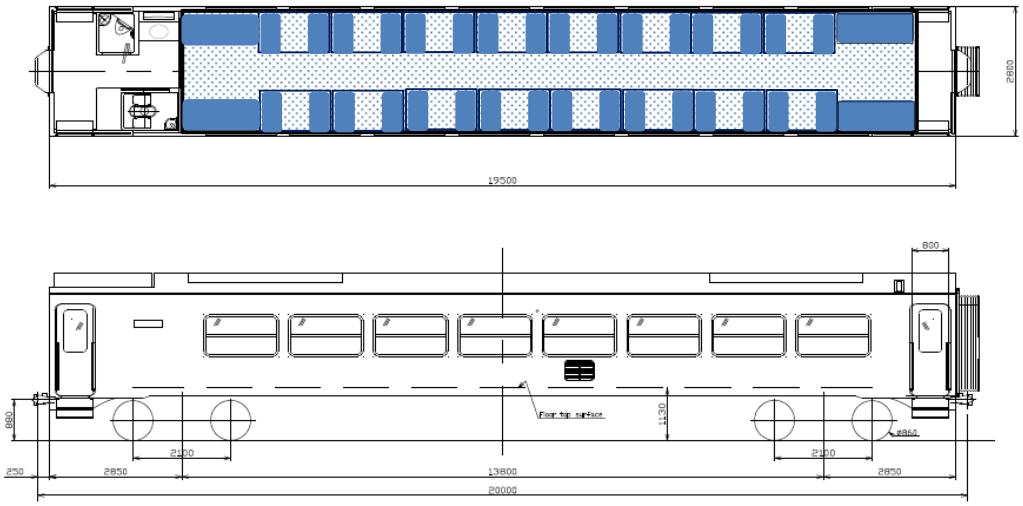
Source: JICA Study Team

Figure 5.10.12 Seat Arrangement of Motor Car with Cab

(2) Motor Car (M)

Long seats are allocated around the deck to deal with baggage.

Capacity: Seat 76, Standing 16, Total 92 passengers



Source: JICA Study Team

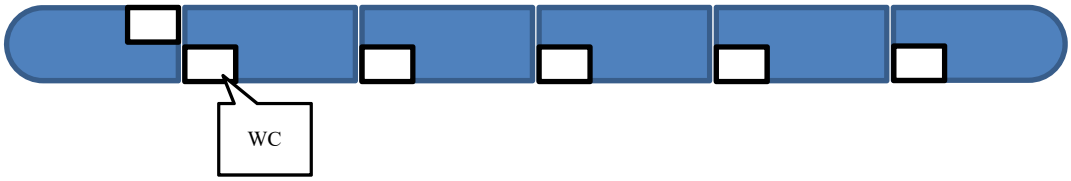
Figure 5.10.13 Seat Arrangement of Intermediate Motor Car

➢ Trainset Plan and Capacity

Figure 5.10.14 shows the comparison of the proposed scheme.

(1) 6-car Train McMMMMMc

Capacity: 552 passengers (seat: 432, standing: 120)



Source: JICA Study Team

Figure 5.10.14 Local Type 6-car Train Plan

(2) Combination of 3-car Train McMMc + McMMc

Capacity: 552 passengers (seat: 408, standing: 144)

Source: JICA Study Team

Figure 5.10.15 Local Type 3-car Train plan

(3) Combination of 2-car train McMc + McMc + McMc

Capacity: 552 people (seat: 384, standing: 168)

Source: JICA Study Team

Figure 5.10.16 Local Type 2-car Train Plan

Table 5.10.4 shows the comparison of these above proposals, Many short trainsets will make it possible to respond flexibly to passenger demand. In this case, as Local Type trains are used as the shuttle service between Yangon and Bago, the JICA Study Team proposes a 6-car trainset plan.

Table 5.10.4 Comparative Table of the Trainset of the Local Type

	Six-car fixed	3 basics	2 basics
Proposed plan	McMMMMMc	2 patterns McMMc (3,6)	3 patterns McMc (2,4,6)
Capacity	Superior	Good	Inferior
Flexibility to transportation volume	Inferior	Good	Superior
Ease to plan operation	Superior	Good	Inferior
Manufacturing cost	Superior	Good	Inferior

Source: JICA Study Team

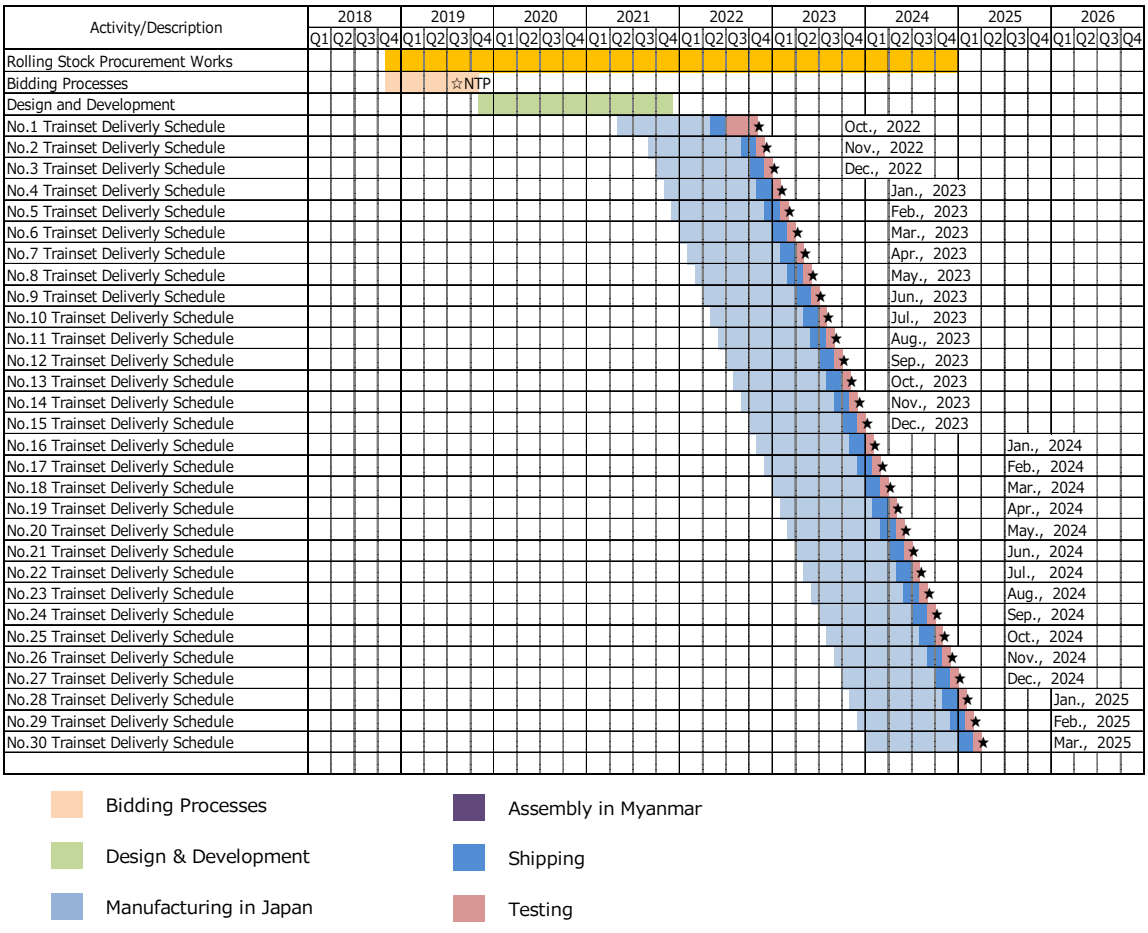
- Comparison of Train Formation
  - ✓ In order to increase the seat capacity, it is advantageous to fasten six cars with many intermediary cars without a cab.
  - ✓ In order to respond flexibly to the increase and decrease of passengers (difference by time zone and operation area), a combination of 2-car train or 3-car train which can flexibly respond to the passenger's demand is advantageous.
  - ✓ It is easier to set the operation plan with less trainsets to be used for operation. In this case, it is easier to plan with only 6-car trainsets.
  - ✓ Since the cost of the rolling stock with a cab is higher, if there are many cars with cab, the manufacturing cost is higher.

5.10.3 Procurement Schedule for Rolling Stock

As described at the beginning of this section, the procurement of only 180 Express DEMU cars is determined. 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 as shown in Table 5.10.5 was made and was proposed to MR.

After this proposal, the JICA Study Team discussed with MR about local assembly and developed the overall procurement schedule for rolling stock. The results are shown in 5.10.4 (12).

Table 5.10.5 Rolling Stock Procurement Schedule



Source: JICA Study Team

5.10.4 Local Assembly

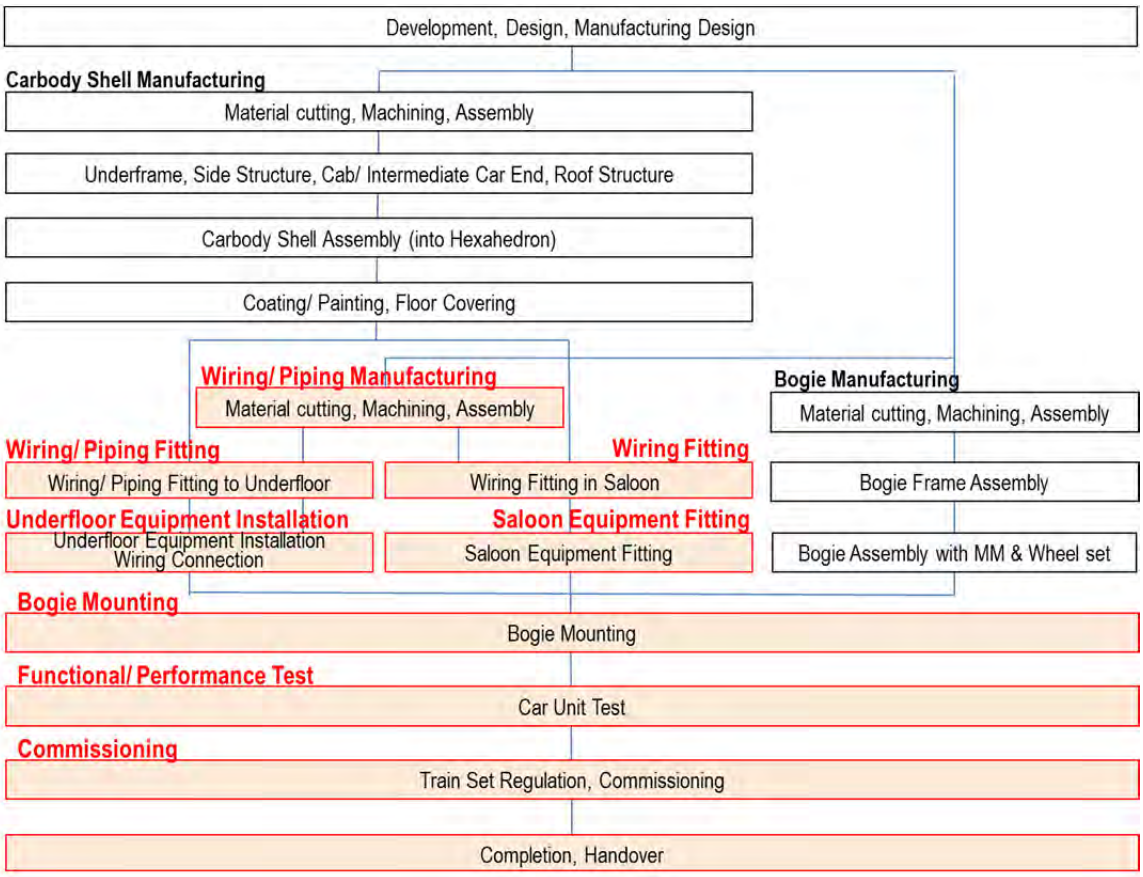
Regarding the local manufacturing of rolling stock, its feasibility was proposed as one of the implementation plans of the rolling stock modernization plan in ”Study on Railway Management Modernization in Myanmar” (2013, MLIT), and more specific studies were conducted in ”Survey of Railway Rolling Stock Modernization in Myanmar” (2014, MLIT). And also, 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 of the 180 cars to be purchased. And so, the study for the local assembly that consists of "scope of works" and "required conditions" is conducted on the condition that some of the 180 cars will be assembled in Myanmar in this project. The basic conditions of the local assembly are to be the same as those of JICA YCR-RS/BD.

(1) Scope of Works

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



Source: JICA Study Team

Figure 5.10.17 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. This study was conducted with various documents and by the hearing from MR as this factory is under construction. The manufacturing of locomotives in New Naypyitaw Locomotive Factory is planed to start in December 2017.

(a) Factory Appearance (Mar. 2017)

(b) Office Building Appearance (Sep. 2017)

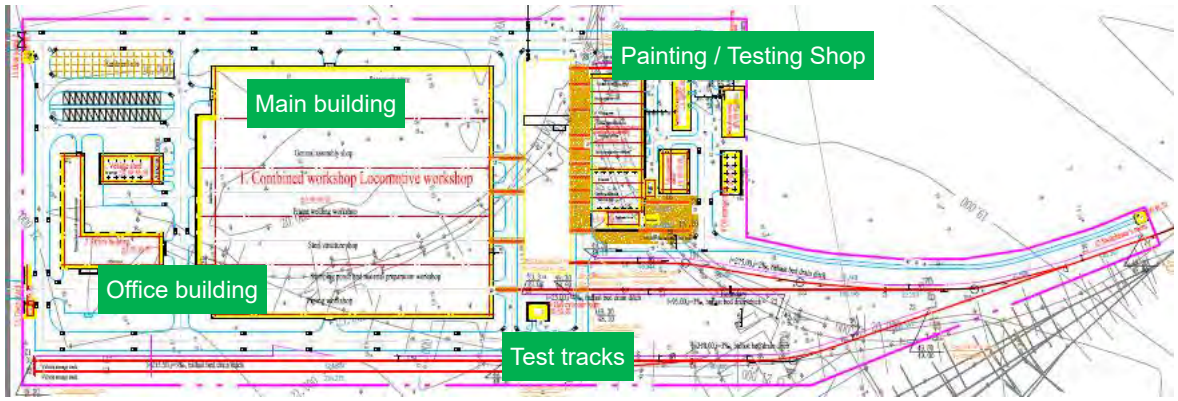
(c) Inside the Main Building 1 (Sep. 2017)

(d) Inside the Main Building 2 (Sep. 2017)

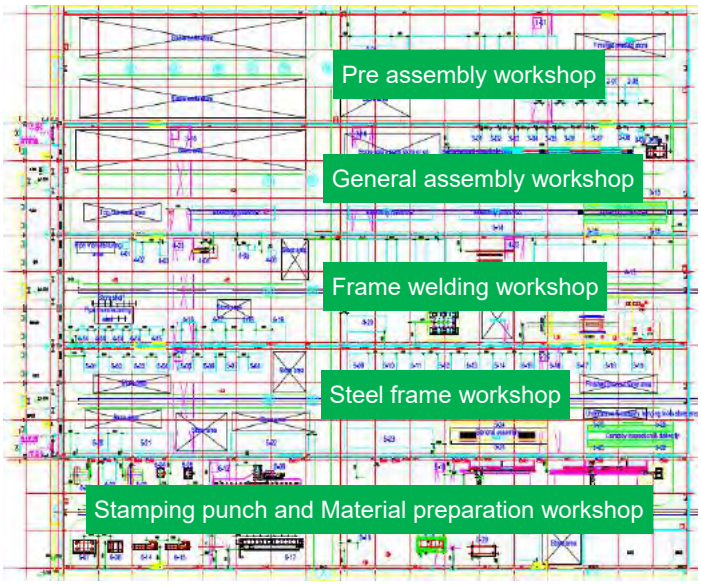
Source: MR

Figure 5.10.18 Current State of New Naypyitaw Locomotive Factory

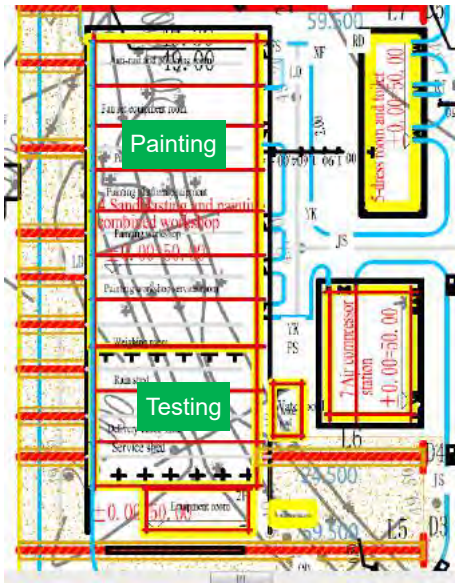
In New Naypyitaw Locomotive Factory; Main Building and Painting/Testing Shop, and all manufacturing flows except manufacturing bogie can be conducted. Bogies of the locomotives will be manufactured in New Myitnge Coach Factory that will be constructed at the same time, and will be delivered to Naypyitaw.



(a) Layout of New Naypyitaw Locomotive Factory



(b) Layout in Main Building



(c) Layout of Painting / Testing Shop

Source: MR

Figure 5.10.19 Layout of New Naypyitaw Locomotive Factory

(3) Work Procedure

Main steps of the work procedures are listed below. Figure 5.10.20 shows their work locations and flows.

(a) Unloading and Setup of Carbody Shell

- Preparation for arriving carbody is to be performed, such as separating the carbody shell from the locomotive that transported the carbody shell into the workshop and removing temporary equipment for the operation on the main line. The parts transported by container are to be unloaded and carried to the parts storage area by using a forklift or others.
- The separation between the carbody shell and the bogie used for mainline transportation is to be performed in a spot with a pit and lifting jack installed.
- The carbody shell is to be moved to the setup spots in the General Assembly Workshop and Steel Frame Workshop. (An overhead crane or temporary bogie is to be used. For the setup, it is assumed that a cradle is also used.)

(b) Manufacturing of Wiring/Piping Fitting Parts

- Preparatory works are to be performed, such as carrying and unloading the materials to the manufacturing location.
- Cutting, threading, and bending of piping steel pipes are to be performed according to the piping procedure.
- Wiring cCutting wires, wire bundle assembly, terminal installation, and wire numbering are to be performed according to the wiring procedure.

(c) Saloon Fitting

- Preparatory works are to be performed, such as carrying and unloading the materials, installing stairs and platform, etc.
- Wiring in the saloon is to be performed, and then the wiring is to be checked.
- The interior parts/equipment are to be installed.

(d) Underfloor Wiring and Piping Fitting Works

- Underfloor wiring and piping fitting are to be performed based on the wire bundle and piping prepared in (b).
- The wiring and piping leak are checked.

(e) Underfloor Equipment Installation Works, Wiring into Equipment

- Preparatory works are to be performed, such as carrying the equipment to the carbody shell setup location and setting a movable lifting table for heavy weight equipment (5t).
- The underfloor equipment is to be equipped using a lifter or others. The movable lifting table for heavy weight equipment (5t) is to be used for the installation of the engine or generator as the positional accuracy is required.
- Wiring into the underfloor equipment box is to be performed.
- The carbody is completed with gangway bellows and coupler, and the inspection, electrical test, and insulation test are to be performed.

(f) Bogie Mounting

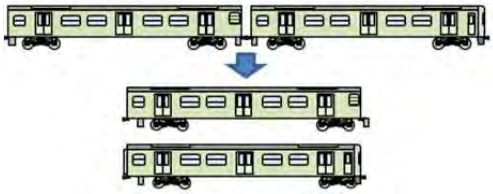
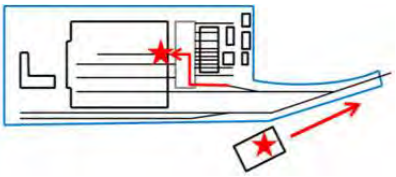
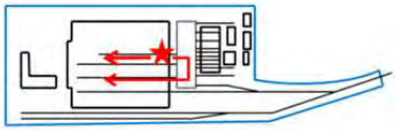
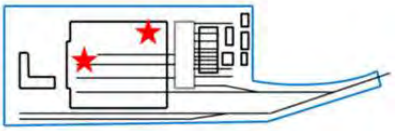
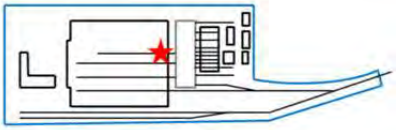
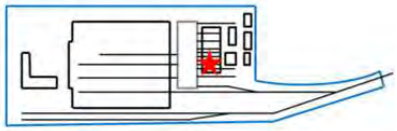
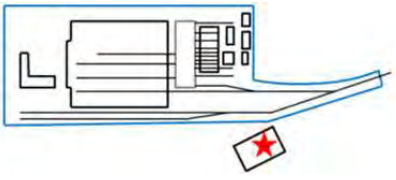
- The carbody completed in (e) is to be moved to the spot that contains a pit and lifting jack by using an overhead crane or temporary bogie.
- The carbody is to be mounted on the completed bogies, and necessary connections and adjustments are to be performed.

(g) Car Unit Test

- The car is to be moved in the building to perform the inspection, braking test, and service equipment operation test.
- Rolling stock gauge and wheel load measuring and the rain leak test are to be conducted.

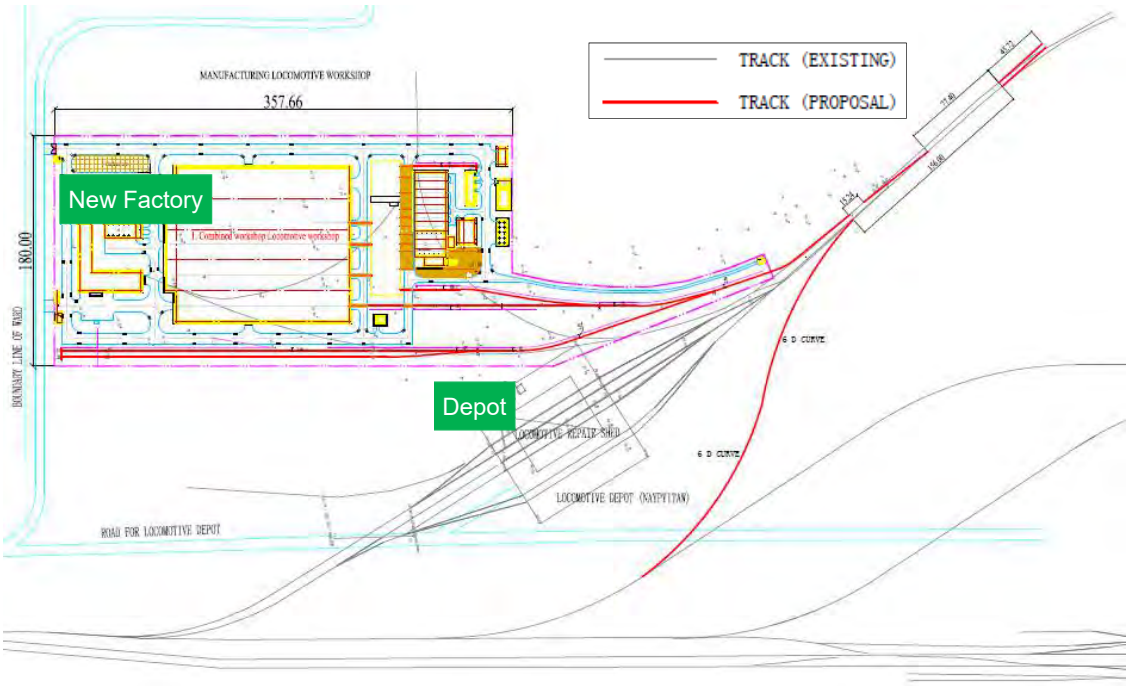
(h) Trainset Composition and Commissioning

- The cars already passing the test are to be sequentially moved to the Adjacent Depot (Figure 5.10.20) so that they can make up a trainset and be subjected to trainset composition.
- The trainset functional/performance test and commissioning are to be conducted.

Work Stage	Graphical Representation of Work	Work Location
(a) Carbody Shell Unloading		
(a) Carbody Shell Setup		
(b) Wiring/Piping Parts Cutting/ Machining/ Assembling		
(c) (d) (e) Wiring/Piping/ Equipment Fitting/ Installation to Saloon and Underfloor		
(f) Bogie Mounting		
(g) Car Unit Test		
(h) Trainset Composition, Commissioning		

Source: JICA Study Team

Figure 5.10.20 Work Location and Flow



Source: MR

Figure 5.10.21 Location of New Naypyitaw Locomotive New Factory and Depot

(4) Facility

Table 5.10.6 summarizes the contents related to the local assembly works in the facility list planned to be consolidated in this factory. The JICA Study Team conducted the survey about the additional check items within the work scope determined in the previous section.

- (1) Scope of wiring/piping works

  The JICA Study Team checked that the new facilities improvement plan includes the manufacturing space for the piping parts and related facilities and includes the manufacturing space for the wiring parts and related facilities. (Red frame in Table 5.10.6)

- (3) Carbody shell unloading conditions, and (4) Cost reduction measure

  Since it is assumed that the carbody shell can unload the factory with the main-line running bogie mounted, we judged that no additional facilities are required.

Table 5.10.6 List of Relevant Facilities Installation Plan

Shop	Facility	
	Name (Specification)	Quantity
Pre Assembly Workshop	Winch for heavy wiring	1
	Overhead traveling crane (10t/3t)	1
	Movable terminal crimping machine	1
	Marking printer	1
	Manual wire crimper	10
	Hydraulic wire crimper	2
General Assembly Workshop	Shifting fork positioner	1
	Lifting table	2
	Lifting jack	4
	Overhead traveling crane (50t/10t)	2
Frame Welding Workshop	Manual bending bench	1
	CNC bending machine and bending position (φ65-φ10)	1
	Single pipe cutting machine (114mm)	2
	Band saw machine	1
	Pipe welding rotation positioner	4
Steel Frame Workshop	Lifting platform	2
	Lifting jack (20t)	4
	Overhead travelling crane (20t/5t)	2

Source: JICA Study Team based on documents by MR

Facilities not listed in Table 5.10.7 are expected to be installed as additional facilities before the implementation of the local assembly works.

Table 5.10.7 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

(5) Work Schedule

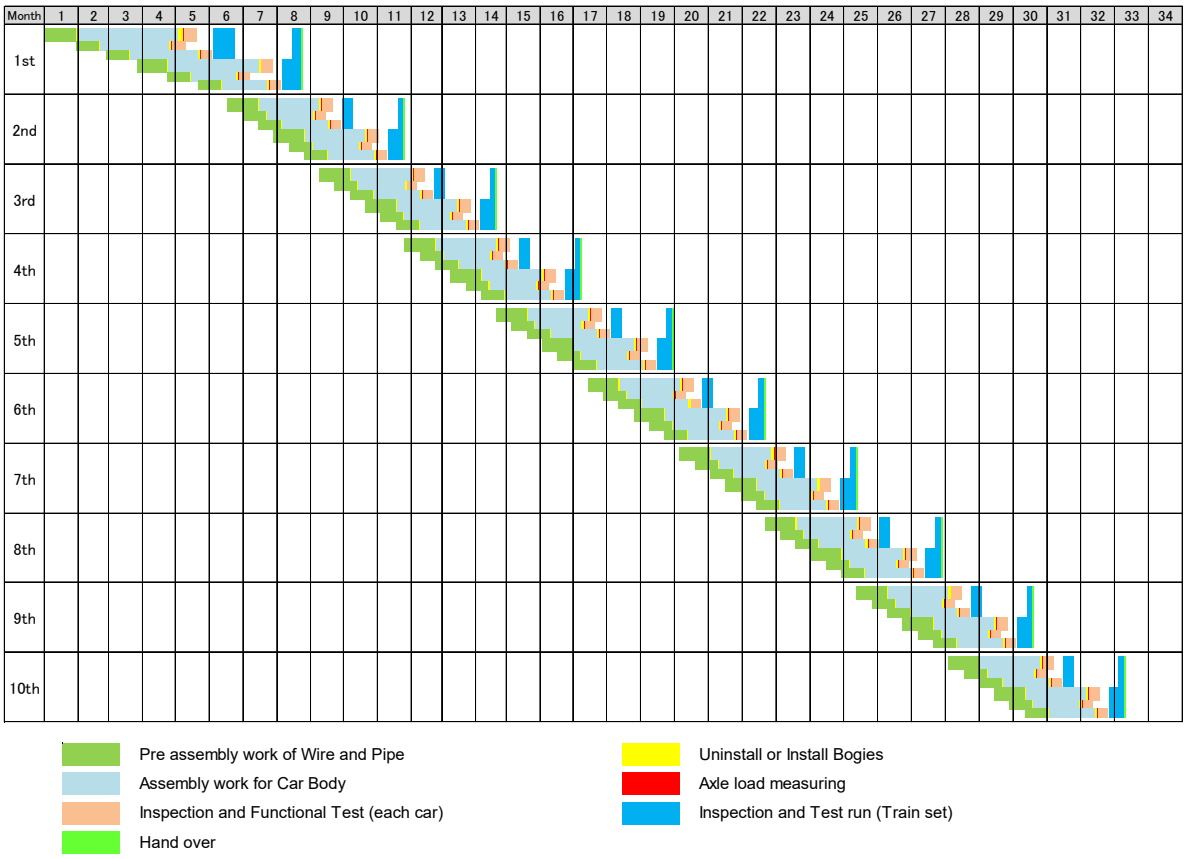
Work schedule was planned based on the experiences of the JICA Study Team and rolling stock manufacturer, while considering that this will be the first project for MR. (Figure 5.10.22)

(1) Fitting and equipment installation : 4 months/car, simultaneous assembly 4 cars (1st - 4th car), 3 months/car (5th and after), simultaneous assembly 4 cars

(2) Inspection and Car unit test : 2 weeks/car

(3) Train set composition and Commissioning : 2 weeks train

(4) Start of the work to Completion/Handover : 8 months (for assembling the first train), 6 months/train (from assembling the second train or after the second train)



Source: JICA Study Team

Figure 5.10.22 Work Schedule (Draft)

(6) Training and Supervising

For the education/training in the rolling stock manufacturer is to target the technical instructor class of MR through On-the-Job Training (OJT), where the works are to be performed with the manufacturing line of the DEMU to be manufactured prior to the local assembly. For the works in Myanmar, technical instructors who have mastered a training course in Japan educate/train work practitioners. Supervisors from the rolling stock manufacturer are expected to take charge of the

entire work management by continuous presence. The outline of MR eligible persons for education/training and rolling stock manufacturer delegates to the site is shown as follows;

(1) Education/training for MR staff in the rolling stock manufacturer (draft)

- Eligible person: Foremen, or equivalent employees from an engineering department (the wiring, piping, interior, equipment installation, or inspection/test/commissioning). It should be noted that these foremen need to have mastered the skills of basic techniques and be at a level on which they can coach employees belonging to Mechanic and Labour classes.
- Target works and number of workers: Total 17
  (Breakdown: wiring 5, piping 3, interior 3, equipment installation 2, inspection/test 4)
- Period: 6 months (Time and duration may differ depending on the work type.)
- Menu: Lecture (car structure, manufacturing/inspection/test/commissioning techniques), practical training, OJT in the manufacturing line)

(2) Management, technical guidance and manufacturing supervision by rolling stock manufacturer engineers (draft)

- Coverage Target works and number of workers: Total 21
  (Breakdown: management 2, wiring 10, piping 2, interior 3, equipment installation 2, inspection/test/commissioning 2)
- Period: 22 months (Time and duration may differ depending on the work type.)

(7) Work Organization

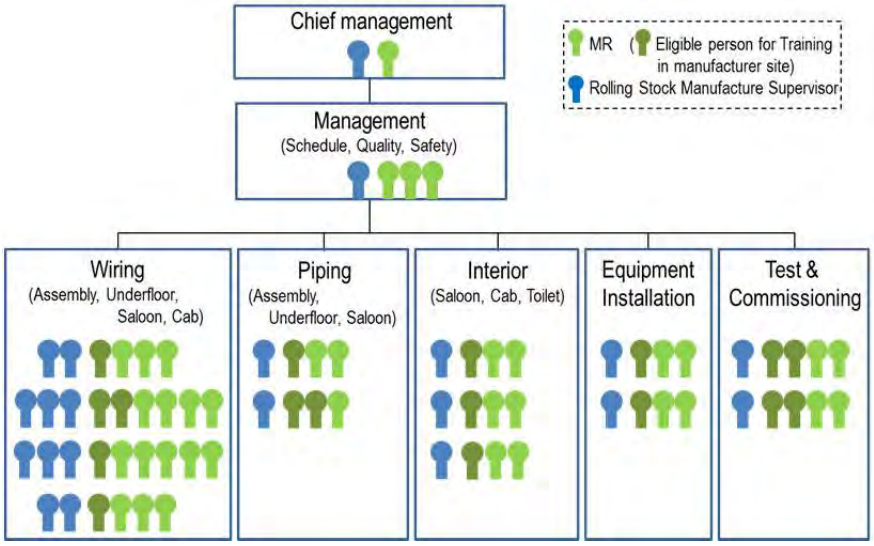
The work organization is planned as follows and organization chart is shown in Figure 5.10.23.

(1) Engineers from the rolling stock manufacturer: Total 21 (same as (2) of Subsection (8))

- Management 2 (chief management, control of schedule/quality/safety)
- Wire fitting instruction 10 (parts manufacturing, underfloor, saloon, cab), pipe fitting instruction 2 (parts manufacturing, underfloor, saloon), interior fitting instruction 3, equipment installation instruction 2, inspection/test/commissioning instruction 2)

(2) MR: Total 53

- Management 4 (chief management 1, control of schedule/quality/safety 3)
- Wire fitting 20 (parts manufacturing, underfloor, saloon, cab), pipe fitting 6 (parts manufacturing, underfloor, saloon), interior fitting 9, equipment installation 6, inspection/test/commissioning 8)

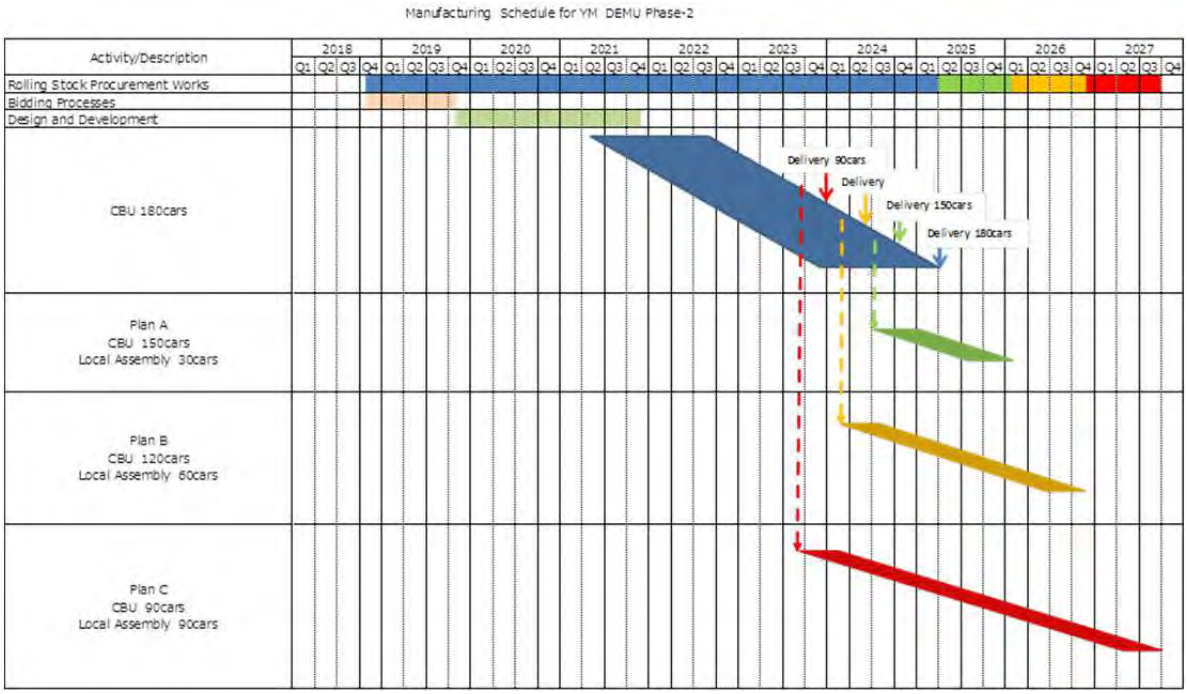


Source: JICA Study Team

Figure 5.10.23 Work Organization Chart (Draft)

(8) Overall Schedule

The JICA Study Team studied the local assembly for three cases, 30 cars, 60 cars and 90 cars. The schedule for each case is shown with overall schedule in Figure 5.10.24. As a result of the discussion with MR, it was concluded that the number of cars for local assembly would be 60 from the viewpoints of schedule and the period necessary for the technology transfer education.



Source: JICA Study Team

Figure 5.10.24 Overall Schedule Including Local Assembly (Draft)

(9) Local Assembly

Here, the cost of the local assembly for each case, 30, 60, and 90, is estimated. The total cost for the rolling stock procurement is shown in Table 5.10.8. The cost for the local assembly includes training expenses, parts transportation expenses, equipment costs, and risk costs related to the training. The cost for the local assembly is shown in Table 5.10.9.

Table 5.10.8 Total Rolling Stock Procurement Cost Including Local Assembly

Cost for Local Assembly

Unit: million YEN

	Reference (No Local Assembling)		Plan A (5Trains Local Assembling)		Plan B (10Trains Local Assembling)		Plan C (15Trains Local Assembling)	
Number of cars	180 cars		180 cars		180 cars		180 cars	
Rolling Stock Constructed in Japan	40,670	6carsX180trains	40,370	6carsX25trains (Completed) 6carsX5trains (Local assembling)	40,070	6carsX20trains (Completed) 6carsX10trains (Local assembling)	39,770	6carsX15trains (Completed) 6carsX15trains (Local assembling)
Spare parts & Consumable parts	1,980		1,980		1,980		1,980	
Training for Maintenance & Driver	150		150		150		150	
Transportation from JPN to YGN Port	1,800	for 180 trains	1,500	for 150 trains	1,200	for 120 trains	900	for 90 trains
Transportation from YGN Port to YGN City	0		0		0		0	
Local assembling	0		1,917	for 5 trains	3,368	for 10 trains	4,825	for 15 trains
Total	44,600		45,917		46,768		47,625	

Source: JICA Study Team

Table 5.10.9 Local Assembly Cost

Cost of local assembly for 5 trains

Item	No.of item	Month	Unit price	Total
Training in Japan				
MR worker training fee	17	6	1.28	131
Training in Myanmar				
Japanese expert fee	21	15.1	2.5	792.75
Sub total				923.75
Facility cost for local assembly	1		90	90
Transportation from JPN to NPT	30		27	810
Training (Risk fee)			10%	93
Total				1916.75

Unit: million YEN

Cost of local assembly for 10 trains

Item	No.of item	Month	Unit price	Total
Training in Japan				
MR worker training fee	17	6	1.28	131
Training in Myanmar				
Japanese expert fee	21	26.2	2.5	1376
Sub total				1507
Facility cost for local assembly	1		90	90
Transportation from JPN to NPT	60		27	1620
Training (Risk fee)			10%	151
Total				3368

Unit: million YEN

Cost of local assembly for 15 trains

Item	No.of item	Month	Unit price	Total
Training in Japan				
MR worker training fee	17	6	1.28	131
Training in Myanmar				
Japanese expert fee	21	37.4	2.5	1964
Sub total				2095
Facility cost for local assembly	1		90	90
Transportation from JPN to NPT	90		27	2430
Training (Risk fee)			10%	210
Total				4825

Unit: million YEN

Source: JICA Study Team

(10) Quality Assurance Scheme

In the process of the local assembly, the technical capabilities of MR staffs should be improved and the quality of the products should be ensured through the education and training at the rolling stock manufacturer site and the technical instruction and supervision at the site in Myanmar.

Another local assembly project for rolling stock in MR supported by a country other than Japan secures one year warranty. However, if a Japanese contractor is required to guarantee the quality of the assembling works by MR, the risk on the local assembly will increase and then the risk would affect the cost of rolling stock procurement. Therefore, the contents of warranty are proposed as follows.

(1) The warranty period for materials, parts, and equipment provided by suppliers is two years.

(2) The manufacturer does not guarantee assembling works by MR.

(11) Points to be Considered for Local Assembly

When this local assembly plan is implemented, the following points should be considered.

- In this local assembly plan proposed in this project, the schedule is set longer than the schedule of manufacturing in Japan for improving MR workers' skill. However, there is a possibility that the required period for rolling stock procurement will be changed depending on the work process made by the manufacturer.
- It is necessary to determine what the required facility is by considering the scope of works, the work process, and actual specifications of DEMU more detail than this study.
- It is necessary to determine which parts and equipment should be transported by considering the scope of works and actual specifications of DEMU in more detail.
- As the study for loading/unloading and the spaces to store parts and equipment was conducted roughly in this survey, there is a possibility that other facilities and/or spaces to store will be required.
- There is a possibility that the contents of training for MR workers will be changed depending on manufacturer's policy for training.

(12) Review Result

Based on the results of the study for the local assembly requested by MR, MR discussed about the local assembly internally and determined that MR will not conduct the local assembly as the project cost and the overall schedule for the rolling stock would increase compared with the case that MR procures completed products from manufacture(s).

Regarding the overall procurement schedule for rolling stock, the JICA Study Team proposed the schedule shown in Table 5.10.7 to MR. However, MR insisted that the procurement be completed by December 2024. Japan side finally accepted MR's proposal, but detail survey will be required in the detailed design regarding the manufacturing capacity of rolling stock supplier(s) and the procurement schedule.

5.11 Depot

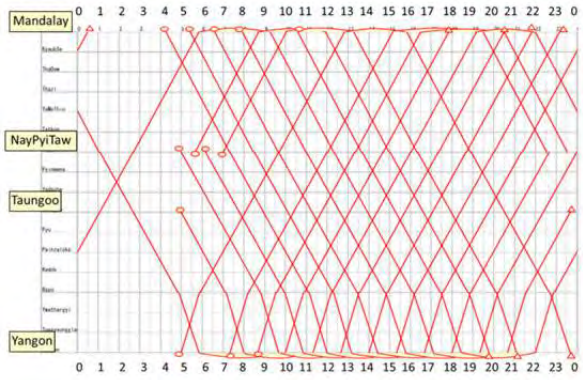
Depot has 4 functions;

- to stable train sets,
- to conduct inspections and preparations before operation,
- to repair the failure on the train set, and
- to overhaul rolling stock.

Depot is an indispensable facility to maintain the quality of train operation. “Inspection”, “repair”, and “preparation” for rolling stock maintenance shall be planned at the same time when rolling stock is examined. Ywathagyi Depot/Workshop that will be constructed in Yangon-Mandalay Railway Improvement Project Phase I (YM-D/D(1)) has all above 4 functions. 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.

In this project, the depot plan will be considered under the following pre-conditions;

- the existing depot that is owned by Myanma Railways (MR),
- the train operation in 2023 that is proposed by JST (Figure 5.11.1), and
- Ywathagyi Depot/Workshop that is planned in YM-D/D(1).



Source: JICA Study Team

Figure 5.11.1 Train Operation proposed by JST

5.11.1 Current Conditions of Depot

According to the train operation in YM-D/D(1), the places to stable train are Yangon, Taungoo, Naypyitaw, and Mandalay. There are MR’s existing depots or planed depot near these places.

- Yangon Area
  - ✓ Ywathagyi Depot/Workshop (YM-D/D(1))
- Taungoo Area
  - ✓ Taungoo Depot
- Naypyitaw Area
  - ✓ Pyinmana Depot
  - ✓ Naypyitaw Depot
- Mandalay Area
  - ✓ Myitnge Carriage and Wagon Repair Workshop

- ✓ Mandalay Locomotive Depot
- ✓ Mandalay Passenger Coach Depot
- ✓ Myohaung Depot

As a result of surveying these depots, their functions are as shown in Table 5.11.1.

Table 5.11.1 Functions of MR's Existing Depot

Depot		Stabling	Inspections & Preparations	Repairing	Overhaul
Yangon	Ywathagyi Depot	DEMU/RBE	DEMU/RBE	DEMU/RBE	DEMU/RBE
Taungoo	Taungoo Depot	Loco.	Loco.	Loco.	
Naypyitaw	Pyinmana Depot	Loco./RBE	Loco./RBE	Loco./RBE	
	Naypyitaw Depot	Loco./RBE	Loco./RBE	Loco./RBE	
Mandalay	Myitnge Carriage and Wagon Repair Workshop				PC
	Mandalay Locomotive Depot	Loco./RBE	Loco./RBE	Loco./RBE	
	Mandalay Passenger Coach Depot	PC	PC	PC	
	Myohaung Depot	Loco./FC	Loco./FC	FC	

Remarks DEMU: Diesel- Electric Multiple Unit, RBE: Rail Bus Engine, Loco.: Locomotive, PC: Passenger Coach, FC: Freight Car.

Source: JICA Study Team

In this study, Ywathagyi Depot/Workshop will not be examined because this depot is planned to conduct DEMU maintenance in YM-D/D (1).

Features of these depots are as follows.

- ➢ Depot for Locomotive and RBE

  The common purpose of the 4 depots is to conduct "inspection" and "repair" for the car with an engine. Therefore, each depot has the pit(s) for inspecting bogies, and the facility for fueling (Figure 5.11.2). However, there is no facility for supplying water that is used for toilets because locomotives have no passenger saloon. Moreover, the length of tracks and its shed in depot are short because locomotives can work as a unit.

(a) Inspection Pit

(b) Fuel Pump Room (Fueling Facility)

Source: JICA Study Team

Figure 5.11.2 Facility Examples in the Depot for Locomotive and RBE (Pyinmana Depot)

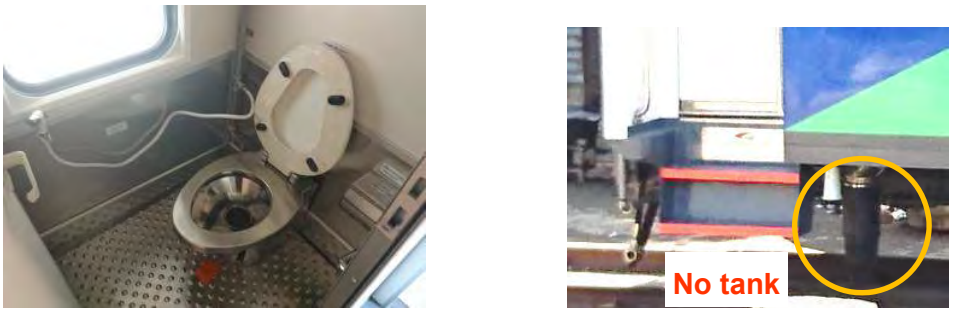
➢ Depot for Passenger Coach

Myitnge Workshop has inspection pits, facilities for overhauling rolling stock, and so on. However, there is no facility for stabling and daily operation because this workshop has the function only to overhaul. On the other hand, Mandalay Passenger Coach Depot has facilities for stabling, daily operation, and repairing. However, there is no facility for fueling because passenger coaches have no engine. Also, there is no facility for discharging sewage tank because MR' passenger coaches with toilets have no sewage tank.

(a) Inspection Pit (b) Facility for Supplying Water

Source: JICA Study Team

Figure 5.11.3 Facility Examples in the Depot for Passenger Coach (Mandalay Passenger Coach Depot)



(a) Toilet on the Passenger Coach (b) Toilet Seen from Outside of the Passenger Coach

Source: JICA Study Team

Figure 5.11.4 Feature of the Toilet of MR's Passenger Coaches

➢ Depot for Freight Car

In Myohaung Depot, freight car maintenances are conducted. The main facility in this depot is to repair the trouble on the freight car.

Source: JICA Study Team

Figure 5.11.5 Facility Examples in the Depot for Freight Car (Lifting Jack and Inspection Pit in Myohaung Depot)

In contrast, main required facilities for DEMU operation are the following items.

Table 5.11.2 Main Required Facilities for DEMU Operation

Maintenance Work / Main Facilities		Outline / Purpose
Stabling	Storage track	The track for stabling DEMU trains: 240m
Inspections & Preparations	Inspection track	The track for inspecting bogies and equipment on the train
	Preparation track	The rack for cleaning trains This track with facilities for supplying water of toilets on the train and discharging sewage tank
	Fuel Supply track	The track for fueling
	Wheel re-profiling lathe	The facility for re-profiling wheels to correct the shape of wheel treads
Repairing	Unscheduled repair track	The track for exchanging bogies and equipment on the train
Overhaul		Facilities for overhauling equipment

Source: JICA Study Team

The MR's depot that meets all the above conditions is only Ywathagyi Depot/Workshop that is planned in YM-D/D(1). Therefore, it is necessary to plan new depot(s) for DEMU.

5.11.2 Recommendation for Future Plan of Depot

In this section, the plan in YM-D/D(1) is reviewed, and, the outline of the depot plan will be proposed.

(1) Required Inspection Capability of Depot and Plan of Each Depot

The required inspection capability in this project calculated under conditions of YM-D/D(1) (target of rolling stock, number of rolling stock, maintenance period, required time for maintenance, and work condition) is shown in Table 5.11.3.

Table 5.11.3 Required Inspection Capability of Depot in YM-D/D(1)

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 5.11.4.

Table 5.11.4 Depot Plan

Work	Ywathagyi	Taungoo	Naypyitaw	Mandalay
Stabling Rolling stock	Conducted		Conducted	Conducted
Light repair	Conducted			Conducted (only Daily Inspection)
Unscheduled repair	Conducted			Conducted
Wheel re-profiling	Conducted			
Train Preparation	Conducted		Conducted	Conducted
Fueling and Supplying water	Conducted		Conducted	Conducted
Overhaul	Conducted			

Source: JICA Study Team

The results of the review are as follows.

(a) 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.

(b) Taungoo Area

According to the operation plan, only one train (2 train-sets) will be stabled at Taungoo area. However, new facilities should not be installed. Due to specifications of the train considering long distance operation, the work of fueling, supplying water, and discharging sewage tank is not required because these works are conducted before operation to Taungoo. And also, the number of stabling train is too small. Therefore, it is recommended that new facilities not be installed at Taungoo area.

(c) Naypyitaw Area

Four trains (12 train-sets) will be stabled at 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, such as fueling, supplying water, and discharging sewage tank should be installed at Naypyitaw.

(d) Mandalay Area

The 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 YM-D/D(1).

From the above results, the depot equipment plan is proposed as shown in Table 5.11.5.

Table 5.11.5 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

(2) Candidate Sites of Each Depot

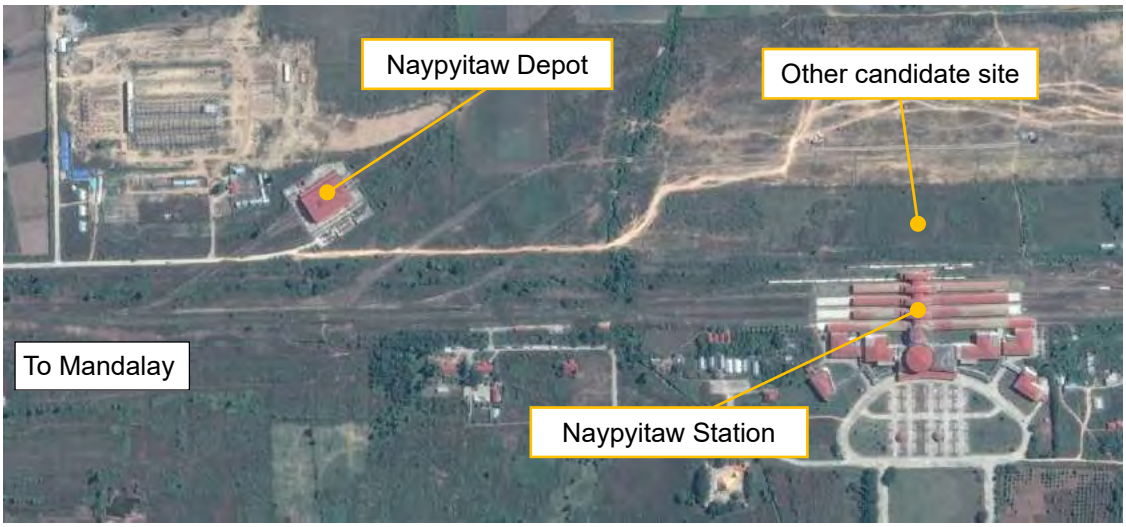
When candidate sites of each depot are considered, MR's existing depots and other lands are compared.

1) Naypyitaw Area

The following 2 places are compared as shown in Figure 5.11.6.

- MR's Existing Depot
  - ✓ Naypyitaw Depot
- Other Land
  - ✓ In Naypyitaw Station

There are 2 depots near Naypyitaw Station. However, only Naypyitaw Depot is nominated because Pyinmana Depot will be combined to Naypyitaw Depot in the future.



Source: Google Earth

Figure 5.11.6 Candidate Sites in Naypyitaw Area

The result of comparison is shown in Table 5.11.6, and the plan to utilize Naypyitaw Depot is recommended.

Table 5.11.6 Evaluation of Candidate Sites in Naypyitaw Area

Evaluation items	Naypyitaw Depot	In Naypyitaw Station
Size of area	Enough space	Enough space
Forwarding distance	Near the station	Near the station
Construction cost	Possible to reduce	Impossible to reduce
Difficulty of Construction	Easy to install	Easy to install
Utilizing existing facilities	Possible	None

Source: JICA Study Team

By utilizing Naypyitaw Depot, facilities in Naypyitaw Depot such as existing office etc. can be utilized, and also existing workers in Naypyitaw Depot can be utilized as workers for DEMU maintenances. As a result, the construction cost in case of utilizing Naypyitaw Depot is less than that in case of constructing a new depot.

From the above, the plan to utilize Naypyitaw Depot is recommended and proposed.

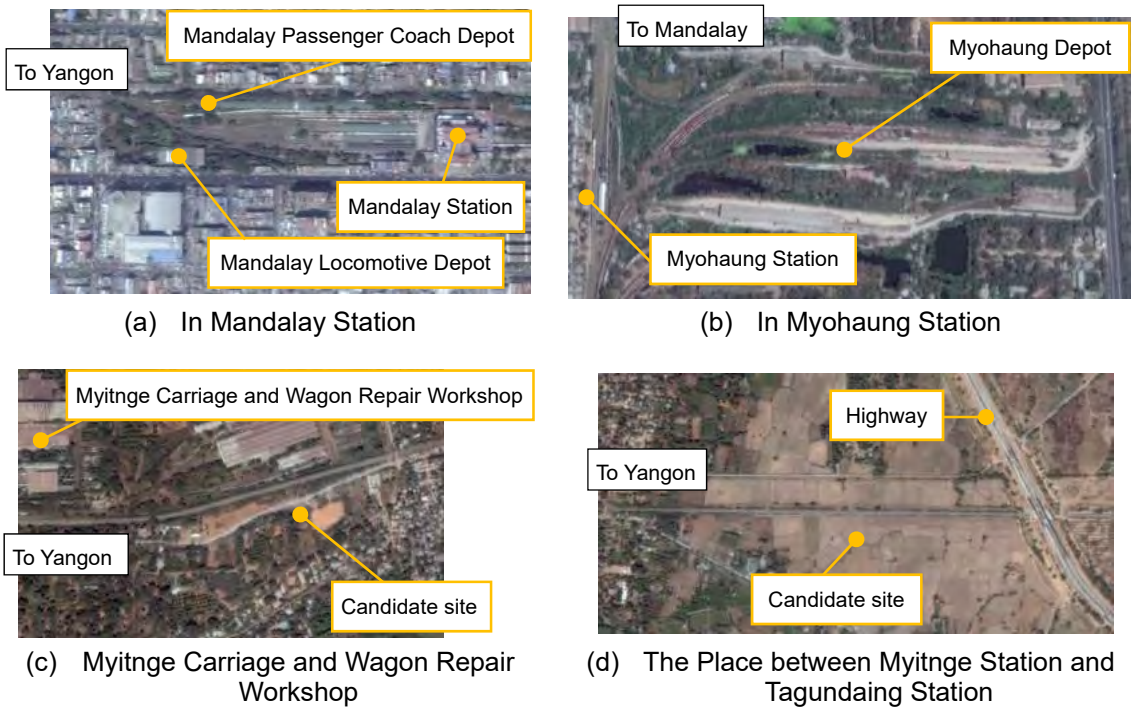
2) Mandalay Area

4 following places are compared as shown in Figure 5.11.7.

- MR's Existing Depot
  - ✓ In Mandalay station (Mandalay Locomotive Depot, Mandalay Passenger Coach Depot)
  - ✓ In Myohaung station (Myohaung Depot)
  - ✓ Myitnge Carriage and Wagon Repair Workshop

➢ Other Land

✓ The place between Myitnge Station and Tagundaing Station



(a) In Mandalay Station

(b) In Myohaung Station

(c) Myitnge Carriage and Wagon Repair Workshop

(d) The Place between Myitnge Station and Tagundaing Station

Source: Google Earth

Figure 5.11.7 Candidate Sites in Mandalay Area

The result of comparison is shown in Table 5.11.7. The plan in Myohaung Station and the plan between Myitnge Station and Tagundaing Station are recommended.

Table 5.11.7 Evaluation of Candidate Sites in Mandalay Area

Evaluation items	In Mandalay Station	In Myohaung Station	Myitnge Carriage and Wagon Repair Workshop	The place between Myitnge Station and Tagundaing Station
Size of area	No space	Enough Space, but need to relocate	No space	Enough Space
Forwarding distance	Near the station	5 km away	14 km away	12km away
Construction cost	Impossible to reduce	Impossible to reduce	Impossible to reduce	Impossible to reduce
Difficulty of Construction	Hard to install	Easy to install	Hard to install	Easy to install
Utilizing existing facilities	Possible	None	None	None

Source: JICA Study Team

➢ In Mandalay Station

There are depots for locomotive and passenger coach in Mandalay Station, and these depots have facilities for rolling stock maintenances. However, specifications of facilities

do not meet required specifications for DEMU maintenances. For example, the length of the track for fueling in Mandalay Locomotive Depot is only 1 or 2 cars length (about 40 m). Also there is no space in Mandalay Station to install facilities for discharging sewage tank. Therefore, it is difficult to construct the facilities for DEMU maintenances.

- In Myohaung Station

  Maintenances for locomotives and freight cars are conducted in Myohaung Depot, but it is necessary to install the facilities for DEMU maintenances because the facilities in Myohaung Depot do not meet facilities for DEMU maintenances. Moreover, Myohaung Station is the base of freight transportation in Mandalay and facilities for freight handling are scattered in Myohaung Station. And so, when a depot is constructed, it is necessary to create the space by relocation of facilities and concentration of functions for freight handling.

- Myitnge Carriage and Wagon Repair Workshop

  It is necessary to construct all required facilities for DEMU maintenances because this workshop has the function only to overhaul. Moreover, there is no space to construct a new depot.

- The place between Myitnge Station and Tagundaing Station

  It is possible to plan the layout of a new depot for DEMU maintenances freely because there is enough space to constructing depot. However it is necessary to acquire the land.

From the above, 2 plans were recommended to MR. MR requests JST to utilize MR's land. The plan that the depot for DEMU is constructed in Myohaung will be planed.

(3) Contents of planning each Depot

1) Nay Phi Taw Depot

In this study, Naypyitaw Depot for DEMU will be established by utilizing the existing Depot. Facilities will be constructed or installed based on Table 5.11.7. Specifically, the existing fuel supply tracks will be extended to stable DEMU trains considering its effective length. On the other hand, new Train Preparation Shop and new stabling tracks will be constructed next to the existing Naypyitaw Depot. The Plan of Naypyitaw Depot for DEMU is shown in Figure 5.11.8.

Source: Google Earth, JICA Study Team

Figure 5.11.8 Image of Naypyitaw Depot for DEMU

2) New Mandalay Depot

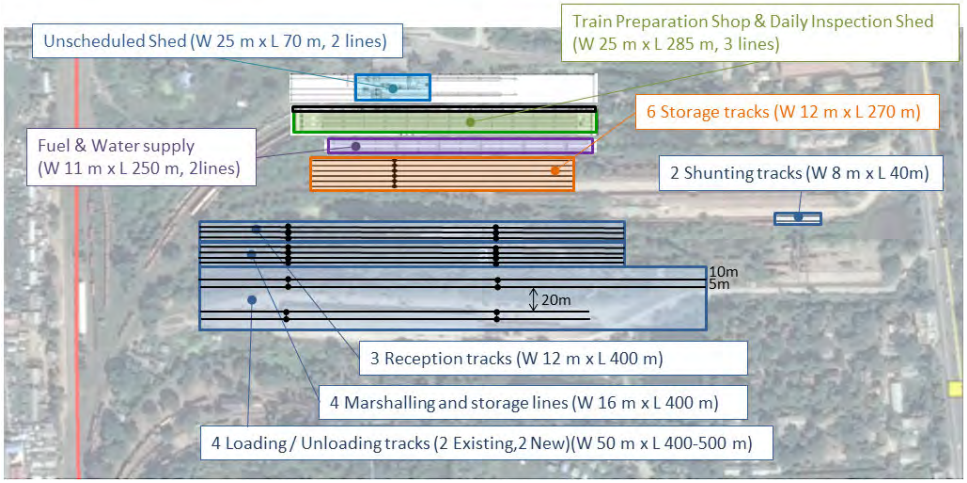
New Mandalay Depot in this study will be established by redeveloping the facilities for not only rolling stock maintenance but also freight trains at Myohaung Station. The existing depot at Myohaung Station will be integrated into New Mandalay Depot because the existing depot will be redeveloped in order to create the space for new facilities. Required facilities at the existing depot at Myohaung are shown in Table 5.11.8.

Table 5.11.8 Main required facilities for maintenance of Locomotive and Wagon at Myohaung Depot

Type	Inspection Item	Required Facility	Where to Install
Locomotive	Visual check of Bogies.	Inspection Pit	Daily Inspection Shed
	Visual check of Equipment on the Locomotive.	Inspection Pit, Deck	Daily Inspection Shed
	Replace Bogie If failure occurred.	Lifting Jack	Unscheduled Shed
	Repair Engine If failure occurred.	Overhead Crane	Unscheduled Shed
	Supply fuel.	Fuel Supply Stand	Fuel and Water Supply Shop
Wagon	Inspect parts of bogie.	Lifting Jack	Unscheduled Shed
	Replace Bogie if failure occurred.	Lifting Jack, Overhead Crane	Unscheduled Shed

Source: JICA Study Team

These facilities are common with Table 5.11.7, and they can be used as common facilities by considering their capacity. Therefore, facilities for rolling stock maintenance will be constructed or installed based on Table 5.11.8. The plan of New Mandalay Depot is shown in Figure 5.11.9.



Source: Google Earth, JICA Study Team

Figure 5.11.9 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. Especially, it is necessary to pay attention on MR's works so that the maintenance for freight rolling stock can be conducted during the construction period as existing depot will be removed. If the maintenance cannot be conducted during the construction period, it is necessary to find alternative facilities for the maintenance.

5.12 SIGNALLING

5.12.1 Current Conditions of Signalling System

The Detailed Design for Yangon-Mandalay Railway Improvement Project Phase I (YM-D/D(1)) was implemented from 2014 to 2015, its bidding was implemented in 2017 and then the construction is expected to start. In Phase I, the modernization of the signalling system for 267 km from Pazundaung Station (except the station yard) to Taungoo Station will be implemented. The signalling system of Yangon Central Station and its adjacent station, Pazundaung Station, is under development by the Grant Aid project by Japan, "The Project for Installation of Operation Control Centre System and Safety Equipment (OCC Project)". The train monitoring system from Yangon Station to Pyuntaza Station is included in the OCC Project.

This preparatory survey covers the section of approximate 353.3 km from Taungoo Station (except the station yard) to Mandalay Station. However, for consistency with the existing operation control section, the Train Monitoring System (hereinafter called TMS) in the section to be provided in Phase II will cover the supervising section of Taungoo OCC from Nyaunlabin Station to Pyinmana Station, of Thazi OCC from Ywadaw Station to Thazi Station and of Mandalay OCC from Ywapale Station to Mandalay Station.

The purpose of this project is to achieve a maximum speed of 100 km/h, and to reduce a minimum travel time between Yangon and Mandalay from greater than or equal to 14 hours at present to less than or equal to 8 hours at the end.

In this project, the signalling system and level crossing control equipment will be developed based on the specifications of the detailed design in Phase I, and considered in order to secure safe, stable and punctual train operation.

(1) Existing Signalling Equipment

1) Block Device

The current block system between two adjacent stations is called “paper block procedure”, in which the section between two adjacent stations is one block without using any safety devices. The paper block procedure is the system which, after the station masters of the two stations check that there is no train occupying the block through the block telephone, the station master departing a train issues the paper of the designated format filling the necessary items and gives it to the train driver. Only the train which brings the paper can run in the block to the next station and thereby the safety is secured.

2) Interlocking Device

(a) Electronic Interlocking Device

At present, the station with an electronic interlocking system is only Naypyitaw Station. This electronic interlocking system has been working for approximately five years. Two power supply systems (rectifier) out of four have failed though the system is still working. The battery system is also not in a good condition, although MR cannot replace it due to the lack of spare parts. Figure 5.12.1 shows the current conditions of the electronic interlocking system at Naypyitaw Station.

(a) Interlocking Control panel

(b) Power Supply

(c) Battery

Source: JICA Study Team

Figure 5.12.1 Electronic Interlocking System

(b) Relay Interlocking Device

A relay interlocking system is installed at three stations, Pyinmana Station, Thazi Station and Mandalay Station. They have been operated for more than 50 years after being installed. MR does not have enough spare parts and thus it is expected to replace them as soon as possible.

Figure 5.12.2 shows the conditions of the interlocking control panel at Mandalay Station.

Source: JICA Study Team

Figure 5.12.2 Interlocking Control Panel

(c) Mechanical Interlocking Device (Key Lock)

The mechanical interlocking system is the system which secures the routes inside stations by interlocking signals and point machines with a key.

Figure 5.12.3 shows the point machine on the main line with an electric point machine made in China. The electric point machine is not connected electrically and the switch operation is conducted by hand crank mechanism. The electric mechanical interlock device in the station master room was manufactured by a UK company, Metropolitan VICKERS GRS Limited in 1960. The procedure to show the Proceeding aspect is first to insert the key, to pull the lever and to swing the handle of the hand operation generator equipped with the device so that the motor equipped with the signal starts moving, and then the Proceeding aspect is shown. The interlocking between the levers is secured by the mechanical matching of steel bars inside the device.

(a) Electric Point Machine and Key Lock

(b) Electric Mechanical Interlocking Device

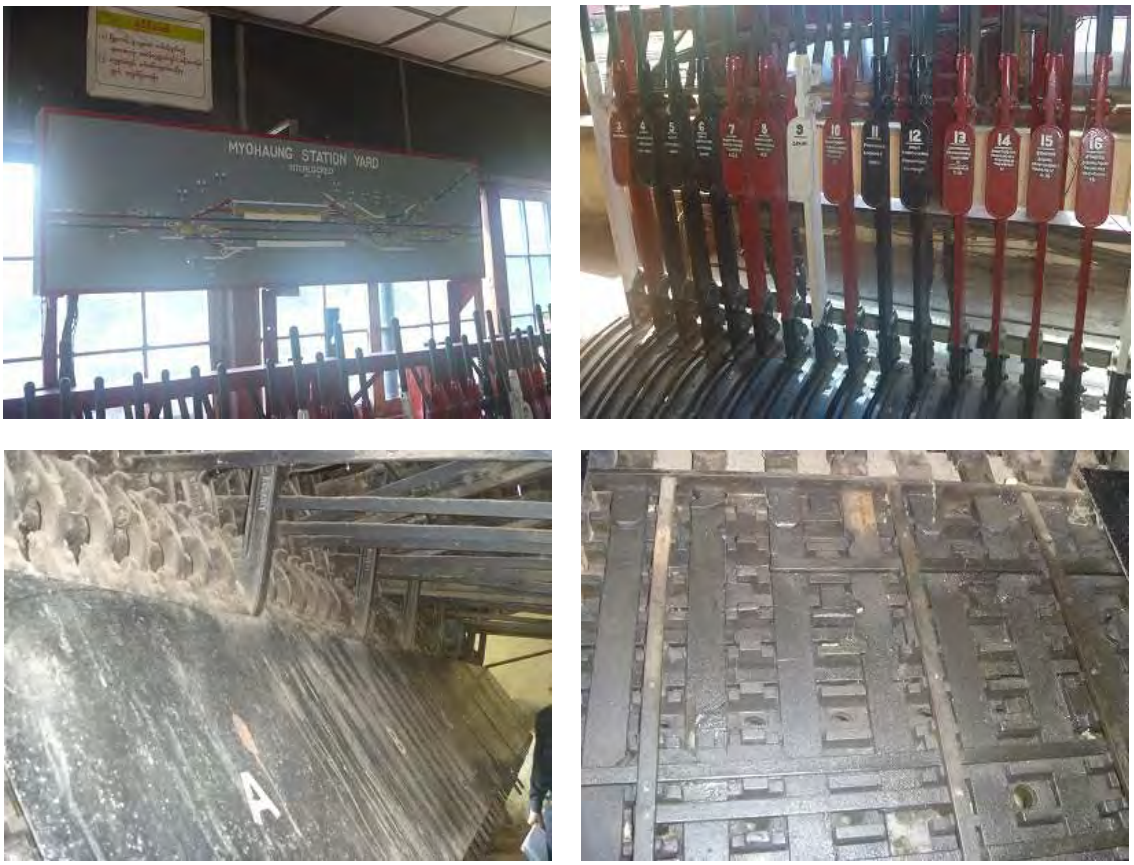
(c) Semaphore Signal

Source: JICA Study Team

Figure 5.12.3 Mechanical Interlocking Device

At Myohaung Station, as Figure 5.12.4 shows, all the signal levers and all the point levers for the mechanical interlocking system are allocated in the signal cabin. The interlocking between levers is secured by the combination of slits of the steel piece placed under the lever mechanism. The

movement of the levers is translated to the electric signal through the relay, then the electric point machine turns and the Proceeding signal on the color light signals is on.



Source: JICA Study Team

Figure 5.12.4 Signal Cabin at Myohaung Station

3) Train Detection Device

Train detection is performed by track circuits at the station with an electronic interlocking system or a relay interlocking system. The type of the track circuit is DC track circuit. An equipment is arranged by dispersion system, power supply, buttery and track relay are installed in an equipment box beside the rail.

4) Signal Device

The color light signals are used at the stations equipped with an electronic interlocking system or a relay interlocking system. The signal lamp has been replaced to a LED type lamp by MR, since the double filament lamp which is to be used for detecting lamp failure is hard to obtain.

The semaphore signal at the station with the Key Lock system is manipulated by station staff near the signal pole, while the semaphore signal at the station with an electric mechanical interlocking system is manipulated by an electric motor attached to the signal.

Source: JICA Study Team

Figure 5.12.5 Semaphore Signal

5) Point Machine

Electric point machines are used in the station with an electronic interlocking system or a relay interlocking system. Manual point machines are used in the stations with the key-interlocking system. Both types of point machine are hard to keep the adhesion of tongue rail as the point machines have been deteriorated.

(a) Electric Point Machine (Naypyitaw)

(b) Manual Point Machine (Key-interlock)

(c) Electric Point Machine (Mandalay)

Source: JICA Study Team

Figure 5.12.6 Point Machine

6) Level Crossing Device

Currently, there are two types of level crossing in the Phase II area, manned level crossing and unmanned level crossing. For the level crossings inside station limits, basically, station staff goes to the level crossing when a train is approaching and works as a gateman. For the level crossings between stations with heavy road traffic including pedestrians and automobiles, the gateman deployed by MR manipulates the switch to start the warning signal and closes the gates. The gateman is supposed to get the information of an approaching train by train horn sound, telephone call and/or radio call from the nearby station. After closing the gates at the intermediate level crossing, the gateman manipulates the gate switch to indicate the Proceeding signal on the gate signal or indicates the proceeding signal by his flag signal. The train driver must stop before the level crossing if the gate signal does not indicate the Proceeding signal. However, most of these level crossing devises are not working properly as they have been deteriorated. The conditions of the exiting manned level crossing are shown in Figure 5.12.7

(a) Warning Signal for Road Side

(b) Gate Signal for Train

(c) Gate with Gate Switch

Source: JICA Study Team

Figure 5.12.7 Level Crossing Device

7) Maintenance Organization

As for the maintenance organization in the Phase II area, maintenance staffs are deployed to major stations and they are also responsible for the maintenance work for neighbor stations. The current status of maintenance staff assignment shows in Table 5.12.1.

Table 5.12.1 Deployment of Maintenance Staff

Division	Station	Number of Staff
Division 5	Taungoo	7
	Tawuti	2
	Pyinmana	12
	Naypyitaw	12
	Shwemyo	1
	Tatkon	4
	Yamethin	8
	Pyawbwe	6
Division 4	Thazi	7
Division 3	Myitnge	6
	Myohaung	10
	Mandalay	12

Source: JICA Study Team

(2) Related Facilities

1) Tracks

Most of the rail has been worn out. Lots of bolts for rail fastening are lost. Track pads and the Pandrol type of fastening devices are missing at many places. The current conditions of turnouts are shown in Figure 5.12.8

(a) Broken Tongue Rail

(b) Point Machine without Proper Maintenance

(c) Turnout and Point Machine without Proper Maintenance

Source: JICA Study Team

Figure 5.12.8 Existing Track Conditions

2) Telecommunication

An exclusive telephone line has been equipped with each station for the station master to communicate with the adjoining station and the OCC. Between Yangon and Mandalay, 24-core optical fiber cable (OFC) was installed for telephone line use. Radio communication is also available between OCC and stations. The existing telecommunication equipment is shown in Figure 5.12.9.


Source: JICA Study Team

Figure 5.12.9 Existing Telecommunication Equipment

3) Electric Power

Since the quality of the electric power distributed from commercial power companies is poor, each station should be equipped with an engine generator and an AVR to compensate the voltage fluctuation.

5.12.2 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.

Since the large scale of station can expect to receive stable electric power, an electronic interlocking system will be installed at such a large station with many signal routes. A relay interlocking system will be installed at the small scale of station.

In Phase I, the level crossings to be equipped with safety equipment were those located near stations, including the section between Distant signal and Outer signal, considering poor power supply in rural area. 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

To meet the request by MR to shorten the construction period for the improvement of Yangon Mandalay Line, JST proposes the following strategy for the design, manufacture and installation of interlocking systems which needs relatively long time.

The interlocking system is designed and manufactured based on the interlocking control table which defines the interlock and lock between signal devices. The interlocking control table specifies the interlock and lock for each route. Therefore, as the stations with more routes have more related routes and point machines, the design of the signalling system for such stations will be rather complex and thus requires longer time. In case of a relay interlocking system, the interlocking control table is proposed first, the wiring diagram is developed and then actual wiring works follow it.

For an electronic interlocking system, firstly the interlocking logic is to be digitalized according to the data format of each supplier after its interlocking control table is defined, and then the data is loading to the memory of the electronic interlocking system.

In case of Phase I, the station with 30 routes or less was to be equipped with a relay interlocking system and the station with 31 routes or more was to be equipped with an electronic interlocking system. In Phase II, the same classification will be adopted.

Since the number of trains is smaller in the Phase II section, north of Taungoo Station, stations with small number of routes are equipped with the key interlocking type of mechanical interlocking or electrical mechanical interlocking system. 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

1) Scope of work

The signalling system includes the following subsystems.

i) Interlocking System

- Electronic interlocking system
- Relay interlocking system

ii) Block System

- Absolute Block System
- Automatic Block System

iii) Train Detection Device

- Track circuits

iv) Automatic Train Protection Device

- Ground equipment

v) Signals and Markers

vi) Switch and Lock Movement

- Electric point machine
- Manual point machine

vii) Level Crossing Safety Equipment

viii) Power Supply System

ix) Cables and Conduits

x) Spare Parts

Note: TMS is mentioned in Section 5.14.

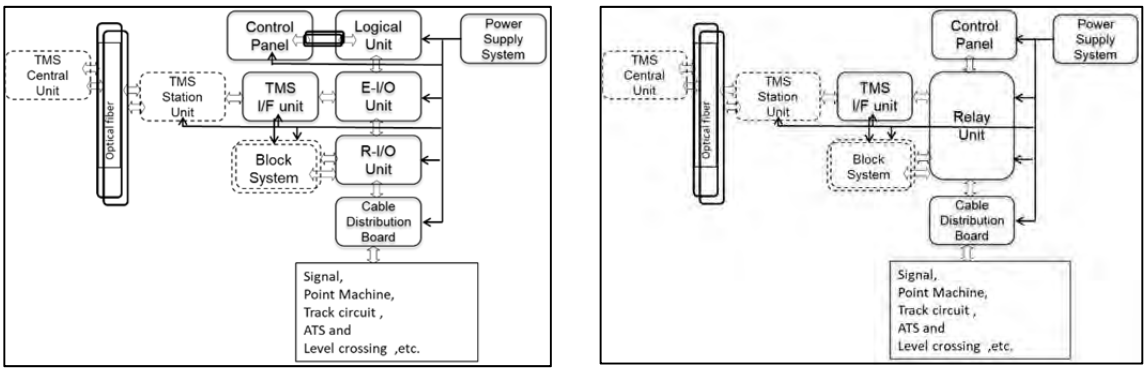
2) Interlocking System

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. A relay interlocking system is expected to work even in unstable electric power conditions as it has been working for a long time in Yangon Mandalay Line. 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

Figure 5.12.10 shows the typical configuration of electronic interlocking and relay interlocking.



(a) Electronic Interlocking System (b) Relay Interlocking System

Source: JICA Study Team

Figure 5.12.10 Configuration of 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, this system should be replaced for the following reasons.

- As the rail for the main line is to be replaced from 75 pound to 50N in this project and thus the point machines will require more throwing force, it will be necessary to replace electric point machines.
- More electric power is required for the bigger electric point machine and thus a bigger electric power device will be required.
- As the existing SSI does not have the block system with the adjacent stations, it is necessary to integrate the SSI with the block interface.
- The interface device must be equipped to input and output the information between the Train Monitoring System (TMS).

Considering the cost for the modification of the existing SSI to solve the above issues, it is reasonable to replace the signal equipment for Naypyitaw Station including SSI.

Electronic interlocking will be installed for large stations. In Japan, signaling equipment room is divided into two or three rooms to avoid many cables connecting into one equipment room from wayside equipment. This design has an advantage for voltage drops, as power source is to be installed in such rooms and thus the distance between the power source and wayside equipment is shorter. Furthermore, electronic interlocking can reduce the cables between each signal house (SH), since each SH will be connected with optical fiber cable. However, MR prefers one SH in one station rather than two or three SHs, since MR worries about the possibilities of the cutting of optical fiber cables and also security of SH located away from the station master room.

In the detailed design stage, if the station building is to be renewed, the location of the SH will be considered in the rebuilding plan so that the signaling equipment room can be assigned in the new station building. Also, as for Pyinmana Stations, Thazi Station, Myohaung Station and Mandalay

Station, where plural SHs are preferable, it is expected to study the possibility of one SH as well as economical disadvantages in the detailed design stage.

3) Block System

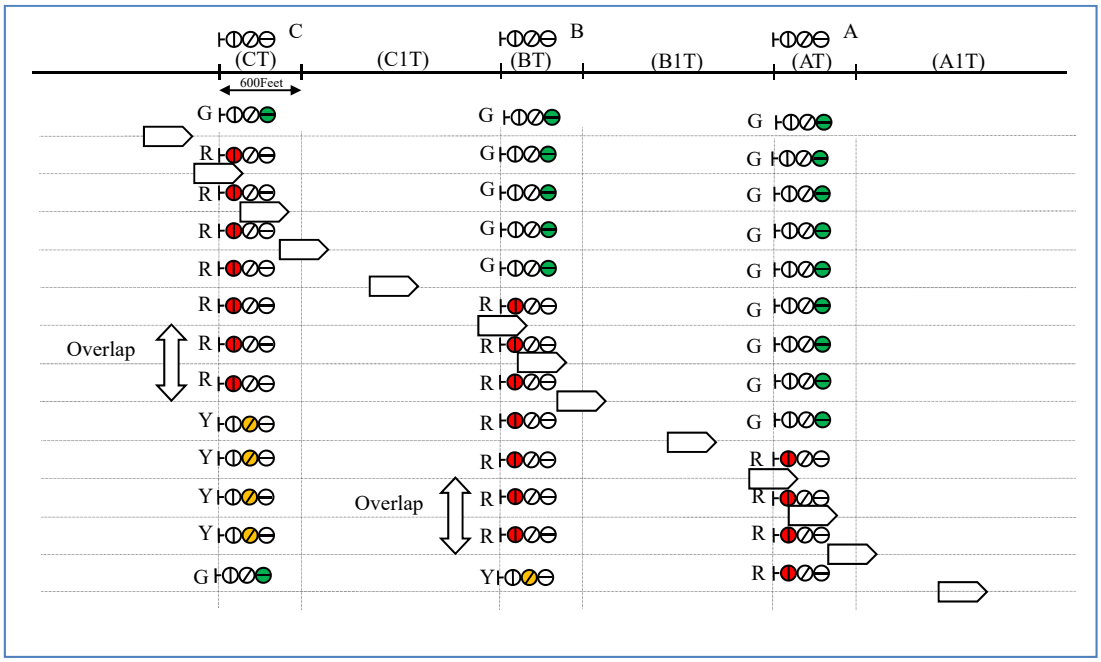
(a) Absolute Block System (AB)

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.

(b) Automatic Block System (ABS)

Shanzu Station is the halt station between Myohaung Station and Mandalay Station, which does not have a block function. This means that only one train can be occupied on this 4 km section between Myohaung Station and Mandalay Station through Shanzu Station. If the traffic volume increases in the future, this station needs to be a block station so that one train between Myohaung Station and Shanzu Station and one train between Shanzu Station and Mandalay Station. In the discussion with MR, however, MR preferred installing the Automatic Block System (hereinafter ABS) between Myohaung Station and Mandalay Station, where plural automatic block signals are installed, and to remain Shanzu Station as a halt station, instead of setting Shanzu Station a block station. 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.

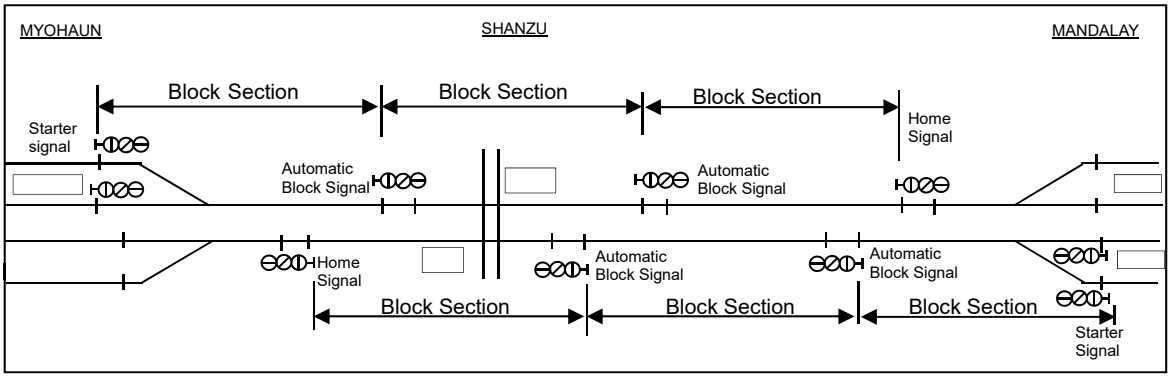
The ABS is the system that the aspect of a signal located at the beginning of a block section is changed automatically as a train moves, which is usually used in Japan on the section where plural trains are occupied between adjacent stations. On Yangon-Mandalay Line, the ABS is supposed to be installed between Yangon Central Station and Ywathagyi Station in Phase I. Figure 5.12.11 shows the system diagram that the aspect of a block signal is controlled as a train moves. The control method of the ABS in Myanmar is a semi-overlapping type. The block signal keeps the stop aspect until the train passes the Overrun, 600 feet, of the block section next to the block section protected by the block signal.



Source: JICA Study Team

Figure 5.12.11 System Diagram of Aspect of the Automatic Block System (Semi-Overlapping Type)

For Phase II, the ABS is to be installed between Myohaung and Mandalay. Comparing the case that Shanzu Station is set a block station, the number of signals will be the same and operating staff of MR does not have to deal with the block for trains. Also the project cost will be smaller than the case of installing the block system at Shanzu Station. Figure 5.12.12 shows an example of the location of the automatic block signals between Myohaung and Mandalay.



Source: JICA Study Team

Figure 5.12.12 Location of Automatic Block Signals (Draft)

4) 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.

(a) Fixed Signal

The fixed signal is classified as follows.

- Outer signal: 3 aspects (G, Y, R)
- Starter signal
  - Advanced starter signal : 2 aspects (G, R) for Absolute block section
  - Platform starter signal : 2 aspects (for main line: G, R, for siding line: Y, R)
    : 3 aspects (G,Y,R) for Automatic Block section
- Shunting signal: Line light

(b) Subsidiary Signal

- Distant signal: 3 aspects (G, Y, YY)

(c) Signal Appendant

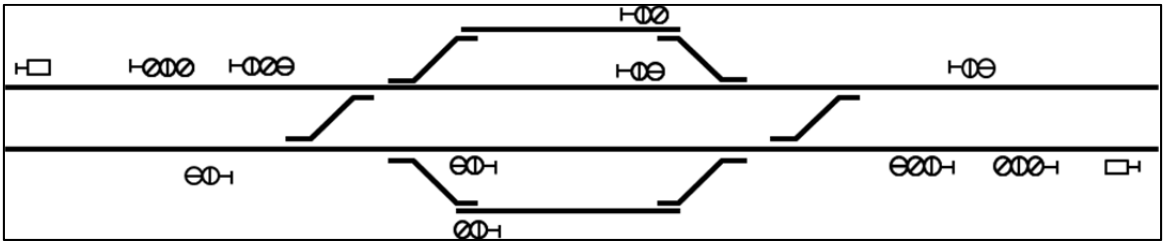
- Route indicator (Number or Letter)

(d) Sign

- Free shunting indicator: Letter 'F'

(e) Signal Allocation in the Station Yard

An example is shown in Figure 5.12.13.



Source: JICA Study Team

Figure 5.12.13 Signal Assignment in Station Yard

5) Point Machine

MR currently uses two types of point machine, mechanical and electric point machine. The mechanical point machine has two types, namely the concentrate type and the local control type.

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.

Tracks are frequently flooded from rivers due to heavy rain on Yangon - Mandalay Line. As the track improvement works will raise the track as the measure for flooding while previous flood records will be considered, the water proof type point machine will not be installed. However, it should be considered to raise point machines for the stations where flood often occurs.

The water proof type point machine has been used in some subway lines but not in Japan Railways (former national railways) as it has disadvantages such as inability of movement in case it is completely flooded and difficulty in maintenance.

6) 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.

7) 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. The current signalling system depends on the driver's attentiveness toward wayside signals based on the interval control. This type of signalling system cannot stop the train safely if the train driver misunderstand or overlooked the signal as there is no back up for such human errors. In order to improve the situation, 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.

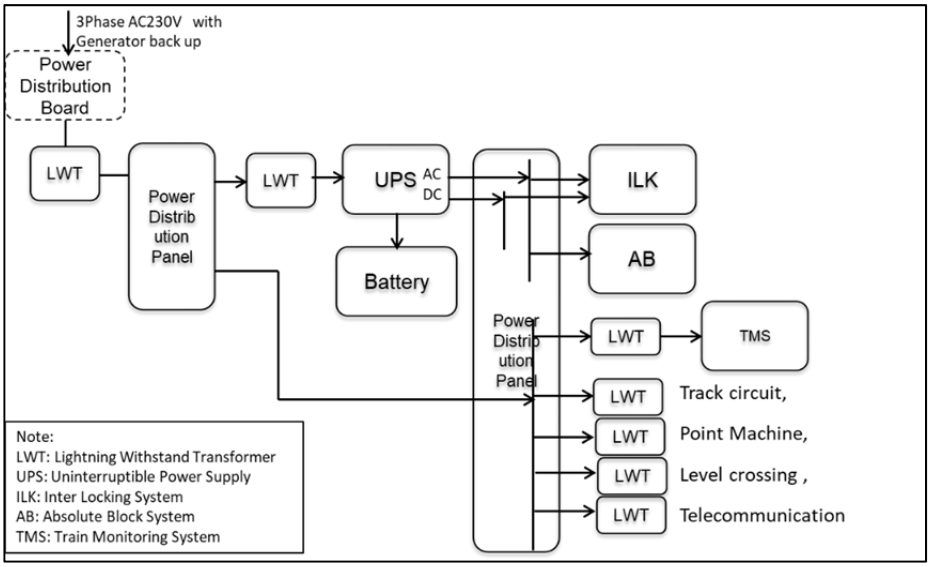
Regarding onboard equipment, MR requested it for 30 locomotives. In Phase I, it was decided that onboard equipment for 50 locomotives will be procured in Contract Package 105. As the bidding procedure of this package will be expected in 2018, the onboard equipment for 30 locomotives is to be added to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

8) 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. However, under the poor electric condition including the voltage drop and the long period of power down, adequate countermeasures are supposed to be taken on the power receiving side. The signal contractor is expected to install the power supply system for signalling. The receiving point of 230V AC electricity from the power supplier with the backup of generator is the power distribution system which the power supply contractor is supposed to install. In case the generator starts operation, the electric power will be supplied from an uninterruptible power supply (hereinafter UPS) for approximately 10 minutes until the output of the generator becomes stable. The electric power supply to the electronic interlocking system has to be stable and even a short time of interruption is not allowed. The measures for protecting from thunder have to be taken for any electronic devices to avoid malfunction and damages. Regarding the backup generator, the continuous operation time is expected 7 hours or more as is mentioned in Section 5.16.

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.

A typical power supply diagram for interlocking system is shown in Figure 5.12.14



Source: JICA Study Team

Figure 5.12.14 Power Supply Diagram

9) 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.

10) 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.

Even if the gateman misses train approach in case the level crossing is set manual gate closing, the train is not to pass the level crossing as the gate signal does not show the Procced signal. However, MR should encourage gatemen to use the autonomic gate closing function from the viewpoint of safety.

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 5.12.2 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 5.12.3 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. For safety, the gatemen are to use a portable radio device as the radio system will be improved in this project so that they can communicate with nearby station master(s). Therefore, the gatemen will be able to know train approaching information from the station master(s) as well as they watch train approaching by themselves. Since train speed will be raised, the education to MR staff and the enlightenment to people near the railroad will be important. Although these activities are supposed to be carried out basically by the contractors, MR is also expected to be engaged in these activities and should ask for the cooperation with the police.

Table 5.12.2 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 on

NSBI : Not Special But Important

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

NOTE: Class
A Inside of Station(Maned)
B Inside of Station(Unmaned) and few traffic
C Intermediate between distant signal and outer signal

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

Power Distribution by POWER / SIGNAL

Measured by Map on

NSBI : Not Special But Important

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

NOTE: Class
A Inside of Station(Maned)
B Inside of Station(Unmaned) and few traffic
C Intermediate between distant signal and outer signal
D Intermediate

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

Power Distribution by POWER / SIGNAL

Measured by Map on

NSBI : Not Special But Important

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

NOTE: Class
A Inside of Station(Maned)
B Inside of Station(Unmaned) and few traffic
C Intermediate between distant signal and outer signal
D Intermediate

Source: JICA Study Team

iii) Equipment Introduced for Maned Level Crossing in Station Yard

The level crossing warning device will be installed to give caution to pedestrians and car drivers and to urge the gateman to close the gate. The level crossing barrier machine will be installed to shorten the gate closing time and to reduce the burden of the gateman. The level crossing control device including train detection device will be installed for controlling the alarm. The obstruction warning indicator will be installed to inform the train driver of an emergency situation at the level crossing such as the failure of the level crossing warning device or barrier machine or car stuck.

iv) Equipment Introduced for Un-man Level Crossing in Station Yard and That with Low Traffic Volume

The level crossing which has low traffic volume in the station yard and un-man one will be also equipped with the level crossing barrier machine as well as with the level crossing warning device and control device including train detection devices to control the alarm will be equipped.

v) Equipment Introduced for Intermediate Level Crossing between Distant Signal and Outer Signal

The level crossing warning device will be installed to give caution to pedestrians and car drivers. The level crossing barrier machine will be installed to shorten the gate closing time and to reduce the burden of the gateman. The gate signal will be installed in order to inform the train driver that the gates are closed. The level crossing control device including train detection device will be installed for controlling the alarm. The obstruction warning indicator will be installed to inform the train driver of an emergency situation at the level crossing such as the failure of the level crossing warning device or barrier machine or car stuck.

vi) Equipment Introduced for Other Intermediate Level Crossing

In Phase I, it was decided that the level crossing safety equipment would not be installed to the intermediate level crossings because of the difficulty in power supply and some technical problem in the procedure of the operation of a maintenance car. However, MR requests that the level crossing of heavy traffic roads such as Yangon Mandalay National Highway be equipped with the level crossing safety equipment for the safety reason if power supply is available. The electric power for the level crossing is to be supplied from the power distribution line near the level crossing by the power supply contractor. Considering the heavy road traffic on the highway, the level crossing barrier and the level crossing warning device will be installed. The overhang type of level crossing warning lamp will be considered to be introduced to secure the visibility from the car driver as the road is wide. Special level crossing gates will be introduced to the wide level crossing as the normal type of level crossing gate can close the width of at most 20 meters by using double bars, while the road width of such special level crossings is about 30 meters for one side.

The gate signal will be installed in order to inform the train driver that the gates are closed. Also, the level crossing control device including the train detection device will be installed for controlling the alarm.

vii) Measures for Special Case

Train detection cannot work when an isolated maintenance car is running. When a maintenance car is to pass the level crossing, a manual control switch is required to start warning and to close the gates. When it has passed the level crossing, the warning is to be stopped and the gates are opened manually.

In case of track maintenance which influences to the train detection for the level crossing, the level crossing control switch is set to the manual mode, and the alarm sequence starts as manual operation.

Since the shunting operation in the station yard is complex in terms of train movement, the warning control could be operated manually to avoid the complicated warning control.

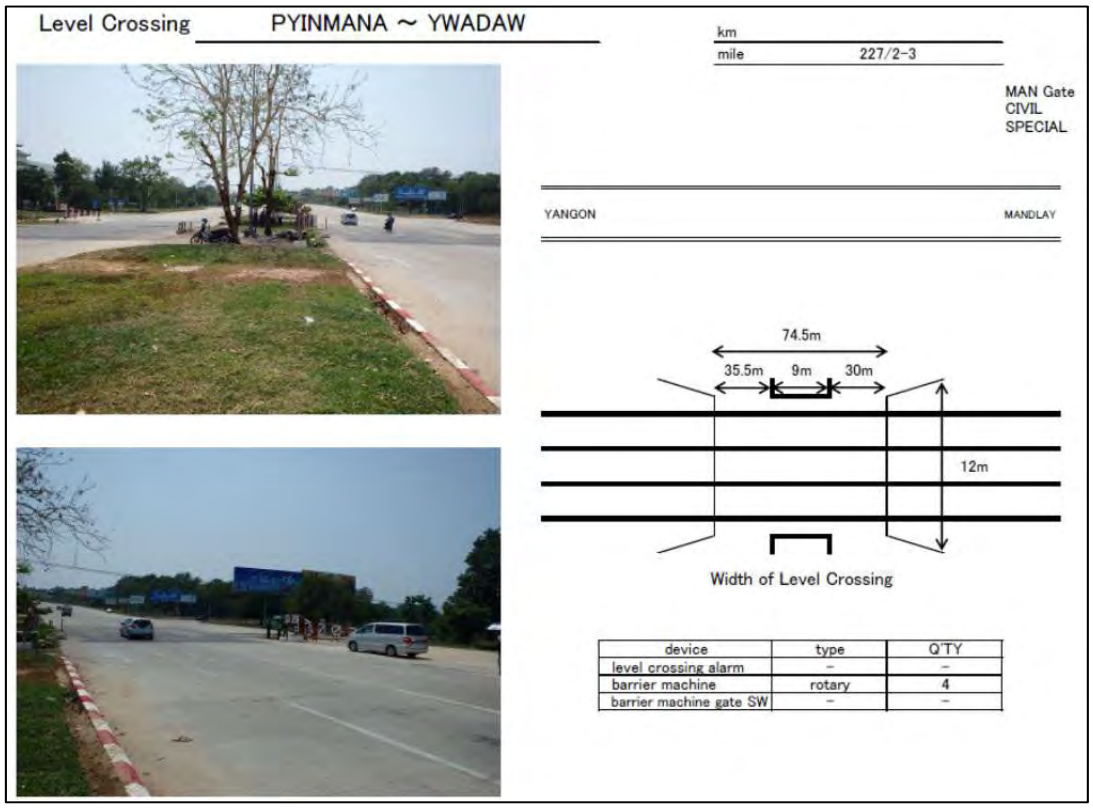
viii) Level Crossing Barrier Machine

Road closing width is decided by the road width and crossing angle with railway. One straight rod type barrier machine can close the road of 8 meters at maximum, although maximum closing length depends on signal suppliers and there is barrier machine which can close 10 meters. If two straight type barrier machines are installed at both sides, the road can be closed for 16 meters at maximum.

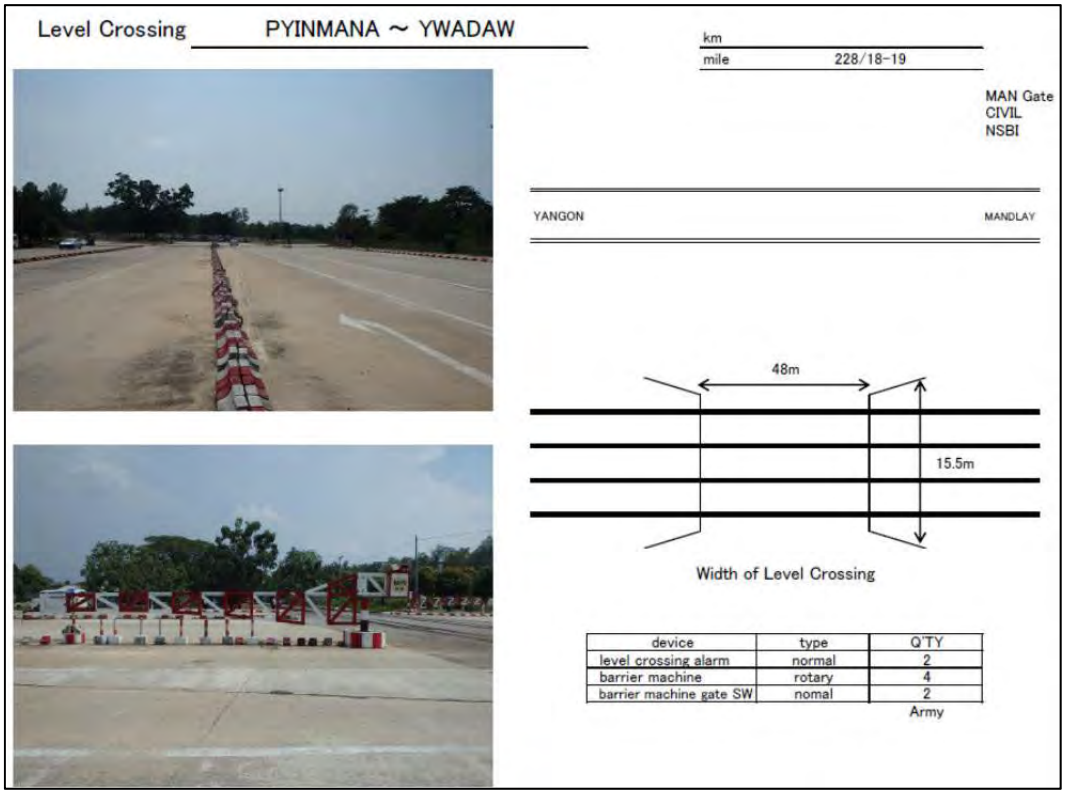
There are 10 level crossings with the road of 16 meters width or more in Phase II. The JICA Study Team would propose the folding type barrier machine which can close 16 meters for such wide level crossings. If two machines are used, they can close 32 meters. There are 7 level crossings which cross the railway with 16 to 32 meters width.

There are three level crossings of 32 meters or more width as bellow.

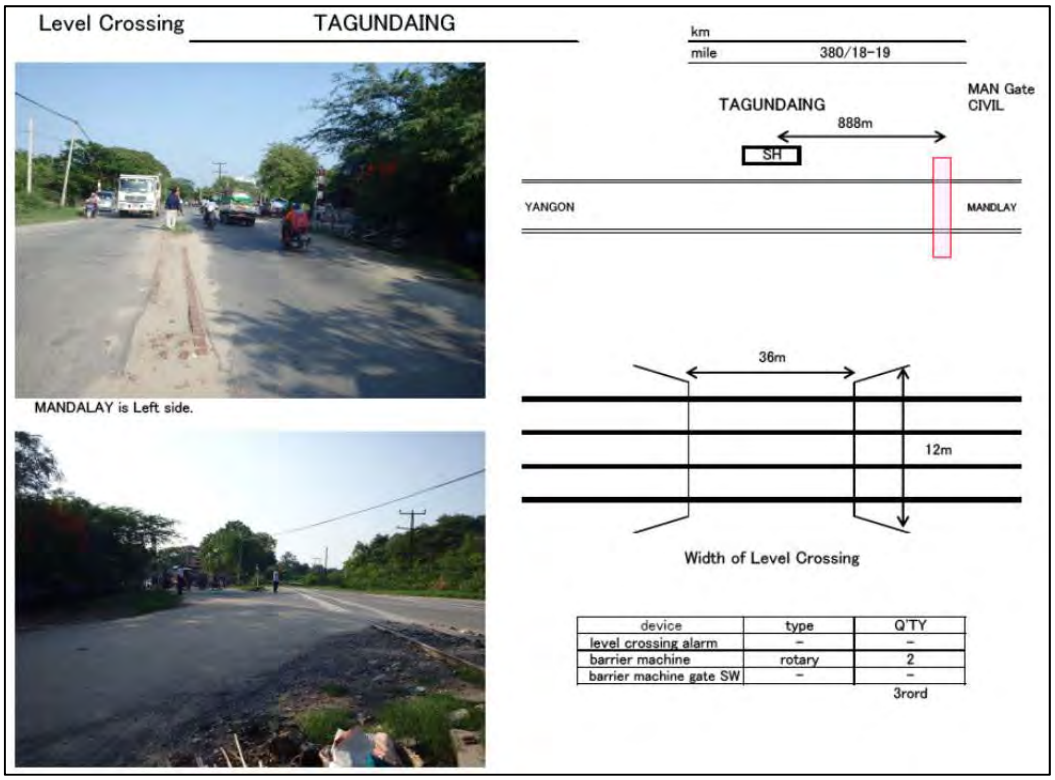
a) Between Pyinmana Station and Ywadaw Station: Mileage 227/2-3, Width = 74.5 meters



b) Between Pyinmana Station and Ywadaw Station: Mileage 228/18-19, Width = 48 meters



c) Tagundaing Station: Mileage 380/18-19, Width = 36 meters



- As for level crossing a), there is a 9 meters island where level crossing barrier machines could be installed. If the folding type barrier machines could be installed at the island, this road would be able to be closed.
- As for level crossing b), the width is 48 meters but there is no island for installing barrier machines. The road could be closed by using the folding type level crossing barrier machines if the island for installing barrier machines could be constructed. Such an island could be constructed if the government agency responsible for road gives the permission. If the project cannot get the permission, the hanged type level crossing barrier machines should be applied.
- As for level crossing c), the width is 36 meters and there is an island of 1 meter wide. The level crossing barrier machine could be installed at the island. In this case, the signs to car drivers for indicating the existence of such barrier machines are needed as well as some protection measures for collision for cars are needed.
- Other than the level crossings mentioned above, there are several level crossings with the possibility of widening road. For these roads, details including the width have not been decided. If the road closing length becomes 32 meters or more, it will be necessary to study the type of level crossing barrier machine as well as the possibility of installation of an island.

(4) Interface with Other Works

1) Civil

Installation of cable protection pipes crossing under the track and crossing under the road is to be requested to civil work. The location and diameter of such pipes are to be instructed by signalling work. In addition, the foundation for signals and location cases, earth retaining and other small works are to be requested to civil work with the instruction of their size and installation position.

2) Track

Selection of fitting apparatus for electric point machines and installation location and method for insulation joint and rail bond must be studied by signalling work in accordance with the turnout structure. In order to install such insulation joints at necessary locations, a rail allocation plan is to be discussed with track work. Signalling work is to request civil works to select the type of sleeper, rail fastening and other equipment which shall satisfy electric performance to work track circuit properly.

3) Architecture

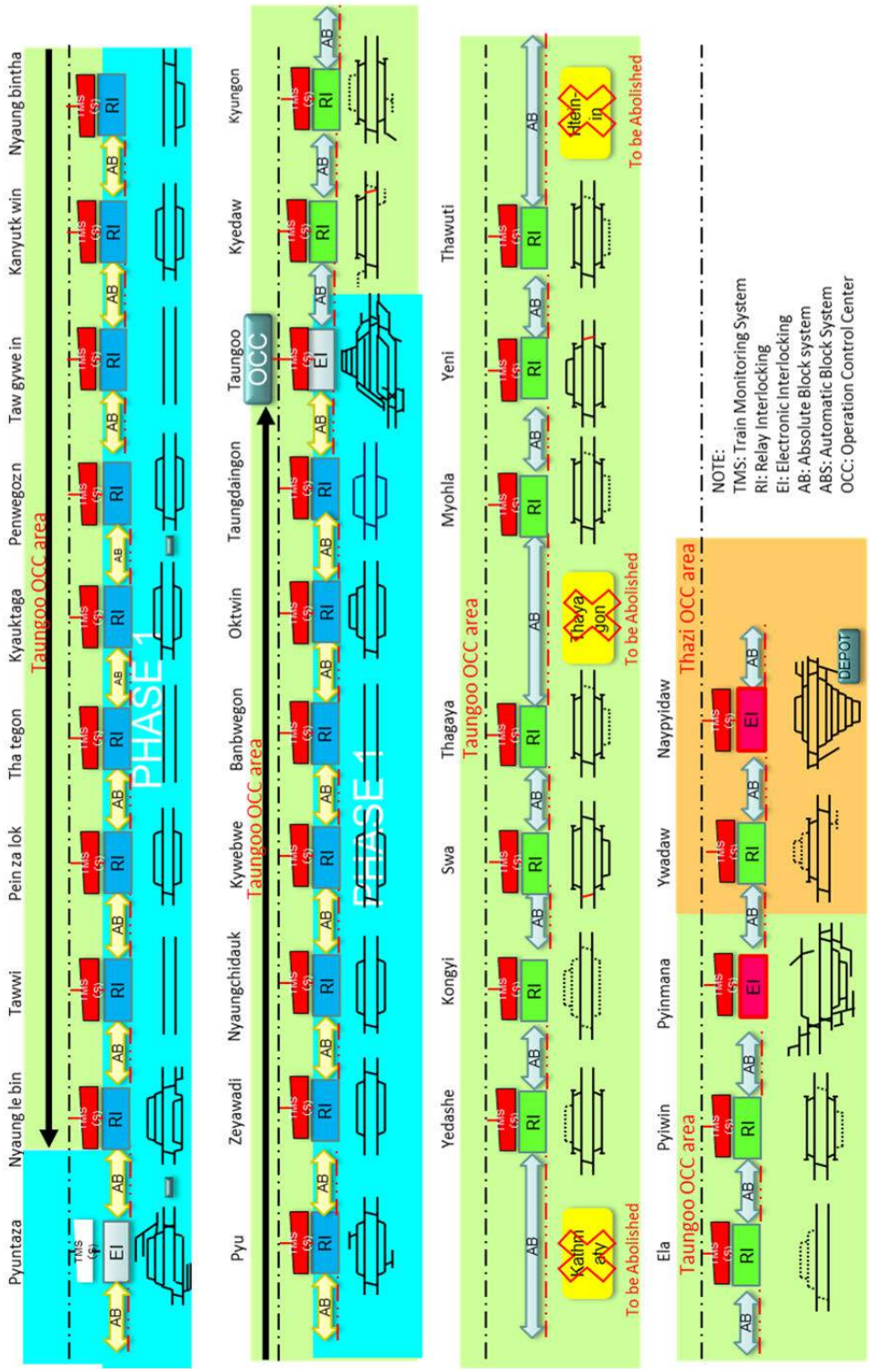
The construction area necessary for the signal equipment room is to be discussed together with architecture work in the detailed design stage. Signalling work is to request architecture work to build signal equipment rooms, OCCs and huts for level crossing equipment.

4) Power Supply

The electric power for signalling is to be supplied by power supply work. Power capacity, location of receiving point and construction boundary is to be discussed with power supply work.

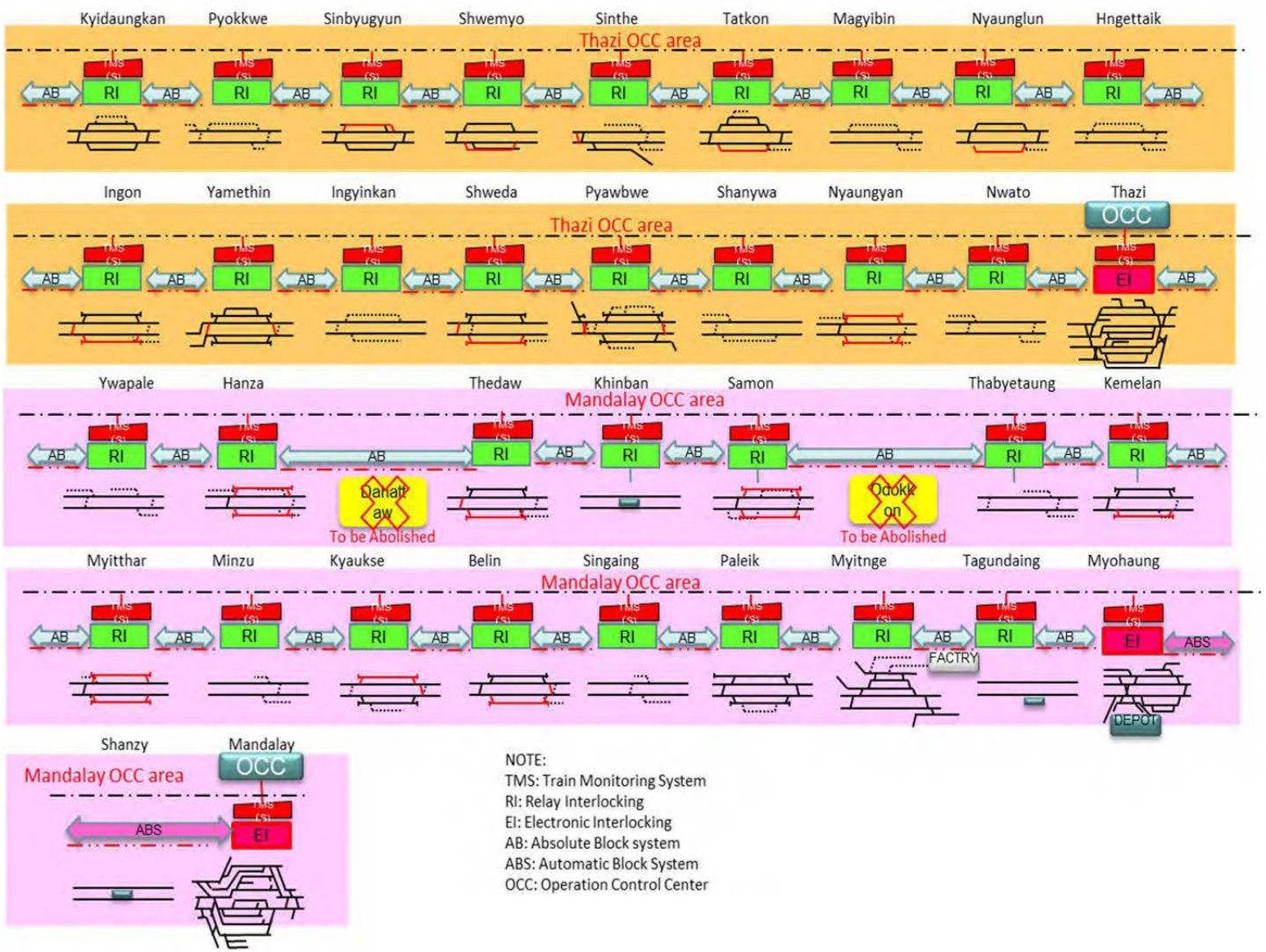
(5) Diagram for Improvement Plan of the Signalling System

The improvement plan of the signaling system in Phase II section is shown in Figure 5.12.15 (excluding Phase I section between Pyuntaza and Taungoo) and Figure 5.12.16



Source: JICA Study Team

Figure 5.12.15 Improvement Plan for Signalling System between Pyuntaza and Naypyitaw



Source: JICA Study Team

Figure 5.12.16 Improvement Plan for Signalling System between Kyidaungkan and Mandalay

(6) List of Signalling System

The signalling system for each station is shown in Table 5.12.3.

Table 5.12.3 Signalling System for Each Station

LIST OF SIGNALING EQUIPMENT

Station						TMS		Interlocking					Block system		Level Crossing	Remarks
Station No	Mile	km	Dist km	Name	DIV OCC	OCC	Station	Present	Plan	Route Main	Route Shunt	Route Total	Present	Plan		
21	87.75	141.22	141	Pyuntaza												
22	97.47	149.27	8.05	Nyaung le bin			1									
23	97.47	156.86	7.59	Tawwi			1									
24	101.8	163.75	6.89	Pein za lok			1									
25	106	170.59	6.84	Tha tegon			1									
26	108.8	175.02	4.43	Kyauktaga			1									
27	114.3	183.87	8.85	Penwegon			1									
28	119	191.51	7.64	Taw gywe in			1									
29	123.7	199.08	7.57	Kanyutk win			1									
30	128.5	206.8	7.72	Nyaung bintha			1									
31	134.3	216.05	9.25	Pyu			1									
32	138.3	222.49	6.44	Zeya wadi			1									
33	143.3	230.54	8.05	Nyaungchidauk			1									
34	149.3	240.19	9.65	Kywebwe			1									
35	152.8	245.83	5.64	Banbwegon			1									
36	158.3	254.68	8.85	Oktwin			1									
37	161.8	260.31	5.63	Thaung dai gon			1									
38	166	267.15	6.84	TAUNGOO	OCC	1	1	R-ILK	EI							
				TAUNGOO-KYEDAW											2	
39	171.8	276.5	9.35	KYEDAW			1	M-Key lock	RI	9		9	Paper	AB	1	
40	175.5	282.5	6	KYUNGON			1	M-Key lock	RI	10	2	12	Paper	AB	1	
41	180.5	290.5	8	KAYTUMADI	HALT								Paper	AB		ABOLISH
42	183.3	295	4.5	YEDASHE			1	M-Key lock	RI	10		10	Paper	AB	2	
				YEDASHE-KONGYI											1	
43	187.3	301.5	6.5	KONGYI			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
44	191.5	308.5	7	SWA			1	M-Key lock	RI	16		16	Paper	AB	1	
45	195.5	314.5	6	THARGAYA			1	M-Key lock	RI	10		10	Paper	AB	1	
46	197.8	318.5	4	THARYARGON	HALT								Paper	AB		ABOLISH
47	201.3	324	5.5	MYOHLA			1	M-Key lock	RI	10		10	Paper	AB	1	
48	206.8	332.5	8.5	YENI			1	M-Key lock	RI	16		16	Paper	AB	2	
49	210	338	5.5	TAWUTI			1	M-Key lock	RI	10		10	Paper	AB	2	
				TAWUTI-HTEININN											1	
50	214	344.5	6.5	HTEININN	HALT								Paper	AB		ABOLISH
				HTEININN-ELA											1	
51	216.8	349	4.5	ELA			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
52	219.3	353.5	4.5	PYAYWUN			1	M-Key lock	RI	10		10	Paper	AB	0	
53	225	362	8.5	PYINMANA			1	R-ILK	EI	25	81	106	Paper	AB	5	
				PYINMANA-YWADAW											2	
54	230	370	8	YWADAW			1	M-Key lock	RI	14		14	Paper	AB	1	
55	232.9	374.7	4.7	NAYPYITAW		1	1	SSI	EI	72	88	160	Paper	AB	1	
56	235.3	378.5	3.8	KYIDAUNGKAN			1	M-Key lock	RI	10		10	Paper	AB	2	
				KYIDAUNGKAN-PYOKKWE											1	
57	240.5	387	8.5	PYOKKWE			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
58	243.5	392	5	SINBYUGYUN			1	M-Key lock	RI	10		10	Paper	AB	0	
59	246.8	397	5	SHWEMYO			1	M-Key lock	RI	10		10	Paper	AB	0	
60	251	404	7	SINTHE	Brunch		1	M-Key lock	RI(BLK)	4		4	Paper	AB	2	
61	253.5	407.5	3.5	TATKON			1	M-Key lock	RI	14		14	Paper	AB	3	
62	257.5	414	6.5	MAGYIBIN			1	M-Key lock	RI(BLK)	4		4	Paper	AB	0	
				MAGYIBIN-NYAUNGLUN											1	
63	261.5	420.5	6.5	NYAUNGLUN			1	M-Key lock	RI	10		10	Paper	AB	2	
64	268	431	10.5	HNGETTHAIK			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
65	270.8	435.5	4.5	INGON			1	M-Key lock	RI	10		10	Paper	AB	0	
66	274.5	441.5	6	YAMETHIN			1	M-Key lock	RI	16		16	Paper	AB	3	
				YAMETHIN -INGYINKAN											1	
67	278.5	448	6.5	INGYINKAN			1	M-Key lock	RI(BLK)	4		4	Paper	AB	0	
68	282.5	454	6	SHWEDA			1	M-Key lock	RI	10		10	Paper	AB	0	
				SHWEDA-PYAWBWE											1	
69	287	462.5	8.5	PYAWBWE	Brunch		1	M-Key lock	RI	19		19	Paper	AB	1	
70	292.8	471	8.5	SHANYWA			1	M-Key lock	RI(BLK)	4		4	Paper	AB	0	
71	299.3	481	10	NYAUNGYAN			1		RI	10		10	Paper	AB	1	
72	302.3	486	5	NWATO			1	M-Key lock	RI(BLK)	4		4	Paper	AB	0	
73	306	492.5	6.5	THAZI	OCC Brunch	1	1	R-ILK	EI	58	60	118	Paper	AB	1	
74	310.5	499.5	7	YWAPALE			1	M-Key lock	RI(BLK)	4		4	Paper	AB	0	
75	315.5	507.5	8	HANZA			1	M-Key lock	RI	10		10	Paper	AB	1	
76	318.7	512	4.5	DAHATTAW	HALT											ABOLISH
77	321.3	517	5	THEDAW			1	M-Key lock	RI	10		10	Paper	AB	1	
78	325.3	523.5	6.5	KHINBAN	HALT		1		RI(BLK)	4		4		AB	2	NEW
79	329	530	6.5	SAMON			1	M-Key lock	RI	10		10	Paper	AB	1	
80	332.3	534.5	4.5	ODOKKON	HALT								Paper			ABOLISH
81	336.3	541	6.5	THABYETAUNG			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
82	341.5	549.5	8.5	KUME LAN			1	M-Key lock	RI	10		10	Paper	AB	1	
83	347	558.5	9	MYITTHAR			1	M-Key lock	RI	10		10	Paper	AB	2	
84	352.5	567	8.5	MINZU			1	M-Key lock	RI(BLK)	4		4	Paper	AB	1	
85	359.3	578	11	KYAUKSE			1	M-Key lock	RI	10		10	Paper	AB	4	
86	363.5	585	7	BELIN			1	M-Key lock	RI	10		10	Paper	AB	1	
87	369	594	9	SINGAING			1	M-Key lock	RI(BLK)	4		4	Paper	AB	2	
				SINGAING-PALEIK											1	
88	374.3	602	8	PALEIK	Brunch		1	M-Key lock	RI	12		12	Paper	AB	1	
89	377.8	607	5	MYITNGE			1	M-Key lock	RI	14	20	34	Paper	AB	3	Special RI
90	380.5	611.5	4.5	TAGUNDAING			1	M-Key lock	RI(BLK)	4		4	Paper	AB	2	
				TAGUNDAING-MYOHAUNG											1	
91	382.8	616	4.5	MYOHAUNG	Brunch		1	M+R-ILK	EI	25	65	90	Paper	AB	0	
92	384	617.5	1.5	SHANZU	HALT									ABS	1	
				SHANZU-MANDALAY										ABS	5	4ABS
93	385.5	620.5	3	MANDALAY	OCC	1	1	R-ILK	EI	16	100	116	Paper			
			360			TGU	29		EI	5			AB	48	79	
						TZI	20		RI	29			ABS	1		4ABS
						MDL	17		RI(BLK)	15						

Source: JICA Study Team

5.13 Telecommunication

5.13.1 Current Conditions of Telecommunication

(1) Main Telecommunication line of Myanma Railway by Optical Fiber Cable (OFC)

The OFC line between Yangon Central Station (St) and Mandalay Station was installed by India and it is buried one (1) meter underground. Its specification is Single Mode (SM) type, totally 24-cores. The OFC is laid to the OFC equipment room of all stations except Dahattaw St (no operation man) and Khinban St (no operation man) and Shanzu (no operation man) St.

Situation of OFC (underground) is as follows.

Figure (a) OFC (underground)

Figure(b) OFC (equipment room)

Source: JICA Study Team

Figure 5.13.1 Optical Fiber Cable (OFC)

The OFC has 24 cores and 12 cores out of the 24 cores are currently being lent to the other companies. The other two cores are used for MR transmission devices and the remaining 10 cores are available. With regard to the JICA OCC project, in the section between Yangon Central St and Pyuntaza St, the other six cores will be used for the OCC project and thereafter the remaining four cores will become available. In the section between Pyuntaza St and Naypyitaw St, two cores will be used, and remaining eight cores will become available.

After the construction of above OFC by India, another new OFC was installed from Yangon Central St to Mandalay St by a Chinese company in 2015. The OFC was installed overhead method by using concrete poles. The OFC has 96-cores. MR is expecting to use 12 cores and remaining 84 cores will be lent to the other companies by the Chinese company. The OFC is drawn into the telecommunication equipment room of Taungoo, Naypyitaw, Pyawbwe, Thazi, Kyaukse and Mandalay stations. MR cannot use the OFC as of 2017. It is under negotiation with the Chinese company now.

The current situation of the OFC (Overhead Line) is as follows.

Figure (a) OFC (Overhead Line)

Figure (b) OFC (Overhead Line)

Source: JICA Study Team

Figure 5.13.2 OFC (Overhead Line)

Therefore, the JICA Study Team makes it prerequisite condition to use the existing main OFC transmission line for the radio telecommunication system.

(2) Transmission Equipment and Telecommunication Facility of Normal Station

The existing transmission method is Synchronous Digital Hierarchy (SDH) system and installed Synchronous Transfer Mode (STM-1: transmission speed is 155.52 Mbps) or STM-4 (transmission speed is 622.08 Mbps) by India. This transmission line is mainly used for MR telephone line. Recently, MR replaced STM-1 system with the new IP interface device from Naypyitaw station to Thazi station.

The current situation of OFC transmission equipment is as follows.

Figure (a) SDH System (STM-1 system)

Figure (b) IP Interface Device

Source: JICA Study Team

Figure 5.13.3 Existing Transmission System Equipment

The arrangement of telecommunication equipment for station is one (1) radio device, one (1) OFC phone and two (2) block Phones as standard.

Telecommunication equipment of a normal station is as follows.

Source: JICA Study Team

Figure 5.13.4 Typical Telecommunication Facilities of Normal Station.

(3) Radio telecommunication system

The radio telecommunication system can be classified two categories. One is Ultra High Frequency (UHF) radio system and the other is High Frequency (HF) radio system. The UHF Radio telecommunication system is used for the communication between operation commanders in OCC and station masters. In some level crossings, it is also used for the communication between the gateman and the station master nearby.

The current situation of the antenna of a normal station and OCC or a repeater station is as follows.

Figure (a) Radio Antenna at Normal Station

Figure (b) Radio Antenna at OCC/Repeater Station

Source: JICA Study Team

Figure 5.13.5 Radio Antenna

The current situation of telecommunication equipment (UHF) at a station and a gateman house is as follows.

Figure (a) UHF Radio System (Station)

Figure (b) Direct Phone and Radio Device (Gateman House)

Source: JICA Study Team

Figure 5.13.6 Telecommunication Device in Station and Gateman House

The HF radio telecommunication system was installed for the communication between operation commanders in different OCCs.

There are four (4) section OCC (Bago, Taungoo, Thazi and Mandalay) and one (1) general OCC in Naypyitaw. But, the HF Radio system is not used now. Commanders in the General OCC usually use the OFC phone for the communication between OCCs.

The current situation of the telecommunication equipment at general OCC in Naypyitaw is as follows.

Figure (a) HF Radio Device

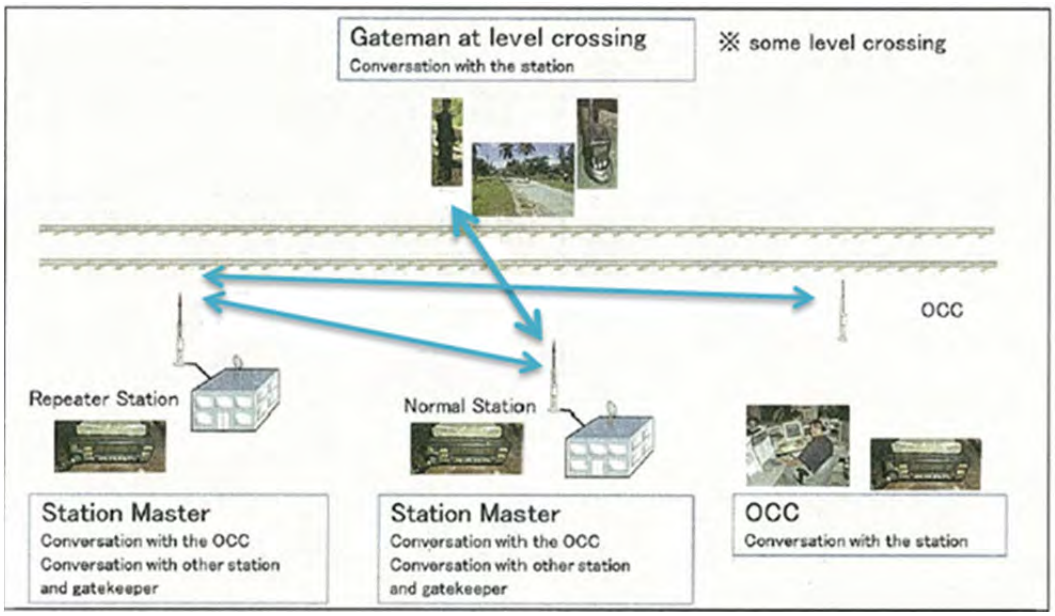
Figure (b) OFC Phone and Carrier Phone

Source: JICA Study Team

Figure 5.13.7 Telecommunication Facilities General OCC

In the existing radio telecommunication system, there is no means to communicate between OCC and the train driver or between the station master and the train driver.

The structure of the existing radio telecommunication (UHF) system is as follows.



Source: JICA Study Team

Figure 5.13.8 Existing Radio Telecommunication System

5.13.2 Scope of Project

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

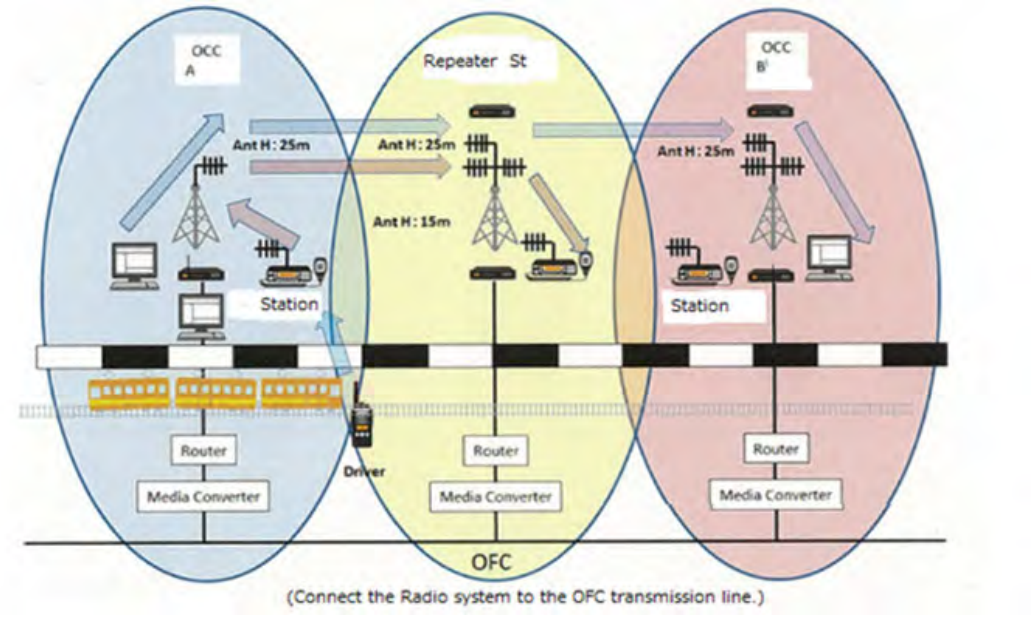
The scope of this project is the improvement of radio telecommunication system. The improvement of the existing main OFC telecommunication line, transmission system (SDH system, STM-1,4, etc.), the OFC phone system, power supply equipment for the existing transmission equipment and the High Frequency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

5.13.3 Improvement Plan of Radio Telecommunication System

The JICA Study Team proposes the new radio telecommunication system for MR. It uses the existing UHF radio frequency band (450MHz band). In a normal situation, 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 radio system should be designed in such a way that, when this normal route becomes unavailable in case of malfunction of the OFC or other reasons, the route between OCC and each repeater station can be shifted from the OFC to the radio link.

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 1.

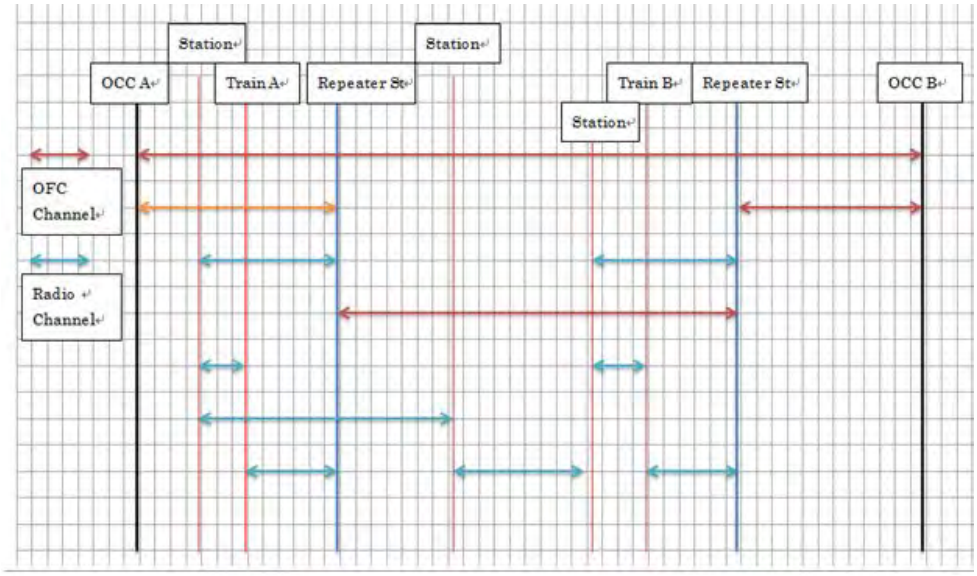
The structure of the new radio telecommunication (UHF) system is as follows.



Source: JICA Study Team

Figure 5.13.9 View of Radio Telecommunication System

The transmission channel of the radio telecommunication (UHF) system is as follows.



Source: JICA Study Team

Figure 5.13.10 Radio Transmission Channel

(1) Arrangement Plan of Radio Device and Type

1) Desk fixed type radio device: for 4 OCCs and repeater stations
2) Desk fixed type radio device: for normal stations
3) Potable type radio device: for train drivers, maintenance staff, level crossing gatemen

(2) Communication to be Available

1) Communication between OCC and OCC
2) Communication between OCC and station master
3) Communication between OCC and train driver
4) Communication between Station master and station master
5) Communication between station master and level crossing gateman
6) Communication between station master and maintenance man.
7) Communication between maintenance man and maintenance man

(3) Functions of Radio Telecommunication System of OCC

1) Individual calling
2) Simultaneous calling
3) Group calling
4) The contents of OCC call shall be record. The period of preservation shall be 5 days.

(4) Antenna of Radio Telecommunication System

Antennas are expected to be replaced at OCCs, repeater stations and normal stations.

(5) Power Supply for Radio Telecommunication System

To secure the stable power supply for the radio telecommunication system, the JICA Study Team proposes to use the signalling power supply line. Several power supply terminals for the radio telecommunication system are to be installed in the new signalling equipment house.

(6) Entrust a work of power supply and repair of telecommunication equipment house

1) Entrust a work of power supply for telecommunication equipment.

a) Power supply for the radio telecommunication system shall be prepared at OCC and repeater stations. Three (3) breaker circuits (AC 230V, 30A) shall be installed in the new signalling equipment house.

b) Power supply for the radio telecommunication equipment of each normal station shall be prepared. Two (2) breaker circuits (AC 230V, 10A) shall be installed in the new signalling equipment house.

2) Civil and Architecture Works to be Implemented

The ceiling, doors, windows and wall of the existing telecommunication equipment house are damaged.

The original plan of the JICA Study Team was to provide transmission devices in the existing telecommunication equipment room and to use the existing underground OFC for the new radio system. Through the discussion with MR, however, it was decided that the overhead OFC will be used instead of the underground OFC after MR draws the overhead OFC into each station. Therefore, the existing telecommunication equipment room will be abolished. Instead, it is necessary to keep space to install the equipment of new radio telecommunication system in the telecommunication equipment room. This space is expected to be kept in the new signalling house.

The current situation of the telecommunication equipment house is as follows.

Figure (a) Hole of Ceiling

Figure (b) Damage of Roof

Source: JICA Study Team

Figure 5.13.11 Damage of Telecommunication Equipment House

(7) Removal of Old Radio Telecommunication Equipment

The existing radio telecommunication equipment (antenna towers, radio equipment, cables, power supply equipment for telecommunication system, batteries, solar systems and other equipment) will be removed by MR.

5.14 Train Monitoring System

5.14.1 Current Conditions of Signalling System

(1) Current Conditions of Signalling System and Train Monitoring Work

The Detailed Design for Yangon-Mandalay Railway Improvement Project Phase I (YM-D/D(1)) was implemented from 2014 to 2015, its bidding was implemented in 2017 and then the construction is expected to start. In Phase I, the modernization of the signalling system for 267 km from Pazundaung Station (except the station yard) to Taungoo Station will be implemented. The signalling system of Yangon Central Station and its adjacent station, Pazundaung Station, is under

development by the Grant Aid project by Japan, "The Project for Installation of Operation Control Centre System and Safety Equipment (OCC Project)". The train monitoring system from Yangon Station to Pyuntaza Station is included in the OCC Project.

This preparatory survey covers the section of approximate 353.3 km from Taungoo Station (except the station yard) to Mandalay Station. However, for consistency with the existing operation control section, the Train Monitoring System (hereinafter called TMS) in the section to be provided in Phase II will cover the supervising section of Taungoo OCC from Nyaunlabin Station to Pyinmana Station, of Thazi OCC from Ywadaw Station to Thazi Station and of Mandalay OCC from Ywapale Station to Mandalay Station.

(2) Existing Condition of Train Dispatch Work

1) Operation Control Center

Train operation dispatching work is mainly processed by using an actual train diagram by hand after OCC staff communicates with station masters through telephone or radio. There is no train operation management system. There are OCCs in Taungoo, Thazi, Mandalay and Naypyitaw. Present status of existing OCC is shown in Figure 5.14.1.

(a) Taungoo OCC

(b) Thazi OCC

(c) Naypyitaw OCC

(d) Mandalay OCC

Source: JICA Study Team

Figure 5.14.1 Current Conditions of Existing OCC

5.14.2 Improvement Plan

(1) Basic Policy

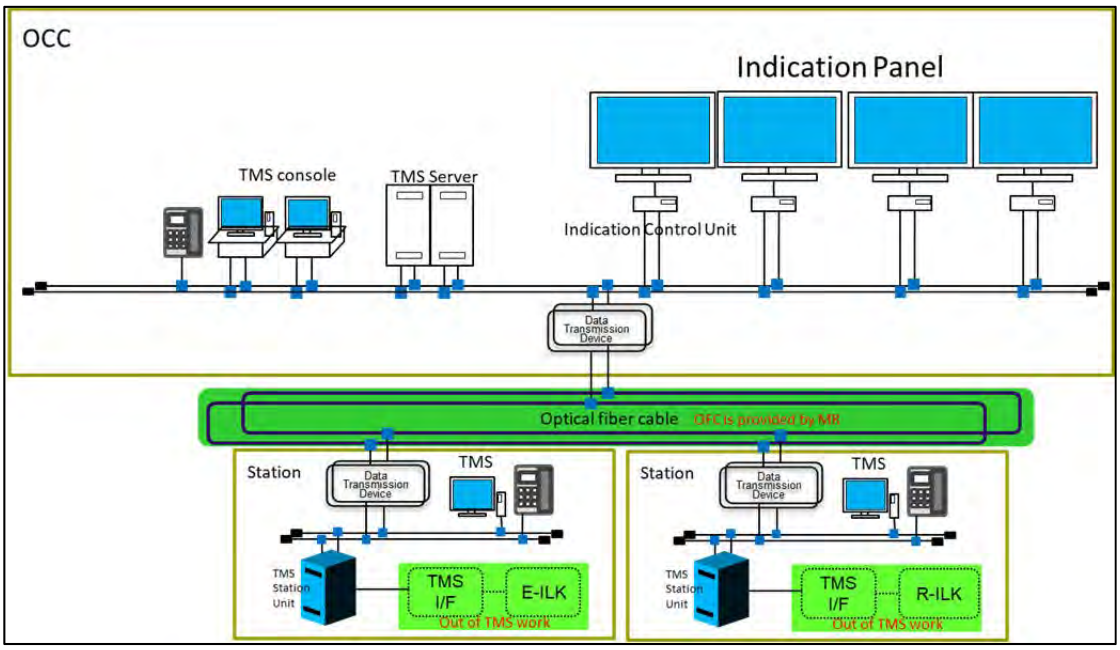
This signalling system is supposed to work for more than 20 years with proper maintenance after the completion of this project. Common specification policy should be adopted for the overall section to take easy maintenance based on the request of MR.

(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) Equipment Composition

The Train Monitoring System consists of the TMS central device, an indication panel, a control panel, the dispatch telephone and the data transmission device which are installed in OCC and the TMS station device, a train information display, the dispatch telephone and the data transmission device which are installed at each station. The indication information of the interlocking device is inputted into the TMS station device through the TMS I/F device at each station. The TMS I/F device is to be installed as a part of station interlocking system of the signalling work. The optical fiber cable and a cable termination frame will be installed by MR.



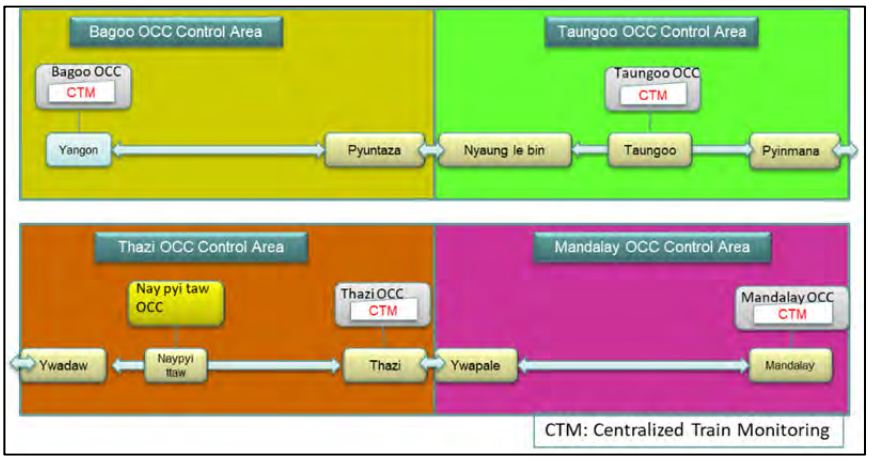
Source: JICA Study Team

Figure 5.14.2 Configuration Diagram of TMS

(4) 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



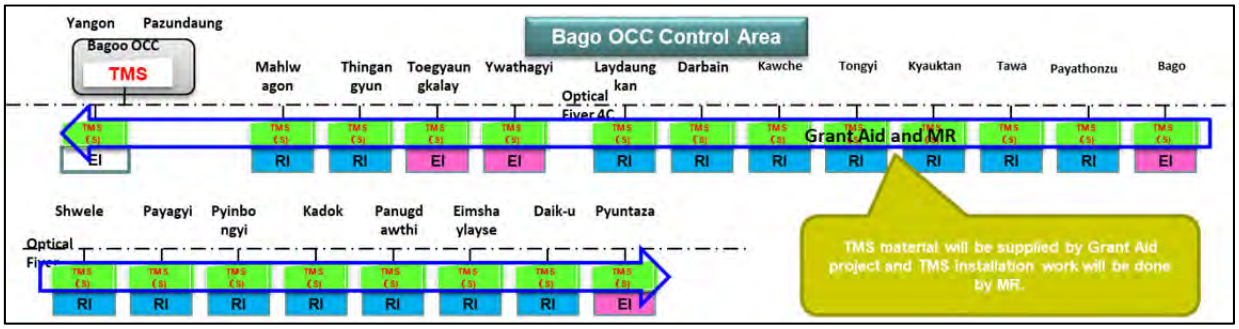
Source: JICA Study Team

Figure 5.14.3 OCC Configuration Diagram

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. As is mentioned in Section 5.8 and Section 5.9, the new Taungoo OCC room is expected to be installed in the OCC building which is expected to be built in Phase II of the Project.

In terms of TMS between Yangon Central Station and Pyuntaza Station, after the design by OCC Project is finished, the design by Phase I project will be carried out in which track circuit, interlocking system and blocking system for each station will be newly installed between Mahlwagon Station and Taungoo Station. Since trains can be detected by track circuit after the completion of Phase I project, the TMS design by OCC Project has been modified so that indication information will be outputted from the track circuits and the interlocking system which are expected to be installed in Phase I project and will be displayed on the indication panel at the OCC. In the scope of TMS work for Bago OCC, the TMS contractor is only to supply the equipment of the central equipment and the station equipment between Mahlwagon Station and Pyuntaza Station while MR is supposed to perform actual installation work.

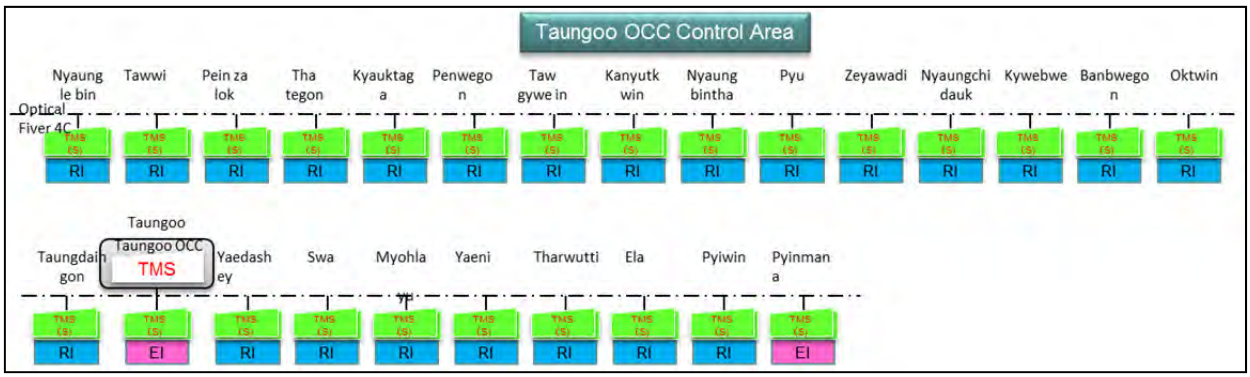
Originally the TMS indication information of each OCC was expected to be displayed at Naypyitaw General OCC. However, MR proposed and decided that the indication panel will not be installed at Naypyitaw General OCC for the reduction of the construction cost. This matter is expected to be further studied in the detailed design stage.



Source: JICA Study Team

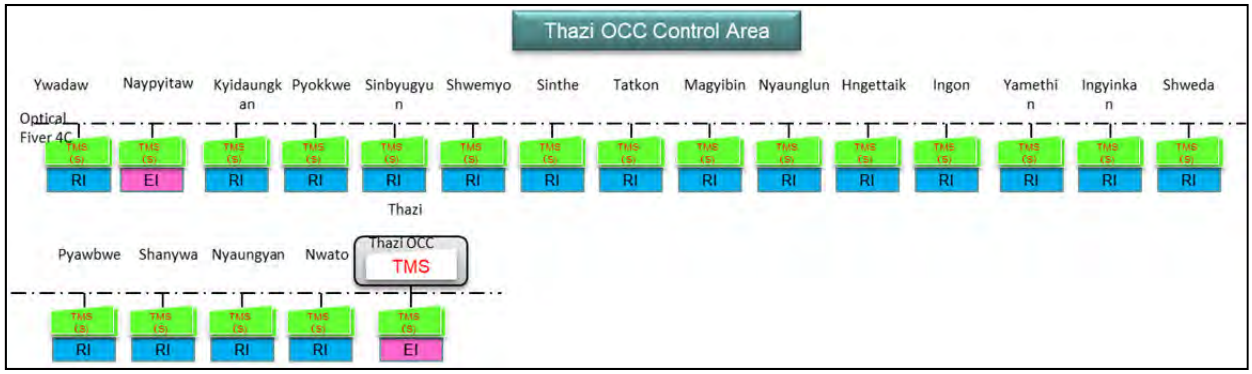
Figure 5.14.4 OCC Control Area (a) Bago OCC

Train Monitoring System for Taungoo OCC, Thazi OCC and Mandalay OCC is to be newly installed in Phase II. MR has requested that the building for OCC be newly built. As the building of Taungoo OCC belongs to Phase I area, it is necessary to study in the detailed design stage whether the construction is to be implemented in the Phase I project as the design modification or the construction is to be implemented in Phase II project. The configuration of TMS for each OCC is shown in the following figures.



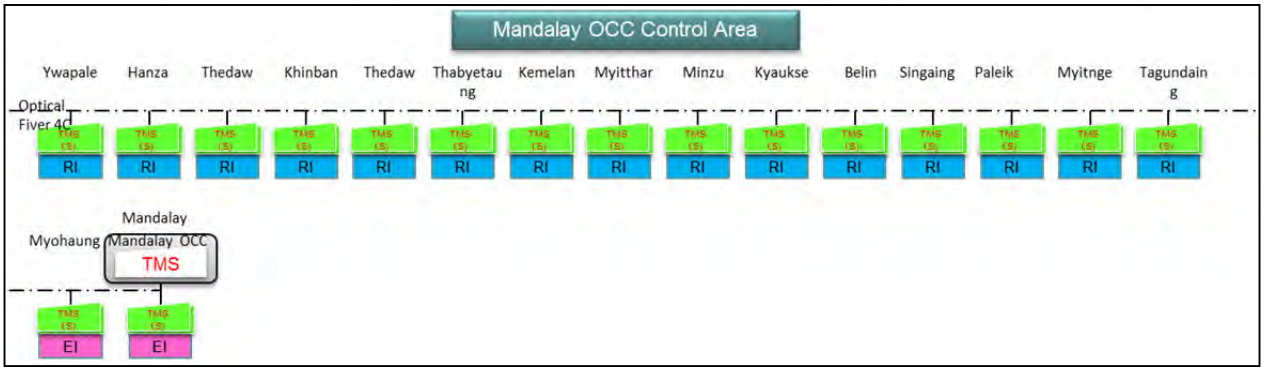
Source: JICA Study Team

Figure 5.14.5 OCC Control Area (b) Taungoo OCC



Source: JICA Study Team

Figure 5.14.6 OCC Control Area (c) Thazi OCC



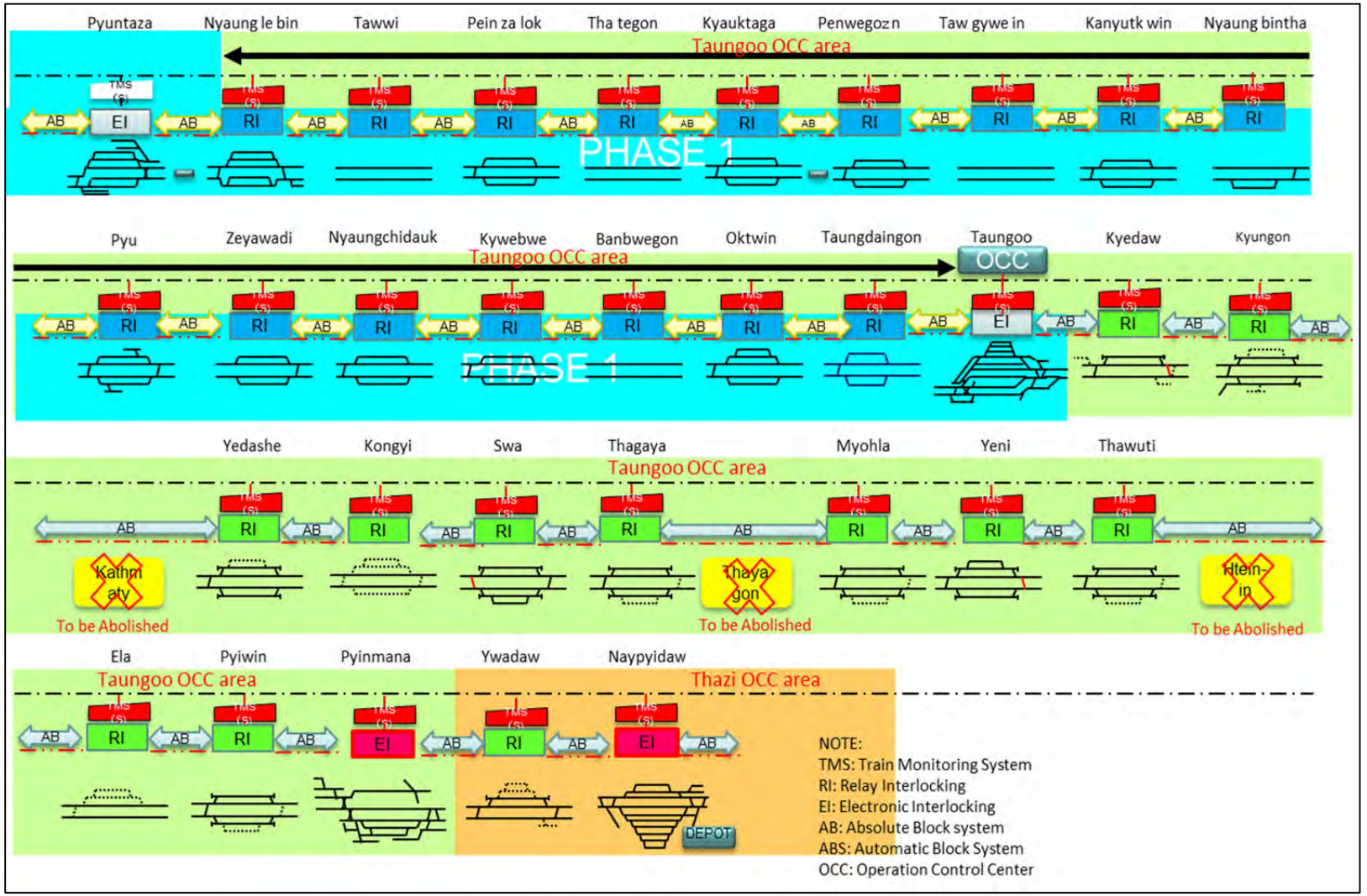
Source: JICA Study Team

Figure 5.14.7 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.

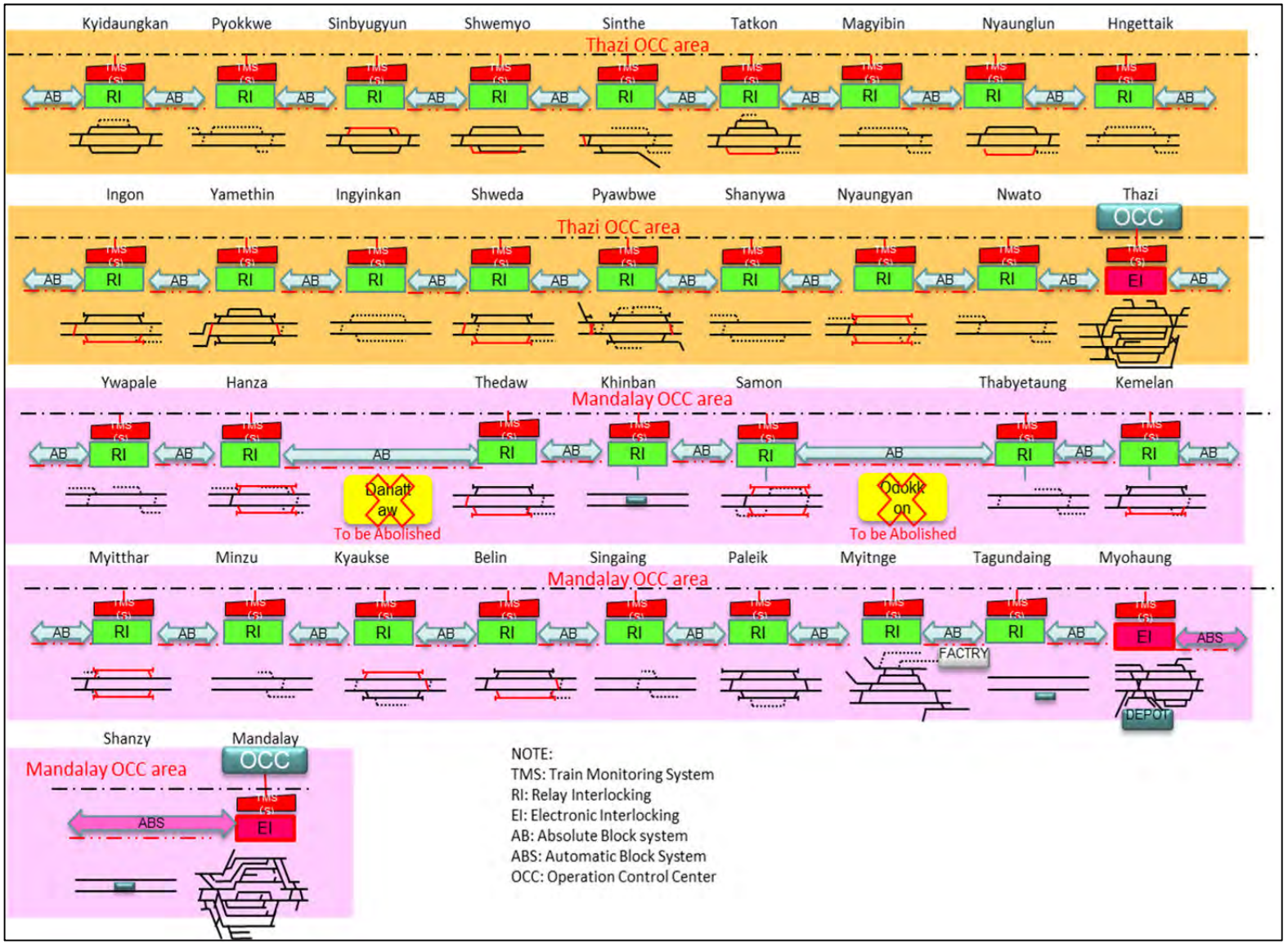
(5) Renovation Plan for Signalling System

The renovation plan for the signalling system including TMS is shown in the following figures.



Source: JICA Study Team

Figure 5.14.8 Renovation Plan for Signaling System (a) Pyuntaza to Naypyidaw



Source: JICA Study Team

Figure 5.14.9 Renovation Plan for Signaling System (b) Kyidaungkan to Mandalay

5.15 Railway Freight Transport Plan

This survey covers the freight railway transport plan between Taungoo and Mandalay, but the logistics in Myanmar is based in the Yangon area, and as will be described later, the dry port development plan in the Yangon and Mandalay districts and the maintenance project of the surrounding area of Thilawa Port and the Thilawa Special Economic Zone (hereinafter Thilawa SEZ) are now under way. This survey focuses on how to plan railway freight transportation between Yangon (including Thilawa district) and Mandalay, therefore, based on the field study and information from stakeholders such as Myanma Railways (hereinafter "MR"), the JICA Study Team proposes a recommendation on the railway freight transportation base plan between Taungoo and Mandalay, as well as the plan of freight railway transport terminal development including the results of the agreement with MR and survey results of the progress of dry port development plan, etc.

5.15.1 Current Status of Railway Freight Transport by Modes

(1) General Freight Transport

In Myanmar currently, transportation by closed vans and open wagons is predominant, and cargo handling for them is carried out on a part of the station premises, except for the Yangon district (Satsan Station, Botataung Station, Wadan Station) and Myohaung Station of Mandalay where a cargo handling platform is maintained. Besides general cargo such as imported food and construction material, railway freight carries out the transportation of goods for the Myanmar army. However, current freight trains have a slow traveling speed, so it is not very advantageous to compare them to truck transportation.

(a) Arrival of Train (Paleik Station)

(b) Unloading of Cargos (Thazi Station)

Source: JICA Study Team

Figure 5.15.1 General Freight Train

(2) Oil Transportation

In Myanmar, most petroleum is imported. There is a plan of large oil storage refinery base in Thilawa Port in the southern part of Yangon, and it is planned to shift the transportation of

petroleum products to Mandalay district from the current transportation by water on the Ayeyarwardy River to railway freight. Thus, MR plans to develop a petroleum base including Mandalay district as a PPP project.

(3) International Marine Container Transportation

In September, 2014, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan conducted a demonstration experiment in which round-trip transport of international marine containers (20, 40 ft) between Yangon port and Mandalay (Paleik Station) for the purpose of promoting the modal shift into freight railway transportation in Myanmar. However in April, 2017, MR and Kerry Logistics Network (a Hong Kong based logistics company, hereinafter called "KLN" and MR and Resources Group Logistics (a Myanmar-based logistics company, hereinafter called "RGL") agreed to develop dry ports at two places: Yangon (Ywathagyi) and Mandalay (Myitnge).

Starting from August 2017, without waiting the completion of the both dry ports, KLN and RGL are operating the international marine container freight train once a week between Yangon (Wadan Station) and Mandalay (Paleik Station). But because of the existing rolling stock gauge and the axle load weight, the size of the container possible for transport is limited (to 8ft 6in in height only, maximum loading capacity under 32t including container tare weight per each wagon).

With this project, the development of the above mentioned dry ports and the expansion of the rolling stock gauge (4,100mm) and structure gauge (4,300mm) which enable a high cube container (height 9 ft 6 in = 2,896mm) and increasing of the axle load weight (from 13 ton to 20 ton) will be realized, thus consequently in the future, within domestic Myanmar especially between Yangon and Mandalay, it is expected that railway freight transportation of international marine containers will increase.

Demonstration Experiment of Marine Container Transportation (2014)

Tentative transportation by KLN, RGL (2017)

Source: JICA Study Team

Figure 5.15.2 International Marine Container Transportation

5.15.2 Current Status of Facilities for Railway Freight Transportation

In May, July and August 2017, the JICA Study Team conducted a field survey at three districts: Naypyitaw district (Pyinmana Station, Ywadaw Station, and Naypyitaw Station), Thazi Station and Mandalay district (Paleik Station, Myitnge Station, and Myohaung Station).

(1) Naypyitaw District

According to MR, currently, demand for railway freight transport is low in the Naypyitaw district, but because of the infrastructure improvement conducted by national policy, it is anticipated that the demand for construction materials (aggregate for concrete, reinforcing bars and road paving materials, etc.) will increase. This time, as a survey in the Naypyitaw district, a field survey was conducted to determine whether each station of Pyinmana, Ywadaw and Naypyitaw in the center of the Naypyitaw district, is suitable as a freight transportation base.

1) Pyinmana Station (362.0 km)

On the survey day in May, 2017, loading and unloading of closed vans was conducted at the end of the platform. Also, cargo handling is carried out at the back of the Mandalay direction leading track. Though there are 7 stabling lines on the side opposite to the main station building, only 4 tracks are actually used (Figure 5.15.3 (b)).

(a) Cargo Handling at the End of the Platform

(b) Storage Track

Source: JICA Study Team

Figure 5.15.3 Current Status of Pyinmana Station

2) Ywadaw station (370.0 km)

There is a stabling line on the western side of the main line, and the station is located along the high standard track (Railway Road, Military Base Road). In the relatively wide space between the 2 lines, in addition to suppliers of Myanmar military bases, petroleum products (drum cans) for road paving arriving from Yangon with open wagons are transferred into trucks manually without power assist.

Source: JICA Study Team

Figure 5.15.4 Cargo Handling at Ywadaw Station

3) Naypyitaw Station (373.2 km)

At Naypyitaw Station, the JICA Study Team could not confirm the actual cargo handling, but in the cargo handling space where the JICA Study Team was directed, it was confirmed that instant noodles that were assumed to be imported from Thailand and believed to have been carried on a mixed train from Yangon were loaded on a truck. In the hinterland of the station, a vast land owned by MR exists, and around the time of capital transfer to Naypyitaw in 2007, future plans were formulated for the construction of passenger car depots besides a cargo yard, but they have not been completed. The JICA Study Team was lead to the station hinterland by station employees, and found that a vast land is used for agriculture by farmers who live nearby. Also, 50m away from the station building, there are two stabling lines for wagons which are not in use now.

(a) Cargos Arriving from Yangon

(b) Storage Track for Passenger Coaches (Station Side)

(c) Unused Storage Tracks

(d) Fence Behind is the Border of MR Owned Land

Source: JICA Study Team

Figure 5.15.5 Current Status of the Naypyitaw Station

(2) Thazi Station (492.5 km)

Thazi Station is a shunting station to Shwenyang and Myingyan, and also the major hub having a locomotive depot.

At the exclusive platform toward Yangon, foods for Myanmar military forces are unloaded with the closed vans and at the platform toward Mandalay, fuel of MPPE (Myanmar Petrol Product Enterprise) is unloaded. There are 9 stabling lines on the other side of the station building, but only 6 stabling lines have wagons waiting for inspection.

(a) Storage of Wagons Awaiting Inspection

(b) Location of Fuel Unloading.

Source: JICA Study Team

Figure 5.15.6 Current status of Thazi Station

(3) Mandalay District

In Mandalay district, Myohaung Station is a hub for cargo handling. The JICA Study Team also surveyed Paleik Station where the railway transportation demonstration experiment of international marine containers was carried out and Myitnge Station which is the construction site of a dry port planned by MR.

1) Paleik Station (602.0km)

Paleik Station was originally a shipping spot for timber, and there are 3 timber freight tracks which diverge from the station premises, but now there is no handling of railway transportation of timber freights, and the station premises are used as a timber stockyard owned by the forestry office.

Until the opening of the Myitnge dry port, KLN and RGL are provisionally operating international marine container trains between Yangon (Wadan Station) and Paleik Station, and containers are loaded and unloaded on the existing stabling line. Temporary platform is simple paved with gravel, and unlike the southern part of the country such as Yangon, even during the rainy season, there is no problem with water drainage in the vicinity since there is not much rainfall.

(a) Temporary Platform for Unloading Containers

(b) Timber Stock Yard

Source: JICA Study Team

Figure 5.15.7 Current status of Paleik Station

2) Myitnge Station (607.0km)

On 3 April, 2017, MR and KLN, RGL (hereinafter called "concessionaires") signed a contract to develop dry ports. In the JICA Study Team's visit of May, 2017, in addition to the investigation of the dry port construction sites by KLN, the JICA Study Team also visited the KLN Bangkok office which administers the Greater Mekong region including Myanmar. The summary of the Myitnge dry ports development plan is as follows.

- The KLN development area is 42,674 acres (about 17 hectares)
- The contract period is 50 years from the conclusion, but it can be extended up to 70 years at the longest.
- MR leases the land to the concessionaire during the contract period.
- Construction of structures in the dry port and operation of dry port are carried out by the concessionaires.
- MR carries out the connection of the track from the main line to the dry port boundary.
- Business approval has already been obtained and within two years, it must be operated completely as a dry port.
- According to the agreement with the two companies, it will not be possible to develop new dry ports within a 50km radius of the Myitnge dry port (Exceptions are as follows: A case of the development in the jurisdictional area of other ministries, and the case in which handling amount reaches to 400,000TEU).

The status of the dry port development confirmed in the visit by the JICA Study Team in August 2017 is as follows:

- In both the KLN development area and the RGL development area, the land preparation and leveling including access roads has almost been completed.
- The position of the base line surface in the dry port is shown.
- MR is to construct the connection line to the dry port. Already the position of the track center line has been determined and the estimation of construction cost is completed.
- Railway track construction will be completed in 2017, and it is expected that the temporary transportation from Paleik Station is to be ended soon and from April, 2018, the transportation from Myitnge Station will be started.

(a) KLN Development Area

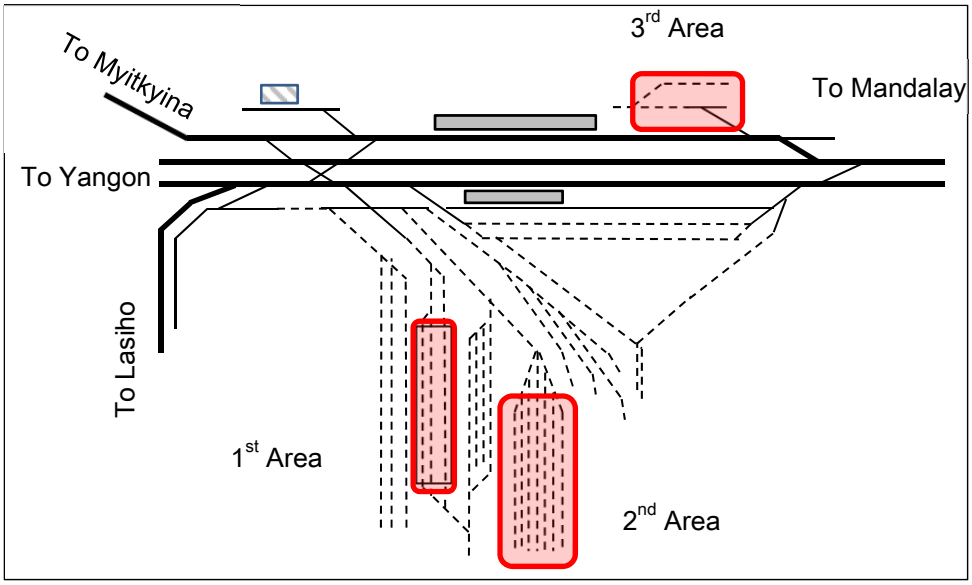
(b) Access Road

Source: JICA Study Team

Figure 5.15.8 Myitnge Dry Port Construction-Progress

3) Myohaung Station (616.0 km)

According to the field survey, cargo handling at Myohaung Station is conducted in three areas by destination (the number of the area is given for convenience). Figure 5.15.9 shows the location of the three areas within the station premises.



Source: JICA Study Team

Figure 5.15.9 Detail of the Myohaung Station Premise Cargo Handling Area

- 1st Area: handles cargos transported between Myohaung Station and Yangon district. There are 3 cargo handling tracks; one track can accommodate 30 wagons and 2 tracks which can accommodate 16 wagons. The JICA Study Team was able to confirm there the cargo handling of feed, salt, bag noodles and edible oils.
- 2nd Area: reloads cargos sent from Yangon to the train which will head to Myitkyina. There are two cargo handling tracks which can accommodate 30 wagons each. The JICA

Study Team confirmed the cargo handling of sugar. Sugar is exported to China through Myitkyina.

- 3rd Area: handles cargos transported between Myohaung and Myitkyina. There are two cargo handling tracks which can accommodate 12 wagons each. The JICA Study Team confirmed the cargo handling of cement and reinforcing bars.

On the station premises, a gate-type crane made in China that can load and unload containers is installed, but since there is no container handling at the moment, it is used to lift car bodies at the time of inspection of passenger coaches and freight wagons. On top of that, unloading of some railway track materials is carried out.

(a) Cargo Handling in the First Area

(b) Container Crane

Source: JICA Study Team

Figure 5.15.10 Current Status of Myohaung Station

Incidentally, due to the restrictions on the entry of heavy trucks into the centre of Mandalay City, it is now difficult to load and unload containers at Myohaung Station.

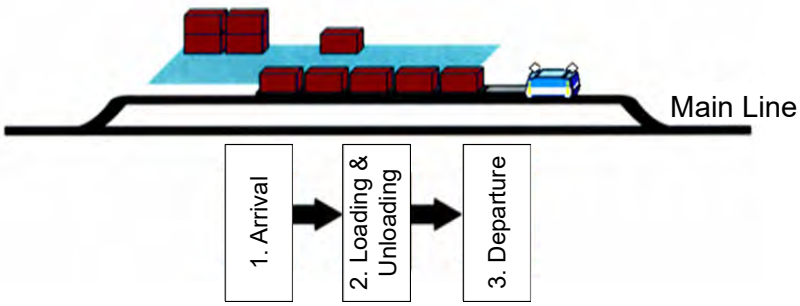
5.15.3 Proposal for the Development of the Railway Freight Transport Facilities

As a result of the survey, in order to modernize railway freight transportation, the JICA Study Team proposes the facilities development corresponding to the following operation modes (excluding military use, etc.), and describes a draft development plan formulated after the discussion with MR.

(1) Express Freight Train between Yangon and Mandalay

Currently the main section of Myanmar's railway freight transport is the section between the Yangon area and Mandalay area, and the freight volume is overwhelmingly larger from Yangon. On the section between Yangon (Satsan Station) and Mandalay (Myohaung Station), there is also a direct express freight train operated by receiving extra charges. 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. The development plan of this project is as follows.



Source: JICA Study Team, JR Freight

Figure 5.15.11 Example of Arrival and Departure Track with Cargo Handling (Tsuchiura Station, Japan)

1) Naypyitaw District

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. In this time, in the Naypyitaw district, the JICA Study Team conducted a field survey to see if the three stations of Pyinmana Station, Ywadaw Station and Naypyitaw Station are suitable for a freight terminal. For selection of a freight transportation terminal, transportation of future container size (small and large) is also taken into consideration.

(a) Pyinmana Station

If the group of stabling lines on the east side of the station is removed, then it could be possible to secure enough width for the cargo handling platform. However, at the east side of the station shops and residences are concentrated and the roads are not uniformly straight, therefore it is not suitable for access by heavy trucks.

(a) Towards Mandalay

(b) Toward Yangon

Source: JICA Study Team

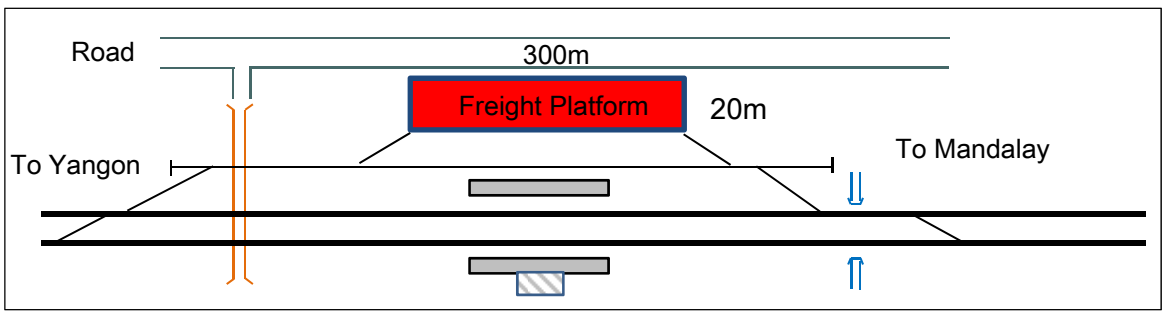
Figure 5.15.12 Behind Pyinmana Station

(b) Ywadaw Station

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.

(a) Site where the Cargo Handling Platform is to be Built

(b) Access Area



(c) Cargo Handling Platform Development Plan

Source: JICA Study Team

Figure 5.15.13 Ywadaw Station Development Plan

(c) Naypyitaw Station

The JICA Study Team studied a plan that a cargo handling platform (length 300m with a width of 20m) using a loop line is to be constructed in the hinterland of the station owned by MR to the extent that renovation of interlocking equipment at the premises is not required. However, as a result of a field survey of July, 2017, the following facts were found:

- There are three stabling lines, but they are used for stabling passenger coaches departing from Naypyitaw, and for 120m to 180m of their effective length it is not suitable for departure and arrival of freight trains.
- In order to develop the stabling line 50m away from the station and not now in use into a cargo platform, ground leveling including embankment in the vicinity and the construction of the access road (about 2 km) are required.
- Even in the future (2030), the anticipated cargo demand in the Naypyitaw district is not large being only about 40 % of the Thazi district.

Therefore the JICA Study Team believes that development of the Naypyitaw Station is not desirable at this time.

The JICA Study Team proposed plan b) to develop Ywadaw Station to MR and obtained their approval, so it was decided that Ywadaw Station will be the freight terminal statin for the Naypyitaw area.

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.

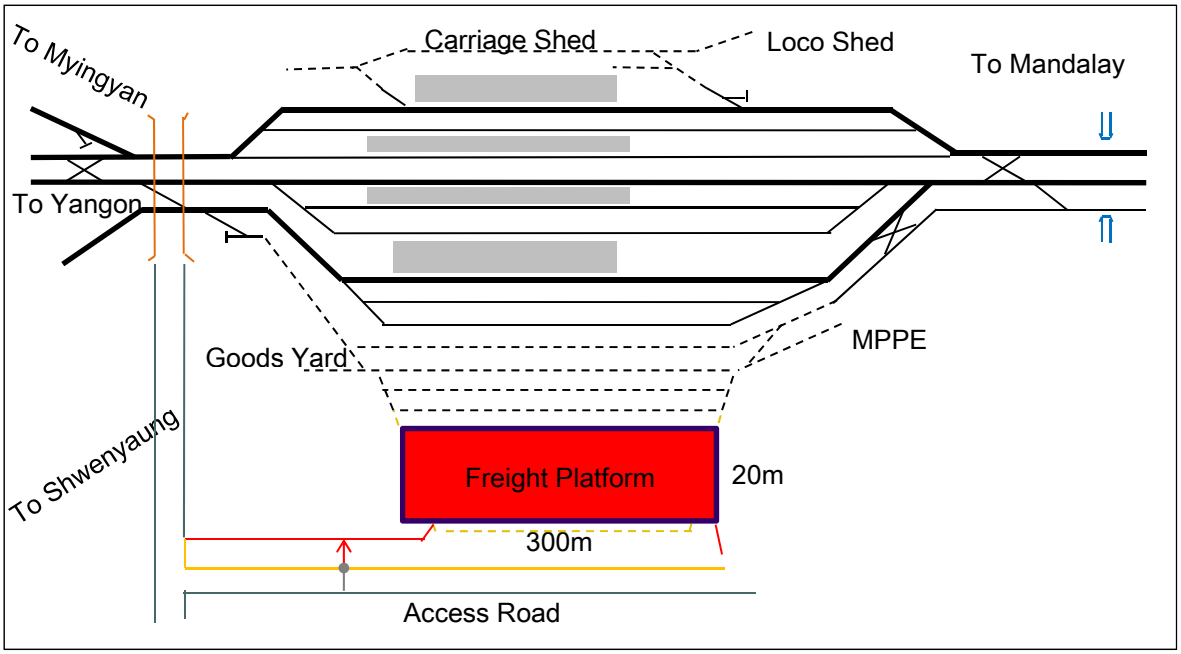
Source: JICA Study Team

Figure 5.15.14 Watermelons of Thazi District

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.

(a) Site where Cargo Handling Platform is to be Built

(b) Access Road



(c) Cargo Handling Platform Development Plan

Source: JICA Study Team

Figure 5.15.15 Thazi Station Development Plan

3) Mandalay District

(a) 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).

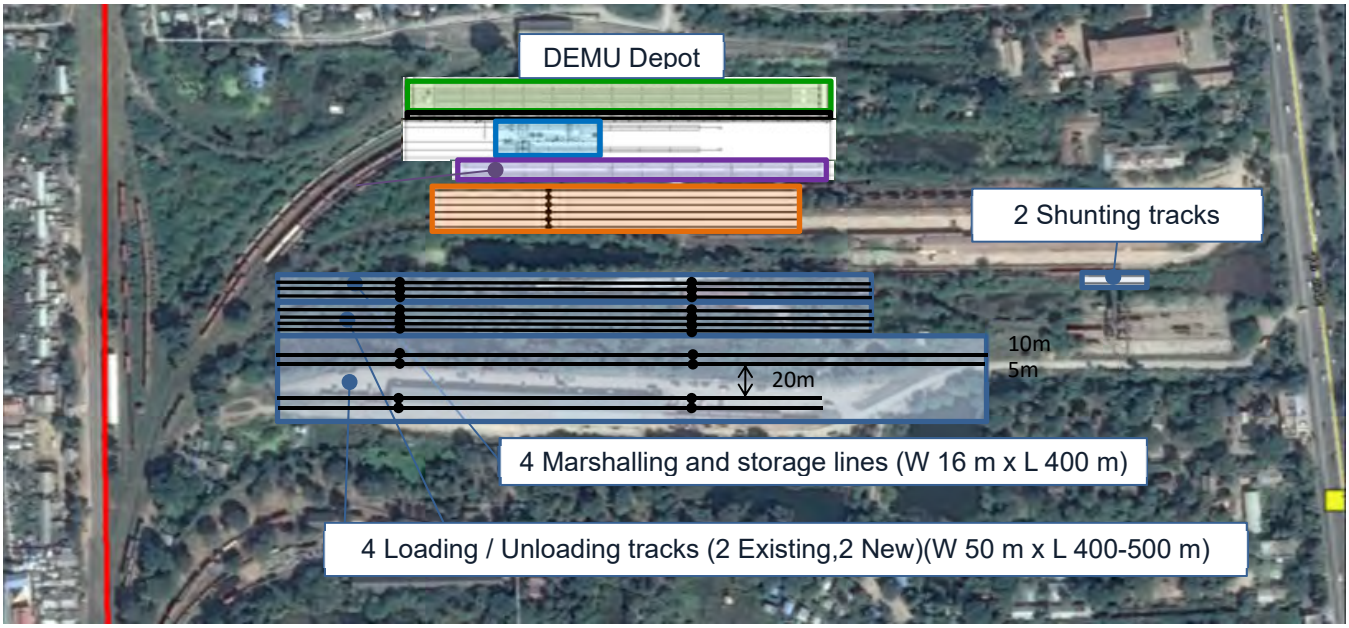
- Marshalling and storage tracks: 4 lines (track length 400m)

  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 5.15.16 Myohaung Station Development Plan (1)

(a) Existing Cargo Handling Platform

(b) Site where Pavement is Planned

Source: JICA Study Team

Figure 5.15.17 Myohaung Station Development Plan (2)

(b) Paleik Station

At Paleik Station, on the west side of the station there is a huge area which used to be used for timber handling in the past, and to prepare for the future increase of railway freight transport in the Mandalay area, the access line from the main line to the timber cargo handling line is left unchanged.

4) Proposal for Express Freight Train

In order to speed up freight trains, it is necessary to operate conventional freight trains as general freight trains by improving the bogies so as to manage the higher operating speeds, and in the future it is necessary to introduce freight trains corresponding to these conditions and to shift into small containers such as the 12ft containers of JR.

At each station, in addition to the paving of the container platform, new lighting on the premises which enables cargo handling at night should be installed. Also 2t forklifts for mechanization of manual cargo handling should be deployed, and office buildings for employees who are in charge of cargo handling should be built.

(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. The outline of provisional operation is as follows.

- The business model is a "door to door service" that takes cargos from the shipping owners and delivers the cargos to the shipping receiver.
- Initially they transport one round trip a week with 11 container wagons per one train (11 - 40ft containers and 22 - 20ft containers).
- Containers to be transported are restricted to containers of 8ft 6in height (high cube is not allowed).
- The maximum load weight per one container is 32t including the container's own weight, that is, cargo weight per container is 13t for a 20ft container and 28t for a 40ft container.
- Railway transport time is within 24 hours. At Wadan Station, cargos are loaded on the train on Friday from 6:00 to 18:00 then transported to the Paleik Station during Friday night. At Paleik Station, on Sunday and Monday, containers from Yangon are unloaded and containers from Mandalay are loaded (including return of empty containers).
- The return train travels to the Myohaung Station and turns back as a train heading to Yangon on Tuesday.

The study of cargo and operational conditions at both stations shows the following;

- Cargo platforms at both stations are simple. Part of the platform at Wadan Station is simply paved, and Paleik Station is gravel paved. Crane vehicle hooks up the wire upon loading and unloading the cargo to and from the freight train and the trailer.
- The JICA Study Team planned to study the current situation of the cargo operation, however, loading to the freight train seems to be scheduled only from 20:00 to 22:00 every Friday, and the JICA Study Team was not able to access there during that time.
- The JICA Study Team witnessed a train going to Paleik Station with international marine containers at Pyinmana Station and found that it was not a train exclusively carrying the containers. This train also connected regular wagons, and disconnection of such wagons could be observed also.

(a) Crane Used for Unloading Containers (Wadan Station)

(b) International Marine Containers during a Stop

Source: JICA Study Team

Figure 5.15.18 Current Situation of Provisional Marine Containers Transport

KLN plans to use railway mainly for exporting industrial products, imported cargos and marble produced in the Mandalay area, and aims to operate 22 container wagons per train. Therefore, in this project, the JICA Study Team considers Myitnge Station as the marine containers terminal in the Mandalay area, and doesn't include it subject to development of railway freight transport facilities in this ODA project. Container trains operated by KLN and RGL which depart and arrive at Myitnge Station are initially planned to operate one service a week with 11 wagons to 22 wagons maximum, and the number of the train operations is planned to increase. Therefore, 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.

(4) Freight Facilities Development Plan in this Project (Summary)

The summary of the freight facilities development plan and the points to note upon developing each station in this project are as follows;

Ywadaw Station:

- Maintenance Details

  Platform pavement work (20m×300m), access road with adjacent road, drainage facility, lighting equipment construction, construction work of a cargo office building, 2t forklift deployment (1 unit)

- Points to Note upon Development

  Construction will start after the existing outside stabling line has been upgraded to a loop line. Although cargo handling is not that frequent, cargos will be mainly military related goods. Dividing the construction area upon construction process is preferable.

Thazi Station:

- Maintenance Details

  Platform pavement work (20m × 300m), widening of access roads, drainage facilities, removal of existing storage tracks (5 lines), lighting equipment construction, freight office building construction, 2t forklift deployment (1 unit)

- Points to Note upon Development

  It is necessary to clarify the effect upon removing 5 stable lines (shunting function into branch lines, securing the fuel transport terminal and the storage function of wagons which are waiting for inspection in the train depot). Understanding of nearby residents with cargo handling during night-time and development of access roads will be crucial. For this reason, thorough meetings with MR and other related organizations will be necessary before the construction.

Myohaung Station

- Maintenance Details (railway facility construction is to be implemented by the premises improvement plan):

  Platform pavement work (20m × 400m), drainage facilities, lighting equipment construction, construction work of freight office building, 2t forklift arrangement (2 units)

- Points to Note upon Development

  Since the improvement construction work in the station premises will be extensive, it is assumed that changeover of tracks will be carried out several times. During that process, temporary suspension of usage of the original 1st and 2nd area will be required. Also, there will be a period when inspection of cargos should cease, thus it will be necessary to implement alternative measures, such as tentative cargo handling facilities built within the station premises, or handling the cargos temporarily at nearby stations. For example, tentative cargo platform or dryports at the Myitnge, if possible, should be considered. The inspection of cargos could be implemented at other places including Thazi or Taungoo. The effect for freight transportation should be minimized with thorough meetings with MR and other related organizations.

  Additionally, upon improvements in the premises at each station, it is necessary to extract construction works related to cargo facilities and coordinate with the experts of signal, telecommunication, electric power and architecture of station main building. Since the project cost has been finalized, it is essential to coordinate with the specialists of cargo transport of MR and other organizations upon improvement of cargo facilities during the detailed design stage.

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.

5.16.1 Existing Equipment for Power Supply

(1) Survey for the Power Supply Equipment in 56 Stations and Important Level Crossings between Stations

Regarding the 56 stations between Taungoo and Mandalay, JST surveyed the existing equipment for power supply. The two power suppliers, Electricity Supply Enterprise (ESE) and Mandalay Electricity Supply Corporation (MESC), supply power to the railway facilities in this section.

Table 5.16.1 shows the existing power supply system of each station excluding Taungoo Station which is planned to be improved in Phase I. There are 7 stations receiving high voltage, 36 stations receiving low voltage and 12 non-electrified stations.

Figure 5.16.1 shows the existing equipment of signal and level crossing. Stations receiving commercial power supply for signal equipment are only 4 stations of Pyinmana, Naypyitaw, Thazi and Mandalay. These stations have signal cabins called "tower".

In other stations, the semaphore of the signal is manipulated by the power generated by turning the steering wheel of the signal equipment in the station building. The position of the semaphore is fixed by the power of a car battery. Commercial power supply is used to charge the car battery as well as for lighting, pumps, etc.

Table 5.16.1 Existing Power Supply System of Each Stations

NO	Station	Phase of Load		Suppling the Signal equipment	EG	Solar	Remark
		Shingle	three				
1	TAUNGOO	-	-	-	-	-	Phase I work
2	KYEDAW	*					
3	KYUNGON	*					
4	KAYTUMADI						
5	YEDASHE	*					
6	KONGYI					*	
7	SWA	*	*				
8	THARGAYA	*					
9	THARYARGON						
10	MYOHLA	*					
11	YENI	*					
12	TAWUTI	*					
13	HTEININN						
14	ELA	*					
15	PYAYWUN						
16	PYINMANA	*	*	*	*		HT (11kV)
17	YWADAW	*					
18	NAYPYITAW	*	*	*	*		HT (11kV), Substation (33kV)
19	KYIDAUNGKAN	*					
20	PYOKKWE	*					
21	SINBYUGYUN	*					
22	SHWEMYO	*				*	
23	SINTHE	*					
24	TATKON	*					
25	MAGYIBIN					*	
26	NYAUNGLUN	*				*	
27	HNGETTHAIK					*	
28	INGON					*	
29	YAMETHIN (YMA)	*					
30	INGYINKAN					*	

NO	Station	Phase of Load		Suppling the Signal equipment	EG	Solar	Remark
		Shingle	three				
31	SHWEDA					*	
32	PYAWBWE	*					
33	SHANYWA						
34	NYAUNGYAN					*	
35	NWATO					*	
36	THAZI	*	*	*	*		HT (11kV)
37	YWAPALE					*	
38	HANZA	*					
39	DAHATTAW						
40	THEDAW	*				*	
41	KHINBAN	*					
42	SAMON	*				*	
43	ODOKKON						
44	THABYETAUNG						
45	KUME LAN	*				*	
46	MYITTHAR	*					
47	MINZU	*					
48	KYAUKSE	*					
49	BELIN	*					HT (11kV)
50	SINGAING	*				*	
51	PALEIK	*				*	
52	MYITNGE	*	*			*	Substation (33kV)
53	TAGUNDAING	*				*	
54	MYOHAUNG	*	*	*	*		HT (11kV)
55	SHANZU						
56	MANDALAY	*	*	*	*		HT (11kV)

Source: JICA Study Team

(a) High Voltage Receiving Equipment in a Station

(b) Signal Cabin (Tower)

(c) Signal Equipment with Hand Generator and Car Battery

(d) Semaphore Signal

(e) Solar Power System

(f) Signal Aspect at a Level Crossing by a Hand Flag

Source: JICA Study Team

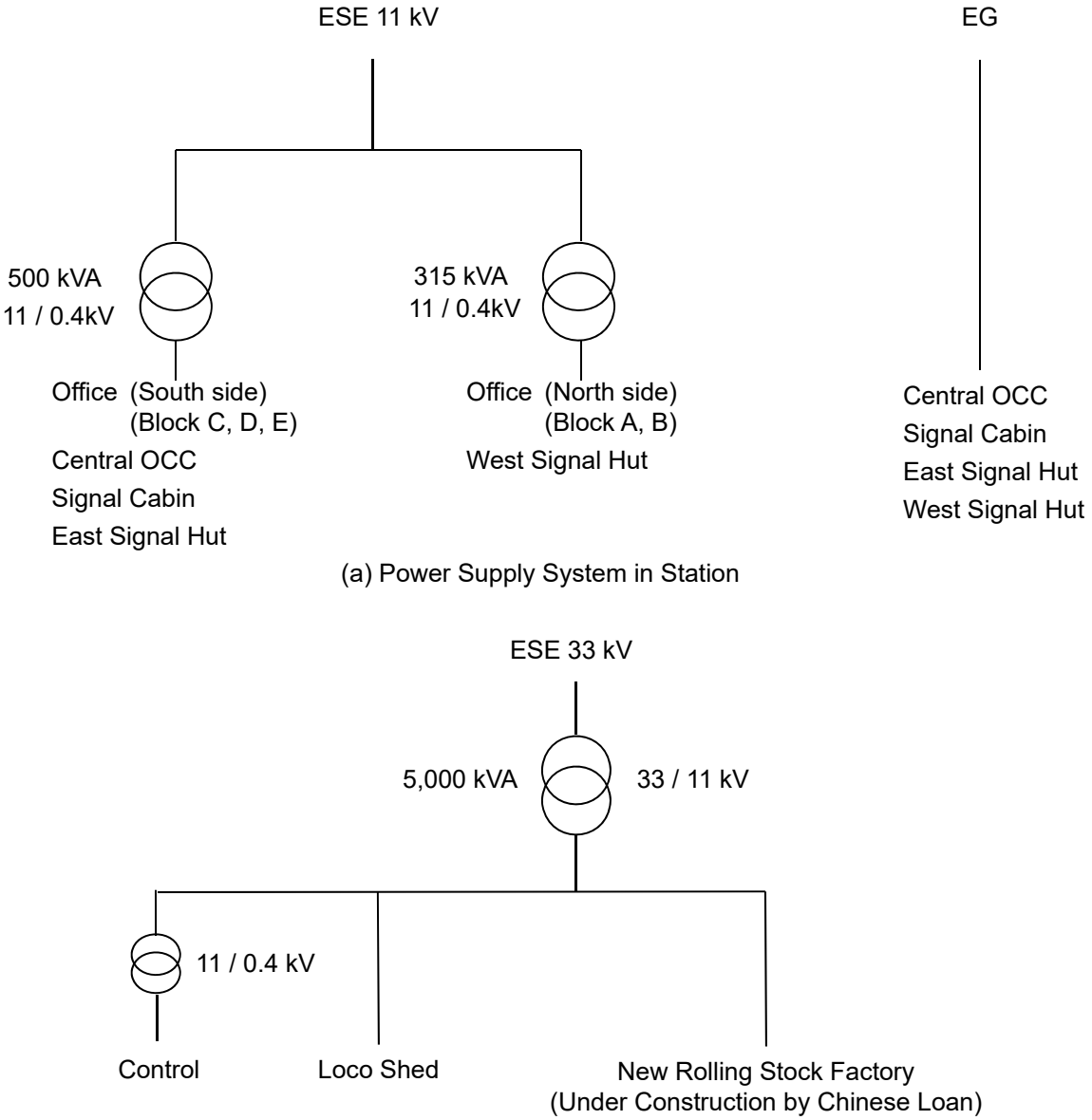
Figure 5.16.1 State of Signal and Level Crossing

The station where commercial power supply is not available has solar panels. The solar panels charge the car battery which is used for holding a raised semaphore and for telecommunication equipment.

At the level crossing, in principle, the gateman confirms the approach of a train visually or by train's horn and closes the gates manually, and then indicates Proceeding signal aspect by a hand

flag. For some level crossings, as an auxiliary means, the station staff of the nearby station notifies the approach of the train to the gateman by a transceiver.

The transceiver is charged by low-voltage commercial power supply at the level crossing if it can receive power from a nearby distribution line. At the level crossing without power supply nearby, the gateman brings and uses a replacement battery which was charged at another place.



Source: JICA Study Team

Figure 5.16.2 Power Supply System of Naypyitaw Station and Depots

Figure 5.16.2 shows the power supply schematic of Naypyitaw Station currently receiving power from the substation owned by MR. Naypyitaw Station receives power for the station load from the ESE's 11 kV power network and for the depot load from the ESE's 33kV power network.

(2) Survey for the Power Supply Equipment in Depots

Table 5.16.2 shows existing power supply system for the depots.

Table 5.16.2 Existing Power Supply System for Depots

NO	Station NAME	Phase		Suppling the Signal equipment	EG	Solar	Remark
		Shingle	three				
1	Naypyitaw (Loco Shed)	*	*		(*)		HT (11kV), EG is out of order
2	Thazi	*	*		*		HT (11kV)
3	Myitnge	*	*		*		Substation (33kV)
4	Myohaung	*	*		*		HT (11kV)

Among them, the improvement plans of Naypyitaw Station and Myohaung Station are as follows.

1) Naypyitaw Station

Figure 5.16.3 shows the existing equipment of the power supply system in Naypyitaw Loco Shed. Power is supplied to the loco shed by the 11 kV transmission line from the MR's 33 kV substation installed in Naypyitaw Station. The loco shed is located about 2 km away from the substation.

An emergency generator is installed at the loco shed. However, it is out of order and inoperative now.

Source: JICA Study Team

Figure 5.16.3 Power Supply of Loco Shed in Naypyitaw Station

In Naypyitaw Station, there is a new rolling stock factory which is under construction by Chinese loan. Figure 5.16.4 shows the situation of the construction of Naypyitaw Rolling Stock Factory. Power is supplied to the factory by an 11 kV transmission line from MR's 33 kV substation in Naypyitaw Station. This factory is located about 2.5 km away from the substation. This transmission line was newly installed with a circuit separated from the loco shed.

Source: JICA Study Team

Figure 5.16.4 Naypyitaw Rolling Stock Factory (Under Construction)

The 5,000 kVA transformer of the substation in Naypyitaw Station supplies power to the depot and the factory. However, this transformer does not have enough capacity for newly installed facilities. According to the regulations of the power supplier, it is impossible to install another substation from a different power source if a substation already exists in the station. Therefore, in order to install the power supply equipment for the depot in Naypyitaw Station, it is necessary to enlarge the existing 33 kV substation.

2) Myohaung Station

Figure 5.16.5 shows the existing power supply equipment for Myohaung Station. Myohaung Station receives power from the transformer which is connected with an 11 kV transmission line drawn into the MR's site from the city network. Myohaung Station has no substation.

(a) For Telecommunication

(b) For Freight Yard

(c) For Sleeper Factory

Source: JICA Study Team

Figure 5.16.5 Transformers for Myohaung Station

5.16.2 Recommendation for Improvement of Power Supply

(1) Summary

Currently, blackout occurs on a daily basis in Myanmar. Sometimes the power supply is not recovered for a long time. In addition, the voltage is unstable and may fall to almost half of the

standard voltage during heavy load time. The voltage fluctuation rate which is allowed for the signal power supply is ± 10%.

In response to such power supply circumstances, the following measures are expected to be planned.

- 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, an OLTC should be installed in the transformers placed at the optimum location with careful consideration of the supply range and load type, as an OLTC is required to be maintained every year. For example, it is not suitable for a special high-voltage main transformer in a large substation in a depot. Instead, if an OLTC is installed in each of the transformers installed in the lower layer, the voltage for the OLTC is lower and therefore the cost of the OLTC is lower. Also the range of blackout will be smaller when power outage happened.

  In addition, the capacity of the load is small at a level crossing. Therefore the transformer with OLTC is not suitable for level crossings. For this reason, 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).

  The reason why OLTC is given priority over AVR is that the current on the secondary side of the transformer can be made smaller by adjusting the voltage with OLTC. As a result, the transformer capacity will be reduced. The loss of power consumption will be also reduced.
- For blackout and intense voltage drop, installing emergency generator (EG) as a backup system. It is assumed that EG will operate frequently. If the power supply for the signaling equipment is lost, it will cause a huge effect on safe and stable transportation. There are various products of EG, but it is important to choose a high quality product, not a product that is cheap and easy to break down.

In the power receiving plan in Myanmar, the JICA Study Team proposes the following policies for the connecting method to the power grid.

- 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.
- If the transformer capacity is over 500 kVA, a circuit breaker and a protection device are necessary for the transformer, although Phase II project does not include such a case so far.

- Although it is a rare case as the load for a station, if the capacity of the transformer exceeds 1,000 kVA, the receiving voltage must be 33 kV or more.
- As for the method of installing a transformer, in principle, a pole mounted transformer is required for the load of 300 kVA or less and a ground transformer is required if its capacity exceeds 300 kVA.
- 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.
- In case there are multiple candidates for power source, the JICA Study Team is to investigate each of such candidates of power source. In this case, top priority is given to the best plan, and a number is assigned to each plan according to the priorities, such as Plan 1, Plan2 and so on. As for future plans of Power Suppliers, reconfirmation is necessary even in the detailed design stage in the future.
- In Myanmar, the transmission line installed between the Power Supplier's transmission line and customer's load is supposed to be owned by customers. In some cases, the station loads will need to be connected to the private transmission line owned by a villager or a company, etc. In suc cases, MR may have to pay royalty to the owner of the transmission line. In principle, no external power source shall be connected to transmission lines owned by military or government agencies. Therefore, the owner of the transmission line must be considered in power source planning.
- Conventionally, Aluminum Conductors Steel Reinforced (ACSR) has been used for overhead transmission lines from a power source to a load. However, mainly in the Yangon area, the Power Supplier instructs concerned parties to use a product called SAC cable (Spaced Aerial Cable: SAC) for the transmission lines newly installed in recent years in Myanmar. This policy is expected to be expanded beyond the Yangon area in the future. The surface of the SAC cable is covered with insulator so that short-circuit rarely occurs even if it is contacted with trees or flying objects such as kites. Therefore, this cable greatly contributes to public safety and stable supply of signal power. For this reason, SAC is recommended for all transmission lines, not limited to the Yangon area.

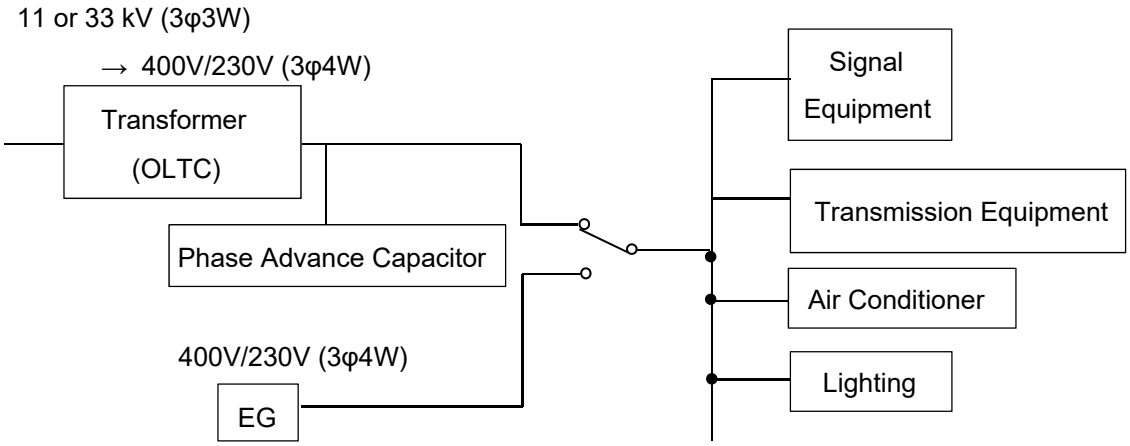
(2) Power Receiving of 50 Stations and Level Crossings between Stations

In the stations between Taungoo and Mandalay, 5 stations are planned to be abolished and one station is supposed to be a halt station in this project. For the 50 stations, except Taungoo Station which is planned to be improved in Phase I, and the level crossings with a lot of traffic which are located between stations (except the level crossings located between the distant signal and the outer signal of the station, which are expected to receive power from the station), a new power supply system will be installed to supply stable power. This power supply system is composed of

high voltage receiving equipment, substation equipment and a standby emergency generator. In order to supply power stably at each station and at such level crossings, suitable equipment has to be planned considering the power supplier's infrastructures near the station and the level crossing.

Figure 5.16.6 shows the plan of the power supply equipment for the 50 stations. For the stations with the Operation Control Center (OCC), power lines dedicated to the OCC have to be installed.

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.

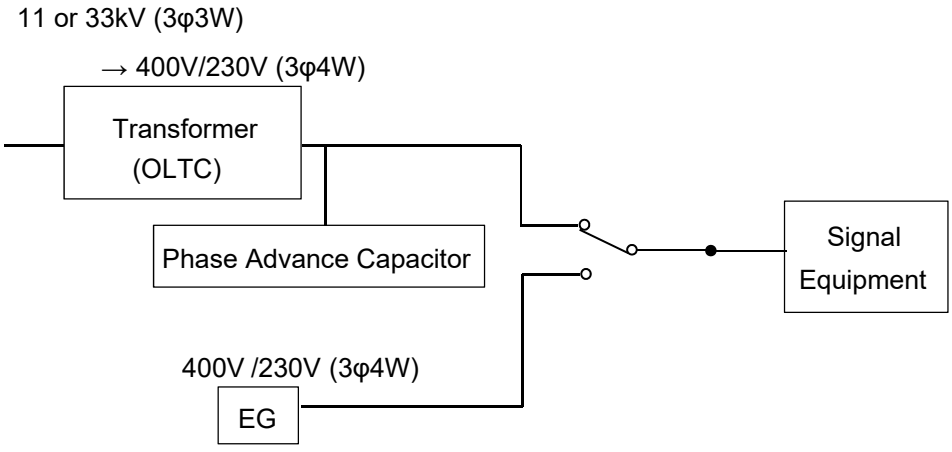


Source: JICA Study Team

Figure 5.16.6 Composition of the Power Supply Facilities in 50 Stations

Figure 5.16.7 shows the power supply configuration for the level crossing.

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.



Source: JICA Study Team

Figure 5.16.7 Composition of the Power Supply Facilities in Level Crossing

1) Power Receiving Equipment

Table 5.16.3 shows the connection distance from the transmission line to the station and the capacity of the new transformer. The data of the capacity of the transformer at each location are an approximate value, and they will be finalized in the detailed design stage.

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. Specific improvement methods will be examined in the detailed design stage.

This preparatory study proposes the best plan as of 2017, based on the consultation with Power Supplies. However, in this proposal, some transmission lines are still long. For the power supply for such stations, the connection point of the transmission line should be planned as close to the station as possible while the future plans of power suppliers for the distribution network are considered. Regarding the private transmission lines to be expected to be connected by this project, it is necessary to reconsider the plan of connection point so that there is any possibility to connect power supplier's transmission lines.

In addition, for the level crossings between stations, solar power generation may be advantageous from the viewpoint of cost as the load is small. Although this preparatory survey is to be summarized on the assumption that the power is supplied by the transmission line based on the site survey, the availability of solar power generation will be examined in the detailed design stage.

Table 5.16.3 Connection Distance of Each Station and Transformer

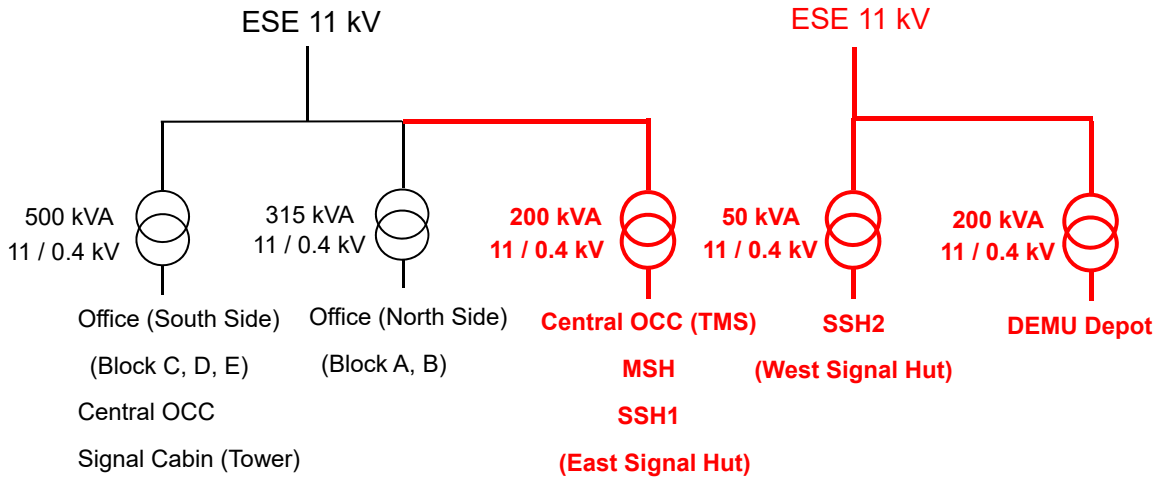
NO	Station NAME	Voltage of HT Line		Type of Transformer	Approx. Connecting Length to H.T Line [m]	Approx. Capacity of Transformer [kVA]	Remark
		11 [kV]	33 [kV]				
1	TAUNGOO						Phase I work
1-1	Level Crossing No.6 (5)	*		Pole mounted	30	*1	
1-2	Level Crossing No.7 (5)	*		Pole mounted	20	*1	
2	KYEDAW	*		Pole mounted	350	*2	
3	KYUNGON	*		Pole mounted	300	*2	
4	KAYTUMADI						To be abolished
5	YEDASHE	*		Pole mounted	300	*2	
5-1	Level Crossing No.16 (5)	*		Pole mounted	20	*1	private HT line
6	KONGYI	*		Pole mounted	20	*2	Future Plan
7	SWA	*		Pole mounted	20	*2	
8	THARGAYA	*		Pole mounted	500	*2	
9	THARYARGON						To be abolished
10	MYOHLA	*		Pole mounted	50	*2	
11	YENI	*		Pole mounted	700	*2	
12	TAWUTI	*		Pole mounted	400	*2	
12-1	Level Crossing No.26 (5)	*		Pole mounted	20	*1	
13	HTEININN						To be abolished
13-1	Level Crossing No.28 (5)	*		Pole mounted	20	*1	private HT line
14	ELA	*		Pole mounted	100	*2	
15	PYAYWUN	*		Pole mounted	1,000	*2	private HT line
16	PYINMANA	*		Pole mounted	500	50	MSH
		*		Pole mounted	300	50	SSH
16-1	Level Crossing No.36 (5)	*		Pole mounted	50	*1	
16-2	Level Crossing No.38 (5)	*		Pole mounted	1,000	*1	private HT line
17	YWADAW	*		Pole mounted	350	*2	private HT line
18	NAYPYITAW	*		Pole mounted	50	200	TMS, MSH, SSH1
		*		Pole mounted	600	50	SSH2
19	KYIDAUNGKAN	*		Pole mounted	20	*2	
19-1	Level Crossing No.43 (5)	*		Pole mounted	20	*1	
20	PYOKKWE	*		Pole mounted	150	*2	private HT line
21	SINBYUGYUN	*		Pole mounted	700	*2	private HT line
22	SHWEMYO	*		Pole mounted	20	*2	private HT line
23	SINTHE	*		Pole mounted	50	*2	private HT line
24	TATKON	*		Pole mounted	300	*2	
25	MAGYIBIN	*		Pole mounted	1,000	*2	Future Plan
25-1	Level Crossing No.54 (5)		*	Pole mounted	500	*1	Need to confirm Future Plan
26	NYAUNGLUN		*	Pole mounted	300	*2	
27	HNGETTHAIK	*		Pole mounted	900	*2	
28	INGON	*		Pole mounted	1,000	*2	private HT line

NO	Station NAME	Voltage of HT Line		Type of Transformer	Approx. Connecting Length to H.T Line [m]	Approx. Capacity of Transformer [kVA]	Remark
		11 [kV]	33 [kV]				
29	YAMETHIN (YMA)	*		Pole mounted	300	*2	
29-1	Level Crossing No.61 (5)	*		Pole mounted	1,000	*1	private HT line
30	INGYINKAN	*		Pole mounted	2,000	*2	from No. 29-1
31	SHWEDA		*	Pole mounted	10	*2	private HT line
31-1	Level Crossing No.62 (5)	*		Pole mounted	600	*1	Agricultural Dept. 11 kV
32	PYAWBWE	*		Pole mounted	150	*2	
33	SHANYWA	*		Pole mounted	5,000	*2	from No.32
34	NYAUNGYAN	*		Pole mounted	300	*2	Future Plan
35	NWATO	*		Pole mounted	5,000	*2	Future Plan
36	THAZI	*		Pole mounted	200	200	MSH, SSH
37	YWAPALE		*	Pole mounted	2,000	*2	
38	HANZA	*		Pole mounted	250	*2	Need ESE's improvement
39	DAHATTAW						To be abolished
40	THEDAW	*		Pole mounted	300	*2	
41	KHINBAN	*		Pole mounted	500	*2	private HT line
42	SAMON		*	Pole mounted	50	*2	
43	ODOKKON						To be abolished
44	THABYETAUNG	*		Pole mounted	2,000	*2	Future Plan
45	KUME LAN	*		Pole mounted	300	*2	
46	MYITTHAR	*		Pole mounted	300	*2	
47	MINZU	*		Pole mounted	100	*2	
48	KYAUKSE	*		Pole mounted	50	*2	
49	BELIN	*		Pole mounted	250	*2	
50	SINGAING	*		Pole mounted	100	*2	
50-1	Level Crossing No.23 (3)	*		Pole mounted	20	*1	private HT line
51	PALEIK	*		Pole mounted	150	*2	Future Plan
52	MYITNGE	*		Pole mounted	50	*2	
53	TAGUNDAING	*		Pole mounted	200	*2	
53-1	Level Crossing No.28 (3)	*		Pole mounted	100	*1	
54	MYOHAUNG	*		Pole mounted	500	100	MSH
		*		Pole mounted	300	100	SSH
55	SHANZU	*		Pole mounted	300	*3	
55-1	Level Crossing No.35 (3)	*		Pole mounted	20	50	
56	MANDALAY	*		Pole mounted	30	200	TMS, MSH
		*		Pole mounted	100	100	SSH

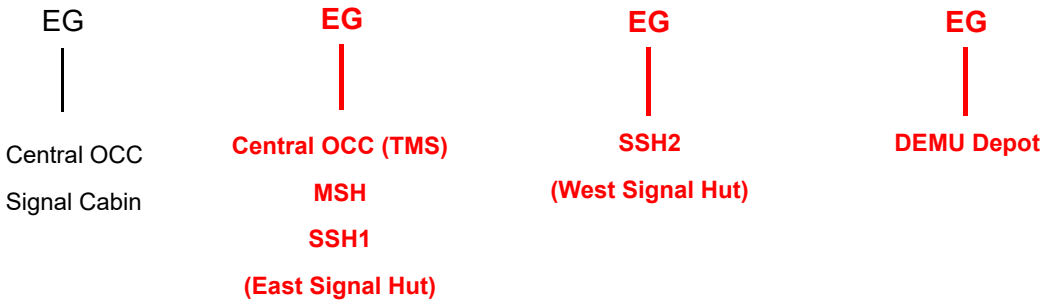
*1: For Level Crossing (Approx. 5 - 25 kVA)
*2: For Station (Approx. 100 - 160 kVA)
*3: This transformer supply power to the Automatic Block System. The load capacity is under consideration.

Source: JICA Study Team

The improvement of the signalling system of Naypyitaw Station is currently under discussion with MR. Assuming that TMS will be installed in Central OCC and the interlocking devices of the signalling system will be improved as their maximum, the improved power system schematic is shown below. Further examination will be required in the detail design stage for details such as capacity.



(a) Power System Schematic of the Station Section (Regular Power Supply)



(b) Power System Schematic of the Station Section (Emergency Power Supply)

Source: JICA Study Team

Figure 5.16.8 Power System Schematic of Naypyitaw Station (After Improvement)

Regarding the power supply system of the station, the plan for extending the power supply with the improvement of the signal load at the present time is the following. In addition, there are many uncertain factos, for example, MR prefers one signaling house instead of two (2) signaling houses. The details will be discussed between the JICA Study Team and MR in the detailed design stage.

- Central OCC, OCC
  TMS will be installed.
- MSH
  The equipment room of the OCC will be improved as MSH.

- SSH1 (East SH)
  The existing East SH will be improved.
- SSH2 (West SH)
  The existing West SH will be improved.

Details will be discussed between JST and MR in the detail design stage.

The new DEMU depot is planned to receive power of about 200 kVA at the present time. A transmission line of approximately 2 km is planned to be installed between the 11 kV power receiving point and the DEMU depot. An on-ground transformer base is planned to be installed near the DEMU depot.

Although there is another ESE 11 kV transmission line in the vicinity, since the power supply of the substation owned by MR already exists in the same premises, it is impossible to mix power sources of a different system.

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) Equipment

The equipment is planned as follows.

- Transformer
  The receiving system of the transformer is 3 phases 3 wires system at 11kV or 33kV. The outputting system of the transformer is 3 phases 4 wires system at 400V (single phase 230V). The transformer shall have an OLTC in preparation for voltage fluctuations.
- EG
  The specifications of the EG are shown in Table 5.16.4.

Table 5.16.4 Specifications of EG

Distribution system and Output Voltage	Three-phase four-wire system 400V (Single phase 230V)
Start-up time	Inside of 40 sec.
Continuous operation time	7 hours and over (Not refuel)
Voltage regulation in not loading state	Within 0.5%(Three phases generator) Within of 2%(Single phase generator)
Fuel	Gas oil
Others	With automatic blackout detection function. Adjustable switching time.

Source: JICA Study Team

- Phase Advance Capacitor
  A phase advance capacitor with automatic power factor adjustment function is planned to be installed on the secondary side of the transformer. The capacity of the phase advance capacitor shall be 1/3 of the capacity of the transformer.

(3) Power Supply Equipment for New Depot

The power sources for the new depots are currently under examination. Table 5.16.5 shows the current plan of the load capacities of the depots and the new transformers.

Table 5.16.5 Depot Load and Transformer Capacity

NO	Station NAME	Voltage of HT Line		Type of Transformer	Approx. Connecting Length to H.T Line [m]	Approx. Capacity of Transformer [kVA]	Remark
		11 [kV]	33 [kV]				
1	Naypyitaw DEMU Depot	*		Pole mounted	800	200	
2	Myohaung New Depot	*		On Ground	500	400	
3	Myohaung New Depot	*		On Ground	200	400	

Source: JICA Study Team

(4) Interface Issues

The interface issues are as follows.

- The design and installation of high-voltage equipment such as high-voltage distribution lines and transformers will be carried out by the power supply contractor of this project. High tension equipment is expected to be designed and installed based on the design guidelines of the power supplier in Myanmar.
- The foundation and fence of the transformer will be installed by the architect contractor of this project. The foundation of the transformer should be at least 4 feet (1.22m) in height from the ground to prevent the transformer from submerging due to the rise of water level in the rainy season.
- The EG is planned to be installed in the signal house built by the architect contractor of this project. The EG will be installed in the generator room separated from the room where the signalling equipment is installed. The foundation for the EG will be installed by the architect contractor of this project.
- The ground resistance of the grounding conductor connected to the distribution board, switch box, WHM board, EG, EG starting board will be installed by the power supply contractor of this project.

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

Table 5.16.6 shows the relevant Power Suppliers concerning connecting points to the grids between Taungoo and Mandalay. The power supply for this section 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. The ”Station Number” in Table 5.16.6 corresponds to the number shown in Table 5.16.6.

As a lesson in the detailed design of Phase I, the JICA Study Team learned that unlike other fields, coordination with government agencies is necessary for power supply works and that it takes time to design due to this coordination. Since the detailed design period of Phase II is shorter than that of Phase I, the JICA Study Team and MR explained the current plan to Township Engineers and Town Engineers of the Power Suppliers in this preparatory survey and confirmed that the load at each staion/level crossing can be connected to the connecting point designated by this plan so that the detailed design will go smoothly.

The location of the transmission line and the load is shown in Attachment **.

Table 5.16.6 Related Power Suppliers

No.	Corporation	Division	Township Engineer	Station No.		Number of locations	Remarks
				from	to		
1-1	ESE	Bago	Taungoo	1-1	2	3	
1-2			Kaytumadi	3	3	1	
1-3			Yedashe	5	6	3	
1-4			Swa	7	7	1	
1-5			Thargaya	8	8	1	
1-6			Myolha	10	10	1	
1-7			Yeni	11	11	1	
2-1		Naypyitaw	Tawuti	12	12-1	2	
2-2			Ela	13-1	15	3	
2-3			Pyinmana	16	16	1	
2-4			Pobbathiri	16-1	21	8	
2-5			Tatkon	22	26	6	
3-1	MESC	Mandalay	Yamethin	27	31	6	
3-2			Pyawbwe	31-1	33	3	
3-3			Thazi	34	38	5	
3-4			Wantwin	40	42	3	
3-5			Kume	43	44	2	
3-6			Myitthar	46	46	1	
3-7			Kyause	47	48	2	
3-8			Singaing	49	50	2	
3-9			Paleik	50-1	51	2	
3-10			Amarapura	52	53-1	2	
3-11			Pyikyi Takun	53	53	1	
3-12			Chan Mya Tharse	54	55	2	
3-13			Ma Har Aung Myay	55-1	55-1	1	
3-14			Chan Aye Thazan	56	56	1	

5.17 Station and Terminal Development Plan

5.17.1 Current Planning of Station and Terminal Development by MR

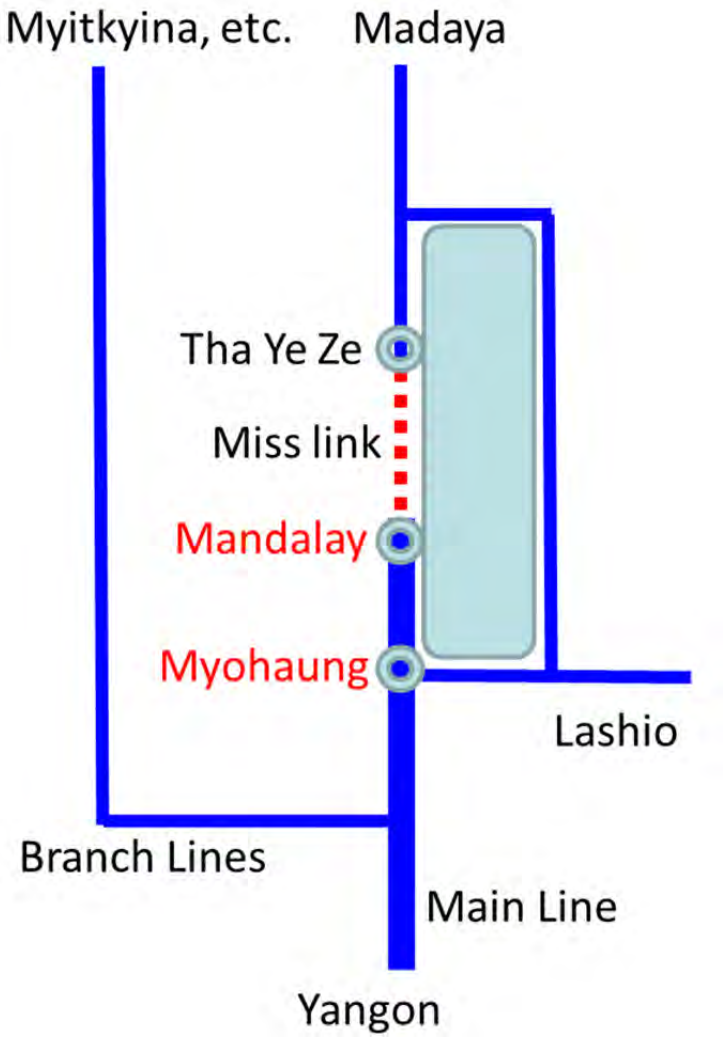
(1) Objected stations and current condition

1) Outline

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.

A length between them is approx. 5 km. Center of Mandalay is formed in a grid pattern, two stations locate south of Royal Palace. A network of railway in Mandalay city looks like reversed "C" shape, the reason is detour route was prepared when Royal Palace section was disused. A locational relation between Mandalay and Myohaung stations is shown in Figure 5.17.1.



Source: JICA Study Team

Figure 5.17.1 Locational relation between Mandalay and Myohaung stations

(a) Mandalay station

A feature, issue and possibility of future change in this station is shown below.

<Features>

Features are shown below.

- The station has a function as central station of Upper Myanmar.
- The station is a terminal of higher category trains from/ to Yangon, the largest city, and Naypyitaw, Capital. Also the station is a terminal of local trains among upper Myanmar cities. The station connects both of them.
- The station has a basement function as workshop for locomotives or passenger cars, warehouse for loading/ unloading function for freight/ passenger mixed local trains, and etc. in large space.

- The station has a complexed station building with on bridge deck for cars. Platform is on ground level, concourse and ticketing are on second level and station function and hotel are on upper floors.
- Escalators are equipped between platform floor and concourse floor. It is possible to use elevator between concourse floor and station plaza, which locates on eastern side of the station.
- Passing through the deck is acceptable for 24 hours, free for pedestrian, charged for vehicles. Large vehicles are not acceptable.
- Space for kiss and park for private cars and taxis are prepared on the deck.
- Large cars are accessible on station plaza which locates on eastern side of the station.
- There is not a station plaza on western side of the station.

<Issues>

Some issues are revealed from a viewpoint of barrier free shown below.

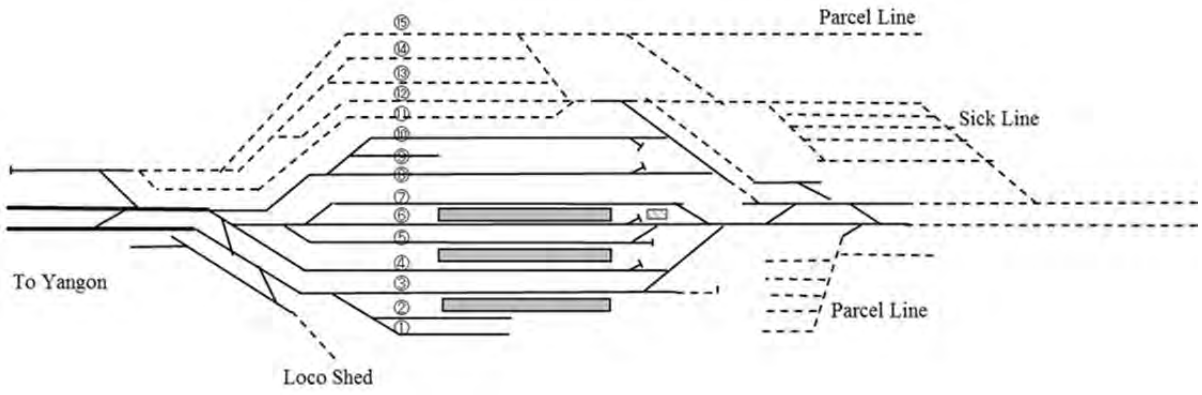
- Some passenger trains use #1 line which has no platform.
- Pedestrian can walk along roadway from/ to western side of the station and the deck, but it is difficult to pass by wheelchairs.
- Buses on regular route touches eastern side of the station, passengers getting on/ off on road.

<Possibilities of future change>

Possibilities of future change are shown below.

- It is expected to be produced an idle land, according to change of composition of trains.
- Potential for commercial and business development will be higher, including land owned by MR leasing to the private sector.

A current skeleton of the Station is shown in Figure 5.17.2.



Source: JICA Study Team

Figure 5.17.2 Current Skeleton of Mandalay Station

(b) Myohaung station

A feature, issue and possibility of future change in this station is shown below.

<Features>

Features are shown below.

- Main function of the Station is freight station.
- Passenger service is 8 Return Trip (RT)/ day, in other words 16 trains/ day.
- The station is ground level station, it is necessary crossing rail between station building on western side and eastern side.
- Passenger service is provided using three lines, one of them does not have a platform.
- There is not road for vehicles connecting east and west for approx. 4km length close to the Station. Over rail bridge close to U Pwar Pagoda (Land Thit Street) locates northern side of the Station.

<Issues>

Some issues are revealed from a viewpoint of barrier free shown below.

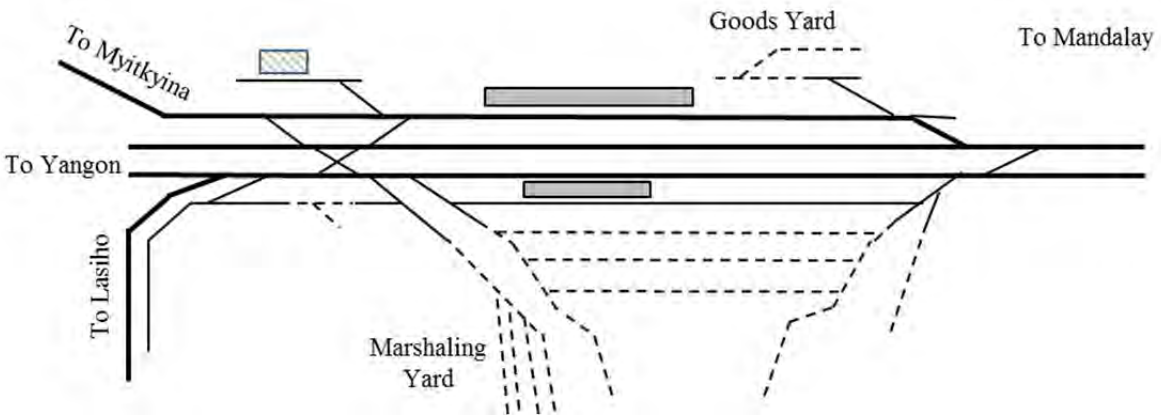
- From/ to eastern side is not possible.
- It is recognized that passenger service at no platform and no walkway crossing the rail.

<Possibilities of future change>

Possibilities of future change are shown below.

- New Central Business District (CBD) Plan, locates eastern side of the Station including a land owned by MR, is planned. It is expected increasing a number of passengers and potential of commercial/ business development.

A current skeleton of the Station is shown in Figure 5.17.3.



Source: JICA Study Team

Figure 5.17.3 Current Skeleton of Myohaung Station

(2) Planning by MR

1) Mandalay Station

A plan of rebuilding of Hotel Amazing Mandalay, which locates on MR's land is progressing.

2) Myohaung Station

The plan concerning about station/ terminal development prepared by MR is not recognized.

(3) Policy in the Survey

1) Policy

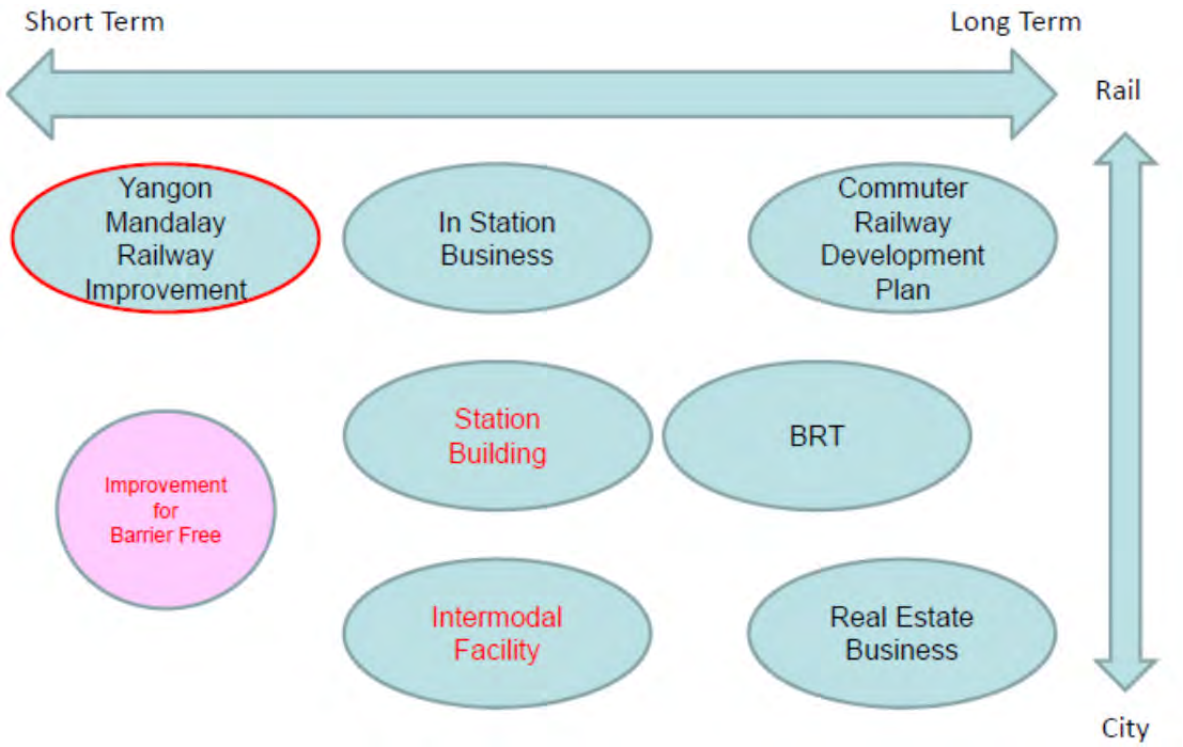
The point which should be considered in planning of station development is Transit Oriented Development or TOD and Universal Design. TOD generates enormous economic, financial social and environmental benefits shown below.

- To ensure mobility of the people and accessibility to services and activities.
- To promote compact and energy efficient urban spatial structure.
- To enhance urban development opportunities at and around the stations.

Universal Design is a concept to enable easier access for any type of passengers as, children, elders, mobility impaired persons, expectant mothers, blind persons, etc. Typical facilities for Universal Design are shown below.

- Flat access for passengers on wheel chairs is provided by slopes and/ or elevators
- Balustrades along stairs with 2 levels for persons with different height are helpful for any generations and any kind of handicap.
- Braille signage and bell support blind persons to move or using ticket vending machine, etc.

A relationship between the Project and Station/ Terminal Development is shown in Figure 5.17.4.



Source: JICA Study Team

Figure 5.17.4 Relationship between the Project and Station/ Terminal Development

Also time series arrangement of each item as city side, railway side and supports is shown in Table 5.17.1.

Table 5.17.1 Time series in each item

ITEM	Now				Future
Mandalay City			BRT LRT	New CBD	Subway
MR	Barrier free	Decreasing DL+PC+FW	Surplus land	Station plaza Commercial facilities	Increasing passengers Diversified business
Mandalay Stn.	Bus access West entrance			Station plaza north end	Circular LRT
Myohaung Stn.	Stopping #1 and #3		Rail Over footway in station area	Station plaza east side	
Support by JICA	Preparatory survey	Detailed design	Supervision		

DL: Diesel Locomotive, PC; Passenger Car, FW; Freight Wagon

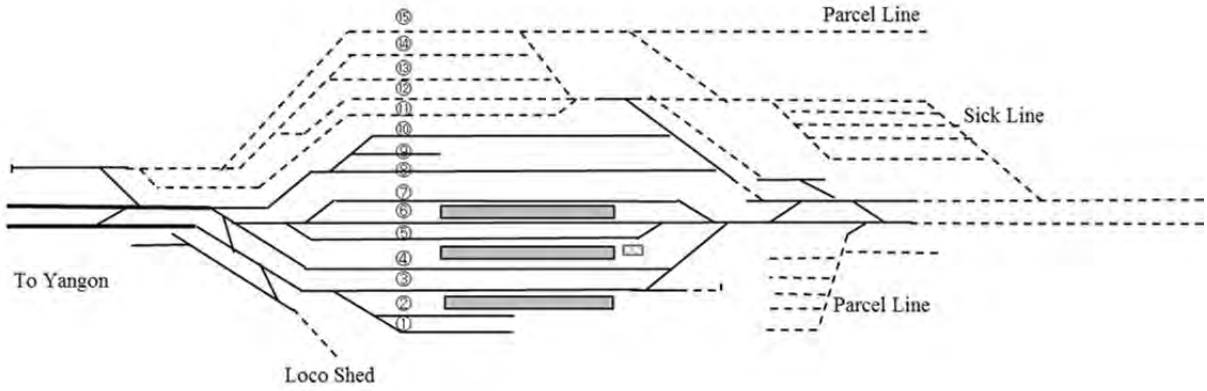
Source: JICA Study Team

Planning should be considered items shown below.

- The target of the Project is improvement of existing line between Yangon and Mandalay, and it is an urgent issue. Any kind of procedure as environmental and social considerations is progressing in limited cost and time.
- Station and terminal development requires a collaboration of railway and city, but a plan of city side is not matured as of now.
- So considering items are divided in this study as 1) Items for the Project, or 2) Items after the Project.

2) Mandalay Station

A draft plan of future skeleton of Mandalay station is shown in Figure 5.17.5.



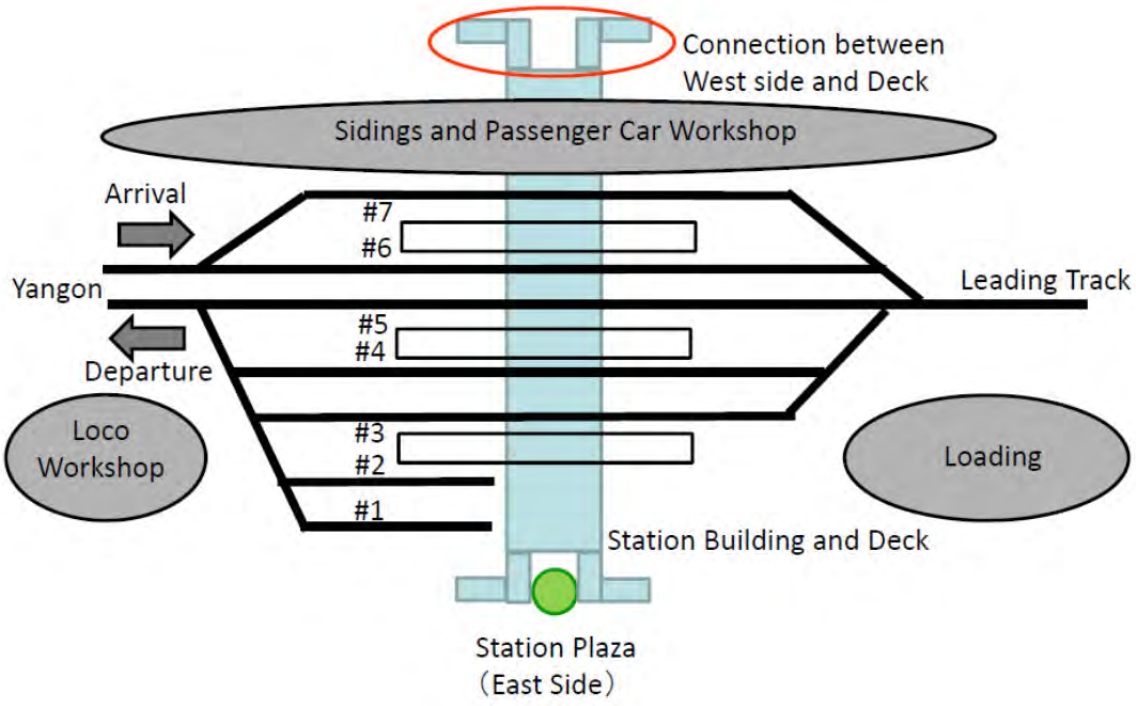
Source: JICA Study Team

Figure 5.17.5 A draft plan of future skeleton of Mandalay Station

Candidate menu in the Project is shown below.

- Enhancement of western side footway approach, as improving existing staircase and existing footbridge and setting up a new elevator.
- Ensuring a safety for passengers of fixed route bus, connecting eastern side, as new bus stop in station plaza, improving existing vehicle, handle/ doors conversion, etc.

Draft image of future Mandalay station is shown in Figure 5.17.6.

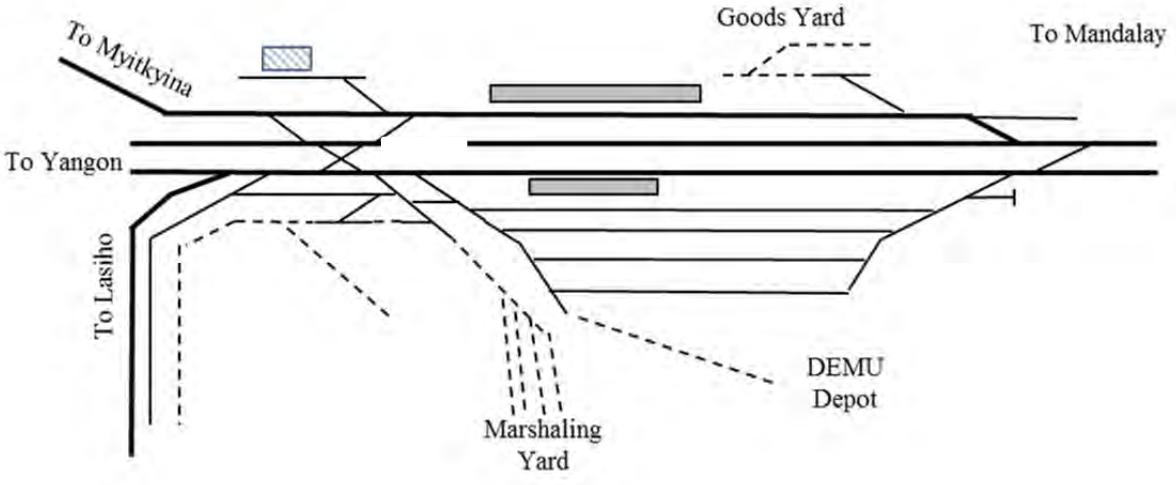


Source: JICA Study Team

Figure 5.17.6 Draft image of future Mandalay station

3) Myohaung Station

A draft plan of future skeleton of Myohaung station is shown in Figure 5.17.7.



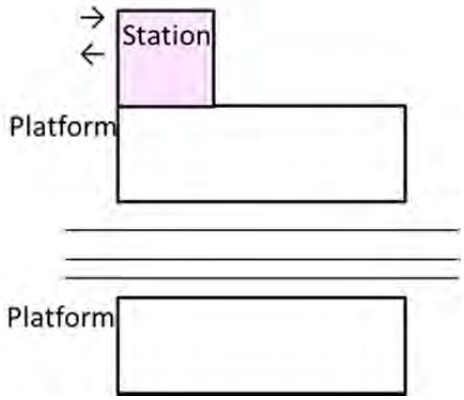
Source: JICA Study Team

Figure 5.17.7 A draft plan of future skeleton of Myohaung station

Candidate menu in the Project is shown below.

- Improvement of train operation as local train use #1 and #3, which has a platform.
- Constructing station plaza east side of the Station
- Constructing an elevated station on the bridge or an footbridge connecting platforms and station buildings.

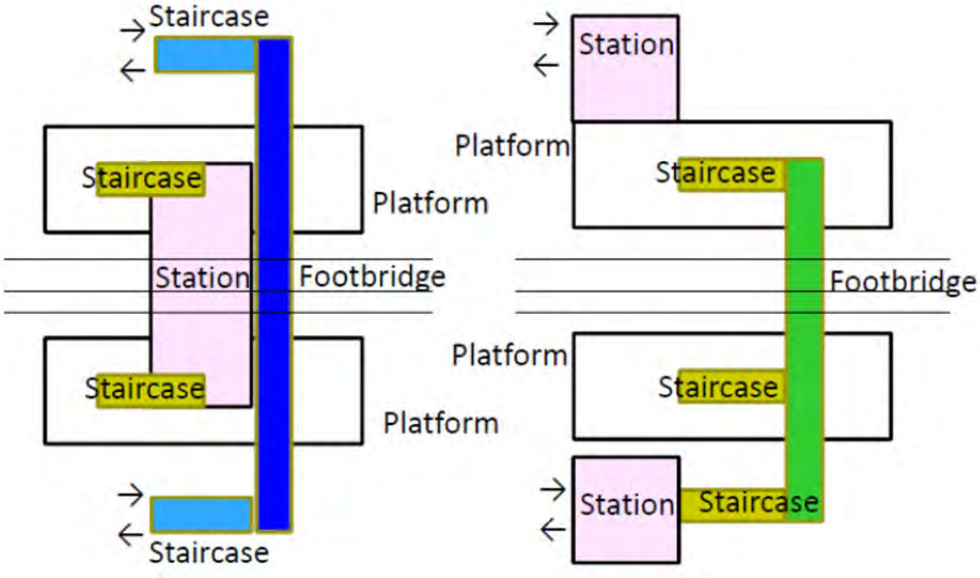
Current situation of passenger handling at Myohaung station is shown in Figure 5.17.8.



Source: JICA Study Team

Figure 5.17.8 Current situation of passenger handling at Myohaung station

Candidate menu of improvement as elevated station and "ground level station building + footbridge" are shown in Figure 5.17.9.



Elevated Station on the Bridge Ground Level Station Buildings + Footbridge

Source: JICA Study Team

Figure 5.17.9 Image of elevated station and "ground level station building + footbridge"

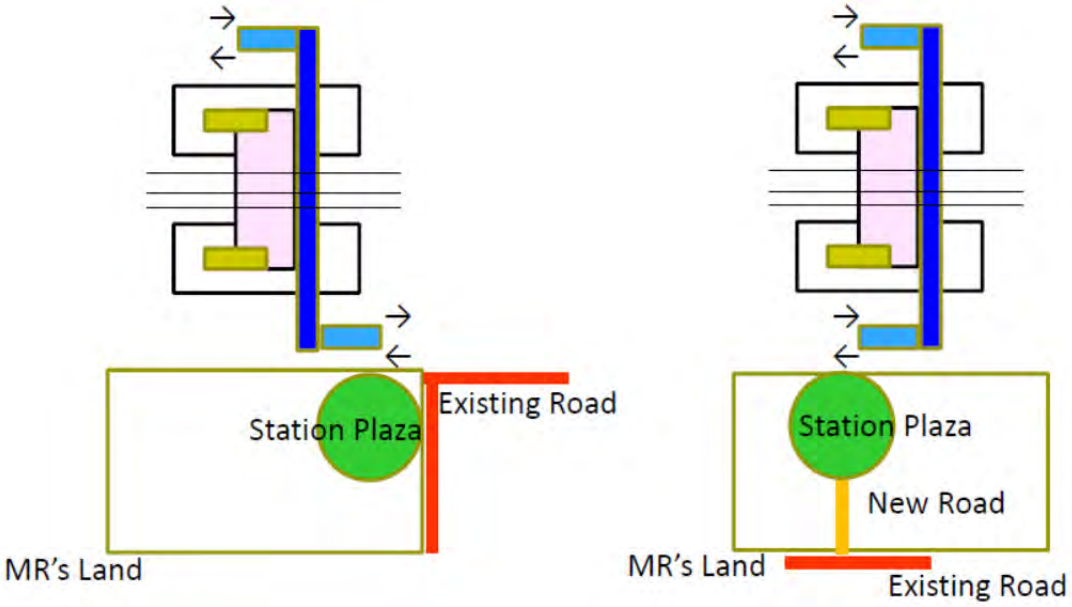
A comparison of Elevated station and "ground level station building + footbridge" is shown in Table 5.17.2.

Table 5.17.2 Comparison of Elevated station and "ground level station building + footbridge"

	Elevated station	Ground level station with a bridge across railroads within its premises
Comment	➢ MR has a merit what station function is integrated. ➢ Residents around the station have a merit crossing the railway free charge.	➢ Lower cost.
Evaluation	Excellent	Fair

Source: JICA Study Team

Access road for station plaza has an alternatives as connecting with existing road or constructing new access road. Image of is shown in Figure 5.17.10.



Existing Road　　New Access Road

Source: JICA Study Team

Figure 5.17.10 Image of alternatives of access road for station plaza

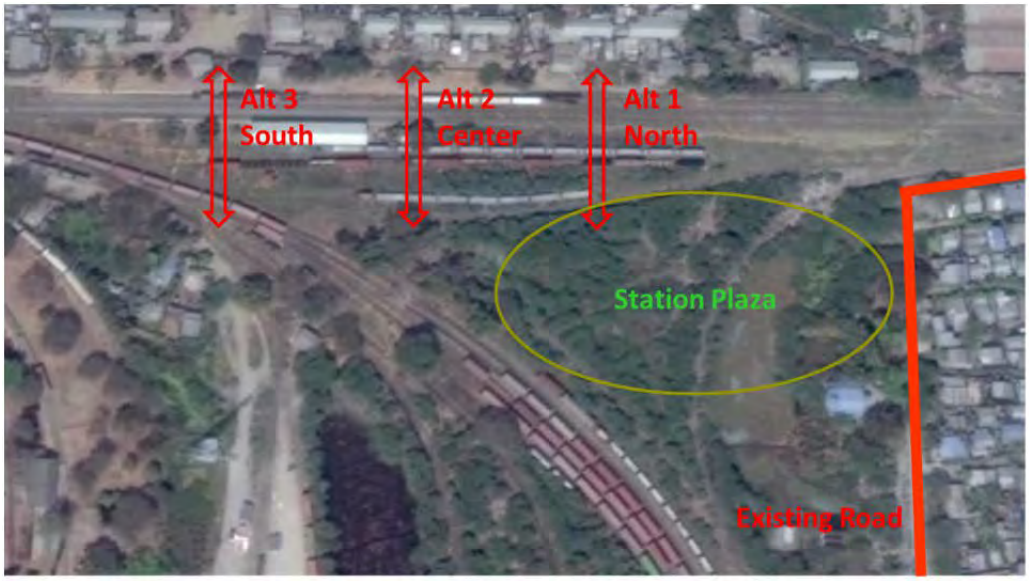
A comparison of alternatives is shown in Table 5.17.3.

Table 5.17.3 Comparison of alternatives of station plaza access road

	Existing Road	New Road
Comment	➢ MR has a merit what layout of any kind of facilities is not restricted. ➢ Residents around the station have a merit as easy access to the station.	➢ It is not necessary widening of existing road for passing large size vehicle.
Evaluation	Excellent	Fair

Source: JICA Study Team

Alternatives of location of elevated station are shown in Figure 5.17.11.



Source: JICA Study Team

Figure 5.17.11 Alternatives of location of elevated station

Comparison of location of elevated station is shown in Table 5.17.4.

Table 5.17.4 Comparison of location of elevated station

	Alt 1 North	Alt 2 Center	Alt 3 South
Comment	➢ MR has a merit what layout of any kind of facilities is not restricted. ➢ Residents around the station have a merit as easy access to the station.	–	➢ Distance between station and plaza is longest.
Evaluation	Excellent	Fair	Poor

Source: JICA Study Team

5.17.2 Recommendation for Station and Terminal Development Plan

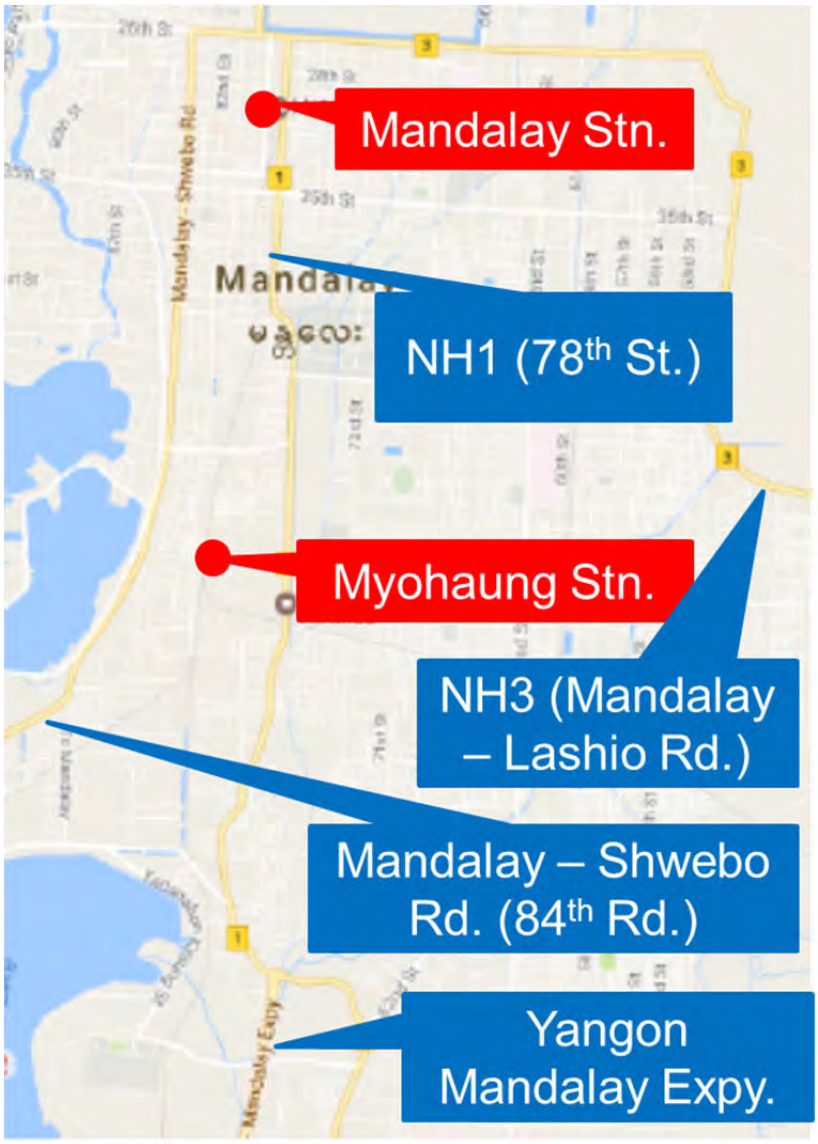
(1) Policy

1) Prerequisite condition

"Urban Development Plan for Mandalay 2040" is not matured plan, which shows zoning and contents but does not show a floor space, a number of visitors and so on. Myohaung station is expected to be a major station as Mandalay station. Therefore demand forecast of the Survey is conservative, as not considered "Urban Development Plan for Mandalay 2040". A recommendation for station and terminal development plan is based on optional scenario in demand forecast considered "Urban Development Plan for Mandalay 2040".

2) Feature of Mandalay station and Myohaung station

Intermodal facility as station plaza should be installed in Mandalay station and Myohaung station. One of the biggest factors for determining a space of station plaza area is bus traffic. Large vehicle requires a large space and a large turning radius. The space around a station has high use value, therefore a clarification of roles of both station plaza is important. NHI（78th St.）and Mandalay – Shwebo Rd. (84th Rd.) are parallel with railroad. Trunk roads in Mandalay area are shown in Figure 5.17.12.



Source: JICA Study Team

Figure 5.17.12 Trunk roads in Mandalay Area

And outline and location of five bus terminals in Mandalay area are shown in Table 5.17.5 and Figure 5.17.13.

Table 5.17.5 Bus terminal in Mandalay

No.	Name	Main Destination	Open Year	Area (ha)
1	Thiri Man Dala	Madaya, Mogoke, Chin State, Kachin State, Sagaing Region, Magway Region	1996	1.2
2	Mahaaungmyay	Around Mandalay Region within 50 miles	2003	1.2
3	Chan Mya Shwe Pyi	Yangon, Naypyitaw, Taunggyi Town, Rakhine Region, Magway Region, Kayin Region	1992	6.8
4	Pyi Gyi Myat Shin	Pyinoolwin, Kyaukme, Hsipaw, Lashio, Muse, Shan State (North)	1991	3.1
5	Daw Na Bwa	Mogaung, Mohnyin, Myitkyina, Hopin	2016	1.4

Source: Proposal of Urban Development Plan for Regional Cities -Mandalay, Pathein and Mawlamyine-

Source: Proposal of Urban Development Plan for Regional Cities -Mandalay, Pathein and Mawlamyine-

Figure 5.17.13 Location of Bus Terminal in Mandalay

The bus access to Mandalay station and Myohaung station is assumed shown below.

Fixed route bus

- Intercity highway bus, Airport bus, Sightseeing bus, Local bus
- Intermediate bus stop between existing bus terminals
- Short time stopping at station plaza

Non fixed route bus

- Chartered bus for railway passengers
- School bus, corporate bus, and courtesy bus for shopping mall
- Short time stopping at station plaza

Outline of station plaza of two stations is shown in Table 5.17.6.

Table 5.17.6 Outline of station plaza

	Mandalay Stn.	Myohaung Stn.
Rail Inter City	Terminal Station	Intermediate Station
Rail in Mandalay Area	Terminal Station	Intermediate Station
Highway Bus	Bus Stop	Bus Stop for Southbound
Bus in Mandalay Area	Bus Stop	Bus Stop
Int'l Airport Access Bus	Bus Stop	Bus Stop
Bus for Tourism	Bus Stop	Bus Stop
Taxi	Berth, Pool	Berth, Pool
Para Transit	Berth, Pool	Berth, Pool
Commercial Facility	Berth, Pool	Berth, Pool

Source: JICA Study Team

3) Assumption of facility size

Assumption of facility size in station plazas is shown in Table 5.17.7.

Table 5.17.7 Assumption of facility size in station plazas

	Mandalay Stn.	Myohaung Stn.
Number of bus berth (Vehicle)	2(East station plaza, Plan)	2
Number of taxi or para transit berth (Vehicle)	2(Deck on bridge, Existing)	2
Number of taxi or para transit pool (Vehicle)	230(Deck on bridge, Including hotel cars, Existing) 15(East station plaza, Including railway police cars, Existing) Parking Fee; 200 Kyat	5
Number of private car berth (Vehicle)		2
Number of private car pool (Vehicle)		5
Number of bike/ cycle parking (Vehicle)	5(Deck on bridge, Existing) 5(East station plaza, Existing) Parking Fee; 100 kyat	10
Area (m^2)	East station plaza; 2,500 Deck on bridge and Approaches; 7,500 Total; 10,000	Approx. 10,500
Comment	Available by present facility Bus stop in station plaza and improvement of pedestrian flow line are necessary.	East side of station, connecting existing road

Source: JICA Study Team

Assumption of station commercial area is shown in Table 5.17.8.

Table 5.17.8 Assumption of station commercial area

	Mandalay Stn.	Myohaung Stn.
Station Building	Existing	Plan
Others	Existing (Station plaza, around platform)	Plan (Station Plaza)

Source: JICA Study Team

(2) Mandalay station

1) During the Project period

Existing facility satisfies a requirement. Improvement items are shown below.

East side station plaza

- Indicating two bus berth and permitting entry of buses.

Connection between deck on bridge and east side of station

- Improvement of pedestrian flow line (Effective use of existing staircase)

2) Long term after the Project

It is expected that creation of idle land after the Project period. Main reason is decreasing a number of "Loco + Coach" trains. It is expected that construction of intermodal facilities or commercial and business facilities. Items shown below should be considered in the planning.

- Connection of articulated bus on BRT route
- Commuter Railway Development Plan with LRT

Concreate image is shown below.

- The role is not only for intercity, but also commuter train in Mandalay city area. (For example, Circular line connecting Mandalay and Tha Ye Ze)
- New road east/ west direction, location is 28th St. between and 30th Rd.
- Station development and intermodal facility along the street, with articulated bus passing smoothly.

Image of Mandalay station area long term plan after the Project is shown in Figure 5.17.14.

Source: JICA Study Team

Figure 5.17.14 Image of Mandalay station area long term plan after the Project

(3) Myohaung station

1) During the Project period

Location of Myohaung elevated station on the bridge and station plaza is shown in Figure 5.17.15.

Source: JICA Study Team

Figure 5.17.15 Location of Myohaung elevated station on the bridge and station plaza

Image of Myohaung elevated station with station plaza is shown in “5.9 Railway Station”.

Access route for station plaza is shown in Figure 5.17.16.

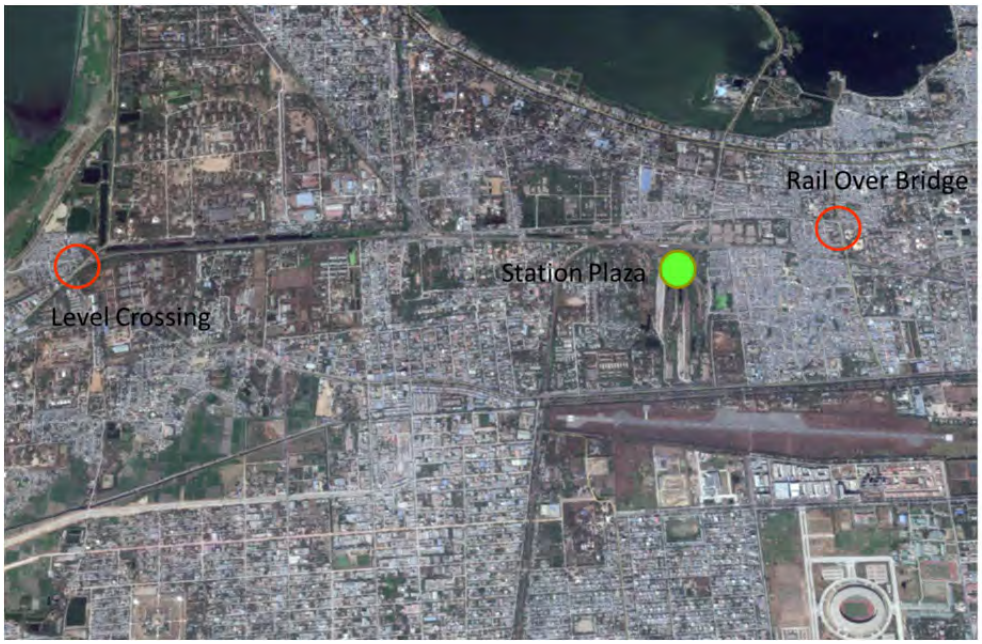
Source: JICA Study Team

Figure 5.17.16 Access route for station plaza

An existing road connecting with station plaza does not have a width accessible for large size vehicles, so only small size vehicle is accessible for the time being. The plan realized in the Project should be collaborate with city side in the next detailed design stage.

2) Long term plan

A location of railway crossing trunk road near Myohaung station is shown in Figure 5.17.17.



Source: JICA Study Team

Figure 5.17.17 Location of railway crossing trunk road near Myohaung station

There is no level crossing and rail over bridge between 4 km section which includes Myohaung station. Therefore it should be considered maturing New CBD Plan shown below after the Project.

- Confirming consistency with a future trunk road network plan prepared by city side.
- Confirming widening plan of existing road connecting with station plaza.

  For example, a plan of rail over road bridge east/ west direction, in case which crosses near Myohaung station, considering a possibility of connecting station plaza.

5.18 Passenger Service

5.18.1 Current Conditions of Passenger Service

Until now, mainly two projects have been implemented for passenger service in Myanma Railways (MR). One project was "Project on Improvement of Service and Safety of Railway in Myanmar" (2013-2016) by JICA, and the other one was "Myanmar Railway Sector Human Resource Development Course" (2016-2017) by JICA.

(1) Project on Improvement of Service and Safety of Railway

"Project on Improvement of Service and Safety of Railway" was a technical cooperation project for track maintenance mainly. And the project also focuses on improving administration and maintenance ability for the enhancement of service and safety of MR.

On this project, in order to analyse customer's satisfaction level of MR, interview survey was conducted on Yangon-Mandalay Line. As a result, the grade of satisfaction with MR's passenger service was found to be low overall. The project team suggested that MR conduct periodical surveys like that. In addition, the project team also suggested MR accept the finding that passengers are dissatisfied, and prioritize improving passenger service.

(2) Myanmar Railway Sector Human Resource Development Course

"Myanmar Railway Sector Human Resource Development Course" was a project that took place from 2016 to 2017. Under the project, a training course was started for personnel of the Ministry of Transport and Communications (MOTC) and MR to introduce information including Japanese advanced railway technology, and railway-related services to assist the development of the railway network in Myanmar.

In Myanmar, the interest for passenger service of MR is growing after the change of government. Then four service training were held in Nay Pyi Taw MR Headquarters, Yangon Station and Mandalay Station. Headquarters staff and field staff together were tackled with the seminar, and customer interviews were also carried out in Yangon Station.

In addition, the lectures of this program had the principal objective of encouraging respective staff to identify things they could do to improve services and to consider improvement methods. And as

the result of two days interview in Yangon Station, many opinions were collected from both long distance and suburban train passengers.

In Yangon Station service seminar, 5 stations in Greater Yangon area were selected as model stations, and a workshop to identify the issues of each station, examine solutions and present results were held. In a group, the theme "A passenger in Yangon Station can purchase a ticket easily and promptly catch a train" was set and discussed. The problems they organized to solve are below: booking office of Yangon Station is so far from the main building, business hours of booking office are too short, double booking, lack of vacancy information for passengers, etc. They said, therefore, the ticket reservation should be managed systematically by the computer system.

Also they pointed out that there are so many problems about the provision of information to passengers. That is to say, both the problems which can tackle to reform by the staff and passenger service facilities should be improved.

Furthermore, according to the customer interview, there are a large numbers of responses about the problems to purchase the ticket, such as "Stations should increase the allotment of reserved seat tickets of nearest station" and about the lack of information for passengers.

However, the main issue that needs to be addressed is how to realize these ideas. As mentioned, according to the progress of Yangon-Mandalay Railway Improvement Project and Yangon Circular Railway Upgrading Project, these improvements are strongly desired to raise the service level of whole MR.

(3) The Project on Improvement of Railway Service and Rolling Stock Maintenance

The technical cooperation project to be implemented, "The Project on Improvement of Railway Service and Rolling Stock Maintenance" by JICA will develop the methods of passenger service of MR. Along with development of human resource and improvement of the passenger service method, passenger service facilities to maximize each project's effects should be considered to install.

5.18.2 Recommendation for Improvement Plan of Passenger Service

(1) Required Level of Passenger Service

After completion of this project, Yangon and Mandalay will be connected within 8 hours, and express trains will be served frequently. Transportation service standards will increase drastically, that means, requests from passenger for the whole service standards must be increased.

The final goal of the passenger service study on this project is to provide higher standards of passenger service, which is suitable for improved railway facilities. Essential main purposes are to fulfil the potential of improved railway facilities and thereby to improve the number of customers and the amount of revenue.

In terms of the increase in customers, considering the current travel time and fare, expected new MR customers are using the bus at present. To transfer passenger from the bus to the time reduced MR train after completion of this project, MR is supposed to provide service standard superior to the bus, or competitive with the aircraft.

Through the technical cooperation project will tackle human resource development and implementation method of passenger service to provide higher standards of passenger service, the facilities to support these activities are also required. Therefore, JST focused on Ticket Reservation System and Passenger Information System.

(2) Ticket Reservation System (TRS)

Long distance buses in Myanmar already provide Internet reservation and credit card paying. Passengers can board the bus with just printing e-ticket by themselves.

Source: JICA Study Team

Figure 5.18.1 Booking Office Entrance (South of Yangon Station)

On the other hand, MR express train tickets are available to buy just 3 days before boarding. Reservation is managed by paper reservation record in the terminal station. As the allotment of reserved seat tickets of each station is fixed, not all seats can be purchased at all stations. As the tickets are often issued by handwriting; problems like double booking happen. Especially in Yangon Station, distance from the main the building to booking office is also the problem.

Source: JICA Study Team

Figure 5.18.2 Yangon Station Booking Office

At the Japanese National Railways (JNR) in the past, reservation seats had been also managed by paper reservation records for long time since the reservation seats were introduced in 1910. In 1960, 4 years before the completion of Tokaido Shinkansen, the first computer-based ticket reservation system named “MARS 1” was released. Reserved seats management has been transferred from paper to computer gradually. In 1965, management of reserved seats of Tokaido Shinkansen was transferred to the MARS system.

In 1968, when large-scale timetable revision was effected, nationwide limited express network was constructed in Japan. At that time, Japanese railway services switched to the modern mass rapid transportation age with Shinkansen and Limited Express, which had the reserved seats.

Source: JICA Study Team

Figure 5.18.3 Reservation Record at Naypyitaw Station (32DN)

The “MARS” reservation system have been improved continuously. At present, passengers can book the train by

themselves with using the Internet or ticket vending machine. The "Yield Management" system, which maximizes the income with vacancy/price management referring the purpose or demand of train, has also developed for railway companies.

Thus, ticket reservation system is essential for modern railway, especially to maximize of the effect of this project.

(3) Proposal for Ticket Reservation System of MR

To manage the reservation by the system is effective for not only operating process of reservation but also the management of seats and the reform of ticket inspection, etc. However, now JST focuses on the ticket reservation system.

Source: JICA Study Team

Figure 5.18.4 Example of Ticket Reservation System in Japan

Firstly, 7 or 9 major stations should be installed the system.

Also, JST fixes the essentials of ticket reservation system below:

- Customers can purchase the reserved seat tickets conveniently at the station or on the Internet,
- Customers also can change or refund the ticket at the station according to the MR regulations, and
- The system should be capable for system extension in the future.

As for the ticket reservation system in Japan Railways Group (JR Group), the "MARS" system has over 50 years history. However, the "MARS" system is extremely complexed to correspond with Japanese complicated railway business regulations and fare adjustment methods within 6 JR Group companies, after the privatization and division of Japanese National Railways.

Now Japanese railway companies are trying to reform the railway business regulation to simplify. IC card fares are an example. The system for MR also should aim at simple configurations.

The system should be composed like 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 (the preparation of the server is to be outsourced)
- 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 a present day 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.

Accordingly, the target described will be achieved.

(4) 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.

However, if MR trains can be reserved freely from all over the world via the Internet, the problem so-called "empty reservation" or "no-show" will be concerned. This means that someone reserves a seat but actually does not take the train.

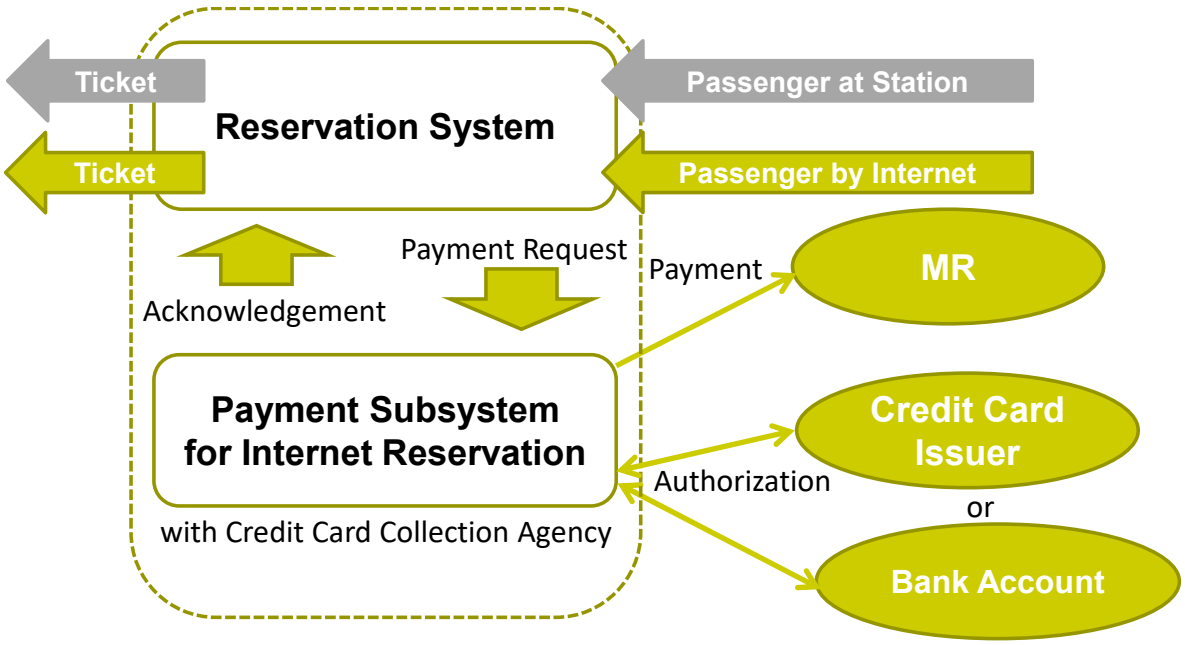
To prevent that problem, Internet reservation system should be connected with Bank Account or Credit Card and collect the fare and charge surely.

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

The payment subsystem will receive payment request about Internet reservation from the reservation system, and handle the authorization process with a credit card issuer or a bank account system. When the authorization process will be completed, the subsystem will send an acknowledgement to the reservation system and the ticket will be issued. The payment subsystem will be managed by a credit card collection agency, so MR will pay the running cost to the agency.

MR also mentioned to use prepaid cards for issuing the ticket. In addition, simple Internet reservation method that does not use a credit card, such as "only booking the seats on the Internet and pay at the station" is also available if ticketing deadline would be set a short term. Such requirements should be discussed on the Detail Design stage.

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



Source: JICA Study Team

Figure 5.18.5 Pattern Diagram of Ticket Reservation System

(5) Passenger Information System (PIS)

The previously implemented projects have reinforced and the future technical cooperation project will reinforce the service structure of MR staff. The Passenger Information System will support the provision of such information to passengers by staff.

Currently in MR, LED information boards were installed at major stations such as Yangon, Taungoo, Naypyitaw and Mandalay stations in Myanmar and English languages.

Source: JICA Study Team

Figure 5.18.6 Existing LED Information Board in Yangon Station

However, the same departure/arrival information is repeatedly displayed by scroll all the day. The boards do not have the function to provide real time information.

Therefore, 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.

Source: JICA Study Team

Figure 5.18.7 Example of Passenger Information System (LCD) in Japan

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.

Source: JICA Study Team

Figure 5.18.8 Example of Passenger Information System (LED) in Japan

- 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.

(6) Future

What is the most valuable merchandise for MR? That is the train, and its tickets. The ticket reservation system which can manage these stocks will be the bare bones of the MR managements. And the reservation system will be the repertory of data such as passenger revenue and trend. The reservation system will be the core of systemization of MR.

The range of using the data obtained from the reservation system is very wide. Improving the efficiency of business with the cooperation with the accounting system, introducing of sales policy to maximize the income and optimizing the train schedule, etc., are examples.

Also by providing fine service and information, the passenger information system will maximize the effect of the TMS.

Japan will be able to support MR in the future for such a kind of fields, not only technical issues but also organization management and ticket sales policy.

The fields such as ticket sales policy are expected to become more and more important with the improvement of railways. As well as the cooperation with on-going technical cooperation projects, new schemes like the direct cooperation by Japanese major railway companies will be required.

5.19 Construction Basic Plan

5.19.1 Introduction

There are various types of Construction work such as bridges, Box culverts, Signals, etc. on this railway improvement work of about 320km between Tangoo station and Mandalay Station in this project. However, in this stage, the basic common items that affect the many kinds of construction work are called the general construction plan, which will be examined and described in this chapter.

The general construction plan in this chapter includes the temporary road plan, the material delivering plan and the basic work camp.

Construction plans for specific constructions such as railway improvement, bridges, signals, railroad crossings, etc. shall be examined and described in the respective chapters in the future.

5.19.2 Existing Conditions

The site survey between Tangoo station and Mandalay station was carried out by car and RGC in order to know the existing condition of this railway.

Between Tangoo station and Mandalay station of MR in this project, most sections are embankment sections, and cut sections are small.

Structurally, the volume of ballast (width and height) is insufficient in most sections, and the sides of the PC sleepers are exposed. Also, due to the effects of wind and rain for many years, the width of the body of the embankment that supports the track is lacking

Figure 5.19.1 Existing condition of railway

Figure 5.19.2 Existing Condition of Ballast

This project is located far from the main trunk road, unlike phase 1, especially between Pyawbwe Station ~Kyakse station about 170km in length is located more than a few kilometres away from the main track road with few level crossings and it takes around one hour to reach the station/railway from the main trunk road because the roads are not well maintained.

That road mainly being utilized as a farm road and a commonly used road for the surrounding residences, so only motorcycles or tractor size vehicles are considered feasible to the use roads and passenger cars have extreme difficulty to reach the stations.

In addition, there are wooden bridges in various places and they are not suitable for passing construction vehicles such as for material transportation.

Furthermore, there is no road along the railway that can be used as a construction road.

Figure 5.19.3 Access Road to Station

Figure 5.19.4 Existing Wooden Bridge

5.19.3 Work procedure and Relationships between Work Items

There are various kinds of work items such as soil work, construction of structures like box culverts and bridges, signals and etc. even though this project is a railway improvement project. Each work item has close relationships with eachother.Fig-5.19.5 shows the work procedure and relationship of each work item.

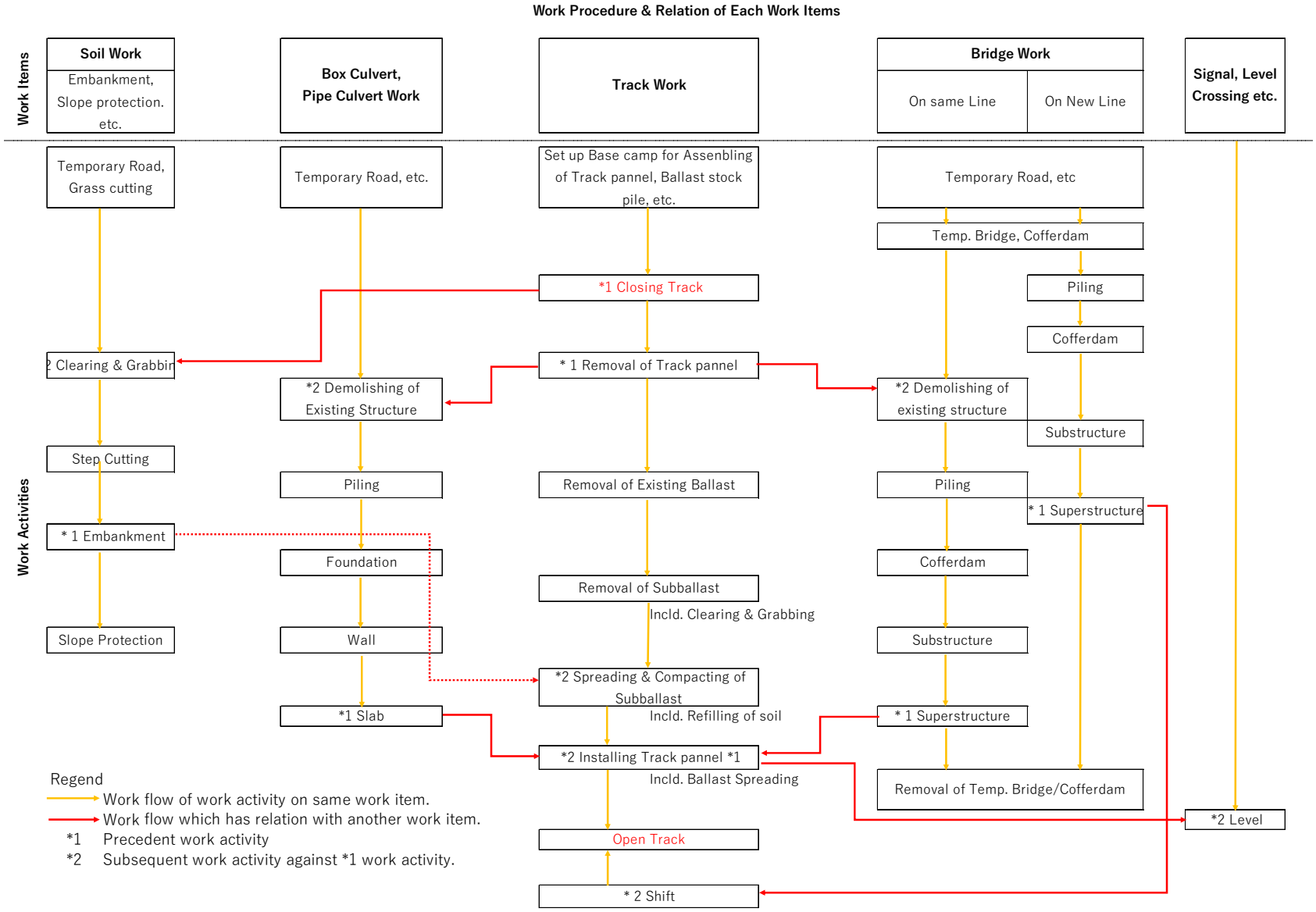


Figure 5.19.5 Work Procedure and Relation of Each Work Items

5.19.4 Study for Construction Schedule

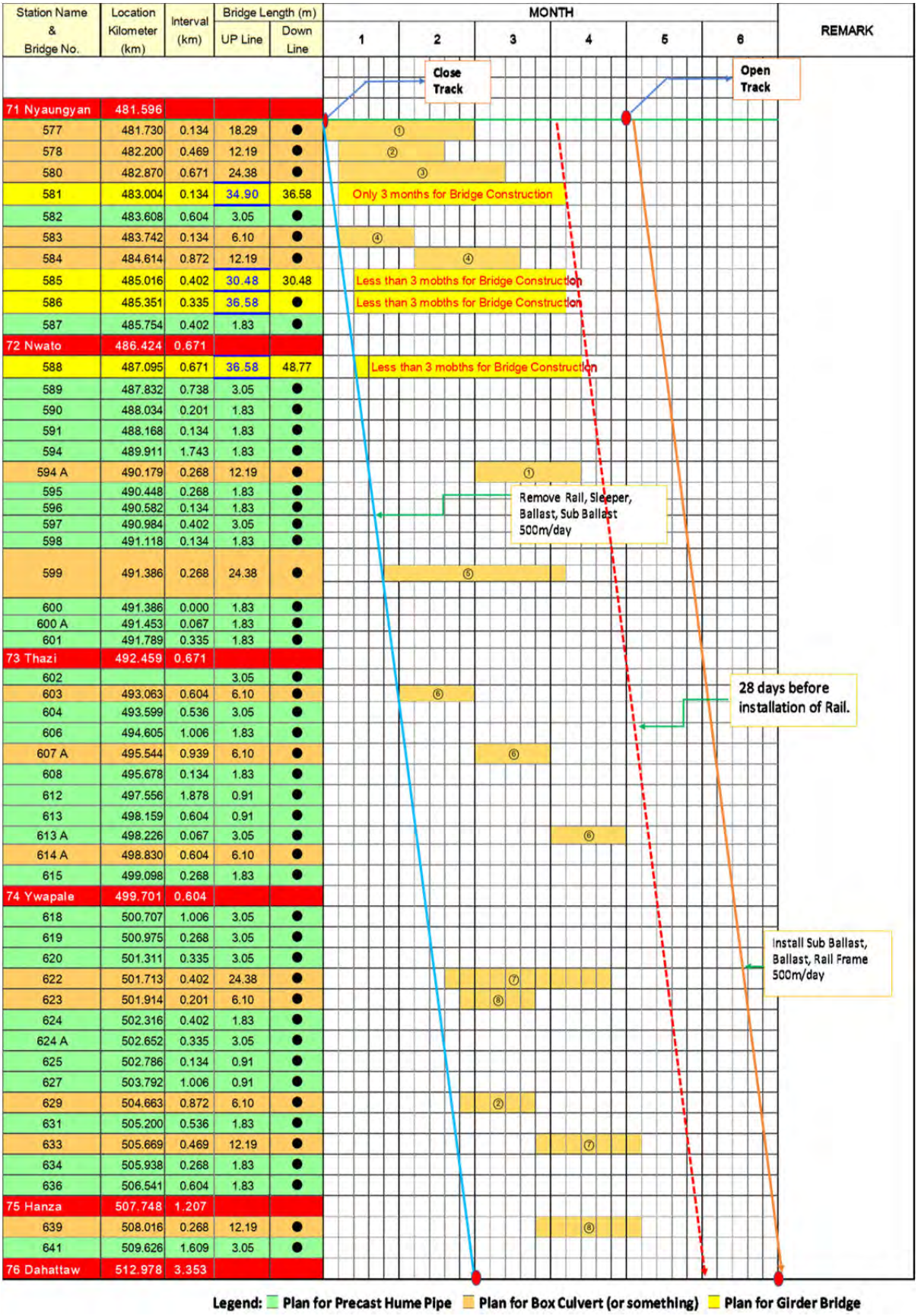
The construction work in the double track section will be carried out during single track operation in this project, and its length will be around 30km.

The JICA study team has studied the outline of the construction schedule as a model case. This covers the stretch between Nyaungyan station and Dahattaw station section which is 30km in length.

(1) Assumptions

- The period from Track closing to track opening is set to 6 months.
- Necessary temporary works such as temporary roads, bridges and cofferdams will have been completed before starting the main works.
- No load is to be placed on the concrete structures until they have reached adequate strength.
- No consider about raining days and holidays.
- Inside size of box culvert will be w=6m, h=5m, l=5m per 1 span.
- Small structures such as pipe culverts are not considered.
- Removal and installation work of rail including ballast/sub ballast are 500 m/day and only one direction work.
- Embankment work has been completed before starting rail installation work.
- Others.

Figure 5.19.6 shows the construction schedule that resulted from the study based on the above assumed conditions.



Station Name & Bridge No.	Location Kilometer (km)	Interval (km)	Bridge Length (m) UP Line	Bridge Length (m) Down Line	REMARK
71 Nyaungyan	481.596				
577	481.730	0.134	18.29	●	
578	482.200	0.469	12.19	●	
580	482.870	0.671	24.38	●	
581	483.004	0.134	34.90	36.58	
582	483.608	0.604	3.05	●	
583	483.742	0.134	6.10	●	
584	484.614	0.872	12.19	●	
585	485.016	0.402	30.48	30.48	
586	485.351	0.335	36.58	●	
587	485.754	0.402	1.83	●	
72 Nwato	486.424	0.671			
588	487.095	0.671	36.58	48.77	
589	487.832	0.738	3.05	●	
590	488.034	0.201	1.83	●	
591	488.168	0.134	1.83	●	
594	489.911	1.743	1.83	●	
594 A	490.179	0.268	12.19	●	
595	490.448	0.268	1.83	●	
596	490.582	0.134	1.83	●	
597	490.984	0.402	3.05	●	
598	491.118	0.134	1.83	●	
599	491.386	0.268	24.38	●	
600	491.386	0.000	1.83	●	
600 A	491.453	0.067	1.83	●	
601	491.789	0.335	1.83	●	
73 Thazi	492.459	0.671			
602			3.05	●	
603	493.063	0.604	6.10	●	
604	493.599	0.536	3.05	●	
606	494.605	1.006	1.83	●	
607 A	495.544	0.939	6.10	●	
608	495.678	0.134	1.83	●	
612	497.556	1.878	0.91	●	
613	498.159	0.604	0.91	●	
613 A	498.226	0.067	3.05	●	
614 A	498.830	0.604	6.10	●	
615	499.098	0.268	1.83	●	
74 Ywapale	499.701	0.604			
618	500.707	1.006	3.05	●	
619	500.975	0.268	3.05	●	
620	501.311	0.335	3.05	●	
622	501.713	0.402	24.38	●	
623	501.914	0.201	6.10	●	
624	502.316	0.402	1.83	●	
624 A	502.652	0.335	3.05	●	
625	502.786	0.134	0.91	●	
627	503.792	1.006	0.91	●	
629	504.663	0.872	6.10	●	
631	505.200	0.536	1.83	●	
633	505.669	0.469	12.19	●	
634	505.938	0.268	1.83	●	
636	506.541	0.604	1.83	●	
75 Hanza	507.748	1.207			
639	508.016	0.268	12.19	●	
641	509.626	1.609	3.05	●	
76 Dahattaw	512.978	3.353			

Source : JICA Study Team

Figure 5.19.6 Outline of Construction

(2) Result of study of construction schedule

The study team has found that there is only a very short period to be spent for construction of the structural work, especially for the bridge construction it is quite difficult to complete it and re-open the rail track.

The overview points are briefly described below.

- It may possible that box culvert work will be completed if no other works such as soil improvement work are needed. However, a large working team including heavy equipment operators and temporary material transporters shall be necessary over a short period.
- There is only around 3 months for the bridge construction. Therefore, it is quite difficult to complete the bridge to be constructed on the same line as the existing line.
- It is certain that a temporary road shall be required because transportation for many pieces of heavy equipment and material shall be required in short period. It is preferable that the removal and installation work of the rails shall be done by 3 to 4 teams in parallel.
- Day and night work shall be necessary.
- Small work such as pipe culvert work also has to be studied in the DD stage because there are many construction sites.

5.19.5 General Construction Plan.

(1) Temporary Road for Construction

There are construction sites like bridges, box culverts, etc. at more than 400 locations between Tangoo station and Mandalay station in this project. So these construction works such as soil work, construction work for structures, railway improvement work and so on surely require a huge volume of construction material and equipment transportation, mobilization and demobilization and a shortage of transportation capacity of the railroad is anticipated. For these reasons and to secure transportation volume, the temporary road routes from major roads will be necessary.

However, there is no road that can be utilized for carrying such construction material and equipment. Therefore, the study team strongly proposes to set up the temporary roads for construction along the railway. The presence of the temporary roads will have a great influence on the construction schedule. It is desirable that the temporary roads for construction are set up along all lines, but at the present stage we tried a plan based on the following conditions

1) Basic Conditions for the temporary road for construction

The temporary roads for construction shall be planned considering with following conditions.

- Access to the ROW is from level crossings basically, however if possible it is acceptable to gain access from the main trunk road or a station area.

- Relocation of private houses will be avoided as much as possible.
- Box culvert work and bridge work shall require temporary roads for construction.
- The temporary roads for construction shall be set up on only one side of the railway, and for the opposite side of the railway, work yards that have an area of 200 ~ 300m^2 will be set up at each work site within the ROW.
- For small structure construction sites other than box culverts and bridges, only work yards will be set up within the ROW.
- The width of the temporary roads for construction shall be 4m and thickness of embankment and crushed stone are 40 cm and 15cm respectively.
- Use of vehicles that can run on both the railway and roads will be considered.
- There will be no recompense for replacement of unsuitable material.

Figure 5.19.7 shows the standards for the temporary road construction.

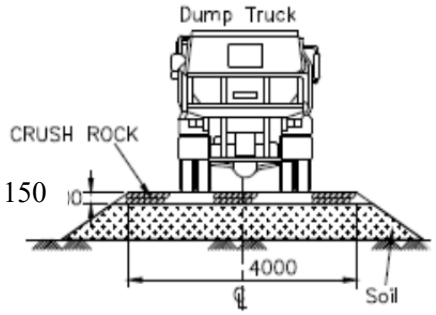


Figure 5.19.7 Standards for the Temporary Roads

The study for the temporary roads for construction showed that considering the above conditions, it is necessary that the temporary roads for construction are about 150 km in length as a rough estimate. Especially it is 80 km between Ingigan station and Kume lun station.

Rough length of the temporary roads for construction for each section are shown in Table 5.19.1

However, depending on the result of the further detailed design and detailed survey such as cross section survey, soil test and so on, because additional roads for replacement work of unsuitable material and reinforcement work of the embankment and clearing and grabbing work become necessary there is a possibility to increase cost and quantity of the temporary roads for construction.

The final plan for the temporary roads during the construction period will be set up by the contractor. Diversion work may be required for the existing fibre cable.

Table 5.19.1 Temporary Road Length (by each section)

Section	Unit	Length	Remark
CP 01	m	25,810	one side only
CP 02	m	19,290	one side only
CP 03	m	79,600	one side only
CP 04	m	28,790	one side only

(2) Construction Depot Plan

A construction base is a base having the functions of providing space for the office for the MR and the contractor, rail storage for assembling rail panels, welding work place, temporary storage of ballast and other equipment and materials storage. At least one main base for each construction package is required.

In addition to the main depot, considering the length of this project and that it is far from the main truck road, satellite depots are required each 5 to 10 km in order to make transportation lengths shorter during the construction period. These depots will be set up according to the contractor's plan.

A satellite base is a working yard to be set up for such work as assembling rail panels, stockyard, batching plant and etc. based on the contractor's plan.

The candidates for the main depot and satellite depots are shown in Table 5.19.2

Basically, these depots are to be set up within the MR station area the same as in Phase 1, however further consultation with MR is necessary in the future

Table 5.19.2 Candidates for the of Main depot & Satellite depots

CP	NO	STATION NAME	KILOPOST	Main Depo Candidate	Sub Depo Candidate	CP	NO	STATION NAME	KILOPOST	Main Depo Candidate	Sub Depo Candidate
01	38	TAUNGOO	267.15	○	○	03	68	SHWEDA	454		
	39	KYEDAW	276.5				69	PYAWBWE	462.5	○	○
	40	KYUNGON	282.5		○		70	SHANYWA	471		
	41	KAYTUMADI	290.5				71	NYAUNGYAN	481		○
	42	YEDASHE	295		○		72	NWATO	486		
	43	KONGYI	301.5				73	THAZI	492.5	○	○
	44	SWA	308.5	○	○		74	YWAPALE	499.5		
	45	THARGAYA	314.5				75	HANZA	507.5		○
	46	THARYARGON	318.5				76	DAHATTAW	512		
	47	MYOHLA	324		○		77	THEDAW	517		○
	48	YENI	332.5				78	KHINBAN	523.5		
	49	TAWUTI	338				79	SAMON	530		○
	50	HTEININN	344.5		○		80	ODOKKON	534.5		
	51	ELA	349				81	THABYETAUNG	541		
	52	PYAYWUN	353.5		○		82	KUME LAN	549.5		○
	53	PYINMANA	362			04	83	MYITTHAR	558.5		○
	54	YWADAW	370		○		84	MINZU	567		
02	55	NAYPYITAW	370	○			85	KYAUKSE	578		○
	56	KYIDAUNGKAN	378.5				86	BELIN	585		
	57	PYOKKWE	387				87	SINGAING	594		○
	58	SINBYUGYUN	392		○		88	PALEIK	602		
	59	SHWEMYO	397				89	MYITNGE	607		
	60	SINTHE	404				90	TAGUNDAING	611.5		○
	61	TATKON	407.5		○		91	MYOHAUNG	616	○	
	62	MAGYIBIN	414				92	SHANZU	617.5		
	63	NYAUNGLUN	420.5		○		93	MANDALAY	620.5		○
	64	HNGETTHAIK	431		○						
	65	INGON	435.5								
	66	YAMETHIN (YMA)	441.5	○	○						
	67	INGYINKAN	448								

(3) Material Transportation Plan

The Material Transportation Plan is for transporting necessary materials to each site. Materials include both materials to be supplied by MR and those to be procured and transported by the contractor.

Materials transportation relating to track works such as ballast, PC sleepers, etc. is under the same conditions as phase 1, but other materials such as concrete, structural steel, rebar, formwork and etc. relating to civil works will be transported by dump truck and trailer using the temporary roads basically.

Vehicle which can run on both the railway and roads will be utilized for transporting small size material or low quantities of material.

These basic construction plans will be studied and examined further after detail design and detail survey has been carried out.

5.19.6 Safety Management Plan

The project is a Railway Improvement Project, which means there will be many works within the railway track ROW while it is under commercial operation. Therefore, prevention of train accidents is the most important safety control item.

The JICA Study Team prepared the Guideline for a Safe Work Management Plan for a Contractor based on "The Guidance for the Management of Safety for Construction Works in Japanese ODA Projects" (September 2014, Japan International Cooperation Agency (JICA) and it makes many references to the Guidance. However, the Guideline emphasizes Prevention of Train Accidents for the reason above mentioned. Furthermore, pay attention to prevention of third party accidents by installing safety fences to prevent the residents along the rail way from invading the construction site because under the existing conditions the residents can freely enter into the rail way area.

5.19.7 Traffic Control Plan

Major policy is shown below.

- "Safety First" is the most important principle.
- Minimizing negative impacts of construction traffic on the general traffic.
- Minimizing negative impacts of construction traffic on the environment along the trunk roads and access roads.

And also, traffic control planning policy measures are shown below.

- Construction vehicles run on trunk roads mainly. Signboards should be used for the attention of the drivers.
- Providing a vehicle wash at the gate of the site depot is important for cleaning mud from the construction vehicles that was picked up in the construction yards/ sites so that it will not pollute the public road. The contractor should propose the pavement specification and operation for decreasing the dust on the access roads.
- It is preferable to drive slowly alongside of schools and hospitals, to decrease the traffic at the time students travel to/ from school.