Republic of the Union of Myanmar

Myanma Railways, Ministry of Rail Transportation

PROJECT ON IMPROVEMENT OF SERVICE AND SAFETY OF RAILWAY IN MYANMAR

PROJECT PROGRESS REPORT

(4th Joint Coordinating Committee)

September 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD
ORIENTAL CONSULTANTS CO., LTD
SUMITOMO CORPORATION

Project on Improvement of Service and Safety of Railway in Myanmar

Progress Report, September 2014

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1. Preface

Since we started the Project in June 2014, about 16 months have passed and the Project has been implemented effectively under the close cooperation between MR officials concerned and JICA Expert Team.

We, JICA Expert Team, would like to express our sincere appreciation to MR officials concerned for their kindness extended to us during the execution of the Project.

This Progress Report deals with the major activities of the Project implemented around between May and September of this year.

We should be grateful, if MR senior officials concerned review the Report and provide us with the various advices so that the Project will be implemented more fruitfully in the coming period.

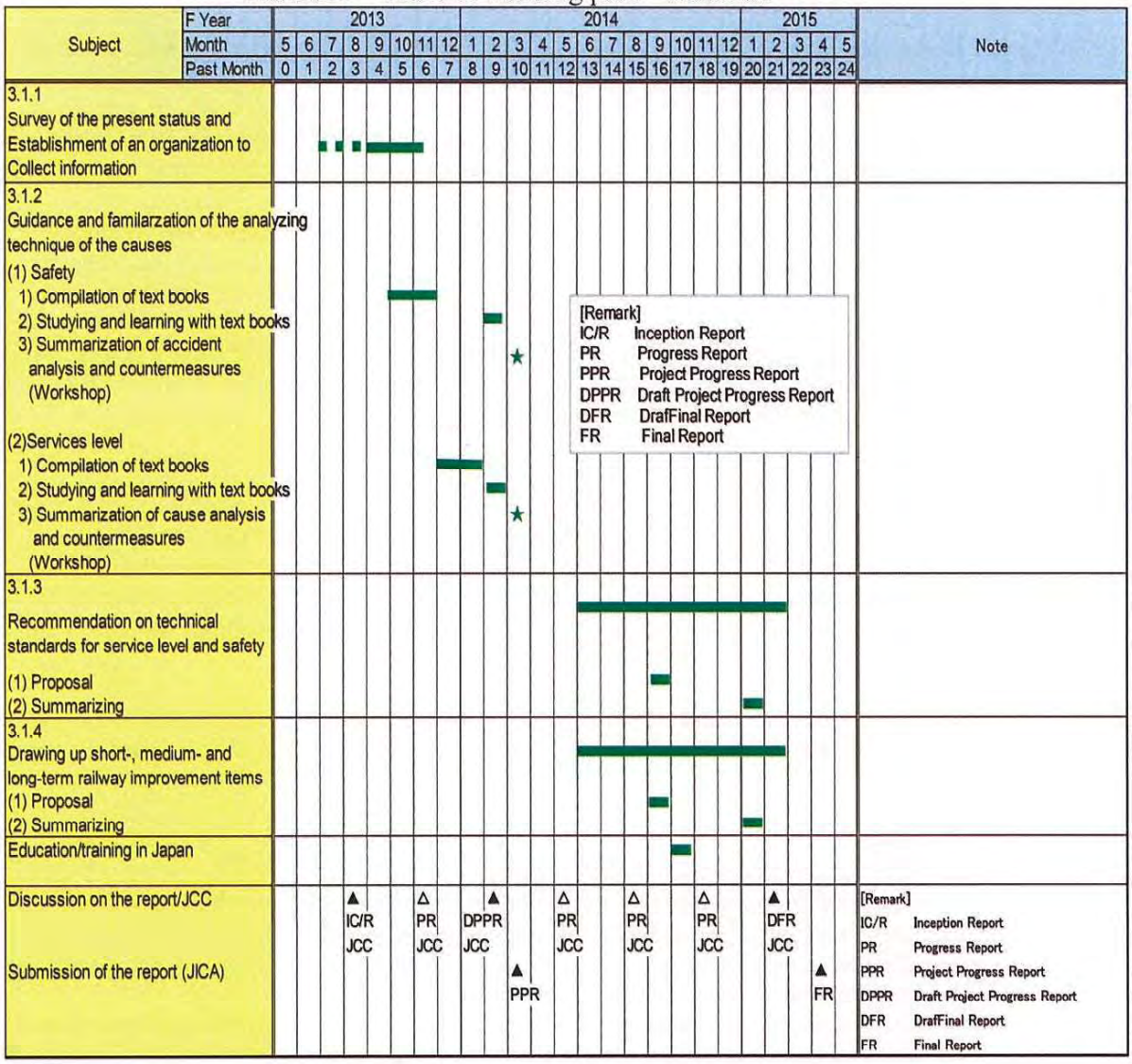
2 Major progress of the Project

2.1 Recommendation of technical standard relating to administrative and maintenance aspect and drawing up railway facilities improvement plan to improve service and safety level

2.1.1 Preparation of a working plan

The Project is progressing as scheduled in Table 2.1.

Table 2.1 Table of working plan schedule



2.1.2 Survey of the present status and establishment of organization to collect information

The present situation of safety and service level of MR was reported in the Appendix 8-1 of the Progress Report, Feb. 2014, and the organization to collect information was established as the Counterpart Team as shown in Table 4.1 of the Progress Report, Feb., 2014.

2.1.3 Guidance and familiarization of the technique to analyze the present status and causes of accident aud poor service

(1) Training program of cause analysis of accidents/ low service level and establishment of couutermeasures

Training program, of which purpose is to guide MR staff and to make them be familiarized about the technique to analyze the cause of accident and low service level, and establishment of countermeasures, was held from Feb. 10 to Feb. 28 jointly by the MR and JICA in the meeting room of MR Headquarters.

19 experts (originally 20, but one expert was absent) of manager level (Track maintenance, Civil works, Signaling, Rolling stocks and Train Operation) of Divisions or Head office of MR participated in the training program.

The whole training program consists of there parts. The first part is class room lecture of the text book prepared by JICA experts. The second one is workshop. The third one is training of vibration measurement of rolling stock.

Further it should be mentioned that interview survey to investigate the customer's satisfaction level of MR's passenger transport was conducted following the training program.

Class room lecture of the text book was held form Feb.11 to Feb. 21 between 9:00 – 12:00 in the morning. Workshop was held from Feb. 11 to Feb.26, mainly between 14:00 – 16:00 in the afternoon. Training of rolling stock vibration measurement was implemented from Feb. 27 to Feb. 28.

(2) Class room lecture of text book

JICA experts explained, based on the text book, about the past accidents and countermeasures in the world mainly in Japan (for examples, derailment, train collision, level crossing, natural disaster and so on), and introduced the measures for improvement of the service level (for examples, increasing train speed, punctuality, riding comfort abilities, train protections and so on).

There were various discussions between JICA lecturers and MR participants. Major advices to MR by JICA experts based on the discussion are summarized in the Progress Report submitted to 3rd JCC held in May, 2014.

(3) Workshops

1) Items selected for presentation by MR experts

The purpose of the workshop is to make MR experts be familiarized with analysis of causes of accidents and low service levels and establishment of countermeasures through making MR staff themselves analyze the causes of actual accidents or low service levels of MR and making themselves establish suitable countermeasures.

In this regard, 25 items relating to accidents and low service levels (train delay and speed restrictions) were selected from the actual MR's events in 2012/ 2013, and MR experts by themselves tried to analyze the causes and to establish the appropriate countermeasures. The 25 items selected are given in Table 2-3.

2) Discussion between MR experts and JICA experts on presentation by MR experts
For each presentation of MR experts, JICA experts made comments on method of cause analysis and establishment of countermeasures presented by MR experts. JICA experts also presented advices to MR regarding major issues identified through discussion in the workshop.
These comments and advices were prepared for each of all presentations which are classified according to kinds of items for presentation.
Summary and details of them are given in Appendix 2-1of Progress Report, May 2014.

(4) Comments of training program by MR participants

In order to find out the major response of MR experts to the Training Program (the lectures by JICA experts and Workshop), the following four questions were asked to each MR participant.

Question 1 According to your opinion, what information/ matters/ Japanese examples were especially useful for improvement of safety and service level of MR?

Question 2 Are there any other information/ matters/ Japanese experiences you would like to know more?

Question 3 Do you think the way/ method by which JICA expert team organized the workshop was satisfactory to you?

Question 4 Do you have any advice how to improve the way/ method of workshop?

The answers to each question by MR participants are shown in Table2.4 of the Progress Report, May 2014.

(5)Training for measurement of train vibration

In order to make MR experts familiarize how to apply the vibration measurement of train to control of track maintenance and improvement of vehicle performance, JICA experts instructed measurement and analysis of actual Train Vibrations on Feb. 27, and 28th. Trainings were implemented by using the device [Digital Vibration Measurement Device W0031]. Trainings included 1) how to use the device to measure the vibration and how to analyses the measured data, 2) measurement of actual MR's express train, and 3) analysis of the measured data.

The details of the training of measurement of train vibration are presented in [Vibration Measurement Report] included as a part of the Progress Report, May 2014.

(6) Investigation of Customer's Satisfaction Level of MR passenger transport

In order to investigation customer's satisfaction level of MR passenger transport, interview survey was conducted on March 4 to 7 2014, between Yangon Station and Nay Pyi Taw Station on Yangon-Mandalay Trunk Line.

Myanmar Railway passengers were targeted excluding foreign travelers, and they are interviewed on the running trains. In case of a group trip, only one passenger of the group was interviewed.

3 kinds of train and class, "Express Upper", "Express Ordinary" and "Local", were targeted and at least 120 passengers were sampled for each train kind/class.

For interviewing, a questionnaire consisting of 20 questions was prepared.

Subjective Evaluation items (Q1~16) are scored and the difference of evaluation by Train kind and passenger class was analyzed The survey items (Q17~20) are for investigating the fundamental properties of passengers such as gender, age, purpose of travel and occupation.

The boarding sections of passengers are plotted on the graph for each train.

The details of the interview survey and the result of the analysis of the answers to the questionnaire are summarized in the Progress Report, May 2014.

2.1.4 Recommendation on technical standards relating to administrative and maintenance aspect to improve the service level and safety

2.1.4.1 Introduction

The training program and workshop for familiarization of cause analysis of accidents and low service level and to conduct these cause analysis and establish counter measures together with MR experts were held from Feb. 10 to 28 at Nay Pyi Taw. In this training program and workshop, major technical standards of MR relating to safety and service level in the field of track, rolling stock, signal/telecommunication, train operation and structure, were discussed between MR experts and JICA experts. Taking this opportunity, JICA Experts collected the relevant major technical standards relating to safety and service level in the respective engineering fields.

JICA Expert Team made reviews on these collected technical standards and proposed recommendations on these technical standards as shown in Appendix2-1[Report of Proposals of Recommendation on Technical Standards of MR and Short-, Medium-, and Long Term Railway Facilities Plan] (Herein after referred to as "Report of Proposals"). The recommendations are not only on the improvement of the existing technical standards, but also are made on new technical standards which MR should consider in view of the future development of MR.

2.1.4-2 Some Major Technical Standards Having Been Reviewed by JICA Experts

They are listed in the Following Table.

List of Technical Standards/ Regulations Reviewed by JICA Experts

	A-Rolling Stock		
1	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule	11	
2	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Elecgrical)	17	
3	Examinatin and repair of C & W stock	16	
4	Technical Specifications for 1200 Horse Power Diesel Hydraulic Locomotive	11	
5	Technical Specifications for Meter Gauge 1200/2000 Horse Power for Hillsection Diesel Electric Locomotives for Plain Section	11	
6	Technical Specirications for Meter Gauge 2000 Horse Power Diesel Electric Locomotives	12	
7	Technical Specifications for In-Service Diesel Elctric Locomotives	6	
8	Technical Specifications for YDM4 Class Locomotive (1000mm Gauge)	13	
9	Technical Specifications for Meter Gauge 2000HP Diesel Electric Locomotives	10	
10	General Technical Specifications for Meter Gauge Bogie Passenger Coaches	21	
11	General Technical Specifications for Meter Gauge Bogie Freight Wagons	12	
12	General Technical Specification for Design, Supply and Domestic Manufacturing of Meter Gauge Bogie	12	
13	General Technical Specifications for Meter Gauge Bogie Passenger Coache Type BDTEZ	6	
14	Technical Specifications for Meter Gauge Bogie Ballasted Hopper Wagons	8	
15	Paticular Technical Specification for Meter Gauge Four-Axle Bogie Welll Wagon for Container	3	
16	Technical Specification for Meter Gauge Bogie Day Upper Class Passenger Coarch	1	
17	Technical Specification for Meter Gauge Bogie Covered Wagon Type - GBHV	1	
18	Technical Specification for Meter Gauge Bogie Sugercane Cum Material Wagon Type - SMBV	1	
19	Technical Specification for Meter Gauge Bogie Material Wagon Type - MBHV	1	
	B.–Track		
1	Manual of the Engineering Department Chapter IV Permanent Way I (material,tool,theory)		
2	Manual of the Engineering Department Chapter V Permanent Way II(construction, and maintenance)		
3	Track Specification		
4	Manual of the Engineering Department Chapter XXII Technical Appendices		
5	Manual of the Engineering Department Chapter IX Miscellaneous		
	C--Structures,Building,Ststion Machinery,Safety Precaution		
1	Manual of the Engineering Department Chapter XII Safety Precaution		
2	Manual of the Engineering Department Chapter VI Bridges		
3	Manual of the Engineering Department Chapter III Formation		
	D-Signalling and Telecommunications		
1	TRAIN SIGNALLING INSTRUCTIONS for the Double and Single Lines by Electric Block Instrumentsand by Telegraph or Telephone	73	
2	Manual of the Engineering Department-Chapter VIII-Signal andTele-communication No.1	67	
3	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules		
	E--Train Operation		
	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules		
1	Chapter 1 Preliminary		
2	Chapter II Signals		
3	Chapte III working of Trains General		
4	Chapter IV Accidents		
5	Chapter XIII The Following Trains System		

2.1.4-3 Items of the major recommendations/comments on technical Standards.

The details of the recommendations/comments are presented in the Appendix 2-1, [Report of Proposals].

However, items or the essences of the recommendations/comments on the reviewed Technical Standards are listed as shown below.

(1) Track

(a) Manuals of the Engineering Department (DEM) Chapter Ⅳ Permanent Way Ⅰ (Materials, Tools, and Theory)

① Adoption of L type wooden bridge sleeper fastening

② Adoption of improved turnout for speed up

③ Including PC sleepers and their rail fastening in the Technical Standards

④ Adoption of supported joint with use of large size sleeper
⑤ Execution of insizing on semi-durable sleepers before creosoting
⑥ Improvement of ballast specification with respect to grading, and physical properties.
⑦ Adoption of opposite joints in curve section in case of rather large radius.
⑧ Specification of maximum cant deficiency
⑨ Determination of transition curve length with consideration not only on allowable limit of temporal change of cant, but also on prevention of derailment due to 3 point support, and allowable limit of temporal change of cant deficiency.
⑩ Adoption of derailment prevention guard in the section where derailment is apt to occur

(b) MED, Permanent Way Ⅱ (Construction and Maintenance)
① Measurement of track irregularities in the inspection and periodical measurement
② Frequency of track inspection according to the importance of the lines
③ Inspection of rail by ultrasonic rail flow defection equipment
④ Effective utilization Of Hallade Track Recorder
⑤ Inspection of points and crossings
⑥ Platform dimension inspection in relation with structure gauge

(c) MED Chapter IX (Miscellaneous)
Chapter IX (Miscellaneous) mainly includes the regulations regarding ①level crossing and gatemen, ②the fences, ③actions to be taken in case of infringements of Standard Structural and Running Dimensions,④ engineering and ballast trains, ⑤assisted siding, ⑥cattles on the railway land.
In view of occurrence of many accidents at level crossings and various issues regarding level crossing such as weak track structure and insufficient maintenance situation of MR, various standards/ regulations of JR were explained in the Report of Proposals so that they could be a good basis, on which technical standards of MR relating to the level crossing could be improved.

The major items explained about technical standards/regulations of JR with respect to level crossings are as follows.

① Basic policy regarding level crossings
② General requirement of level crossings
③ Type of level crossings
④ Pavement of level crossing
⑤ Crossing facilities considering increased railway speed

(d) Track Specification
The document of Track Specification includes three systems of irregularities allowances: System-1 specifying track irregularities allowances from the viewpoint of construction, maintenance and safety according to the lines classified by the maximum train speed, System-2 specifying the track irregularities allowances from the viewpoint of riding comfort, and System-3 consisting of 3 different documents specifying track irregularities for track laying/constructions.

JICA Experts recommended ①Unification of various systems for track irregularities allowance, ②consideration of track irregularities allowances after tack rectification, ③ stipulation of train vibration acceleration allowances from the viewpoint of safety and riding comfort, ④specification of number of days within which track should be rectified in case the

track irregularities exceed the safety allowances, and ⑤stipulation of train speed down in case where track irregularities cannot be rectified within specified days.

(e) Other recommendations/comments in view of the future development of MR
① Various methods for improving low joints
② Several major points to which attention should be paid for installation of long welded rail and their maintenance
③ Several major points to which attention should be paid for using big track machine such as MTT, Flash Butt Welding Machine, Track Measuring Machine etc.

(2) Rolling Stock

Two types of technical standards are required for rolling stock, one is for construction and the other is for maintenance.
For construction, general criteria that will assure the safety and compatibility shall be defined. Particular specification for each type of rolling stock will be prepared based on the criteria.
For maintenance, rank and interval of scheduled maintenance including items to inspect in each rank shall be defined. Also criteria that will assure the normal/safe operation until next regular maintenance shall be defined.
(a) Recommendation on technical standards relating to construction of rolling stock.
It is deemed that for constructing new rolling stock, criteria is stipulated for the requirement of rolling stock type but no general rule exists in MR.
General criteria for rolling stock construction shall be stipulated and specification of each type of rolling stock shall comply with the general criteria.
The following are some recommendation items on general criteria to be stipulated for rolling stock construction.

① Load gauge and widening of load gauge on the curve section
② Sufficiently strong running gear ensuring safe and stable running of rolling stock
③ Suitable arrangement of axles of rolling stock
④ Appropriate performance of internal – combustion engine to prevent generation of extreme heat, fuel leakage, hazard for passengers by the heat and exhausted gas etc.
⑤ Stipulation of maximum axle load
⑥ Stipulation of effective breaking system such as air brake, continues through brake, an independent braking function.
⑦ Appropriate structure of passenger cabin relating to window, lightening of room, toilets
⑧ Appropriate automatic control device of passenger door
⑨ Appropriate coupling device
⑩ Fire prevention of rolling stock

(b) Recommendation on technical standards relating to maintenance of rolling stock
① Locomotive
Inspections for the rank M1-M5 are stipulated, but those for the rank M6 to M8 are not clear, should be stipulated. Different pressure gauge is used depending on the type of the locomotive. Standardization of pressure gauge is recommended.
② Coach and Wagon
Manuals are out of date, and very simple. They should be updated and more detailed.
Further the following items should be stipulated.
a. Electrical equipments other than battery and lighting system
b. Solid type wheel
c. Air suspension bogie
d. Rolling bearing
e. Air brake system

③ DMU
Maintenance manuals of DMU should be prepared.

④ General
The following items should be stipulated in the maintenance manuals
- dimension of the wheel
- difference of the wheel diamater
- air leakage of brake system
- insulation of electrical circuit

(3)Signal/Telecommunication

① Establishment of unified technical standards for newly introduced equipments.
For newly introduced equipments, there are not established any unified technical standards, accordingly equipments of different technical standards are installed at stations, resulting in undesirable conditions from the viewpoint of maintenance to ensure safe and reliable train operation.
Unified technical standards should be established for each kind of equipment for ensuring safe and reliable train operation.

② Maintenance standards
MR has adopted preventive maintenance system for some of their equipments.
Maintenance standards should be established urgently for the newly introduced equipments, so as to execute appropriate maintenance.
Especially unified technical standards and maintenance standards should be established for equipments to be introduced newly such as optical fibre, electronic interlocking system, level crossing alarm system, automatic train protection system, and also for equipments which are already introduced, but are to be increased further, such as electric point machine, track circuit etc.

(4)Train Operation

① Chapter 2 Signals
- How to put back the signal to "ON", after the signal has been taken "OFF"
- Conditions to which a train can enter or advance to the station
- Personnel assignment to the points at non-interlocking stations
- Supervision method of the signal person in charge by the stationmaster
- Inspection of points by the guards of the halting trains, and the responsibility

② Chapter 3 Working Of Trains Generally
- Set method of the clock of the guard and the driver
- Notes when removing the flags or the lamps placed in the case of the work of the carriage circumference

③ Chapter 4 Accidents
- First priority at the time of the accident outbreak
- Measures at the time of the fire outbreak

④ Matters not prescribed in the existing rules
- Safety norms and the management of quality of railway employees
- Restriction of train operation at disaster
- Safety precaution in the case of connecting other trains with a trouble train

(5)Structures

·The present status of structures and economic scale in Myanmar are similar to the one of

1963-1970 in Japan.

・In Japan, around 1963-1970, railway facilities had changed their maintenance method, from corrective maintenance to preventive one, hence, the number of disaster threatened railway facilities has been decreasing.

・It is quite effective for Myanma Railways to refer to the Japanese maintenance method, and in addition patrolling against disaster.

①Bridges (Manual of the Engineering Department ChapterⅥ)

・We recommended the proper maintenance execution to keep bridges in good soundness.

・In actual Standard of MR:

・The required performance of bridges are not specified.

・Maintenance for bridge except steel structures are not specified .

・Actual procedures for inspection, of the structures such as those to be inspected carefully and so on are insufficient.

・Details of countermeasures are insufficiency.

・We recommended as follows from Japanese standard "Maintenance Standards for Railway Structures and Commentary, RAILWAY TECHNICAL RESEARCH INSTITUTE"

・Detail of required performance for bridges; safety, serviceability and restorability

・The maintenance for concrete bridges; foundation/ retaining structure

・The categories for proper maintenance, such as Initial inspection, General ordinary/ special inspection, individual inspection, extraordinary inspection

・The details of respective inspections, their timings, survey methods, judgment of soundness and countermeasures are insufficient.

② Formations (Manual of the Engineering Department ChapterⅢ)

・We recommended the proper maintenance execution to keep adequate formation structure in good soundness.

・In actual standard of MR:

・Slope protection work should be provided only in the area where the annual rainfall exceeds 100".

・ Allowance for shrinkage are prescribed according to the annual rainfall.

・ It is described that, regarding the angle of cutting slope , it would be able to be vertical if it is good rock.

・ Description for maintenance of formations are insufficiency.

・We recommended as follows from Japanese standard "Maintenance/Design (Earth Structure)s Standards for Railway Structures and Commentary, RAILWAY TECHNICAL RESEARCH INSTITUTE"

・ Every slope should be provided with some protection works, because erosions are easy to occur on slope surfaces by rain

・ Allowance for shrinkage should be confirmed by consolidation test and by calculated settlement about bearing ground of embankment.

・ Concept of "performance level" of formation ,so to speak, the order of priority of line. And even it is lowest performance level with good rock, its angle of slope is at least, 1:0.3. for the consideration of rock weathering.

・ The details of formation maintenance, such as inspection categories, timings, survey methods, judgment of soundness and countermeasures should be specified.

③Safety precautions (Manual of the Engineering Department ChapterⅫ)

・We recommended in the purpose of efficient train operation control in the case of disasters to

improve the service and safety level of Myanma Railways

・The actual standard of MR is almost sufficient for reopening train operation safely, if all described actions are strictly taken by relevant authorities. Especially, followings are quite essential article for preventing disaster that we'd like to emphasize.

§Article1256: The object of such investigation is to ascertain the cause of the accident in order that suitable action may then be taken to endeavor to prevent the recurrence of any similar accident in the future.

§Article1257: Every railway servant present at an accident must therefore do his best to foster such spirit of cooperation in the interests of the speedy completion of the restoration.

・But some judgments are almost made personally, and no clear standard criteria are existing, so it would take a longer time for the train operation control.

・For reopening train operation safely, also more rapidly, we recommended "the example of guarding and standard value for train operation control about rainfall and strong wind" from Japanese Ministerial Ordinance.

2.1.5 Drawing up of short-, medium-, and long-term railway facilities improvement plan

(1) Introduction

The principles for drawing up short-, medium-, and long-term railway facilities improvement plan

In drawing up short-, medium-, and long-term railway facilities improvement plan (hereinafter referred to as RFIP) from the viewpoint of upgrading safety and service of MR, the following principles are adopted,

① RFIP focuses on the rehabilitation and modernization of the existing lines.
② Railway facilities plan relating to new line construction and improvement of international transport will be excluded.
③ RFIP will focus on improvement of facilities relating to upgrading safety and service, but exclude the improvement of facilities relating to economic development of the area along the lines, railway business expansion, or revenue increase such as development of ICD, freight yard, connection to sea ports.
④ The railway projects proposed by Myanmar Development Cooperation Forum which took place on Jan.19 and 20, 2013 will be duly taken into consideration.
⑤ "Survey Program for National Transport Development Plan in the Republic of the Union of the Myanmar" prepared by JICA (June 2014) will be duly taken into consideration.

(2) Proposal of short-, medium-, and long-term railway facilities improvement plan

① Introduction

In drawing up RFIP, the principles described in (1) introduction have been duly taken into consideration. Further the following preconditions or policies have been assumed.

(a) In MR railway network, Yangon – Mandalay line and Yangon Transit System (Circular line + Danyingon ~ Hlawga+ Mahlwagon ~ Ywathagyi + Thilawa line) have been defined as "Most Important Lines".
(b) Mandalay – Myitkyna line, Yangon – Pyay line, Yangon-Pathein line and Yangon – Dawei line have been defined as "the Next Important Lines".
(c) All other lines have been defined as "Other Lines".
(d) As indicated in the Inception Report,

Short term corresponds to	2015 – 2018
Medium term corresponds to	2018 – 2025
Long term corresponds to	2025 – 2045

②Short-, medium-, and long-term railway facilities improvement plan

Details of improvement plans are explained in Appendix 2-1. Just as an example of improvement Plan, the track case is explained here.

Track case Example

The basic strategy in drawing up RFIP in the field of track is as follows.

(a) Improvement of the urgent places of Most Important Lines and Next Important Lines shall be completed as a short- term plan to ensure safe train operation urgently.
(b) With respect to improvement of the Most Important Lines, the Next Important Lines, and the Other Lines, the items (1) – (7) will be improved according to the schedule shown in Table Ⅱ-2.2-1.
    (i) Regarding the items (1) & (2)
        - They will be implemented as a medium term plan for the Most Important Lines.
        - They will be implemented as a, med/ long term plan (up to 2030-2035) for the Next Important Lines.
        - They will be implemented as a long term plan for the Other Lines.

(ii) Regarding the items (3) – (7).

These items perform their functions covering not a single line, but various lines. As such,

- the functions are to be displayed as a medium term plan for the Most Important Line
- the functions are to be displayed as a med/ long term plan (up to 2030-2035) for the Next Important Line.
- the functions are to be displayed as a long term plan for the Other Lines

Table-Ⅱ-2, 2-1 Short-, Medium-, and Long Term Railway Facilities Improvement Plan
(for levelling up Safety and Service Level) -Track-

Facilities to be improved	2015 Short term	2018 Medium term	2025	2030	2035 Long term	2045
1.Urgent improvement of the Most and Next Important Lines (Y-M Line, Y Transit System) (M-Myitkyna, Y-Pyay, Y-Pathein, Y-Dawei)						
(1)Improvement of urgent places	Most Important Lines					
・replacement of old aged rails	Y-M					
・improvement of joints and rail welding	Y Transit System →					
・replacement of damaged turn out						
・replacement of damaged PC sleeper, replacement of wooden sleeper by PC sleepers	Next Important Lines					
・supply of ballast	M-Myitkyna					
・urgent improvement of important level crossings	Y-Pyay					
・track irregularity rectification	Y-Pathein					
(2)procurement of small/medium type track maintenance machine/tool	Y-Dawei					
(3)procurement of track inspection equipment						
2. Improvement of the Most Important Lines, Next Important Lines and Other Lines		Most Important Lines				
(1)Improvement of track structure		Y-M				
・increase the unit weight of rail appropriately		Y,C,L →				
・producting long welded rail						
・replacement of existing turnout to appropriate advanced turnout			Next Important Lines M-Myitkyina Y-Pyay Y-Pathein Y-Dawei			
・increase of sleepers per km appropriately, and promote laying of PC sleepers						
・supplement of ballast, increase the depth of ballast			→	→	Other Lines	
・improvement of level crossing track structures						
・track irregularity rectification					→	
・constructuin of track posts						
(2) procurement of large track maintenance machines (MTT, BR, BHC etc) and construction of the depots						
(3)Usage of high speed track inspection car		to cope with the needs of the Most Important Lines (Y-M, Y,C,L)	to cope with the needs of the Next Important Lines		to cope with the needs of the Other Lines	
(4)Improvement of ballast production factory and expansion of its production capacity		→	→	→	→	
(5)Construction of rail welting depot						
(6)Improvement of turnout factory and expansion of its production capacity						
(7)Improvement of PC sleeper factory and expansion of its production capacity						

2.1.6 Education/ training in Japan

Schedule of training in Japan was proposed by JICA Expert Team to MR in August, 2014, which MR received and agreed with on the condition that Railway Museum is desirable to be included.

As the result, the following schedule of training in Japan was finalized as shown in Table 2.2 For the 11 participants as shown in Table 2.3 were nominated by MR.

Now the preparation for implementing the training in Japan is under way.

Table2.2 Schedule of Training in Japan (Institutional Management Improvement Course)

No.	Date	Time			Lecture/ Visit	Content	Lecturer	Location of Training	Stay at
1	Oct. 19 (Sun)	6:50	~			arrival at Narita			JICA Tokyo
2	Oct. 20 (Mon.)	9:00	~	14:00	Lecture	Program Orientation	JIC/JICA	JICA Tokyo	JICA Tokyo
		14:00	~	15:30	Lecture	Outline of Railway Transport in Japan	MLIT	JICA Tokyo	
		15:30	~	17:00	Lecture	Outline of JR East	JIC	JICA Tokyo	
3	Oct. 21 (Tue)	9:30	~	10:00	Lecture	Orientation	JIC	JICA Tokyo	JICA Tokyo
		10:00	~	12:00	Lecure	Outline of railway development in Japan	JIC	JICA Tokyo	
		13:00	~	15:00	Lecure	Management & technorogy of JRE to ensure safe railway transport	JIC	JICA Tokyo	
		15:00	~	17:00	Lecture	Management and technology of JRE to ensure comfortable/ convenient railway transport	JIC	JICA Tokyo	
4	Oct. 22 (Wed)	7:30	~	10:00	trip	Tokyo – Shinshirakawa – Training Center			JICA Tokyo
		10:00	~	11:30	Lecture	Outline of staff training of JRE	JEPS	JRE Training Center	
		11:30	~	12:00	Visit	Museam of railway accident	JEPS	JRE Training Center	
		12:00	~	15:00	trip	Shinshirakawa-Tokyo			
		15:00	~	17:00	Visit	Tokyo monorail	Tokyo monorail	Hamamatsu-cho	
		17:00	~	18:00	Trip				
5	Oct. 23 (Thur)	9:00	~	10:00	trip	(Tokyo – Keiyo Line)			JICA Tokyo
		10:00	~	14:00	Visit	High speed Track Inspection Car (East-i)	JRE, NSG	Keiyo Line	
		14:00	~	15:00	trip	Tokyo- Omiya			
		13:00	~	16:00	Visit	Railway museum	JIC	Omiya	
		16:00	~	17:00	trip				
6	Oct. 24 (Fri)	8:30	~	9:30	Trip	Tokyo – Kunitachi			JICA Tokyo
		9:30	~	12:00	Visit	Railway Technical Researchi Institute RTRI	RTRI	Kunitachi	
		12:00	~	13:30	trip	Kunitachi – Tokyo freight terminal			
		13:30	~	17:00	Visit	Tokyo Freight terminal	JRF	Shinagawa	
		17:00	~	18:00	trip				
7	Oct. 25 (Sat)				Holiday	Free			JICA Tokyo
8	Oct.26 (Sun)				Holiday	Free			JICA Tokyo
		14:30	~	19:30	trip				
9	Oct. 27 (Mon)	7:00	~	12:00		Free			Akita
		13:00	~	14:00	Lecture	Outline of Akita Branch Office	JRE	Akita Branch office	
		14:00	~	15:30	Vist	Akita General Training Center (AGTC)	JRE	AGTC	
		15:30	~	17:30	Visit	Riding train on Oga line	JIC	Akita Branch office	
10	Oct. 28 (Tue)	9:30	~	12:30	Visit	Akit aGeneral Rolling Stock Center (AGRSC)	JRE	AGRSC	Akita
		13:30	~	15:00	Vist	Akita rolling Stock Center (ARSC)	JRE	ARSC	
		15:00	~	16:30	Vist	Train Control Center	JRE	Akita Branch office	
		16:30	~	17:00	Lecture	follow-up orientation	JIC	AGTC	
11	Oct. 29 (Wed)	9:30	~	11:00	Visit	Akita Track maintenance Technical Center (ATMTC)	JRE	ATMTC	Akita
		12:30	~	13:00	Trip	Akita – Oga Line			
		13:00	~	15:00	Visit	Oga line	JRE/JIC	Oga Line	
		15:00	~	18:00	Lecture	Natural Disaster Prevention system	JIC	Oiwake Traing Center	
12	Oct. 30 (Thur)	9:00	~	10:00	Lecture	Akit Station in General	JRE	Akita Station	JICA Tokyo
		10:00	~	12:00	Visit	Various Station Facilities	JRE	Akita Station	
		13:00	~	14:00	Visit	Non-Railway Business Station Plaza etc.	JRE	Akita Station	
		14:00	~	18:00	trip	Akita – Tokyo			
13	Oct. 31 (Fri)	9:30	~	11:00	Lecrue	Question and Answers	JIC	JICA Tokyo	JICA Tokyo
		11:00	~	17:00	Presentation and Wrap up	Opinion/ comments on Trainonig Program by MR trainees, Wrap up meeting	JIC/JICA		
14	Nov. 1 (Sat)	11:00				Leave Narita			

JEPS = JR East Personnel Service, RTRI = Railway Technical Research Institute

Table 2.3 The List of Trainees for the Course of Railway

No	Name	Rank	Age
1	U Win Naing	Deputy General Manager (Carriage)	51
2	U Htay Myint Aung	Deputy General Manager (Operation)	58
3	Daw Kyi Kyi Nwe	Assistant General Manager (Finance)	52
4	U Lwan Thu	Executive Engineer (Civil)	52
5	U Maung Maung Tin	Manager (Supply)	52
6	U Aung Chan Myint	Manager (Commercial)	35
7	U Myint Lwin	Executive Engineer (Communication)	50
8	U Aung Wai Soe	Assistant Manager(Inspection)	47
9	Daw Khin May Than	Assistant Manager (plan & News)	50
10	U Nyo Aung	Assistant Engineer (Electric)	40
11	U Aung Myint	Assistant Manager (Planning)	28

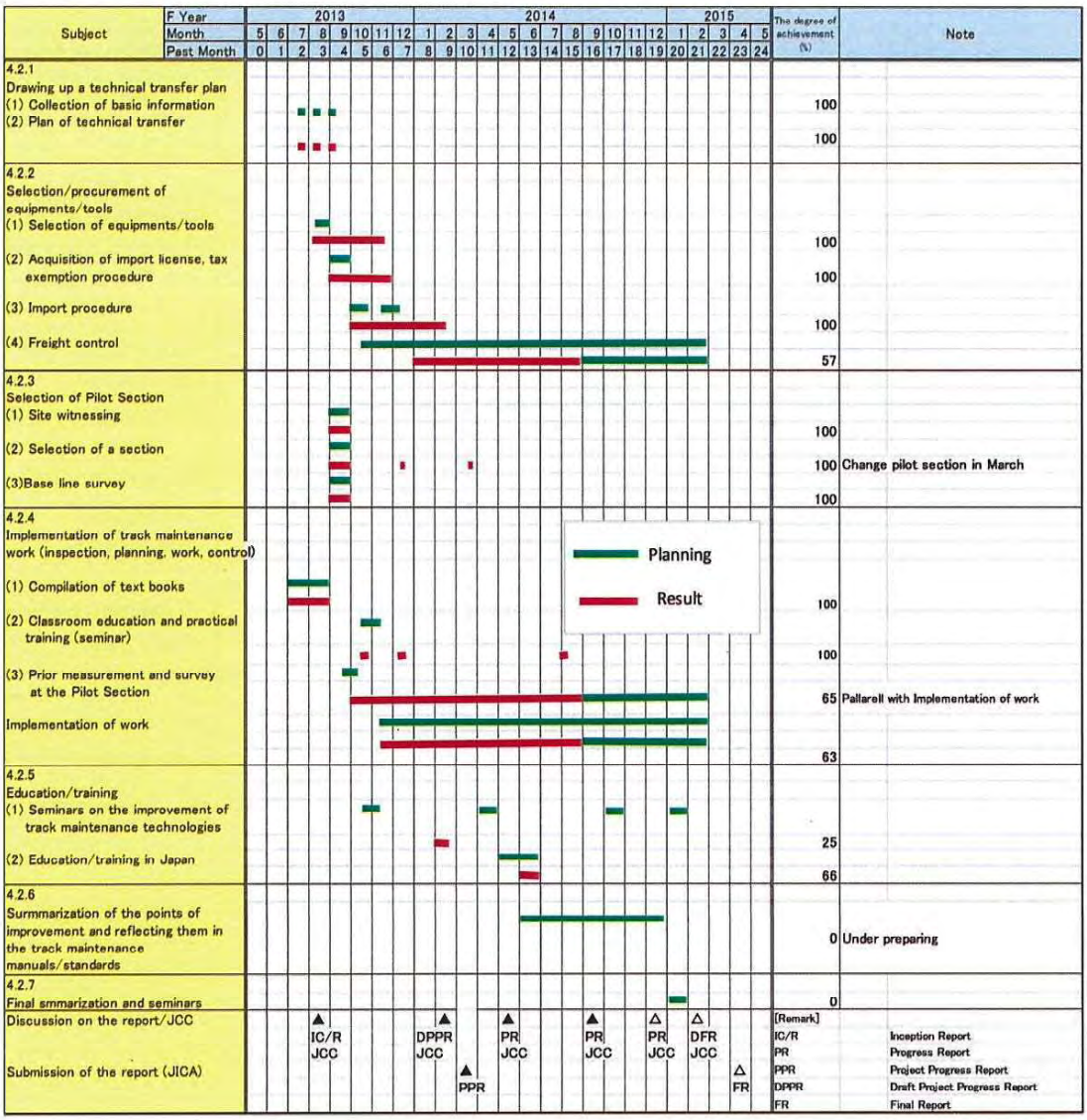
Institutional Management Improvement Course

2.2 Technology Transfer of Track Maintenance Technology to improve the level of Service and Safety through Implementation of The Pilot Project

2.2.1 Schedule of technology transfer (planning and result)

In Myanmar, rainy season starts every year at the end of May. At first, we were planning that curriculums of rainy season were not track maintenance. But MR hoped to continue track maintenance and attend lectures to many MR staffs. So we have continued track maintenance since last May. Schedule of technology transfer shows Table 2.1.

Table 2.1 Schedule of technology transfer (planning and result)



2.2.2 Education/training in Myanmar

Trainees of MR change every month. We show divisions of trainee and members till now (Table 2.2). We have educated 183 trainees who are belonging to all divisions in Myanma Railways.

Table 2.2 Divisions of trainee and members till now

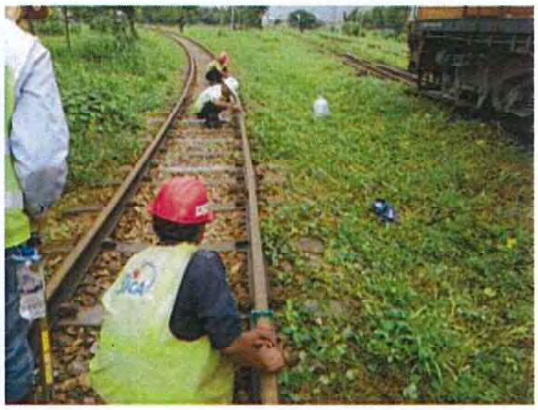
	Date From	Date To	Division	Number	Remark
1	25.10.2013	12.5.2014	(7)Yangon (6)Bago	24 6	
2	12.5.2014	12.6.2014	(7) Yangon (5)Taunggu (7)Yangon (8)Mawlamying (9)Hinthada	10 6 5 4 5	To perform the chainging of trainees
3	12.6.2014	12.7.2014	(7) Yangon (2)Ywataung (3)Mandalay (10)Pakauku	10 8 8 7	To perform the chainging of trainees
4	12.7.2014	12.8.2014	(7) Yangon (1)Myitgyinar (4)Kalaw (11)Bagan	10 6 7 7	To perform the chainging of trainees
5	12.8.2014	12.9.2014	(7) Yangon (5) Taunggu (8) Mawlamying (9) Hinthada	10 6 6 8	To perform the chainging Of trainees
6	12.9.2014	Until now	(7) Yangon (2) Ywataung (3) Mandalay (6) Bago	10 6 6 8	To perform the chainging Of trainees
Total				183	

We educated 1st group for half year and many kinds of program. From 2nd group, trainees change every month. So we are programing training schedule to master many things about track maintenance for short term.

Minister visited site

Set up scaffolding at bridge

Tamping at turnout



Mcasuring at curvc scction

Measuring at turnout

Under calculation at site

2.2.3 Education/workshop in Japan

We implemented two-week education/workshop program twice in Japan (1st group is from 9th to 20th in June and 2nd group is 23th in June to 4th in July.) each for approximately 11 trainees including some MTT operators, in which education/workshop on track technologies (centering on lectures and practical training) will be performed under the cooperation of JR East and Japan Railway Track Consultants, at the Integrated Education/Training Center (Shin-Shirakawa), JR East. MTT operators are included in the above program to prepare for introduction of MTTs into track maintenance in the future.

We report at appendix-3 in detail

Lecture from Dr. Osanai

Turnout inspection

Investigation of ballast factory

Study on MTT

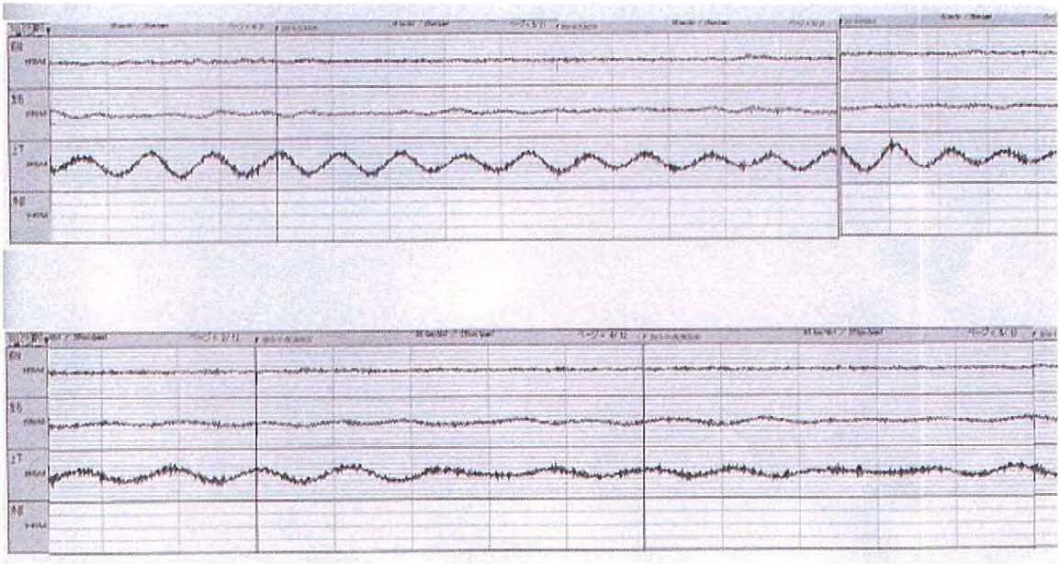
2.2.4 Measuring Vibration

We are checking that track condition has become good by measuring train vibration. At the 3rd JCC, there was a request of continuing the train vibration measurement by the measurement device on Yangon ― Mandalay line. We are thinking support of measuring.

If MR side can prepare a coach, we will support of measuring.

Measuring circumstance

Measuring device on the floor



Example of measuring result
(Up : before track maintenance, Down : After track maintenance)

2.2.5 Summarization of the points of improvement and reflecting them in the track maintenance manuals/standards

We summarize the points of reflection through the whole of maintenance work and compile the maintenance manuals to meet the present status of the track maintenance in Myanmar in consideration of the local organizations, working conditions and climates. The essentials of maintenance manuals will be easy to use, while including the steps of work and handling of machines/materials for track maintenance.

2.2.6 Final summarization and seminars

In closing the above technical transfer course on track maintenance work, we will open seminars for the trainees participated in the program and track maintenance members for other sections selected through consultation with MR. As this is the final step for MR employees to receive technology transfer, which is expected to evolve as a model shop to every section of the country in the future, we will avail ourselves of this opportunity to totally wipe unknowns out of MR members regarding the whole of track maintenance work.

2.2.7 Major issues to be tackled with, good schemes for better implementation, lessons obtained through implementation

To implement the Project more smoothly, some JICA track experts were added to the original JICA experts.

3. Concluding remarks

We have already covered about two thirds of the whole Project, but still have various significant activities to be executed in the coming period.

We would like to continue our activities effectively with the cooperation from MR officials concerned.

Appendix 1

Republic of the Union of Myanmar

Myanma Railways, Ministry of Rail Transportation

Project on Improvement of Service and Safety of Railway in Myanmar

Report of Proposals of Recommendation on Technical Standards of MR and Short-, Medium-, Long-Term Railway Facilities Improvement Plan

September/ October, 2014

JICA Expert Team

Report of Proposals of Recommendation on Technical Standards and Shot-, Medium-, Long-Term Railway Facilities Improvement Plan

Table of Contents

II. Part II Proposal of Short-, Medium-, and Long-Term Railway Facilities Improvement Plan

Preface

As prescribed in the Inception Report, which was agreed upon between MR and JICA Expert Team in the first JCC held on August 28th 2013 at Nay Pyi Taw, JICA Expert Team should make recommendation on technical standards of MR to improve the service and safety, and also draw up shot-, medium-, and long-term railway facilities improvement plan relating to upgrading safety and service level through discussion with the "Working Group for Service and Safety Improvement".

In this context, JICA expert team is presenting the Report of the Proposal of Recommendations on Technical Standards of MR and Short-, Medium-, and Long Term Railway Facilities Improvement Plan here.

Both the proposals should be discussed by the "Working Group for Service and Safety Improvement" of which members were increased as agreed upon between MR and JICA Expert Team by the attached minutes of the meeting held on 13th August 2014 at Nay Pyi Taw.

I Part I Proposal of Recommendations on Technical Standards of MR

1. Introduction

The training program and workshop for familiarization of cause analysis of accidents and low service level and to conduct these cause analysis and establish counter measures together with MR experts were held from Feb. 10 to 28 at Nay Pyi Taw. In this training program and workshop, major technical standards of MR relating to safety and service level in the field of track, rolling stock, signal./ telecommunication, train operation and structure, were discussed between MR experts and JICA experts. Taking this opportunity, JICA Experts collected the relevant major technical standards relating to safety and service level in the respective engineering fields.

JICA Expert Team made reviews on these collected technical standards and proposed recommendations on these technical standards as shown in the following chapters. The recommendations are not only on the improvement of the existing technical standards, but also are made on new technical standards which MR should consider in view of the future development of MR.

2. Some Major Technical Standards Having Been Reviewed by JICA Experts

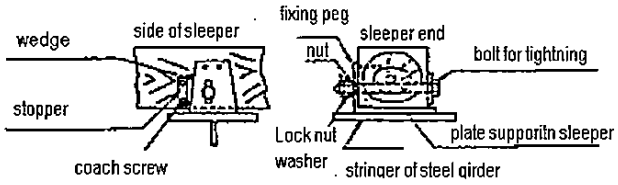
They are listed with the Following Table.

List of Technical Standards/ Regulations Reviewed by JICA Experts

1	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule	11	
2	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Elecgrical)	17	
3	Examinatin and repair of C & W stock	16	
4	Technical Specifications for 1200 Horse Power Diesel Hydraulic Locomotive	11	
5	Technical Specifications for Meter Gauge 1200/2000 Horse Power for Hillsection Diesel Electric Locomotives for Plain Section	11	
6	Technical Specirications for Meter Gauge 2000 Horse Power Diesel Electric Locomotives	12	
7	Technical Specifications for In-Service Diesel Elctric Locomotives	6	
8	Technical Specifications for YDM4 Class Locomotive (1000mm Gauge)	13	
9	Technical Specifications for Meter Gauge 2000HP Diesel Electric Locomotives	10	
10	General Technical Specifications for Meter Gauge Bogie Passenger Coaches	21	
11	General Technical Specifications for Meter Gauge Bogie Freight Wagons	12	
12	General Technical Specification for Design, Supply and Domestic Manufacturing of Meter Gauge Bogie	12	
13	General Technical Specifications for Meter Gauge Bogie Passenger Coache Type BDTEZ	6	
14	Technical Specifications for Meter Gauge Bogie Ballasted Hopper Wagons	8	
15	Paticular Technical Specification for Meter Gauge Four-Axle Bogie Welll Wagon for Container	3	
16	Technical Specification for Meter Gauge Bogie Day Upper Class Passenger Coarch	1	
17	Technical Specification for Meter Gauge Bogie Covered Wagon Type - GBHV	1	
18	Technical Specification for Meter Gauge Bogie Sugercane Cum Material Wagon Type - SMBV	1	
19	Technical Specification for Meter Gauge Bogie Material Wagon Type - MBHV	1	
	B.–Track		
1	Manual of the Engineering Department Chapter IV Permanent Way I (material,tool,theory)		
2	Manual of the Engineering Department Chapter V Permanent Way II(construction, and maintenance)		
3	Track Specification		
4	Manual of the Engineering Department Chapter XXII Technical Appendices		
5	Manual of the Engineering Department Chapter IX Miscellaneous		
	C--Structures,Building,Ststion Machinery,Safety Precaution		
1	Manual of the Engineering Department Chapter XII Safety Precaution		
2	Manual of the Engineering Department Chapter VI Bridges		
3	Manual of the Engineering Department Chapter III Formation		
	D-Signalling and Telecommunications		
1	TRAIN SIGNALLING INSTRUCTIONS for the Double and Single Lines by Electric Block Instrumentsand by Telegraph or Telephone	73	
2	Manual of the Engineering Department-Chapter VIII-Signal andTele-communication No.1	67	
3	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules		
	E--Train Operation		
	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules		
1	Chapter 1 Preliminary		
2	Chapter II Signals		
3	Chapte III working of Trains General		
4	Chapter IV Accidents		
5	Chapter XIII The Following Trains System		

3.1 Track

3.1.1 Major recommendation/ comments on Manuals of the Engineering Department (MED) Chapter IV permanent Way I (Materials, Tools, and Theory)

Title of Standards of MR		Manuals of Engineering Dept. Chapter IV Permanent way I (Materials, tools, Theory)	
No. of item	409	Item	Bridge Fastenings
Recommendation/ Comments by JICA Expert Team			
Fook bolt or L type sleeper fastening device is used in JR for fixing wooden bridge sleepers on the girder of open type steel girders. L type sleeper fasten device is more reliable than the fook bolt, accordingly it is adopted for the long welded rails on the steel bridges. It is recommended that MR should also consider adoption of L type sleeper fastening device.  Fig. 2.6.11 L type sleeper fastening device			
No. of item	411 & 412	Item	Point & Crossing
Recommendation/ Comments by JICA Expert Team			
For speeding up the maximum train speed up to 100km/h on Yangon – Mandalay line, it is necessary to speed up the train speed up to 90 – 100km/h on the straight side of turnout. For this, the turnouts of MR should be improved as explained in the following. Turnout structure has the following disadvantage points compared with the ordinary track structure. (Fig 1.7) 1) Cross section of tongue rail is small. 2) The whole part of the tongue rail cannot be fastened to the sleeper tightly. 3) End joint of the tongue rail is a flexible joint and cannot be fixed firmly. 4) Slack in the point part is small. 5) There is no transition curve between the point part and the lead curve. 6) At the front part of the point part, there is a switching device, which interferes the ballast tamping work 7) Radius of lead curve is small 8) Lead curve does not have sufficient superelevation 9) There is a rail gap at the crossing part.			

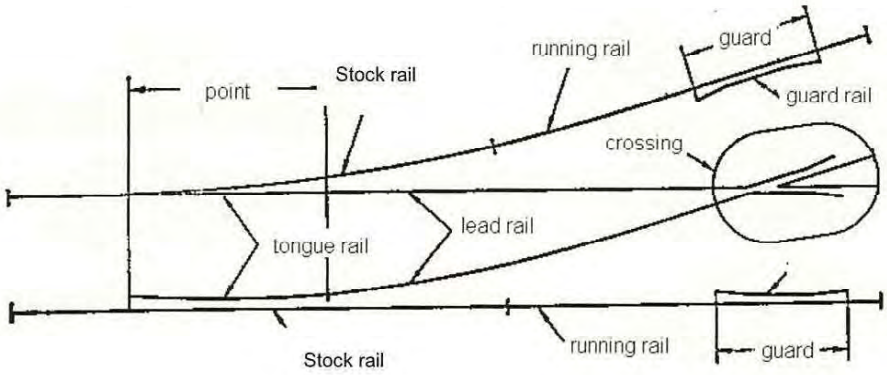
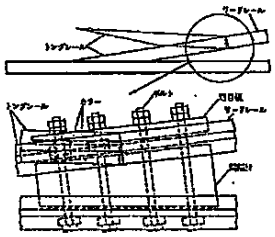


Fig 1.7 Skelton of turnout

Table 1-5 speed restriction on the straight side of turnout (JR)

Kind of rail	Turnout adopting elastic point (Fig 1.8) and welded crossing (Fig 1.9)	Turnout adopting full web tongue rail (Fig 1.10) and Mn crossing	Turnout adopting full web tongue rail and assembled crossing	Ordinary turnout
50N or heavier	95km/h. However for high performance passenger car 100km/h	95km/h. However for high performance passenger 100km/h	90km/h	—
50	—	90km/h	85km/h	80km/h
40N	—	—	80km/h	—
37	—	—	—	70km/h
30	—	—	—	65km/h

In order to achieve 95km/h for train speed on the straight side of turnout, 50N or heavier rail, elastic point or full web tongue rail and welded or Mn crossing should be adopted.



(Elastic point)

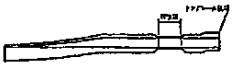


Fig 1.8 Elastic point and Jointed point

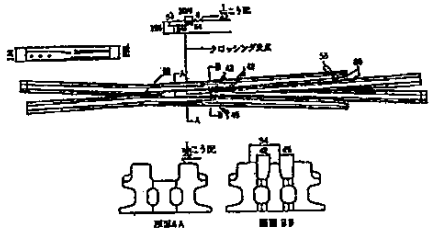


Fig 1.9 Welded crossing

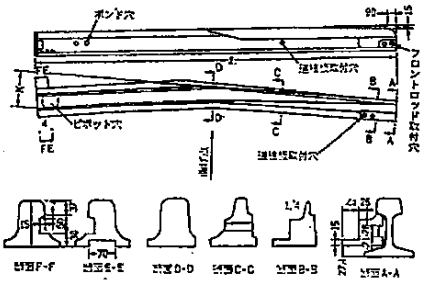


Fig 1.10 Full web tongue rail

(Jointed point)

No. of item	413	Item	Types of Sleepers

Recommendation/ Comments by JICA Expert Team

Recently PC sleepers have been adopted by MR on important trunk lines such as Yangon – Mandalay line. Accordingly Item No. 413 should include PC sleepers together with rail fastening devices for PC sleepers.

No. of item	414	Item	Varieties of Sleepers

Recommendation/ Comments by JICA Expert Team

In JR, large size joint sleeper is adopted for supporting rail joints.

For supporting rail joints by sleepers, there are two methods: supported joint method and suspended joint method.

According to the results of research by JR, it was found out that supported joint with use of large size sleeper indicated good performances for rail settlement as shown in the figure 2.3.13. It is recommended that MR should consider adoption of supported joint type with use of large size sleeper.

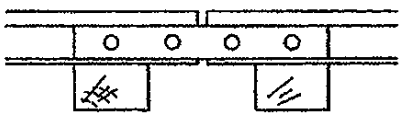


Fig 2.3.11 suspended joint

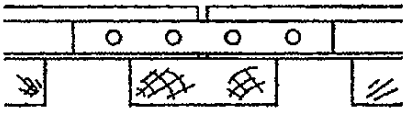


Fig.2.3.12 Supported joint with large

I -3-1-4
Accumulated passing tonnage (million ton)

size sleeper

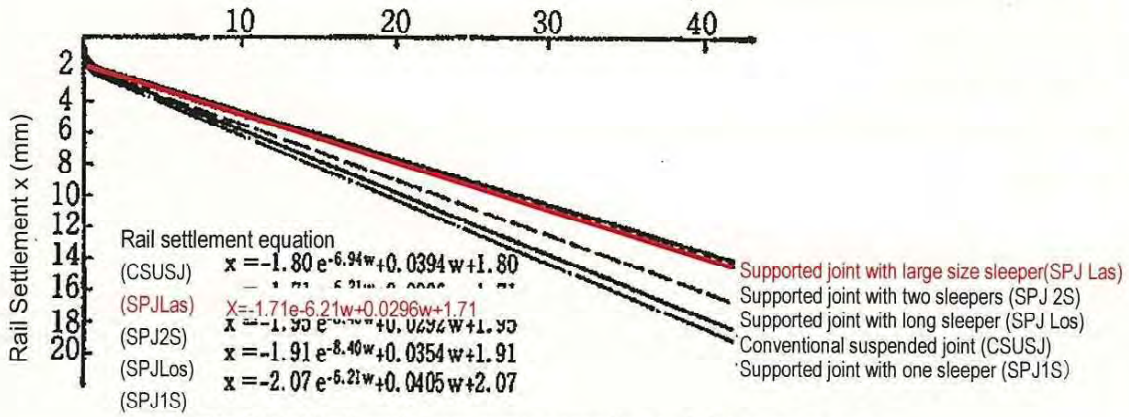


Fig 2.3.13Rail settlement curve according to joint support type

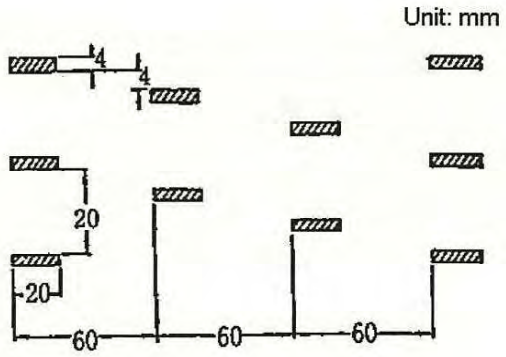
No. of item	418	Item	Semi-durable sleepers

Recommendation/ Comments by JICA Expert Team

In order to increase the endurance of wooden sleepers, creosote impregnation is carried out.

In JR, incising is carried out on sides of wooden sleepers.

Four sides of sleepers are stabbed before creosoting the sleepers so that creosote can be impregnated into the core of sleepers.



Note 1. Depth of incising = 18 – 20mm

Note 2. Incising should be made on 4sides of sleepers.

Fig. 2.4.1 Method of Incising

No. of item	421	Item	Ballast

MR Standards

Relating to this item, the ballast is specified in Group 8, Chapter XVII Standard Specification of MR,
In this article following items are established

1. Supply and measurement of ballast.
2. Adherence to specification for ballast.
3. Inspection ballast
4. Payment for ballast

But, MR explained us that Indian Railways' standard specification of making ballast is used in MR for the time being.

Recommendation/ Comments by JICA Expert Team

1. The content of Indian Railways' standard specification for making ballast is severer than that of JR.
2. We recommend that MR should instruct strictly to keep Indian Railways' standard specification for making ballast. Because we found big shape ballast mixed at the test section between Yangon and Bago where JICA Team is instructing the track maintenance technology. We suppose that this is caused become the sieve at the quarry is broken and it is preferable to repair it as soon as possible.
3. We recommend also that it is better for MR to establish his standard specification for making ballast as soon as possible.
4. For your information, we show an example of the comparative table of ballast size and its drawing between Indian Railways' standard specification for making ballast and those of JR.

Table 1.4.1 Example of the comparative table of ballast size and its drawing between Indian Railways' standard specification for making ballast and those of JR.

	Weight Percentage which pass through the related sieve							
	65.0mm	63.0mm	53.0mm	40.0mm	37.5mm	26.5mm	20.0mm	19.0mm
JR's Standard		100	80~100		35~75	0~40		0~5
Indian Railways' Standard	95			40~60			≦2	

JR's standard

Indian Railways' standard

It is further recommended that physical properties of ballast should be specified in the Standard Specifications.

In case of JR, the following physical properties are specified (1st class line)

- Weight of unit volume: ≧1.4t/m^3
- Absorption coefficient: ≦ 3%
- Abrasion ratio: ≦27%
- Brinell hardness: ≧17
- Pressure resistance after water absorption: ≧ 0.8t/cm^2
- Rate of crushing by pressure: ≦24%

No. of item	468	Item	Joints

Recommendation/ Comments by JICA Expert Team

In MR, opposite joint is adopted in straight sections, and alternate joint, in curved sections.

In JR, opposite joint is adopted in straight sections in the same way as in MR, however, also in the curved section with the radius more than 400m, opposite joint is adopted.

Generally the alternative joint is apt to cause rolling vibration of vehicle more than the opposite joint. However, in case of sharp curves sections the opposite joint will cause the different length of rails for outer rails and inner rails, resulting in cutting the rails partly.

Accordingly in JR, in the sharp curve section with the radius less than 400m, the alternate joint is allowed to be adopted in the same way as in MR.

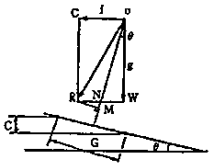
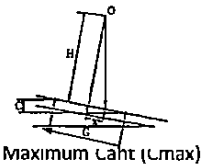
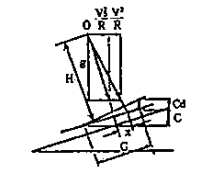
It is recommended that MR should consider to adopt opposite joints even in the curve section, in case the radius of curve is rather large.

No. of item	474	Item	Super-Elevation

Recommendation/ Comments by JICA Expert Team

In Item No. 474, allowable maximum cant is specified and balanced cant is shown.
To cope with the coming speed up of MR, the allowable maximum cant deficiency should be specified.
The allowable maximum cant deficiency is determined from both the safety viewpoint and the riding comfort view point.
In the following, how JR specifies the maximum cant deficiency is explained.

Further how JR calculates the balanced cant, and how JR specifies the maximum allowable cant are explained for the reference of MR.

 Balanced Cant (C)	Train speed $v=\frac{V}{3.6}$(m/sec) V= (km/h) Gravity acceleration g=9.8(m/sec²) Centrifugal acceleration $f=\frac{V^2}{R}=\frac{1}{R}(\frac{V}{3.6})^2=\frac{V^2}{13R}$(m/sec) $NR=f\text{-}WN=\frac{V^2}{13R}-g\tan\theta$ $MR=NR\cos\theta=(\frac{V^2}{13R}-g\tan\theta)\cos\theta$ $\tan\theta\fallingdotseq\sin\theta$ $\cos\theta\fallingdotseq1$ $\sin\theta=C/G$ P: component of centrifugal force in the direction parallel to track surface. $P=MR=\frac{V^2}{13R}-\frac{C}{G}g(m/sec^2)$ $\alpha=\frac{P}{g}=\frac{V^2}{127R}-\frac{C}{G}$ P=O Balanced Cant $C=\frac{GV^2}{127R}$ G=1067mm $C=8.4\frac{V^2}{R}$ G=1000mm $C=7.87\frac{V^2}{R}$
 Maximum Cant (Cmax)	H=height of center of gravity $\frac{X}{H}\fallingdotseq\frac{C}{G}$ max $C_{max}=\frac{X}{H}G$ $X\leqq\frac{G}{6}$ $C_{max}\leqq\frac{G^2}{6H}$ H= 1700mm G=1067mm $C_{max}\leqq112$mm JR $C_{max}=105$mm
 Cant deficiency (Cd)	$C_m=\frac{GV_0^2}{127R}$ $Cm+Cd=\frac{GV^2}{127R}$ $\frac{Cd}{G}=\frac{X}{H}$ $X\leqq\frac{1}{8}G$ $Cd\leqq\frac{G^2}{8H}$ C_m=actual cant, V_0=Balanced speed for Cm C_d= Cant deficiency H=1700m G=1067mm JR Cd≦84mm JR general vehicle 50mm EC, DC 60mm

The maximum cant is determined by taking the safety factor of 3 for overturning of vehicles standing on the curve by the wind blowing from the outside of the curve. The maximum cant should also be not so large as to make the passengers aboard uncomfortable.
The maximum cant deficiency is determined by taking the safety factor of 4 for overturing of vehicles running on the curve with the maximum speed by the wind blowing from the inside of the curve. The maximum cant deficiency should also be not so large as to make the passengers aboard uncomfortable..

No. of item	475	Item	Transition Curves
Recommendation/ Comments by JICA Expert Team			

In MR, the length of transition curve is determined so that temporal change of cant does not exceed 0.2 radian/sec.

In JR, on the 1st and 2nd class line, temporal change of cant should be less than 29mm/sc.

Considering that width of 50N rail head is 65mm, 29mm/sec can be converted to 0.026 radian/sec as given below.

$29\text{mm/sec}=\frac{29}{1067+65(50N)}=\frac{29}{1132}=0.026\text{rad/sec}$

In JR, on the 3rd class line, temporal change of cant should be less than 35mm/sec 35mm/sec$=\frac{35}{1132}=0.031$ radian/sec

On the 4th class line, temporal change of cant should be less than 40mm/sec=0.035 radian/sec,

In other countries, allowances of temporal change of cant are given as follows,

France	0.04rad/sec
Germany	0.023rad/sec
G. Britain	0.038rad/sec

Considering these allowance values in various advanced railway systems, 0.2rad/sec of MR seems too large. May be it is mistyping of 0.02 rad/sec.

Transition curve length should be determined not only from the viewpoint of temporal change of cant (L_2), but also from the viewpoint of temporal change of cant deficiency (L_3), and prevention of derailment due to 3 points support of 4 wheels of the bogie (L_1).

In JR, the length of transition curve is determined by selecting the maximum one among L_1, L_2, L_3.

(1) $L_{1(m)} \geqq K_1 C_{m\,(mm)}$ determined from the prevention of derailment due to 3 points support

(2) $L_{2(m)} \geqq K_2 C_{m\,(mm)} \cdot V$ (km/h) determined by C_{mo}, allowable limit of temporal change of C_m from the view point of riding comfort

$$\frac{Cm}{L2/\frac{V}{3.6}} \leqq C_{mo} \qquad L_2 \geqq \frac{Cm}{Cmo}\,\frac{V}{3.6} = K_2\, C_m\, V$$

(3) $L_{3(m)} \geqq K_3 C_{d\,(mm)} V$(km/h) determined by C_{do}, allowable limit of tempoval change of C_d from the view point of riding comfort

$$\frac{Cd}{L3/\frac{V}{3.6}} \leqq C_{do} \qquad L_3 \geqq \frac{Cd}{Cdo}\,\frac{V}{3.6} = K_3\, C_d\, V$$

JR

Line category	L_1	C_{mo}	L_2	Cdo	L_3
1st class	1.0 Cm	29 mm/sec	0.010 CmV	32 mm/sec	0.009 CdV
2nd class	0.8 Cm	29 mm/sec	0.010 CmV	32 mm/sec	0.009 CdV
3rd class	0.6 Cm	35 mm/sec	0.008 CmV	32 mm/sec	0.009 CdV
4th class	0.4 Cm	40 mm/sec	0.007 CmV	32 mm/sec	0.009 CdV

L_1, L_2, L_3 (m): length of transition curve

$C_{m\ (mm)}$, $C_{d(mm)}$: Cant and cant deficiency

V(km/h) = train speed

It is recommended that MR should also consider to adopt the longest one among L_1,L_2,L_3 as transition curve length.

No. of item	481	Item	Guard rail

Recommendation/ Comments by JICA Expert Team

(1) Derailment prevention rail

MR is installing gurd rails.The purpose of the gurad rail by MR is to prevent the derailed vehicles from running far from the track , and to minimize the damage caused by derailment.

In case of JR, derailment prevention rail or derailment prevention guard are installed in the sections where derailment will cause the serious damages, such as in the curve section with radius less than 250m, in the curve section on the sharp gradient, on the high bank.

The derailment prevention rail is installed inside the rail laid on the side opposite to the dangerous side of the track.

Gap between the running rail and the derailment prevention rail is set at 65mm + slack in case of JR.

(2) Derailment prevention guard

The effectiveness of derailment prevention rail was confirmed by the derailment experiment on Karikachi Experimental Track of Hokkaido.

At the same time, derailment prevention guard was designed which is easily installed or removed.

In view of the frequent occurrence of derailment of freight trains caused by combination of multiple factors in the section where gradient and curve are superposed, derailment prevention guard is stipulated to be installed in the section specified in Table 2.49 in case of JR.

Configuration of derailment prevention guard is as shown in Fig 2. 206.

They are installed inside the running rails. The gap between guard and running rail is set at 85mm.

85mm is determined on the condition that the maximum distance between the inner sides of wheel is 994mm, the gauge is minimums due to the slack of 5mm for R≦600m and gauge irregularly of−11mm, the width of head of rail is reduced by 20mm due to wear, and allowance is 10mm.

85＝1067+5-11-994－15+63－20－10

Table 2.49 Installment Standard of Derailment Prevention Guard

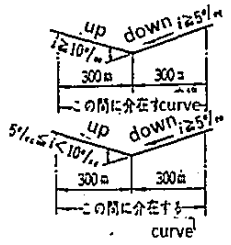
Item			Installemnet Section			Installment Section	Remark
			more than double track line		Single track line		
			Genral (excluding special)	special line (*)			
(1) Sharp curve section		passenger-cum- freight line and commuter electric car line	R<410m	R<410m	not necessary	over the whole cruve	(*) specia line. Trunk doouble track line section where traffic volume and number of train par day is large (*2) The places where installment of guard is unnecessary from the view point of train operation The places where freight trains are in power operation and couples are tensioned. These places include the section before the station where most freight trains stop, but freight trains are in power operation, and the section which is located on the concave alignment (gradient change point), but the front part of train located on the up gradient is in power operation
		line dedicated for freigtht transport	R<510m	R<510m	not necessary		
		line considered necessary for installment of guard	reverse curve of R< 510m	Reverse curve of R <510m	not necessary		
Sections where gradient and curve are superposed (excluding the section where freight trains are not operated)	(a) the places where gradient changes (exxcluding the places where installments of guard is unnecessary from the view point of train operation (*2)		R≦600m	R≦800m	not necessary	over the whole curve on the train entering side. On the train leaving side, over the curve located within 300m from the gradient change point	
			not necessary	R≦600m	not necessary	ditto	
	(b) Continuous gradient places (excluding the place where installment of guard is unnecessary from the viewpoint of train operation)	Curve located on the gradinent of 5‰≦i <10 ‰ of the length more than 1000m	not necessary	R≦600m	not necessary	Overt thewhole curve	
		Curve located on the gradient of 10‰≦i <15 ‰ of the length more than 500m	not necessary	R≦600m	not necessary	ditto	
		curve located on the gradient of 15‰≦i of the length more than 300m	not necessary	R≦600m	not necessary	ditto	

Fig. 2. 206 Configuration of derailment prevention guard

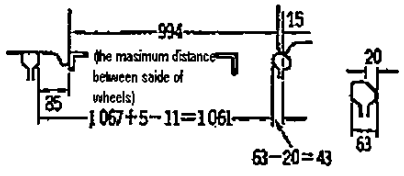


Fig. 2. 207 Method to attach the derailment prevention guard to rail

3.1.2 Major Recommendations/ Comments on Manual of the Engineering Dept. (MED) Permanent Way ⅡChapterⅤ (Construction and Maintenance)

(1) Track Specification and Method of Track Inspection(No.581 Article)

Actual Standard	1 Concerning about the method of inspection(No.581 Article of MED(ChapterⅤ)), (1) it is not specified to measure the track irregularity values in case of the track inspection. (2) In case of track maintenance, it is more efficient to measure track irregularity value and to make a plan to select the sections which the track maintenance is needed with the order of priority, according to the track measuring result and to do track maintenance work at site. 2 Concerning about the irregularity allowance, the document of Track Specification of MR specifies the values. Regarding the contents of the document and recommendation/ comments by JICA Experts, please refer to the Section 3.1.4
Comment	1 Concerning about the method of inspection(No.581 Article of MED(ChapterⅤ)), (1) JICA Study Team recommend for Myanma Railways(MR) to add clearly the track measuring inspection and periodic measuring of track irregularity into No.581 article. 2. Regarding the track irregularity allowances, please refer to the Section 3.1.4

3. MR classifies the lines by the maximum train speed. However, it may be more reasonable to select the type of the track structure not only by the maximum train speed, but also by the annual passing tonnage and the maximum axle weight.

In this regard, in the age of Japanese National Railways (JNR), the following classification of the lines was used, and the track structure type, track irregurty tolerances were decided according to this classification of the line as shown below.

Table-.1.5.1. Classification of railway lines in J.N.R

Classification			1st class lines	2nd class lines	3rd class lines	4th class lines	Remark
Annual passing tonnage (1000 tons / Year)			Over 20,000	10,000～ 20,000	5,000～ 10,000	2,000～ 5,000	
Maximum speed	High quality express train	Straight lines (km/h)	120	110~120	105	95	Prescribed speed : Maximum speed prescribed rules on the curve lines
		Curved lines (km/h)	Prescribed speed +5km/h	Prescribed speed +5km/h	Prescribed speed +5km/h	Prescribed speed	
	Ordinary train	Straight lines (km/h)	110	100	95	85	
		Curved lines (km/h)	Prescribed speed	Prescribed speed	Prescribed speed	Prescribed speed	
Maximum load (ton)			18	17	15	14	

Table1.5.2 Tolerance limits for the ordinary and the emergency in J.N.R

	Ordinary track tolerance standards				Emergency track tolerance standards			
Classification	1st class lines	2nd class lines	3rd class lines	4th class lines	1st class lines	2nd class lines	3rd class lines	4th class lines
Gauge	+10 (+6)							
	− 5 (−4)							
Crosslevel	11	12	13	16				
	(7)	(8)	(9)	(11)				
Longitudinal level	13	14	16	19	23	25	27	30
	(7)	(8)	(9)	(11)	(15)	(17)	(19)	(22)
Alignment	13	14	16	19	23	25	27	30
	(7)	(8)	(9)	(11)	(15)	(17)	(19)	(22)
Twist					23 (18) (Containing super elevation tapering)			

Note : Values show ones measured by High Speed Track Inspection Car and values in the parentheses show ones measured statically.

(2) Frequency of Inspection of Track(No.582 Article of MED(Chapter V))

Actual standard

In this article, Frequency of Inspection of Track is settled as follows;

1. Every employee should inspect his section as often as possible.
2. Frequency of whole track inspection is as follows;
   (1) District Engineer……Once in two months
   (2) Assistant Engineer…Once a month
   (3) P.W.I. ……Once a week
   (4) A.P.W.I. ……Twice a week

Comment

1. Generally, lines are classified according to their importance such as Maximum Speed, Annual Passing Tonnage, Axle Load etc.
2. And Frequency of Inspection of Track is ordinarily settled according to the classified category of lines.
3. Therefore, we recommend for MR to classify lines according to their importance and to establish Frequency of Inspection of Track.
4. For your information, Frequency of Inspection of Track of East JR is shown on the following table

Table 1.4.1 Frequency of Inspection of Track of East JR

Kind of track irregularity	Section to be inspected	Frequency of inspection of track irregularity		Remark
		Classified categories	Frequency	
Gauge, Cross level, Longitudinal level, Alignment, Composite, Check gauge	Main lines	1st class ~4th class	4 times/ year	See the Note
	Second main lines	Ditto	Twice/year	
	Other lines	Ditto	Once/year	
Cross level on curve sections	Main lines	Ditto	Twice/year	

Note; 1. Track irregularity should be measured by High Speed Track Inspection Car (HSTIC). For the lines which HISTIC does not be operated, Track irregularity should be measured by Track Master Equipment or by man power.

2. This inspection contains the turnout inspection

3. In the case where freight trains are not operated or the speed of the freight train is less than 45km/h, it does not need to measure composite track irregularity

4. The Frequency of Inspection for branch line of the turnout should be established by General Director who control this turnout.

Comment	5. Further, for your information, we show the tables below of the example of track inspection frequency in the age of Japanese National Railways.

Table 1.2.3.1 Track irregularity inspection frequency in J.N.R

Classification	Items	Lines	Inspection Interval	Remark
Ordinary track	Gauge Cross level Longitudinal level Alignment Twist	Main line	1st, 2nd,…6 times / year 3rd …4 times / year	Inspection by High Speed Track Inspection Car
			Others…2 times / year	Ditto or Inspection by machine
		Secondary main line	2 times / year	Inspection by machine or by man power
		Siding	Once / year	Ditto or Inspection by track patrol

（3） Inspection of Rail and Fastenings(No.582 Article of MED(Chapter V))

Actual Standard	In this article, it is settled that inspection rail and fastenings such as ;1) Side-worn and End-worn rail, 2) Loose or Missing Fish Plates, Bolts and Nuts,3) Unoiled Fish Plates and Bolts,4) Wide and Narrow Joints should be implemented by eyes of P.W.Is (Permanent Way Inspectors)

Comment

1. Nowdays, the technology is progressing year by year, and almost rail failures can be found ahead of the time when rail failure accident occurs, by using ultrasonic flow detection method.
2. As the rail contacts directly with the vehicle wheels, if the rail failure accident occurs, train derailment may occur in the worst case, and it takes more times until resuming the normal service
3. Therefore, we recommend for MR to provide Ultrasonic rail flow detection car and ultrasonic rail flow detector and to apply rail inspection system using these equipment as soon as possible.
4. It is very convenient to use this equipment as they can also measure value of rail wear and gap of rail joint automatically.
5. We show the example photographs of Ultrasonic rail flow detection car and ultrasonic rail flow detector of East JR Company

Photo3.5.1 Ultrasonic rail flow detection car of JR East Railway Company

- **Structure of the car: Self- moving type**
- **Detection speed: 40km/h**
- **Continuous detection hours: 4.5 hours**

Photo3.5.2. Staff is inspecting the rail by ultrasonic rail flow detector

Comment

Table3.5.1 Rail Inspection Standard of East JR

Classification of the lines	Inspection interval	Remark
Main line Second main line Others	Once / year	Using by ultrasonic rail flow detection car or ultrasonic rail flow detector or other equipment

(4) Inspection by Hallade Track Recorder(No.590 Article of MED(Chapter V))

Actual Standard

1. We understand that Hallade Track Recorder is a vehicle oscillation measuring equipment from the explanation of Technical Appendix 2268.
2. According to the 590 article, he provides that
   1) The track of all the more important section should be inspected by Hallade Track Recorder.
   2) P.W.Is Shall study the charts in comparison with the previous chart, and shall take immediate action to rectify.

Comment

1. We strongly believe that it is more efficient to study the result of track measuring data in comparison with one of Hallade Track Recorder.
2. Further, we want to recommend that it is preferable to establish the tolerance limit for vehicle oscillation(Value of Hallade Track Recorder).
3. To establish the tolerance limit for vehicle oscillation, it takes more times for MR.
   So, it is better to apply JR Standards or other country's ones for the time being, and it is better for MR himself to establish these standards after MR has many experiences.
4. For your information, we show the example table of tolerance limits for vehicle oscillation of East JR

Table 4.4.1 Tolerance limits for vehicle oscillation of East JR in case of ordinary maintenance

Kind of oscillation / Measuring vehicle	Vertical Oscillation (Full Amplitude)	Lateral Oscillation (Full Amplitude)
High Speed Track Inspection car or High Quality Express Train	0.20g	0.20g
Other Passenger cars	0.25g	0.25g

Table 4.4.2 Tolerance limits for vehicle oscillation of East JR in case of emergency

Kind of oscillation / Measuring vehicle	Vertical Oscillation (Full Amplitude)	Lateral Oscillation (Full Amplitude)
High Speed Track Inspection car or High Quality Express Train	0.25g	0.25g
Other Passenger cars	0.30g	0.30g

(5) Inspection of Points & Crossings (No.592 Article of MED(Chapter V))

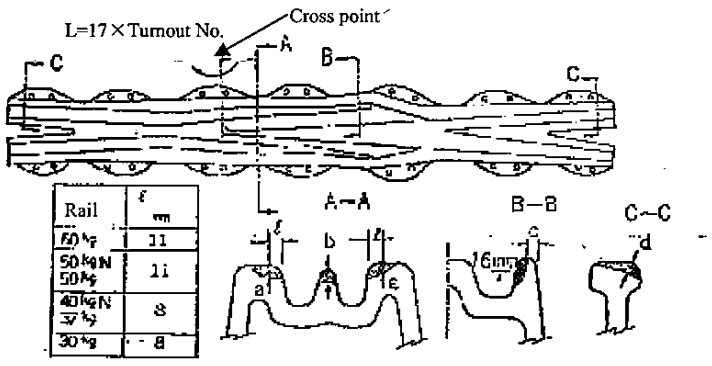
Actual Standards	This article provides following items. 1. To check Longitudinal level, Cross level, Gauge, Clearance of open toe of switch, Wing rail clearance, Depth clearance over all check blocks, etc. 2. There shall normally be no change of gradient and super elevation between point and crossing 3. Every gang maistry or his wrench man shall inspect all the points and crossings in his section every day. 4. Every A.P.W.I. shall do so once a week, every P.W.I. shall do so once a month and shall quarterly submit to his District Engineer through his Assistant Engineer a certificate.
Comment	1. Basically, the turnout has the following weak points in comparison with the ordinary track, a) There are many rail joints in the turnout. b) Turnout has the track irregularity from the stage of design. C) Turnout have to accept the compulsory force from the wheel by the guidance of guard rail So, turnout is in the severe condition in comparison with the ordinary track and should be maintained carefully. 2. We recommend that it is preferable to establish the standards of the inspection frequency, inspection method, judgments for inspection results in order for Staff to be able to check easily the turnout 3. For your information, we show the example table of a part of tolerance limits for turnout of East JR. **Table 5.3.I Standard of Turnout Renewal of East JR** **(1) Turnout parts of which wear depth reaches to the following quantity should be changed to new ones (Except manganese crossing)**

Comment

Parts of turnout	Classification of lines	Wear depth (Unit: mm)		Remark
		40N Rail 37kg Rail	50N Rail 50kg Rail	
Switch rail	1st Class Line	8	11	Wear depth should be measured at right angles to the worn surface and at the maximum wear point
	2nd Class Line	8	11	
	Other lines	9	12	
Crossing	1st Class Line	8	11	Ditto. But, Wear depth should be measured at right angles to the crossing surface
	2nd Class Line	8	11	
	Other lines	10	12	
Check rail	All lines	In the case where check rail can't keep check gauge		Wear depth should be measured at the low nose point of crossing
Turnout rail	1st Class Line	8	11(8)	Same as the switch rail. ( ) shows level wear depth from the rail surface.
	2nd Class Line	8	11(8)	
	Other lines	9	12	

(2) Manganese crossing of which wear depth reaches to the following quantity should be changed to new ones

Classification of lines		Wear depth (Unit:mm)			
		a and b	c	d	
		Ordinary crossing		40kgN, 37kg	50kgN, 50kg
Main lines	1st class line	9	12	10	15
	2nd class line	10	11	12	16
	3rd class line	11	10	14	16
	4th class line	13	9	15	16
Sidings	Important sidings	11	10	14	15
	Others	13	9	15	16



Rail	f mm
60kg	11
50kgN 50kg	11
40kgN 37kg	8
30kg	8

Table 5.3.2 Standard of Turnout Inspection of East JR

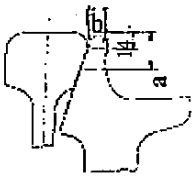
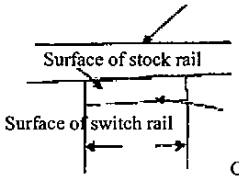
(1) Inspection items and inspection frequency

Inspection items		Inspection frequency			Remark
Conditions of maintenance and efficiency	Condition of Rail surface (Base rail, Switch rail, crossing, Lead rail etc,) which contact with the vehicle's wheel.	Once / Year			
	1.Condition of closed contact of switch rail 2. Condition of contact of switch rail 3.Irregularity of right angles of right side and left side switch rails 4. Condition of rail flow 5.Condition of flange way width 6.Condition of rail flow of crossing nose and check rail 7. Condition of presence and tightness of all fittings 8.Condition of the width between stock rail and switch check rail	**Classified Category**	**Main line , Second main line**	**Other lines**	*: Divisional General director's designation
		1st class line	Once / 3Months*	Once / 3Months~6 months*	
		2nd class line	Once /3Months~6 months*	Once /6Months~Year*	
		3rd class line	Once /4Months~Year*	Once / Year*	
		4th class line	Once /6Months~Year*	Once / Year*	
Condition of materials	1.Condition of rail wear, rail flawand rail erosion of front part of switch rail (1)Condition of rail wear of front part of switch rail (2)Condition of cutting off flaw of switch rail (3) Condition of fitting between stock rail and switch rail	All lines	Once / Year		
	2. Condition of rail wear, rail flaw and rail erosion at the part except front part of switch rail		Once / Year		

(2) Inspection method and judgments standard for inspection results of turnout

Inspection items	Inspection Method	Judgments standards
Condition of maintenance and efficiency		
1.Condition of closed contact of switch rail	By Measuring the gap between stock rail and switch rail with thickness gauge	The gap should be less than 1mm
2. Condition of contact of switch rail	By Measuring the gap between stock rail and switch rail with thickness gauge at the contact section except the closed contact section.	The gap should be less than following one. (1) Turnout on which the trains pass through the speed over 120km/h→3mm (2) Turnout on which the trains pass through the speed less than 120km/h→4mm (3) Turnout of the siding →5mm
3.Irregularity of right angles of right side and left side switch rails	By measuring with T-type square scale or folding scale.	Irregularity of right angles of right side and left side switch rails should be less than 15mm
4. Condition of rail flow	By inspecting the condition of rail flow at the section connected with stock rail head and switch rail head	The rail flow shouldn't prevent the closed contact and contact between stock rail and switch rail. And shouldn't prevent also the moving of the switch rail.

Comment

5.Condition of flange way width	By measuring flange way widths of crossing and check rails	Flange way width shouldn't invade the lower part of structure gauge. Flange way width should keep more than 56mm at the section changing point of the check rail in the case where the trains pass through with the speed 120km/h
6.Condition of rail flow of crossing nose and check rail	By measuring with eyes or measuring instruments such as scale	Rail flow should be within 1mm
7. Condition of presence and tightness of all fittings	By measuring with eyes or measuring instruments such as scale	(1) There is no large lateral or vertical mismatch at the toe joint of switch rail (2) Lateral mismatch at the toe joint of switch rail should be less than 1.5mm (Less than 1mm in the case where trains pass through with the speed 120km/h). (3)Rail flow at the toe joint of switch rail shouldn't prevent the movement of switch rail.
8.Condition of the width between stock rail and switch check rail	By measuring with eyes or measuring instruments such as scale	The width should keep the range between necessary width(42mm + slack + versine) +5mm ~ −4mm (between necessary width +5mm ~−0mm in the case where trains pass through with the speed 100km/h)
Condition of materials		
1.Condition of rail wear, rail flawand rail erosion of front part of switch rail (1)Condition of rail wear of front part of switch (2)Condition of cutting off flaw of switch rail (3)Condition of fitting between stock rail and switch rail 2. Condition of rail wear, rail flaw and rail erosion at the part except front part of switch rail	1.Condition of rail wear, flaw and rail erosion of front part of switch (1) Condition of rail wear of front part of switch 1) Staff should mark signs at the rail head width 6mm and 10mm, and measure the rail wear at these points. 2) Quantity of rail wear of stock rail should be measured at the point 10mm ahead from the front end of switch rail 3) Rail wear of stock rail should be measured at the point 10mm ahead from front end of switch rail (2) Cutting off flaw of upper part of switch rail 1) a and b should be measured in the case where upper part material of switch rail is cut off continuously from front end . 2) a,b and L should be measured in the case where cutting off flaw is in the middle.   L Cutting off flaw of upper part of switch rail	1.Condition of rail wear, flaw and rail erosion of front part of switch (1)Condition of rail wear of front part of switch Renewal standard of front part of switch rail and stock rail is as follows; <table><tr><td></td><td>Maximum rail wear (Unit;mm)</td></tr><tr><td>Stock rail</td><td>5</td></tr><tr><td>Switch rail</td><td>6</td></tr></table> (2) Cutting off flaw of upper part of switch rail <table><tr><td colspan="3">In the case where cutting off flaw exists within 1m from the front end of switch rail</td></tr><tr><td>(1.)</td><td>In case of a=15mm b=2mm</td><td>To grind the flaw and to change intentionally</td></tr><tr><td>(2)</td><td>In case of a=15mm b=5mm or a=18mm b=2mm</td><td>To change immediately</td></tr><tr><td colspan="3">In the case where cutting off flaw exists in the middle of switch rail</td></tr><tr><td>(1)</td><td>In case of a=15mm b=2mm L=75mm</td><td>To grind the flaw and to change intentionally</td></tr><tr><td>(2)</td><td>In case of a=15mm b=2mm L=75mm</td><td>To change immediately</td></tr></table>

Comment

(3)Condition of fitting between stock rail and switch rail

1) By measuring with eyes or measuring instruments such as the scale with which condition of fitting between stock rail and switch rail.

2) Rail wear of stock rail should be measured at the point 10mm ahead from front end of switch rail

2. Condition of rail wear, rail flaw and rail erosion at the part except front part of switch rail

1) By measuring with eyes or measuring instruments

2) Quantity of rail wear should be measured at right angles from the rail wear surface.

3) Location of measuring the rail wear of switch except front part of switch is as follows;

Width of switch rail head			
20mm	30mm	40mm	Full section

4) Crossing

Quantity of rail wear should be measured at right angles from the rail wear surface.

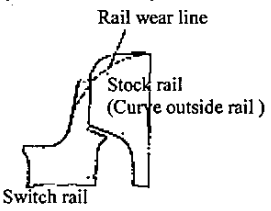
But at the low part near nose of crossing should be measured at right angles from the surface of low part

5) Check rail

Staff should measure at the point which corresponds to the low part near nose of crossing

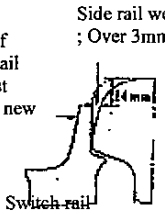
(3)Condition of fitting between stock rail and switch rail

Judgments as follows;

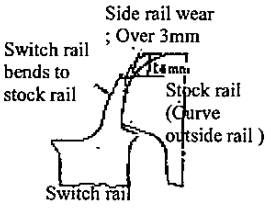


Type Ⅰ: Good contact

Shape of switch rail is almost same as new one

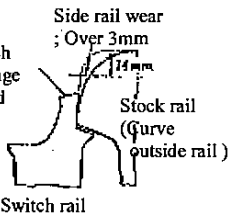


Type Ⅱ: Stock rail only should be changed



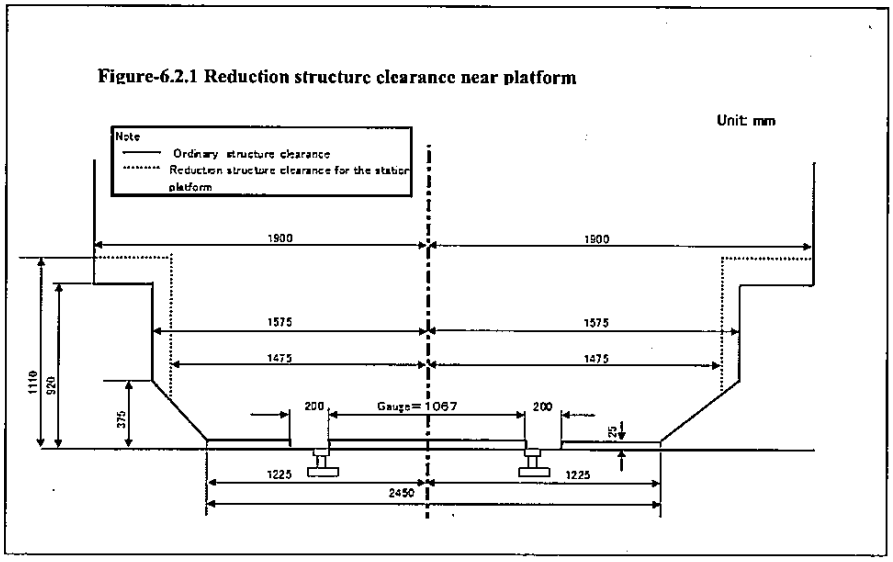
Type Ⅲ: Both stock rail and switch rail should be changed

There is a trace which wheel flange had passed



Type Ⅳ: Both stock rail and switch rail should be changed immediately

（6） Platforms Inspection (No.595 Article of MED(Chapter V))

Actual Standard	In this article, 1. The values of platform height, distance from center line of track and widening of the structure gauge in case of the curve don't be specified. 2. Staff in charge of the structure inspection can't clearly judge whether the results of his inspection pass or not
Comment	1. We recommend for MR to establish the values of platform height distance from center line of track and widening of the structure gauge in case of the curve. 2. The values of platform height distance from center line of track and widening of the structure gauge in case of the curve in JR are as follows;  **Figure-6.2.1 Reduction structure clearance near platform** ・Limit height of platforms from the rail level for platforms ＝1,110mm(190mmhigher than the height of the ordinary structure gauge) ・Distance from center line of track＝1,475mm (100mm narrower than the width of the ordinary structure gauge) ・Widening of the structure gauge on the curves。 w＝23,100 / R (w: Widening quantity: mm 、 R: Radius of curve: m)

3.1.3 Major recommendation/ comments on MED Chapter IX (Misellaneous)

Title of Standards of MR		Manual of Engineering Dept. Chapter IX (Miscellaneous)	
No. of item	900-922	Item	Various regulations for level crossing, gate, and gate man

Recommendation/ Comments by JICA Expert Team

Introduction

Chapter IX (Miscellaneous) mainly includes the regulations regarding ①level crossing and gatemen, ②the fences, ③actions to be taken in case of infringements of Standard Structural and Running Dimensions,④ engineering and ballast trains, ⑤assisted siding, ⑥cattles on the railway land

Out of these regulations, the ones regarding the level crossings and gatemen include ① classification and types of the level crossings ②responsibility of gatemen, ③gates ④level crossing structure and maintenance.

In view of occurrence of many accidents at level crossings and various issues regarding level crossing such as weak track structure and insufficient maintenance situation of MR, various standards/ regulations of JR will be explained here so that they could be a good basis on which technical standards of MR relating to the level crossing could be improved.

Technical Standards of JR relating to the level crossings will be explained below,

1. Basic Policy regarding level crossings

   Railway shall not intersect with roads at grade (Roads here mean the roads used by the general public traffic. The same definition sball apply hereinafter.). This definition, however, does not apply to the case where the trains operate at the speed less than 130km/h and rail and road traffic volume at rail crossing are small or the case where it is difficult to make a separate crossing from the topographical standpoint.

2. General requirement of level crossing

A level crossing road of an ordinary railway shall conform to the following criteria.

(1) The surface of a level crossing road shall be paved.

(2) The angle of intersection between the railway and the road must be at least 45 degrees.

(3) A warning sign must be erected.

(4) The level crossing security facilities shall be provided.

(5) A level crossing road over which a train passes at very high speed (more than 130 km/h but no more than 160 km/h) shall be provided with a crossing gate and obstruction detecting device (limited to level crossing roads used by automobiles). In this case, the level crossing road over which automobiles pass must not be used by large vehicles. Note, however, that a level crossing road over which large automobiles must unavoidably pass shall be provided with such equipment as the one to effectively prevent large automobiles from interfering with the operation of the level crossing, by way of increasing the visibility of the level crossing, etc., such as by using a double bar barrier device, a large size barrier device, an overhung crossing signal, etc.

3. Type of level crossing roads

3.1 Level crossing roads are categorized into Class 1, Class 3, and Class 4 crossings depending on their

facilities (Table 40.1) (Photos 40.1 to 40.3). Class 2 crossing, which currently does not exist, is a type where personnel are stationed at the crossing during times of heavy traffic to open and close the crossing by means of a gate.

Table 40.1 Types of crossing facilities

Level crossing type	Specification	Description
Class 1	Automatic	Bar barriers of level crossing operated by automatic control
	Semi-automatic	Bar barriers of level crossing operated by automatic control and manually
	Manual	Bar barriers of level crossing operated manually
Class 3	Automatic	An alarm of level crossing operated by automatic control
	Semi-automatic	An alarm of level crossing operated by automatic control and manually
Class 4		Level crossing other than the above

3.2 Specification of Class 3 level crossing

A level crossing should be classified as Class 3, in case the level crossing meets at least one of the following conditions.

However, such level crossings as safisfy the conditions described in 3.3 should be excluded.

(1) Road traffic per day exceeds the amount specified corresponding to railway traffic per day in Table 47.

(2) More than two accidents occur per year, and installment of an alarm is recognized as effective for prevention of accidents.

(3) The level crossings are located on the double track section and installment of an alarm is recognized as effective for preventing accidents.

(4) Preschool or elementary school is located near the level crossing, or due to other special situations, crossing of the level crossing by road vehicle or pedestrian has much possibility to meet dangerous situations.

3.3 Specificasion of Class 1 level crossing

A level crossing which satisfies at least one of the following conditions is classified as class 1 level crossing.

(1) Its width is more than 2.3m, and road vehicles are allowed to cross.

(2) The level crossing which satisfies at least one of the conditions given in 3.2 above, and road traffic per hour exceeds the amount specified corresponding to the rail way traffic per hour in Table 48.

(3) The level crossing which satisfies the conditions given in (1) and (2) of 3.2. Further visibly distance of flash of an alarm is less than 45m (22m in case vehicles can not approach the level crossing with the speed more than 35km/h due to topography)

(4) The level crossing should be recognized as being very dangerous for vehicle crossing, and installment of barrier on the level crossing is recognized as effective for preventing accident.
Namely the level crossing should satisfy the condition (1) and (2) of 3.2, and they are recognized as very dangerous level crossing because there exist more than 2 level crossings close to each other, or inter section of roads is close to the level crossing or there exist other particular situations.

Table 47
Railway and Road Traffic per day etc.

Kind of Railway Traffic	Conversion rate
Shunting vehicle	0.5
Train	1.0

Kind of Road Traffic		Conversion rate
Pedestrian		1
Bicycle		2
Light vehicle (excluding bicycle)		4
Motored bicycle and auto cycle		8
Auto tricycle		19
Auto mobiles other than auto cycle and auto tricycle	Passenger automobile	12
	other automobiles	14

Railway traffic per day	Road traffic per day			
	A class line		B class line	
	In case visibility distance is less than 50	In case visibility distance is more than 50	In case visibility distance is less than 50	In case visibility distance is more than 50
less than 15	4000	4500	6300	7000
15≦ <30	3700	4200	6200	6900
30≦ <50	3300	3800	6000	6700
50≦ <100	2500	3000	5200	5800
100≦ <150	2300	2800	4000	4500
150≦ <200	2100	2600	3200	3500
200≦ <300	2000	2400	2500	2800
300≦	2000	2000	2000	2000

Note 1: A class line is the line where the maximum speed and length of operated train are more than 65km/h, and more than 150m respectively.

B class line is the line other than A class line.

Note 2: Define the crossing point between the road center line and the center line of the most outer track of the level crossing as X.

Define the point of the visibility distance on the road from the point 1.2m above the ground and 5m apart from the point X as Y.

The distance between X and Y is defined as visibility distance.

Table 48

Road an Railway Traffic per hour

Railway traffic per hour	Road traffic per hour
3≦ <10	2400
10≦ <15	2200
15≦ <20	1800
20≦ <25	1400
25≦ <30	1100
30≦ <40	750
40≦ <50	500
50≦	360

Class 4 should not be installed in case of new constructions.

Photo 40.1 Example of Class 1 level crossing road

Photo 40.2 Example of Class 3 level crossing road

Photo 40.3 Example of Class 4 level crossing road

4. Structure of level crossing road

4.1 Pavement of level crossing road

The factors that determine the type of pavement when constructing or improving a level crossing road include the volume and type of traffic on the crossing road, the number of train operations on the railway, the bearing capacity of the roadbed, and the weather conditions. When designing the pavement of a level crossing road, as in the case of paving ordinary roads, the characteristics inherent to road pavement should also be taken into account.

The pavement for level crossing roads is classified into the following types based on the materials used:

① Planking or old sleepers

② Concrete block

③ Asphalt
④ Concrete
⑤ Continuous concrete block track
⑥ Other

In addition, the following points should be kept in mind when constructing any type of pavement:

① Considering the drainage from the trackbed ballast, replace the ballast in the level crossing road section and in the areas in front and back of that section, and thoroughly compact the ballast in advance.
② Replace the sleepers as required.
③ Avoid providing rail joints in the level crossing road section. If this cannot be avoided, weld the rails wherever possible.
④ Use tie plates that are common to the main track rails and crossing guards.
⑤ Install crossing guard spacers on the guards at intervals of two sleepers, in the middle of two adjacent sleepers.
⑥ For wide level crossing roads, paint white lines or provide sidewalks to separate the carriageway from the sidewalk.

An outline of the construction work, characteristics, etc. for each type of crossing pavement surface is described below.

(1) Plank pavement

Plank pavement offers a convenient way of repairing a track due to the lightweight pavement materials and simple construction work. However, considerable damage is caused by heavy road traffic, and smoothness is inferior compared to other types of pavement (Fig. 40.1).

Cross-sectional View

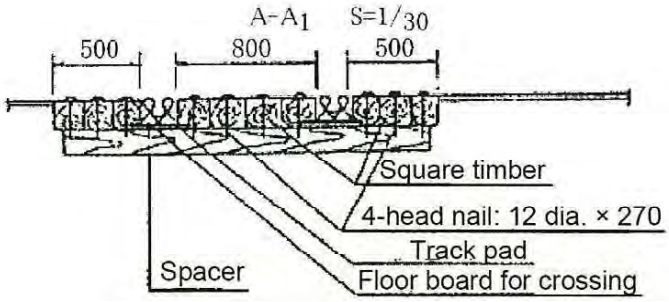


Fig. 40.1 Example of plank paved crossing

(2) Block pavement

This type of pavement uses factory-made reinforced concrete blocks, with steel frames fitted as required to prevent destruction. These blocks are typically supported by sleepers, but there is also a structure where steel angles are attached to sleepers along the cushioning materials in the direction of the rails, tie pads or adhesive materials are placed on the steel angles, and the blocks are supported by the steel angles. The areas at the ends of the sleepers are trenched, filled with cobblestones, and thoroughly compacted, or cast with edge concrete, as required, to install the blocks. In addition, Japanese cypress or Hiba splints are inserted in areas where the blocks touch the main track rails and guard (Fig. 40.2).

Cross-sectional view

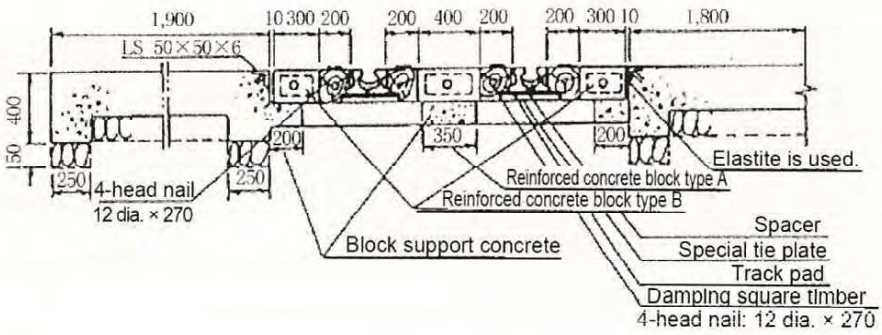


Fig. 40.2 Example of reinforced concrete block paved crossing

(3) Asphalt pavement

Asphalt pavement is suitable for non-clayey, hard subgrade having high drying properties in sunny places. Any defect in the subgrade tends to appear directly on the pavement surface. Therefore, asphalt-based pavement is not suitable for structures such as level crossing roads where the subgrade settles due to passing trains, or where a sand and crushed stone ballast on the subgrade needs to be removed for railway track maintenance. For this reason, asphalt pavement is not commonly used except on level crossing roads where road traffic is relatively heavy, but the number of train operations is small (Photo 40.4).

The construction work for asphalt pavement consists of filling the ballast gaps with crusher run, performing rolling compaction, then spraying and spreading asphalt emulsion, and thoroughly performing rolling compaction.

Photo 40.4 Example of asphalt paved crossing

(4) Concrete pavement

Concrete pavement, which is constructed by casting concrete in place on the ballast and the pavement section of a level crossing road, has advantages in terms of the bearing capacity for the train load and road traffic, as

well as wear resistance.

However, it has some shortcomings, including difficulty in fastening the rails to provide the same level of elasticity as ordinary tracks, difficulty in maintaining the boundary with the ordinary trackbed, and a prolonged construction period that leads to lengthy restriction of road traffic (Photo 40.5).

In planning and constructing concrete pavement, the following points should be kept in mind, in addition to the general precautions for pavement work described above:

① Considering the relatively long lifespan of pavement, the bearing capacity of the roadbed needs to be retained for a long period of time (i.e., longer than the pavement life).

② Use crushed stone on the trackbed or carry out roadbed improvements in the connecting area between the crossing pavement and ordinary trackbed sections so that the amount of track maintenance is reduced.

③ In concrete works, fully compact the concrete with a vibrator and do not stop casting the concrete at the middle of joints.

④ Use asphalt joint materials on the expansion joints.

Photo 40.5 Example of concrete paved crossing

(5) Continuous concrete block track

A continuous concrete block track consists of wide reinforced concrete sleepers tightly laid along the rails and post-tensioned to construct a strong track panel of PC beams (photo . 40.6).

Since the continuous concrete block track is integrated with the sleepers even in paved areas due to its structure, a sufficient effective height of tensile reinforcement is provided against the negative bending moment caused by vehicle loading, and its strength and weight increase which minimizes the pressure on the roadbed when the ends of sleepers are loaded and eliminates most of the local settlement of the road surface, which is the main cause of the destruction of crossing pavement. Thus, the continuous concrete block track offers great strength that is not comparable to the conventional plank or block pavement.

In addition, the rails are directly and elastically fastened to the complete concrete trackbed. Such track structure can sufficiently bear wheel pressure and lateral pressure, and is also durable to vibrations and creeping of rails.

Cross-sectional view

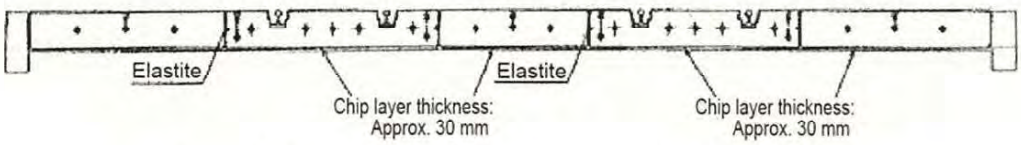


Photo 40.6 Example of continuous concrete block track crossing

(6) Other pavements

Rubber crossings and rubber-covered crossings are gaining acceptance as new types of crossings (photo 40.7). Since these crossings are widely adopted in the U.S. and other countries and their effectiveness has been reported, they are expected to be increasingly used. The main characteristics of rubber crossings include:

① Panel modules allow easy installation and removal.
② Removed panels can be reused or diverted to other purposes.
③ Good wear resistance and water resistance.
④ Less noise caused by passing vehicles.
⑤ Elastic. Free from damage, warping and corrosion.
⑥ Good workability allows use in turnouts and curved sections.
⑦ Uneven surface has slip prevention effect.

Cross-sectional view

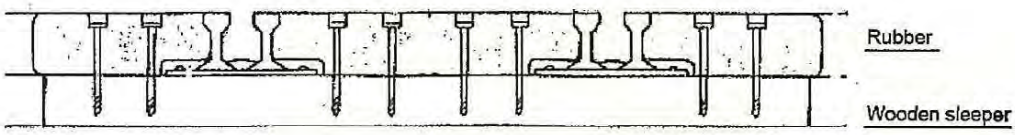


Photo 40.7 Example of rubber crossing

Other types of new crossing pavement include the RTRI (Railway Technical Research Institute) type developed for light traffic crossings with a width of about 5 meters or less. This type provides flangeways, eliminating guard rails, and allows the use of PC sleepers.

In addition, the pavement can be quickly removed and restored using a crane for maintenance of the track in the crossing pavement area (photo. 40.8).

Cross-sectional view

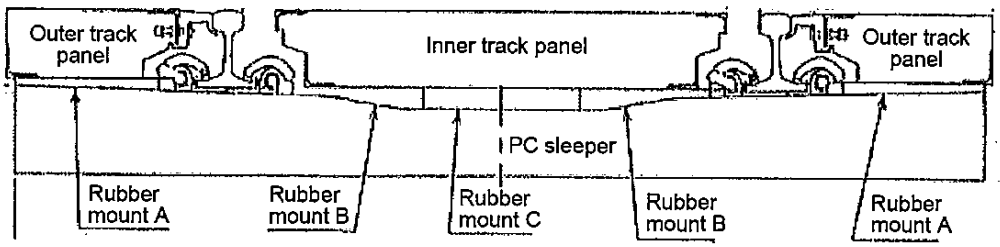


Photo 40.8 Example of detachable crossing

5. Crossing facilities considering increased railway speed

5.1 Concept on issues such as intersections with roads considering increased railway speed

As railway speeds increase, so does the risk of accidents

To cope with this, it is necessary to establish a method for organizing such issues as the type of intersection between a railway and road for each train speed and the criteria for providing crossing safety facilities in cases where a level crossing road is constructed.

Considering the increased risk of accidents due to the increased railway speed, issues such as the type of intersection between a railway and road taking the increased speed into consideration, should be organized as shown in Table 40.2.

Table 40.2 Concept on issues such as type of intersection considering increased railway speed

	Intersection with road	Level crossing road	
		Installation of barrier/obstruction detection device	Measures for large-sized vehicles
160 km/h <	Grade separation	–	–
130–160 km/h	Grade separation is required as a general rule, but does not apply if such measure is not possible and if measures (*1) and (*2) are implemented.	(*1) Barriers and obstruction detection devices (Photo 40.9) shall be provided on level crossing roads with vehicle traffic.	(*2) There shall be no traffic of large-sized vehicles. This requirement does not apply if measures* such as increasing the visibility of the crossing to effectively prevent large-sized vehicle from interfering with operation of the level crossing.
< 130 km/h	Same as before.		

* Measures to effectively prevent large sized vehicle form interfering with operation of level crossing include:

- Improving the visibility of the crossing (by means of large barrier bars, overhead crossing signals, gatepost type crossing warning signs, etc.)
- Making level crossing roads easy to pass (by means of structural improvement, etc.)

5.2 Specific methods for reducing the risk of accidents

Based on the above concept, the specific methods for reducing the risk of accidents can be categorized as follows:

(Ground facilities)

① Reducing the number of level crossings and the number of vehicles that pass the level crossings by means of grade separation.

② Introducing a crossing structure that can almost completely prevent the entrance of obstacles when a train approaches.

③ Increasing the visibility of level crossing roads.

④ Making level crossing roads easy to pass.

(Equipment on vehicles)

⑤ Strengthening the heads of trains or introducing a shock-absorbing structure to reduce the impact of collision.

⑥ Introducing train forward detection devices, etc. to increase the sight distance.

(Operations)

⑦ Reducing the train speed near the level crossings that require special care.

5.3 Specific measures for level crossings considering increased railway speed

Analyses of past serious accidents on level crossing roads reveal that the majority were caused by large- or medium-sized vehicles. Therefore, accident prevention measures need to be implemented in circumstances where large-sized vehicles must be allowed to pass.

When considering specific measures for crossings in terms of ground facilities based on the specific methods for reducing the risk of accidents, the following measures are suggested:

(1) Level crossing structure that can almost completely prevent the entrance of obstacles when a train approaches

It is necessary to provide a structure to prevent vehicles, etc. from entering a level crossing road when a train approaches by installing crossing barriers. For cases where a vehicle stalls on a crossing due to engine failure or traffic jam, obstruction detection devices (Photo 40.9) that activate to stop the train are also available. There are various types of obstruction detection devices including the photoelectric type shown in the photo, the LED type, and also the loop coil type that detects obstacles using a loop coil buried in the paved surface of the crossing

Photo 40.9 Example of crossing obstruction detection device

(2) Improving the visibility of level crossing road

Measures to improve the visibility of level crossing roads currently include the following:

① Double-bar barrier device (Photo 40.10)

In addition to an ordinary barrier bar, another bar is provided for easy recognition by drivers sitting high up in large-sized vehicles, etc.

② Large-size barrier device (Photo 40.11)

A bar that is about two times as thick as an ordinary bar is used to improve the visibility of the barrier bar.

③ Overhead crossing signal (Photo 40.12)

A signal is installed high above a crossing to make the existence of the crossing more noticeable from afar.

④ Color painting within level crossing road

A different color is used within the level crossing road to clearly distinguish the road so that the safety of pedestrians in the crossing is ensured.(photo 40.13 Left)

⑤ LED flashing device on barrier bar (Photo 40.13 Right)

A high-intensity red LED flashing device is installed on the barrier bar to improve the visibility of the crossing.

Photo 40.10 Example of double-bar barrier device

Photo 40.11 Example of large-size barrier device

Gatepost type

Photo 40.12 Example of overhead crossing signal

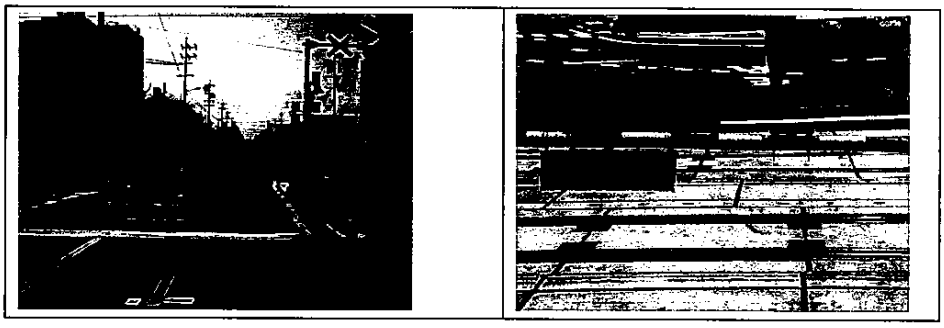


Photo 40.13 Example of Color Painting within level crossing road and LED flashing device on barrier bar

(3) Structural improvements of level crossing road

Structural improvements for making level crossing roads easy to pass generally include increasing the width of the level crossing road and making the intersection angle as close to 90° as possible. Considering that the purpose of structural improvements is to reduce the risk of accidents in an existing crossing structure, improvements such as employing a continuous concrete block track in a crossing and decreasing the gradient between the level crossing road and the connecting road are also deemed to be effective measures.

All of these measures should be accompanied by additional measures that meet the specific conditions of individual level crossing roads to minimize the risk of accidents through discussions on the passage of large-sized vehicles among road administrators, police officers and other relevant parties. However, these measures apply to level crossing roads that exist in a section where trains are actually operated at a speed of 130 km/h or more and 160 km/h or less, not to all level crossing roads on that line section.

3.1.4 Main Recommendations/Comments on Track Specification

Title of Standards of MR		Track Specification	
No. of item		Item	

The document of Track Specification includes three systems of irregularities allowances of track as shown in Table-X. Each system is described in relevant papers.

1. System-1

(1)Document Title: Allowance Tolerance for Track Laying and Maintenance

(2)Author : Indian Railway Institute of Civil Engineering, Pune

(3)Content: The lines are classified into three classes according to the maximum train speeds, and track irregularities allowances are specified for each class of the lines from the viewpoint of construction, limit for maintenance, safety.

2. System -2

(1)Document Title: Maintenance Tolerance

(2) Author : B.L. Gupta and Amit Gupta

(3)Content : Track irregularities allowances are specified from the viewpoint of riding comfort, which is classified into two levels:
Maximum comfort and good riding comfort.

3. System -3 This system is explained by the following three documents, all of which specify the track irregularity tolerances for track laying.

Document1 (1)Title: Track Laying Standards

(2) Author: J.S. Mundarey

(3)Content: This document specifies the track irregularity tolerances for track laying.

Document2 (1)Title: New Track Tolerances

(2) Author: B.L. Gupta and Amit Gupta

(3) Content: Track irregularity tolerances for new track laying.

Document3 (1)Title: Tolerance for Track laid with new track materials

(2) Author: B.L. Gupta and Amit Gupta

(3) Content: Track irregularity tolerances for new track laying in case of using new materials.

Irregularity tolerances shown in Document 1,2,3 have almost the same values.

Recommendation/ Comments by JICA Expert Team

In JR, in order to keep the good riding comfort, the target values of track irregularity allowances are specified as shown in Table 52, and further target values of train vibration acceleration allowances are specified as shown in Table 53.

(Table52) **Track maintenance target values**

(Unit: mm)

Type of track irregularity \ Maximum speed		Maintenance target value				Remarks
		Line section of 120 km/h or more	Line section exceeding 95 km/h	Line section exceeding 85 km/h	Line section of 85 km/h or less	
Gauge	Section with a radius of 800 m or more	+10 (+6) −5 (−4)	+10 (+6) −5 (−4)			
	Section with a radius of 200 m or more		+15 (+9) −5 (−4)			
	Section with a radius of less than 200 m		+10 (+6) −5 (−4)			
Cross level		11 (7)	12 (8)	13 (9)	16 (11)	
Longitudinal level		13 (7)	14 (8)	16 (9)	19 (11)	
Alignment		13 (7)	14 (8)	16 (9)	19 (11)	
Twist		———				

Notes: (1) The above figures are dynamic values acquired by high-speed track inspection cars. The figures in parentheses are static values.

(2) The twist value shows the variation in cross level per 5 meters.

(3)Slack cant and versine are not included in curved sections including vertical curve.
(4)The values for 85km/h or less apply to side tracks.

(Table53) Target values of train Vibration acceleration allowances

Kind of measuring vehicle \ Kind	Vertical vibration acceleration (full amplitude)	Lateral vibration acceleration (full amplitude)
High speed track inspecsion car or high performance passenger vehicle	0.20g	0.20g
Other passenger vehicle	0.25g	0.25g

Further, in order to ensure the safe train operation, the track irregularity allowances and train vibration acceleration allowances from the viewpoint of safe train operation are specified as shown in Table 64 and Table 65.

In case the measured values exceed these values, track should be rectified as soon as possible.

Table 64 Track maintenance standard values

(Unit: mm)

Maximum speed (km/h) / Type of track irregularity	Maintenance standard value				
	Line section of 120 km/h or more	Line section exceeding 95 km/h	Line section exceeding 85 km/h	Line section exceeding 45 km/h	Line section of 45 km/h or less
Gauge	・Straight line and curve with a radius exceeding 600 m 20 (14) ・Curve with a radius of 200 to 600 m 25 (19) ・Curve with a radius of less than 200 m 20 (14)				
Cross level	(Maintenance work is conducted based on the twist.)				
Longitudinal level	23 (15)	25 (17)	27 (19)	30 (22)	32 (24)
Alignment	23 (15)	25 (17)	27 (19)	30 (22)	32 (24)
Twist	23 (18) (Includes the decrease in cant)				

Notes: (1) The above figures are dynamic values acquired by high-speed track inspection cars. The figures in parentheses are static values.

(2) The twist value shows the variation in cross level per 5 meters.

(3) Slack, cant and versine are not included in curved section (including vertical curve)

(Table65) Train vibration acceleration allowances from the viewpoint of safe train operation

Kind of vibration / Kind of measuring vehicle	Vertical vibration acceleration (full amplitude)	Lateral vibration acceleration (full amplitude)
High speed track inspecsion car or High performance passenger vehicle	0.25g	0.25g
Other passenger cars	0.30g	0.30g

In case the measured values reach the allowances shown in Table 64 and Table65, the track rectification should be executed as shown below.

(1) Track irregularity

① Track irregularity should be rectified within 15 days, however, in case the measured values exceed the allowances remarkably when measured, the irregularity rectification should be executed earlier.

② Even if the measured values do not reach the allowances, the track irregularities of which progress is very quick or which cause especially large train vibration should be rectified within 15days.

(2) Train Vibration

① In case the measured values reach the allowances, and as a result of site investigation, it was found out that urgent rectification of track is necessary, track irregularities should be rectified within 15 days. However, in case the measured

values exceed the allowances remarkably when measured, track rectification should be executed earlier.

(3) Track irregularity and train vibration acceleration

In case the measured values reach the allowances and the track irregularity rectification cannot be executed within 15days (in case the measured values exceed the allowances remarkably when measured, earlier), train speed slow down must be implemented.

In JR, in case of track construction, or after the track irregularity rectification, the allowances shown in Table 7.3 are specified.

Table7.3 Track irregularity tolerances in case of track laying or after the track rectification work

Kind of track irregularity	Allowances
gauge	(+1) (-3)
cross level	(4)
longitudinal level	(4)
horizontal alignment	(4)
twist	(4) (excluding cant decreasing rate of transition curve)

Note 1 Numerals are the values measured dynamically by high speed track inspection car
The values in parenthesis show the static measured value.

2 Twist is the difference of cross level per 5m.

3 The allowances in the curved section exclude slack, cant and versine.
The versine of vertical cure is also excluded.

Based on the technical standards of JR, the following is recommended for MR with respect to track irregularity.

(1) MR specifies track irregularity allowances from the viewpoint of track laying, safety and riding comfort. However, as shown in Table X, there exist 3 different systems and they cause confusion. It is recommended that they are unified into one single system.
For example, Indian Railway of Civil Engineering, Pune may be suitably reviewed and

specified as a unified track irregularity allowance system.

(2) Track irregularity allowance after the track rectification is recommended to be specified.

(3) It is recommended to stipulate the train vibration acceleration allowances from the viewpoint of safety and riding comfort.

(4) In case, the track irregularity cannot be rectified within specified days, train speed should be slow down.

(5) The allowances specified by MR, from the viewpoint of safety and riding comfort are severer than those of JR,
However, these allowances should be carefully specified according to characteristies of track structure and rolling stock performances. For that purpose careful study should be executed on relationship among track irregularity, wheel vehicle load, wheel lateral pressure and vibration of train running on the track.

Table-X Track Specification

Title of Specification	ALLOWABLE TOLERANCES FOR TRACK LAYING & MAINTENANCE (Indian Railway Institute of Civil Engineering, Pune)									Track Laying Standards (Railway Track Engineering J.S. Mundrey)		Maintenance Tolerances(Railway Engineering-B.L. Gupta and Amit Gupta)				New Track Tolerances (Railway Engineering - B.L. Gupta and Amit Gupta)				Tolerances for track Laid with new track materials (Railway Engineering-B.L. Gupta and Amit Gupta)			
Class Of Line - Max. Permissible Speed-	Class I 90 km/hr i.e.56 m.p.h			Class II 75 km/hr i.e.45 m.p.h			Class III 50 km/hr Or 35 m.																
	Construction	Limits For Maintenance	Safety	Construction	Limits For Maintenance	Safety	Construction	Limits For Maintenance	Safety			Track Parameters	Tolerance with wear; comfort	Tolerance for good riding comfort: General	Tolerance for good riding comfort: Isolated Locations	No.	Track Parameters	Item of measurements	Value	No.	Parameter	Location	Value
1 (a) Track Gauge (static)	+2 -2	+6 -2	+10 -4	+2 -2	+6 -4	+14 -6	+2 -2	+6 -4	+16 -6	(a) Gauge	Sleeper to sleeper variation ±2mm	1 Gauge	3mm	-	-	1	Gauge	Sleeper to sleeper variations	±2mm	1	Gauge	Straight B.G Curves up to 4° M.G Curves up to 6° N.G Curves up to 14°or Steeper or Sharper Curves	Sleeper to Sleeper ±2mm from nominal gauge Sleeper to Sleeper -3mm / Sleeper to Sleeper +1mm — For nominal gauge Sleeper to Sleeper ±2mm from gauge Specified
(b) Track Gauge (dynamic)	-2	+10 -2	+12 -4	+2 -2	+10 -4	+16 -6	+2 -2	+10 -4	+16 -6														
(c) Variation between adjacent sleepers	±2	±3	±4	±2	±3	±4	±2	±4	±6														
Expansion gap										(b) Expansion gap	Average gap worked out by recording 20 successive gaps ±2mm					2	Expansion gap	Average gap of 20 successive gaps	±2mm	2	Expansion gap	-	±2mm from prescribed value
Joints										(c) Joints	(i) Low joint not permitted (ii) High joints not more than 2mm (iii) Squareness of joins on straight ±10mm					3	Joints	(a) No low joints permitted (b) High joints not more than (c) Squareness of joint in straight	2mm ±10mm	3 4 5	Joint out of square or squareness Low Joint High Joint	(a) On straight (b) On Curve - -	±10mm ±1/2mm or 1/2 Pitch of fish bolt holes Not Permitted 2mm
Spacing of Sleepers										(d) Spacing of sleeper	With respect to theoritical spacing ±20mm					4	Spacing of sleeper	With respect to theoritical spacing	±20mm	6 7	Sleeper Spacing Packing (To be checked by canvas - a- boule)	- -	Variation from the specified Spacing ±20mm 20% Sleeper loose
2 (a) Cross Level (static)	2	8	12	2	9	14	2	10	14	(e) Cross level	To be recorded on every 4th sleeper ±3mm					5	Cross Levels	To be measured on every 4th sleeper	±3mm	8	Cross Level	Straight	±3mm
(b) Cross Level (dynamic)	3	12	16	3	13	18	4	14	18														
3 (a) Vertical Alignment (static)	3	8	12	3	9	14	3	10	16	(f) Longitudinal level	Variation in longitudinal level with reference to approved longitudinal sections ±50mm	2 Undulations measured on a 2.74m chord	3mm	5mm	8mm	6	Longitudinal Level	Variation with reference to approved sections	±50mm				
(b) Vertical Alignment (dynamic) (cover a 10m chord)	6	14	16	6	16	20	8	16	22														
4 (a) Lateral Alignment (static)	2	8	12	3	9	14	3	10	16	(g) Alignment	(i) On straight on 10m chord ±2mm (ii) On curves of radius more than 600m on 20m chord Variation over theoritical versines 5mm (iii) On curves of radius less than 600m on 20m chord Variation over theoritical versines 10mm	3 Alignment measured as versine on 10m chord (a) Straight (b) Curve (c) Change of versine from chord to chord measured at 5m apart	3mm 3mm -	5mm 5mm 10mm	8mm 8mm -	7	Alignment	(a) On straight on 10m chord (b) On curve of radius more than 600m on 20m chord variation over theoretical versine (c) On curve of radius less than 600m on 20m chord variation over theoretical versine	±3mm 5mm 10mm	9	Alignment	(a) Straight on 10m chord (b) Curves of radius 600m On 20m chord (c) Curves of radius more than 600m on 20m chord	±2mm ±5mm ±10mm
(b) Lateral Alignment (dynamic) (cover a 10m chord)	4	14	18	6	15	20	6	16	22														
5 (a) Twist (static)		2mm/m	3mm/m		2.5mm/m	3.5mm/m		3mm/m	4mm/m			4 Twist measured on a 2.74m base in loaded condition (a) Straight and Curved track (b) Transition Track	1.5mm/m 1.0mm/m	2mm/m 1.5mm/m	3mm/m 2mm/m								
(b) Twist (dynamic)		3mm/m	4mm/m		3.5mm/m	4.5mm/m		4mm/m	5mm/m														

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3.1.5 Main Recommendation/Comments on Manual of the Engineering Department(MED) Chapter XXII Technical Appendices

The comments for main specifications of the actual Specifications of Myanmar Railways which JICA Study Team is aware that they are preferable to be revised as soon as possible by Myanmar Railways are shown below.

(1) Standard numbers of sleepers per mile (No. 2259 Article of MED (Chapter XXII)

Current Standards	In this article, following items are established 1. Numbers of sleepers per length of rail 2. Numbers of rails per mile 3. Numbers of sleepers per mile (In case of straight and 90% straight, 10% curve) 4 Numbers of sleepers per 100' (In case of 90% straight, 10% curve) But there are no descriptions to exchange numbers of sleepers per rail or mile according to the classified categories of lines.
Comment	1. We suppose that numbers of sleepers per rail or mile should be established according to the classified categories of lines. Because track destructibility depends upon weight of wheel, maximum speed and passing tonnage and lines should have also track bearing capacity corresponding to them. 2. Therefore, numbers of sleepers per rail or mile should be established according to the classified categories of lines from the economic view point too. 3. We show the example of East JR concerning about numbers of sleepers, ballast thickness and rail type according to maximum train speed and annual passing tonnage **Table 2.3.1 Numbers of sleepers, ballast thickness and rail type according to maximum train speed and annual passing tonnage**

Designing Max. speed	Track structure	Designing annual passing tonnage (Unit: 1,000ton)											
		>20,000			20,000~10,000			5,000~10,000			<5,000		
V_{max} >110	Weight of Rail (kg/m)	50	60	50	50	60	50	50	60	50	50	60	50
	Numbers of Sleepers(/25m)	39	39	42	37	37	40	37	37	40	37	37	40
	Thickness of Ballast(mm)	250	200	200	200	150	150	200	150	150	200	150	150
110≧ V_{max} >90	Weight of Rail (kg/m)	50	60	50	50	60	50	37	40	37	37	37	40
	Numbers of Sleepers(/25m)	39	39	42	37	37	40	37	37	40	200	150	150
	Thickness of Ballast(mm)	200	150	150	200	150	150	200	150	150	200	150	150
90≧ V_{max} >70	Weight of Rail (kg/m)	50	60	50	50	60	50	37	40	37	30	37	30
	Numbers of Sleepers(/25m)	39	39	42	37	37	40	37	37	39	34	34	36
	Thickness of Ballast(mm)	200	150	150	200	150	150	150	120	120	150	120	120
70≧ V_{max}	Weight of Rail (kg/m)	50	60	50	50	60	50	37	40	37	30	37	30
	Numbers of Sleepers(/25m)	39	39	42	37	37	40	37	37	39	34	34	36
	Thickness of Ballast(mm)	200	150	150	200	150	150	120	100	100	120	100	100

Note: 1. This table is available in the case where maximum speed is lower than 130km/h
2. Numbers of sleepers is one less than above numbers in case of long rail
3 Thickness of ballast smaller than above ones can be used in the case where roadbed is made with concrete, rock or the equivalent.

3.1.6 Other recommendations/ comments in view of the future development of MR

JICA Study Team wants to recommend other following countermeasures, taking the actual track condition and rehabilitation work in near future into consideration.

1) **Countermeasure to strengthen many low joints**
2) **Several main points to be paid attentions for installation of long welded rail and their maintenance.**
3) **Several main points to be paid attention for using big track machines such as Multiple Tie Tamper, Flash Butt Welding Machine, Track Measuring Machine etc.**

(1) Methods for strengthening low joints

Actual Condition	**1.** JICA Study Team carried out observation the track between Yangon and Mandalay, and we found that there were many low joints and big vehicle oscillation occurred on their joints.
Recommendation	(1) To install actively long welded rail. After rehabilitation works are carried out, ordinary rail joints exist still because the sections which the long welded rails are installed are limited according to the line alignment of the sections Main points to be paid attention for long welded rail are explained after. (2) To install the wider timber sleeper

Photo 1.2.1 Wide timber sleeper for rail joint applied in JR East

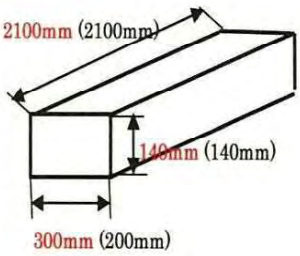


Figure 1.2.2 Wide timber sleeper and ordinary timber sleeper for rail joint applied in JR East
(Red number is the value of wider timber sleeper)

(3)To install middle raising fish plate and rail grind

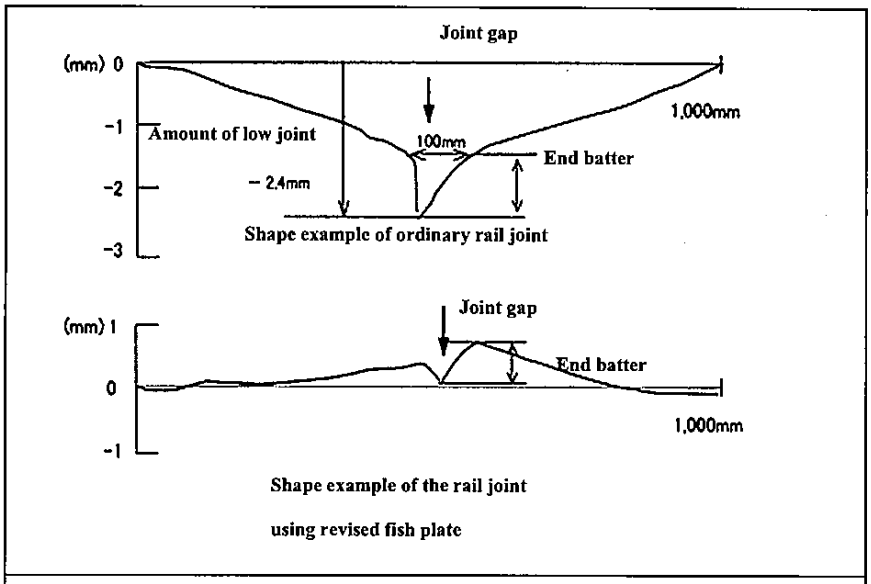


Figure-1.3.1. Shape example of the rail joint
(Single track, Annual gross tonnage: 50million ton)

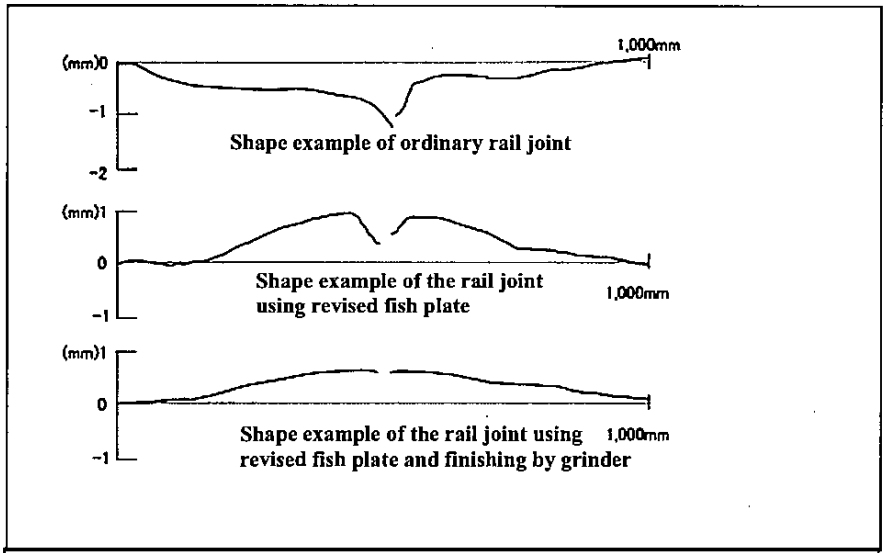


Figure-1.3.2. Shape example of the rail joint using revised fish plate and finishing by grinder

(4). End Hardened rail (EHrail)

End Hardened rail is the rail of which material is hardened by quenching rail head the range of 150mm length from the end of rail like Figure - 2.4.1..

The shape of low joint used EHrail shows on Figure - 2.4.2, Settlement of low joint is less than ordinary rail joint and the range of end rail batter is about 50mm. Namely, it is about 50mm narrower than ordinary rail joint.

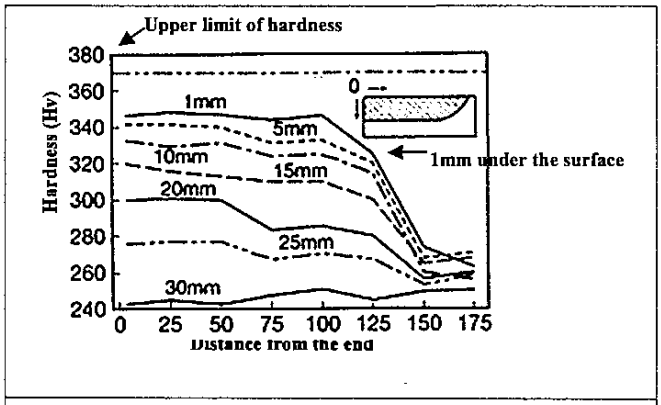


Figure - 1.4.1. Hardness of EHrail

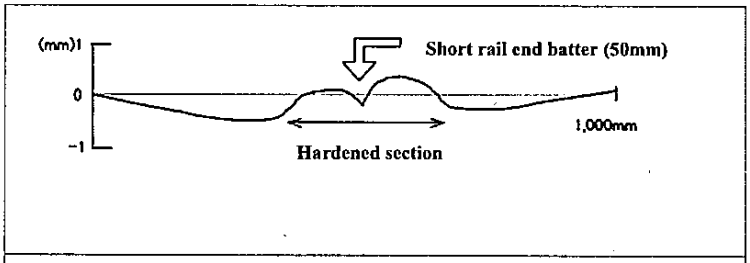


Figure - 1.4.2.

Shape example of the rail joint using ordinary fish plate

(5). Joint straightener

Photo - 2.5.1 shows the equipment example of joint straightener. This type of joint straightener is the equipment which is improved to use without moving of sleepers and ballast around the rail joint.

This type joint straightener can bend not only the main rail but also fish plates and fish plates are bent and raised.

Photo - 1.5.1

Example of Rail joint straightener

(6). To apply Anti-vibration sleeper method

This new working method is the method that the bags are installed into the gaps between sleeper and ballast and synthetic resin is installed into the bags and rail pads are changed to low spring constant pads at the same time. (See Figure - 2.6.1.)

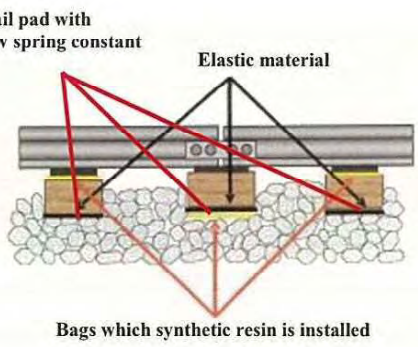


Figure - 1.6.1. Revised method for keeping suitable elasticity at the rail joint

(2) Several main points to be paid attentions for installation of long welded rail and their maintenance.

Actual Condition

1. Nowadays, MR installs 72m rail at sites after welding six 12m rails with on-rail flash-butt welding machine at depot.
2. Generally, JR named over 200m length of welded rail as "long welded rail". So, 72m rail isn't the long welded rail in Japan.
3. It is quite necessary to install long welded rails (Here in after, LWR) for increasing the riding comfort ,particularly for high speed lines, and reducing the maintenance cost

Recommendation

We want to introduce the example of several main points to be paid attentions for installation of LWR and their maintenance.

(1). Conditions in order to install LWR

1) To install them on the sections where curve radius is over 300m, in case of the curve section

2) The rail temperature in case of installing them should be kept within the range of following table in order to prevent their buckling and extreme contraction and expansion.

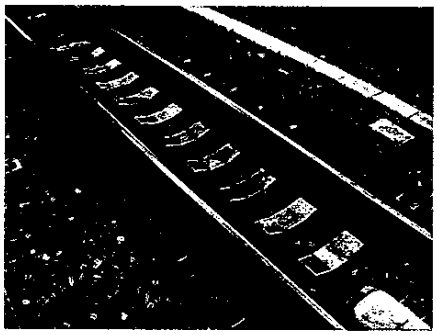
Table 2.1.2 LWR temperature for installing

	Radius of curve	Kind of rail	Lowest limit temperature than assumed maximum temperature (℃)	Highest limit temperature than assumed lowest temperature (℃)
Ballast section	R≧600m	50, 50N, 40N	35 40 (In the case where lateral ballast resistance can keep over 500kg/m)	50
	300≦R<600m	Ditto	35	50
Tunnel section [1]			20	30
Bridge section [2]			40	40

Note: 1. Assumed maximum temperature and lowest temperature should be used as temperatures in the tunnel.
2. Special measurement should be used in case of installing the long welded rail on the bridge.

3) In principle, expansion joint should be installed at both ends of LWR and shouldn't be installed in the transition curve section. (We show a example photograph of expansion joint of JR as follow;)

Photo.2.1.3 Expansion joint of JR



4) Lateral ballast resistance in the long welded rail should be kept over the values of the following table

Table 2.1.4 Lateral ballast resistance in the long welded rail of East JR

		Kind of rail	Lateral ballast resistance		
			R≧600m	600m> R ≧400m	400m> R ≧300m
Ordinary section except tunnel		50, 50N, 40N	Over 400kgf	Over 520kgf	Over 600kgf
Tunnel	Wooden sleeper	50, 50N, 40N	Over 200kgf		
	PC sleeper	50, 50N, 40N	Over 300kgf		
Turnout section which is installed in LWR		50N	Over 760kgf		
Tapering rail section which is installed in LWR			Over 600kgf		

5) LWR should be installed in the section which radius of vertical curve is over 2000m.

6) LWR shouldn't be installed in the section where extreme rail creep and/or many wheel burns don't occur.

7)Number of PC sleepers in ordinary section for LWR should be applied by the following table

Table 2.1.7-1 Number of PC sleepers in ordinary section for LWR of East JR

	Kind of rail	Number of PC sleepers
Ordinary section	40kgN rail	Over 36 PC sleepers/25m
	50kg, 50kgN rail	Over 38 PC sleepers/25m

And wooden sleepers can be used for LWR in the tunnel and on the bridge

Table 2.1.7-2 Number of wooden sleepers in tunnel section for LWR of East JR

	Classified category of line	Number of wooden sleepers
Tunnel section	1st class line	48 wooden sleepers/25m
	2nd class line	Over 41wooden sleepers/25m
	3rd class line	Over 39wooden sleepers/25m
	4th class line	Over 37wooden sleepers/25m

Table 2.1.7-3 Number of wooden sleepers on the bridge section for LWR of East JR

	Center distance of bridge girders	1st class line	2nd class line	3rd class line	4th class line	Remark
Bridge section	ℓ<1.7m	46	46	41	41	
	ℓ=1.7m	52	52	52	46	
	ℓ=1.8m	60	60	60	54	
	ℓ>1.8m	68	68	68	63	

8) Countermeasures for the non-ballast bridges in the LWR should be applied with the following methods.

a. Rail fastenings and fastenings between sleepers and bridge girders should have the structures with lateral resistance and have the structures to prevent upper lift resistance.

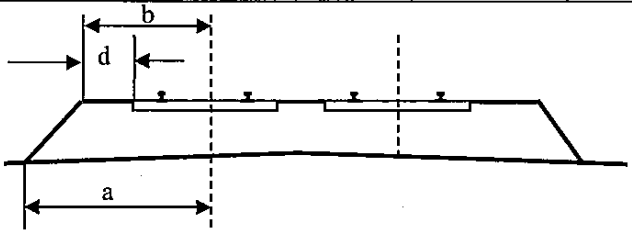
b. In principle, rail fastenings shouldn't have longitudinal resistance.

9) Methods of flash butt welding, gas pressure welding, enclosed arc welding should be used for welding methods of LWR.

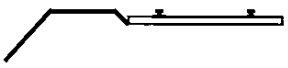
10) Ballast sholder width in the section of LWR hould be kept over the values of following table.

Table 2.1.10 Ballast sholder width in the section of LWR (In the section of double tracks)

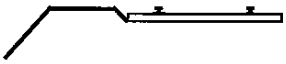
a. in case of R≧600m

Designed maximum speed (V_{max}, km/h)	Kind of rail	(a) (mm)	(b) (mm)	(d) (mm)	Remark
V_{max}>110	50, 50N,40N	Over 2,310	1400	400	
110 ≧V_{max}>90	Ditto	Over 2,310	1400	400	
90≧V_{max}	Ditto	Over 2,310	1400	400	
					

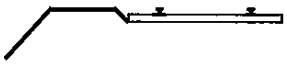
b. in case of 400m ≦R<600m and 300m ≦R<400m

Designed maximum speed (V_{max}, km/h)	Kind of rail	(a) (mm)	(b) (mm)	(d) (mm)	Remark
V_{max} >110	50, 50N,40N	Over 2,510	1,600	600	
110 ≧V_{max} >90	Ditto	Over 2,510	1,600	600	
90≧V_{max}	Ditto	Over 2,390	1,600	600	
			Ballast sholder width;600mm +Rising up ballast(150mm) +sufficiet stabilizing		

c. In the case where Turnout sections which are installed in LWR

Designed maximum speed (V_{max}, km/h)	Kind of rail	(a) (mm)	(b) (mm)	(d) (mm)	Remark
V_{max} >110	50, 50N,40N	Over 2,510	1,600	600	
110 ≧V_{max} >90	Ditto	Over 2,510	1,600	600	
90≧V_{max}	Ditto	Over 2,390	1,600	600	
			Ballast sholder width;600mm +Rising up ballast(150mm) +spraying ballast stabilizing liquid		

d. In the case where Tapering rail section which is installed in LWR

Designed maximum speed (V_{max}, km/h)	Kind of rail	(a) (mm)	(b) (mm)	(d) (mm)	Remark
V_{max} >110	50, 50N,40N	Over 2,410	1,500	500	
110 ≧V_{max} >90	Ditto	Over 2,410	1,500	500	
90≧V_{max}	Ditto	Over 2,290	1,500	500	
			Ballast sholder width;500mm +Rising up ballast(100mm) + sufficiet stabilizing		

11) Maintenance work restriction for the long welded rail section

a. After finishing the rehabilitation works between Yangon and Mandalay, a lots of long rail are installed. So, it is very important to obtain the knowledge concerning about long welded rail.

Particularly in hot season, the knowledge concerning about maintenance work restriction for the long welded rail section is the most important item, because of being directly connected with the train operation.

If track maintenance work in the long welded rail section which breaks standard of maintenance work restriction should be carried out, there is much possibility that the train derailment occurs.

Photo 2.1.11. Long welded rail buckling test at JR Technical Research Institute

b. In your information, we show the table below of JR's standard about maintenance work restriction for the long welded rail section

Table 2.1.11 JR's standard about maintenance work restriction for the long welded rail section

Class of work	Case where rail temperature is higher than the setting rail temperature			Case where rail temperature is lower than the setting rail temperature		
	Location of track maintenance work	Permissibly continuous work length	Permissible rail temperature higher than setting rail temperature	Location of track maintenance work	Permissibly continuous work length	Permissible rail temperature higher than setting rail temperature
・Ballast tamping (Rail rising amount: over 20mm) ・Alignment (Large track moving) ・Cure re-alignment、 ・Super elevation improvement	All sections	No restriction	+10℃	All sections	No restriction	−30℃
・Ballast tamping (Rail rising amount: over 20 mm)	All sections	No restriction	+15℃			
・Ballast arrangement ・Adjacent track work which give the effect to lower the lateral resistance force of ballast bed ・Test of the lateral resistance force of ballast bed ・Other works in the same works above	All sections			All sections	No restriction	−40℃
・Ballast renewal ・Ballast	All sections	Less than 2m	+10	Straight line and Curve of R≧2000m	Less than 25m	−25℃

screening ・Track lowering ・Sleeper renewal ・Fastening repair ・Gauge repair ・Other works in the same works above		2m or more than 2m	0℃	Curve of 800m≦R＜2000m	Less than 25m	−10℃
				Curve of R＜800m	Less than 25m	−5℃
				All sections	Less than 5m	−40℃

Note:

Track works which lateral resisting force of ballast shows about 250kg/m just after track maintenance works

Track works which lateral resisting force of ballast shows about 300kg/m just after track maintenance works

Track works which lateral resisting force of ballast shows about 350kg/m just after track maintenance works

Track works which lateral resisting force of ballast shows about 200kg/m just after track maintenance works

(3) Several main points to be paid attention for using big track machines such as Multiple Tie Tamper(MTT), Flash Butt Welding Machine(FBWM), Track Measuring Machine(TMM) etc.

Actual condition	1. We, JICA Study Team suppose that MR has two MTTs and FBWM now and establishes their maintenance and operating manuals already. 2. On the other hand, if the rehabilitation works between Yangon and Mandalay and of Yangon circular line commence, we suppose that many big track maintenance work machines such as MTT, FBWM, TMM etc. are needed. 3. So, we want to recommend that it is preferable for MR to look over those manuals again, taking our comments into consideration.

Comment

We want to recommend establishing the following items, taking the East JR maintenance and operating standard of track machines into consideration.

1. To establish inspection details and inspection frequency of these machines.

We show a table example of East JR's inspection details and inspection frequency of these machines.

	Inspection before starting to work		Monthly inspection		Annual inspection		Over·haul inspection	
	A	B	A	B	A	B	A	B
·Each motor Trolley	Every Before Starting to work.	7 Machine's Working days	1 machine's Working month	6 machine's Working months	1 machine's Working year	2 machine's Working years	6 machine's Working years	12 machine's Working years
·MTT, ·Rail grinding car, ·Ultrasonic rail flow detection car,						———	3 machine's Working years	6 machine's Working years
·Machines for structure maintenance				———		2 machine's Working years	6 machine's Working years	12 machine's Working years
·Auto power wrench ·Track liner		———		6 machine's Working months			———	———
· Each Road/ Rail machine		———		———		———	———	———

Note: 1.Above inspection frequency is standard.
2. In case of inspections which are established by statute, these inspections and above mentioned inspections should be carried out.

3. A,B are explained on the following table

Inspection before starting to work	A	Inspection, oiling, cleaning and simply maintenance work of important parts of machine are carried out every before starting to work.
	B	Inspection, oiling, cleaning and simply maintenance work of important parts of machineare carried out every **7 machine's working days**
Monthly inspection	A	Inspection, oiling, cleaning and maintenance work of more important parts of machineare carried out every **1machine's working month**
	B	Inspection, oiling, cleaning and maintenance work of more important parts of machine are carried out **every 6 machine's working months**
Annual inspection	A	Inspection of more important parts of machine are carried out **every 1 machine's working year**
	B	Inspection of more important parts of machine are carried out **every 2 machine's working years**
Over-haul inspection	A	**Detailed inspection of whole parts** of machine is carried out **every 3 machine's working years**
	B	**Detailed over haul inspection** is carried out according to the machine's working condition

(Remark)

These machines have to be imported from foreign country and many parts of these machines are needed for maintenance in future.

So, it is more important for MR to keep the budget in order to be able to procure the necessary parts for maintenance of these machines and also to secure foreign currency.

2. To give license to operators of these machines and personnel in charge of controlling whole works by using these machines and shunting them safely at the station with connection to the station master after finishing their training programs.

(Remark)

Especially, the result of track maintenance works by using track machines depends upon the operator's skill.

So, it is preferable to train them to get sufficient knowledge of structure of these machines and to get the operating skill well.

Anyway, we suppose that it takes at least six months trainings for getting the good skill.

And it is more preferable for them to train at Japan or other countries.

3. To establish the maximum speed limit of these machines when they move. Because, as many other track maintenance groups do their works at related sections ordinarily, we have many experiences of accidents between these machines and other track maintenance groups.

We show an table example below of maximum speed limit of track maintenance machines.

Table 3.3 Maximum speed limit of track maintenance machines of East JR.

When track maintenance machines move at outside sections from the stations	45km/h
When they move and haul the trolley	30km/h
When they move in the stations	25km/h

3.2 Rolling Stock

3. 2 Rolling Stock

3.2.1 General

Technical standards are essential to operate the railway safely and efficiently. However technical standards are not defined systematically.

3.2.2 Review of Documents Regarding Technical Standard of Rolling Stock

Regarding technical standard of rolling stock, the following documents have been reviewed.

Table 3.2.1 List of Documents Reviewed

No.	Title
1	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Mechanical)
2	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Electrical)
3	Examination and repair of C & W stock
4	General Technical Specifications for Meter Gauge Bogie Passenger Coaches
5	General Technical Specifications for Meter Gauge Bogie Freight Wagons
6	General Technical Specification for Design, Supply and Domestic Manufacturing of Meter Gauge Bogie Passenger Coaches
7	General Technical Specifications for Meter Gauge Bogie Passenger Coach Type BDTEZ
8	Technical Specifications for 1200 Horse Power Diesel Hydraulic Locomotive
9	Technical Specifications for Meter Gauge 1200/2000 Horse Power for Hillsection Diesel Electric Locomotives for Plain Section
10	Technical Specifications for Meter Gauge 2000 Horse Power Diesel Electric Locomotives
11	Technical Specifications for In-Service Diesel Electric Locomotives
12	Technical Specifications for YDM4 Class Locomotive (1000mm Gauge)
13	Technical Specifications for Meter Gauge 2000HP Diesel Electric Locomotives
14	Technical Specification for Meter Gauge Bogie Day Upper Class Passenger Coach
15	Technical Specifications for Meter Gauge Bogie Ballasted Hopper Wagons
16	Particular Technical Specification for Meter Gauge Four-Axle Bogie Well Wagon for Container
17	Technical Specification for Meter Gauge Bogie Covered Wagon Type - GBHV
18	Technical Specification for Meter Gauge Bogie Sugarcane Cum Material Wagon Type – SMBV
19	Technical Specification for Meter Gauge Bogie Material Wagon Type - MBHV

Two types of technical standards are required for rolling stock, one is for construction and the other is for maintenance.
For construction, general criteria that will assure the safety and compatibility shall be defined. Particular specification for each type of rolling stock will be prepared based on the criteria.
For maintenance, rank and interval of scheduled maintenance including items to inspect in each rank shall be defined. Also criteria that will assure the normal/safe operation until next regular maintenance shall be defined.

Documents listed above are classified as follows.

Table 3.22 Classification of the Documents

		Locomotive		Passenger Coach	Freight Wagon	DMU
		Electric	Hydraulic			
Construction	General criteria	-	-	-	-	-
	Specification	9,10,11,12,13	8	4,6,7,14	5,15,16,17,18,19	-
Maintenance	Item to Inspect	1	2	3	3	-
	Criteria*	(1)	(2)	(3)	(3)	-

Number in the table indicates item listed in table 1.1
** Items described are not sufficient.*

For the construction it is deemed there are no documented general criteria. Criteria for construction are described in specification of each car type.

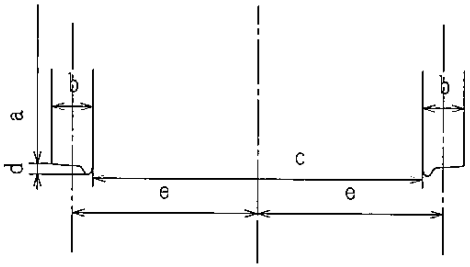
For maintenance of locomotive, maintenance rank are classified into M1 to M8. Maintenance interval and items to inspect from M1 to M5 are described in the documents listed above. However it is not clear if criteria for maintenance and items for M6 to M8 are documented or not.
For maintenance of coaches and wagons "Circular C&W No.38/1952" is used as maintenance manual. Interval and items to inspect are described but criteria are described for very few items. The items to be inspected are too simple because this manual was issued more than 60 years ago.

There are various rolling stocks donated from foreign countries and many of them are second hand rolling stock. It should also be considered that those rolling stock should comply with new standard.

3.2.3 Construction of Rolling Stock

It is deemed that when constructing new rolling stock, criteria is defined in the requirement of rolling stock type by type and no general rule exists.
General criteria for rolling stock construction shall be defined and specification of each type of rolling stock shall comply with the criteria. It will be applied for remodeling or modifying the rolling stock as well.
The following table indicates the general criteria recommended to be defined for rolling stock construction.

No.	Title	Description Recommended	Note
1.1	Size Limit	Rolling Stock shall be constructed within load gauge.	*Load gauge is already defined in Myanmar Railway as figure No. 2S.0489.C&W.* *Load gauge is defined under condition that rolling stock is stand still on tangent track.* *Construction Gauge or Structure Gauge is also defined for wayside structures.*
1.2	Widening of load gauge	On the curved track, width of load gauge can be widened depending on radius of curve.	*On the curved track, structure gauge should be widened depend on radius of curve. Dimension of widening of structure gauge is defined based on standard type of rolling stock. Dimension for widening of load gauge shall be same as widening of structure gauge. When longitudinal dimension of rolling stock is same or less than standard type of rolling stock, any part of rolling stock will be within construction gauge but when dimension of rolling stock is more than standard rolling stock, it must be checked that any part of rolling stock will not exceed load gauge on curved track.* *In Japanese Railway, the following formula is applied for calculating widening of structure gauge.* $W = 23,100/R$ *Where W : dimension to be widened (mm)* *R : radius of curve (m)*

No.	Title	Description Recommended	Note
2.1	**Running Gear**	Running gear shall be solid with sufficient strength, shall be capable of ensuring the safe as well as stable running of rolling stock and shall not damage the track.	*Dimensions of wheel and tread profile shall be defined.* *At least following dimensions shall be defined*  a: wheel diameter b: wheel rim width c: distance between inner surface of pair wheel rims (back gauge) d: tire flange height e: distance from center line of wheel pair to wheel tread
2.2		The distribution of the axles of a car shall allow the vehicle to pass the minimum radius of the running line without any problems.	*Minimum radius of curve to pass shall be defined.*

No.	Title	Description Recommended	Note
3	**Motive Power Apparatuses**	Vehicle with internal-combustion engine shall conform to the following criteria.	*In Myanmar Railway, diesel engine is used to create motive power of rolling stock. When electrification is introduced criteria for electric train shall be defined.*
		a. Engine shall be suitably protected so as not to generate extremely high heat.	*Engine should be equipped with protection system such as to stop the engine when pressure of lubricating oil is low also to stop or to unload the engine when temperature of cooling water is high.*
		b. Floor and side wall shall be installed to prevent taking fire by the heat of engine.	
		c. Fuel tank and fueling pipe shall be constructed so as to be prevented from fuel leakage and flash off.	*Inlet of the fuel and outlet of releasing gas shall be constructed to prevent leakage of fuel by vibration of the vehicle and shall not face inside the cabin.*
		d. Exhaust pipe shall be constructed so as to prevent hazard for passengers by the heat and exhaust gas, and to prevent malfunction of other equipment by the heat.	*Exhaust pipe shall not be installed in passengers saloon except that the pipe is well protected and thermally insulated.*
4	**Constraints with Respect to Track and Structures**	Maximum axle load shall be 12.5ton	*Maximum axle load shall be defined. It is also important that load distribution determined by arrangement of axles. However allowable load is varied by lines. It should be checked for line by line when installing rolling stock each time.*

No.	Title	Description Recommended	Note
5.1	**Brake System**	Brake system shall be air brake system.	*It is preferable to standardize the brake system to air brake for safety and improvement of the service level.*
5.2		Brake system shall have capability to stop the train within ***m from maximum speed.	*Basic function of brake system is to stop the train within certain distance that will be defined by signaling system.* *Brake distance shall be defined based on the condition of Myanmar Railway. For reference, maximum brake distance is defined 600m in Japanese railways.*
5.3		Brake equipment shall be controlled throughout all cars composing a train when operated from the crew section.	*To stop the train safely, all cars composing a train shall be equipped with brake system and those shall be controlled from crew cabin and activate brake force for all cars simultaneously.*
5.4		Brake equipment shall automatically produce braking force in case any of cars of a train is disconnected.	*This function is very important for railway system. Even when the brake system is not air brake such as vacuum brake or actuator powered by electricity vehicles shall have function to stop automatically in case of train parting.*
5.5		Rolling stock shall be equipped with an independent braking function to stop the train in case of failure of normal brake equipment.	*Currently this function is not equipped in existing rolling stock except some DMU donated from foreign countries. The brake system is called straight air reserve brake and it can be operated by switch installed in drivers cab in case of emergency. It shall be examined when train speed becomes higher.*

No.	Title	Description Recommended	Note
6	**Structure of Passenger Cabin**	The structure of passenger cabin shall conform to the following requirement.	
		a. Windows shall have sufficient strength and shall not touch any wayside structures at open condition and there shall be no possibility for passengers to fall down from windows.	*Windows shall have sufficient strength and shall not touch any wayside structures at open condition and there shall no possibility for passengers to fall down from windows.*
		b. The passenger room shall have lighting equipment required at night or when running through tunnels, and enough brightness shall be maintained in case of emergency.	*Illumminance level of the room shall be defined depending on usage of the room.*
		c. Toilets shall be provided depending on the usage and operation distance of rolling stock.	*When toilet is installed, sanitation system shall be installed as well.*
7.1	**Passenger Door**	Passenger doorway will have a structure which ensures the safe and smooth boarding and disembarking of passengers and there shall be no danger of passengers stumbling.	*Width and height of door way and height of floor or step from platform level shall be defined depending on car type.*

No.	Title	Description Recommended	Note
7.2		Passenger door shall be operated by automatic door control device to secure the safety.	*Currently passenger doors of most of the cars of Myanmar railway are opened manually and it allows passengers to go in/out the car while train is running. There is a possibility that passenger will fall from running train. Safety of the passengers should be secured by automatic door control device.*
7.3		Automatic door control device shall have following function.	*Door opening and closing time, minimum door force at closing, shall be defined in each car type.*
		a. Door control device shall allow the verification of door status of open or closure by crew.	*Usually in the DMU or EMU in the world, door pilot lamp is installed at the side of car body and door close pilot lamp is installed in drivers cab.*
		b. Train shall not be able to accelerate when any of doors is open.	*It can make an exception of the case where status of door is confirmed by train crew for the train drawn by locomotive.*
		c. Door will not open when train is moving.	*There is possibility that crew will activate door open command by mistake while train is running. To prevent such incident, door control device will get the signal from speed detector and keep the doors close even door open command is activated when train is not standing still.*
		d. Door control device shall allow manual opening at the time of emergency	*In case of accident such as train fire it is not safe in passenger cabin and passengers have to evacuate form the car. There is also possibility that door control system failure occurs or train crew is not available to open the door. Doors shall have manual opening function.*

No.	Title	Description Recommended	Note
8.1	**Coupling Device**	The device required to connect rolling stock shall be solid with sufficient strength and shall be capable of connecting the cars securely withstanding vibrations and impacts.	*Strength against the load such as maximum compressive load and maximum tensile load shall be defined depending on the type of rolling stock.*
8.2		Coupler of locomotive, passenger car and freight wagon shall be automatic coupler.	*Two types of coupler are used in Myanmar Railway, ABC Hook type and AARE type. They should be standardized to keep compatibility in coupling and AARE type is recommended for the standard. Contour and height of the coupler shall be defined. For DMU, vehicles are coupled with same type of car therefore compatibility is not important. However considering the rescue operation it is preferable to install compatible coupler.*
9.1	**Fire Prevention for Rolling Stock**	Onboard wires shall not cause fire or spreading of fire even in the presence of anticipated heat generating sources. Onboard heat generating equipment shall not adversely affect other sections of rolling stock.	*Engine and exhaust pipe of the engine shall be thermally isolated from structures and other equipment of rolling stock.*
9.2		Vehicle body shall be composed of construction and materials which can prevent breaking out and spreading of fire.	*Materials to be used in the rolling stock shall be classified based on the level of flame resistance. It shall be certified by authorized agency, and the material without certification shall not be used.*
9.3		Facilities to extinguish a fire shall be installed in locomotive, vehicles with passenger saloon and wagons with crew cabin.	*Fire extinguisher shall be installed in the drivers cab, engine room, passengers saloon and crew cabin to fight with fire at early stage.*

3.2.4 Maintenance of Rolling Stock

(1) Maintenance of Locomotive

Maintenance of diesel electric locomotive is defined in "Diesel Electric Locomotive and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Electric)" and maintenance of diesel hydraulic locomotive is defined in "Diesel Electric Locomotive and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Electric)". In these manuals the period, and the item to be inspected for the rank of M1 to M5 are defined. It is not clear if there are such manuals for M6 to M8.

For checking air pressure, different units are used depending on the type of the locomotive. It is recommended to standardize the unit of pressure gauge.

(2) Maintenance of Coach and Wagon

For passenger coach and freight wagon, "Circular C&W No.38/1952 Examination and Repair of C & W stock" is the manual for maintenance. However this manual is issued in 1952. Some of the description is out of date and new system such as air brake system is not included. Following item shall be added.

a. Electrical equipments other than battery and lighting system
b. Solid type wheel
c. Air suspension bogie
d. Rolling bearing

Compared to the maintenance instructions of locomotive, description is too simple. Detailed manual shall be required for actual maintenance work.

(3) Maintenance of DMU

Also it is not clear if there is manual for DMU. There are several types of DMU because most of them are donated from foreign countries and systems are varied.

It is recommended to prepare maintenance instruction for each car type systematically and following items described in table 3.2.4 shall be included.

Table 3.2.4 Recommended Criteria for Rolling Stock Maintenance

No.	Title	Description Recommended	Note
1	**Dimensions of wheel**	Following dimension shall be measured. a. Wheel diameter b. Distance from center of wheel pair to outer surface of wheel rim c. Flange height d. Flange wear e. Distance between inner surface of pair wheel rims	*Wheel will wear when the car is running long time. Worn wheel might cause derailment especially the case of flange wear. Dimensions of the wheel shall be checked for safety operation.* *Criteria shall be defined based on designed dimensions.*
2	**Deference of wheel diameter**	Difference of wheel diameter shall be within following value. (1) Locomotive a. same wheel set 1.0mm b. same bogie 1.0mm c. same car 20 mm (DEL) 1.0mm(DHL) (2) Coach and wagon a. same wheel set 1.0mm b. same bogie 3.0mm c. same car 12 mm	*When there is difference in wheel diameter it will cause unusual wheel wear and degradation of train performance.*
3	**Air leakage of brake system**	Pressure of main reservoir and brake cylinder shall be measured at lapping position. After 1 minute, dropping of air pressure shall not exceed 20kPa.	*Even if function is good at starting, when there is leakage of air, it might cause an accident. Air leakage shall be checked at least monthly.*
4	**Insulation**	Insulation of electrical circuit shall be measured by 100V megohmmeter. Insulation resistance shall be less than 0.05MΩ.	

3.3 Signaling/Telecommunication

3.3 Signaling / Telecommunication

1. The current status of the technical standards and other regulations in the signal and telecommunication divisions, Myanma Railways

We confirmed the current status of the technical standards and other regulations in the signal and telecommunication divisions, Myanma Railways (hereinafter referred to as "MR"), through the present study and made proposals to improve safety and service levels based on the study results as described below. In the process of the study, we inquired and consulted with MR counterparts and those in the signal and telecommunication divisions regarding the current regulations and technical standards. As a result, we found that MR has the following regulations and technical standards on signal and telecommunication.

1) Railways in Burma, General rules for ALL OPEN LINES OF RAILWAS IN BURMA ADMINISTERED BY BURMA RAILWAYS BOARD Part I & II Together with The SUBSIDIARY RULES
2) BURMA RAILWAYS. TRAIN SIGNALLING INSTRUCTIONS FOR THE Double and Single Lines BY Electric Block Instruments AND BY Telegraph or Telephones ON THE Absolute Block System
3) BURMA RAILWAYS.MANUAL OF THE ENGINEERING DEPARTMENT
CHAPTER VIII SIGNAL AND TELE - COMMUNICATION

These regulations were all adopted way back in 1948. These rules are very old. However, signal and telecommunication equipment and facilities we observed in the field were all old-fashioned to match such present standards. This means that the regulations are paradoxically fairly up-to-date when MR's current situation is duly taken into consideration or that MR's signal and telecommunication equipment and facilities are extremely obsolete and impoverished in other words, though there are some exceptions.

Following are discords between the standards to present situation of equipment and facilities in fields.

(1) The present status of signal equipment and facilities, and problems regarding the standards

The basic systems of signal equipment and facilities are used in principle in accordance with present standards. However, the regulation of the equipment introduced after the regulation was defined is not added. To locate problems in the current standards, we extracted such prohlematic equipment and facilities as cited below.

1) BURMA RAILWAYS. TRAIN SIGNALLING INSTRUCTIONS FOR THE Double and Single Lines BY Electric Block Instruments AND BY Telegraph or Telephones ON THE Absolute Block System
Block systems working with electric instruments in Chapters III and IV
The block system equipment of Tyer's type using telecommunication lines is specified in the regulation as a

block system. In the same the line-clear ticket system to use telegraph is stipulated for double track lines. However, MR is not using the block system equipment of Tyer's type, because telecommunication lines had broken. In the current line-clear ticket system, blocking is established through communications between station-masters involved over wireless or automatic telephones using optical fiber cables in place of defective telecommunication lines. After that line-clear tickets are issued. This is not the formal train operation in compliance with the relevant standards, however.

The automatic block system using three-aspect signals is stipulated for some sections. Despite that, three-aspect signaling is not implemented in automatic block sections. The reason why is that three-aspect signaling is using only two aspects remaining effective to indicate whether the protected section is occupied or non-occupied.

This doesn't mean that standards are too obsolete to cope with the current situation. Rather that, block system cannot be operated in accordance with regulations, because block system equipment are too used up.

2) Railways in Burma, General rules for ALL OPEN LINES OF RAILWAS IN BURMA ADMINISTERED BY BURMA RAILWAYS BOARD Part I & II Together with The SUBSIDIARY RULES

Signals in Chapter II

The regulation of the signal equipment is defined about the semaphore signal. The field equipment is maintained still now according to it. However, most of distant signals don't function.

A regulation provides color light signals with the meaning of route-clear as three-aspects and another regulation prescribes G-, Y- and YY-aspects for distant signals. In this manner, there are regulations for main signals, with the actual signal system introduced approximately in compliance with them.

A shunting signal is to be governed by regulations in basically. Despite that, those installed at each station are differenced in specification as an aftermath of the installation of different versions matching the relay interlocking systems of different origins after such regulations were put in force. As there are no rules for shunting indicators or route indicators.

In contrast, point machine indicators are formally adopted in a regulation, with those in compliance therewith being used.

3) BURMA RAILWAYS.MANUAL OF THE ENGINEERING DEPARTMENT

Signal and telecommunication equipment and facilities in Chapter VIII

The voltage or types are not unified for point machines, with power-driven machines imported from corresponding relay interlocking system exporting countries and those to replace them later from other countries, for example. There are no detailed rules to specify their types or procedures for introduction

either, with no action has been taken to prepare unified regulations on imported equipment and facilities. Therefore, methods of maintenance or specifications are not set forth for point machines that require much manpower for maintenance in particular, with promiscuous machines imported and methods of maintenance entrusted to experience field workers.

Regarding the interlocking system, mechanical interlocking and electric interlocking versions are referred to in regulations. But, there is no regulation of Relay interlocking system on specifications for those introduced in the 1960s. As a result, those of different versions, Japanese and German, and other types are used in the field, for which workers are suffering hardships in maintenance. Regarding the electronic interlocking system for which introduction work is under way in recent years, no specifications set forth for introduction. In contrast, a variety of regulations have been adopted for the mechanical interlocking system including point machines and other components.

In regard to DC and AC type track circuits, regulations are in force for components, specifications and methods of maintenance, with the methods of maintenance and measurement for track circuits supplemented. No large-degree deviations are seen from the relevant regulations with the current equipment and facilities.

Level crossing warning devices are being introduced into some level crossings in recent years, for which standards or rules similar thereto haven't been adopted so far, however. Despite that maintenance workers have difficulty in providing these level crossings with their own maintenance services, level crossing equipment or facilities don't work satisfactorily partly due to superannuation.

(2) Telecommunication equipment and facilities

A regulation exists to govern telecommunication lines and methods of maintenance. At the moment, however, MR doesn't implement maintenance or upkeep of telecommunication lines, with equipment and facilities not functioning excepting some as a result. Specifications or regulations don't exist either for wireless equipment and facilities, optical cables or others introduced in recent years.

(3) Methods of maintenance

As we explained for some equipment and facilities above, regulations are in force for the contents and methods of maintenance. For track circuits and telecommunication lines, detailed measurement items are specified in a format to record changes observed through monthly measurement. For the mechanical interlocking system, a format is specified to record the results of monthly or weekly maintenance on a regular basis. A history card format is specified for storage batteries to record in succession the results of regular inspections. For the method of maintenance of such signal and telecommunication equipment and facilities, provisions are set forth to implement preventive maintenance through prior inspection instead of breakdown maintenance. However, such detailed regulations cover only part of and not the whole of the

existing equipment and facilities. For the equipment and facilities introduced after adoption of regulations, it doesn't seem that action has been taken to adopt regulations every time when an item is introduced. This means that the newer the equipment and facilities are, the less unified methods have been established for maintenance. Such equipment and facilities are provided with maintenance services based on the experience in the field.

(4) Structure for maintenance

Structure for maintenance and responsibility is specified in regulations, and the structure for maintenance of signal and telecommunication are established based on the regulations. The structure for maintenance including the number of maintenance workers changes according to the changes in the route length and the size and number of equipment and facilities.

2. Recommendations and proposals for technical standards and regulations in the signal and telecommunication divisions

The standards in signal and telecommunication are governed by certain regulations as explained above, part of which have contents effective even at present. However, they are extremely old-fashioned as a whole, with no traces seen to indicate integrated regulations have been discussed for newly introduced equipment and facilities in particular. As a result, different stations are installed with equipment and facilities of different specifications, as standards are not unified in introducing new equipment and facilities. This is far from an appropriate state from the viewpoint of guaranteeing safety. It is required, therefore, to adopt definite standards to encompass different equipment and facilities under an umbrella, thereby unifying methods of use, maintenance and upkeep in order to guarantee safety. For the equipment and facilities introduced so far, therefore, scrutinize and clarify specifications once again and adopt specifications and standards on maintenance appropriate for each item of the equipment and facilities.

For equipment and facilities that have been introduced in recent years or to be introduced in the future including electronic interlocking systems, prepare standards and specifications based on MR's experience in the past and eliminate those that don't suit MR's current status as far as possible. For this purpose as well, arrangement shall be made within MR to adopt specifications and standards on introduction of such new equipment and facilities, which makes the role of engineers in the signal and telecommunication divisions more important. In preparing such standards, assistance from third parties may be necessary to some extent, in that Japan offer advice to MR based on its experience for long years and extend cooperation to work together with MR.

Regarding the methods of maintenance, standards shall be renewed to implement maintenance based on the concept of preventive maintenance that has already been shown for some equipment and facilities. The

safety of the hitherto functioning equipment and facilities cannot be guaranteed, unless standards on the method of maintenance are urgently established and put in force to suit the equipment and facilities existing and to be newly introduced in the future. As the skill and morale of signal and telecommunication engineers are fortunately high enough, adopt regulations corresponding to equipment and facilities, make them understood among signal and telecommunication engineers and implement once again a technical guidance program to apply them to maintenance. At the same time, standards and regulations shall quickly be formulated for the equipment and facilities introduced in recent years and those to follow suit. In such procedures as well, it will be effective to accept advice and proposals from Japan or other third parties.

Integrated specifications and methods of maintenance shall be established in particular, for (1) optical fibers cable, (2) electronic interlocking equipment, level-crossing alarms, automatic train protection systems and other equipment and facilities to be newly introduced and (3) electric point machines and track circuits at present and in the future.

3.4 Train Operation

3.4 Train Operation

Operation rules are instituted with certain preconditions assumed on train operation handling equipment and facilities, personnel in charge thereof, environments and other miscellaneous matters. As far as the preconditions remain unchanged, therefore, operation rules shall never be reviewed unnecessarily. In the railways of Japan, however, higher levels of safety are ceaselessly pursued based on the accidents and lessons in the past, with untiring efforts being made continuously to improve hardware and software measures depending on the levels.

Let's introduce hereunder comments and cases in relation to part of General Rules based on the operation rules of the current railway companies in Japan. We wish that these comments and cases help contribute to the quality improvement of Myanmar Railways in the future.

[Chapter 2]

	Provision	Cases in Japanese railway companies
1	P40 <Original> S.R36 (4) If in a case, other than that of emergency, it is found necessary, after a signal has been taken "OFF" for a train, to put back the signal to "ON", the Station Master shall, before putting back the signal to "ON", - (i) ensure that the train has not yet commenced to move or, if it is already on the move, bring the train to a stop by means of hand signals, and	
	[Comments] (1) Prescription meaning that, when the station master returns a signal to "ON" in a non-emergency state, the train that has already started shall be stopped by a hand signal. → To stop a train by a hand signal, the signal shall be displayed before the train for acknowledgment by the driver. When the train has moved in the opposite direction or has passed the position of flag man/woman, however, he/she cannot show a hand signal before the train.	(1) It is stipulated that the person in charge of a station or a dispatcher shall instruct the driver to stop the train through a wireless transmitter.

	Provision	Cases in Japanese railway companies
2	P40 <Original> 37. Reception and Despatch OF Trains. (a) The Station Master shall not give permission to take signals "OFF" or issue an authority to pass signals at danger, to admit a train or allow a train to leave the station until, (i) all facing points over which the train will pass are correctly set and locked; (ii) all trailing points over which the train will pass are correctly set and locked; (iii) the line over which the train is to pass is clear and free from obstructions.	(1) It is prescribed that, in the state where signals don't function due to track short-circuiting, the person in charge can start trains after confirming that there are no obstacles on the route. (2) When the interlocking system is normal, it isn't checked whether obstacles are on the route for the train.
	[Comments] (1) Prescription meaning that the station master shall not issue permission for trains to enter into or depart from the station, before the above action (i), (ii) or (iii) has been taken. → Although the paragraph (iii) above stipulates that "the line over which the train is to pass is clear and free from obstructions ," it is not possible, at night, to check whether the route is clear without obstructions, unless an inspector witnesses the spot every time.	

	Provision	Cases in Japanese railway companies
3	P42 <Original> S.R.37 (5) Manning of Points. (a) At all NONINTERLOKED stations when trains run through, all facing points over which the train shall pass must be manned. In the case of stopping trains only the outermost facing points must be manned. When points are manned, the man in charge shall, if the conditions of G.R.37 for the reception of an approaching train are not carried out, show towards the train a red flag by day and red light by night until they are carried out, when he shall show a green flag by day and a green light by night until the train has passed. (b) Trailing points need not be manned.	
	[Comments] (1) The following prescriptions in the GENERAL RULES for totally non-interlocked stations • Each of the facing points shall be manned when a train passes. • The outermost facing point alone shall be manned for stopping trains. • "Trailing points need not be manned." → Whereas facing points shall be manned, why aren't trailing points manned? → Trailing points are apprehended to potentially cause a trailing accident or derailment when the set route is wrong.	(1) As the signal and the point are interlocked, the signal remains with a red aspect, in case the point has caused improper contact between stock and tongue rails. (2) It is stipulated that, when the stock and tongue rails aren't in close contact in establishing a route for a departing train by manually switching a point, the person in charge shall use a locking metal to guarantee the contact in between. (3) In manning points, trailing and facing points are not distinguished.

	Provision	Cases in Japanese railway companies
4	P48 <Original> 44.Signal Cabins. The Station Master shall make himself thoroughly acquainted with the duties of the staff employed in the signal cabins, if any, at his station and satisfy himself that they perform their duties correctly; and in order to maintain an effectual supervision over the said staff frequently visit the signal cabins.	
	[Comments] (1) Prescription "The Station Master… and in order to maintain an effectual supervision over the said staff, frequently visit the signal cabins." → In actuality, he/she who is busy enough in performing his/her duties needn't do so. To facilitate a variety of supervisory actions, specify a number of alternative means, therefore.	(1) As CTC is quickly being introduced, most of the train operation handling services are implemented at the train dispatching center. (2) Station masters responsible for supervising subordinates rely on a method dependent on the worksite conditions.

	Provision	Cases in Japanese railway companies
5	P50 <Original> S.R.48 (f) where the running through train is crossing or preceding any other train or trains the Guards of the halting trains shall inspect all facing points over which the running through train will pass and shall remain with the Station Master at the outermost facing points until the train has passed. The Guard shall be jointly responsible with the Station Master that all facing points over which the running through train will pass are correctly set and locked.	(1) There are trains a conductor in charge is not on board
	[Comments] (1) Prescription meaning that the Guards of the halting trains shall inspect all facing points over which the running through train will pass and shall be jointly responsible with the Station Master that all facing points over which the running through train will pass are correctly set and locked. → Regarding the track layout and routes for passing trains in a station yard, those who have the best knowledge thereof are the staff of that station. It is hardly believable, therefore, that the Guards on duty for a train casually at stop at the station can correctly check the point on the route set for a passing train. → Even though the Guards on duty for the train casually at stop at the station is supposed to check the route for a passing train jointly with the station master, not the Guards but the station master shall wholly be responsible therefor.	(2) The station master is wholly responsible for setting a route required for the departing train.

[Chapter 3]

	Provision	Cases in Japanese railway companies
6	P70 <Original> 87. Setting watch. Before a train starts from a terminal or engine-changing station, the Guard in charge shall set his watch by the station clock and communicate the time to the Driver who shall set his watch accordingly.	
	[Comments] (1) Prescription meaning that the Guard in charge shall set his watch by the station clock at and communicate the time to the Driver who shall set his watch accordingly. → The services of the Guard in charge start at the time of their reporting to the station, when their watches should have been set. Even if they are allowed to set their watches at the station, isn't it possible for the Driver to set his/her watch according to the station clock, as he/she is also present at the station? If the watches of the Guard and that of the train driver are compared with each other thereafter, errors in setting watches can be avoided.	(1) Train drivers and conductors set their watches at the work place where they report to.

	Provision	Cases in Japanese railway companies
7	P91 <Original> S.R.105. Staff working under vehicles. Whenever it is necessary for the Carriage or Electrical staff to work underneath or between carriage or in any other dangerous position, where they are likely to be injured by the movement of such vehicle or train, they must – (1) First protect themselves by placing two red flags or lamps at each end of the train. (2) These flags or lamps should be placed so as to be clearly visible on both sides and in both directions, and may only be removed by the person who put them in position, or under his direct instructions.	(1) Regarding the procedure to remove red flags or lamps after completing underfloor services, what is prescribed is not only the person who has the authority to do so but also obligation to confirm that there are no persons under the car.
	[Comments] (1) Prescription meaning that the worker who implements car-underfloor inspection and maintenance services shall place two red flags or two red lamps to protect himself/herself beforehand at each end of the relevant train set, which flags or lamps can be removed only by the person who put them in position, or under his direct instructions. → What is important before removing the red flags or red lamps after completion of underfloor services is to confirm that there are no persons under the car or the train set. → As a person allowed to remove the flags or lamps specified is the person so directed by the person who put them. Unless the person strictly check the underfloor safety, however, only the order by the person who put them is meaningless from the viewpoint of safety assurance.	

[Chapter 4]

	Provision	Cases in Japanese railway companies
8	P120- P121 163. Duty for securing safety. 164. Accident or obstruction.	
	[Comments] (1) Prescription meaning that the following items shall be observed as the duty to secure safety at accident. (a) See that every exertion is made for ensuring the safety of the public. (b) Promptly report to his immediate superior any occurrence affecting the safe or proper working of the railway which may come to his notice.. (c) Render on demand all possible assistance in case of an accident or obstruction. → There are no descriptions on the concrete action to prevent secondary accidents or to behave with the top priority placed on human life	Based on the lessons regarding the serious accidents in the past, it is stipulated that top priority be placed on the following. (1) Prevention of concurrent accidents (2) Relief and protection of passengers.

	Provision	Cases in Japanese railway companies
9	P128 <Original> 171. Fire In the event of a Railway servant noticing a fire likely to cause damage to railway property, he shall take all possible steps to extinguish it and to prevent it from spreading, and report the occurrence to the nearest Station Master, except that in case of fire on electrical equipment he shall make no attempt to extinguish the fire but shall in every case report the occurrence to the nearest Station Master immediately unless he shall have received special instructions directing otherwise. Station Masters on receipt of information of fire on electrical equipment shall take such action as may be prescribed by special instructions.	
	[Comments] (1) Prescription meaning that action be taken by a Railway servant at fire likely to cause damage to railway property. → It is not possible for a Railway servant to judge whether railway property be damaged or not at fire. It is often the case that a fire judged by a Railway servant optimistically as "possibly safe" led to a catastrophic disaster in the event. Not relying on the judgment by a Railway servant, immediately take due action against a fire irrespective of its scale. → No provisions are set forth to immediately stop relevant trains.	(1) It is stipulated that relevant trains shall be stopped immediately, when occurrence of train fire has been observed. Based on the lessons regarding a catastrophic accident occurred when a train on fire was stopped in a tunnel: (2) It is prescribed that trains shall be stopped at places other than in tunnel or on bridge.

[Matters not prescribed in the existing rules]

	Comments	Cases in Japanese railway companies
10	(1) As this General Rules shall be observed by railway employees, norms to be abided by always by railway employees shall be set forth at the beginning. (2) There are no provisions on the aptitude or knowledge of the staff in charge of train operation services or methods to confirm their skill or those related to their nature.	(1) Stipulate safety norms and important mental preparedness of railway employees at the beginning of the General Rule. (Example) • Guarantee of safety is the soul of transport. • Observance of rules is the basis of safety. • Rigorous services are a requirement for safety. [Detailed rules] Carrying a rule book, understanding and observance of rules, thoroughness of communication, repetition of confirmation, etc. (2) Stipulate the matters related to the management of quality of employees Aptitude test, education, training and knowledge, confirmation of skill
11	(1) There are no rules to regulate train operation in heavy rainfall or strong winds	(1) Restriction of train operation at disaster and the removal procedure therefor are prescribed. * Concrete rules on the restriction of train operation and speed are specified for civil engineering fields.
12	(1) In case a separation accident occurs with a train running coupled with another disabled due to failure or for other reasons, arrangements shall be made for brakes to be effective on the head and tail cars, which is not prescribed, however. (2) In case the arrangements referred to above are not practical, arrangements shall be made to prevent a train separation accident. There are no provisions therefor, however. → An MRT train derailment accident in Manila, the Philippines (August 13, 2014) A car that became inoperative before the terminal of MRT line 3 was running coupled with and pushed by a succeeding train, when a coupler connection of the car failed just immediately before the terminal to cause collision with a car stopper and derailment as brakes were not functional.	The following are stipulated. (1) In case a separation accident occurs with a train running coupled with another disabled due to failure or for other reasons, arrangements shall be made for brakes to be effective on the head and tail cars. (2) In case the arrangements in the above paragraph (1) are not practical, take measures to prevent a train separation.

3.5 Structure

3.5. Structures

Structures are one of the railway facilities which ensure the safety and on-time train operation. For the achievement of its purpose, responsible way or work engineers and bellows should maintain structures in good soundness and alternate it if any. And in the case of natural disaster, they should consider whether the line is unsafe or not by patrolling as soon as possible. We, JICA Expert Team suppose that it is quite similar work for the purpose of structure between Myanmar and Japan.

Hereby, we show the annual number of disaster occurred railways in Japan in past 45years in figure 3.6.1. It is thought that after changing maintenance method for all railway facilities including structures, corrective maintenance to preventive maintenance, the number has been decreasing. Corrective maintenance means that repair the facilities after deterioration or some accidents occurred. On the other hand, preventive maintenance means that repair the facilities before those throughout the execution of proper inspection and repair, hence railway facilities always are in better soundness and less vulnerable length. But, unless adequate budge can be invested, it never comes true.

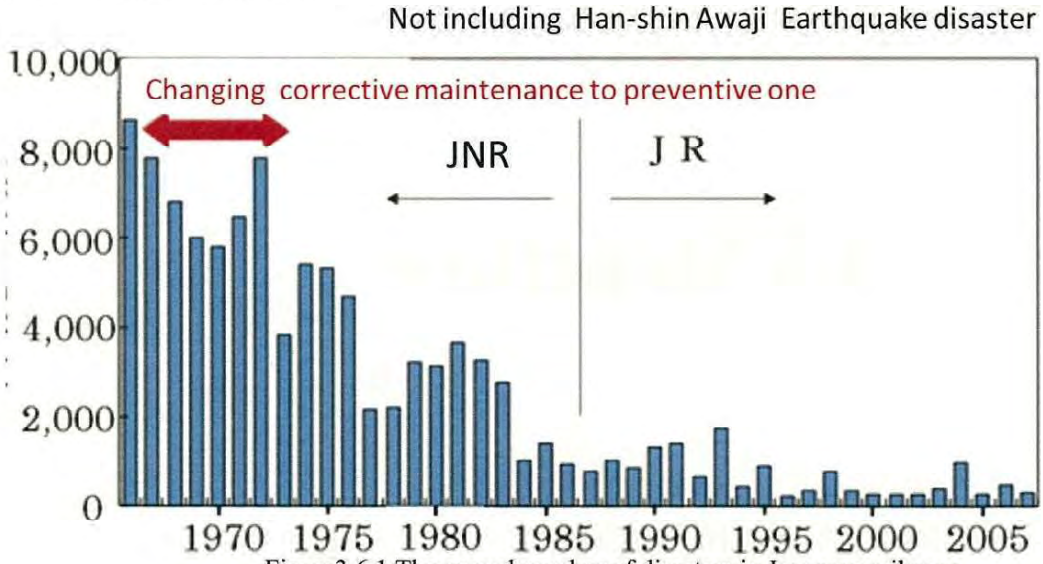


Figure3.6.1 The annual number of disasters in Japanese railways
(Refer to "The journal of Japan Railway Civil Engineering Association Vo147.No.6, pp.17-19, 2009)

It is said, according to the per capita gross domestic product, Myanmar economical scale likely to be as same as the past state of 1963's in Japan, especially Yangon metropolitan areas are 1970's. According to the Figure3.6.1, assuming that the annual number of 1963 or 1970 is present state of Myanmma Railways, it would drastically decrease in the future.

We suppose the economic growth of Myanmar and changing maintenance methods of railway facilities present one to preventive one. For the proper maintenance and patrolling to be executed in the modernized railways, hereby, we review the present technical standard of MR and recommend some comment comparing Japanese standard. This chapter is concerned with structures, namely bridges (Manual of the Engineering Department ChapterVI), formation (Manual of the Engineering Department ChapterIII) and safety precaution (Manual of the Engineering Department ChapterXII). And we recommend as succeeding.

3.5.1 Recommendations on Technical Standards of MR (Bridge)

<table>
<tr><td colspan="2">Title of Standards of MR
Manual of Engineering Dept. Chapter VI (Bridges)</td><td rowspan="2">Recommendations by JICA Expert Team</td></tr>
<tr><td>No. of item</td><td>Item</td></tr>
<tr><td>602</td><td>Function of Bridge Inspector</td><td>It is described that inspector and their assistant should be knowledgeable about steel works in MR standard. They should be knowledgeable about not only steel works, but also concrete works. Because of some accidents may occurred such as spalling of concrete fragments threatens public safety , or aged prestressed steel break and so on, it is necessary to inspect concrete structure to prevent it. In Japan, all bridges are inspected by engineers to maintain in good soundness.
The fundamental action of the maintenance of structures is to check whether or not the inspected structure sustains the required performance which should be determined in advance. Though there are various types of structures and the required functions of each structure are multifarious, safety is set as a required performance to enable trains to run safety and to prevent threats to the life of passengers and the public. Serviceability and restorability are prescribed whenever necessary. Table 1 show the main required performance, performance items and verification indices.
Table 1 Example of Required Performances and Performance Items (Concrete structures, steel/composite structures, foundations/ retaining structures)
<table>
<tr><th rowspan="2">Required Performance</th><th rowspan="2">Performance Item</th><th colspan="3">Examples of Verification Indices</th></tr>
<tr><th>Concrete structures</th><th>Steel/composite Structures</th><th>Foundations/Retaining Structures</th></tr>
<tr><td rowspan="5">Safety</td><td>Failure/capacity/ safety of members</td><td>Force, displacement/ deformation</td><td>Section force, stress, displacement/deformation</td><td>Capacity, displacement, deformation</td></tr>
<tr><td>Fatigue</td><td>Stress, force</td><td>Section force, stress
Structural details in consideration of fatigue</td><td></td></tr>
<tr><td>Running safety</td><td>Displacement/deformation</td><td>Displacement/deformation, frequency</td><td>Displacement, deformation</td></tr>
<tr><td>Public safety</td><td>Carbonation depth, chloride ion concentration</td><td>Bolt strength
Stress, section force
Carbonation depth, chloride ion concentration</td><td>Peeling, spalling off</td></tr>
<tr><td>Safety</td><td></td><td>Overturning moment of girders, uplift force</td><td>Settlement, slippage, inclination</td></tr>
<tr><td rowspan="4">Serviceability</td><td>Riding comfort/dynamic displacement during train passage</td><td>Displacement/deformation</td><td>Displacement/deformation, number of vibrations</td><td>Displacement, deformation</td></tr>
<tr><td>External appearance/ progress of displacement, and cumulative displacement</td><td>Crack width, stress</td><td>Extent of degradation of paint film, selection of paint materials
Crack width, stress</td><td>Displacement, deformation</td></tr>
<tr><td>Watertightness</td><td>Crack width, stress</td><td></td><td></td></tr>
<tr><td>Noise/ vibration</td><td>Noise level, vibration level</td><td></td><td></td></tr>
<tr><td rowspan="3">Restorability</td><td>Damage</td><td>Displacement/deformation, force, stress</td><td>Section force, stress, displacement/deformation</td><td>Capacity, displacement, deformation</td></tr>
<tr><td>Stability of foundation</td><td></td><td></td><td>Settlement, slippage, inclination, changes in surrounding environment</td></tr>
<tr><td>Runability</td><td></td><td></td><td>Drainage/elevation displacement</td></tr>
</table></td></tr>
<tr><td>603,604</td><td>Inspection of Bridges by Officers, Subordinates</td><td>It is described that officer inspects bridges in MR standard. But in Japan, inspections should be done by only inspector. Officer Engineer receives the report from inspector and confirm that whether the inspection has done or not according to the implementation standard by Railway operator. And officer arranges repair cost for worse soundness structure.
Although it is described the interval of inspection by several titled engineers, no detail of inspection in MR standard. Hereafter, we recommend MR the detail of</td></tr>
</table>

inspection partially from "Maintenance Standards for Railway Structures and Commentary".

In regard to inspection

1. Categories of Inspections

Figure 1. shows inspection categories for structures.

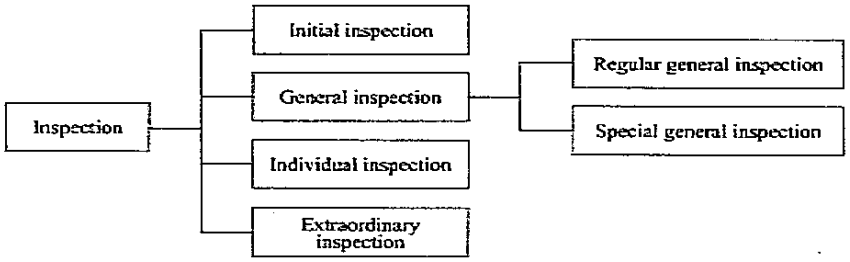


Figure1. Inspection Categories for Structures

2. Inspection Timing

Initial Inspection is the one to be conducted before starting service of structures that were newly constructed, reconstructed, and largely repaired/strengthened to a) confirm that appropriate construction has been performed and b) obtain initial data that is used in subsequent maintenance. Surveys are performed principally by careful visual inspection based on the documents and drawings of design and construction.

The general inspection of the maintenance standards shown in Fugure1 is performed every two years, excluding special instances.

Other Inspection to be performed if necessary.

3. Verification of Performance and Judgment of Soundness

Performance is verified by judging soundness. It is prescribed that soundness be judged, in principle, by providing appropriate judgment categories based on the results of determined deterioration causes and prediction of deterioration

Table2 shows standards judgment of soundness. This table shows that prescriptions are established, in principle, in consideration of the characteristics of each structure.

Judgment of soundness in general inspection and extraordinary inspection is generally categorized into ranks A, B, C, and S (shown in Table 2) based on survey results. However, when a state to be thought to cause a hazard on normal train operation is found, the rank is judged as AA, and measures such as stopping trains shall be taken. The rank is also judged to be AA when spalling of concrete fragments threatens public safety, and countermeasures such as immediately knocking down loose concrete fragments, and prohibiting entry underneath viaducts must be devised in this instance.

As for individual inspections, if the state of a structure is judged as rank A in the general inspection and/ or extraordinary inspection, identification of causes of deterioration, and prediction of deterioration are conducted. Judgment of soundness is also further sub-categorized into A1 and A2.

Table2 Judgment of Structure States and Standard Soundness

Soundness		Structure State
A		State that threatens operational safety, safety of passengers, public safety, guarantee of regular train operation, or deterioration that might cause this state
	AA	Deterioration that threatens operational safety, safety of passengers, public safety, or the guarantee of regular train operation, and which require emergency countermeasures
	A1	Progressive deterioration that causes the performance of structures to drop, or heavy rain, floods, or earthquakes that might impair the performance of structures
	A2	Deterioration that might cause a future performance drop of structures
B		Deterioration that might result in a future soundness rank of A
C		Slight deterioration
S		Sound

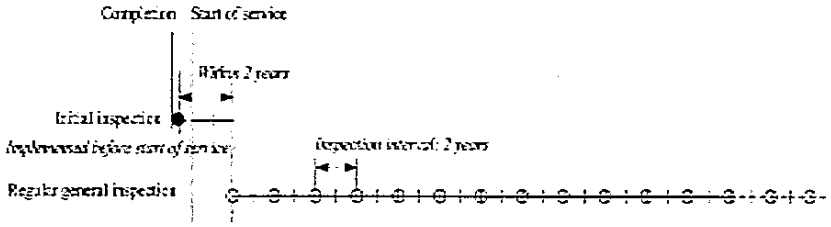
Note: Soundness ranks A1 and A2, and soundness B, C and S may be categorized by individual railway operators in consideration of the actual inspection circumstances.

4. Initial Inspection

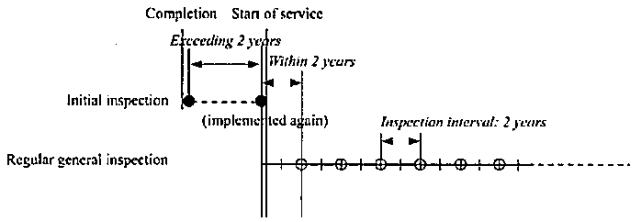
"Initial inspection" prescribes items relating to types of structures, implementation timing, purpose, and methods covered by this inspection.

4.1 Timing of Initial Inspection

Initial inspection covers new structures and reconstructed/ replaced structures, and is performed for the purpose of ascertaining the initial state of the structure (See Figure2). Initial inspection should also be performed as necessary when large-scale repair/ strengthening has been made.



(a) In cases where the interval between initial inspection and start of service is within 2 years



(b) In cases where the interval between initial inspection and start of service exceeds 2 years

Figure 2 Examples of Initial Inspection Timing

4.2 Survey Items

The survey items in the initial inspection conform to the inspection items in a regular inspection. The design and construction management documents may be included as necessary. The following describes survey items for each type of structure.

4.2.1 Concrete Structure

Survey items for concrete structures include the presence and extent of excessive deformation, cracks, peeling off and spalling of concrete. Additional items also include design documents, concrete mixing(water-cement ratio, water content, type of cement, kind of aggregate, content of chlorides, etc.), and concrete cover thickness.

		4.2.2 Steel/composite structures Survey items for steel and composite structures include main dimensions and clearance gauge. Stress and deformation will be included when vehicle running tests are implemented. 4.2.3 Foundations/Retaining Structures Survey items for foundations and retaining structures include seating conditions of girders, longitudinal/transverse geodetic data of riverbed levels, and state of inclination of structures. 4.3 Survey Methods The survey method in initial inspection is basically carefully visual inspection. To achieve accurate inspection, it is preferred that data surveys are permitted on the design documents of the structure and construction management documents before starting initial inspection. 4.3.1Concrete Structures It is often difficult to detect peeling, hollowing or other defects in concrete simply by a visual inspection-based survey, so hammering tests should also be used as necessary. 4.3.2 Steel/Composite structures It is preferred to use surveying instrument, strain measuring apparatus or other measurement equipment for Measuring main dimensions, clearance gauges, stress, and deformation. 4.3.3 Foundations/ retaining structures It is described in the maintenance standard that data obtained by various measurements (e.g. main dimensions, clearance gauge and the results of the impact vibration test) in addition to visual inspection on foundations/retaining structures and structure surroundings will provide useful information in subsequent inspections. 4.4 Judgment of soundness Judgment of soundness in initial inspection is performed in compliance with "5.2.3 Judgment of Soundness " in regular general inspection. When deterioration are found in the initial inspection of newly constructed structures, countermeasures are generally implemented immediately to make the soundness of the structure ranked as S. However, the soundness is sometimes not ranked as S in the initial inspection of existing structures, which have undergone large-scale repair or strengthening, because of the advancement of deterioration over time. In such cases, countermeasures such as continuous monitoring are required. 5. General Inspections "General Inspections" prescribes items relating to the purpose of general inspections, inspection categories, scope and items of inspection, inspection interval, and survey methods. 5.1 General Inspection Categories The maintenance standard categorizes general inspection into two categories, regular general inspection and special general inspection. Regular general inspection is performed mainly to detect deteriorated structures. Special general inspection is performed mainly to improve accuracy in judging soundness.

5.2 Regular General Inspection

Regular general inspection is performed periodically in order to detect reliably the deterioration of structures or to grasp the presence of progress of detected deterioration. Generally, two years is the standard inspection interval for regular general inspection. However, this can sometimes be extended if required conditions are satisned as indicated in "5.3 Specia1 General inspection."

5.2.1 Survey Items

1) Survey iteins for concrete structures

a) Reinforced concrete girders and pre stressed concrete girders.

- State of cracking
- State of concrete peeling, spalling off, hollowing, honeycombs
- State of exposed reinforcements
- Presence of discoloring, free lime (efflorescence)
- Deterioration of concrete
- State of drainage and water leakage
- State of bearings
- Deterioration along main cables(strands) caused by defective grouting, ejection of transverse prestressing steel bars
- Abnormal camber of prestressed concrete girders

b) Rigid frame viaducts, arched bridges, rigid frame abutments

- State of displacement of supports (settlement, shift, rotation)
- State of cracking at corner sections and around openings
- Other items: compliant with reinforced concrete girders
- State of joints in masonry/ stone masonry structures

c) Abutments, piers

- State of girder seats
- State of scouring
- State of settlement, shift, inclination
- State of cracking at root of overhanging member
- Other items: compliant with reinforced concrete girders
- Masonry/ stone masonry structures: state of cracks, cracks in joints, cracks in surrounding of base stone

2) Survey items and deterioration examples of steel/composite structures

a) State of deterioration of paint films and corrosion
b) Penetration of stable rust (protective rust) of weathering steel (See Figures 3)
c) Presence of obstacles in clearance gauge
d)Vibration state of bridge girders during train passage
e)Deterioration of bearing (See Figures 4)
f)Deterioration of rivets/bolts
g)Deterioration of welded sections and base metal (See Figure 5)
h)Deterioration of repaired/strengthened locations
i) Locations where fatigue crack are likely to occur due to impact
j)State of drainage facilities
k)Deterioration of equipment such as sidewalks and sound barriers
l)Affect on surrounding environment

(a) Example of Scale-shaped Peeling Rust　　(b) Example of Layered Peeling Rust

Figure 3 Deterioration of Stable Rust of Weathering Steel

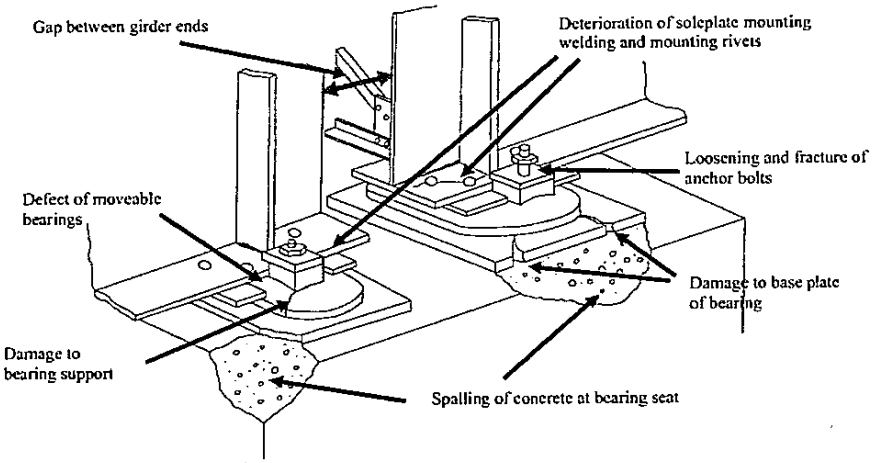


Figure 4 Example of Deterioration of Bearings

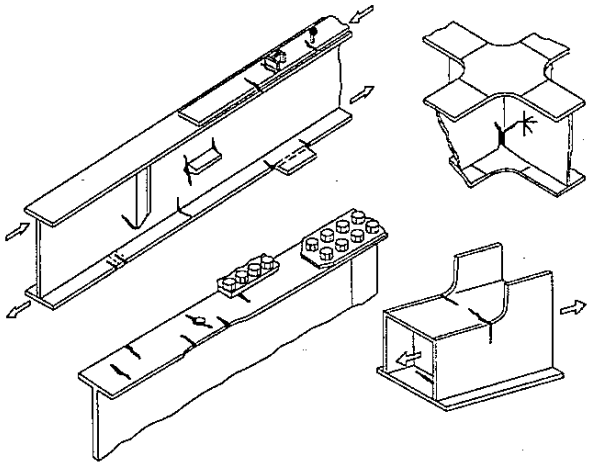


Figure 5 Locations Where Fatigue Cracks are Likely to Form

3) Example of deterioration of railway infrastructure

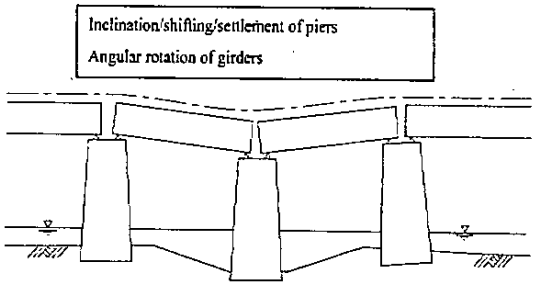


Figure 6 Settlement of Pier

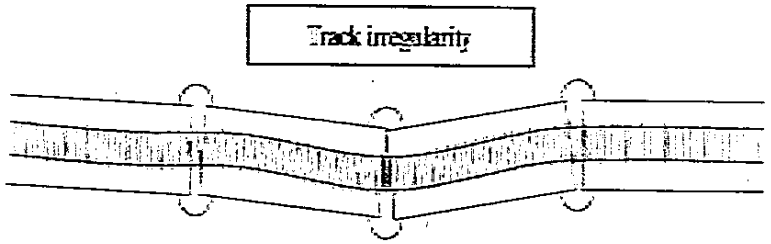


Figure 7 Sway of Pier

5.2.2 Survey Methods

Visual inspection is the major survey method in regular general inspection. However, it is prescribed that there are some additional survey methods required for each individual structure. The following describes example for each structure.

With concrete structures, it is sometimes difficult to detect cracks or peeling of concrete merely by visual inspection from a distance. For this reason, the inspectors are recommended to either approach the structure as close as necessary, or perform surveys by careful visual inspection using binoculars when approaching the structure is difficult, or perform surveys by hammering tests.

With steel/composite structures, it is prescribed that paint film be partially removed to perform the survey when paint cracking has occurred at sections where fatigue cracks might be present.

In foundations/retaining structures, it is important that measurements be performed whenever necessary according to the extent of deterioration of the structure and other actual circumstances.

5.2.3 Judgment of Soundness

Judgment of soundness in regular general inspection is prescribed to conduct comprehensively based on the result of surveys relating to type, extent, and risk of progress of the deterioration.

When soundness is judged to be AA, emergency countermeasures (e.g. restriction of service) must be performed. The cause of deterioration on the structure must be determined by individual inspection, and the appropriate countermeasures (e.g. repair/strengthening, reconstruction/replacement) must be performed according to the state of the deterioration.

For structures having deterioration judged as soundness A, the cause of the deterioration is judged by individual inspection, and soundness is judged according to the additional sub-categories.

The following describes examples of deterioration on concrete structures and steel/composite structures that are judged to be soundness AA in the maintenance standard.

1) Concrete structures

a) When cracks that are several millimeters wide and concrete crushing of upper surface are present at the span center of reinforced concrete girders and reinforced concrete rigid frame viaducts, or when cracks of wider than several millimeters are present.

b) When spalling of concrete cover is occurring on the entire section of lower surface of reinforced concrete girders and slabs of reinforced concrete rigid frame viaducts, and when exposed reinforcements are present.

c) When diagonal cracks are developing along the supporting direction on reinforced concrete girders and the crack width is large/

d) When spalling of concrete is occurring as high as approximately 300mm or more in the column of reinforced concrete rigid frame viaducts, and reinforcements along the entire periphery are completely exposed.

e) When cracking of approximately 0.5mm in width originating from bearings is occurring and cracking is progressing at reinforced concrete piers, posing a risk of the bridge falling.

f) When the bricks of masonry/stone masonry structures are damaged and they are affecting the track.

2) Steel/composite Structures

a) Deterioration that seriously affect the functions of main members

The final crack length (crack length to be regarded as soundness AA) has been used to indicate the relationship between crack length and the standard for judging soundness A. The following items are causes that affect final crack length. These must be sufficiently surveyed.

(1) Minimum air temperature at the location of steel member

(2) Amount of energy absorption of steel member

(3) Detailed structure of where cracks are forming

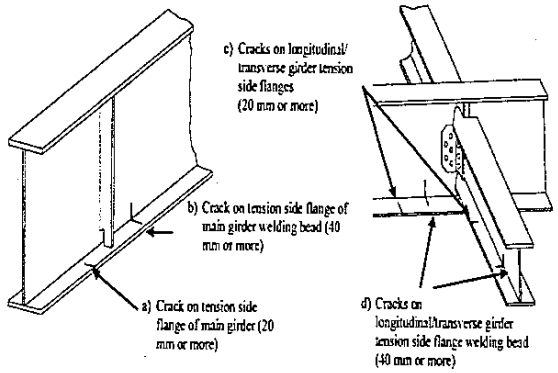


Figure 8 Examples of Steel Structures Judged as Soundness AA

b) When rivets and bolts are loose

The affect of loose rivets and bolts differs according to location. The following table may be used as a reference for judging the influence.

Table 3 Reference for Judging Loose Rivets and Bolts

Structure	Description of Deterioration	Ratio (%)
Deck plate girder	Looseness of rivets/bolts for splicing main girders	About 50% or more of one group
Trough plate girder	Looseness of rivets/bolts for splicing main girders	About 50% or more of one group
	Looseness of rivets/bolts for longitudinal and transverse girders	
Truss	Looseness of rivets/bolts for main truss, longitudinal and transverse girders	About 50% or more of one group

c) Significant deterioration of bearings

The following table shows references for judging soundness AA with respect to deterioration of bearings and amount of settlement of support.

Table 4 References for judgment of Bearing Deterioration

Structure	Description of Deterioration	Condition
All structures	Fracture of bearing	Penetrated fracture
Through girder	Settlement of support	Approximately 15 mm or more
Deck plate girder		
Composite girder		
Through plate girder	Settlement of support	Approximately 25 mm or more
Truss		

3) Foundations /Retaining Structures

The state of soundness AA is that the structure has deterioration which threatens train operational safety, safety of passengers, public safety, and the guarantee of regular operation of trains. At this level, emergency countermeasures (e.g. restriction of service) must be performed, the cause of deterioration on the structure must be identified by individual inspection, and the appropriate countermeasures (e.g. repair/ strengthening, reconstruction/ replacement) must be performed according to the state of the deterioration.

5.3 Special General Inspection

Special general inspection is conducted to improve accuracy in judging soundness. Compared with regular general inspection, special general inspection as it is performed with higher accuracy.

5.3.1 Inspection Timing

Current ministerial ordinances (ministerial ordinances and notices that stipulate technical standards pertaining to railways) prescribe that regular general inspection be performed within every two years. On the other hand, the maintenance standard is specifying that the inspection interval can be extended when structures satisfy certain conditions and they are confirmed to be in a sound condition at special general inspection.

The inspection interval can be extended to six years in the case of concrete structures and foundations/ retaining structures, and to four years in the case of steel/composite structures (See Figure9). However, it is prescribed that the inspection interval cannot be extended in the case of retaining structures, earth structures, tunnels where peeling of concrete might injure third parties.

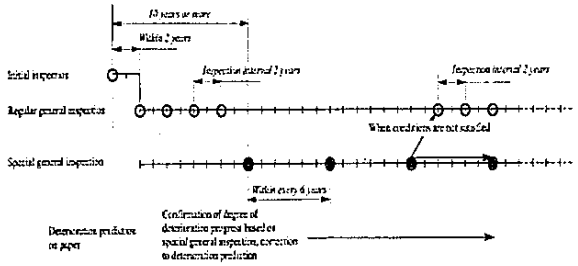


Figure 9 Example of Extension of Inspection Interval

5.3.2 Survey Items

Special general inspection is performed for two purposes: to increase inspection accuracy and to extend the inspection interval. Survey items matched to the respective purpose of the inspection are set. In addition to these survey items, the following describes survey items for concrete structures.

For concrete structures, when the purpose of inspection is to increase inspection

accuracy, carbonation and chloride induced deterioration should be surveyed in detail as necessary. When the purpose of inspection is to extend the inspection interval, required items from among detailed survey items (cracking, carbonation, chloride induced deterioration, frost attack, alkali-aggregate reaction, chemical attack) must be surveyed in consideration of the environment conditions that the structure is subjected to.

5.3.3 Survey Methods

In addition to careful visual inspection in special general inspection, various inspection methods will be conducted according to requirements.

5.3.4 Judgment of Soundness

Judgment of soundness in special general inspection must comply with "5.2.3 Judgment of Soundness" in regular general inspection.

6. Individual Inspection

"individual inspection" prescribes items relating to the purpose of individual inspections, inspection categories, scope and items of inspection, inspection interval, and survey methods.

6.1 Individual Inspection Procedure

Individual inspection is performed for the purpose of judging soundness with high accuracy on structures where deterioration has occurred or might occur.

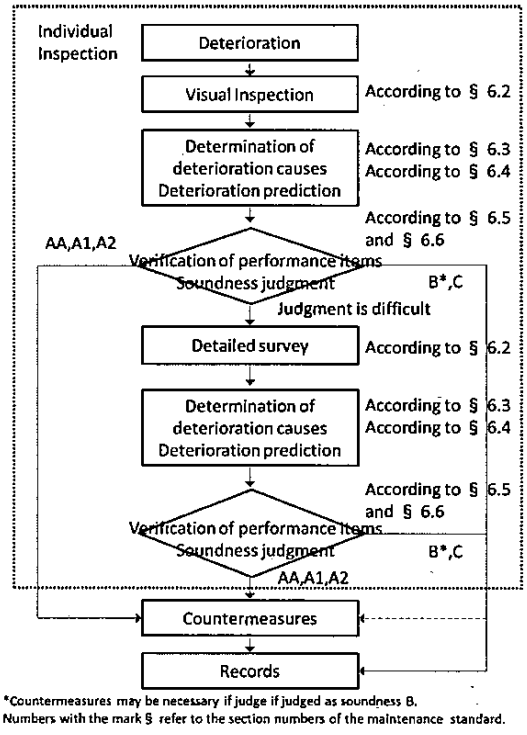


Figure 10 Individual Inspection Procedure

Individual inspection is performed on deterioration judged as soundness A in general inspection and extraordinary inspection to reliably ascertain the state of that deterioration and to perform higher accuracy judgment of soundness. Even when attempting to extend the inspection interval by special general inspection

through surveys, methods for determining the causes of deterioration and predicting deterioration shall conform to the provisions of individual inspection. When the life cycle cost is taken into consideration, even for structures with integrity of B to S, the concept of preventative maintenance is also sometimes important and countermeasures should be taken for predicted deterioration. Even for such purpose, judgment of soundness and selection of countermeasures should be conducted in compliance with the provisions of individual inspections. Figure 10 shows the procedure of individual inspections.

6.2 Survey Items

The following describes example of survey items for each type of structure.

6.2.1 Concrete structures

With concrete structures, the external appearance is evaluated, and data such as the state of concrete deterioration and state of corrosion of reinforcing steels should be quantitatively obtained. Survey items must be selected appropriately according to the purpose of the survey and deterioration.

General survey items include a) crack width, depth, progression status, b)peeling, spalling off, scaling, c) corrosion status of reinforcing steels, d) extent of reinforcing steel exposure, e) concrete cover thickness, position of reinforcement, f) properties of concrete, g) carbonation depth, h) chloride ion content, i) amount of residual expansion, j) presence of internal defects, k) presence of section loss in concrete, l) amount of displacement or deformation, m) vibration characteristics, n) supporting condition, o) presence of free lime (efflorescence) or water leakage, p) presence of surface discoloration, q) permeation depth of cause of chemical reaction, and r) changes in action or support condition of a structure.

6.2.2 Steel/Composite structures

Table 5 shows example of survey items in individual inspection of steel/composite structures.

Table5 Example of Survey Items in Documents for Individual Inspection

Name of Document	Description
Design documents	Structure design drawings, design computation documents, specifications of materials used, design summary tables Quality records of materials used Tonnage of passing trains, number of trains, design speed
Construction records	Construction records of superstructures and infrastructures
Inspection records	Records of initial inspection, regular general inspection, special general inspection, individual inspection, and extraordinary inspection (survey records of deterioration region and deterioration state, and tracking records of deterioration)
Other	Year of completion of construction Loading history Record of past disasters Changes in effect of environment Record of countermeasures (e.g. repair/strengthening)

6.2.3 Foundations/Retaining Structures

Foundations/ retaining structures require design documentation/ construction records, inspection records, and records of countermeasures.

6.3 Survey Methods

Individual inspection is basically performed visually. The following describes examples of survey methods for each type of structure.

		6.3.1 Concrete Structures Surveys performed in individual inspection of concrete structures involve visual inspection and detailed surveys. 1) Visual Inspection "Visual inspection" in individual inspection basically involves an experienced inspector looking directly at deterioration. If necessary, this survey may be accompanied by hammering tests, and is performed for the purpose of aiding the identification of deterioration causes, prediction of deterioration, verification of performance items, and judgment of soundness. 2) Detailed survey When it is difficult to identify the causes of deterioration, verify performance items, and judge soundness through visual inspection, detailed surveys may be performed using tools as required. Generally, a) sampling of concrete core at deteriorated region or surroundings, b) checking the state of reinforcement arrangement (concrete covers and clear distance between reinforcements) by either non-destructive inspection using electromagnetic induction methods or chipping methods, and c) checking the state of corrosion of reinforcements by non-destructive inspection using the half-cell potential method or chipping methods are required. 3) Survey methods required for identifying deterioration causes and deterioration prediction Survey methods have to be selected that enable identifying causes of deterioration, and collecting data required for predictive models of each deterioration causes in detail. 4) Survey content required for verification of performance items When performance items important in identifying the causes of deterioration and for predicting deterioration are specified, survey items closely associated with that performance shall be selected. 5) Typical survey methods The following are typical survey methods: a) Visual inspection, photography, hammering tests b) Cross-sectional dimension measurement c) Displacement/ deformation measurement d) Stress measurement e) Vibration measurement. f) Rebound hammer methods g) Chipping methods h) Core methods k) Radar methods l) Electromagnetic induction methods m) Infra-red methods n) Half-cell potential methods o) Polarization resistance methods 6.3.2 Steel/ Composite structures The following shows example of survey items in individual inspections of steel/ composite structures. 1) Careful visual inspection 2) Measurement of corrosion sections of crack length Generally, vernier calipers, calipers, ultrasonic thickness gauges, or other instruments are used to measure corrosion section or crack lengths (See Figure 11).

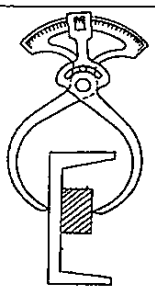


Figure 11 Example of Use of a Caliper

3) Actual bridge measurement

Actual bridge measurement is method of quantitatively ascertaining the stress and deflection characteristics of the structure, in which deterioration has occurred, during train passage. It is useful for identifying the causes of track deformation.

With stress measurement, stress waveforms can be obtained by using strain gages, causes of fatigue cracks can be quantitatively evaluated, and data used for assessing load bearing capacity or fatigue capacity can be easily obtained.

4) Non-destructive inspection

(1) Ultrasonic testing(UT)

(2) Magnetic particle testing(MT)

(3) Eddy current testing(ET)

(4) Penetration testing(PT)

5) Materials tests

Generally, the types of steel materials currently used in bridges are clearly indicated in design drawings. However, for the girder whose history of usage is unclear (for example, drawings not available), materials must be surveyed because the strength of the materials cannot be determined when verification of capacity is required.

6) Fracture surface survey

A lot of information can be obtained by fracture surface of high-strength bolts for identifying the cause of deterioration.

7) Survey of unpainted bridges

(1) Survey of environment and amount of airborne sea salt.

(2) Identification of damage cause (brine particles or freezing inhibitor sprayed on roads during snowfall)

(3) Measurement of rust depth

Table 6 shows survey items and survey methods for layered peeling rust.

Table 6 Survey Items and Survey Methods for layered peeling rust

Survey Items	Survey Methods
Residual plate thickness measurement	Measurement is performed using micrometers and ultrasonic thickness gages, the thickness is compared with design plate thickness, and the result is assessed.
Survey of causes of layered peeling rust and scale-shaped peeling rust	Survey is performed with the priority on water leakage, retaining water (aquiferous), retaining moisture, and presence of adhered salt at locations where rust is occurring. The cause is then identified.
Rust characteristics survey	The following items are surveyed as a means for judging causes of layered peeling rust and scale-shaped peeling rust: • Rust composition, structure, salt content of rust • Fineness of rust

6.3.3 Foundations/ Retaining Structures

It is often difficult to directly visually check deterioration of underground structures. In cases such as these, deterioration of sections above ground should

be surveyed using non-destructive testing methods. The following describes general survey methods corresponding to each survey item:

1) Document survey

2) Survey of deterioration in section above ground

With surveys on the deterioration of sections above ground, necessary items shall be selected, referring to the following examples, in order to quantitatively ascertain the extent of deterioration, in addition to careful visual inspection.

a) Structure dimensions

Table 7 explains survey methods relating to structure dimensions. Details on surveys into the position of reinforcements shall be in accordance with the "Maintenance Standards (Concrete Structure Standard)".

b) Static displacement

The implementation of surveying or measurement by tape of girder alignment irregularities and displacement/ differential settlement of infrastructures is indicated as a method for surveying the deterioration of members in sections above ground caused by deterioration of underground structures

Table 7 Main Survey Methods Relating to Structure Dimensions

Survey Category	Structure Type	Survey Items	Main Survey Methods	Explanation
Structure dimensions	Entire structure	Member dimensions	Measurement by tape, etc.	Check differences with dimensions in completion drawing
		Position of reinforcements (amount of reinforcement as required)	(Refer to "Concrete Structure Standard")	Surveys of reinforcements in concrete include visual inspection/measurement by chipping, electromagnetic wave examination, and impact examination

c) Member damage

When performing surveys into member damage, survey methods described in both the "Maintenance Standards (Concrete Structure Standard) and (Steel/ Composite Structure Standard)" should also be referred to.

d) Bearing capacity characteristics

Of the survey items relating to bearing capacity characteristics of structures that are to be surveyed in section above ground, items directly related to deterioration on the foundation include natural frequency, dynamic displacement during train passage, and ultimate bearing capacity.

3) survey of underground deterioration

Careful visual inspection after having excavated the surrounding ground is considered the most reliable and detailed survey method for surveying underground deterioration, Yet, generally, excavation surveys are difficult, and underground deterioration is determined by other surveys. Figures 12 and 13 show example surveys.

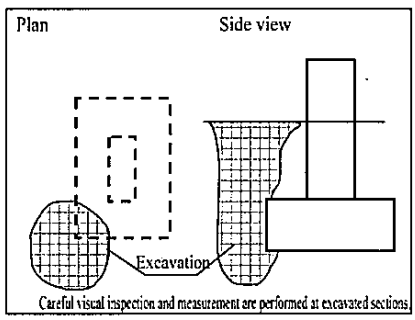


Figure 12 Example of Partial Excavation Survey

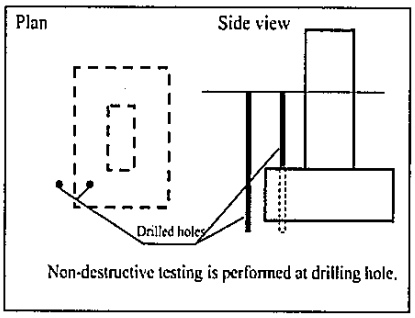


Figure 13 Example of Survey Using Sounding or Boring

6.4 Identification of Causes of Deterioration

In individual inspection, causes of deterioration are identified based on past experiences and on the results of visual inspection and actual bridge measurement. The following categories are examples of the main causes of deterioration:

- Deterioration by mechanical influences
- Deterioration by design and construction
- Deterioration by degradation of materials

6.5 Deterioration Prediction

Deterioration prediction is conducted for the purpose of a) predicting the state and progression of deterioration in the future based on the results of visual inspections and detailed surveys into the causes of deterioration, and b) reflecting those results in verification of performance, judgment of soundness and countermeasures. Soundness can be judged with judgment sub-categories A1 and Ae by predicting when required performance will no longer be satisfied due to progression of the deterioration. Predicting deterioration also provides important information in selecting appropriate timing of countermeasures and methods when conducting maintenance specifically intended to minimize life cycle costs.

To judge how deterioration will progress in the future, judgment should be cross-referenced against experienced knowledge, theory, and similar precedents. However, it is prescribed that when changes in surrounding environments and the action of external forces that cause deterioration are anticipated, these too should be considered in predicting deterioration.

6.6 Verification of Performance Items

6.6.1 Types of Verification Methods

There are two verification methods, a quantitative method based on verification equations, and a semi-quantitative method that principally involves careful visual inspection.

Though performance items should ideally be quantitatively verified using appropriate verification equations, it is difficult to apply quantitative methods to all performance items. In some cases, quantitative verification methods are not available for performance items, and proposed verification equations are not sufficiently accurate.

Furthermore, conducting exhaustive quantitative verification of performance items on all structures is both complex and is often unnecessary. When the soundness of a structure can be reliably judged from deterioration precedents of the same type, status of similar structures in the surroundings, experienced deterioration precedents, and specialist knowledge, semi-quantitative assessment

may be performed by grading (i.e. ranking of structural performance) based on careful visual inspection. Performance items may be verified and soundness judged according to these grades.

6.6.2 Verification Methods of Performance Items

a) Verification Methods

Basically, in verifying performance items, appropriate limit state for each required performance are anticipated, and it is verified that structures or members do not reach these limit states. It is prescribed that each performance item is verified using the maintenance index J shown in Equation (1) in compliance with "Design Standards for Railway Structure (Concrete Structure). 3.4 Performance Verification Methods."

$$J = K_m \times \gamma_i \frac{I_{Rm}}{I_{Lm}} \quad \text{(Eq.1)}$$

where, J: maintenance index , K_m: coefficient for maintenance index J, γ_i : structure factor

γ_i: maintenance response value, γ_i: maintenance limit value

Basically, performance items are verified at inspection of the structure and at the end of the target service life. Also, values closer to the actual circumstances are used in computing maintenance response value γ_i and maintenance limit value γ_i at this current stage. Maintenance response value γ_i and maintenance limit value γ_i at the end of the target service life are computed taking progression of deterioration into consideration.

b) Functions for computing response values and limit values

As the function for computing response values, the average value of response values computed when action, material characteristics, rigidity, and other factors are taken as actual values. Also, the function for computing the limit values of structure and member performance takes the average value of the limit values computed when material characteristics, rigidity and other factors are as actual values.

c) Safety factor

In compliance with "Design Standards for Railway Structures (Concrete Structures)," the standard uses five partial safety factors, namely, action factor γ_f, structural analysis factor γ_f, material factor γ_f, member factor γ_f, and structure factor γ_f. Generally, the state of soundness S means that performance items satisfy verifications using all safety factors prescribed in "Design Standards for Railway Structures (Concrete Structures)."

5.6.3 Verification of Safety- related Performance Items

Verification of safety-related performance items involves the followings.

- Verification of safety associated with failure and fatigue failure
- Verification of running safety and judgment of soundness
- Verification of safety associated with public safety- related and judgment of soundness
- Verification of serviceability- and restorability- related performance items.

6.7 Judgment of Soundness

Soundness in individual inspection shall be judged comprehensively based on the results of identifying the causes of deterioration and deterioration protection obtained from surveys, and on the example judgments of soundness with respect to verification of each performance item given in "6.6 Verification of

Performance Items."

For example, in the case of concrete structures, multiple deterioration often occurs in the same structure. In this case, soundness should be judged by individual deterioration or causes of said deterioration. When soundness is managed intensively on individual structures, soundness should be judged referenced to the severest deterioration.

For structures judged as soundness A in regular General inspection or in extraordinary inspection, soundness is further divided into sub- categories A1 and A2 based on "3 Confirming Performance and Judging Soundness" by conducting individual inspections which are more accurate than judgment of soundness in a general inspection or extraordinary inspection.

7. Extraordinary Inspection

"Extraordinary Inspection" prescribes items relating to the purpose of extraordinary inspection, inspection categories, scope and items of inspection, inspection timing, and survey methods.

7.1 Timing and Procedure of Extraordinary Inspection

When deterioration has occurred in a structure, track, or overhead catenaries due to earthquakes, heavy rain, or automobile collisions, restriction of service (e.g. suspension or slowdown of train operation) are generally placed in accordance with the operation control manual stipulated by the railway operator. The following prescribes inspection, judgment criteria, and countermeasures to be performed to judge whether or not the restriction of service (suspension or slowing down) should be continued before performing individual inspection. Figure 14 shows the procedure of extraordinary inspection when there is the fear that an earthquake will cause deterioration.

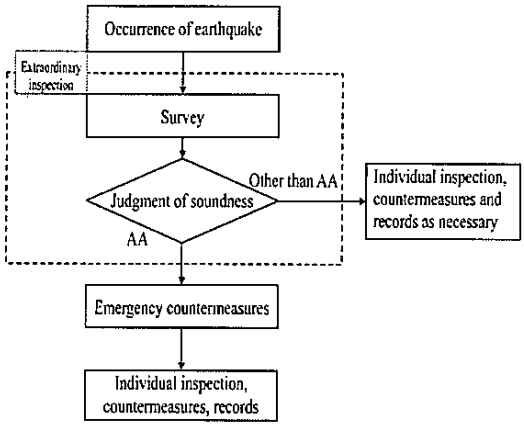


Figure 14 Extraordinary Inspection Procedure (in an earthquake)

Inspections for structure that are performed non-periodically include roundup or blanket inspections performed when an earthquake or other disaster has occurred, and when a deterioration has been discovered on similar structures, and inspection of locations where a public disaster is feared due to concrete spalling off. These inspections also are included and handled within the scope of extraordinary inspections.

7.2 Judgment of Soundness

Judgment of soundness in extraordinary inspections must comply with "5.2.3 Judgment of Soundness" in regular general inspections.

8. Countermeasures

"Countermeasures" prescribes items relating to countermeasure methods, timing, type, monitoring methods, repair/ strengthening, restriction of service of structures, reconstruction/ replacement, and handling after countermeasures.

Some countermeasures will be performed based on the soundness judgment category. These methods are a) monitoring, b) repair/strengthening, c) restriction of service, and d) reconstruction/ replacement, and one or a combination of these is selected. Of course, in selecting the countermeasure, the soundness, importance, constructability, economy, and other factors of the structure are taken into consideration. Selection of these and setting of the timing are indicated in Figure 15. Table 8 shoes the type of measure and gives their outlines.

1) For structures judged as soundness AA, countermeasures such as limiting use must be devised immediately because deterioration associated with main functions are present that threaten operation safety, safety of passengers, public safety, and guarantee of regular operation of trains.
2) For structures judged as soundness A1 or A2, countermeasures are devised urgently or at the appropriate timing as it is anticipated that here is already deterioration present, and the performance of the structure will drop even further by future progression of this deterioration. Countermeasures for soundness A1 are devised to be implemented before measures for soundness A2.
3) For structure judged as soundness B, countermeasures such as monitoring are devised as necessary as there is the risk that the structures might lapse into soundness A in the future.
4) For structures judged as soundness C or S , no particular countermeasures are required as deterioration is either non-existent or slight. However, for structures judged as soundness C, surveys are performed as necessary with the emphasis on whether or not deterioration has progressed at inspection.

Table 8 Types of Countermeasures

Type	Description
Monitoring	Countermeasures for confirming the status and progression of deterioration by visual inspection.
Repair/strengthening	Countermeasures intended for recovering the performance of a structure on which deterioration has occurred or for delaying a drop in performance, and countermeasures intended for improving the mechanical performance of a structure to a level higher than the initial state
Restriction of service	Countermeasures for restriction of service by stopping train operation, stopping entry onto tracks, limiting loads, or limiting speed.
Reconstruction/replacement	Countermeasures for changing the structure type in part or in whole, or for demolition and reconstruction of part of the structure

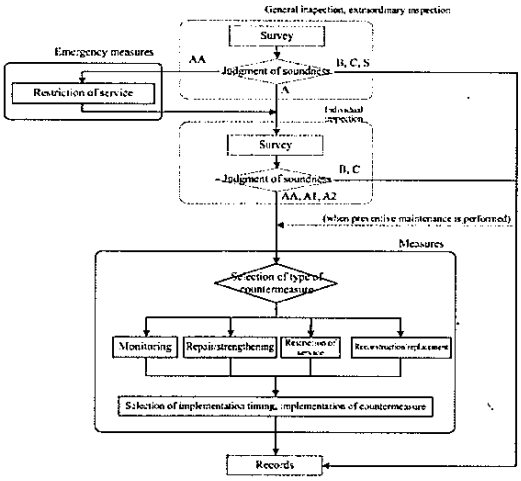


Figure 15 Example of Procedure Leading to Countermeasures

9.Records

"Records" prescribes items relating to the purpose of the records, scope of application, and items to be recorded.

In order to make maintenance of structures efficient and rational, it is prescribed to record and archive necessary information among design documents, construction management records, inspection results, and countermeasures. Also, the validity of maintenance can be confirmed by analyzing records. Inspection, countermeasures and other items required for maintenance of structures are prescribed as record items. Table 9 shows example of inspection record items.

Teble9 Example of Inspection Record Items

Inspection Category	Record Item	
	Common Items	Items for Individual Inspection Categories
Initial inspection	● Inspection category ● Survey date ● Weather ● Name and title of inspector, etc. ● Line name/section/location ● Name of structure ● Survey method and survey result ○ Content (name, and distribution/extent/other features of deterioration) and position (when deterioration is present) of deterioration ● Soundness judgment category	● Materials used ○ Concrete cover to steel reinforcement ○ Design drawings, design computation documents ○ Construction conditions ○ Displacement, deformation ○ Grout filling status (in case of prestressed concrete girders)
Regular general inspection		—
Special general inspection and Individual inspection		○ Survey results (carbonation depth, amount of chloride ions, extent of reinforcement corrosion, concrete strength, amount of residual expansion, extent of frost attack/acidic deterioration, etc.) ○ Cause of deterioration, deterioration prediction, verification result of performance items
Extraordinary inspection		● Date/time of occurrence and outline description of disasters, etc. that have occurred at the structure

●:Items to be recorded ○:Items to be recorded as necessary

626	Programme painting of Girders	Inspections are implemented for judging the soundness of structure. In addition it should be done for all steeled bridge, and record the rust region of paint coating on the surface thereof. And then, painting work should be done for the bridge which has larger rust region or worse corrosion on a priority basis. It is almost important to grasp all bridges soundness comprehensively and habitually.

5.3.2 Recommendations on Technical Standards of MR (Formation)

<table>
<tr><td colspan="2">Title of Standards of MR Manual of Engineering Dept. Chapter Ⅲ (Formation)</td><td rowspan="2">Recommendations by JICA Expert Team</td></tr>
<tr><td>No. of item</td><td>Item</td></tr>
<tr><td>300</td><td>Definition</td><td>Formation definition is just “Trace” in Myanmar, but there are some performances required thereof in Japan.
【Reference; Design standards for Railway and Commentary (Earth Structures)】
Formations should be constructed and maintained its required performance. Safety is set as a required performance of formation to enable trains to run safety and to prevent threats to the life of passengers and the public. Serviceability and restorability are prescribed whenever necessary. Table 1 show the main required performance, performance items and verification indices.
Table 1 Example of Required Performances and Performance Items
<table>
<tr><th>Required performances</th><th>Performances</th><th>Examples of Verification Indices</th><th>Actions Considered</th></tr>
<tr><td rowspan="3">Safety</td><td>Failure</td><td>Degree of danger of internal failure of earth structure (circular slip safety factor, safety factor for double wedge computation method), displacement and deformation</td><td rowspan="3">• All actions and their repetitive occurrence during the design service lifetime
• Accidental actions that are rare but have large impact</td></tr>
<tr><td>Stability</td><td>Stability of supporting ground (circular slip, consolidation settlement), displacement and deformation</td></tr>
<tr><td>Running safety*1</td><td>Displacement and deformation (repeated cumulative displacement, dynamic displacement)</td></tr>
<tr><td rowspan="4">Serviceability</td><td>Riding comfort*1</td><td>Displacement and deformation (track maintenance standard value, dynamic displacement)</td><td rowspan="4">• Frequent actions and their repetitive occurrence during the design service lifetime
• Large actions that occur relatively often during the design service lifetime</td></tr>
<tr><td>Workability of track maintenance</td><td>Displacement or deformation (repeated cumulative deformation, settlement speed)</td></tr>
<tr><td>Vibration and noise</td><td>Vibration level, noise level</td></tr>
<tr><td>Appearance</td><td>Deformation, cracks, etc.</td></tr>
<tr><td>Restorability</td><td>Deformation*2, damage, residual strength</td><td>Residual deformation after an earthquake, deformation during rainfall</td><td>• Accidental actions with extremely low probability of occurrence, but with large impact</td></tr>
</table>
Legend: *1. Verified based on the displacement limit standard, *2 Verification item in the seismic design standard.</td></tr>
<tr><td>304</td><td>Consolidation of Embankments</td><td>It is described that only where the rainfall exceeds 100” per annum, should be provided by turfing in MR. But in Japan, every slope of embankment or cut should be protected by several protection works. Because the surface of bare slope might be deteriorated by rainfalls, it is necessary protection work on it for keeping its better condition.
【Reference; Design standards for Railway and Commentary (Earth Structures)】
(1) Embankment slope protection works
On embankment slope, basic slope protection work prevents surface layer erosion, prevents surface layer slippage, and conserves the environment.</td></tr>
</table>

Table 2 shows the required function of slope protection work according to the performance level.
Table 3 shows the main functions of slope protection work. Generally a suitable work method is selected from these according to the performance rank of the embankment.

Table 2 Necessary Functions of Slope Protection Works by performance Level

Required performances	Functions	Actions	Slope work performance level		
			I	II	III
Safety	Preventing surface layer erosion	Action of weather (rainfall)	◎	◎	◎
	Preventing surface layer slippage and failure	Action of weather, action of groundwater seepage	◎	○	○
	Preventing runoff of soil by spring water	Action of groundwater seepage	◎	○	○
	Preventing surface layer failure caused by frost heaving	Action of weather (air temperature), action of groundwater seepage	◎	○	△
Serviceability	Maintenance	State of vegetation	◎	○	△
	Conserving the environment	State of vegetation, scenic appearance of slopes	△	△	△

Note: ◎: Definitely necessary, ○: Necessary if possible, △: Provide as necessary

Table 3 Types and Functions of Major Embankment Slope Protection Works

Examples of major slope protection works	Functions				
	Preventing surface layer erosion	Preventing slope layer slippage	Preventing slope layer failure	Preventing sediment runoff	Conserving the environment
Concrete-block pitching	◎	○	○	○	×
Lattice frame protection work	◎	◎	◎	◎*1	◎*2
Random masonry	◎	○	○	○	×
Sodding	○	×	○	×	◎

Notes: ◎ Provides advanced functions, ○: Provides functions, ×: Does not provide functions
*1: Cobble stones are used to protect inside the lattice.
*2: Sodding is used to protect inside the lattice.

(2) Cut Slope protection works

On a cut slope, slope protection works must be conducted to prevent surface layer erosion, surface layer failure, weathering of rock, and the runoff of soil by spring water, and to conserve the environment. Table 4 presents the required functions that slope protection works should provide for each performance level.

Table 5 shows the major slope protection works and their functions.

Table 4 Necessary Functions of Cut Slope protection Works by Performance Level

Required performances	Functions	Actions	Slope work performance level		
			I	II	III
Safety	Preventing surface layer erosion	Action of weather (rainfall)	◎	◎	◎
	Preventing surface layer failure or exfoliation	Action of weather, earthquakes	◎	○	○
	Preventing advance of weathering	Action of weather	◎	○	△
	Preventing runoff of soil by spring water	Action of groundwater seepage	◎	○	△
Serviceability	Maintenance	State of sodding	◎	○	△
	Conserving the environment	State of sodding, scenic appearance of slopes	△	△	△

Notes: ◎: Definitely necessary, ○: Necessary if possible, △: Provide as necessary

Table 5 Major Cut slope Protection Works and Functions

Examples of major slope protection works	Functions				
	Preventing surface layer erosion	Preventing advance of weathering	Preventing surface layer failure, exfoliation	Preventing spring water triggered soil runoff	Restoring vegetation to conserve the environment
Concrete-block pitching	◎	◎	×	○	×
Lattice frame protection work by precast concrete	○	○	○	◎*1	◎*2
Lattice frame protection work by cast-in-place concrete	◎	○	◎	◎*1	◎*2
Lattice frame protection work by concrete spraying	◎	○	◎	◎	◎
Concrete protection works	◎	◎	◎	○	×
Mortar spraying works	◎	◎	○	○	×
Shotcreting works	◎	◎	○	○	×
Sodding	○	×	×	×	◎

Notes: ◎: provides advanced functions, ○: provides functions, ×: does not provide functions
*1: cobble stones are used to protect inside the lattice
*2: sodding is used to protect inside the lattice.

Every slope on embankment and cutting, should be protect by several protection work, moreover, there is no slope without protection works in Japan.

In regard to "Concept of performance level"

The restorability of an earth structure is verified by, in principle, checking that damage caused by accidental actions such as earthquakes and rainfall will not reach the limit state of the deformation level considering the degree of difficulty of restoring its functionality. Also the slopes, roadbed work, drainage work, and other constituent parts of the earth structure will not reach the limit state of the damage level considering the degree of difficulty of restoring its functionality are also verified. The following is an outline of the deformation levels and damage levels.

Table 6 shows the deformation level and repairs, while Table 7 shows the criteria for deformation level and damage level limit values by performance rank for the performance level of standard earth structures.

Table 6 Deformation Levels and Repairs

	Overall earth structure deformation levels (Earth Structure Case)	Repair (Case of a track with ballast)
Deformation level 1	Almost no deformation, sound functions, and usable without repair work (For example: no circular slip under predicted action).	No repair, (as necessary, track improvement)
Deformation level 2	Some deformation, but functions can be restored promptly by repair work (For example: circular slip occurs under predicted action, but little residual deformation).	Minor repairs: ballast replenishment, slope recompaction, or partial widening of the formation leve
Deformation level 3	Large residual deformation, but functions can be restored with partial reconstruction (For example: large residual deformation of embankment under predicted action, and partial reconstruction is necessary, irreparable failure has not occurred).	Partially removing slope surface or roadbed surface to reconstruct the embankment or track.
Deformation level 4	Extremely large residual deformation, and functions cannot be restored without overall reconstruction (For example: extremely large residual deformation of the embankment has been caused by the predicted action, and irreparable failure has occurred).	Complete removal of the embankment and overall reconstruction.

Table 7 Criteria for Limit Values of Performance Rank, Deformation Level, and Damage Level

Performance rank	Performance rank 1	Performance rank 2	Performance rank 3
Earth structure deformation level	Deformation level 1	Deformation level 1 to 3	Deformation level 1 to 4
Damage level of each structural member	Damage level 1 to 3	Damage level 1 to 4	Damage level 1 to 4

305	Allowance for Shrinkage	Allowance for shrinkage is arranged according to the rain fall amount in Myanmar, but formations should be constructed with consolidation, never shrink by rainfall in Japan. It should be confirmed consolidation test and calculated settlement about bearing ground of embankment.
306	Dimensions of Cuttings	In regard to Manual of the Engineering Department, the angle of side slope of cuttings in good rock is practically vertical. But even if the soil condition is good, such as hard rock, its angle is more than least 8/10. And more, in performance rank 2 or 3, its angle might be more than 3/10.

【Reference; Design standards for Railway and Commentary (Earth Structures)】

(1) Embankment slope gradient (from Design standards for Railway and Commentary (Earth Structures))

Table 8 shows the performance rank and standard gradient of slope relationship in cases where an embankment is designed using the deemed-to-satisfy specification method. Figure 1 shows the standard section shape.

Table 8 Performance Rank-Embankment Standard Gradient of Slope

Height from formation (m)	Performance rank I	Performance rank II	Performance rank III
Less than 9 m	1:1.8	1:1.5 to 1:1.8	1:1.5
Higher than 9 m and less than 15 m	1:2.0	1:1.8 to 1:2.0	1:1.8
15 m or longer	1:2.3	1:2.0 to 1:2.3	1:2.0

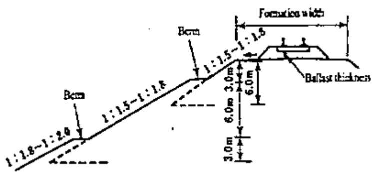


Figure 1 Standard Embankment Shape

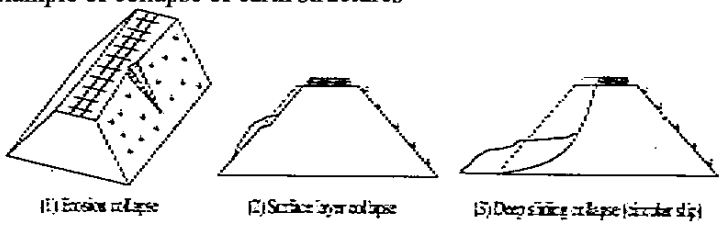
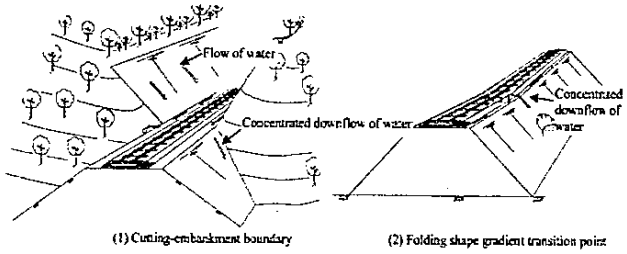
(2) Cutting slope gradient

Table 9 presents the standard performance rank and gradient of slope for a case based on deemed-to-satisfy specifications.

Table 9 Performance Rank and Standard Gradient of Slope

Topography, soil, rock			Performance rank I *1	Performance ranks II, III	Others
Normal soil *2	Soft soil Fragile soil	Soft fine-grained soil	–	1:1.5 or more	
		Soft sandy soil Soft gravelly soil	1:1.8	1:1.5 to 1.8	
	Medium hard soil Slightly compacted soil	Moderately hard fine-grained soil Moderately compacted sandy soil Moderately compacted gravel soil	1:1.5	1:1.2 to 1.5	
	Hard soil Compacted soil	Hard fine-grained soil Compacted sandy soil Compacted gravel soil	1:1.2	1:1.0 to 1.2	
Special soil	Volcanic ash type cohesive soil	Soft	–	1:1.2 or more	
		Hard *3	1:1.5	1:1.0 to 1.5	
		Haido *4	–	1:1.0 or more	
	Decomposed granite		1:1.5	1:1.0 to 1.5	
	Pit sand		1:2.0	1:1.5 to 2.0	
	Shirasu *5	Soft *Shirasu*	1:1.4	1:1.0 to 1.4	
		Medium hard *Shirasu*	1:1.0	1:0.7 to 1.0	
		Hard *Shirasu*	1:0.7	1:0.5 to 0.7	
Rock	Fragile rock		1:1.2	1:0.8 to 1.2	
	Soft rock *6		1:1.0	1:0.5 to 1.0	
	Hard rock		1:0.8	1:0.3 to 0.8	

*1: If the natural ground is weak (prescribed in commentary), it must be reinforced with natural ground reinforcing material.
*2: In case of SP, the soil is regarded as the pit sand of special soil.
*3: *Kanto* loam layer, *Iwate* loam etc.
*4: *Haido* is weathered pyroclastic flow deposits.
*5: *Shirasu* is sedimentation of white volcanic sand and pozzolana, including loose volcanic bombs.
*6: Tuffaceous rocks with good consolidation may be considered to be hard rock.

308-316	Maintenance	There are no standards regarding to the inspection of formation in MR standard, causes corrective maintenance have to take more repair cost than prevention maintenance. In Japan, inspections should be implemented for all structures including formations. The inspection of formation is basically as same standards as we mentioned on 5.3.1. Hereafter, additional items for inspection of formation are shown as bellow, and the other items, not described in detail this chapter, are as same as 5.3.1. Inspection 1. Categories of Inspections 2. Inspection Timing 3. Verification of Performance and Judgment of Soundness 4. Initial Inspection 4.1 Timing of Initial Inspection 4.2 Survey Items 4.2.4 Earth Structures For earth structures, means formations, mainly initial states of the condition of embankments and cuttings, protective facilities, drainage facilities, and the surrounding environment are surveyed. The initial state of the surrounding environment of embankments and cuttings must be ascertained beforehand as its change considerably affects the stability of the embankments and cuttings. Survey items include soil test, rock tests, boring investigations, sounding tests, base rock fissure surveys, and cross-section surveying of embankments and cuttings. 4.3 Survey Methods 4.4 Judgment of soundness 5. General Inspections 5.1 General Inspection Categories 5.2 Regular General Inspection 5.2.1 Survey Items 4) Example of collapse of earth structures  Figure 1 Types of Embankment Collapse  Figure 2 Embankment Location Conditions

5.2.2 Survey Methods
5.2.3 Judgment of Soundness

4) Earth structure
The following describes examples of deterioration on earth structures are judged to be soundness AA in maintenance standard
(1) When it is clear that crack width or length and the amount of settlement, upheaval, and sliding are progressing
(2) When it is clear that cracks, settlement, upheaval, and sliding have occurred recently
(3) When caving has occurred on the formation level.

5.3 Special General Inspection
5.3.1 Inspection Timing
5.3.2 Survey Items
5.3.3 Survey Methods
5.3.4 Judgment of Soundness
6. Individual Inspection
6.1 Individual Inspection Procedure
6.2 Survey Items
6.2.4 Earth Structures
Basically, with earth structures, periodic special general inspection is not performed. However, special general inspection may be performed when it is judged as necessary with the following reasons by the railway operator; a) surveying the current status of embankments and cuttings in detail to reveal and file the attention locations, or b) positioning the inspection conducted with the purpose of re-arranging the files by a certain interval as a special general inspection.
1) Survey items for deterioration
- State of embankments and cuttings
- State of protection facilities and drainage facilities

2) Survey items for instability
- Site conditions of embankments/ cuttings, surrounding environment
- State of embankments/cuttings, protection facilities and drainage facilities (other than deterioration)

6.3 Survey Methods
6.3.4 Earth Structure
Though survey methods in individual inspections differ according to the type of survey, survey are basically performed by careful visual inspection. When surveys of earth structures are judged to be necessary as a result of careful visual inspection, surveys using soil test, geological surveys, rock tests, boring investigations, and various other surveys using instruments should be performed.

6.4 Identification of Causes of Deterioration
6.5 Deterioration Prediction
6.6 Verification of Performance Items
6.7 Judgment of Soundness
7. Extraordinary Inspection
8. Countermeasures
9.Records

3.5.3 Safety Precaution

We recommended in the purpose of efficient train operation control in the case of disasters to improve the service and safety level of Myanma Railways. In actual standard of MR is almost sufficiency for reopening train operation safely, if all described actions are strictly taken by relevant authorities. Especially, followings are quite essential article for preventing disaster that we'd like to emphasize.

§Article1256: The object of such investigation is to ascertain the cause of the accident in order that suitable action may then be taken to endeavor to prevent the recurrence of any similar accident in the future.

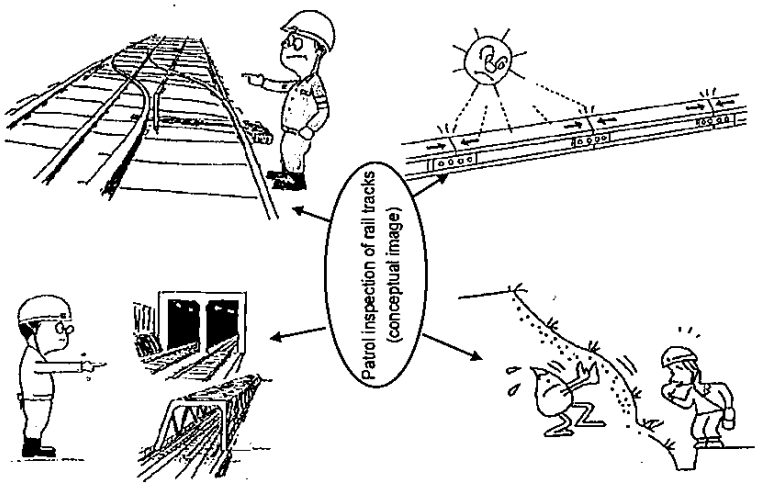
§Article1257: Every railway servant present at an accident must therefore do his best to foster such spirit of cooperation in the interests of the speedy completion of the restoration.

But judgments whether it would be unsafe or not, almost be taken by individually and personally, no clear standard value existing, would take a longer time to take an action for the train operation control.

For reopening train operation safety, also more rapidly, we recommended "the example of guarding and standard value for train operation control about rainfall and strong wind" from Japanese Ministerial Ordinance.

Title of Standards of MR Manual of Engineering Dept. Chapter XII (Safety Precautions)		Recommendations by JICA Expert Team
No. of item	Item	
1210-1224	Patrolling for unsafe line, Instruction	We'd like to recommend MR the example of concept, "Ministerial Ordinance" and its "Approved Model Specifications", "Explanation", about safety operation under the disaster. [Ministerial Ordinance] (Patrol Inspection and Monitoring of Main Track as well as Overhead Contact Line Installed over the Main Line and Inspection of Train) Article 89. Patrol inspection shall be conducted for the main track and overhead contact line installed over the main track, according to the situation of the section block and traffic conditions of trains. 2. When a possibility of disasters that can interfere with the safe train operation on the main track is found, the relevant track shall be carefully monitored. 3. Main component of a rolling stock shall be inspected according to the type and traffic condition of trains. [Approved Model Specifications] 1 Patrol inspections of the rail tracks as well as overhead contact line installed on the main line shall be appropriately carried out considering the situation of the section block and traffic conditions in order to maintain them in the condition as to secure the safe operation of rolling stock at the pre-determined speed. Details of frequency, timing, method, etc. of the patrol inspections shall be determined considering the surrounding circumstances. 2 When a certain disaster that may influence or interfere with the operation of trains, is expected to occur on the main line, it is necessary to monitor the main line, and to limit the running speed of trains, if necessary, or to stop the operation of trains on the line or the relevant section block. Moreover, an appropriate monitoring arrangement, restricted operation speed of the train, etc. corresponding to the foreseeable disasters shall be prepared in advance. 3 A railway operator shall carry out the inspection of trains pursuant to the pre-determined content of the inspection at the pre-determined timing in consideration of the usage of the rolling stock, design method, the management

		method applied to them, and the traffic condition of the trains. [Explanation] This article stipulates matters pertaining to the patrol inspection and monitoring of rail tracks, and the inspection of trains in order to maintain the rail tracks, overhead contact lines and trains in conditions that ensure safe train operation at all times. 1. Patrol inspection of rail tracks 1.1 Purpose of patrol inspection of rail tracks The function of rail tracks is to support the trains and secure their running space, and thus they must be maintained in conditions that ensure safe train operation at all times. The conditions of a rail track constantly change depending on various factors including the influence of train traffic and aging, and the environment along the track such as drainage, water retention capability, etc. which are affected by land development, deforestation, etc. in the surrounding area. Therefore, it is necessary to periodically inspect the functions of individual facilities and to know the state of these functions as well as the overall maintenance conditions of the rail track, whether or not construction limits are exceeded, changes in the surrounding environment, etc. through periodic patrol inspection of the rail track. 1.2 Frequency of patrol inspection of rail tracks Patrol inspection of a rail track is required to ensure the safety and stability of daily train operation over the entire rail track, and the frequency of inspection must be set by comprehensively considering various factors including the conditions of track structures (rail weight, sleeper type, trackbed thickness, roadbed, etc.) and civil engineering structures (bridges, tunnels, banking, cutting, etc.) of the line section, the expected loading force on the rail track based on the bearing capacity, train speed, vehicle performance, traffic volume, etc., the method of periodic inspection, and the natural environment and site conditions such as the terrain, geology, land use, weather conditions, etc. in the surrounding area. The methods for track patrol inspection include inspection over the entire line on foot or by a service car to check the maintenance conditions of the entire rail track, on-vehicle inspection performed from the driver's platform of a train to check the maintenance conditions as well as the train ride comfort. Effective inspection should be conducted by combining these methods according to the frequency of inspection and the items to be checked. Introducing an important inspection item in different seasons, etc. is also an effective means for enhancing the awareness of inspection personnel. If any abnormal condition is found during the track patrol, it is necessary to promptly contact the relevant departments and take necessary actions including inspection, monitoring, operation control, etc. The method, etc. for track patrol inspection shall comply with the "Maintenance Standards for Railway Structures (Tracks Part)".



2. Monitoring of rail tracks

2.1 Monitoring of tracks

In the case of the discovery of a damaged rail, joint bar, etc., poor bonding/adhesion of a turnout, a sunken roadbed or other conditions that may affect safe train operation, appropriate actions must be taken based on the nature and severity of the problem in order to avoid a serious accident. Such actions include making arrangements for stopping trains, arrangements for slowing down trains while preparing for the replacement of materials, placing a monitoring mark to indicate a place that requires special attention and periodic monitoring.

2.2 Monitoring of civil engineering structures

In the case of discovery of a deformation of a slope, risk of falling rocks, crack in a bridge girder or other conditions that may affect safe train operation, appropriate actions must be taken based on the nature and severity of the problem in order to avoid a serious accident, while making arrangements for protecting the trains and conducting periodical monitoring.

Once an accident occurs involving a civil engineering structure, train operation is often restricted for a long period of time. Therefore, it is necessary to recognize the warning signs as early as possible and systematically install prevention facilities such as those specified in Article 27 "Facilities to Prevent Disasters and Other Incidents".

2.3 Monitoring of rail tracks when there is a risk of disaster

In cases where damage to a rail track is expected due to a natural disaster such as typhoon, heavy rainfall, flood, tsunami, snowfall, dense fog, earthquake, etc. or other factors such as a fire in the vicinity of the track, construction work close to the track, rise in rail temperature, etc., the subject rail track must be effectively monitored in accordance with the respective situation. In addition, appropriate actions must be taken to ensure safe train operation, such as restricting the operation speed by setting a slow speed as required or canceling train operation in the relevant line or line section depending on the circumstances.

Attempting to devise appropriate measures after a disaster has occurred may result in serious damage.

Therefore, assuming the possibility of a disaster, it is desirable that susceptible line sections be specified, and the monitoring method and system, speed reduction, etc. be determined in advance.

[Reference]

1. Principle of guarding against disasters

Railway structures are exposed to external natural forces such as rain and earthquake; it is difficult to completely avoid the deformation or damage of structures caused by these forces. Therefore, safe train operation should be ensured by keeping guard when there is a risk of disaster, or by carrying out operation control, while steadily promoting disaster prevention measures for improving the yield strength of structures.

1.1 Guarding plan

The purpose of guarding against disasters is to ensure safe train operation by checking for abnormalities in rail tracks in the event of weather conditions that pose a high risk of a natural disaster. To appropriately and securely implement protection measures against disasters, a plan must be created in advance so that the necessary protection system is appropriately established.

1.2 Example of guarding and standard values for operation control, etc.

(1) Rainfall

Typical disasters caused by rainfall include landslide disasters on earthworks such as cutting and banking or on natural slopes. These disasters are often caused by factors such as amount or intensity of rainfall, etc. Therefore, rainfall is generally monitored in order to ensure safe train operation by detecting signs of a disaster, and an alert is issued or operation control is executed when the observed amount of precipitation (rainfall), intensity of rainfall, etc. has exceeded the predetermined standard value.

○ Examples of JR (conventional line)

Examples of categories, methods and release criteria for operation control, etc. depending on the rainfall situation are shown in Table 89.1 and onward. In cases where, due to structural and geographical conditions, etc. there is no risk of disaster caused by rainfall or only minor damage is expected in the event of a disaster, it is possible that some or all of the categories of operation control are not applied.

Table 89.1 Example of categories, methods and release criteria for operation control, etc.

Category	Alert	Speed control	Operation cancellation
	There is almost no risk of disaster, but some of the signs are observed.	There may be a risk of minor disaster.	There is a risk of disaster.
Operation control method	–	Train speed is restricted if the standard value is reached.	Suspend train operation.
Guarding method	The predetermined guarding places are patrolled on foot, etc. at intervals of 3 to 4 hours.	In addition to the method shown on the left, the entire section is guarded by train at 2-hour intervals.	The entire section is patrolled on foot, etc. whenever and wherever possible.
Release criteria	Rainfall ending trend is confirmed and the hourly rainfall has dropped to below the alert standard value. Alternatively, a significant length of time has passed since the rain stopped.	It is confirmed that there are no abnormal conditions in the predetermined guarding places, the rainfall has dropped to below the alert standard value, and it is confirmed by passing trains, etc. that there are no abnormal conditions over the entire section.	The rain has stopped or the rainfall has dropped to below the standard value, and it is confirmed on foot, etc. that there are no abnormal conditions over the entire section.

The rainfall indexes used for operation control include the amount of hourly rainfall and amount of continuous rainfall, which are applied alone or in combination with each other. One example of application is shown below.

○Hourly rainfall, continuous rainfall and their combination

Operation control, etc. is issued if the amount of hourly rainfall or continuous rainfall has exceeded the respective standard value. The standard value for hourly rainfall may be reduced in some cases if continuous rainfall has exceeded a certain value (Fig. 89.1).

・Hourly rainfall is the total amount of rainfall until any given time starting from one hour before that time.

・Continuous rainfall is the total amount of rainfall that has continued without interruption of more than a certain period of time (12 hours or more) until any given time starting from the start of the rain.

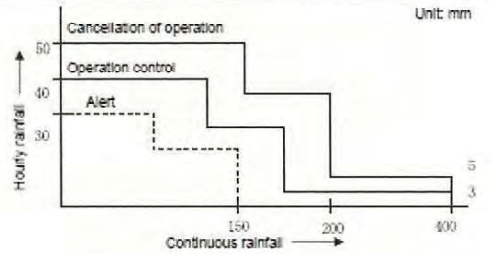


Fig. 89.1 Example of operation control based on combination of hourly rainfall and continuous rainfall (conceptual image)

○ Example of private railway

There are two types of operation control due to rainfall: speed control and cancellation of operation

The sections subject to operation control are classified as follows:

Section A: Relatively strong main line section where only slight damage, if any, is expected.

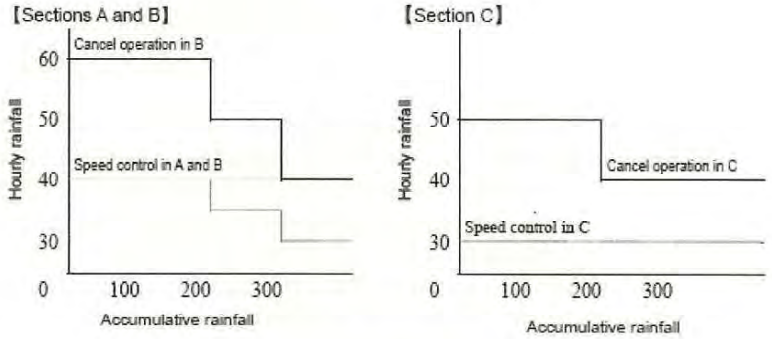
Section B: Main line section where significant damage such as a landslide is expected due to heavy rain.

Section C: Branch line or a section where cancellation of operation has little effect.

The standard values for issuing operation control, etc. are shown in Table 89.2.

Table 89.2 Standard values for operation control, etc.

Operation control section class	Type of operation control	Standard value		
		Accumulative rainfall of less than 200 mm	Accumulative rainfall of 200 mm up to 300 mm	Accumulative rainfall of 300 mm or more
A	Speed control	Hourly rainfall of 40 mm or more	Hourly rainfall of 35 mm or more	Hourly rainfall of 30 mm or more
B	Speed control	Hourly rainfall of 40 mm or more	Hourly rainfall of 35 mm or more	Hourly rainfall of 30 mm or more
	Operation cancellation	Hourly rainfall of 60 mm or more	Hourly rainfall of 35 mm or more	Hourly rainfall of 40 mm or more
C	Speed control	Hourly rainfall of 30 mm or more		
	Operation cancellation	Hourly rainfall of 50 mm or more	Hourly rainfall of 40 mm or more	



・Hourly rainfall is the amount of rainfall in the last one hour, which is measured every 15 minutes (4 times:0, 15, 30 and 45 minutes of each hour).

・Accumulative rainfall is the cumulative amount of rainfall starting from a point of time when there has been no rain for the last 48 hours. (Rainfall is measured every 15 minutes as in hourly rainfall.)

(2) Strong Wind

Strong wind is generally monitored in order to ensure safe train operation by

<table>
<tr>
<td></td>
<td></td>
<td>detecting signs of a disaster, and an alert is issued or operation control is executed when the observed wind velocity has exceeded the predetermined standard value, shown in table89.3.

Table 89.3 Standard values for train operation(strong wind)
<table>
<tr><td rowspan="2">Wind velocity</td><td colspan="2">Type of operation control</td></tr>
<tr><td>Normal Section</td><td>Specific Section</td></tr>
<tr><td>15m/s and over, under 20m/s</td><td>-</td><td>Alert</td></tr>
<tr><td>20m/s and over, under 25m/s</td><td>Alert</td><td>Speed control</td></tr>
<tr><td>25m/s and over, under 30m/s</td><td>Speed control</td><td rowspan="2">Operation cancellation</td></tr>
<tr><td>30m/s and over</td><td>Operation cancellation</td></tr>
</table>
"Specific Section" is where threaten by strong wind without countermeasure works such as wind-shield. "Normal Section" is where threaten by strong wind without countermeasure works</td>
</tr>
<tr>
<td>1202</td>
<td>Safety definition for maintenance of structures</td>
<td>We already mentioned on Previous chapter,bridges and formation.</td>
</tr>
</table>

Part II Proposal of Short-, Medium-, and Long Term Railway Facilities Improvement Plan

1. Introduction

1.1 The principles for drawing up short-, medium-, and long-term railway facilities improvement plan

In drawing up short-, medium-, and long-term railway facilities improvement plan (hereinafter referred to as RFIP) from the viewpoint of upgrading safety and service of MR, the following principles are adopted,

(1) RFIP focuses on the rehabilitation and modernization of the existing lines.
(2) Railway facilities plan relating to new line construction and improvement of international transport will be excluded.
(3) RFIP will focus on improvement of facilities relating to upgrading safety and service, but exclude the improvement of facilities relating to economic development of the area along the lines, railway business expansion, or revenue increase such as development of ICD, freight yard, connection to sea ports.
(4) The railway projects proposed by Myanmar Development Cooperation Forum which took place on Jan.19 and 20, 2013 will be duly taken into consideration.
(5) "Survey Program for National Transport Development Plan in the Republic of the Union of the Myanmar" prepared by JICA (June 2014) will be duly taken into consideration.

1.2 Railway projects proposed by Myanmar Development Cooperation Forum.

Among the railway projects proposed by Myanmar Development Cooperation Forum, those which are within the framework of the principles for drawing up RFIP mentioned in 1.1 above are given below.

(1) Yangon – Mandalay Line rehabilitation and modernization
(2) Yangon Circular line Modernization and Rehabilitation
(3) Upgrading of Mandalay – Myitkyina track and signaling
(4) Track upgrading of Bago – Dawei
(5) Yangon – Pyay track upgrading
(6) Repowering of locomotives and purchasing new passenger coaches.

1.3 Railway Program for National Transport Development Plan in the Republic of the Union of Mayanma ((hereinafter referred to as MYT – Plan) (JICA, June 2014)

1.3.1 Railway section vision of MYT – Plan

"Develop safe rail network and services along the designated major economic development corridors in order to fulfill social and economic transport needs of the nation in a coordinated manner with other modes of transport to achieve higher inter-modality; contribute to the environmental improvement through introduction of low carbon technologies, and build preferred business environment through provision of safe, punctual, comfort and high capacity rail transport services with affordable yet reasonable prices."

1.3.2 Identification of Major issues of railway by MYT – Plan meeting the principles of RFIP described in 1.1 above.

- The low quality of railway transport services because of deteriorated tracks, aging rolling stock as well as poor maintenance.
- Many old rail bridges needing urgent rehabilitation or replacement to mitigate against large-scale accidents.
- The existing main railroads of Yangon-Mandalay, Yangon–Pyay, Yango-Mawlamyine are not utilized effectively.
- The service level of Yangon Circular Line must be improved to accommodate the increasing travel demand in Yangon
- Other important actions that MR should undertake include:
  - Upgrading of the Yangon Station Yard facilities.
  - Establishing a modernized track maintenance system.
  - Upgrading the Insein Diesel Locomotive Workshop.
  - Moving RBE workshop to Ywarthargyi.
  - Rehabilitation rail lines, including:
    - Bago – Mawlamyine rail line (Progress to 100 k/h running speed)
    - Yangon – Pyay – Bagan rail line
    - Ywahtaung – Khin U rail line (Progress to 100km/h running speed)

1.3.3 Corridor – Based Transport Infrastructure Development

(1) Introduction

In drawing up Myanmar's national transport development plan, MYT – Plan adopted an approach to develop Myanmar's corridors – based transport infrastructure and priority corridors, and necessary transport infrastructures and services along the designated corridors were identified.

In order to identify priority corridors, MYT – Plan carried out quantitative analysis for each transport corridor, based on socio – economic framework, passenger and freight demand forecast, characteristics and transport needs of each corridor.

As a result, 10 priority corridors were proposed together with significant component projects for each of priority corridor.

(2) Development Corridors in Myanmar

In this analysis, core development centers are grouped into a three level hierarchy: national, regional, agro-industrial/ special function.

At the first hierarchy level, there are three national growth centers: Yangon, Mandalay and Nay Pyi Taw. At the second level, seven regional growth centers were identified, including: Myitkyna, Sittwe, Kyawkpyu, Pathein, Bago (Hanthawaddy), Mawlamyine, and Dawei. At the third level, major concentrations of agro-industry and commerce exist and are often related to the agricultural economic-base, border towns and other special function settlements. MYT Plan identified 10 development corridors as given below.

A. Central North-South Corridor
B. East- West Corridor
C. Northern Corridor
D. Mandalay – Tamu Corridor
E. Second East – West Corridor
F. Main Rive Corridor (part of the Western North-South corridor)
G. East – West Bridging Corridor
H. Delta Area Network
I. Southern Area Development Corridor
J. Western North-South Corridor (including Corridor F)
K. Eastern North – South Corridor

(3) Quantitative evaluation of 10 priority corridors

MYT – Plan evaluated the 10priority corridors from the viewpoint of population and GRDP along the corridor, freight and passenger demand, and volume capacity ratio, and obtained the average score of each corridor as given in Table 10.5

According to table 10.5, the especially significant corridors include:

A Central North – South Corridor (Yangon – Mandalay – Myitikyna)
K Western North – South Corridor (Yangon – Pyay – Magway – Mandalay)
B East – West – Corridor (Yangon – Hpa-An – Myawaddy – Dawei)
H Delta Area Network (Yangon- Pathein- Hinthada)

Table 10.5 Multi-criteria Analysis and Indicated Priority Development Corridors

Development Corridor	Section	Code	Growth Center	Contribution (Economy)	Investment Impact (Traffic)	Investment Efficiency	Average Score
A. Central North-South Corridor	Yangon - Nay Pyi Taw	A1	5	5	5	5	5.0
	Nay Pyi Taw - Mandalay	A2	5	3	5	5	4.5
	Mandalay - Myitkyna	A3	4	4	2	2	3.0
B. East - West Corridor	Yangon - Hpa-An - Myawaddy	B1	4	5	4	3	4.0
	Mawlamyine - Dawei	B2	3	1	1	1	1.5
C. Northern Corridor	Mandalay - Muse	C1	4	3	3	4	3.5
D. Mandalay - Tamu Corridor	Mandalay - Tamu	D1	4	4	2	1	2.8
E. Secibd East - West Corridor	Tachilek - Meiktila - Kyaukpyu	E1	3	4	2	1	2.5
G. East - West Bridging Corridor	Hapasawing - Pyay	G1	3	1	1	1	1.5
	Loikaw - Magway	G2	3	2	1	1	1.8
H. Delta Area Network	Yangon - Pathein	H1	4	4	3	4	3.5
	Pathein - Hinthada	H2	3	1	1	1	1.5
J. Southern Area Development Corridor	Thanbyuzayat - Hpayarthonesu	J1	3	1	1	1	1.5
	Dawai - Thai Border	J2	3	1	1	1	1.5
	Dawei - Kawthaung	J3	3	1	1	1	1.5
K. Western North-South Corridor	Yangon - Pyay - Magway	K1	4	5	3	4	4.0
	Magaway - Mandalay	K2	4	4	2	3	3.3
L. Eastern North - South Corridor	Bilin - Loikaw	L1	3	1	1	1	1.5
	Loikaw - Nawnghko	L2	3	1	1	1	1.5

First priority corridor
Second priority corridor
Soyurce: JICA Study Team

Priority railway projects proposed by MYT – Plan

MYT – Plan, proposes the priority railway projects meeting the principles of RFIP for significant corridors A, K, B as follows.

A Central North – Corridor

Yangon – Mandalay line

Mandalay – Myitkyna line

K Western North South Corridor

Yangon – Pyay line

B East – West corridor

Bago – Mawlamy line

H Delta–Area Network

Yangon–Pathein

(4) Capital investment plan of MYT – plan

According to MYT – plan, the required investment is allocated to two programs:1) a vive-year program (2014 – 2020) that will see 87% of the program funding for national-level transport system; and 2) a ten-year program (2020 – 2030) that includes an investment allocation (pattern) that is "well-balanced" between national systems and urban/ rural systems.

2. Proposal of short-, medium-, and long-term railway facilities improvement plan

2.1 Introduction

In drawing up RFIP, the principles described in Chapter 1 Iintroduction have been duly taken into consideration. Further the following preconditions or policies have been assumed.

(1) In MR railway network, Yangon – Mandalay line and Yangon Transit System (Circular line + Danyingon ~ Hlawga+ Mahlwagon ~ Ywathagyi + Thilawa line) have been defined as "Most Important Lines".
(2) Mandalay – Myitkyna line, Yangon – Pyay line, Yangon-Pathein line and Yangon – Dawei line have been defined as "the Next Important Lines".
(3) All other lines have been defined as "Other Lines".
(4) As indicated in the Inception Report,

Short term corresponds to	2015 – 2018
Medium term corresponds to	2018 – 2025
Long term corresponds to	2025 – 2045

2.2 Track

The basic strategy in drawing up RFIP in the field of track is as follows.

(1) Improvement of the urgent places of Most Important Lines and Next Important Lines shall be completed as a short- term plan to ensure safe train operation urgently.
(2) With respect to improvement of the Most Important Lines, the Next Important Lines, and the Other Lines, the items (1) – (7) will be improved according to the schedule shown in Table 2.2.1.
   (a) Regarding the items (1) & (2)
      ① They will be implemented as a medium term plan for the Most Important Lines.
      ② They will be implemented as a, med/ long term plan (up to 2030-2035) for the Next Important Lines.
      ③ They will be implemented as a long term plan for the Other Lines.

   (b) Regarding the items (3) – (7).
      These items perform their functions covering not a single line, but various lines. As such,
      ① the functions are to be displayed as a medium term plan for the Most Important Line
      ② the functions are to be displayed as a med/ long term plan (up to 2030-2035) for the Next Important Line.
      ③ the functions are to be displayed as a long term plan for the Other Lines

Table-2.2.1 Short-, Medium-, and Long Term Railway Facilities Improvement Plan
(for levelling up Safety and Service Level) -Track-

Facilities to be improved	2015 Short term	2018 Medium term	2025	2030	2035 Long term	2045
1.Urgent improvement of the Most and Next Important Lines (Y-M Line、Y Transit System) (M-Myitkyna, Y-Pyay, Y-Pathein, Y-Dawei) (1)improvement of urgent places ・replacement of old aged rails ・improvement of joints and rail welding ・replacement of damaged turn out ・replacement of damaged PC sleeper, replacement of wooden sleeper by PC sleepers ・supply of ballast ・urgent improvement of important level crossings ・track irregularity rectification (2)procurement of small/medium type track maintenance machine/tool (3)procurement of track inspection equipment	Most Important Lines Y-M Y Transit System Next Important Lines M-Myitkyna Y-Pyay Y-Pathein Y-Dawei					
2. Improvement of the Most Important Lines, Next Important Lines and Other Lines (1)Improvement of track structure ・increase the unit weight of rail appropriately ・producting long welded rail ・replacement of existing turnout to appropriate advanced turnout ・increase of sleepers per km appropriately, and promote laying of PC sleepers ・supplement of ballast, increase the depth of ballast ・improvement of level crossing track structures ・track irregularity rectification ・constructuin of track posts (2) procurement of large track maintenance machines (MTT, BR, BHC etc) and construction of the depots		Most Important Lines Y-M Y.C.L.	Next Important Lines M-Myitkyina Y-Pyay Y-Pathein Y-Dawei		Other Lines	
(3)Usage of high speed track inspection car (4)Improvement of ballast production factory and expansion of its production capacity (5)Construction of rail welting depot (6)Improvement of tumout factory and expansion of its production capacity (7)Improvement of PC sleeper factory and expansion of its production capacity		to cope with the needs of the Most Important Lines (Y-M, Y,C,L)	to cope with the needs of the Next Important Lines		to cope with the needs of the Other Lines	

2.3 Rolling stock

2.3.1 Current Condition

Following matters are recognized regarding safety and passenger service as problems for improvement.

(1) 2 (two) types of brake system (vacuum brake and air brake) are applied.

(2) Vibration of passenger car is much bigger than that of DMU.

(3) Break down of bogie suspension is occurring frequently.

(4) In some trains brake is applied only locomotive.

(5) There are no sanitation system on the train and track structures are damaged by sewage

(6) Train delay is occurring by poor maintenance of rolling stock.

(7) Most of rolling stock are air non conditioned.

2.3.2 Measures for Improvement

(1) Improvement of running gear

Vibration of passenger car is very high. It is not only lower the service level by ride quality but also affect the safety. High vibration might cause the derailment accident. It is also presumed that high vibration will accelerate the fatigue of metal of suspension system and accelerate the damage of tracks. Improvement of running gear is argent issue for safety.

Bogie of passenger car is composed of coil spring and oil damper. Bogie of some of DMU is similar configuration bogie of passenger car. However vibration is much smaller than passenger car when running same section of the track. It means vibration of passenger car is not only because of track condition but it can be solved by rolling stock side.

It is anticipated that vibration can be lowered by selecting appropriate characteristics of coil spring and oil damper.

(2) Improvement of brake system

Two types of brake system are used in Myanmar railway air bake and vacuum brake. It is not efficient for maintenance to use two deferent types of brake system. Vacuum brake requires long release time after brake is applied and it cannot be expected higher brake force.

Also to speed up the trains for improvement of service level brake system is very important and performance of vacuum brake is not sufficient. It is recommended to standardize the change brake system to air brake for safety, passenger service and efficiency.

(3) Installation of sanitation system

Sewage from the toilet of the coach is directly dropped down to the track from the coach. That will damage the track structures and bogie structures. More over it is not good in a sanitary manner. It is recommended to install a sanitation system on the coach that storages the sewage in the tank. Sewage will be drain out when train comes back to the depot. A treatment system for train sewage shall be installed in the depot.

(4) Conversion of passenger trains to DMU

Most of the passenger trains in Myanmar railway is composed of locomotive and passenger coach. When train is composed of locomotive and passenger coach locomotive has to be changed position every time at terminal station. In DMU (Diesel Multiple Unit) drivers cab is installed on both end of the train and it is easy to turn back. Usually more than one engine unit is installed in DMU therefore acceleration is much higher than locomotive and coach. It can shorten the traveling time and turn back therefore much convenient train schedule is available. It is advantageous for commuter trains.

Currently DMUs are operated suburban area of Yangon and Naypidaw. In circular line that is most congested line in Myanmar railway coaches and DMUs are operated. Acceleration and deceleration of coaches are much smaller than DMU. When operation headway is short trains composed by locomotive and coaches will disturb DMU trains. Therefore it is recommended to change all the trains to DMU.

Most of DMUs operated in Myanmar Railway are second hand rolling stock. Merit of secondhand rolling stock is very low cost compare to procuring new rolling stock. It can be expected that more secondhand DMUs will be available from Japan because there are still many DMUs are operated and they will be surplus because of electrification or renewal of rolling stock. However following

issue are identified on secondhand DMU.

- Modification is required
  - Lowering of roof
  - Installation of steps
- Types of cars become too varied.
- Available DMU is not for commuter train but local train.

It is recommended to procure new rolling stock to standardize the specification and to provide suitable train for commuter service.

(5) Air Conditioning of Passenger Coach

Most of the coaches are not air conditioned even upper class however buses running high way are already air conditioned. To improve the service level of railway and to compete with other traffic mode it is recommended to install air conditioning system on the rolling stock.

(6) Improvement of Depot and Workshop

When trains are shifted to DMU facilities of depot and workshop shall be capable of DMU. Also some of the facilities of workshop are already old and not available for recent rolling stocks.

When tracks are improved and new lines are constructed in Myanmar railway more rolling stock are required. Depot and workshop will have to be enhanced to conduct the maintenance.

(7) Electrification

Most of the modern railways in the world are electrified.

Advantages of electrified railway are as follows.

a. less energy consumption
b. no emission of fumes and carbon dioxide from train
c. higher acceleration
d. less noise
e. no interval for fueling

However it requires much cost for installing power supply system including substation, overhead contact line, etc. Electrified railway is much profitable than non electrified railway when number of trains are sufficient.

It is recommended to electrify Yangon circular line at first to utilize the advantage of electrification. DMUs running on Yangon circular line will be transferred to other urban section around Yangon and Naypidaw when EMUs are installed.

Yangon – Mandalay line will be electrified in next stage and construction will be implemented section by section. Electric locomotive will be installed to replace old diesel locomotive. Long distance train will be pulled by electric locomotive at electrified section and change to diesel locomotive at non electrified section. When section between Yangon and Naypidaw is electrified EMU express train will be introduced to provide better service.

However construction gauge in Myanmar railway is very short in height and there is no space for installing overhead contact wire. Further study will be required for electrification. Time for construction of electrification and installation of electric train will be decided when feasibility study of electrification makes progress. Construction of electrification will be commenced as soon as possible when conditions become available.

2.3.3 Schedule of Improvement Plan

Following table shows the schedule of improvement plan

Table 2.3.1 Schedule of Short-, Medium-, and Long-Term Railway Facilities Improvement Plan (Rolling Stock)

Year	2015	2018	2025	2035	2045
Item for Improvement	Short Term	Middle Term	Long Term		
1. Improvement of running gear					
• Investigation of bogie maintenance	↔				
• Trial manufacture and test	←	→			
• Modification of coach	←	→			
2. Improvement of brake system					
• Installation of air brake on locomotive		←	→		
• Convert from vacuum brake to air brake on coaches and wagons		←	→		
3. Installation of sanitation system					
• Installation of sanitation system on the coaches		←	→		
4. Introduction of DMU					
• Procurement of DMU		←	→		
• Manufacture of DMU			←	→	
5. Installation of air conditioning system					
• Modification of coach		←	→		
6. Electrification					
• Study of electrification	←	- - - - - - - - - -			
• Electrification of Yangon circular line		- - - - - - - - - -	- - - - - - - - - -	- - - - - -	
• Introducing EMU commuter train		- - - - - - - - - -	- - - - - - - - - -	- - - - - -	
• Electrification of Yangon Mandalay section		- - - - - - - - - -	- - - - - - - - - -	- - - - - -	
• Introducing electric locomotive		- - - - - - - - - -	- - - - - - - - - -	- - - - - -	
• Introducing EMU express train		- - - - - - - - - -	- - - - - - - - - -	- - - - - -	
7. Improvement of depot and workshop					
• Renewal of facilities for modern rolling stock	←	→			
• Providing facilities for maintenance of DMU		←	→		
• Providing facilities for manufacturing of DMU			←	→	
• Installation of facilities for sanitation system			←	→	
• Installation of facilities for air conditioning system			←	→	
• Installation of facilities for electric train			- - - - - - - - - -	- - - - - -	
• Enhancement of depot and workshop		←	- - - - - - - - - -	→	

2.4 Signaling/ Telecommunication

A number of equipment and facilities modernization schemes through JICA Grant Aid Project and ODA projects have also been proposed based on the railway modernization master plan worked out by Japan, based on which we will propose a short-, medium- and long-term railway equipment and facilities upgrading plans to raise safety and service levels of signal and telecommunication systems.

2.4.1. Short-term equipment and facilities improvement plan (up to 2018)

Up to 2018, three projects are scheduled relying on Grant Aid Project by JICA They are (1) introduction of electronic interlocking systems into the Yangon and Pa Zun Daung stations, (2) Introduction of a new centralized train monitoring system (TMS) into the Yangon-Pyuntaza section and (3) Installation of a new warning device system into the Kyan Sit Thar level crossing between the Togyaunggalay and Ywar Thar Gyi stations. Regarding these equipment and facilities that will start full-fledged operation in 2018, imperative subjects urgently required for MR are (1) formulation of standards for safe maintenance and upkeep, (2) institution of regulations on maintenance and (3) education of engineers. An electronic interlocking system started operation in April 2014 at the Naypyidaw station as the first one of its kind in MR. And,introduction work for small-scale versions is under way at six small stations. To make these latest equipment and facilities function without compromising safety, their status shall appropriately be assessed through preventive maintenance and inspection. To duly implement this mission as well, it is essential that standards be established with methods of maintenance described to ensure understanding among all MR employees by MR's engineers who have the best knowledge of such new equipment and facilities. It is also important to train engineers having skills for maintenance of such new equipment and facilities, and formulate a program for MR to educate engineers for this purpose by itself. Assessment of the status of such equipment and facilities will be facilitated, if MR positively participates in the installation work for equipment and facilities in the future. A short-term target shall be placed on grasping the status of these equipment and facilities to be introduced and establishing an organization for the maintenance thereof.

The TMS aims at establishing a centralized train operation control system that is more prompt and effective than the existing system while facilitating assessment of the status of train operation by regional train dispatchers. It is important, therefore, that formulation of regulations on train operation control based on the TMS shall be the start of the modernization of MR's organization. Furthermore, as another aspect of the modernization scheme, we can also cite introduction of the electronic interlocking system to eliminate lever handling work, thereby aiming at raising the efficiency of regulations on the signal handling command system and personnel responsible therefor. It is apprehended that equipment and facilities will be renewed alone with the old-fashioned organization and obsolete methods of operation remaining unchanged and the improvement of safety and service levels left unattended, unless regulations on equipment and facilities are established together with the modernization of operation control

from the aspects of software and rules. Therefore, modernization of operation control to match the introduced equipment and facilities shall also be one of the elements in the improvement plan to be addressed as urgently as possible on a short-term basis.

Every year, maintenance, upkeep and repair of these new equipment and facilities will entail prohibitive amounts of cost on an unprecedented scale in MR's history. Equipment and facilities to ensure the safety of railways will not be maintained, even though whatever new equipment and facilities are introduced, unless a budget required to maintain the equipment and facilities is guaranteed. During this period, MR shall determine a budget size required to appropriately maintain and control equipment and facilities, methods to calculate and guarantee the budgetary amount and organization for maintenance and management.

MR maintains a policy to outsource the maintenance of wayside optical cables to private companies and other external organizations. In this respect, it shall be noted that wayside optical cables will become an infrastructure indispensable for the safety of railway operation. Outsourced maintenance of optical cables may be continued as a new management stance. MR is required to bear in mind, however, that the subject how to guarantee the quality of optical cables and establish the method of their maintenance will become an extremely important element in the modernization plan for MR in order to improve safety and service levels into the future.

2.4.2. Medium-term equipment and facilities improvement plan (up to 2025)

The modernization project for the section up to the Taungoo station on the Yangon–Mandalay trunk line financed with a yen credit from Japan is scheduled to complete by 2025 to implement 100 km/h operation. In this context, it is required for MR to establish an organization for maintenance and formulate regulations to appropriately assess and maintain the signal and telecommunication equipment and facilities required for the project.

The paper line clear ticket blocking system is used to protect the section between two adjacent stations on the Yangon–Mandalay trunk line. This system sole relies on the attention of relevant station masters in particular. While taking advantage of the modernization project, it is important to make the paper line ticket blocking system added with a function to mechanically lock the system in case a train exists in the protected section, thereby guaranteeing the safety of train operation. MR shall discuss introduction of this system having a new function into other sections on the Yangon–Mandalay trunk line. Furthermore, this function shall also be introduced into single-track sections on different lines to improve the function to prevent train collision.

The automatic train protection (ATP) system will be introduced to prevent train collision due to overrun. MR shall adopt definite policies regarding the formulation of the standards on the installation of ATP system, methods of operation, specifications and other matters relevant to the system. It is desirable that the ATP system cover all trains running on the section where it is installed. The system will not exert its instinct function to the full, unless it

has been introduced to cover whole the section in question. It is essential, therefore, that the system be introduced with specifications unified, the required budget guaranteed and process control implemented appropriately, based on a minutely established improvement plan for on-the-ground and car-borne equipment and facilities.

The level-crossing warning device system will steadily be introduced. As it is difficult to introduce the system into all level-crossings at a stretch, however, determine the priority order and criteria for introduction in order to effectively prevent level-crossing accidents through installation of the alarm system. Formulation of the criteria and planning of the introduction of level-crossing warning device system are two important subjects to be addressed immediately to promote the medium-term modernization plan. Regarding the traffic control for ever-increasing pedestrians and cars on level-crossings, it is required to consult with relevant divisions and sections on the countermeasures while referring to the cases in Japan where accidents on level-crossings have substantially decreased.

MR's plan is to introduce more electronic interlocking systems, track circuits, electric point machines, optical cables, train radio systems and other already existing equipment and facilities, which require regulations on maintenance control, training of engineers and establishment of an educational system to ensure their stable operation. It is also required to work out a plan in conjunction with other divisions to guarantee stable operation of train operating equipment and facilities through improvement of external conditions such as minimization of the inundation at rainfall, construction of drain ditches to protect the equipment and facilities and reinforcing the power source for the fail-safe function at power failure.

2.4.3. Long-term equipment and facilities improvement plan (up to 2045)

Electrification of railway lines, together with new measures and equipment and facilities for signal and telecommunication, will become necessary as railway modernization has progressed through steady promotion of the short- and medium-term equipment and facilities improvement plans, on the basis of standards and education of engineers adopted and implemented during the periods to promote short- and medium-term plans. To secure electric engineers required for the electrification in the future, MR is advised to promote preparation to integrate the power and signal/telecommunication divisions into a new division dedicated to electric engineering and organize in the long run a new electricity division standing in line with the rolling stock and civil engineering divisions in the organization of MR.

A centralized organization for train operation control becomes imminent as a result of urbanization of railways through introduction of EMUs and implementation of high-frequency operation, when MR shall adopt the centralized train control (CTC) system based on the TMS system to establish a more efficient organization for train operation control. This makes it indispensable to introduce the electronic interlocking system and optical cables into relevant sections. To improve the service level, strengthen the components for operation control at the introduction of CTC and adopt a system simultaneously capable of dealing with passenger guidance information on train

operation and delays as a leader in the long-term equipment and facilities improvement plan.

More efficient maintenance and upkeep will be possible for equipment and facilities, if the monitoring function therefor were automated simultaneously at the introduction of the operation control system. Introduction of SCADA into different divisions to continuously monitor the status of equipment and facilities will contribute to building-up of railways equipped with high-level functions.

To promote operation of railways by relying on equipment and facilities having such high-level functions, it is conceivable that maintenance by MR's competent divisions alone become sooner or later impossible to sufficiently cope with such equipment and facilities. It may be possible that the equipment and facilities purposefully introduced for modernization will not root in MR, if they were all imported from foreign countries. We propose to MR, therefore, that an organization be established to locally manufacture at least signals, electric point machines, level-crossing alarm systems and other simple machines and systems. This doesn't necessarily mean that MR shall have its own manufacturing plants. If railway signal equipment and facilities can be supplied in the country using overseas funds, however, modernization of railways will be further accelerated.

MR shall prepare for the introduction of automatic ticket vending machines, automatic ticket gates and automatic fare collecting machines (AFCs) into the Yangon metropolis zone as necessity arises. Provide customers with information on approaching trains to improve the passenger service level and inspire their augmented satisfaction. To make such services functional through a network, optical cable trunk lines will become increasingly important.

Table 2.4.1 Short-, medium- and long-term railway equipment and facilities improvement plan (signals and telecommunication)

2.5 Train Operation

From the viewpoint of security and stable transportation, we refer to Japanese railway system and will show visions in the future of the railway system as follows.

1	**Current system** There are following three categories of fixed signals: (1) Two-aspect lower quadrant semaphore signal (2) Multi-aspect upper quadrant semaphore signal (3) Color light signal **Recognition of issues** Semaphore signals are inferior to color light signals in terms of the visibility from train drivers, compelling them to judge whether the signal aspect ahead is red or whether it is a remote signal based on the recognized arm end profile to potentially induce mistaken signal acknowledgment and/or dead reckoning operation. Furthermore, drivers are operating trains largely relying on their attention or judgment as trains are not protected with ATC or other security systems. It is required, therefore, that such burdens on drivers be minimized as far as possible. **Vision in the future** Use only color light signals.
2	**Current system** The aspects of signals at stations are manually set and changed by those in charge according to the instructions by the station master. Some point switching machines are manually locked after manipulation on the spot by a member sent thereto from the station office. **Recognition of issues** Erroneous setting of routes and signal aspects for trains shall never be allowed in railway operation. Once a mistaken route or signal aspect has been set, it will potentially lead to derailment, collision or other train accidents to claim hundreds of lives or cause large-scale confusion of train operation diagrams. To prevent at least accidents or disturbance of train operation diagrams due to human errors, it is ideal to make the work of setting routes and signal aspects isolated as far as possible from human intervention relying on judgment or attention of those in charge. **Vision in the future** (1) Interlock route setting and signal control at stations. (2) Adopt track circuits interlocked with the signal system to disable setting the red signal aspect and manipulating switching machines when another train exists on the route to be established for a particular train. (3) Introduce an automatic signal control system that satisfies the conditions prescribed in (1) and (2).

3	**Current system** Communication routes exist between the operation control center and stations and between adjacent stations, but not to/from the drivers on the trains running between adjacent stations. **Recognition of issues** To prevent a secondary accident in case an accident has occurred with a running train, it is required to communicate with the driver of the train running behind to stop immediately. A communication means shall be introduced for this purpose. **Vision in the future** Install a train radio system in driver's cabin to implement emergency communication with train drivers running in the sections between stations from the operation control center and/or relevant station masters.
4	**Current system** When a train separation accident has occurred, brakes are not activated on separated cars. **Recognition of issues** Uncontrolled runaway of the cars separated from a train will lead to train collision, derailment or accidents to cause injuries or deaths. In case a train separation accident has occurred, therefore, separated cars shall instantaneously be stopped. **Vision in the future** Equip trains with an automatic air brake to immediately activate emergency brakes at train separation accidents.
5	**Current system** There are no rules to regulate train operation at heavy rainfall or against strong winds. **Recognition of issues** It is apprehended that sand and soil flow into or out of railway tracks at heavy rainfall while train derailment and/or overturn accidents occur in strong winds. To prevent damage at disasters, the rainfall and winds in the wayside areas shall appropriately be assessed. Adopt a train operation regulating system to restrict train speed or suspend operation when the measurements of such adverse natural phenomena have exceeded a threshold values to potentially cause accidents. **Vision in the future** Set rain-gauges and anemometers along tracks at constant intervals and install monitors for these instruments at stations and the train operation control center. Make arrangements for station masters and the train operation control center to regulate train operation according to the limit values of rainfall and wind speed specified in advance.

2.6 Structure

2.6.1 Current Condition

Regarding to safety and passenger service as problem for improvement, for structure, it should be necessary to 1) Maintain, inspection and repairing, the structure in good condition, 2) Strength work against the disaster, 3) In stalling facilities for public safety. In this respects, following matters are recognized in Myanma Railway Facilities.

(1) There is an accident risk during the maintenance work about structure. Because of none safety equipment installed, it may be falling down from bridges.

(2) Working circumference of structures, such as Bridges or formation existing with rubbish and filth, are terrible dirty that interrupt maintenance work.

(3) Public people are easy to enter railway facilities.

(4) Bridges are threaten by water level raising, formations are threaten by collapse with heavy rain.

(5) Few drainage systems are installed on railway facilities, causes a pool of water.

(6) Almost bridges and formations are aging without repairing. Its soundness is not good.

2.6.2 Necessary measures for improvement

(1) Bridges

① Maintenance work improvement

As we mentioned, it is quite effective for preventing disaster to changing maintenance method. And more, preventive maintenance would not require long repair, just short repair. In the preventive maintenance, it is thought that life cycle cost would be lower and service life would be longer. Thus, we propose the measures for changing to preventive maintenance as follows.

【Items】

- Collecting of drawings, compilation of maintenance work recording book
- Computerized Bridge data, profile, inspection and rehabilitation records.
- Investigation for river bed and compilation of "Bridge Book". (ref: Manual of the Engineering Department ChapterVI Bridges)

【Explanation】

Preventive maintenance is always consists of proper inspection and repair. Structure information, such as drawings, construction record and its profile, is absolute necessity for it. In the future, they should better to be done in computer system connecting with network for every engineer can refer whenever and wherever they want.

【Items】

・Foot plate installation between two rails

・Foot way and scaffolding for inspection installation.

・Construction of side path to approach a bridge

【Explanation】

For the scene of inspection work, foot plate and foot path are necessary items for safety and efficiently. On the other hand, they would be a passenger's evacuation route in the case of accidents. At the same time side path is also important for easy accessing to bridge sides and help passengers.

Photo 2.6.1 Example of foot plate and foot path

(Ref. Technical Regulatory Standards on Japanese Railways (Civil engineering))

②Rehabilitation of aged bridges

【Items】

・Rehabilitation of aged bridges

【Explanation】

The present conditions of structures are not good, rusty, corrosion thereof and so on. Repairing, repainting or replacing member and so on, or reconstruction are necessary for existing bridges. It shall be done until 2023 by Japanese loaned project.

③Disaster prevention work

Bridges should support track and train operation safety at any moment, even if it

was heavy natural disaster. Once bridges are damaged by disaster , it would be quite long l time to restore. For improve the service and safety level, natural disaster prevention works are necessary.

On the other hand, structures including bridges are weak point of a line. Thus, train operations are controlled by operator when the structures are threat by disaster as soon as possible.

【Items】
・Installation of water level gauge
・Installation of automatic measuring water gauge and its signal.
・Countermeasure against wind by train control or wind break fence installation.
【Explanation】
These 2 items are for controlling train operation safety against raising water level or strong wind. Measuring by man has individual difference, for improve it, it is better by mechanical measuring with its connecting signal installed.

【Items】
・Installation of protection work for river bed
・Installation of bridge protection work on under pass
・Installation of fall fence on cross over
【Explanation】
These 3 items are equipment for preventing bridge from scouring, public traffic and languages fallen down from traffic on cross over bridges.

④Others

【Items】
・Mahlwagon Bridge work shop modernization
【Explanation】
Its facilities are quite aged. It should better to install new facilities for bridge work and brush up technology.

【Items】
・Investigation and countermeasure work for abating extreme noise and vibration.
【Explanation】
In the future, most of train operates over 80km/h and surrounding area development, environmental countermeasure for public welfare and would be absolute necessary.

(2) Embankment

① Improvement of drainage

【Items】

・Investigation the situation of drainage

・Dredging of exist drain facilities

・Laying new drain

・Countermeasure for the influent from outside of railway land

【Explanation】

Although embankments are threaten by water, existing drainage facilities are not functionally. Therefore, it is necessary water poor location investigation, and maintaining existing one in good condition or laying new drain. And some of water are from outside of railway land, and countermeasure should be done.

② Rehabilitation or Improvement of embankment

It supposed that, because of no slope protection existing embankments on Myanma Railways are not good soundness, its shape is not standard cross section. Collapse is easy to occur on the time train pass over them and would be fallen down, if embankment soundness goes worse.

【Items】

・Reconstructing by the standard cross section

・Investigation for soft roadbed

・Counter measure work for soft roadbed

【Explanation】

Embankments have to keep the shape by standard cross section for its performance. And soft soil have to be improved. Measurements for soft soil are difference depending on its situation. Careful investigation are necessary for it.

On the other hand, these three items of Yangon-Mandalay probably will be done by Japanese loaned project until 2023.

③ Natural Disaster Prevention Work

【Items】
・Showing the each Vulnerable length on site
・Slope protection work on Vulnerable length
・Installation of stone fence
【Explanation】
When it would be heavy rain, patrolling staff has to inspect vulnerable length condition. For help the patrol, showing the length on the site is necessary. On the other hand, it should be making effort to reduce the vulnerable length by installing slope protection work on it, or installing stone fence if any.

【Items】
・Installation of detecting sensors against land slide and its signal
【Explanation】
It might be not practical for installing slope protection for every embankment and cuttings. In this situation, it is necessary controlling train operation rapidly in the case of disaster. For the purpose, and to detect land slide safety and stop train rapidly, installation detecting sensors and its signal is necessary.

(3) Others

【Items】
・Installation of boundary fence
【Explanation】
In the present condition, no fence installed, publics can enter track easily. This time train operates low speed and publics can go out of track safety. But in future, train speed faster, they can't. This item is absolute necessary to prevent public from train accident.

【Items】
・Clean-up the circumference of structure
・Importation of current inspection tools
【Explanation】
These items, keeping clean and good tool, are necessary for higher quality maintenance work.

Table 2.5.1 Short-, Medium-, and Long- term railway improvement items(Bridge)

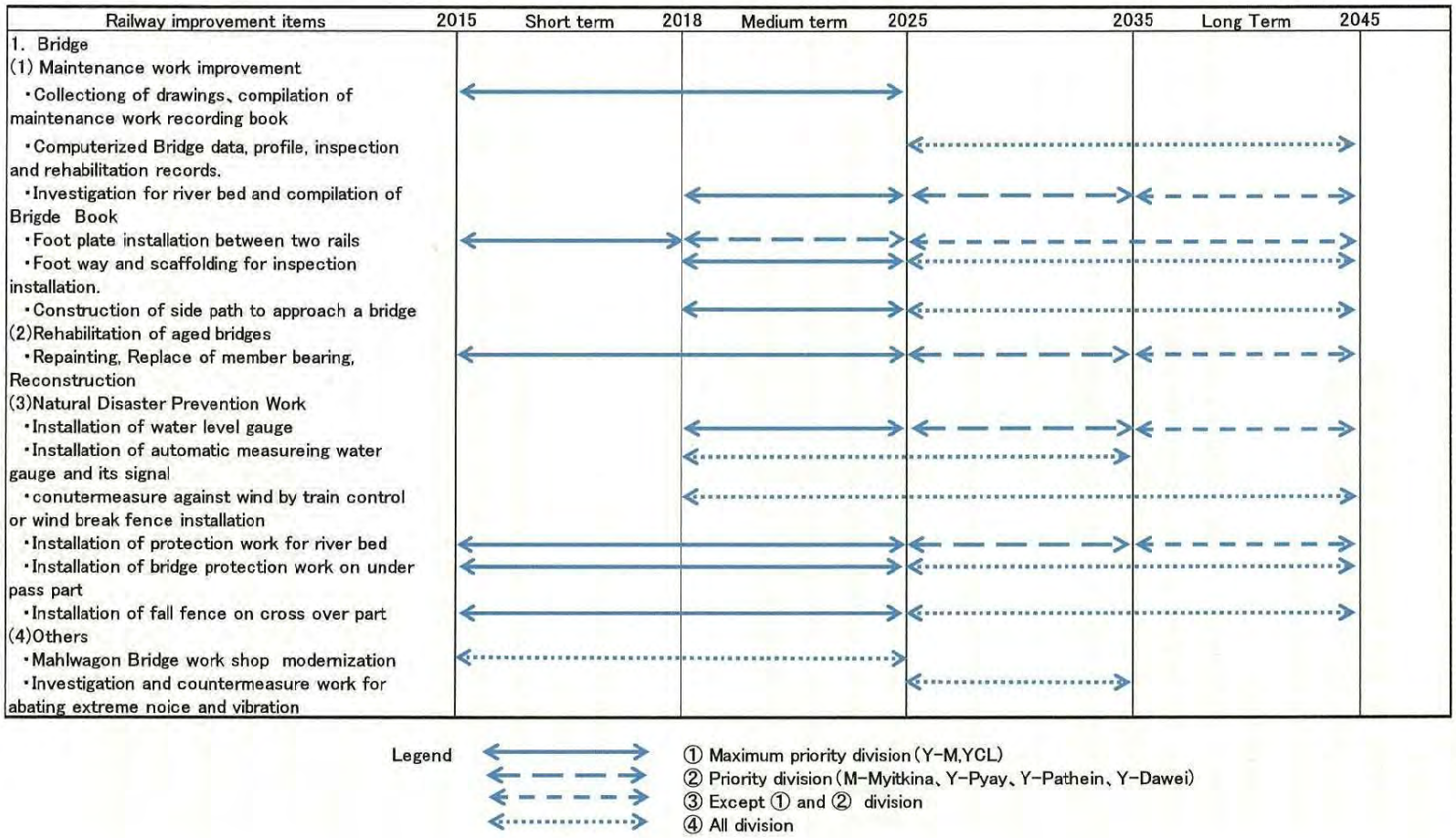
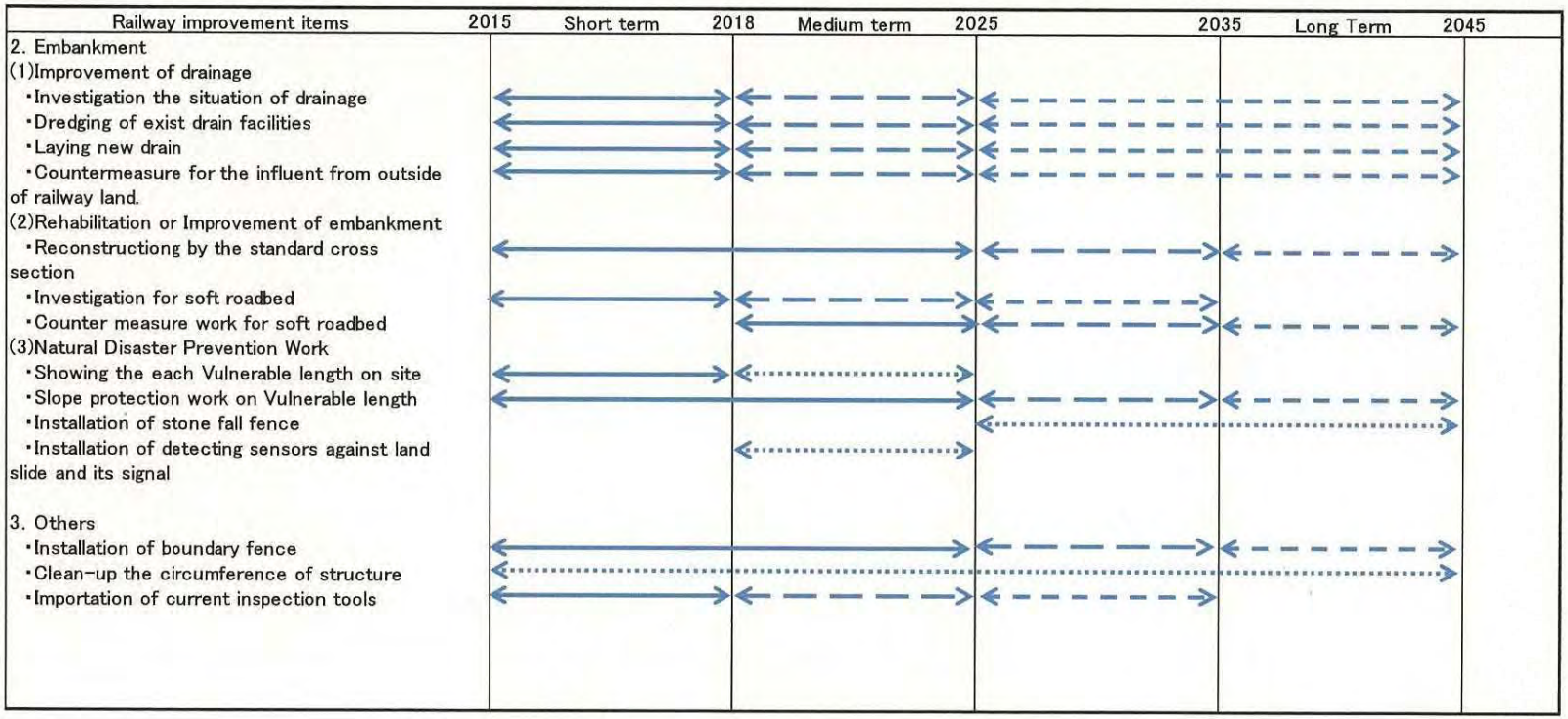


Table 2.5.2 Short-, Medium-, and Long- term railway improvement items(Formation)



Nest Steps to be Taken and Closing Remark

JICA Expert Team is proposing the Recommendations on Some Major Technical Standards of MR relating to safety and service, and the Short-, Medium-, and Long-Term Railway Facilities Improvement Plan to the "Working Group for Service and Safety Improvement". To review and discuss the Proposals, the workshop is to be held at MR headquarters from Sep. 30 to Oct. 3rd, and various opinions are expected to be presented by the members of the Working Group.

JICA Expert Team would like to request the members of Working Group to send their more opinions, if any, to JICA Expert Team in Japan by the end of October, 2014.

These opinions in the workshop and the additional opinions sent to Japan by the end of October will be duly taken into consideration in revising the Proposals.

The revised proposals of "Recommendations on Technical Standards of MR" and "Short-, Medium-, and Long-Term Railway Facilities Improvement Plan" will be presented to the 2nd and summarizing workshop to be held from Dec. 15 to 18, 2014 at MR headquarters, where the "Working Group for Service and Safety Improvement" will finalize the Recommendations on Technical Standards of MR and the Short-, Medium-, and Long-Term Railway Facilities Improvement Plan.

- End –

Appendix - 2

Minutes of Meeting

1. Date and Place August 11, 2014 at Headquarters of MR
2. Subject Training Program (Railway Institutional Management Improvement Course), Dates of 4th and 5th JCC, and Members and Schedule of Workshops
3. Attendants

MR side

U Saw Valentine
General Manager (Technical Admin & Support)

Daw Myint Myint San
General Manager (Planning & Admin)

U Tin Soe
General Manager (Civil)

U Aung Win
General Manager (Mechanical & Electrical)

U Maung Maung Lwin
General Manager (Finance)

U Maung Maung Thwin
Deputy General Manager (Civil)

U Than Htay
Deputy General Manager (Civil)

U Htay Myint Aung
Deputy General Manager (Operating)

U Khin Maung Thein
Deputy General Manager (Signaling)

U Myint Soe
Deputy General Manager (Mechanical/ Operating)

U Htaung Sain Kam
Deputy General Manager (Planning)

U Maung Maung Than
Assistant General Manager (Civil)

U Min Aung
Assistant Engineer (Civil)

JICA Expert Team

	Mr. Sadaaki Kuroda	Leader of Team
Sumitomo Corporation Asia & Oceania Pte. Ltd. Nay Pyi Taw Office	Mr.Yuichi Taniguchi	Deputy General Manager
	U Htun Htun Kyaw	Manager

1

4 Major agreements

(1) List of participants of Training Program was handed over to JICA Team on 13th August.

(2) The content and schedule of Training Program proposed by JICA Expert Team were agreed by MR. However, MR would like to add a visit to Railway Museum to the training program. JICA Team will arrange the visit to Railway Museum on Saturday or Sunday.

(3) Dates of 4th JCC and 5th JCC were mutually agreed to be September 29th and December 19th, 2014 respectively.

(4) Datee of Workshops. With respect to "Recommendation on Technical Standards" and "Drawing Up Short-, Medium-, and Long-Term Railway Facilities Improvement Plan", the first workshopswill he held from Sep.30th to Oct.3rd,and the second and summarizing workshops will be held from Dec.15th to 18th 2014.The general execution plan of the workshops will be as shown in the attached Table A Tentative Timetable of Workshops.

(5) Members of the Workshops. Members of Administrative and Counterpart Personnel and members of Working Group for Service and Safety Improvement were respectively modified by increasing the members as shown in the attached Table B Members ofAdministrative and Counterpart Personnel and Members of Working Group for Service and Safety Improvement. Both "Workshop of Recommendation on Technical Standards" and "Workshop of Drawing Up Short-, Medium-, and Long-Term Railway Facilities Improvement Plan"should be discussed by the members of "Working Group for Service and Safety Improvement".

13th August 2014,Nay Pyi Taw

U Saw Valentine	Mr. Sadaaki Kuroda Dr.Eng.
Project Director	Leader of JICA Expert Team
General Manager (Technical Admin & Support)	
Myanma Railway	

Table A Tentative Timetable of Workshops

	1st Wrokshop					2nd Summarizing Workshop				
Month	September		October			December				
Day	29	30	1	2	3	15	16	17	18	19
Day of the Week	Mon	Tue	Wed	Thr	Fri	Mon	Tue	Wed	Thr	Fri
Time										
9:00			Signal & Telecom -1	Signal & Telecom -2	Train Operation-1	Track-1	Signal & -1	Track-2	Rolling stock -2	5th JCC
10:00		Track-1	Structure-1				Train Operation-1		Train Operation-2	
11:00	4th JCC			Rolling Stock-2	Train Operation-2					
12:00	Lunch					Lunch				
13:30		Rolling Stock-1	Track-2	Rolling Stock-2	Train Operation-2	Rolling Stock-1	Structure-1	Signal-2	Structure-2	
14:30				Structure-2	General Discussion					
15:30		Signal & Telecom -				Signal-1	General discussion	Rolling Stock-2	General discussion	
16:30										

Table B

"Member of Administrative and Counterpart Personnel"		" Member of Working Group for Service and Safety Improvement"		
Fields	Myanma Railways	Fields	Myanma Railways	Japanese Side (JICA Expert Team)
Project Director	U Saw Valentine,General Manager (Technical & Admin.support)	Project Director	U Saw Valentine,General Manager (Technical & Admin.support)	Sadaaki KURODA(Leader)
Project Manager	U Tin Soe ,General Manager (civil)	Project Manager	U Tin Soe ,General Manager (civil)	Nobuyuki MATSUO (Duputy Leader)
Railway Policy/ OM Improvement	U Kyaw Kyaw Myo AGM (Passenger)	Railway Policy/ OM Improvement	U Kyaw Kyaw Myo AGM(Passenger)	Hiroshi KOMATSU
Track Maintenance	U Min Aung , AE (Civil) U Than Htay, DGM (Civil) U Maung Maung Than, AGM (Civil)	Track	U Min Aung , AE (Civil) U Than Htay DGM (Civil) U Maung Maung Than, AGM (Civil)	Masato WAKATSUKI Kiyoshi MIYAMOTO
Signalling & Telecommunications	U Han Nyunt ,AGM(S&T) U Myint Lwin, DE (S&T)	Signalling & Telecommunications	U Han Nyunt ,AGM (S&T) U Myint Lwin DE (S&T)	Ryuhei MITANI
Rolling Stock	U Thet Lwin,DGM(M&E) U Aung Kyaw Naing,DME (M&E)	Rolling Stock	U Thet Lwin,DGM(M&E) U Aung Kyaw Naing , DME (M&E)	Makoto ISHIKAWA
Train Operation	U Zaw Pe Sein , AGM (Operating) U Htay Myint Aung,DGM(operating)	Train Operation	U Zaw Pe Sein , AGM (Operating) U Htay Myint Aung ,DGM(Operating)	Shunji MORIHARA
Structure	U Maung Maung Thwin, DGM (Civil) U Tin Win ,DGM(Civil) U Zaw Min Oo (Ex, E (Civil))	Structure	U Maung Maung Thwin, DGM (Civil) U Tin Win ,DGM(Civil) U Zaw Min Oo, (Ex, E(Civil))	Mitsuru TAKAMI (Coordination)
Procurement of Equipment &Materials	U Win Htein,DGM (Supply) U Kyaw Naing Oo, AM (Finance)			

Appendix-3

Workshop report

(1) Structure of the workshop

①Course

Workshop on Enhancing Track Maintenance

②Period of Program

・Group 1 Jun.9.2014 to Jun.20.2014 ・Group 2 Jun.23.2014 to Jul.4.2014

③Number of Participants Each group 11 Persons

④Trainees List

Group1 Jun.9.2014 ～ Jun.20.2014

No.	Name	Position	Division
1	Mr. Ye Htut	Assistant Engineer (Civil)	Nay Pyi Taw
2	Mr. Kyaw Lwin	Assistant Engineer (Civil)	Division(3)
3	Mr. Saw Naing	Permanent Way Inspector (1)	Division(3)
4	Mr. Aung Swe	Permanent Way Inspector (1)	Division(6)
5	Mr. Han Tin Soe	Permanent Way Inspector (1)	Division(8)
6	Mr. Win Nyunt	Permanent Way Inspector (2)	Central Institute of Transport and Communication,Meiktila
7	Mr. San Yu	Permanent Way Inspector (2)	Division(1)
8	Mr. Chit Ko Ko	Permanent Way Inspector (2)	Division(2)
9	Mr. Than Naing	Permanent Way Inspector (2)	Division(3)
10	Mr. Aung Thein Win	Permanent Way Inspector (2)	Division(6)
11	Mr. San Naing	Permanent Way Inspector (2)	Division(6)

Group2 Jun.23.2014 ~ Jul.4.2014

No.	Name	Position	Division
1	Mr. Soe Myint Aung	Assistant Engineer (Civil)	Division(4)
2	Mr. Aye Nyeub Swe	Assistant Engineer (Civil)	Division(3)
3	Mr. Han Thein	Permanent Way Inspector (1)	Division(11)
4	Mr. Kyaw Thu Ya	Permanent Way Inspector (1)	Katha-Bahmo
5	Mr. Moe Kyaw Aung	Permanent Way Inspector (2)	Yangon-Pathein
6	Mr. Kyaw Htet Zaw	Permanent Way Inspector (2)	Division(6)
7	Mr. Aye Min Aung	Permanent Way Inspector (2)	Division(11)
8	Mr. Kyaw Tun Linn	Permanent Way Inspector (2)	Division(2)
9	Mr. Aung Aung	Permanent Way Inspector (2)	Division(5)
10	Mr. Hla Htay Win	Permanent Way Inspector (2)	Division(4)
11	Mr. Thaung Tun Aye	Permanent Way Inspector (3)	Division(5)

(2) Outline of the Workshop

①Flow of the Workshop

Program Objective

Service and safety level of Myanma Railways is improved

1	To be able to acquire the basic knowledge of the Track Maintenance.
2	To be able to Make use of Track Maintenance work in Myanma Railways through on the job training in japan.
3	To be able to Raising Myanma railway's issues and discussing a solution of Track maintenance work

②Outline of the Curriculum

No.	Content	Type	Time (h)	Lectures
1	Summary of Japanese Track maintenance Technology and present state of track in Myanma	Lecture	1:00	NSG
2	Technology standards and Rules of Track Maintenance	Lecture	3:00	NSG
3	Tamping Machine and Ballast Regulator	Lecture	1:30	Kotsu transport Construction & Engineering Corporation
4	Turnout (Structure , inspection . Maintenance)	Lecture	3:00	NSG
5	Past Train Accident caused by Track Conditions and its Countermeasure	Lecture	2:00	JIC
6	Track structure and Track work , Track material	Lecture	6:30	NSG
7	Track material (Rail , Fastening , Sleeper , Turnout)	Lecture	2:30	NSG
8	Tokyo Operation Control Center	Visit	2:00	JRE
9	Tokyo Rail Center (Factory welding , Long Rail wagon)	Visit	2:30	JRE
10	Turnout Factory	Visit	3:00	SUMIHATSU
11	Sleeper Factory	Visit	2:30	ABE NIKKO KOGYO
12	Ballast Factory	Visit	2:00	Seeds
13	General Education Center Museum of the History of Railway Accidents	Visit	2:00	JEPS
14	Tamping Machine and Ballast Regulator	Practice	2:30	Kotsu transport Construction & Engineering Corporation
15	Track inspection , Track maintenance work	Practice	4:00	NSG
16	Replacement of Rail and Sleeper , Adjustment of joint gaps	Practice	7:00	NSG
17	Question and answer Review and presentation	Lecture	3:00	NSG , JIC

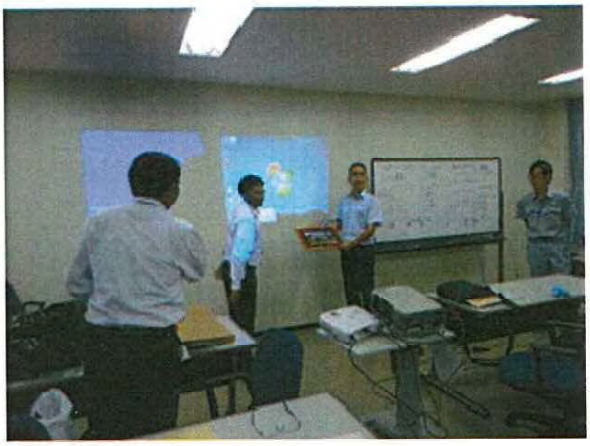
JRE:East Japan Railway Company , JEPS:JR-East Personnel Service , NSG:Japan Railway Track Consultants

（3） Details of the implementation of measures

Date	①JUN.9(Mon)13:00～14:00	②JUN.23(Mon)13:00～14:00
Content	Summary of Japanese Track maintenance Technology and present state of track in Myanma	
Lectures	①Dr.Masahiro Osanai （NSG）	②Mr Kazuhiko Murao
Purpose	Study Summary of the Japanese Track maintenance and the present Myanma Railways.	
Details of Content	・Track structure(Track structure determined by the Track category) ・Optimal structure with optimal cost	

Date	①JUN.9 （Mon） 14:00～17:00	②JUN.23 （Mon） 14:00～17:00
Content	Technology standards and Rules of Track Maintenance	
Lectures	Dr.Masahiro Osanai （NSG）	
Purpose	Study on a technical standards and Rules of track maintenance. Study on the track inspection.	
Details of Content	・Safety management ・Track inspection in law and rule ※Track inspection ： Rail/Fastening/Sleeper/Trackbed/Roadbed/Turnout examination , Joint gap/Vibration measurement etc.	

Lecture from Dr. Osanai at NSG



Lecture from Mr. Murao at NSG

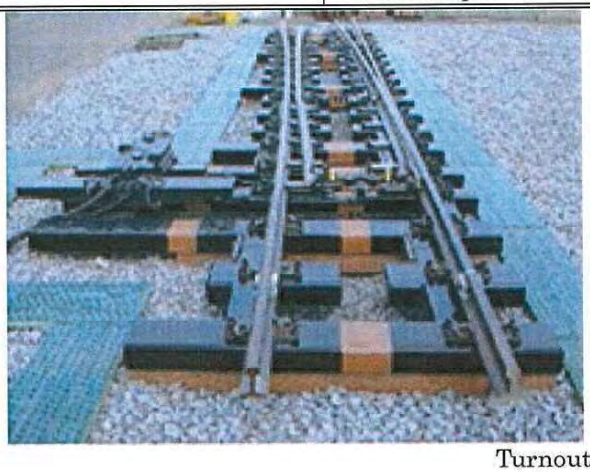
Date	①JUN.10 (Tue) 10:00～12:00	②JUN.27 (Fri) 10:00～12:00
Content	Tokyo Operation Control Center	
Lectures	Mr.Shinji Hayashi (JRE)	
Purpose	Study on the control operation center through summary description and visit to them.	
Details of Content	・Transport Control ・Crew and Car Control ・Information Transmission ・Equipment Management	

Tokyo Operation Control Center

Date	①JUN.10 (Tue) 13:30～16:00	②JUN.27 (Fri) 13:30～16:00
Content	Tokyo Rail Center	
Lectures	Mr.Kazuo Yamamoto (JRE)	
Purpose	Study on the Plant welding line and long rail carrying wagon.	
Details of Content	・Plant welding ・Welding line ・Rail welding machine (Flash butt welding) ・Rail grinding ・Rail examination ・Rail carrying wagon ・Long rail ・Quality control ・Quality control	

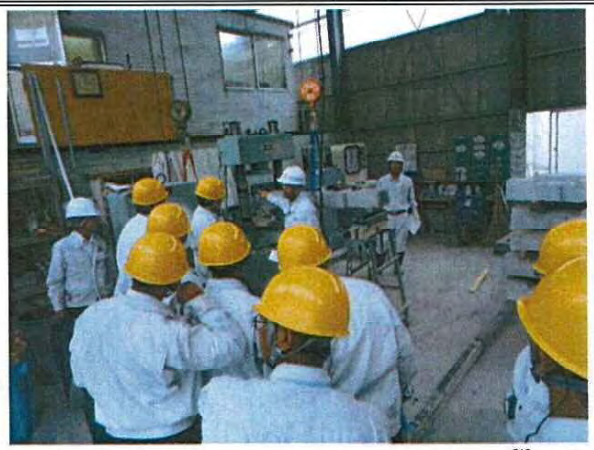
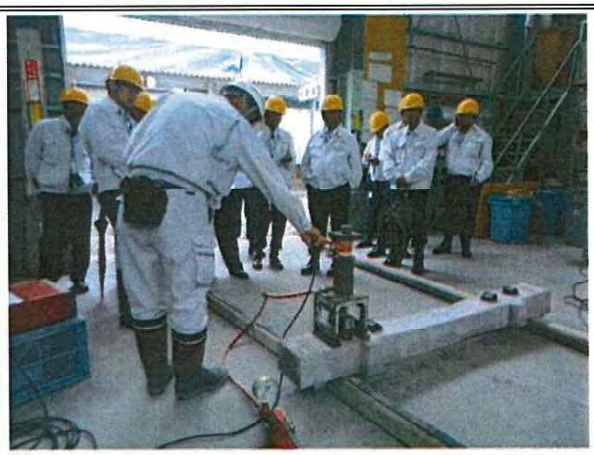
Tokyo Rail Center

Date	①JUN.11 (Wed) 13:00～16:00	②JUN.24 (Tue) 13:00～16:00
Content	Turnout Factory	
Lectures	Mr.Katsuyuki Doumeki (SUMIHATSU)	
Purpose	Study on the manufacture of turnout.	
Details of Content	・Turnout ・Crossing ・Rail shape ・Gard(Check) rail ・Tongue rail ・Quality control	




Turnout Factory

Date	①JUN.12 (Thu) 9:30～12:00	②JUN.26 (Thu) 9:30～12:00
Content	Sleeper Factory	
Lectures	①Mr.Shuiti Onuma	
Purpose	Study on the PC-sleeper manufacturing process and method of the quality verification testing.	
Details of Content	・PC sleeper manufacturing line ・Pre-tensioning , Post-tensioning ・Steam curing ・Product testing (load test : bending test , pull out test) ・Quality control	

Sleeper Factory

Date	①JUN.12 (Thu) 13:00～15:00	②JUN.26 (Thu) 13:00～15:00
Content	Ballast Factory	
Lectures	Mr.Hajime Koizumi (Sheeds)	
Purpose	Study on the ballast manufacturing and method of the quality verification testing	
Details of Content	・Particle size control ・Product testing (Particle size , Shape , Hardness , resistance abrasion) ・Quality control ・Manufacturing rules	


Ballast Factory

Date	①JUN.13 (Fri) 11:00～16:00	②JUN.30 (Mon) 11:00～16:00
Content	Tamping Machine(MTT) and Ballast Regulator(BR)	
Lectures	Mr. Hidetoshi Takahashi (Kotsu transport Construction & Engineering Corporation)	
Purpose	Study on the track maintenance by the MTT and BR	
Details of Content	・Levelling, lifting, lining and tamping machines ・Stabilisation and Consolidation	


Track Maintenance Company
(Kotsu transport Construction & Engineering Corporation)

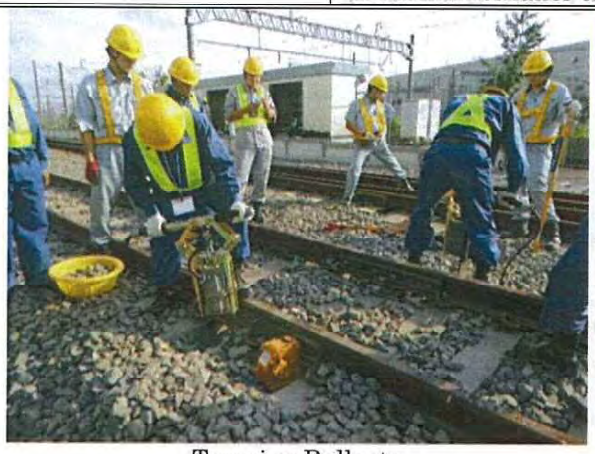
Date	①JUN.14 (Sat) 9:00～12:00	②JUL.1 (Tue) 9:00～12:00
Content	Turnout	
Lectures	Mr.Minoru Obi (NSG)	
Purpose	Study on the turnout maintenance	
Details of Content	・Component of turnout ・Kind of turnout ・Turnout replacement	


Lecture from Mr. Obi

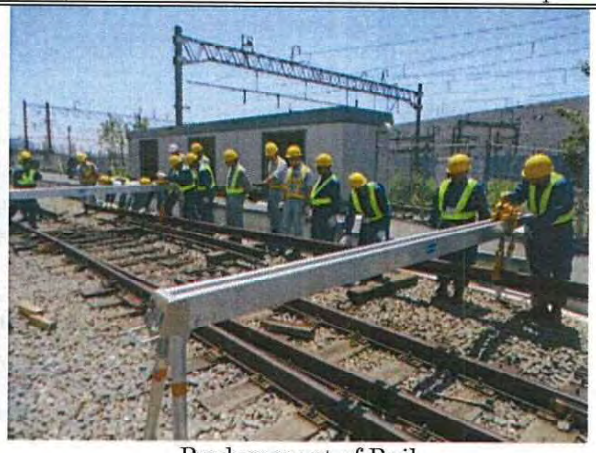
Date	①JUN.14 (Sat) 13:00～17:00	②JUL.1 (Tue) 13:00～17:00
Content	Track inspection , Track maintenance work	
Lectures	Mr.Minoru Obi (NSG)	
Purpose	Acquire knowledge of the track measurement and track inspection	
Details of Content	・track/turnout inspection ・track/turnout measurement	


Track inspection , Track maintenance work

Date	①JUN.15 (Sun) 9:00～17:00	②JUL.2 (Wed) 9:00～17:00
Content	Replacement of Rail and Sleeper , Adjustment of joint gaps	
Lectures	Mr.Minoru Obi (NSG)	
Purpose	Practice track materials replacement	
Details of Content	・track materials Replacement method by track maintenance tools ・safety work Track materials : rail / sleeper / tongue rail / stock rail Track maintenance tools : jack traverser / rail stretcher / hand tamper	



Tamping Ballasts



Replacement of Rail

Date	①JUN.18 (Wed) 13:00～15:00	②JUN.25 (Wed) 13:00～15:00
Content	General Education Center Museum of the History of Railway Accidents	
Lectures	Mr.Susumu Yamasaki (JEPS)	
Purpose	Study on various railway facilities / equipment prepared for training of JRE staff.	
Details of Content	・Training facilities / equipment	

General Education Center

Museum of the History of Railway Accidents

Date	①JUN.18 (Wed) 15:00～17:00	②JUN.25 (Wed) 15:00～17:00
Content	Past Train Accident caused by Track Conditions and its Countermeasure	
Lectures	①Mr.Mitsuru Takami (JIC)	②Mr.Takaaki Naka,ira (JIC)
Purpose	Study on history of railway accidents	
Details of Content	・Explanation of the outline of the railway accidents ・accident cause ・security measures	

Date	①JUN.19 (Thu) 9:30～17:00	②JUL.3 (Thu) 9:30～17:00
Content	Track structure and Track work , Track material	
Lectures	①Dr.Masahiro Osanai (NSG)	②Mr.Kazuhiko Murao (NSG) Mr Masato Wakatsuki (NSG)
Purpose	Generalize track maintenance management	
Details of Content	・curve / turnout / bridge / level cross / speed up.	

Date	①JUN.20 (Fri) 9:30～12:00	②JUL.4 (Fri) 9:30～12:00
Content	Track material (Rail , Fastening , Sleeper , Turnout)	
Lectures	Mr.kazuhiko Murao (NSG)	
Purpose	Generalize track materials	
Details of Content	・rail / rail fastening / sleeper / ballast bed	

Date	①JUN.20 (Fri) 13:00～17:00	②JUL.4 (Fri) 13:00～17:00
Content	Question and answer Review and presentation	
Lectures	Mr.Minoru Obi (NSG)	
Purpose	Solve a question	
Details of Content	・discussion	

Group 1

Group 2

The Project on Improvement of Service and Safety of Railway in Myanmar

Progress Report
September 29th, 2014 at Nay Pyi Taw

JICA EXPERT TEAM

Japan International Cooperation Agency

Table of Content

Appendix-1 Report of Proposals of Recommendation on Technical standards of MR and Short-, Medium-, and Long-Term Railway facilities Improvement Plan

2 Minutes of Meeting, August 11, 2014, at NayPyiTaw

3 Workshop Report (in Japan)

1. Preface

This Progress Report deals with the major activities of the Project implemented around between May and September of this year.
We should be grateful, if MR senior officials concerned review the Report and provide us with the various advices so that the Project will be implemented more fruitfully in the coming period.

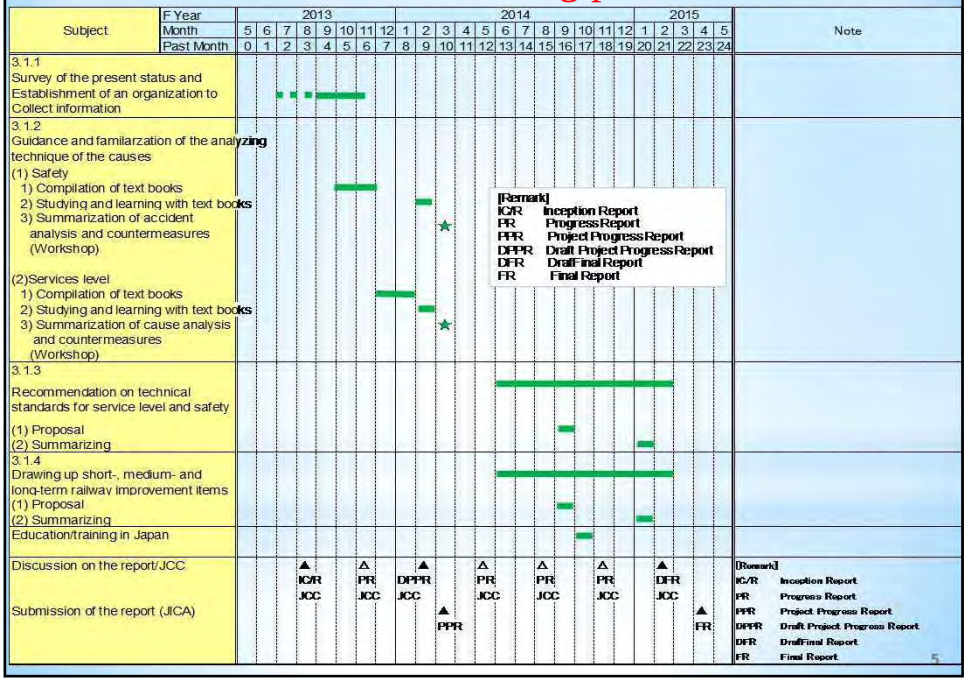
2.Major progress of the Project

2.1 Recommendation of technical standard relating to administrative and maintenance aspect and drawing up railway facilities improvement plan to improve service and safety level

· Preparation of a working plan

The Project is progressing as scheduled in Table 2.1

Table 2.1 Table of working plan schedule



2.1.1 Recommendation on technical standards relating to administrative and maintenance aspect to improve the service level and safety

2.1.1.1 Introduction

JICA Experts collected the relevant major technical standards relating to safety and service level in the respective engineering fields.

JICA Expert Team made reviews on these collected technical standards and proposed recommendations on these technical standards as shown in Appendix1[Report of Proposals of Recommendation on Technical Standards of MR and Short-, Medium-, and Long Term Railway Facilities Plan] (Herein after referred to as “Report of Proposals”). The recommendations are not only on the improvement of the existing technical standards, but also are made on new technical standards which MR should consider in view of the future development of MR.

These recommendations will be fully discussed with work shop to be held from Sep 30th to Oct 3rd, 2014.
In the JCC, we would like to just introduce the outline of the recommendations, and would like to request JCC to leave the discussion on these recommendations to the workshop.
The schedule of the workshop is shown in Table A, and discussion will be made by the members of " Working Group for Service and Safety Improvement" shown in Table B

Table A Tentative Timetable of Workshops

	1st Wrokshop					2nd Summarizing Workshop				
Month	September		October			December				
Day	28	30	1	2	3	15	16	17	18	19
Day of the Week	Mon	Tue	Wed	Thr	Fri	Mon	Tue	Wed	Thr	Fri
Time										
9:00			Signal & Telecom -1	Signal & Telecom -2	Train Operation-1	Track-1	Signal & -1	Track-2	Rolling stock -2	5th JCC
10:00		Track-1	Structure-1				Train Operation-1		Train Operation-2	
11:00	4th JCC			Rolling Stock-2	Train Operation-2					
12:00	Lunch					Lunch				
13:30		Rolling Stock-1	Track-2	Rolling Stock-2	Train Operation-2	Rolling Stock-1	Structure-1	Signal-2	Structure-2	
14:30				Structure-2	General Discussion					
15:30		Signal & Telecom -				Signal-1	General discussion	Rolling Stock-2	General discussion	
16:30										

Table B

"Member of Administrative and Counterpart Personnel"		" Member of Working Group for Service and Safety Improvement"		
Fields	Myanma Railways	Fields	Myanma Railways	Japanese Side (JICA Expert Team)
Project Director	U Saw Valentine,General Manager (Technical & Admin.support)	Project Director	U Saw Valentine,General Manager (Technical & Admin.support)	Sadaaki KURODA(Leader)
Project Manager	U Tin Soe ,General Manager (civil)	Project Manager	U Tin Soe ,General Manager (civil)	Nobuyuki MATSUO (Duputy Leader)
Railway Policy/ OM Improvement	U Kyaw Kyaw Myo AGM (Passenger)	Railway Policy/ OM Improvement	U Kyaw Kyaw Myo AGM(Passenger)	Hiroshi KOMATSU
Track Maintenance	U Min Aung , AE (Civil) U Than Htay, DGM (Civil) U Maung Maung Than, AGM (Civil)	Track	U Min Aung , AE (Civil) U Than Htay DGM (Civil) U Maung Maung Than, AGM (Civil)	Masato WAKATSUKI Kiyoshi MIYAMOTO
Signalling & Telecommunications	U Han Nyunt ,AGM(S&T) U Myint Lwin, DE (S&T)	Signalling & Telecommunications	U Han Nyunt ,AGM (S&T) U Myint Lwin DE (S&T)	Ryuhei MITANI
Rolling Stock	U Thet Lwin,DGM(M&E) U Aung Kyaw Naing,DME (M&E)	Rolling Stock	U Thet Lwin,DGM(M&E) U Aung Kyaw Naing , DME (M&E)	Makoto ISHIKAWA
Train Operation	U Zaw Pe Sein , AGM (Operating) U Htay Myint Aung,DGM(operating)	Train Operation	U Zaw Pe Sein , AGM (Operating) U Htay Myint Aung ,DGM(Operating)	Shunji MORIHARA
Structure	U Maung Maung Thwin, DGM (Civil) U Tin Win ,DGM(Civil) U Zaw Min Oo (Ex, E (Civil))	Structure	U Maung Maung Thwin, DGM (Civil) U Tin Win ,DGM(Civil) U Zaw Min Oo, (Ex, E(Civil))	Mitsuru TAKAMI (Coordination)
Procurement of Equipment &Materials	U Win Htein,DGM (Supply) U Kyaw Naing Oo, AM (Finance)			

List of Technical Standards/ Regulation Reviewed by JICA Expert Team

	A-Rolling stock
1	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Mechanical)
2	Diesel Electric Locomotives and Diesel Hydraulic Locomotives Maintenance Instruction Schedule (Elecgrical)
3	Examinatin and repair of C & W stock
4	Technical Specifications for 1200 Horse Power Diesel Hydraulic Locomotive
5	Technical Specifications for Meter Gauge 1200/2000 Horse Power for Hillsection Diesel Electric Locomotives for Plain Section
6	Technical Specirications for Meter Gauge 2000 Horse Power Diesel Electric Locomotives
7	Technical Specifications for In-Service Diesel Elctric Locomotives
8	Technical Specifications for YDM4 Class Locomotive (1000mm Gauge)
9	Technical Specifications for Meter Gauge 2000HP Diesel Electric Locomotives
10	General Technical Specifications for Meter Gauge Bogie Passenger Coaches
11	General Technical Specifications for Meter Gauge Bogie Freight Wagons
12	General Technical Specification for Design, Supply and Domestic Manufacturing of Meter Gauge Bogie Passenger Coaches
13	General Technical Specifications for Meter Gauge Bogie Passenger Coache Type BDTEZ
14	Technical Specifications for Meter Gauge Bogie Ballasted Hopper Wagons
15	Paticular Technical Specification for Meter Gauge Four-Axle Bogie Welll Wagon for Container
16	Technical Specification for Meter Gauge Bogie Day Upper Class Passenger Coarch
17	Technical Specification for Meter Gauge Bogie Covered Wagon Type - GBHV
18	Technical Specification for Meter Gauge Bogie Sugercane Cum Material Wagon Type - SMBV
19	Technical Specification for Meter Gauge Bogie Material Wagon Type - MBHV
	B.--Track
1	Manual of the Engineering Department Chapter IV Permanent Way I (material,tool,theory)
2	Manual of the Engineering Department Chapter V Permanent Way II(construction, and maintenance)
3	Track Specification
4	Manual of the Engineering Department Chapter XXII Technical Appendices
5	Manual of the Engineering Department Chapter IX Miscellaneous

	C--Structures,Building,Ststion Machinery,Safety Precaution
1	Manual of the Engineering Department Chapter XII Safety Precaution
2	Manual of the Engineering Department Chapter VI Bridges
3	Manual of the Engineering Department Chapter III Formation

	D-Signalling and Telecommunications
1	TRAIN SIGNALLING INSTRUCTIONS for the Double and Single Lines by Electric Block Instrumentsand by Telegraph or Telephone
2	Manual of the Engineering Department-Chapter VIII-Signal andTele-communication No.1
3	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules

	E--Train Operation
	General Rules for all open lines of railway in Burma Parts I&II together with the subsidiary rules
1	Chapter 1 Preliminary
2	Chapter II Signals
3	Chapte III working of Trains General
4	Chapter IV Accidents

2.1.1.2 Items of the major recommendations/comments on technical Standards.
The details of the recommendations/comments are presented in the Appendix 1, [Report of Proposals].
However, items or the essences of the recommendations/comments on the reviewed Technical Standards are listed as shown below.

(1)Track
(a)Manuals of the Engineering Department (DEM) Chapter Ⅳ Permanent Way 1 (Materials, Tools, and Theory)
①Adoption of L type wooden bridge sleeper fastening
②Adoption of improved turnout for speed up
③Including PC sleepers and their rail fastening in the Technical Standards
④Adoption of supported joint with use of large size sleeper
⑤Execution of insizing on semi-durable sleepers before creosoting
⑥Improvement of ballast specification with respect to grading, and physical properties.
⑦Adoption of opposite joints in curve section in case of rather large radius.
⑧Specification of maximum cant deficiency
⑨Determination of transition curve length with consideration not only on allowable limit of temporal change of cant, but also on prevention of derailment due to 3 point support, and allowable limit of temporal change of cant deficiency.
⑩Adoption of derailment prevention guard in the section where derailment is apt to occur

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(b)MED, Permanent Way Ⅱ(Construction and Maintenance)
①Measurement of track irregulation in the inspection and periodical measurement
②Frequency of track inspection according to the importance of the lines
③Inspection of rail by ultrasonic rail flaw defection equipment
④Effective utilization Of Hallade Track Recorder
⑤Inspection of points and crossings
⑥Platform dimension inspection in relation with structure gauge

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(c)MED Chapter IX (Miscellaneous)

Chapter IX (Miscellaneous) mainly includes the regulations regarding ①level crossing and gatemen, ②the fences, ③actions to be taken in case of infringements of Standard Structural and Running Dimensions,④ engineering and ballast trains, ⑤assisted siding, ⑥cattles on the railway land.

In view of occurrence of many accidents at level crossings and various issues regarding level crossing such as weak track structure and insufficient maintenance situation of MR, various standards/ regulations of JR were explained in the Report of Proposals so that they could be a good basis, on which technical standards of MR relating to the level crossing could be improved.

The major items explained about technical standards/regulations of JR with respect to level crossings are as follows.

①Basic policy regarding level crossings
②General requirement of level crossings
③Type of level crossings
④Pavement of level crossing
⑤Crossing facilities considering increased railway speed

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(d)Track Specification

The document of Track Specification includes three systems of irregularities allowances:

System-1 specifying track irregularities allowances from the viewpoint of construction, maintenance and safety according to the lines classified by the maximum train speed, System-2 specifying the track irregularities allowances from the viewpoint of riding comfort, and System-3 consisting of 3 different documents specifying track irregularities for track laying/constructions.

JICA Experts recommended ①Unification of various systems for track irregularities allowance, ②consideration of track irregularities allowances after tack rectification, ③stipulation of train

vibration acceleration allowances from the viewpoint of safety and riding comfort, ④specification of number of days within which track should be rectified in case the track irregularities exceed the safety allowances, and ⑤ stipulation of train speed down in case where track irregularities cannot be rectified within specified days.

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(e)Other recommendations/comments in view of the future development of MR

①Various methods for improving low joints

②Several major points to which attention should be paid for installation of long welded rail and their maintenance

③Several major points to which attention should be paid for using big track machine such as MTT, Flash Butt Welding Machine, Track Measuring Machine etc.

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(2)Rolling Stock

Two types of technical standards are required for rolling stock, one is for construction and the other is for maintenance.

For construction, general criteria that will assure the safety and compatibility shall be defined. Particular specification for each type of rolling stock will be prepared based on the criteria.

For maintenance, rank and interval of scheduled maintenance including items to inspect in each rank shall be defined. Also criteria that will assure the normal/safe operation until next regular maintenance shall be defined.

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(a)Recommendation on technical standards relating to construction of rolling stock.

It is deemed that for constructing new rolling stock, criteria is stipulated for the requirement of rolling stock type but no general rule exists in MR. General criteria for rolling stock construction shall be stipulated and specification of each type of rolling stock shall comply with the general criteria.

The following are some recommendation items on general criteria to be stipulated for rolling stock construction.

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①Load gauge and widening of load gauge on the curve section
②Sufficiently strong running gear ensuring safe and stable running of rolling stock
③Suitable arrangement of axles of rolling stock
④Appropriate performance of internal – combustion engine to prevent generation of extreme heat, fuel leakage, hazard for passengers by the heat and exhausted gas etc.
⑤Stipulation of maximum axle load
⑥Stipulation of effective breaking system such as air brake, continues through brake, an independent braking function.
⑦Appropriate structure of passenger cabin relating to window, lightening of room, toilets
⑧Appropriate automatic control device of passenger door
⑨Appropriate coupling device
⑩Fire prevention of rolling stock

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(b) Recommendation on technical standards relating to maintenance of rolling stock

①Locomotive

Inspections for the rank M1-M5 are stipulated, but those for the rank M6 to M8 are not clear, should be stipulated. Different pressure gauge is used depending on the type of the locomotive. Standardization of pressure gauge is recommended.

②Coach and Wagon

Manuals are out of date, and very simple. They should be updated and more detailed.

Further the following items should be stipulated.

a. Electrical equipments other than battery and lighting system
b. Solid type wheel
c. Air suspension bogie
d. Rolling bearing
e. Air brake system

③ DMU

Maintenance manuals of DMU should be prepared.

④General

The following items should be stipulated in the maintenance manuals

- dimension of the wheel
- difference of the wheel diamater
- air leakage of brake system
- insulation of electrical circuit

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(3)Signal/Telecommunication

① Establishment of unified technical standards for newly introduced equipments.

For newly introduced equipments, there are not established any unified technical standards, accordingly equipments of different technical standards are installed at respective stations, resulting in undesirable conditions from the viewpoint of maintenance to ensure safe and reliable train operation.

Unified technical standards should be established for each kind of equipment for ensuring safe and reliable train operation.

② Maintenance standards

MR has adopted preventive maintenance system for some of their equipments. Maintenance standards should be established urgently for the newly introduced equipments, so as to execute appropriate maintenance.

Especially unified technical standards and maintenance standards should be established for equipments to be introduced newly such as optical fibre, electronic interlocking system, level crossing warning device system, automatic train protection system, and also for equipments which are already introduced, but are to be increased further, such as electric point machine, track circuit etc.

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(4) Train Operation

① Chapter 2 Signals

・How to put back the signal to “ON”, after the signal has been taken “OFF”

・Conditions to which a train can enter or advance to the station

・Personnel assignment to the points at non-interlocking stations

・Supervision method of the signal person in charge by the stationmaster

・Inspection of points by the guards of the halting trains, and the responsibility

① Chapter 3 Working Of Trains Generally

・Set method of the clock of the guard and the driver

・Notes when removing the flags or the lamps placed in the case of the work of the carriage circumference

① Chapter 4 Accidents

・First priority at the time of the accident outbreak

・Measures at the time of the fire outbreak

① Matters not prescribed in the existing rules

・Safety norms and the management of quality of railway employees

・Restriction of train operation at disaster

・Safety precaution in the case of connecting other trains with a trouble train

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(5)Structures

・The present status of structures and economic scale in Myanmar are similar to the one of 1963-1970 in Japan.

・In japan, around 1963-1970 railway facilities had changed their maintenance method, from corrective maintenance to preventive one, hence, the number of disaster threatened railway facilities has been decreasing.

・It is quite effective for Myanma Railways to refer to the Japanese maintenance method, and in addition patrolling against disaster.

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①Bridges (Manual of the Engineering Department ChapterⅥ)

・We recommended the proper maintenance execution to keep bridges in good soundness.

・The actual Standard of MR:

・The required performance of bridges are not specified.

・Maintenance for bridge except steel structures are not specified .

・Actual procedures for inspection of the structures, such as these to be inspected carefully are insufficient.

・Details of countermeasures are insufficient.

・We recommended the following from Japanese standard “Maintenance Standards for Railway Structures and Commentary, RAILWAY TECHNICAL RESEARCH INSTITUTE”

・Details of required performance for bridges: safety, serviceability and restorability

・The maintenance for concrete bridges: foundation/ retaining structure

・The categories for proper maintenance, such as Initial inspection, General ordinary/ special inspection, individual inspection, extraordinary inspection

・The details of respective inspections, their timings, survey methods, judgment of soundness and countermeasures.

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② Formations (Manual of the Engineering Department ChapterⅢ)

・We recommended the proper maintenance execution to keep formation structure in good soundness.

・The actual standard of MR:

・ Slope protection work should be provided only in the area where the annual rainfall exceeds 100”.

・ Allowance for shrinkage are prescribed according to the annual rainfall.

・ It is described that, regarding the angle of cutting slope , it would be able to be vertical if it is good rock.

・ Description for maintenance of formations are insufficiency.

・We recommended as follows from Japanese standard “Maintenance/Design (Earth Structure)s Standards for Railway Structures and Commentary, RAILWAY TECHNICAL RESEARCH INSTITUTE”

・ Every slope should be provided with some protection works, because erosions are easy to occur on slope surfaces by rain

・ Allowance for shrinkage should be confirmed by consolidation test and by calculated settlement about bearing ground of embankment.

・ Concept of “performance level” of formation ,so to speak, the order of priority of line. And even if it were 3rd performance level with good rock, the angle of slope thereof would be at least, 1:0.3. for the consideration of rock weathering.

・ The details of formation maintenance, such as inspection categories, timings, survey methods, judgment of soundness and countermeasures should be specified.

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③Safety precautions (Manual of the Engineering Department ChapterⅫ)

・We recommended the efficient train operation control in the case of disasters to improve the service and safety level of Myanma Railways

・The actual standard of MR is qualitatively almost sufficient for reopening train operation safely, if all described actions are strictly taken by relevant authorities. Especially, followings are quite essential article for preventing disaster that we'd like to emphasize.

§ Article1256: The object of such investigation is to ascertain the cause of the accident in order that suitable action may then be taken to endeavor to prevent the recurrence of any similar accident in the future.

§ Article1257: Every railway servant present at an accident must therefore do his best to foster such spirit of cooperation in the interests of the speedy completion of the restoration.

・But some judgments are made personally, and no clear standard criteria are existing, so it would take a longer time for the train operation control.

・For reopening train operation safely, also more rapidly, we recommended "the example of guarding and standard value for train operation control about rainfall and strong wind" from Japanese Ministerial Ordinance.

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2.1.2 Drawing up Short-, Medium-, and Long- Term Railway Facilities Improvement Plan

We are proposing the Short-, Medium-, and Long- Term Railway Facilities Improvement Plan in the Appendix 1 "Report of Proposals of Recommendation on Technical Standards of MR and Short-, Medium-, and Long- Term Railway Facilities Improvement Plan".

Our proposal will be fully discussed in the workshop to be held from Sep30 to Oct 3rs, 2014, in the same way as the Recommendation on Technical Standards.

In the JCC, we would like to just introduce the outline of the proposal, and would like to request the JCC to leave the discussion or the Proposal to he workshop.

The schedule of the workshop and the discussion members are the same as those for Recommendation on Technical Standards as explained in the previous slides.

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(1) Introduction

The principles for drawing up short-, medium-, and long-term railway facilities improvement plan

In drawing up short-, medium-, and long-term railway facilities improvement plan (hereinafter referred to as RFIP) from the viewpoint of upgrading safety and service of MR, the following principles are adopted,

① RFIP focuses on the rehabilitation and modernization of the existing lines.
② Railway facilities plan relating to new line construction and improvement of international transport will be excluded.
③ RFIP will focus on improvement of facilities relating to upgrading safety and service, but exclude the improvement of facilities relating to economic development of the area along the lines, railway business expansion, or revenue increase such as development of ICD, freight yard, connection to sea ports.
④ The railway projects proposed by Myanmar Development Cooperation Forum which took place on Jan.19 and 20, 2013 will be duly taken into consideration.
⑤ "Survey Program for National Transport Development Plan in the Republic of the Union of the Myanmar" prepared by JICA (June 2014) will be duly taken into consideration.

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(2) Proposal of short-, medium-, and long-term railway facilities improvement plan

①Introduction

In drawing up RFIP, the principles described in (1) introduction have been duly taken into consideration. Further the following preconditions or policies have been assumed.

(a) In MR railway network, Yangon – Mandalay line and Yangon Transit System (Circular line + Danyingon ~ Hlawga+ Mahlwagon ~ Ywathagyi + Thilawa line) have been defined as "Most Important Lines".
(b) Mandalay – Myitkyna line, Yangon – Pyay line, Yangon-Pathein line and Yangon – Dawei line have been defined as "the Next Important Lines".
(c) All other lines have been defined as "Other Lines".
(d) As indicated in the Inception Report,

Short term corresponds to	2015 – 2018
Medium term corresponds to	2018 – 2025
Long term corresponds to	2025 – 2045

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②Short-, medium-, and long-term railway facilities improvement plan

Details of improvement plans are explained in Appendix 1. Just as an example of improvement Plan, the track case is explained here.

Table-Ⅱ-2, 2-1 Short-, Medium-, and Long Term Railway Facilities Improvement Plan
(for levelling up Safety and Service Level) -Track-

Facilities to be improved	2015 Short term	2018 Medium term	2025	2030	2035 Long term	2045
1.Urgent improvement of the Most and Next Important Lines (Y-M Line、Y Transit System) (M-Myitkyna, Y-Pyay, Y-Pathein, Y-Dawei)						
(1)improvement of urgent places	Most Important Lines					
・replacement of old aged rails	Y-M					
・improvement of joints and rail welding	Y Transit System →					
・replacement of damaged turn out						
・replacement of damaged PC sleeper, replacement of wooden sleeper by PC sleepers	Next Important Lines					
・supply of ballast	M-Myitkyna					
・urgent improvement of important level crossings	Y-Pyay					
・track irregularity rectification	Y-Pathein					
(2)procurement of small/medium type track maintenance machine/tool	Y-Dawei					
(3)procurement of track inspection equipment						
2. Improvement of the Most Important Lines, Next Important Lines and Other Lines						
(1)Improvement of track structure		Most Important Lines				
・Increase the unit weight of rail appropriately		Y-M				
・producting long welded rail		Y.C.L. →				
・replacement of existing turnout to appropriate advanced turnout			Next Important Lines M-Myitkyina Y-Pyay Y-Pathein Y-Dawei			
・increase of sleepers per km appropriately, and promote laying of PC sleepers						
・supplement of ballast, increase the depth of ballast	→		→	→		
・improvement of level crossing track structures					Other Lines	
・track irregularity rectification	→		→	→	→	
・constructuin of track posts						
(2) procurement of large track maintenance machines (MTT, BR, BHC etc) and construction of the depots						
(3)Usage of high speed track inspection car		to cope with the needs of the Most Important Lines (Y-M, Y,C,L)	to cope with the needs of the Next Important Lines		to cope with the needs of the Other Lines	
(4)Improvement of ballast production factory and expansion of its production capacity	→	→	→	→	→	
(5)Construction of rail welting depot						
(6)Improvement of turnout factory and expansion of its production capacity						
(7)Improvement of PC sleeper factory and expansion of its production capacity						

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2.1.3 Education/ training in Japan

Schedule of training in Japan was proposed by JICA Expert Team to MR in August, 2014, which MR received and agreed with on the condition that Railway Museum is desirable to be included.

As the result, the following schedule of training in Japan was finalized as shown in Table 2.2 For the 11 participants as shown in Table 2.3 were nominated by MR.

Now the preparation for implementing the training in Japan is under way.

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Table2.2 Schedule of Training in Japan (Institutional Management Improvement Course) 1/2

No.	Date	Time	Lecture/ Visit	Content	Lecturer	Location of Training	Stay at
1	Oct. 19 (Sun)	6:50 ～		arrival at Narita	JICA Tokyo		
2	Oct. 20 (Mon.)	9:00 ～ 14:00	Lecture	Program Orientation	JIC/JICA	JICA Tokyo	JICA Tokyo
		14:00 ～ 15:30	Lecture	Outline of Railway Transport in Japan	MLIT	JICA Tokyo	
		15:30 ～ 17:00	Lecture	Outline of JR East	JIC	JICA Tokyo	
3	Oct. 21 (Tue)	9:30 ～ 10:00	Lecture	Orientation	JIC	JICA Tokyo	JICA Tokyo
		10:00 ～ 12:00	Lecure	Outline of railway development in Japan	JIC	JICA Tokyo	
		13:00 ～ 15:00	Lecure	Management & technorogy of JRE to ensure safe railway transport	JIC	JICA Tokyo	
		15:00 ～ 17:00	Lecture	Management and technology of JRE to ensure comfortable/ convenient railway transport	JIC	JICA Tokyo	
4	Oct. 22 (Wed)	7:30 ～ 10:00	trip	Tokyo – Shinshirakawa – Training Center			JICA Tokyo
		10:00 ～ 11:30	Lecture	Outline of staff training of JRE	JEPS	JRE Training Center	
		11:30 ～ 12:00	Visit	Museam of railway accident	JEPS	JRE Training Center	
		12:00 ～ 15:00	trip	Shinshirakawa-Tokyo			
		15:00 ～ 17:00	Visit	Tokyo monorail	Tokyo monorail	Hamamatsu-cho	
		17:00 ～ 18:00	Trip				
5	Oct. 23 (Thur)	9:00 ～ 10:00	trip	(Tokyo – Keiyo Line)			JICA Tokyo
		10:00 ～ 14:00	Visit	High speed Track Inspection Car(East-i)	JRE、NSG	Keiyo Line	
		14:00 ～ 15:00	trip	Tokyo- Omiya			
		13:00 ～ 16:00	Visit	Railway museum	JIC	Omiya	
		16:00 ～ 17:00	trip				

Table2.2 Schedule of Training in Japan (Institutional Management Improvement Course) 2/2

6	Oct. 24 (Fri)	8:30 ～ 9:30	Trip	Tokyo – Kunitachi				JICA Tokyo
		9:30 ～ 12:00	Visit	Railway Technical Researchi Institute RTRI	RTRI	Kunitachi		
		12:00 ～ 13:30	trip	Kunitachi – Tokyo freight terminal				
		13:30 ～ 17:00	Visit	Tokyo Freight terminal	JRF	Shinagawa		
		17:00 ～ 18:00	trip					
7	Oct. 25 (Sat)		Holiday	Free				JICA Tokyo
8	Oct.26 (Sun)		Holiday	Free				JICA Tokyo
		14:30 ～ 19:30	trip					
9	Oct. 27 (Mon)	7:00 ～ 12:00		Free				Akita
		13:00 ～ 14:00	Lecture	Outline of Akita Branch Office	JRE	Akita Branch office		
		14:00 ～ 15:30	Vist	Akita General Training Center (AGTC)	JRE	AGTC		
		15:30 ～ 17:30	Visit	Riding train on Oga line	JIC	Akita Branch office		
10	Oct. 28 (Tue)	9:30 ～ 12:30	Visit	Akit aGeneral Rolling Stock Center (AGRSC)	JRE	AGRSC		Akita
		13:30 ～ 15:00	Vist	Akita rolling Stock Center (ARSC)	JRE	ARSC		
		15:00 ～ 16:30	Vist	Train Control Center	JRE	Akita Branch office		
		16:30 ～ 17:00	Lecture	follow-up orientation	JIC	AGTC		
11	Oct. 29 (Wed)	9:30 ～ 11:00	Visit	Akita Track maintenance Technical Center (ATMTC)	JRE	ATMTC		Akita
		12:30 ～ 13:00	Trip	Akita – Oga Line				
		13:00 ～ 15:00	Visit	Oga line	JRE/JIC	Oga Line		
		15:00 ～ 18:00	Lecture	Natural Disaster Prevention system	JIC	Oiwake Traing Center		
12	Oct. 30 (Thur)	9:00 ～ 10:00	Lecture	Akit Station in General	JRE	Akita Station		JICA Tokyo
		10:00 ～ 12:00	Visit	Various Station Facilities	JRE	Akita Station		
		13:00 ～ 14:00	Visit	Non-Railway Business Station Plaza etc.	JRE	Akita Station		
		14:00 ～ 18:00	trip	Akita – Tokyo				
13	Oct. 31 (Fri)	9:30 ～ 11:00	Lecrue	Question and Answers	JIC	JICA Tokyo		JICA Tokyo
		11:00 ～ 17:00	Presentation and Wrap up	Opinion/ comments on Traionig Program by MR trainees, Wrap up meeting	JIC/JICA			
14	Nov. 1 (Sat)	11:00		Leave Narita				

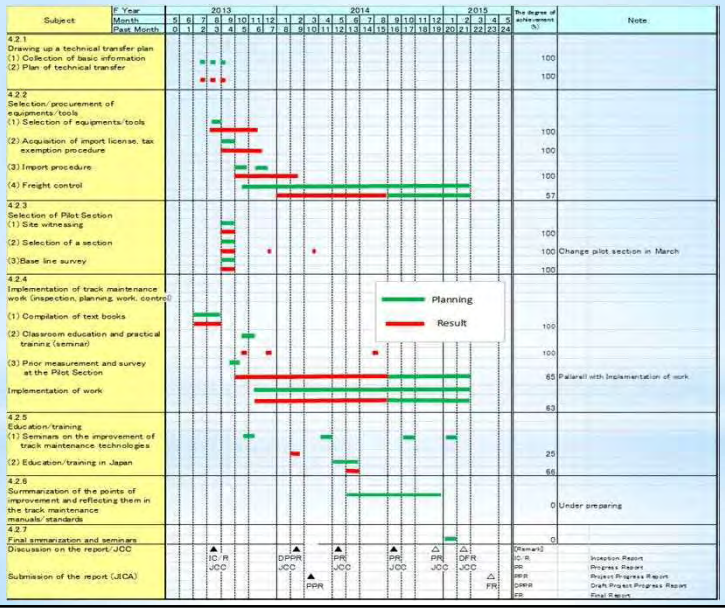
JEPS = JR East Personnel Service, RTRI = Railway Technical Research Institute

Institutional Management Improvement Course

No	Name	Rank	Age
1	U Win Naing	Deputy General Manager (Carriage)	51
2	U Htay Myint Aung	Deputy General Manager (Operation)	58
3	Daw Kyi Kyi Nwe	Assistant General Manager (Finance)	52
4	U Lwan Thu	Executive Engineer (Civil)	52
5	U Maung Maung Tin	Manager (Supply)	52
6	U Aung Chan Myint	Manager (Commercial)	35
7	U Myint Lwin	Executive Engineer (Communication)	50
8	U Aung Wai Soe	Assistant Manager(Inspection)	47
9	Daw Khin May Than	Assistant Manager (plan & News)	50
10	U Nyo Aung	Assistant Engineer (Electric)	40
11	U Aung Myint	Assistant Manager (Planning)	28

2.2 Technology Transfer of Track Maintenance Technology to improve the level of Service and Safety through Implementation of The Pilot Project

2.2.1 Schedule of technology transfer (planning and result)



2.2.2 Education/Training in Myanmar

	Date From	Date To	Division	Number	Remark
1	25.10.2013	12.5.2014	(7)Yangon (6)Bago	24 6	
2	12.5.2014	12.6.2014	(7) Yangon (5)Taunggu (7)Yangon (8)Mawlamying (9)Hinthada	10 6 5 4 5	
3	12.6.2014	12.7.2014	(7) Yangon (2)Ywataung (3)Mandalay (10)Pakauku	10 8 8 7	
4	12.7.2014	12.8.2014	(7) Yangon (1)Myitgyinar (4)Kalaw (11)Bagan	10 6 7 7	
5	12.8.2014	12.9.2014	(7) Yangon (5) Taunggu (8) Mawlamying (9) Hinthada	10 6 6 8	
6	12.9.2014	Until now	(7) Yangon (2) Ywataung (3) Mandalay (6) Bago	10 6 6 8	
Total				183	

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Minister visited site

Set up scaffolding at bridge

Measuring at curve section

Measuring at turnout

2.2.3 Education/Worksop in Japan

We implemented two-week education/workshop program twice in Japan (1st group is from 9th to 20th in June and 2nd group is 23th in June to 4th in July.) each for 11 trainees.
We report at appendix-3 in detail.

Lecture from Dr. Osanai

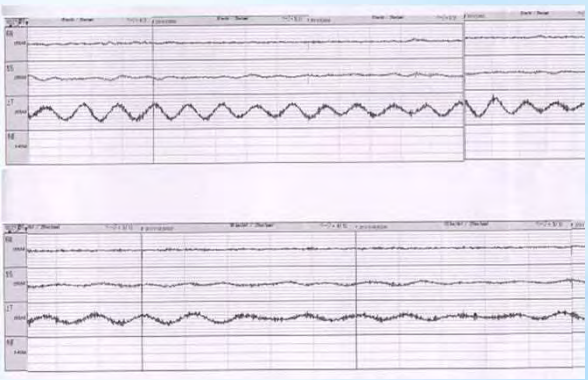
Investigation of ballast factory

2.2.4 Measuring Vibration

At the 3rd JCC, there was a request of continuing the train vibration measurement by the measurement device on Yangon ─ Mandalay line. We are thinking support of measuring.

Measuring Circumstance

Measuring device on the floor



Example of measuring result
(Up : before track maintenance,
Down : After track maintenance)

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2.2.5 Summarization of the points of improvement and reflecting them in the track maintenance manuals/standards

We summarize the points of reflection through the whole of maintenance work and compile the maintenance manuals to meet the present status of the track maintenance in Myanmar in consideration of the local organizations, working conditions and climates.

2.2.6 Final summarization and seminars

In closing the above technical transfer course on track maintenance work, we will open seminars for the trainees participated in the program and track maintenance members for other sections selected through consultation with MR.

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3. Concluding remarks

We have already covered about two thirds of the whole Project, but still have various significant activities to be executed in the coming period.
We would like to continue our activities effectively with the cooperation from MR officials concerned.

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Thank you for your attention.