GHANA RAILWAY DEVELOPMENT AUTHORITY
REPUBLIC OF GHANA

STUDY FOR
SAFETY OPERATION AND MANAGEMENT
OF
RAILWAY IN GHANA

FINAL REPORT

JULY 2014

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.

JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD.

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Exchange Rate (As Of January 2013)

US$1= GHC 1.89
US$1= JPY 88.94

Location MAP

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Abbreviation

Term	English
BOM	Board Operating Manual
CCE	Chief Civil Engineer
CDB	China Development Bank
CIOW	Chief Inspector of Works
CME	Chief Mechanical Engineer
CMEE	Chief Mechanical and Electrical Engineer
COS	Control of supply
CST	Chief Superintendent of Track
DCCE	Deputy Chief Civil Engineer
DCERI	Design and Construction of the Western Railway Line Infrastructure Including Procurement Rolling Stock
DME	Deputy Mechanical Engineer
DMU	Diesel Multiple Unit
DST	District Superintendent of Track
EDF	European Development Fund
FSWCIP	The feasibility study of the Western Corridor Infrastructure Project
GPHA	Ghana Ports And Harbors Authority
GPRS	Growth and Poverty Reduction Strategy
GPRS II	Growth and Poverty Reduction Strategy
GRC	Ghana Railway Co., Ltd
GRCL	Ghana Railway Company Limited
GRDA	Ghana Railway Development Authority
GSGDA	Ghana Shared Growth and Development Agenda
HIPCs	Heavily Indebted Poor Countries
HRD	Human resource development
HRM	Human resource management
IC	Inter-City
IR	Inter-Regional Road
IT	Inspector of Track
JICA	Japan International Cooperation Agency
LCK	Level Crossing Keeper
MD	Managing Director
MOFEP	Ministry of Finance and Economic Plan
MOHR	Ministry of Harbors and Railways
MORT	Ministry of Roads and Transport

Term	English
MOT	Ministry of Transport
N	National Road
NTP	National Transport Policy
OCC	Operation Control Center
OJT	On the Job Training
PA	Procurement Act
PIOW	Principal Inspector of Works
PPP	Public-Private Partnership
RHA	Railway and Harbors Authority
SIOW	Senior Inspector of Works
SLM	Senior Length Man
SME	Senior Mechanical Engineer
SPV	Special Purpose Vehicle
SSNIT	Social Security National Insurance Trust
SST	Senior Superintendent of Track
ST	Superintendent of Track
SV	Steel Van
T.O	Train Officer
TO	Track Overseer
TRP	Transport Recovery Program
WB	World Bank
WCGIP	The Western Corridor Gas Infrastructure Project
WCIRP	Western Corridor Infrastructure Renewal Project - Railway Rehabilitation and Modernization Component
WCPT	The Western Corridor Petroleum Terminal （Pumpuni）
4M	Man, Machine, Material, Method

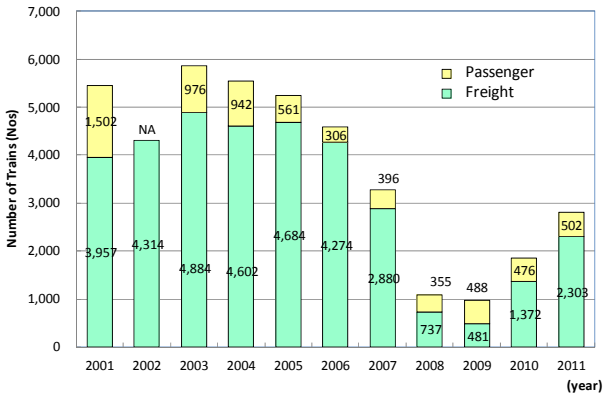
INTRODUCTION

Background of the Study

The lack of sufficient budget for maintenance of infrastructure and rolling stock in Ghana Railways Company ltd (GRCL) has led to the reduction in the number of railway operations in Ghana railway. Out of the 97km of railway lines in Ghana, the passenger trains are operated only on 64km of the Eastern Line, which includes Tema Line in the suburbs of the capital Accra, which has five round trips per day

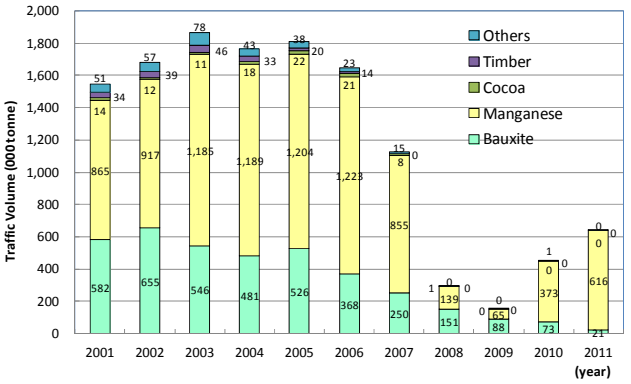
Freight trains are operated on 61km section of the network between Takoradi and Nsuta on the Western Line, and there are only five round trips per day. The freight traffic has decreased rapidly from a peak of 1.8 million tonnes through 2003 to 2005 and fell to a minimum traffic of 154 thousand tonnes in 2009. However, it turned upward after 2009.

Previously the railways transported bauxite between Takoradi and Awaso, three to four times per week. Currently, its operation has been suspended due to the need to undertake rehabilitation works on some sections of the Line. Transportation of cocoa, cement and timber etc. has since been suspended on the western Line from Kumasi to Takoradi.



(Source: Ghana Annual Transport Data)

Figure 1 Number of Train Operations (Western Line)



(Source: Ghana Annual Transport Data)

Figure 2 Trends in Freight Transport (Western Line)

Ghana National Railway Equipment;

One of the main reasons for which 52% of the freight cars/locomotives were not operated in 2008 is the lack of signalling, train control system & station facilities, defective rolling stock (locomotives/passenger coaches/freight cars), and the lack of appropriate maintenance for track structure. The old-fashioned rolling stocks which have been used for more than 45 years could not have been kept in sufficiently good conditions because of the spare parts, i.e. wheel axles, the parts relating to the engine systems and brake systems were not available. Therefore, almost all the rolling stocks are left in the depot.

Figure 3 Derelict Locomotive

The insufficient track maintenance: the levels of left and right rails were not being adjusted, resulting in gauge irregularities, which have resulted in causing the heavy rolling when the rolling stocks are passing through such locations.

There are other problems such as the following;

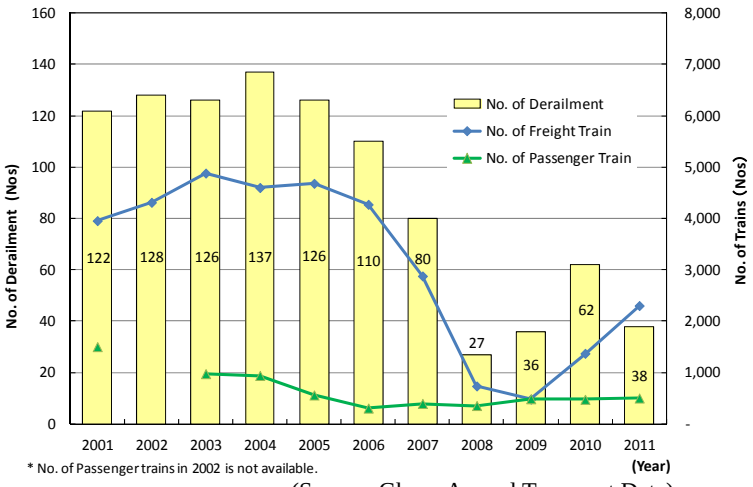
- Worn rails.
- Sleepers (wooden, some parts are steel) have been used beyond their estimated service life.
- Ballast under the sleepers is missing mostly from bottom of outer rails.

In addition, almost all drainage systems along the track are not functional due to the lack of maintenance and aging. Therefore, when the water flows into the station yard from surrounding areas during/after a slight rain, the track becomes submerged easily. This problem often leads to the shutdown or suspension of daily train operation.

Figure 4 Waving Track

Figure 5 Water Covered Track

Several accidents have occurred on the railway network in Ghana. From 2005 to 2008, the number of accidents has decreased because of the reduction in train services. It means that the number of accidents did not decrease relative to the frequency of train services, but rather the number of accidents has been increasing since 2009.



(Source: Ghana Annual Transport Data)

Figure 6 Number of Accidents (Western Line)

Objectives of the Study

The objectives of this study are to support improvement initiatives & methods for the operation & maintenance, by researching and analysing the status of facilities and service for the safe operation of the railways in Ghana.

Area of the Study

The project section for this Study is between Takoradi and Awaso of the Western Line. The total length is approximately 236.2 km.

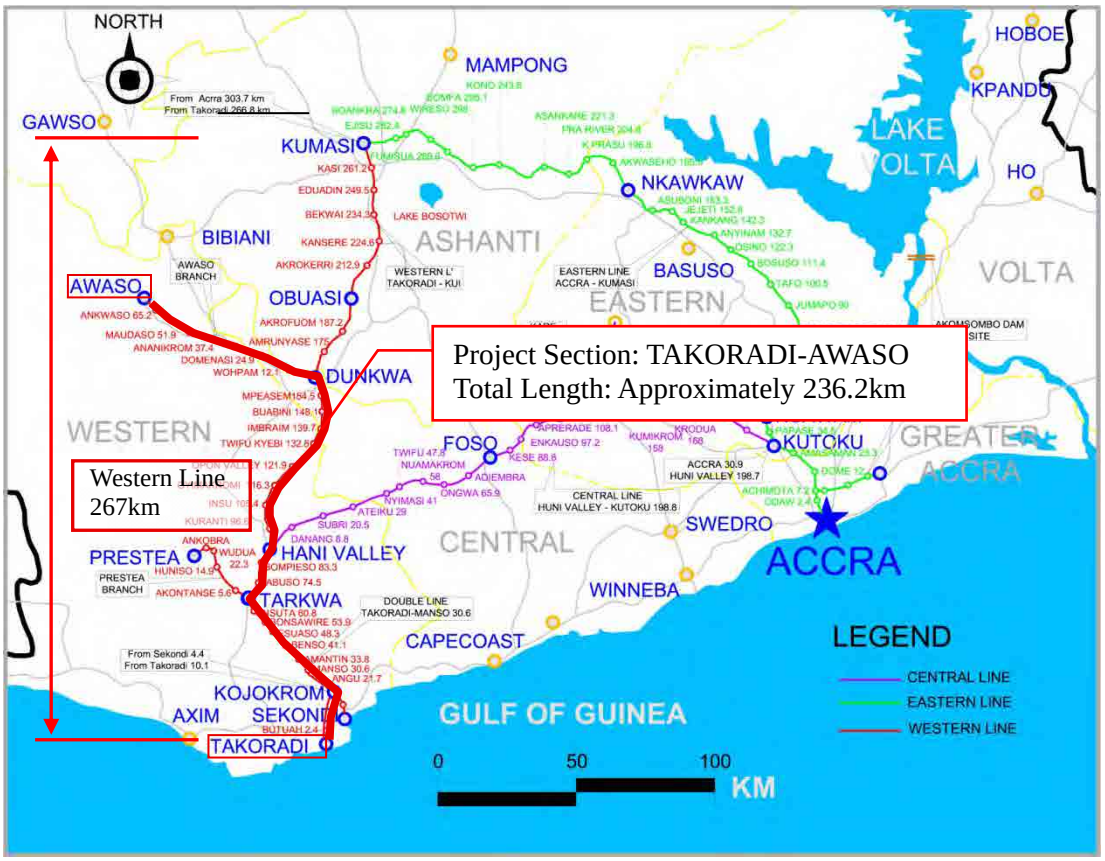


Figure 7 Project Section

Items to be Studied

The study items are shown in the Table below.

Table 1 Items to be Studied

Scope	Task	
1. Preliminary Study & Preparation of Inception Report	【1-1】	Collection and Analysis of Related Materials and Information
	【1-2】	Examination of Study Policy, Approach and Methodology
	【1-3】	Preparation Work for Site Survey
	【1-4】	Preparation of Inception Report
	【1-5】	Explanation and Consultation regarding Inception Report
2. Grasping the Present Situation and Analysis of Ghana Railway	【2-1】	Grasping the Existing Facilities
	【2-2】	Grasping the Existing Operation / Maintenance Regulations, Method and Organization Structure
	【2-3】	Procurement of Materials and Equipment for Site Reconnaissance
	【2-4】	Grasping and Analysis of Deformation/Deficiency Situation
3. Setting Improvement goals	【3-1】	Sharing the Recognition of the Present Situation and Challenges with GRDA/GRCL
	【3-2】	Setting Goals for Safety Improvement and Enforcement system
	【3-3】	Holding Workshop (W/S)
	【3-4】	Preparation of Interim Report
4. Implementation of Operation and Maintenance training	【4-1】	Procurement for Training Instruments
	【4-2】	Explanation and implementation of training contents
	【4-3】	Report of the training results
	【4-4】	Preparation of Draft Final Report
5. Preparation of Final Report	【5-1】	Preparation of Final Report

Chapter 1 Objectives and Background of the Study

1.1 Objectives of the Study

The lack of sufficient budget for maintenance of infrastructure and rolling stock in Ghana Railways Company ltd (GRCL) has led to the reduction on the number of railway operations in Ghana railway. Out of the 97km of railway lines in Ghana, the passenger trains are operated only on 64km of the Eastern Line, which includes Tema Line in the suburbs of the capital Accra, which has five round trips per day. Similarly, freight trains for transportation of manganese have been operated on only 61 km of the section between Takoradi and Nsuta of the Western Line originating at Takoradi, with also five round trips per day.

In addition, over-age facilities and the lack of appropriate maintenance regime have led to insufficient and unreliable conditions of locomotives as well as tracks and track bed, resulting in frequent severe accidents, such as derailments.

The Government of Ghana has established the Ghana Railway Development Authority (GRDA) in accordance with the Railway Act, 2008 enacted in December 2008. GRDA has been tasked to prepare railway development plans, examine and regulate railway operators, develop suburban railways, etc.

Currently, the organization of GRDA is in its formative period and therefore not robust enough to ensure safe train operations, thus the introduction of adequate maintenance methods to investigate the causes of frequent accidents is urgently required.

This study aims at establishing a new operation and maintenance plan to further improve the safe train operation and reinforce the maintenance systems as well as providing technical training to railway operation and maintenance staffs. Hence the Study Team held discussions with concerned parties to understand the background of the request by the Government of Ghana to the Government of Japan for assistance in developing the railway sector and to obtain general information as well as learn about the issues and concerns of the railway of Ghana by conducting the site surveys.

1.2 Overview of Railway in Ghana and Other Related Projects

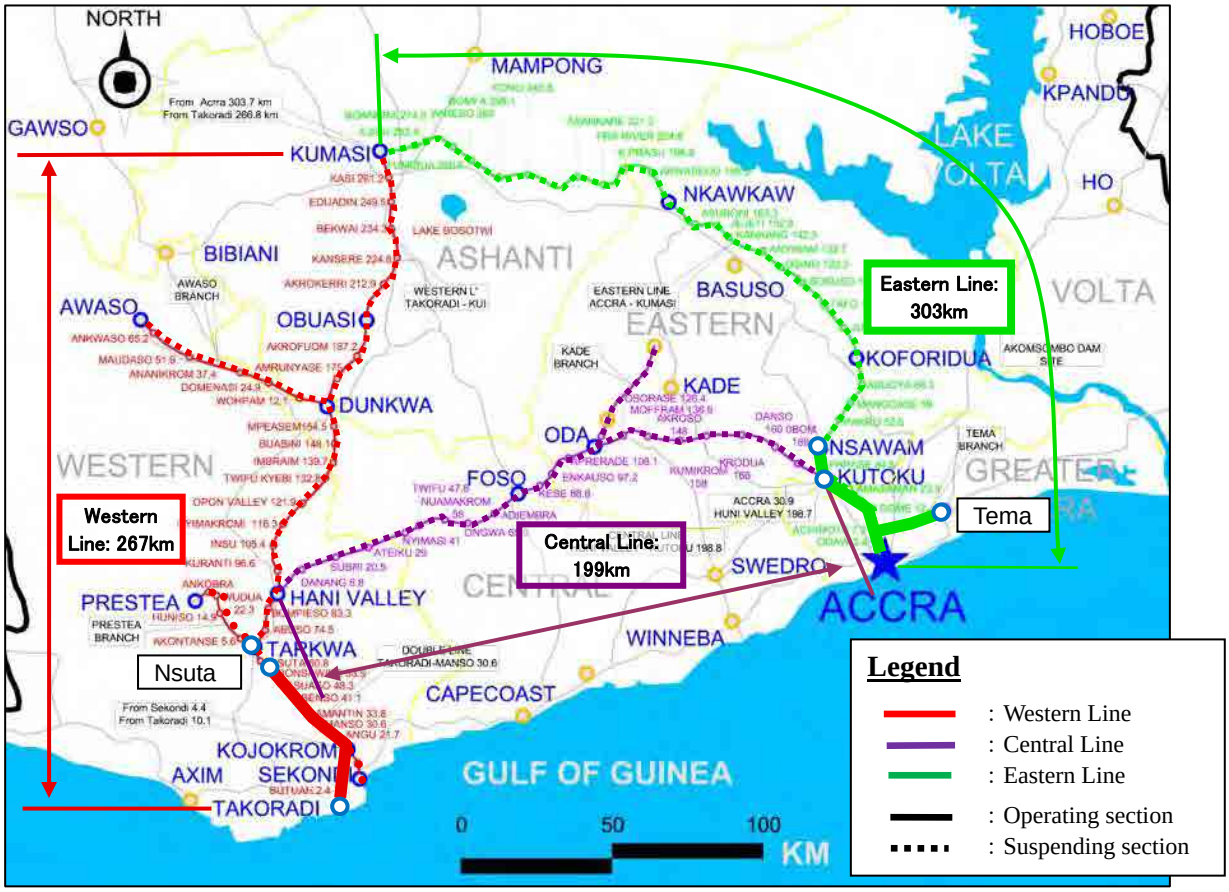
1.2.1 Overview of Railway in Ghana

The railway network in Ghana has the shape of an ‘A’, which consists of Kumasi, the second largest city in Ghana, at the apex, Takoradi Port at the western edge and Accra, the capital of Ghana, at the eastern edge. The Ghana railway network occupies a total rail route length of 947 km consisting of 3 lines. The major rail routes are the Eastern Rail Line that connects Kumasi to Accra and has a length of 303.9 km, the Western Rail Line that connects Kumasi to Sekondi-Takoradi with a length of 266.8 km, and the Central Rail Line that connects the Eastern Rail Line and Western Rail Line which has a length 198.8 km. There is also a branch line which extends to Tema Port in the east. The Western line, the oldest among all lines in Ghana, started its operation in 1903. This line was

the main line among all lines due to the transportation of the main exporting products in Ghana, such as bauxite, manganese, cacao, timber, etc. The Central Line and the Eastern Line were mainly used for passenger transport, however, the Central Line also transported cacao and timber, and the Eastern Line contributed to the transportation of agricultural products from the producing areas in the central part of the country to the consumption areas in the southern part.

However, due to the economic crisis that started in the 1970s and continued into the beginning of 1980, the railway facilities deteriorated and became obsolete. After the crisis was over, the volume of the traffic and the transportation once increased, thanks to support and investments from other countries, including the implementation of Feasibility Studies as well as the establishment of various improvement and extension plans. Notwithstanding such support and investments, the volume of the traffic and the transportation have been decreasing again in recent years because of insufficient budget of GRCL (Ghana Railway Company Limited) for operation and maintenance, which has resulted in lack and/or loss of railway systems, such as rolling stocks (locomotives/coaches/freight cars), tracks, signalling systems, communication systems, station facilities, and so on.

The Eastern Line, including Tema Line, runs through the suburban area of Accra and has a length of 330.5km. There are five round trips of passenger trains, where two round trips per day are operated by locomotives between Accra and Nsawam (40.6km), and three round trips per day by DMU trains between Accra and Tema (37.5km). The operation of long-distance trains has been suspended since May 12, 2002, whereas the operation of the Central Line ceased on Dec 1, 2002. The Western Line, which originates at Takoradi, also stopped the operation of Inter City (IC) trains (passenger trains) on Sep 13, 2007, as well as the operation of freight trains transporting timber on May 12, 2009. As the transportation of bauxite between Awaso and Takoradi was also suspended on May 24, 2011, there are currently only two types of train operation, which are five round trips per day of freight trains for manganese between Takoradi and Nusta (60.8 km) and two round trips per day of passenger trains by locomotives for labour transportation between Takoradi and Kojokrom.



(Source: JICA Study Team)

Figure 1.2.1 Ghana Railway Network

1.2.2 Policies and Superior Plan for Ghana's Railway Sector

Established in 1991 as the long-term national development plan, "Ghana Vision 2020" was formulated for the development of Ghana's entire economy. It placed a high priority on railways as well as on roads in the country's transportation sector, and it included reinforcement of locomotives and freight cars. This plan was replaced by the "Growth and Poverty Reduction Strategy (GPRS)" established in 2002 as a plan to reduce the national debt of heavily-indebted poor countries (HIPCs). GPRS focused on improving the social development sector and action directly aimed at reducing poverty. However, most railway rehabilitation programs, including procurement of rolling stock, are either under implementation or not yet implemented. In this context, continuing to reinforce transportation to build greater transport capacity is indispensable for the revitalization of the Ghana economy.

Subsequently, in November, 2005, the "Growth and Poverty Reduction Strategy, GPRSII," was started and according to this strategy, the development plan for the transportation sector was positioned as a strategic assistance for industrial improvement. The National Transport Policy (NTP) approved in the Assembly in September 2008 set seven long-term tasks, which are outlined below.

1. Establish Ghana as a Transportation Hub for the West African Sub-region

2. Create an accessible, affordable, reliable, safe, secure effective and efficient transport system that meets user needs
3. Integrate land use, transport planning, development planning and service provision
4. Create a vibrant investment and performance based management environment that maximizes benefit for public and private sector investors.
5. Develop and implement comprehensive and integrated Policy, Governance and institutional frameworks.
6. Ensure sustainable development in the Transport Sector.
7. Develop adequate Human Resources and apply new technology.

Railway development under this policy includes a plan for rehabilitating the Accra–Tema Line on the basis of the urban development plan for the areas around Accra and Tema.

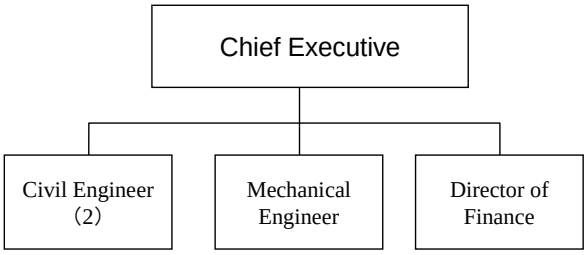
1.2.3 Organizational Structure of Implementing Authority

The Ghana Transport Division was organized into its present state after many twists and turns through frequent reorganizations since the 1970s. When the ports of Takoradi and Tema were opened in 1934, the railway and port services were put under control of the Ministry of Roads and Transport established by reorganizing the Railway and Harbour Authority. In 2003, only seventy y ears later, railway services and port services were separated to function as independent divisions, both of which were under control of the newly established Ministry of Harbours and Railways.

During this time, the degradation of railway facilities has progressed heavily influenced by the national economic crisis from 70s to early 1980. A “Transport Rehabilitation Project (TRP)” was implemented in three phases with World Bank funding, which aims to rectify the bad conditions of the railway facilities in Ghana. However, due to the serious financial difficulties faced by GRC, which were led by reduced government subsidies, railway facilities i.e. maintenance facilities and equipment did not receive sufficient maintenance and GRC became unable to maintain the functioning of its mechanical equipment. Those factors have caused frequent accidents such as derailment and labour disputes with consequential increases in sections going out-of-service. As a way out of such difficulties and to recover proper railway system functions, the Ministry of Transport established, in November 14, 2008, the Railway Act 2008, which was approved by the President’s Office in January 6, 2009. The objective was to improve railway functions by introducing a scheme of separating infrastructure and operation for the promotion of a privatization policy.

The Railway Act 2008 aimed at founding of the Ghana Railway Development Authority (GRDA) which is to take charge of the railway development plan. This will include examination and regulation of the operators, development of the suburban railways and implementation of the “scheme of separating infrastructure and operation”. GRDA was to undertake development of the railway and promotion of railway services, management and operation of railway assets as well as construction and improvement of urban railways. Currently, GRDA is an extremely small organization with five personnel, however, the business plan of GRDA: “Scheme of Service” states

that it will have an organization consisting of 130 job categories. This means that the actual number of staff is insufficient and greater effort or measures must be taken. Adequate maintenance methods to investigate the causes of the frequent accidents will be required to ensure safe train operation. Faced with these current situations, the Ministry of Transport requested that the World Bank undertake a "Study of Technical Assistance related to establishing the GRDA," including an organizational structure, a clarification of its assets. The World Bank has submitted to MoT a specification (draft), "Survey on Technical Assistance related to the Foundation of GRDA," in March, 2012. Concretely, World Bank assisted studies: 1) preparation of all necessary regulations for GRDA to fulfil its mandate. 2) Business plan and an organizational structure for GRDA Details are described in 1.1.2, World Bank Assistance.



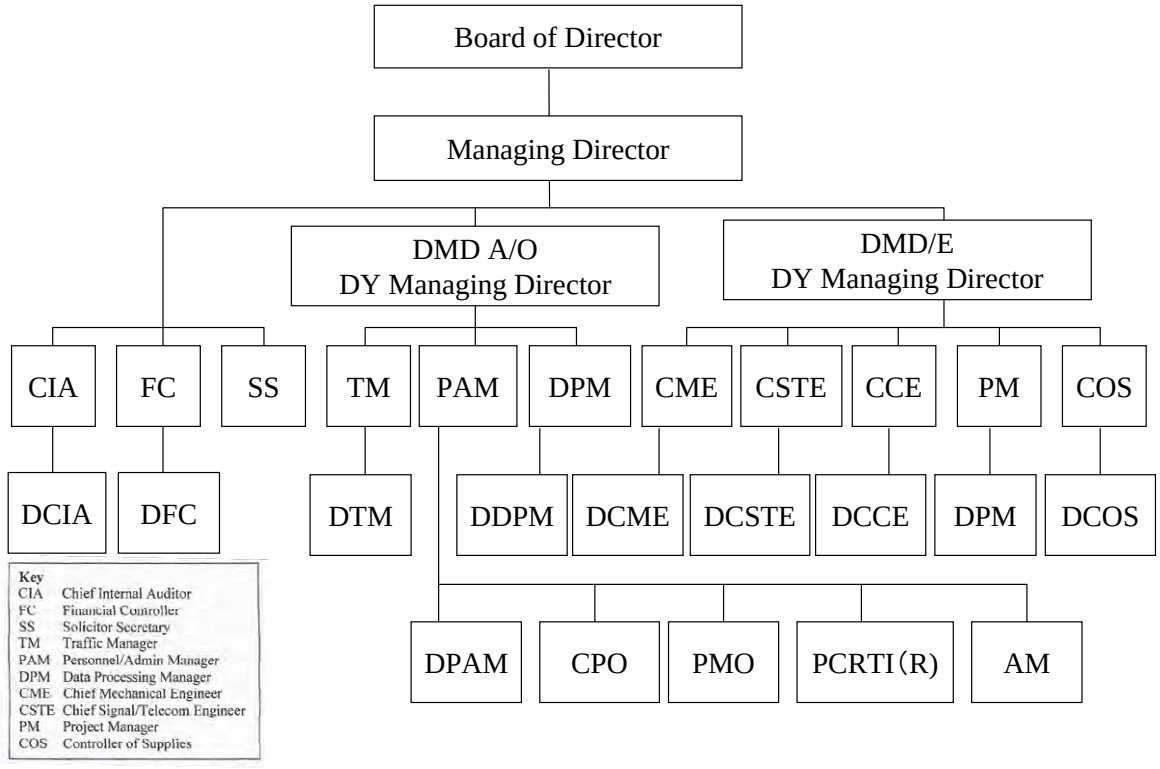
(Source: JICA STUDY TEAM)

Figure 1.2.2 Organization Chart of GRDA (2012.12)

According to the articles of the Railway Act 2008, GRC which was the national railway operator has undergone organizational changes and GRCL has been established as a private company. For the time being, GRCL is to take over railway operation and maintenance during the transition to the private sector. Since the Ghana government holds 100% of the entity's shares, it would be described as a national enterprise under the control of the Ministry of Transport, however, GRCL is equivalent to a private enterprise considering the relevant laws.

Despite the fact that the Government would like private companies to be railway operators in Ghana, private companies are yet to be invited to participate thus GRCL has continued to undertake operation and maintenance of the railway. The Railway Act 2008 established responsibility related to GRCL, which is the entity to undertake railway operation and maintenance, during the transfer phase until entry of the private sector. Therefore, GRCL has no contract regarding the railway operation with GRDA or the Government.

A detailed description of the organization of GRCL is shown in 2.2.3, Organization of Chapter 2.



(Source: JICA Study Team)

Figure 1.2.3 Organization Chart of GRCL (As of 2012.12)

1.2.4 Operating Area and the State of Service of the Western Line

Among the total route length of all the lines in Ghana of 947km, only two sections have been operating which are the 64.3 km of the East Line including Tema branch line in the suburb of Accra, and the 60.8 km between Takoradi and Nsuta of the West Line starting from Takoradi. This study covers the section between Takoradi and Awaso (236.2 km) of the West Line, thus we discuss mainly the train operation services in this section.

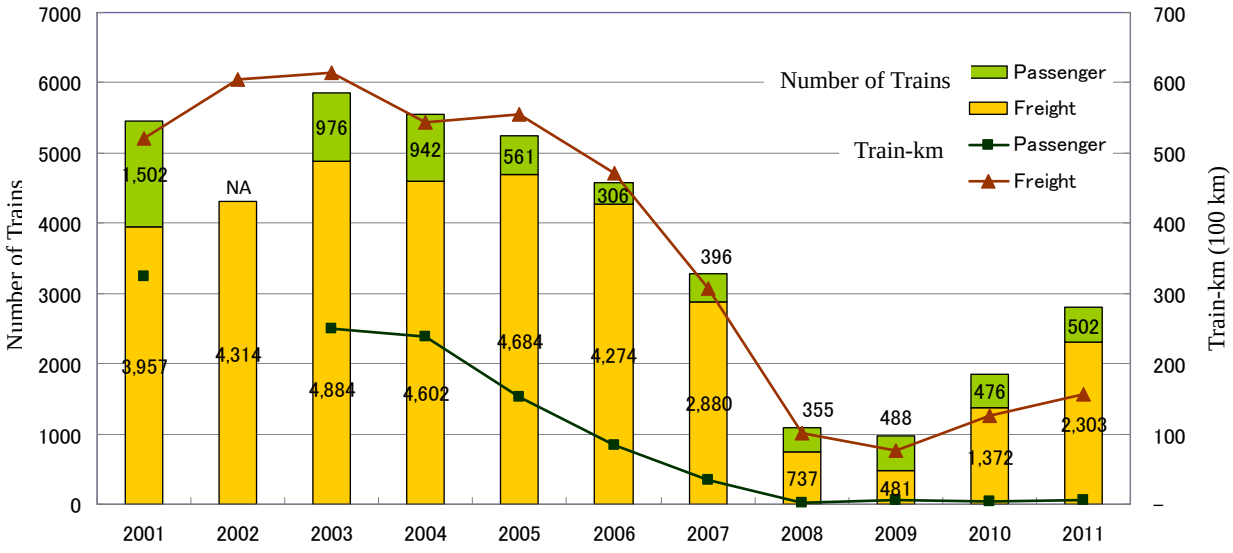
Currently, the passenger trains have been operating one round trip a day in the morning and evening from Takoradi to Kojokrom. The freight trains for manganese have been operating four or five round trips a day from Takoradi to Nusta. Due to the increase in accidents, the freight train for bauxite has been suspended since May 2011.

The number of train operations per year and the total distance travelled during 2001 to 2011 are shown in the graph below (Data of number of passengers' trains and train-km in 2002 is missing; it is not known exactly why).

Until around 2005, 4,300 - 4,800 freight trains a year had been operating, but the number of those began to decrease rapidly due to aging facilities such as the failure of the locomotive. In addition, a large-scale strike occurred in 2008, and train service was suspended for a month and a half, and then, the number of trains was decreased by 1/5 of the number of trains in 2005. After 2009, •Manganese transportation has returned to the railways and the number of trains has gradually increased. On the other hand, demand for passenger transport has decreased due to the road network development. Inter-city train between Takoradi and Kumasi was suspended in 2008, and

few local trains are operating between Takoradi and Kojokrom currently.

The annual number of trains is greatly influenced by freight demand, the handling status in the port or mine, and the occurrence of accidents, especially the length of the disruption to train operation.



(Source:GRCL)

Figure 1.2.4 Number of Trains and Train-km

1.2.5 Current Situation of Railway Transport

(1) Amount of Freight Handled

The western Line covered by this study has been transporting primary products from Ghana industries i.e. bauxite, manganese, cacao and timber. This line was opened in 1903 as mentioned before. The economic crisis which lasted from the 1970s to the beginning of 1980 adversely affected train operations and led to deterioration of the railway equipment. As a result, The "Transport Rehabilitation Project (TRP)" was implemented in three phases under the sponsorship of the World Bank. In the third phase of the Transport Rehabilitation Project, old facilities were replaced along the western Line (Takoradi – Kumasi). As a part of this third-phase project, the yen loan project, "Procurement of Locomotives, Rolling Stock and Workshop Modernization Project", financed by a 6.218 billion yen loan was also implemented for 77 months from March 1994 to July 2000. The project provided the related consulting services and facilities as well as equipment i.e.14 locomotives (diesel 1651 type, 1600 horsepower), 100 box wagons, some equipment for the rolling stock Depot and one crane truck.

Table 1.2.1 Traffic Volume of Freight Transportation by Type of Cargo (per year)

(Unit: thousand ton)

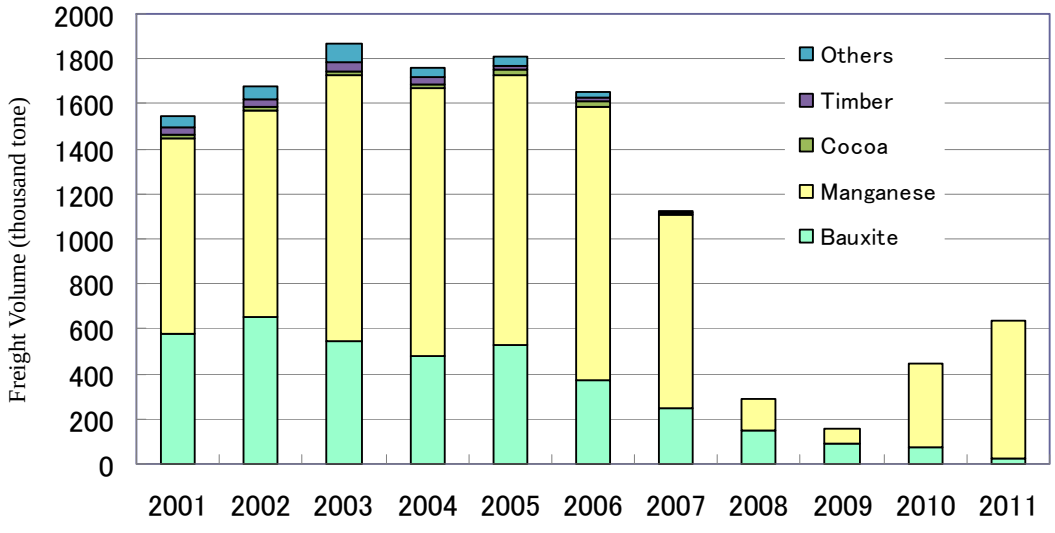
Term	Cocoa	Bauxite	Manganese	Others	Total
1965-1977 (Before the economic crisis)	205	318	399	719	1,641
1978-1996 (During the economic crisis to the third-phase of TRP)	54	280	248	95	677
1997-2005 (Recovery period of third –phase of TRP)	20	485	781	102	1,388

(Source: Transport Division Rehabilitation Project (TRP))

Through the "Transport Division Rehabilitation Project", freight volume was recovered to the level before the economic crisis, and then most bauxite and manganese transportation returned to the railway. However, railway transportation of cacao, which was a major export product in Ghana in the past, went steadily down with the drop in production capacity and the fall of the international price of cacao.

Although the railway transported 18 million tons of freight a year in the 2000's, traffic volume suddenly decreased in 2007 as shown below. The reason seems to be because accidents occurred frequently due to insufficient maintenance and also strikes occurred in 2008.

Since 2008, when the labour issues were resolved to some extent, the volume of transportation has increased although the minimum volume of freight transported was recorded in 2009. However, the freight trains for bauxite between Takoradi and Awaso have been suspended since May 2011 because accidents occurred frequently. At the present, the freight trains mainly transport manganese and there has been no freight transport of bauxite, cacao, cement, timber, etc., on the western Line from Kumasi to the port of Takoradi since May 2009.



(Source: GRCL)

Figure 1.2.5 Freight Volume in the Western Line

(2) Fare for Freight Transportation

Gold, cacao, and timber accounts for 70 -80 % of the export value in Ghana. The export value of bauxite and manganese is much smaller. But still, for Ghana, bauxite, and manganese are important export products and Ghana intends to acquire foreign currency from exports of those products. Although the railway has to play a key role in the transportation, transporters are currently forced to rely on road transport due to repeated delays and frequent accidents on the railway.

Due to frequent accidents and a decreasing number of trains operated, GRCL, the railway operating organization, cannot cover railway operation costs with revenue from transport fees. As a result, funds for maintenance have become completely insufficient and train operation is not fully functional. Passenger trains are operated several times a day over the 30.9 km between Accra and Tema (Tema Line), the 40.5 km between Accra and Nsawan (East Line), and the 10.1 km between Takoradi and Kojokrom (West Line), but the fare yield from these train operations is extremely small. In addition, bauxite, which had been the prime source of income along with manganese, is not transported now. As a result, freight transport of manganese is currently almost the sole source of income for GRCL.

Manganese and bauxite transport fare from 2000 to 2011 is shown below.

Table 1.2.2 Transport Fare of Freight (2000-2011)

(Unit: US$/t/km)

FREIGHT	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
BAUXITE	0.039	0.036	0.035	0.037	0.039	0.039	0.039	0.039	0.044	0.044	0.044	0.044
MANGANESE	0.053	0.053	0.053	0.056	0.056	0.057	0.057	0.057	0.063	0.075	0.075	0.075

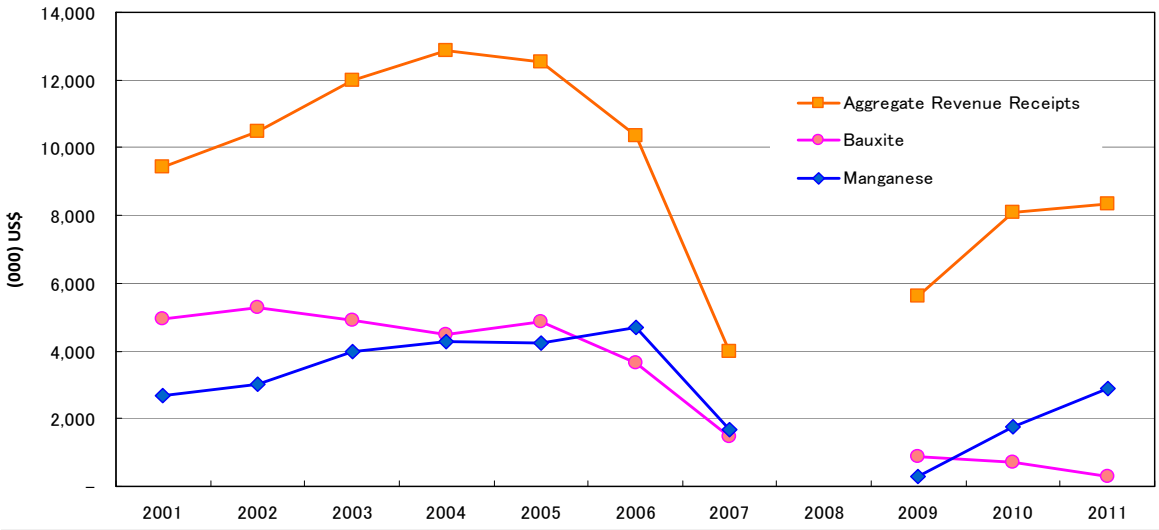
(Source: GRCL)

Transport fare of manganese and bauxite is based on the value of the US$, and the fare is determined by negotiations with GRCL and the shipper every year. As indicated in the table above, freight transport fees were roughly stable from 2000 to 2007, but have increased by US$1 for bauxite and about US$1.2 for manganese since 2008. As of 2013, the transport fare is set to US$5.2/t for manganese (from Nsuta to Takoradi; 60 km) and US$10.5/t for bauxite (from Awaso to Takoradi; 236 km).

According to the agreement concluded between the Manganese Company and GRCL, the fare is paid only for the amount of freight arriving at Takoradi Port due to concerns about the rather high probability of loss of product due to accidents during loading and transport. The freight amount is weighed by a scale attached to the unloading system in Takoradi Port. The existing facilities can handle 1.0 -1.2 million ton of manganese per year. The manganese company has expansion plans for facilities for the completion of the modernization and rehabilitation project of the Western line funded by China. In this plan, the target of output will be twice the current output. In addition, expansion of the Takoradi port has been started. Stockyard expansion is under way with the draft increased from 10 or 11 meters to 15 or 16 meters, which will allow utilization by larger ships. In the future, transport of resources will be undertaken totally by the railway. Note

that the manganese company is not considering participation as an operator because of lack of railway operation know-how.

The total annual revenue of GRCL and fares from the transport of manganese and bauxite are illustrated below for the period from 2000 to 2011.



(Source: GRCL)

Figure 1.2.6 Revenue of GRCL (2001 - 2011)

The annual revenue[1] of GRCL is proportional to the freight transport volume, which reached a peak during the period from 2003 to 2005 and has decreased rapidly since 2006. With the recovery of manganese transport, transportation revenue has also increased since 2009. For the period from the latter half of 2007 to March 2008, the correct data on annual revenue and expenditure is not available because of strikes at GRCL.

(3) Financial Conditions

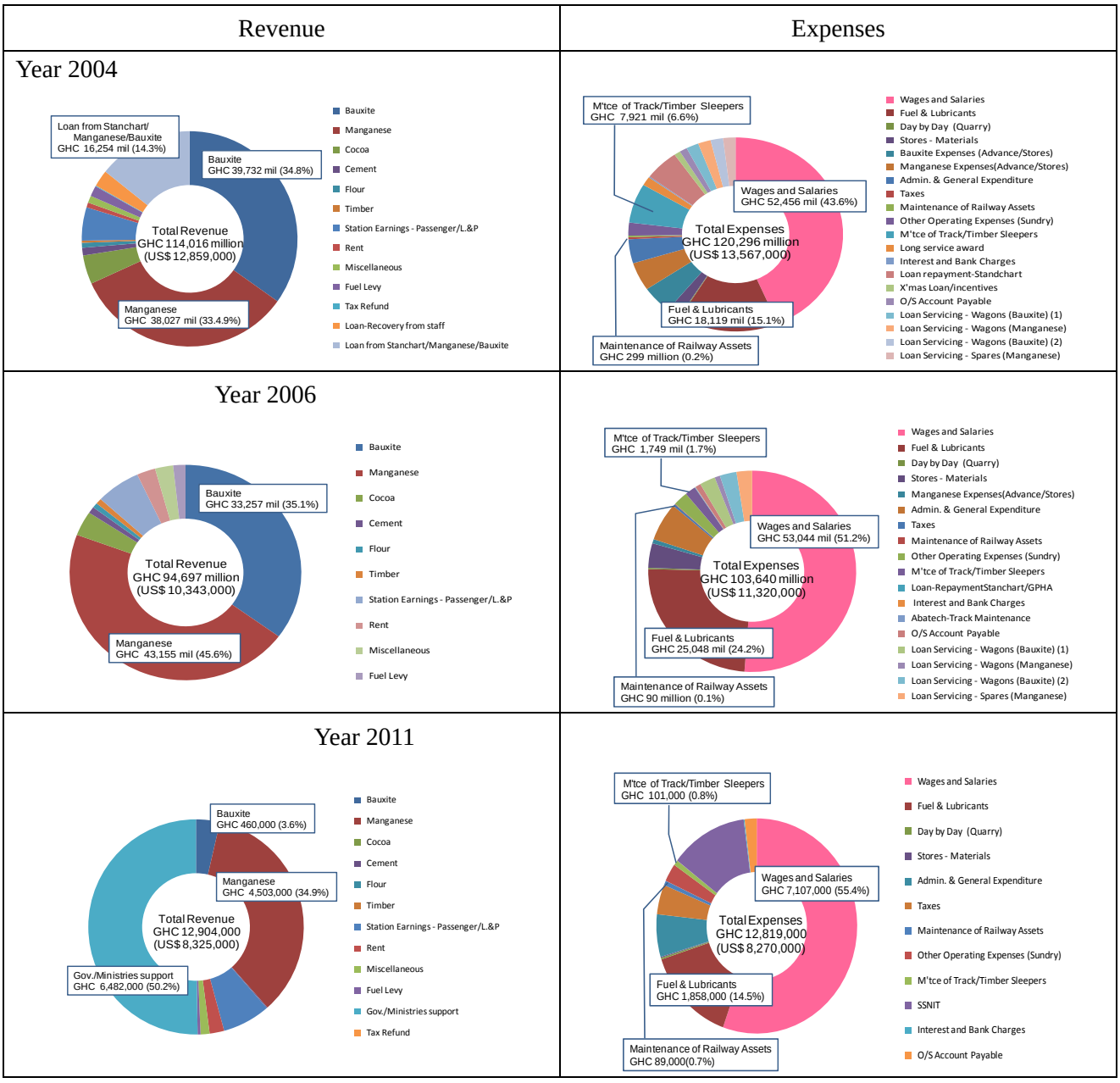
Budget allocations for railway operation in Ghana was compiled for use in the financial analyses to determine if wages are adequate and if the maintenance budget allocated for tracks and rolling stock, etc. is adequate.

The present state of railway transport was described in the Chapter 1.2.5. First, GRCL annual revenue and expenditures were analysed for the three years when substantial changes occurred in shipment volumes and revenue. This included the year 2004 in which shipments peaked, the year 2006 in which the transport amount and annual revenue decreased, and the most recent year 2011. For each of these selected years, the ratio of annual revenue to expenditure is illustrated in circle graphs.

[1] *The Ghana government revaluated the currency, the Ghana cedi on July 1, 2007. Exchange rate (GHC / US $) as of December 31 each year are as follows.*

year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
GHC/US$	*7176.00*	*7964.98*	*8509.31*	*8866.50*	*9019.34*	*9155.77*	*0.95*	*1.08*	*1.43*	*1.43*	*1.55*

Source: OANDA (URL: www.oanda.com/currency/historical-rates/)



(Source: GRCL)

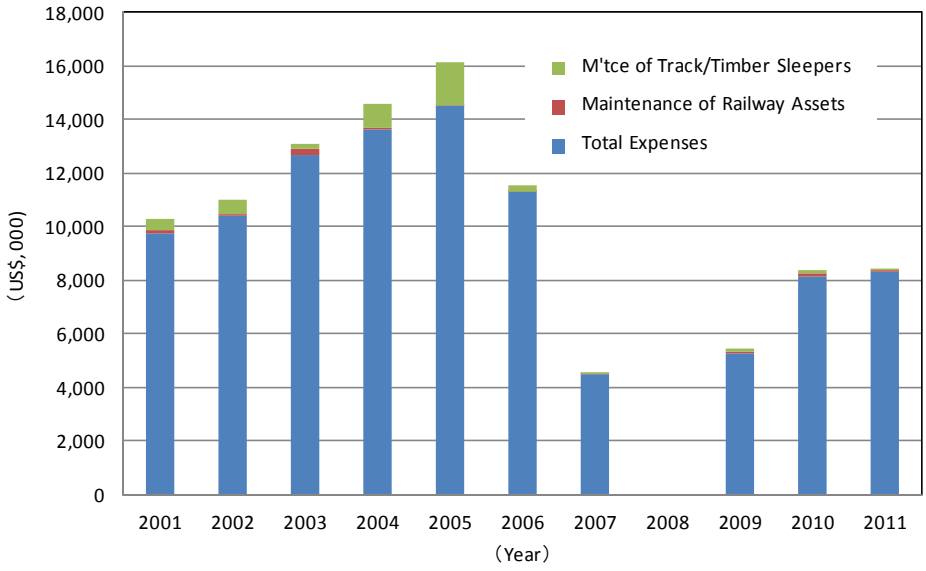
Figure 1.2.7 Revenue and Expenditure of GRCL in 2004, 2006 and 2011

A remarkable feature of annual revenue is that loans from manganese and bauxite companies are included as items only in 2004. To confirm this, an examination of detailed data for 2001 to 2011 indicates annual increases in such funding from 2001 to 2005. The lowest annual amount was 2.5 billion GHC (about 2.28 million US $) in 2001. The highest annual amount was about 180 GHC (about 2.5 million US$) in 2005. This funding was stopped from 2006 on. An examination of detailed data on annual GRCL expenditures indicates that loan repayments up to the year 2005 accounted for nearly one half of annual expenditures. Loan repayments rose to 15 billion GHC (about 1.8 million US$) in 2003 when the number of trains operated began being stable thanks to foreign aid. Loan repayment amounts then decreased after 2004. Absolutely no repayments were made from 2006 on. (Data for 2008 was missing for the reasons described

above.) Although data on total loan amounts could not be obtained, the above facts suggest that a large amount of debt remains. Later, because of continuing arrears in payments to part of the staff, a large scale retrenchment occurred in March 2008. The strike was called off on the condition that the Ghana Government would provide financial assistance. From May 2009 to 2011, subsidies were paid monthly by the Ministry of Transport to bolster fare revenue.

A key element appearing in a breakdown of annual expenditures is that loan repayments were a major item up to 2005. Then, since 2006, the largest percentage of spending became wages and salaries, fuel, and lubricant costs. Since the appointment of a GRDA director in July 2009, social security (SSNIT) contribution is withheld from the workers' wages every month.

An examination as of 2006 of the percentage of expenditures accounted for by management and maintenance costs shows that this spending accounted for 4% of total spending in 2004 and only 5% of the total for 2006. This is an indication that spending on maintenance was extremely low in all years concerned. Management and maintenance costs for 2001 to 2011 are shown in the graph below, and detailed amounts are summarized in the table.



(Source: GRCL)

Figure 1.2.8 Management Expenses for 2001 to 2011

Table 1.2.3 Maintenance Expenses (2001 – 2011)

(Unit: 000 US$)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Expenses	9,736	10,383	12,655	13,657	14,504	11,320	4,508	(n.a)	5,273	8,155	8,291
Maintenance of Railway Assets	126	90	260	34	16	10	6	(n.a)	34	117	57
Maintenance of Track/ Timber Sleepers	428	535	166	893	1600	191	58	(n.a)	115	79	66
Total of Maintenance Expense	554	625	426	927	1616	201	64	(n.a)	149	196	123

(Source: GRCL)

Data obtained from GRCL shows two major maintenance cost items: one for facilities and rolling stock and the other for tracks and sleepers. Maintenance expenses for railway assets between 2004 - 2009 were only US $6,000 - 34,000 a year. This means that there is a crucial lack of maintenance budget. For Maintenance expenses related to the track, sleepers were allocated US$ 893,000 in 2004 and US$ 1,600,000 in 2005, but were allocated US$ 191,000 in 2006 year. This is only a tenth of the previous year. As mentioned in the Chapter 1.2.5, section, the decrease in the number of trains due to frequent accidents and the subsequent decrease in revenue, and decline of railway operation function of GRCL, which is the railway operational implementing organization, seem greatly affected. It seems that GRCL cannot purchase most of the materials and equipment required due to a chronic lack of maintenance budget.

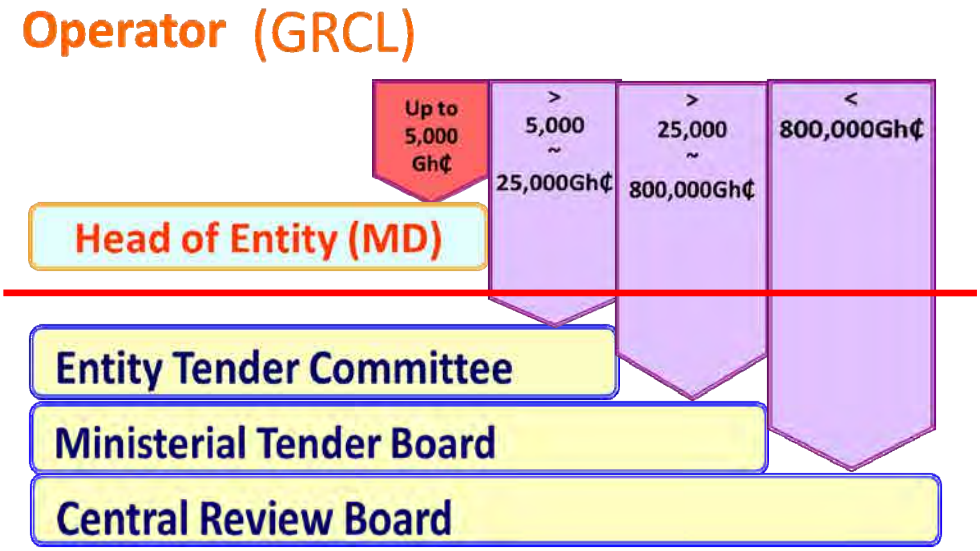
(4) Procurement Procedure and Control of Supply

For inventory control, the manager in Control of Supply (COS) receives all requests for purchases of all material and equipment, everything from spare parts for rolling stock to office supplies. He confirms individual amounts of items purchased and the sums of money involved, and carries out the procedure for procurement.

Procedures for the procurement of material/equipment are based on the Procurement Act, 2003. This Act was not revised even after revaluation of the currency in 2008. The fact that the law does not match the present currency level is highlighted as a critical issue. Actually, the sums available for purchase of materials and equipment that GRCL can settle by itself remain at GHC5000.

According to the flow of materials/equipment procurement as set forth in the Procurement Act, 2003, procurement for materials and equipment of GHC5,000 or less requires approval of the Managing Director (MD). Approval of the External Tender Committee is necessary for procurement exceeding GHC5,000. Depending on the procurement amount, material and equipment procurement can require approval of three tender committees: the Entity Tender Committee (GHC 5,000 to GHC 25,000), the Ministerial Tender Board (GHC 25,000 to GHC 800,000) and the Central Review Board (GHC 800,000 or more). The Entity Tender Committee, Ministerial Tender Board, and Central Review Board are positioned external to GRC.

Consulting the tender committees as described above results in about nine months being required to complete a transaction, from the announcement of tender to delivery. This is considerable time and trouble for procurement of materials/equipment. It seems essential to establish rational procurement methods for urgently needed materials/equipment.



(Source: Procurement Act, 2003)

Figure 1.2.9 Flow of the Procurement of Materials and Equipment

The budget for GRCL itself is insufficient, and GRCL is only temporarily in charge of Ghana railway operations. No agreement has been concluded with GRDA, which means the Procurement Act, 2003 is not operative. The flow of materials and equipment procurement consists of summarizing requests from each GRCL department, regardless of the sum of money involved, at the controller of supplies (COS) office in a form of materials and equipment list, submission of the summary to the Ministry of Transport for approval, and, after approval, the Ministry of Transport obtains approval of the Ministry of Finance. In most of cases, approval cannot be obtained from the Ministry of Finance, which in turn makes it impossible for each department to purchase necessary materials and equipment.

In this way, in addition to GRCL's severe budget problems, operations are also hindered by delays in procurement caused by the need to obtain approval from each government agency — approvals that are not necessarily received. As a result, the present condition is that requests from each department are not approved to a satisfactory degree.

1.2.6 The Progress of Other Projects for the Railway in Ghana

(1) Railway Master Plan of Ghana

1) Background and the State of the Plan

The Government of Ghana is carrying out an ambitious plan for the development and modernization of the railway system, both at national and suburban level. The basic policy framework of this process is the restructuring and expansion of the railway system and an increased private sector participation in the provision of rail transport services. An Italian firm has bid on this project as a consultant. An Italian firm Team Engineering SpA has been engaged on this project as a consultant. The project period was defined to be from February to August 2012. However, since the project period was expanded because of the delayed payment for the consultant fee, eventually the draft final report was submitted in November 2012 by the consultant. Then, the Study Team obtained the draft final report regarding this project from GRDA in December 2012. The final report is yet to be submitted.

Definition and characterization of the railway network that is the subject of the investments ranges from some existing narrow gauge lines that are obsolete and not in use, to the construction of new standard gauge lines (see Figure 1.2.10 Schematic Map of Proposed New Rail Network) and in this way achieve a total network of approximately 4000km that covers the country from north to south. These operations are foreseen to be carried out in phases lasting 33 years. This rehabilitation involves the civil works (tracks, stations, buildings, etc.), the signalling and communication systems and rolling stock (locomotives, coaches, etc.).

The Rehabilitation and Modernization of the existing infrastructure will consist of:

a) Increasing the minimum curve radii;
b) Decrease the maximum gradients in the direction of trains loaded with minerals;
c) Increase the axle load
d) Reinforce the permanent way;
e) Reconstruct existing bridges and culverts due to the increase in axle load;
f) Lengthen passing loop lengths in stations and junctions to be compatible with the forecast lengths of the trains.

The objectives of the Rehabilitation are to:

a) increase line capacity;
b) increase average speed/reduce travel time;
c) increase passenger comfort,
d) increase efficiency/reduce maintenance costs.

The annual development increase in the various sectors is between 6 and 8%. Hence, further economic growth is foreseen that will bring the per capita income to approximately 3,000US$ by 2020. This improvement is due to the development and socio-economic growth in the various

sectors and also to the new contribution that should be derived from the oil and gas sectors and from the mining industry in the north-west and east of the country

Regarding the financial analysis of the investments, it considered the profitability and usefulness of the design interventions and the benefits derived for the socio-economic development of the entire country. In terms of feasibility and returns for GRDA, it was analysed from the viewpoint of the owner of the infrastructure and the eventual management companies operating the railway in PPP, in anticipation of a possible division of responsibility between the proprietor of the infrastructure and the transport operations.

2) Summary of Future Development Plans for the Railway in Ghana

On the basis of analyses of the current transport system and the proposed development plan of the Government of Ghana to expand the existing railway infrastructures, a "New Railway Network" in the future is foreseen to include the infrastructures and services that will be necessary to satisfy the growing demand for mobility in Ghana.

This is of strategic importance in the development plans for the Ghanaian Railways and includes important interventions for the reorganization of transport and the requalification of the areas to be crossed: stations, regional and urban railway services, and routes dedicated to the transport of mineral products.

The Proposed Expansion of the National Railway Network runs along several corridors in a north-south and east-west direction and, besides linking the main cities, also connects both existing and potential mineral deposits with the two important Ports in the country (Takoradi and Tema).

The New Railway Network is comprised mainly of two north-south routes (Western Expansion and Eastern Expansion), a coastal line running in an East-west direction (Trans Ecowas Expansion) and four transversal connections.

The expansion of the National Railway Network will be realized by the construction of new standard gauge lines to ensure a more complete transportation service for the whole country. Rehabilitation and this expansion will be developed in 6 phases as follows;

<u>Phase 1- Rehabilitation of Existing Lines</u>

1 W Western Line (340km)

1 E Eastern Line (327.6 km)

<u>Phase 2- Central Spine Expansion</u>

2 W Takoradi - Kumasi (266 km)

2 E Accra - Kumasi (300 km)

2 C Kumasi - Paga (595 km)

Phase 3- Transversal Expansion

3.1 Tamale - Yendi (102 km)

3.2 Fufulsu - Sawla (126 km)

3.3 Techiman - Kwadwokurom ((198 km)

3.4 Nyinahin - Kumasi (58 km)

Phase 4- Trans Ecowas Expansion

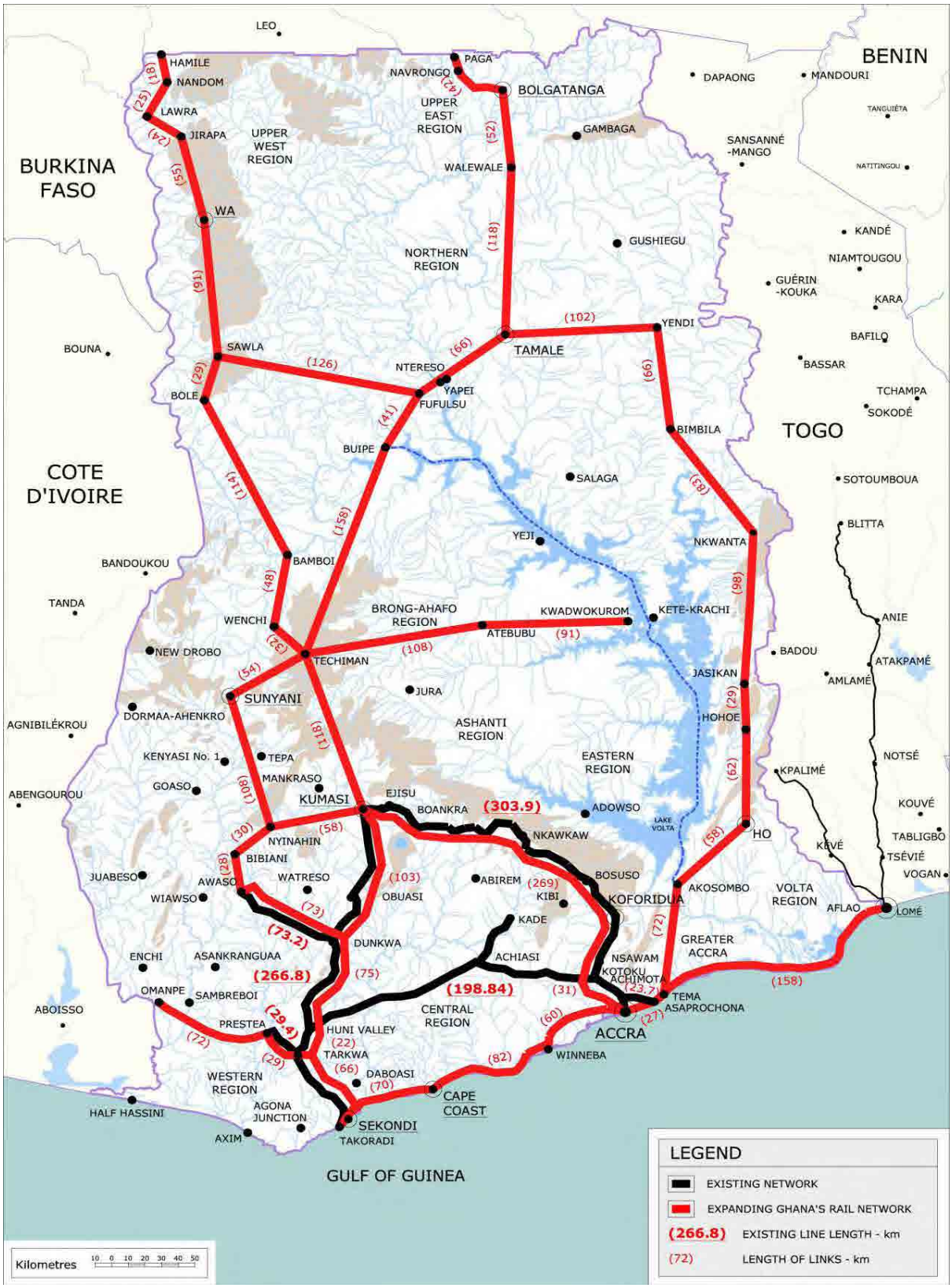
Aflao - Accra - Takoradi - Omanpe (498 km)

Phase 5- Western Expansion

Dunkwa - Awaso - Hamile (729 km)

Phase 6- Eastern Expansion

Tema - Yendi Tamale (468 km).



(Source: "Railway Master Plan of Ghana" Draft Final Report, Nov, 2012)

Figure 1.2.10 Schematic Map of Proposed New Rail Network

a) Phase 1- Rehabilitation of Existing Lines

Only two of the three existing lines are forecast to be rehabilitated: the Western Line (1W): Takoradi-Kumasi and Dunkwa-Awaso line and the Eastern Line (1E): Accra-Kumasi and Achimota-Tema lines.

The traffic assignment shows that the Western Line has a greater tendency for goods transportation, in particular, traffic related to the mines, while the Eastern Line has more passenger traffic. The Central Line, however, is unappealing for both goods and passenger traffic and will be substituted, in the successive phases, by the foreseen Coastal line.

The following table shows the length of the existing rail lines that will be rehabilitated and the total length of the relative routes.

Table 1.2.4 Rehabilitation of Existing Rail Lines

(Unit: km)

Phase 1	
Western Line (1 W)	
1- Takoradi - Kumasi	266.8
2- Dunkwa - Awaso	73.2
Subtotal	340.0
Eastern Line (1 E)	
Accra - Kumasi	303.9
Achimota - Temai	23.7
Subtotal	327.6
Total	667.6

(Source: "Railway Master Plan of Ghana" Draft Final Report, Nov, 2012)

(Source: "Railway Master Plan of Ghana" Draft Final Report, Nov, 2012)

Figure 1.2.11 Phases of Expanding of New Lines (Phase 1)

b) Phase 2- Central Spine Expansion

Phase 2 involves the doubling of the two lines restructured in Phase 1, by constructing the standard gauge lines: Takoradi-Kumasi (2W) and Accra-Kumasi (2E) and the conversion to standard gauge of the previously restructured track. Furthermore, the new standard gauge line from Kumasi to Tamale and Paga (2C) will also be constructed for a total of 1161 km .

c) Phase 3- Transversal Expansion

Phase 3 involves the construction of single track, standard gauge, transversal lines for the routes Tamale - Yendi (3,1), Fufulsu - Sawla (3,2), Techiman - Kwadwokurom (3,3) and Nyinahin – Kumasi (3,4), for a total of approximately 484 km.

d) Phase 4- Trans Ecowas Expansion

Phase 4 sees the construction of two single tracks, standard gauge lines. The first section of the line starts from Aflao, near the border with Togo and heads west, mainly along the coast of the Gulf of Guinea, connecting the important cities of Tema, Accra, Cape Coast and Takoradi. The second section starts at Tarkwa and ends at Omanpe, near the border with the Cote D'Ivoire. The two stretches have a total length of approximately 498 km.

e) Phase 5- Western Expansion

Phase 5 sees the construction of a single, standard gauge line that extends the original Western Line northwards to reach and connect the future mines. The line starts from Dunkwa-Awaso and extends as far as Techiman, Sawla and Hamile for a total of 729 km.

f) Phase 6- Eastern Expansion

Phase 6 sees the construction of a single, standard gauge line heading east, near the border with Togo, that from Tema reaches the river port of Akosombo and then heads towards Ho and Yendi in the North, for a total length of 468 km.

(Source: "Railway Master Plan of Ghana" Draft Final Report, Nov, 2012)

Figure 1.2.12 Phases of Expanding of New Lines (Phase 1 - Phase 6)

3) Implementation Schedule

An implementation programme has been elaborated regarding the rehabilitation of the existing narrow gauge lines, approximately 667 km (2015 - 2018), and the construction of new standard gauge lines, approximately 3,340 km (2017 - 2039) for a total length of 4,007 km.

Table 1.2.5 Implementation Program

Ghana Railway Master Plan	IMPLEMENTATION PROGRAMME AND RELATED INVESTMENTS (INFRASTRUCTURE) AT CONSTANT (2015) RATES																																		
Lines	(a)	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	
	L Km	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
		Rehabilitation				Construction new lines -Standard gauge																															
A PHASE 1: Rehabilitation of existing line	667.6																																		
1W - Western Line	340	1	1	1	1																														
1- Takoradi - Tarkwa - Dunkwa - Kumasi	266.8																																		
2- Dunkwa - Awaso	73.2																																		
1E - Eastern Line	327.6	1	1	1	1	1																													
1- Accra - Kumasi	303.9																																		
2- Achimota - Tema	23.7																																		
B PHASE 2: Eastern "A" Expansion	1161																																		
2W-Takoradi-Kumasi	266					1	1	1	1	1	1																								
2E- Accra - Kumasi	300						1	1	1	1	1	1	1																						
2C Kumasi - Techiman - Tamale	383							1	1	1	1	1	1	1	1	1																			
Tamale - Paga	212											1	1	1	1	1																			
C PHASE 3: Transversal Expansions	484																																		
1- Tamale - Yendi	102																			1	1	1													
2- Fufulsu - Sawla	126																1	1	1																
3- Techiman - Atebubu - Kwadwokurom	198																1	1	1	1	1														
4- Nyinahin - Kumasi	58																			1	1														
D PHASE 4: Trans Ecowas Expansion	498																																		
1- Aflao - Tema - Accra	185																						1	1	1	1									
2- Accra - Takoradi	212																				1	1	1	1	1										
3- Tarkwa - Omanpe	101																							1	1	1									
E PHASE 5: Western Expansion	729																																		
1- Dunkwa - Awaso	73																									1	1								
2- Awaso - Techiman	220																										1	1	1	1	1				
3- Techiman - Sawla	223																							1	1	1	1	1							
4- Sawla - Hamile	213																										1	1	1	1	1				
F PHASE 6: Eastern "B" Expansion	468																											1							
1- Tema - Ho	130																													1	1	1			
2- Ho - Yendi	338																											1	1	1	1	1	1	1	
Total New Construction Km	3'340	Years (new constr.)	0	0	1	2	3	3	3	3	3	3	2	2	2	2	2	2	3	4	2	2	4	4	4	4	4	3	4	4	2	1	1		
Grand Total (Rehabilitation + New Construction) Km	4007.6																																		

(Source: "Railway Master Plan of Ghana" Draft Final Report, Nov, 2012)

(2) Rehabilitation Project for Takoradi to Sekondi

This project is to be carried out funded by the Ghana Government as a part of the "Western Corridor Infrastructure Renewal Project - Railway Rehabilitation and Modernization Component" mentioned in the next section "1.3.1 China". And this project aims to restore the section between Kojokrom and Sekondi for commuter service.

The basic information regarding this project is as follows;

- Section: Takoradi – Kojokrom - Sekondi (14.5km)
- Funding: Ghana Government
- Finance: US$165million
- Period: 18 months; Completion is scheduled for mid-2014 (construction was partly started as of January 2014).
- Scope of Work: Track, signals and communications, stations, and procurement of DMU for two compositions
- Contractor: Amandi (Israel)

(3) Extension Project for Tema Line

The basic information regarding the Extension Project for Tema line is as follows;

- Section: Tema Community One Station (3.3km)
- Funding: Ghana Government
- Finance: US$ 9million
- Period: Service opened in February 7, 2013
- Scope of Work: Civil engineering (including station platform), track, station facilities[2]

1.3 The Status of Assistance to the Railways of Ghana by Other Donors

1.3.1 China

(1) State of Assistance to Ghana

The area along the western Line, which is also the area covered by the study of this project, is called the "Western Corridor Development District." Three infrastructure development projects are to be implemented there under a loan extended by the China Development Bank (CDB). Respective projects will be implemented concurrently with infrastructure development and expansion projects already under way in Ghana. The loan amount is said to be a total of 3 billion US$.

[2] Civil engineering, track, and station facilities are to be separate packages. Procurement of rolling stock is not included. No signaling and communications, cellular phones as conventional communication method will be used for this line as well.

- The Western Corridor Gas Infrastructure Project
- The Western Corridor Petroleum Terminal (Pumpuni)
- Western Corridor Infrastructure Renewal Project - Railway Rehabilitation and Modernization Component

Of the three projects listed above, the West Line covered by the "Western Corridor Infrastructure Renewal Project - Railway Rehabilitation and Modernization Component" is also an area covered by this project. It is considered to be an influential future project component. In this context, the study team obtained the outline and contents of the above project from GRDA in May 2012. The details and background of the project are presented below.

(2) Background and Outline of the "Western Corridor Infrastructure Renewal Project — Railway Rehabilitation and Modernization Component"

In mid-2009, the Ghana Government contracted a project investigation with the intention of taking urgent measures. The objectives were to prevent further deterioration of the wayside of the western Line and to achieve early recovery of safe manganese and bauxite rail shipments, which are the principal source of revenue for the western Line.

In March, 2010, the Italian consultant, Bonifica, prepared an Urgent Measures Plan with financing from the European Development Fund. Although it was an urgent plan for much-needed repairs, this Plan is also prepared on the basis of expenditures needed to achieve sustainable Ghana railway service by the year 2030. Great potential for railway operations is envisioned.

Table 1.3.1 Urgent Measures Package

(Unit: US$ Millions)

Rehabilitation	**Cost**
Rehabilitation of tracks (excluding Kasi-Kumasi)	$ 40.220
Rehabilitation of bridges, culverts and drains (excluding Kasi-Kumasi)	$ 1.761
Rehabilitation of Signalling and telecommunications	$ 5.961
Rehabilitation of locomotives	$ 3.640
Rehabilitation of wagons	$ 10.410
Rehabilitation of coaches	$ 1.880
Building repair, workshops and minor maintenance equipment	$ 1.527
Kasi-Kumasi line rehabilitation	$ 14.238
TOTAL	**$ 79. 637**

(Source: Urgent Measures Plan (May 2011))

This provides for a supply of rolling stock and maintenance equipment for rehabilitation of the wayside and to ensure safe operation while maintaining the existing design parameters (narrow gauge, axle load 16t, and speed 40-50km/h).

A feasibility study for the "Western Corridor Infrastructure Project" was also conducted by the Italian consultant, Bonificia, which submitted its final report in August 2010. This project was implemented, as a program to assist Ghana's mining industry, with financing from European Union.

On the basis of these studies, the Ghana government allocated an amount of 500million US$ from the China Development Bank (CDB), loan facility for the western corridor.

In this project the Ghana Government expects modernization and future nationwide expansion of the railway network as per the Bonifica report and specifications the consultant included a plan to expand the existing narrow gauge to the standard gauge, and have set the steepest grade. Then, the Government set the steepest grade to an average of 1% (maximum 1.25%) to cope with the maximum speed and axle weight of the new line and recognizes the necessity of concrete sleepers for dual gauge to facilitate gauge modification from narrow to standard. Finally, the Government would consider assistance with the initial investment for these plans.

In Phase 1 of the Western Corridor Infrastructure Renewal Project — Railway Rehabilitation and Modernization Component, the implementing agency is GRDA, and a consultant will be in charge of design, construction, supervision and shall include a maintenance agreement in the course of project implementation.

According to Part 2 (Articles 33 to 44) of the Railway Act 2008, GRDA will be providing the railway operation license and charging of access fees from owners of the freight transport business (bauxite, manganese, petroleum products, and cocoa) in order to provide a source of revenue for recovering the initial investment in this project.

The objective of this project is redevelopment of the total length of 340 km of the West Line (Takoradi-Dunkwa, Dunkwa-Awaso, and Dunkwa-Kumasi). The final type of works, gauge, and sections concerned will be finalized through negotiations with the contractor. It is highly possible that the Takoradi – Awaso section will be selected as the priority section.

The construction schedule will be about two years for the Takoradi-Awaso section and three years for the Takoradi-Kumasi section (including Awaso branch line). Because of the election held at the end of 2012, progress of the project slowed down. At present, consensus-building with the Government is being achieved, and the work is scheduled to start in the latter half of March or the first half of April 2015.

(3) Service to be Provided for the Project

Normally, tender documents are prepared after completion of a survey and study. However, in this project, the tender documents were prepared in advance, and a subsequent detailed survey and study, detailed design, and construction will be undertaken by the contractor. As the general consultant, the Italian Team Engineering developing the railway master plan was selected as consultant on the project.

Although details of the service to be provided by the contractor are shown below, specific contents are supposed to be based on negotiations carried out between the contractor and the GRDA in the future.

1) Detailed Design

The scope of detailed design is as follows:

- In-situ topographic survey
- Detailed topographical map
- 1 : 2000 plan with contours
- 1:20001:100 profile
- 1; 200 cross sections (each 100 m)
- Typical cross section
- 1:2000 land acquisition plan

Detailed design and implementation will be for the following items:

- Design speed 120-80km/h
- 54 kg/m rail type
- Pre-stressed concrete sleepers (for dual gauge) and other structures
- Maintaining the existing narrow gauge (1067 mm)
- Strengthening, widening, and construction and rehabilitation of existing bridges and culverts
- Structure
- Track
- Stations
- Buildings
- Water supply
- Signals
- Telecommunication
- Power supply
- Weighbridge

2) Geological and Soil Surveys

The contents of the geological and soil surveys are as follows:

- Soil geology and ground profile
- Taking typical samples for laboratory tests

(4) Rolling Stock

1) Rehabilitation of Existing Rolling Stock

Details pertaining to the rolling stock and freight cars are summarized in the table below.

Table 1.3.2 Rolling Stock Rehabilitated

Type of Rolling Stock	Nos.
Locomotives	33
Wagons for ore	115
General Cargo Wagons	262
Coaches	131
Trollies	4
Wagons for narrow gauge (New purchase)	(undecided)

(Source: GRDA)

2) Procurement of Rolling Stock

Details on the rolling stock:

- 68 freight cars for bauxite (max axle load 21 tons)
- Two container freight cars (max axle load 21 tons)

3) Rehabilitation of the Depots

The depots at Sekondi, Takoradi, Awaso, and Kumasi will be rehabilitated.

(5) Maintenance

The contractor will guarantee full maintenance for five years after completion.

1.3.2 World Bank

(1) State of Assistance to Ghana

The World Bank and the International Bank for Reconstruction and Development prepared the report that scopes out the factors affecting the source of long term financing for public-private partnerships in Cameroon, Côte d'Ivoire, Kenya, Nigeria, Senegal and Ghana. In light of the challenges that are faced in the domestic long-term financing market in these targeted African markets, an outline of some medium term options for PPP financing was given. The report further describes the current PPP initiatives in the sample countries and highlights the obstacles that prevent the enabling environment required for PPP programs to grow. This work explores the

supporting legislative, regulatory and institutional environments for PPPs; examines issues connected with the importance of developing a sound pipeline of PPP projects; and tackles the critical aspects of managing the increased government fiscal commitments that are commonly associated with PPPs.

The report concludes by putting forth policy recommendations intended to assist in overcoming the challenges in building private sector confidence in the infrastructure markets in sub-Saharan Africa in order to attract greater levels of financing for private sector investment in core public services.

In the final report, recommendations are shown as below.

1) Policies for Reforms and Institutional Developmental Actions to Mobilize a Deeper Financing Market for PPPs

   - Building of a clear and transparent PPP policy, legislative, regulatory (particularly regarding procurement), and institutional frameworks
   - Definition of clear roles and responsibilities across the central and sector-line ministries, departments, and agencies (MDAs) and their subsidiary government entities including the capacity building
   - Provision of budgetary support to produce a quality pipeline of PPP projects and to make them commercially viable
   - Fostering of project finance capabilities within key institutions in the financial sector
   - Initiation of the PPP program with carefully identified pilot projects to showcase successful transactions
   - Management of fiscal liabilities related to PPP
   - Development and implementation of effective communications strategy to government and private sector stakeholders and citizens

2) Tools that Enhance Private Sector Engagement such as Risk Mitigation Products and Financial Incentives

   - Support for PPP projects to reduce the entrance cost for the private sector and to make infrastructure assets more commercially viable
   - Development of intermediate pricing strategies that build the long-term debt market
   - Provision of mitigation products for political risk
   - Development of the PPP roles of Regional Economic Communities (RECs) and regionally active financial institutions to reduce the impact on smaller economies and for the regional and cross-border infrastructure needs

(2) Study of Technical Assistance Related to Establishing the GRDA

As described in 1.2.3, Organization of the Implementing Authority, the Ministry of Transport requested that the World Bank conduct a "Study on Technical Assistance related to the Foundation of GRDA" whose scope of work includes establishing an organization in GRDA, and identification of assets, etc. In the draft version of the Terms of Reference[1] presented by the World Bank to the Ghana Government, the Railway Act 2008 highlighted, as a principal role of GRDA, jurisdiction in the railway field in Ghana, development and improvement of technologies, and establishing a railway system for connections with neighbouring countries. The ownership of infrastructure is transferred to GRDA, which is obliged to take charge of managing all assets possessed by the railway operator, GRC. GRDA is also responsible for setting operating and technical standards for the operator, while aiming at utilization of the assets transferred to GRDA. In addition, GRDA will play the following five roles:

- Promote and manage planning and development of freight and passenger services, and suburban railways
- Provide regulations and licenses necessary for development of railway operation services, establish technical standards for railway construction and operations, utilization of transferred or leased licenses, and supervision of railway duties and laws in order to manage the railway business in Ghana
- Establish a railway transport plan, develop administrative procedures, and guidelines for best practices and reports submitted to the government
- Foundation and supervision of a railway development fund
- Granting a license for railway operations and services to GRCL, and establishing a provisional framework for operations.

Therefore, this study is to assist the Ghana Government in establishing the GRDA and operating the entire organization within the shortest possible time. It will be conducted in two phases;

- Phase 1: Development of a business plan and organization development plan needed to utilize the authority granted and perform the functions defined in the Railway Act, 2008
- Phase 2: Assist the GRDA directors and the board of operation with planning and implementation until a personnel system for GRDA is established

In Phase 1 above, definitions related to the scope of duties, functions, and services of GRDA will first be reviewed, followed by organizational planning. It is also stated that training will be provided setting up a system and legal framework and to strengthen GRDA roles. A structure with the following five departments will be constructed:

- Safety regulations and assurance
- Development planning and study

- Legal affairs
- Financial affairs
- Business administration

GRDA is also to take charge of developing proposals for control of railway operating funds, capital procurement, and auditing, and to establish a petition system and examination committee to handle disputes related to railway operations which are described in the pertinent laws. GRDA will also handle the allocation of railway work and ownership between GRCL and GRDA. Plans also call for setting up a workshop which will produce a report analysing the present state of the GRDA, the business plan, including proposals for raising railway operating funds, and an organization development plan (draft) to be submitted to the GRDA management board.

It is proposed that a guideline be developed for employment, appointments, and performance evaluation of human resources as a means of carrying out human resources management (HRM), and to provide an education and training program for the staff as part of a human resources development (HRF) strategy.

GRDA is also expected to propose and develop from the very beginning a system — one clearly distinct from the existing system thought to be adequate for the GRDA operations — for projecting revenues and expenditures and identifying risks and risk countermeasures.

On the basis of the considerations described above, a final business plan and organizational plan are to be established, for implementation, after approval of the GRDA board, in Phase 2.

In Phase 2, the detailed proposals of the duties to be handled in all positions required will be proposed. Operating standards will be established, including standards to be adhered to in human resources recruiting and candidate selection criteria and a Board Operating Manual (BOM) will be produced. Support will be provided to enable learning how to manage an accounting and control system in accordance with the business plan. This will include learning how to create balance sheets and business agreements. An initial accounting system will be established and the proper documentation needed to manage GRDA assets will be prepared. Additionally, as part of the study, training will be conducted on taking over acquired technology. At the end of the study, a report covering the four points listed below will be presented to the GRDA and the GRDA board:

- The staff employment process
- Operation manuals and guidelines
- Registration of all systems introduced (including instructions and manuals)
- The results of the training carried out

This is a study for about one year conducted by five experts in the field of general affairs, railway planning, organization establishment, human resources training, economics and finance, and will take approximately 39 M/M.

1.3.3 India

The Indian government supported the Ghana government for supplying of railway wagons, equipment and materials in September, 2009. Total contract price was 13,000,000 USD. Main supply items were high capacity mineral wagons (mineral trucks) at 8,670,000 USD, track materials for rail fastening at 2,756,000 USD, spares for low capacity mineral wagons at 864,000 USD.

1.3.4 EU

The feasibility study on the western Line was conducted with assistance from the EU, and a final report was submitted at the end of November 2009. This study was conducted by the Italian consultant, Bonifa, under contract from EU. This was a large-scale study conducted by transportation experts and specialists in such areas as railways, ports and harbours, economic analysis, and environmental protection. PPP experts also contributed (this took 91 M/M).

1.4 Present State of Other Transport Modes

1.4.1 Roads

(1) Current Situation of the Roads

Approximately 60,000 km of Road network is set up all over Ghana centered on the route linking the Accra economic bloc consisting Accra, the capital of Ghana, and the port of Tema, the Kumasi economic bloc inland, and the western economic bloc around the port of Takoradi.

Many of agricultural products such as cocoa and timber and minerals such as gold, manganese and bauxite have been produced in the economic bloc around Kumasi. And they are exported from the port of Takoradi via the railway and National Road No.1(N1).

As mentioned in the previous section, the train operation between Takoradi and Kumasi has been suspended due to deterioration of railway facilities and rolling stock. Transportation of most exported goods, except manganese from Nsuta and transit cargo, depends on trucks.

Since the roads in Ghana were not designed and developed for heavy vehicles such as trucks carrying ore and there is a lack of sufficient control of overloaded trucks, the increase in traffic volume caused the rapid deterioration of the pavement and roadbeds.

The repair work for pavement and road beds has been making slow progress because the maintenance budget of the road sector is insufficient also. According to the “Ghana Shared Growth and Development Agenda (GSGDA 2010-2013)”, “Good” condition accounts for only 42% of the 68,000km network, and “Poor” condition requiring repair works was 30%.

(2) Trend of Other Donors in the Road Sector

Many donors, such as the World Bank, EU, and the African Development Bank, have implemented support for the road sector.

The following table shows the status of repair works by other donors along the Western Line.

Table 1.4.1 Status of Repair Works by Other Donors along the Western Line

Road	Section	Length	Donor	Status
National Road No.1(N1)	Takoradi- Agona Jct	15km	DANIDA (Denmark)	Completed
National Road No.1(N1)and Inter-Regional Road No.6(IR 6)	Axim Jct.- Agona Jct.-Tarkwa	62km	EU	Completed
Inter-Regional Road No.6(IR 6)	Tarkwa - Ayamfuri	54km	EU	Under Construction
Inter-Regional Road No.6(IR 8)	Ayamfuri – Awaso - Asawinso	54km	WB	Under Construction

(Source: JICA Study Team)

(3) Situation of the Roads along the Western Line

Among of the main roads along the Western Line, at N1 and a part of IR6 (Agona Junction-Tarkwa), the rehabilitation project has been already finished, and there are paved road of two lanes. But, other section (Tarkwa – Ayamfuri) of IR 6 and IR 8 are unpaved or paved road which are damaged.

Since bauxite produced in Awaso is transported by trucks instead of the railway on this route, damage to the pavement is progressing further due to heavy trucks passing.

The rehabilitation program of this IR 6, which is to be completed in the 36 months started on 30 March, 2011, is funded by EU estimated at Euro 70 million (approx. GHC 150million).

(Source: JICA Study Team)

Photo 1.4.1 Inter-Region Road No. 6

(Source: JICA Study Team)

Photo 1.4.2 Truck for Bauxite Transportation

(4) Situation of Manganese and Bauxite Transportation by Truck

Manganese transportation by trucks is carried out as a supplement to transportation by railway.

On the other hand, all bauxite transportation is carried out by trucks due to train operation suspension since May 2012. Therefore, Ghana Bauxite Company procured 80 trucks from China for transportation. However, they have problems since truck transportation cost is approximately twice that of railway transportation and many accidents occur. In addition, due to lack of the maintenance budget of the road administrator, road maintenance cannot be fully carried out. Therefore, the Ghana Bauxite Company repairs the road, e.g. filling holes in the pavement, by themselves in order to maintain transportation safely.

1.4.2 Port

The Study Team collected the information about the freight throughput and condition of the port facilities for Takoradi Port, which exports those mineral resources.

(1) Location

Takoradi Port is located 230km south west of Accra, and is midway between the Ports of Tema and Abidjan. The Port is well connected to its hinterland, which makes it the preferred and ideal gateway to the middle and northern part of Ghana and the Sahelian Countries such as Burkina Faso, Niger and Mali.

(2) Trade

Annually, the Port handles over 600 vessels, 37% of national seaborne traffic, 62% of national exports and 20% of total national imports.

The main exports include Manganese, Bauxite, Cocoa and Forest products while key imports are Clinker, Containerized cargo, Oil products and Wheat. In recent years Takoradi has been handling large volumes of transit cargo for Burkina Faso, Mali and Niger.

(3) Berthing Facilities

Designs of berthing facilities are shown below.

Table 1.4.2 Berthing Facilities of Takoradi Port

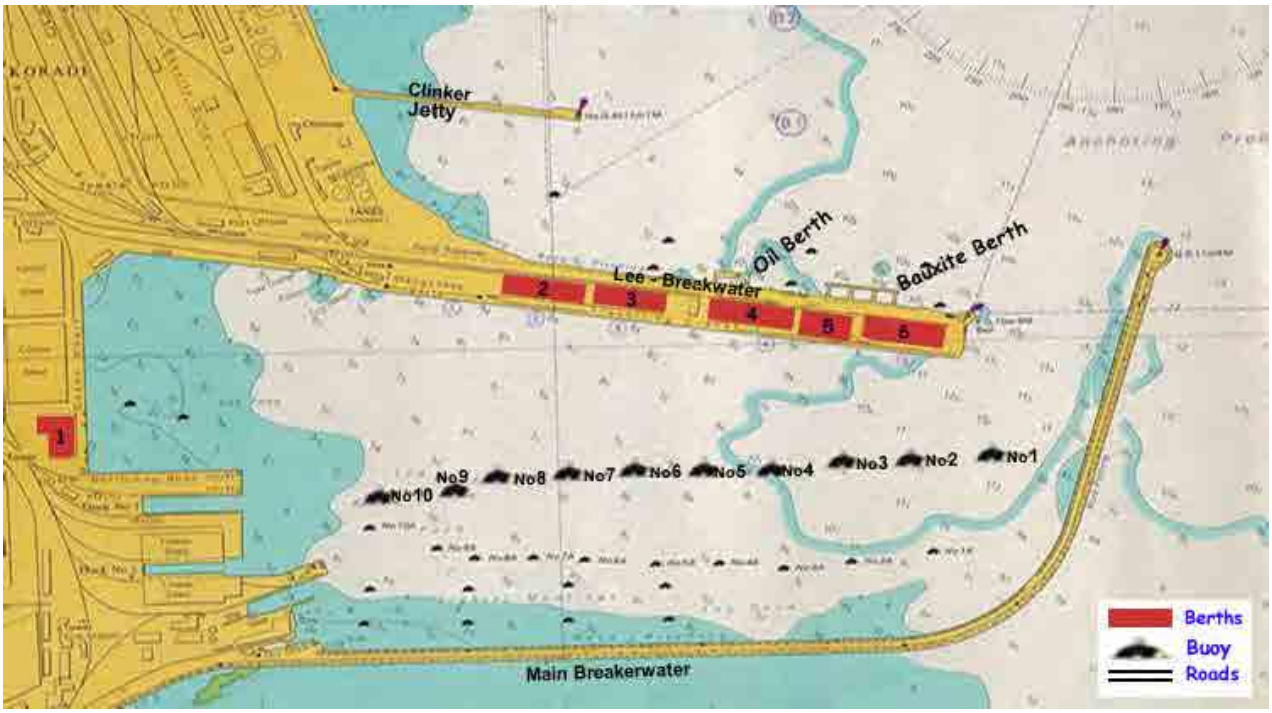
Facility name	Length of Berth	Depth limit
Berth 2	153m	9.0m
Berth 3	153m	9.0m
Berth 4	-	9.0m
Berth 5/6	225m	10.0m
Manganese Berth	157m	8.6m
Bauxite Berth	170m	9.3m
Oil Berth	120m	8.4m
Buoys 1	-	10.3m
Buoys 3	203m (Ship max 180m)	11.0m
Buoys 6	174m (Ship max 150m)	8.4m
Buoys 7	150m (Ship max 120m)	7.4m
Buoys 9	92m	5.5m

(Source: The homepage of Ghana Ports and Harbours Authority)

(4) Storage Facilities, Reefer Points, and Vessel Repair Facilities

With the completion of its three modern sheds, the Port now has a covered storage area of 140,000m^2 and an open storage area of 250,000m^2. The Port has a container holding capacity of more than 5,000 TEUs. The Port has 100 reefer points for storing refrigerated containers for frozen food items.

Rehabilitation work is currently underway to modernize and expand the Port's slipway and dry-dock facilities. The slipway is being expanded to accommodate vessels and crafts up to 500 tonnes deadweight and a length of 40 to 45m. The dry-dock is being extended to a length of 55m and a breadth of 14.5m.



(Source: The homepage of Ghana Ports and Harbours Authority)

Figure 1.4.1 Layout of Takoradi Port

(Source: JICA Study Team)

Photo 1.4.3 Bauxite Yard

(Source: JICA Study Team)

Photo 1.4.4 Unloading Facilities for Manganese

Chapter 2 Grasping the Current Situation and Analysis of the Ghana Railway

2.1 Grasping the Existing Facilities

The Study Team undertook to determine the existence or absence of plan and profile drawings or records, the facility ledgers, the rolling stock ledgers, operation records, accident records etc., and grasps the status of the facilities and rolling stock of the railway of Ghana. The Study Team classified the task for site reconnaissance based on this information and carried out the site reconnaissance.

However, there are many missing documents and non-digitized documents. The document control system of GRCL is not sufficient.

2.1.1 Civil Structure

There are a total of 46 bridges form Takoradi to Awaso through Dunkwa with 23 on the Takoradi - Dunkwa section and 23 on the Awaso Branch Line (Dunkwa - Awaso). There are three flyover-bridges on the Takoradi - Dunkwa. Table 2.1.1 shows location (mileage), type, number of spans and date construction of bridges. These bridges are already more than 60 to 110 years old. Their as-built drawings are mostly lost. Although the design drawings for certain bridges have not been lost, these are only original or blue-print drawings and it seems that there is not almost CAD data.

Steel upper-deck plate girders, steel through plate girders and steel through truss girders are used for existing bridges.

In all of these bridges, only railway track structures (rails/sleepers) exist, without cable or other components on the girders. Derailment preventive rails are provided inside the girders.

Table 2.1.1 Bridge List

(a) Western Line (Takoradi - Dunkwa section)

No	Mileage	Type	No. of Spans	Date constructed
1	1 1/4+1208'	Girder/Steel	1x66'0	1949
2	19 1/2+57'	Steel	1x20'0	(unknown)
3	29 2/4+1099'	Steel deck plate girder	1x30'0	(unknown)
-	30+932'	Rivet	1x56,1x100,1x58	1922 (abandoned)
4	30+932'	Rivet Welded Plate	3x63'8 3/4"	(unknown)
5	33+40'	Steel Through Plate	63' 00"	(unknown)
6	36+00'	Rivet Welded Plate	2x29'8	1901
7	37+11/12p	Rivet Welded Plate	1x29'0	1922
8	38+00	Concrete	1x20'0	1922
9	38 1/2	Steel	1x15'0	1922
10	47-2P	Rivet Steel Joint	1x20'0	1922
11	47-10P	Rivet Steel Joint	1x20'0	(unknown)
12	53 1/2	Rivet Welded Plate	1x20'0	(unknown)
13	63 3/4+1277'	Rivet Welded Plate	1x30'0	1923
14	68 1/4+560'	Rivet Welded Plate	1x20'0	1923
15	71 3/4+248'	Rivet Welded Plate	1x30'0	1923
16	72 1/4+1157'	Rivet Welded Plate	1x20'0	1923
17	79+929'	Rivet Welded Plate	1x20'0	1923
18	85 3/4+961'	Rivet Welded Plate	1x20'0	1923
19	86 1/4+88'	Rivet Welded Plate	1x15'0	1923
20	93 1/4+1011'	Rivet Welded Plate	1x20'0	1923
21	93 3/4+397'	Rivet Welded Plate	1x20'0	1923
22	97 3/4+373'	Rivet Welded Plate	1x20'0	1923
23	98 1/4+1277'	Rivet Welded Plate	1x15'0	1923

(Source: GRCL)

Table 2.1.1 Bridge List (cont.)

(b) Awaso Branch Line (Dunkwa - Awaso)

No	Mileage	Type	No. of Span	Date constructed
A-1	1 1/4+20'	Rivet Welded Plate	1x30'0	1945
A-2	9+1300'	Rivet Welded Plate	1x20'0	1945
A-3	12 1/4+380'	Rivet Welded Plate	1x30' 0	1945
A-4	14+900'	Rivet Welded Plate	1x20'0	1945
A-5	16 1/4	Rivet Welded Plate	1x20'0	1945
A-6	17 1/4 +280'	Rivet Welded Plate	3x20'0	1945
A-7	18 1/2+400'	Rivet Steel Joint	1x10'0	1945
A-8	19 1/4+1000'	Rivet Steel Joint	1x10'0	1945
A-9	19 3/4+1000'	Rivet Steel Joint	1x10'0	1945
A-10	21 1/4+1000'	Rivet Welded Plate	1x20'0	1945
A-11	22 1/4+1000'	Rivet Welded Plate	1x20'0	1945
A-12	23 3/4+200'	Rivet Steel Joint	1x10'0	1945
A-13	25 1/4	Welded Plate	1x30'0	1945
A-14	26+1300'	Welded Plate	1x30'0	1945
A-15	26 1/2+280'	Rivet Steel Joint	1x10'0	1945
A-16	28 3/4+80'	Rivet Steel Joint	1x15'0	1945
A-17	32 1/2+600'	Rivet Steel Joint	1x10'0	1945
A-18	32 1/2+900'	Welded Plate	1x20'0	1945
A-19	33+1000'	Truss Girder	2x56'0	1945
A-20	33 1/4+600'	Rivet Steel Joint	1x10'0	1945
A-21	35 1/4+40'	Welded Plate	1x20'0	1945
A-22	38+400'	Welded Plate	1x20'0	1945
A-23	39 3/4+380'	Truss Girder	1x124'0	1945

(Source: GRCL)


(a) Steel Upper-Deck Plate Girder


(b) Steel Through Plate Girder and Steel Through Truss Girder

(Source: JICA Study Team)

Photo 2.1.1 Types of Bridges

2.1.2 Track

The total length of the section for the scope of this Study is 163.0km of the Western Line (Takoradi - Dunkwa section) and 73.7 km of the Awaso Branch Line (Dunkwa – Awaso), totalling 236.7km. Table 2.1.2 shows the Station list of all the sections.

The plan and profile drawings, the descriptions of the types of structures and the maps of their locations were prepared for the entire Western Line in the course of a study undertaken for the Western Line Development Study by DE CONSUL of Germany in 1996. Due to improper control of the drawings, however, those for a certain section (about 27 km between Takoradi and Manso) are lost. Please note that the Dunkwa-Awaso section was outside the scope of this study. So, there are no drawings for this section.

Table 2.1.2 Station List (Takoradi – Dunkwa – Awaso)

	No.	Station	Type of Station*	Mileage		Distance between Stations (km)	Single/ Double Track
				(mile)	(km)		
Western Line	1	TAKORADI	◎	0.0	0.0	—	Double
	2	BUTUAH	○	1.61	2.6	2.6	Double
	3	NKWANTA	−	3.48	5.6	3.0	Double
	4	ADIEMBRA	−	4.22	6.8	1.2	Double
	5	KOJOKROM	◎	6.27	10.1	3.3	Double
	6	ANGU	○	13.48	21.7	11.6	Double
	7	MANSO	○	19.01	30.6	8.9	Double
	8	AMANTIN	○	20.99	33.8	3.2	Single
	9	BENSO	○	25.53	41.1	7.3	Single
	10	ESUASO	○	30.00	48.3	7.2	Single
	11	BONSAWIRE	○	33.48	53.9	5.6	Single
	12	NSUTA	○	37.76	60.8	6.9	Single
	13	TARKUWA	◎	40.99	66.0	5.2	Single
	14	ABOSO	○	46.27	74.5	8.5	Single
	15	WORKERS BRIGADE	−	48.51	78.1	3.6	Single
	16	BOMPIESO	○	51.74	83.3	5.2	Single
	17	HUNI VALLEY	◎	55.22	88.9	5.6	Single
	18	KURANTI	○	60.00	96.6	7.7	Single
	19	INSU	○	65.47	105.4	8.8	Single
	20	PENESO	−	68.01	109.5	4.1	Single
	21	GYIMAKROM	○	72.24	116.3	6.8	Single
	22	OPON VALLEY	○	75.71	121.9	5.6	Single
	23	OPOKUKROM	−	80.00	128.8	6.9	Single
	24	TWIFUKYEBI	○	82.48	132.8	4.0	Single
	25	JERUSALEM	−	84.47	136.0	3.2	Single
	26	IMBRAIM	○	86.77	139.7	3.7	Single
	27	RUBBERKROM	−	89.01	143.3	3.6	Single
	28	BUABIN	○	91.99	148.1	4.8	Single
	29	SOBROSO	−	93.23	150.1	2.0	Single
	30	MPEASEM	○	96.00	154.5	4.4	Single
	31	DUNKWA	◎	101.24	163.0	8.5	Single
Awaso Branch Line				0.00	0.0	—	Single
	32	WOMPAM	○	7.52	12.1	12.1	Single
	33	NKOTUMSO	−	11.24	18.1	6.0	Single
	34	DOMENASI	○	15.40	24.8	6.7	Single
	35	ANWIA	−	18.51	29.8	5.0	Single
	36	ANANIKROM	○	23.23	37.4	7.6	Single
	37	MAUDASO	○	32.24	51.9	14.5	Single
	38	ANKWASO	−	36.27	58.4	6.5	Single
	39	ANKWASO	○	40.50	65.2	6.8	Single
	40	AWASO	◎	45.78	73.7	8.5	Single
			Total	147.02	236.7	Ave. 6.1	

* ◎: Main Station / Jucntion Station, ○: Station with Platform
−: Station without Platform (Holt)

(Source: JICA Study Team)

(Source: JICA Study Team)

Photo 2.1.2 Main Station (Kojokrom Station)

(Source: JICA Study Team)

Photo 2.1.3 Station with Platform (Nsuta Station)

(Source: JICA Study Team)

Photo 2.1.4 Station without Platform (Reference: Tema Line)

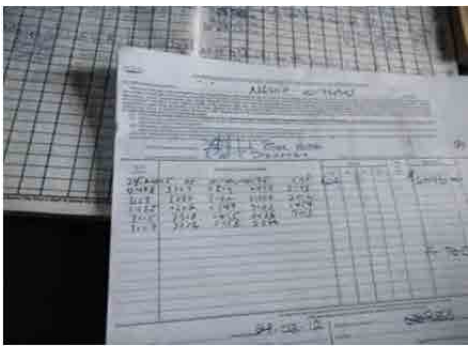
2.1.3 Train Operation

(1) Documents of Stations

The records of the blockades, composition of the train, goods, and condition of daily train operation are put on record at the stations.

(Source: JICA Study Team)

Photo 2.1.5 Blockade Records



(Source: JICA Study Team)

Photo 2.1.6 Goods Records

(2) Documents of Loading Sites

The invoice of manganese ore on the each wagons are delivered personally to the driver by manganese company's staff at loading site Nsuta.

(Source: JICA Study Team)

Photo 2.1.7 Invoice (1)

(Source: JICA Study Team)

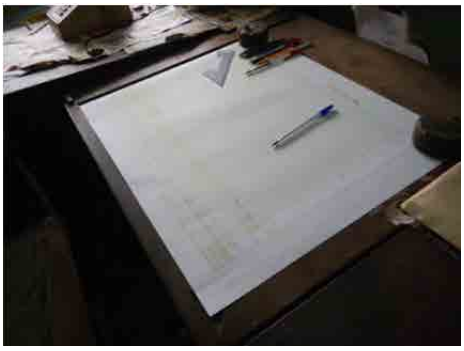
Photo 2.1.8 Invoice (2)

(3) Operation Control Center (OCC)

The daily train operation records are put on record as the actual train diagram. And also the operation records of the locomotive and the wagons are put on record too. The weekly report regarding the traffic volume and the accidents is submitted from traffic the manager to management every week.

(Source: JICA Study Team)

Photo 2.1.9 The Actual Diagram

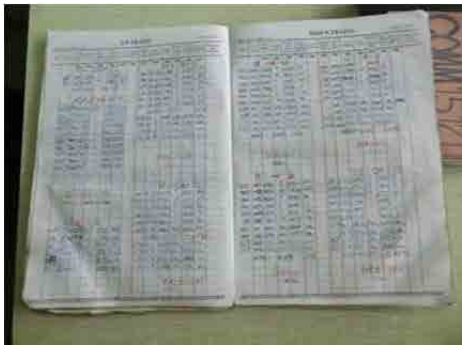


(Source: JICA Study Team)

Photo 2.1.10 The Past Actual Diagram

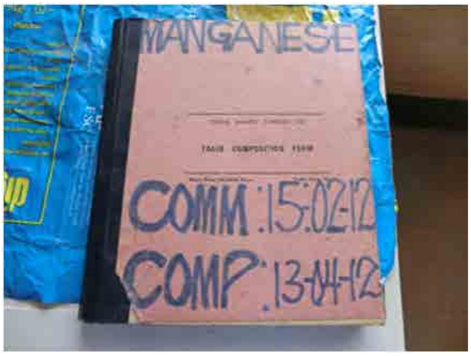
(Source: JICA Study Team)

Photo 2.1.11 Communication Records Each Station (1)



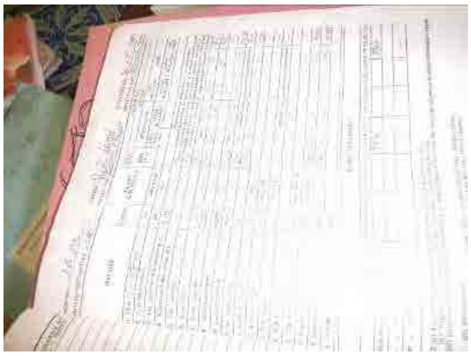
(Source: JICA Study Team)

Photo 2.1.12 Communication Records Each Station (2)



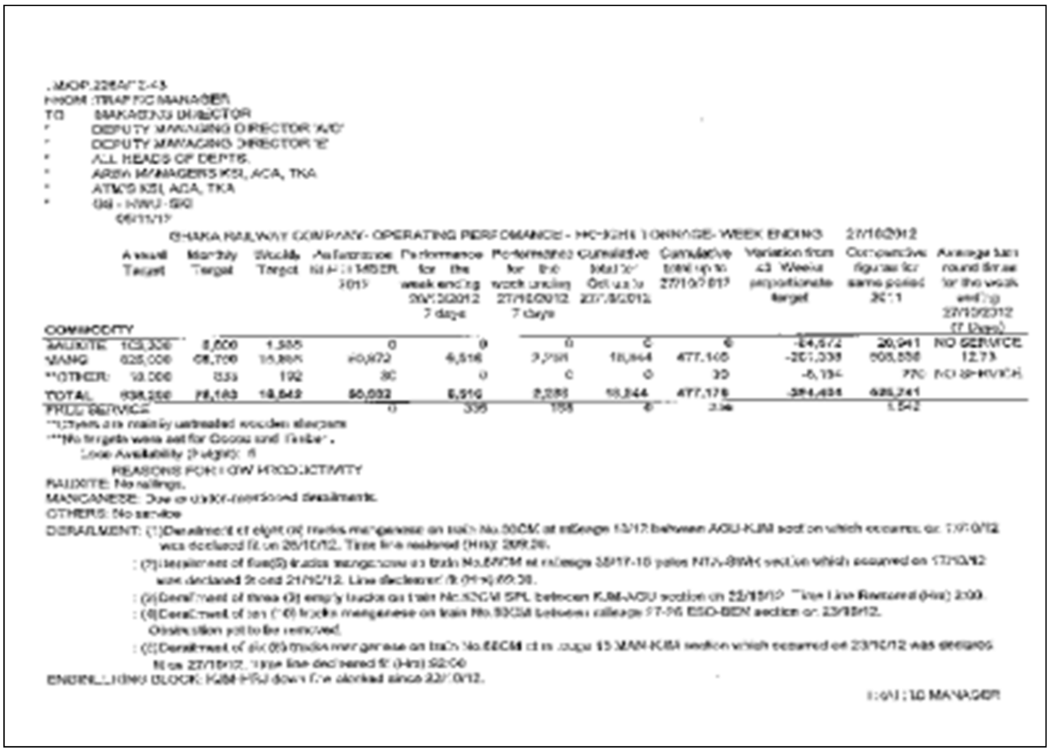
(Source: JICA Study Team)

Photo 2.1.13 Operation Records of the Rolling Stocks (1)



(Source: JICA Study Team)

Photo 2.1.14 Operation Records of the Rolling Stocks (2)



[illegible]
FROM :TRAFFIC MANAGER
TO MANAGING DIRECTOR
" DEPUTY MANAGING DIRECTOR 'A/O'
" DEPUTY MANAGING DIRECTOR 'E'
" ALL HEADS OF DEPTS.
" AREA MANAGERS KSI, ACA, TKA
" ATMS KSI, ACA, TKA
" [illegible]
[illegible]

GHANA RAILWAY COMPANY- OPERATING PERFORMANCE - [illegible] TONNAGE- WEEK ENDING 27/10/2012

COMMODITY	Annual Target	Monthly Target	Weekly Target	[illegible]	Performance for the week ending [illegible]/2012 7 days	Performance for the week ending 27/10/2012 7 days	Cumulative total for October [illegible]	Cumulative total up to 27/10/2012	Variation from 43 Weeks proportionate target	Comparative figures for same period 2011	Average turn round time for the week ending 27/10/2012 (7 Days)
BAUXITE	[illegible]	8,600	1,985	0	0	0	0	0	[illegible]	20,941	NO SERVICE
MANG	825,000	68,700	[illegible]	[illegible]	6,516	[illegible]	[illegible]	477,145	[illegible]	[illegible]	12.73
**OTHER	10,000	833	192	30	0	0	0	30	[illegible]	770	NO SERVICE
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	6,516	[illegible]	[illegible]	477,175	[illegible]	[illegible]	
FREE SERVICE				0	335	155	[illegible]	[illegible]		1,542	

[illegible] are mainly untreated wooden sleepers
***No targets were set for [illegible] and Timber.
Loco Availability [illegible]
REASONS FOR LOW PRODUCTIVITY
BAUXITE: No railings.
MANGANESE: Due to [illegible] derailments.
OTHERS: No service
DERAILMENT: (1)Derailment of eight (8) trucks manganese on train No.[illegible] at mileage [illegible] between [illegible] section which occurred on [illegible] was declared fit on 26/10/12. Time line restored (Hrs): [illegible]
(2) Derailment of five(5) trucks manganese on train No.[illegible] at mileage [illegible] section which occurred on [illegible] was declared fit on 21/10/12. Line declared fit (Hrs) [illegible]
(3) Derailment of three (3) empty trucks on train No.[illegible] SPL between KJM-AGU section on 22/10/12. Time Line Restored (Hrs) [illegible]
(4) Derailment of ten (10) trucks manganese on train No.[illegible] between mileage [illegible] section on 23/10/12. Obstruction yet to be removed.
(5) Derailment of six (6) trucks manganese on train No.[illegible] at mileage [illegible] section which occurred on 23/10/12 was declared fit on 27/10/12. Time line declared fit (Hrs) [illegible]
ENGINEERING BLOCK: [illegible] down line blocked since [illegible]
TRAFFIC MANAGER

(Source: JICA Study Team)

Photo 2.1.15 Weekly Report

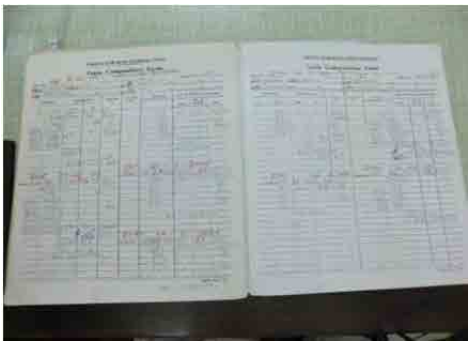
(4) Documents of the Driver's Office

Drivers report the information of their driving condition to inspectors after finishing their work.

And it was put on record. The accident general situation by oral information from the drivers was reported after finishing their work.

(Source: JICA Study Team)

Photo 2.1.16 Drivers Office

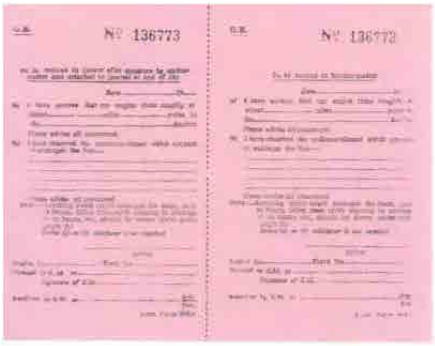


(Source: JICA Study Team)

Photo 2.1.17 Driving Records

(Source: JICA Study Team)

Photo 2.1.18 Documents of Driving Information (1)

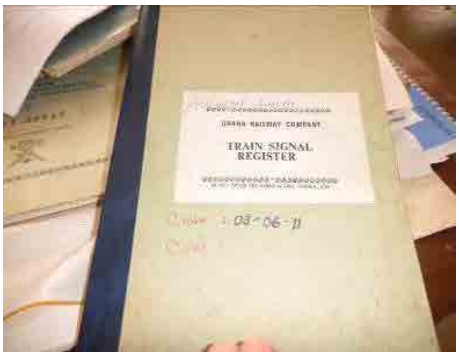


(Source: JICA Study Team)

Photo 2.1.19 Documents of Driving Information (2)

(5) The Accident Records

When accidents happen, the driver reports to the nearest stationmaster, and then the stationmaster reports the accident to the dispatcher at OCC. The information of the accident is recorded in the accident diary first. Then the records regarding when the line clears are recorded in the accident records and the accident report is submitted from the traffic manager to the Managing Director. The general accident reports and official records are submitted from each area manager to the traffic manager later. The general accident report includes too many items, but actually there are many blanks in these reports. It becomes a mere facade. All the documents of the accident are written down on the paper, so there are many problems regarding missing important records and degradation.

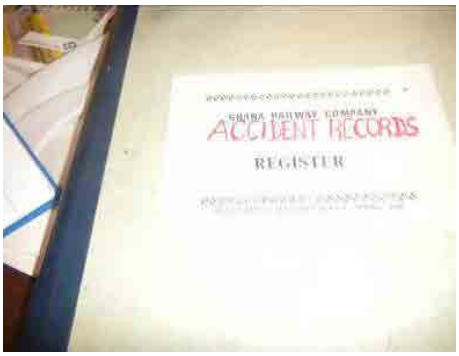


(Source: JICA Study Team)

Photo 2.1.20 Accident Diary (1)

(Source: JICA Study Team)

Photo 2.1.21 Accident Diary (2)

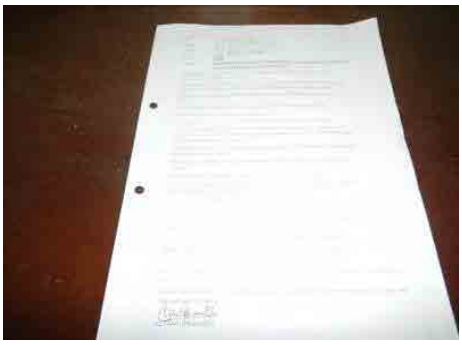


(Source: JICA Study Team)

Photo 2.1.22 Accident Records (1)

(Source: JICA Study Team)

Photo 2.1.23 Accident Records (2)

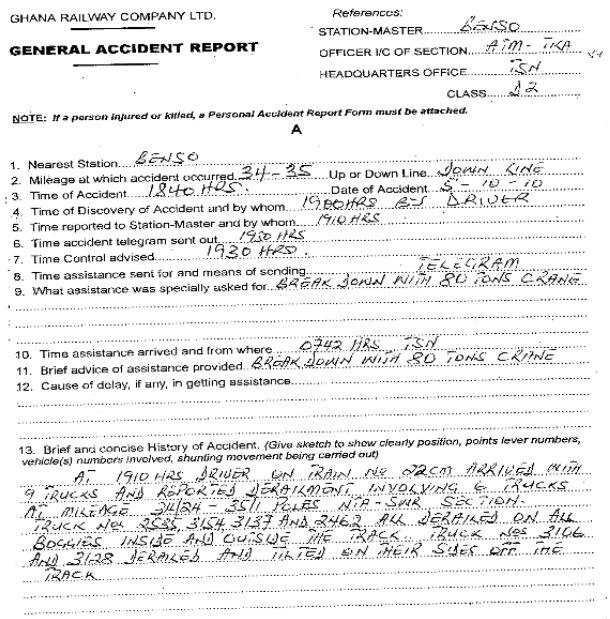


(Source: JICA Study Team)

Photo 2.1.24 Accident Report

(Source: JICA Study Team)

Photo 2.1.25 Accident Documents File



GHANA RAILWAY COMPANY LTD.

References:

STATION-MASTER BENSO

GENERAL ACCIDENT REPORT

OFFICER I/C OF SECTION AIM - TKA

HEADQUARTERS OFFICE TSN

CLASS A2

NOTE: *If a person injured or killed, a Personal Accident Report Form must be attached.*

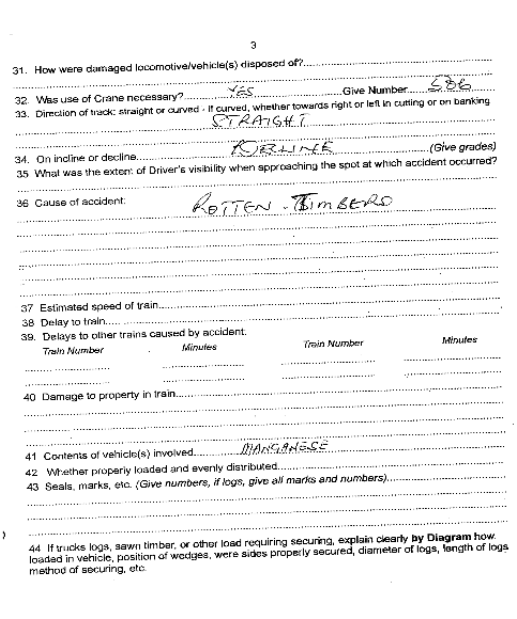
A

1. Nearest Station BENSO
2. Mileage at which accident occurred 24 - 25 Up or Down Line JOHN KING
3. Time of Accident 1840 HRS. Date of Accident 5 - 10 - 10
4. Time of Discovery of Accident and by whom 1900HRS BY DRIVER
5. Time reported to Station-Master and by whom 1910 HRS
6. Time accident telegram sent out 1930 HRS
7. Time Control advised 1920 HRS. TELEGRAM
8. Time assistance sent for and means of sending
9. What assistance was specially asked for BREAK DOWN WITH 80 TONS CRANE

10. Time assistance arrived and from where 0742 HRS. TSN
11. Brief advice of assistance provided BREAK DOWN WITH 80 TONS CRANE
12. Cause of delay, if any, in getting assistance

13. Brief and concise History of Accident. *(Give sketch to show clearly position, points lever numbers, vehicle(s) numbers involved, shunting movement being carried out)*

AT 1910 HRS DRIVER ON TRAIN NO 72CM ARRIVED WITH 9 TRUCKS AND REPORTED DERAILMENT INVOLVING 6 TRUCKS AT MILEAGE 24/24 - 25/1 POLES NTP - SMR SECTION. TRUCK NOS 2535, 3154, 3137 AND 2462 ALL DERAILED ON ALL BOGIES INSIDE AND OUTSIDE THE TRACK. TRUCK NOS 3106 AND 3128 DERAILED AND TILTED ON THEIR SIDES OFF THE TRACK



3

31. How were damaged locomotive/vehicle(s) disposed of?
32. Was use of Crane necessary? YES Give Number 526
33. Direction of track: straight or curved - if curved, whether towards right or left in cutting or on banking STRAIGHT
34. On incline or decline ROLLING (Give grades)
35 What was the extent of Driver's visibility when approaching the spot at which accident occurred?
36 Cause of accident: ROTTEN TIMBERS
37 Estimated speed of train
38 Delay to train
39. Delays to other trains caused by accident.

Train Number	Minutes	Train Number	Minutes

40 Damage to property in train
41 Contents of vehicle(s) involved MANGANESE
42 Whether properly loaded and evenly distributed
43 Seals, marks, etc. (*Give numbers, if logs, give all marks and numbers*)
44 If trucks logs, sawn timber, or other load requiring securing, explain clearly by **Diagram** how loaded in vehicle, position of wedges, were sides properly secured, diameter of logs, length of logs method of securing, etc.

(Source: JICA Study Team)

Photo 2.1.26 General Accident Report (1)

(Source: JICA Study Team)

Photo 2.1.27 General Accident Report (2)

2.1.4 Rolling Stock

(1) Locomotives

Total number of diesel locomotive is 39. Among them, 3 locomotives are deployed at Accra for the Eastern Line. Other locomotives are deployed at Takoradi for the Western Line. At present, 6 types of diesel locomotives 4 types for the main line and 2 types for shunting are operating.

1) 2601 Class

Nine (9) locomotives were supplied by Alstom of France in 1993. Since the axle load of this locomotive is 16t and heavier than the other locomotives, these locos are not operating now because of the bad track condition. This type of loco is equipped with both the vacuum brake system and an air brake system.

2) 1670 Class

Fourteen (14) locomotives were supplied by General Electric of USA in 1996. This type of loco is also equipped with a vacuum brake system and air brake system. The locos equipped with the air brakes are 2601 class and 1670 class, but since the 2601 class has stopped operating, the 1670 class is the only type which can haul air brake wagons.

3) 1661 Class

Three (3) locomotives were supplied by Henschel of Germany in 1995. These locos are similar to 1651 Class for the most part.

4) 1651 Class

Ten (10) locomotives were supplied by Henschel in 1978 and 1979.

5) 721 Class

Four (4) locomotives were supplied by Daewoo of South Korea. This loco is equipped with a generator supplied by Toshiba. Only one loco is left now but this loco is not available because of engine problems.

6) 541 Class

These locomotives were supplied by Henschel in 1975 and 1976. Two locos are left now.

General specification of each locomotive is shown in the Table 2.1.3.

Table 2.1.3 General Specification of GRCL Locomotives

Class	Manufacturer	Year	HP	Weight (t)	Axle Load (t)	Length (m)	Brakes	Quantity	No. available
2601	Alstom	1993	2516	96	16	18.7	Air/Vacuum	9	0
1670	GE	1996	1500	87	14.5	15.1	Air/Vacuum	14	4
1661	Henschel	1995	1650	85.8	14.3	18	Vacuum	3	2
1651	Henschel	1978-79	1650	85.3	14.2	17.6	Vacuum	10	2
721	Daewoo	1983	740	56	14	12.3	Vacuum	1	0
541	Henschel	1975-76	660	42.6	14.2	8.6	Vacuum	2	1
Total								39	9

(Source: GRCL, JICA Study Team)

Present condition of each locomotive is shown in the Table 2.1.4.

Table 2.1.4 Present Condition of the Locomotives

Class	Number	Photo	Location	Condition	Remarks
2601	2601		Workshop - Location	Defective	Defective traction motors to be changed with reconditioned ones
2601	2602		Running shed - Takoradi	Defective	
2601	2603		Running shed - Takoradi	Defective	
2601	2604		Running shed - Takoradi	Defective	
2601	2605		Running shed - Takoradi	Defective	
2601	2606		Workshop - Location	Defective	
2601	2607		Running shed - Takoradi	Defective	Accident Loco
2601	2608		Workshop - Location	Defective	Accident Loco
2601	2609		Workshop - Location	Defective	Scrapped tires, need to recondition bogies
1670	1670	N/A	Fell in a valley by accident	Defective	Accident Loco
1670	1671		Workshop - Location	Defective	Accident Loco
1670	1672		Running shed - Takoradi	<u>In service</u>	On Manganese Train
1670	1673	N/A	Accra shed	<u>In service</u>	On Accra – Nsawam passenger train
1670	1674		Workshop - Location	Defective	Collided with truck at Benso crossing

Class	Number	Photo	Location	Condition	Remarks
1670	1675	N/A	Accra shed	Defective	Defective bogies & defective engine
1670	1676		Running shed - Takoradi	Defective	Defective clutch mechanism
1670	1677		Running shed - Takoradi	In service	On Manganese Train
1670	1678		Running shed - Takoradi	In service	On Manganese Train
1670	1679	N/A	Accra shed	Defective	Defective bogies i.e. Grounded traction motors
1670	1680		Workshop - Location	Defective	Low engine output
1670	1681		Workshop - Location	Defective	Worn-out liners
1670	1682		Running shed - Takoradi	Defective	Accident Loco
1670	1683		Running shed - Takoradi	Defective	Defective clutch mechanism
1661	1661		Workshop - Location	Under repair	Under bogie repairs
1661	1662		Running shed - Takoradi	In service	On Manganese Train
1661	1663		Running shed - Takoradi	In service	On Manganese Train
1651	1651		Workshop - Location	In service	On Manganese Train
1651	1652		Workshop - Location	Defective	Awaiting batteries, bogies, shock absorbers, axle bearings, etc.
1651	1653		Running shed - Takoradi	In service	On Manganese Train

Class	Number	Photo	Location	Condition	Remarks
1651	1654		Workshop - Location	Defective	Need over hauling, tires, brass bearings, batteries
1651	1655		Workshop - Location	Defective	Awaiting bogies, tires, brass bearings, shock absorbers
1651	1656		Workshop - Location	Defective	Skelton structure beyond repair
1651	1657		Workshop - Location	Defective	Accident Loco
1651	1658		Workshop - Location	Defective	Need over hauling, bogies complete, etc.
1651	1659		Running shed - Takoradi	Defective	Defective main generator
1651	1660		Workshop - Location	Defective	Need complete bogies
721	724		Workshop - Location	Defective	Need engine spare parts
541	552		Workshop - Location	In service	On shunting works
541	544		Workshop - Location	Defective	Need engine spare parts

(Source: GRCL, Study team)

As the Table 2.1.4 shows, only one loco for the Eastern line and 8 locos for the Western line (one of those loco is for shunting) are available now.

(2) Passenger Cars

27 passenger cars out of 151 cars are available and those are used for passenger trains on the Eastern line. 4 cars for workers' trains and one standby car in Takoradi are also available. Other passenger cars are neglected in the stations or in the workshop, and the corrosion of the car bodies is significantly proceeding as shown in the Photo 2.1.25.

(Source: JICA Study Team)

Photo 2.1.28 Passenger Cars Left Neglected at Takoradi Station

Present condition of passenger cars is shown in the Table 2.1.5.

Table 2.1.5 Present Condition of the Passenger Cars

Category	Quantity	No. available
Sleeping Car I	23	9
Sleeping Car II	21	4
Sitting I	10	2
Sitting II	59	8
Brake & Luggage	28	3
Buffet Car	4	0
Tourist Car	5	1
Total	151	27

(Source: GRCL)

(3) Diesel Multiple Unit (DMU)

2 DMU train sets which have 6 cars each were supplied from China in 2008 and the DMUs started operation in 2010 for passenger trains of 3 round trips per day on the Accra – Tema line. One of the two train sets was under repairs for engine trouble when we visited in Oct. 2012.

(Source: JICA Study Team)

Photo 2.1.29 DMU Supplied by China

(4) Freight Wagons

155 freight wagons out of 416 wagons are available. In addition, some parts of 70 new mineral wagons from India have arrived and are in service. Manganese trains between Takoradi and Nsuta are the only freight trains operating now. Therefore, the wagons for bauxite are also used for manganese trains.

1) Bauxite

90 bauxite wagons were supplied from South Africa in 2000. Their loading capacity is 43t. These wagons are now used for manganese trains because the bauxite trains have been suspended.

2) Manganese

There are 130 traditional manganese wagons whose loading capacity is 38t each.

3) Steel Vans

100 Steel Vans for cocoa, cement and etc. were purchased in 1995 with Japanese aid. These vans were supplied from South Africa and equipped with self-steering bogies. These vans are not in operation now because the cocoa and cement transportation by train has been suspended.

4) Bolsters

There are 40 bolster wagons for the haulage of round logs but these wagons are also not operated now because of the suspension of the trains for logs.

5) Ballast Hopper

There are 15 ballast hopper wagons in this system.

Present condition of freight wagons is shown in the Table 2.1.6.

Table 2.1.6 Present Condition of the Freight Wagons

Category	Quantity	No. of available
Bauxite	90	52
Manganese	130	44
Bolster	40	13
Steel Van	100	40
Flat Wagon	2	0
Well Wagon	3	0
Water Tank	2	0
Tank Wagon	30	0
Hopper Wagon	15	6
Brake & Caboose	4	0
Total	416	155

(Source: GRCL)

As already mentioned, 70 new mineral wagons from India have been introduced. 14 of those wagons had arrived by Oct. 2012 when we visited for the survey and the operation. Traditional freight wagons are equipped with vacuum brakes but these new wagons have air brake systems. Therefore, only the 1670 class locos can haul these new wagons.

(Source: JICA Study Team)

Photo 2.1.30 New Mineral Wagons from India

(5) Maintenance Facilities

According to the list we received, about 40% of all maintenance facilities are not working now. Especially facilities for advanced purposes like impregnating insulation apparatus for traction motors obtained with the aid from foreign countries have been abandoned and deteriorated. But indispensable facilities such as cranes, wheel lathe, and wheel press are also decrepit but maintained for use. In addition, indispensable consumables such as grease, oil, and gases (acetylene and oxygen) for welding are depleted by the lack of budget. Therefore maintenance work itself is difficult to carry out now.

(6) Accidents Caused by Rolling Stock Failures

Among the 240 accidents which occurred from 2000 to May, 2012, causes for 35 derailments, about 15 % of the total, were indicated as “Jerking”. Jerking derailment is a phenomenon caused when the brake of each car acts unequally. Leakage of air from pneumatic piping, lack of the brake shoe and uncertain connection of the brake hose are considered as the cause of the brake defect. In order to prevent such accidents, it is important to ensure the brake test is completed at the time of daily inspection and train composition.

(7) Failures of Locomotives

Table 2.1.7 shows the locomotive failures from April to June in 2012. Main causes of failure are defective reversers and grounding faults of the generator or traction motor.

Table 2.1.7 Locomotive Failures (from April to June in 2012)

LOCO FAILURES FOR THE MONTH OF APRIL, 2012

NO.	DATE	LOCO NO.	TRAIN NO.	STATION/SECTION	CAUSE OF FAILURE
1.	27/4/12	1653	92 CM	NTA	DEFECTIVE TRACTION MOTOR CAUSED WHEEL SLIP
2.	28/4/12	1663	98 CM	NTA	FUEL SHORTAGE
					1651 CLASS :1 1663 CLASS: 1
					TOTAL = 2

LOCO FAILURES FOR THE MONTH OF MAY, 2012

NO.	DATE	LOCO NO.	TRAIN NO.	STATION/SECTION	CAUSE OF FAILURE
1.	7/5/12	1659	42 CM	MAN	DEFECTIVE REVERSER
2.	8/5/12	1662	47 CM	AGU-KJM	FIRE DETECTED UNDER BOGIE
3.	10/5/12	1659	52 CM	NTA	DEFECTIVE REVERSER
4	10/5/12	1662	54 CM	NTA	DEFECTIVE REVERSER
5	11/5/12	1659	60 CM	NTA	GROUNDER GNERATOR
6	11/5/12	1653	71 CM	MAN	DEFECTIVE REVERSER
7	16/5/12	1659	101 CM	KJM	GROUNDER GENERATOR
8	17/5/12	1662	TIPPING	HBR	DEFECTIVE REVERSER
9	19/5/12	1659	123 CM	KJM	GROUNDER GENERATOR
10	20/5/12	1661	133 CM	NTA	GROUNDER TRACTION MOTOR 1 & 6
11	24/5/12	1661	161 CM	AGU	FUEL SHORTAGE
					1661 CLASS – 5 1651 CLASS – 6 TOTAL = 11

LOCO FAILURES FOR THE MONTH OF JUNE, 2012

NO.	DATE	LOCO NO.	TRAIN NO.	STATION/SECTION	CAUSE OF FAILURE
1.	8/6/12	1653	B/D. SPL	BEN	DEFECTIVE REVERSER
2.	18/6/12	1653	73 CM	KJM	DEFECTIVE REVERSER
3.	20/6/12	1651	87 CM	HBJ-KJM	FIRE DETECTED AT ELECTRICAL COMPARTMENT
4	26/6/12	1651	138 CM	ESO-BEN	FIRE DETECTED AT ELECTRICAL COMPARTMENT
					TOTAL OF FAILURES = (4) FOUR – CLASS OF LOCO 1651

(Source: GRCL)

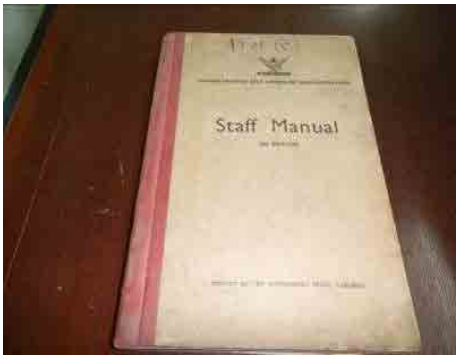
2.2 Grasping the Existing Operation/Maintenance Regulations, Methods and Organization Structure

2.2.1 Train Operation and Operation Regulations

(1) Rules and Regulations for Train Operation

Current train operations are subject to rules and regulations as published in the following manuals. Rule Book, Traffic Manual, Staff manual and Working Time table. Those are all outdated and not suitable with current conditions including the facilities and equipment. And the management of documents is sloppy, like the years of publication are different or loosing pages.

(a) Rules and Regulations (1)



(b) Rules and Regulations (2)

(c) Manual with Missing Pages

(d) Old Edition Manual

(Source: JICA Study Team)

Photo 2.2.1 Rules and Regulations for Train Operation

(2) Current Condition of the Train Operation

1) Number of Trains on the Western Line

As described in the Chapter 1, 2 pairs of passenger trains run between Takoradi and Kojokrom in the morning and evening, and 4 or 5 pairs of manganese trains run between Nsuta and Takoradi per day in the Western Line. Bauxite trains from Awaso have been suspending since May 2012 because of series of accidents.

Appendix-1 shows the result of a site survey of train operation condition.

2) Maximum Running Speed

Maximum Running Speed on the Western Line is shown in the following:

Table 2.2.1 Maximum Running Speed

Train Type	Maximum Running Speed (Km/h)
Passenger Trains	56
Freight Trains	40

(Source: GRCL)

3) Hauling Capacity

Table 2.2.2 Train Operation Specification

Freight Commodity	Wagon Type	Wagon Tare Weight (Tonnes)	Wagon Capacity (t)	Length of Wagon (mm)	No. of Wagons per Train	Hauling Capacity (t)	Minimum Train Length (mm)
Cocoa	Covered Van	18	30	13,396	25	750	334,900
Timber	Bolster	14	15.25	11,694	25	381.25	292,350
Bauxite	High Capacity Truck	17	43	12,162	25	1075	304,050
Manganese	Mineral Truck	14	26	11,741	30	780	352,230
Other	Covered Van	18	36	13,396	25	900	334,900

(Source: GRCL)

(3) Speed Restriction on Curves, Grades, Turnouts etc.

In the section of sharp curves or reverse curves, speed restrictions are installed. The following table show speed restriction on curves.

Table 2.2.3 Speed Restriction on Curves

No	Section	Mileage (mile)	Length (m)	Speed (km/h)	Alignment	Radius (m)
1	Angu - Kojokrom (down line)	5/1 -4/13	900	24	Reverse curve	565.8
2	Tarkwak - Nsuta	37 1/2 – 38 1/4	800	24	Sharp curve	196.08
3	Kuranti - Insu	59/24 – 60/8	612	40	Reverse curve	482.72
4	Gyimakrom - Opon Valley	67/6 – 67/20	793	40	Reverse curve	297.88

(Source: Western Line Development Study, DE-CONSUL)

(4) The Train Operation Plan

The passenger trains are regular trains and determine operation time. But freight trains are unscheduled trains, so freight trains are scheduled depending on the demands, operation condition of the harbour and operation condition of the rolling stocks every day at the Train Control Center (OCC). Mainly the departure time of the UP manganese train is determined by the operation condition at the harbour. Maximum manganese train operation per day is six under current conditions of the facilities. The master plan diagram is prepared that supports 6 round trips.

(5) Rules and Regulations for Planning Train Operation

Current train operation on the western line is subject to the Working Time Table No.12 published in 1997. And it has never been revised. There are no manuals describing the running speed or the method for calculation of running time.

GHANA RAILWAY CORPORATION

(Source: GRCL)

Figure 2.2.1 Working Time Table No.12

(6) Compared Actual Train Operation to the Operation Plan

The normal travelling times from one station to the next station are described in the Working Time Table No.12 published in1997. The master train diagram is planned by these travelling times. The actual train diagrams are compared with the master train diagram for understanding actual train operation.

Table 2.2.4 Comparison of the Travelling Times

Station		Distance	Normal Running Time(min) Direction		Actual Running Time(min) 2012.10.1 ～10.2 UP			DOWN	Actual Running Time (min) 2012.10.2～10.3 UP		DOWN	
From	To		UP	DOWN	1CM	3CM	5CM	10CM	21CM	23CM	24CM	26CM
Takoradi	Butuah	2.4	13	12								
Marshalling Yard	Harbour Jun				3	3	9	6	6	6	6	12
Harbour Jun	Butuah				21	18	24	12	18	18	21	18
Butuah	Kojokrom	7.7	17	22	12	9	12	6	9	12	9	9
Kojokrom	Angu	11.6	22	30	27	30	30	27	36	39	36	39
Angu	Manso	8.9	19	24	36	27	27	21	39	33	30	18
Manso	Amanti	3.2	10	13	21	15	15	24	21	18	24	21
Amanti	Benso	7.3	18	21	18	12	12	18	15	12	18	12
Benso	Esuaso	7.2	18	22	30	21	33	21	24	51	18	24
Esuaso	Bonsawire	5.6	14	17	24	18	24	24	27	18	24	21
Bonsawire	Nusta	6.9	17	21	15	15	21	18	21	15	21	12
		60.8	***148***	***182***	***207***	***168***	***207***	***177***	***216***	***222***	***207***	***186***

The UP trains that are empty are delayed remarkably. On the other hand, the DOWN trains that are loaded with manganese ore arrive early. Those delays are mainly caused by stopping because of illegal passengers, or sometimes caused by wheel slips. It is easy to guess the over-speed driving by the DOWN train's driver who wants to recover time lost by the UP train's driver.

(7) Current Condition of the Safety Devices

The safety devices such as the Signal blocking system on the western line are all out of order.

Train operations are controlled by the stationmasters. They secure the blocking section using

mobile phones to the next station's stationmasters and give the tickets that are the line clear certificate and the caution order. The mile posts, the indicator of the speed restrictions and cancellations and the alarm whistle indicator are provided on the current western line.

The level crossings are two types, manned and unmanned. There is no way to know of an approaching train, the level crossing staff notice the approaching trains by alarm whistle and prevent entrance of the cars.

(8) The Rules and Regulations regarding Driver's Credentials

There are no rules or regulations that stipulate the necessary credentials of the driver. To become a driver the assistant drivers should be required to gain experience through basic training, but when they are promoted to main line drivers, they don't need to pass any special examination. It was determined that promotion to driver depends on the demands of the man power planning of the main line drivers.

(9) Comparison with Japanese Train Operation Management

Japanese railway business operators should be given approval and a license by the Ministry of Land, Infrastructure, Transport and Tourism for their Business. And their business operations are controlled strictly by the laws, rules and regulations of the governments. But the structures and the systems of GRDA that have the same function in GHANA are inadequate, and the supervision of the governments is ill-researched. So GRCL's business operations continue under their old bylaws the same as the Ghana national railway. The resignation by deficit is spreading and their operations are lacking strict policies regarding safety.

2.2.2 Criteria for Building and Maintaining Railway Structures

(1) Civil Structures and Track

1) Criteria for Building and Maintaining Railway Structures

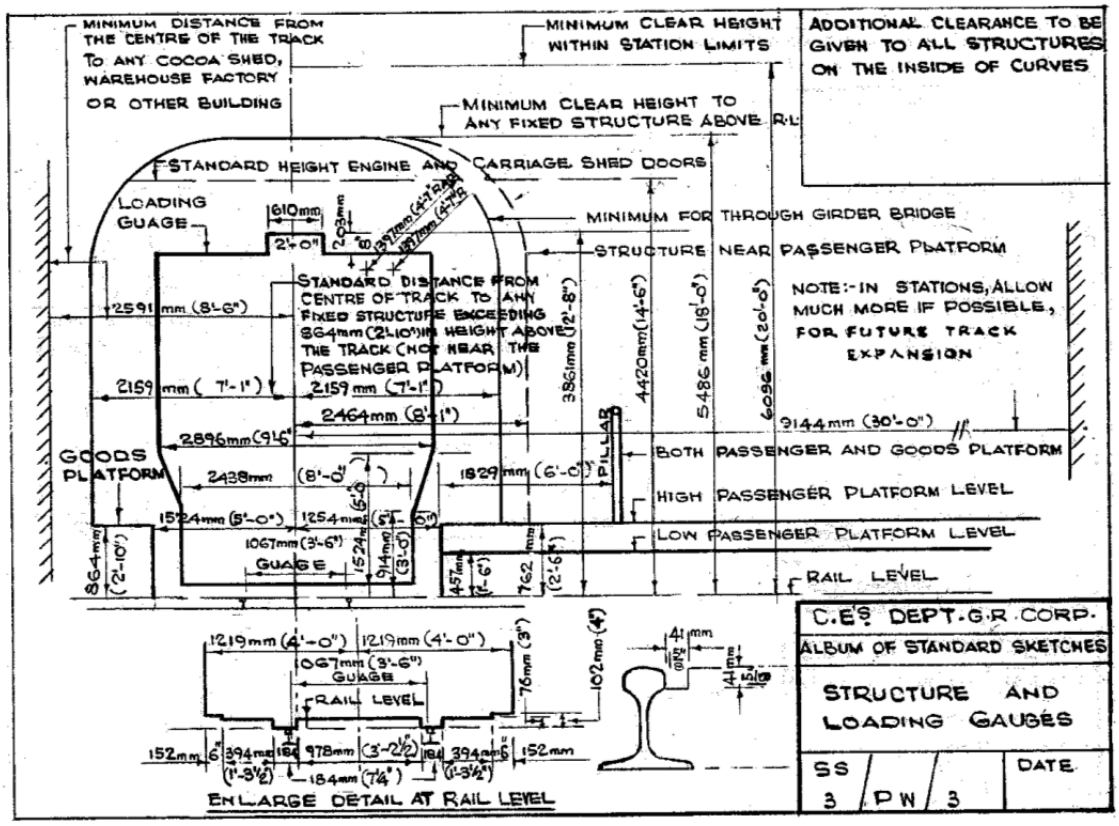
The criteria for building and maintaining railway structures, such as the structure gauge, loading gauge, minimum radius, steepest gradient, and maximum axle load, are stipulated in an Engineering Manual revised in 1956.

The minimum curve radius is 660 feet (201m), the maximum gradient is 1.25%, and the axle load is 16 tons. These data are for the existing lines. The minimum curve radius is set at 955 feet (291m) and the maximum gradient is set at 1.00% for construction of the new line.

For the structure and loading gauges, see Figure 2.2.2 and for standard dimensions for formation, see Figure 2.2.3. For major alignment data, refer to Table 2.2.5.

Actually, however, some sections have curves with a radius smaller than the specified minimum and gradients greater than the specified maximum. These are shown in Table 2.2.6 and Table

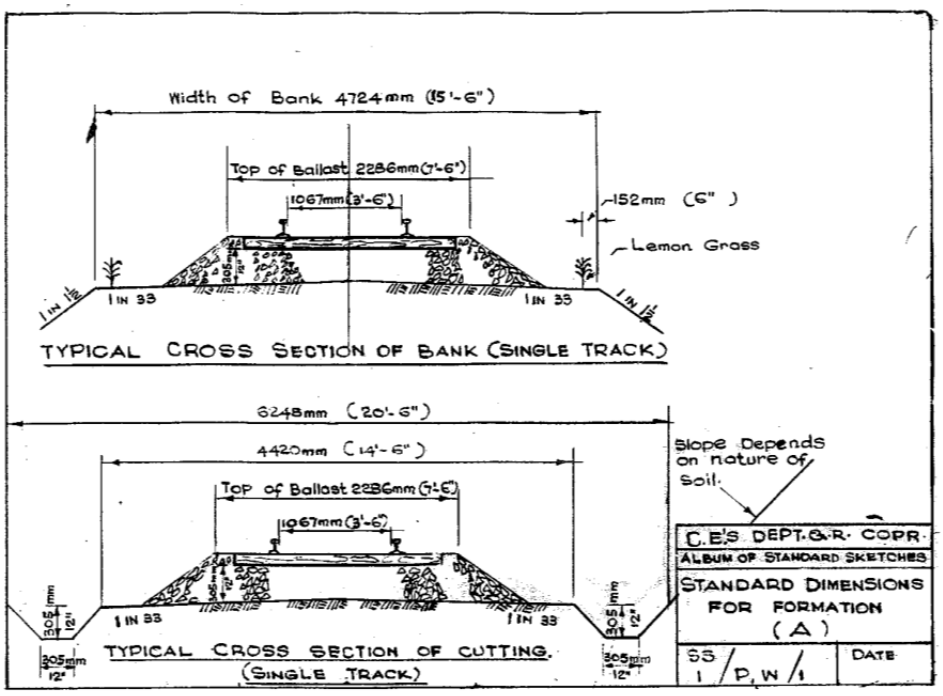
2.2.7 respectively. Although the standard values at the time of construction of these sections are not known, it is probable that construction with alignments stipulated in the present criteria was difficult.



(Source: GRCL)

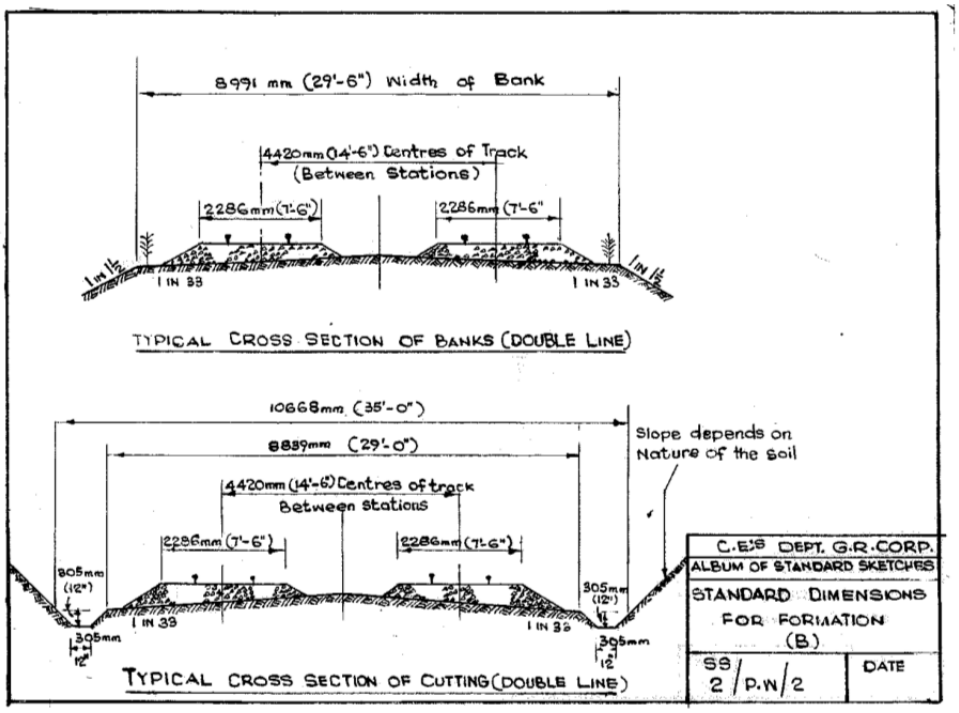
Figure 2.2.2 Structure and Loading Gauges

(a) Standard Dimensions for Formation (single track)



(Source: GRCL)

(b) Standard Dimensions for Formation (double track)



(Source: GRCL)

Figure 2.2.3 Standard Dimensions for Formation

Table 2.2.5 Major Alignment Data

Item		Specification
Permissible Line Speeds		Western Line: Takoradi – Sekondi - Kumasi Passenger 35 mph (56km/h) Mineral Trains 25 mph (40km/h) General cargo trains 15 mph (24km/h) Awaso Branch Line: Dunkwa - Awaso Passenger 25 mph (40km/h) Mineral Trains 25 mph (40km/h) General cargo trains 15 mph (24km/h)
Axle load		Western Line: Takoradi - Sekondi - Kumasi 16t Awaso Branch Line: Dunkwa - Awaso 16t
Gauge		1,067mm (Narrow gauge) On the curve Up to and including 6° (955') 3'6" (1067mm) Between 6° (955') and 8° 40'(660') 3'6 1/4" (1073mm) From 8° 40' (660') to 12° (478') inclusive 3'6 1/2" (1080mm) Over 12° (478') 3'6 3/4" (1086mm)
Structure and Loading gauge		(Refer to Figure 2.2.2)(Source: GRCL)
Track	Rail	BS80A and BS80R (36kg/m), 40' (12.2m)
	Sleepers	Timber sleeper and Steel sleeper
	Fastening	Shank－spike or dog spike for wooden sleepers and Pandrol fastening for steel sleepers
	Ballast profile	Min. thickness under sleeper on the vertical of the rail:12' (305mm)
Vertical alignment	Ruling Gradient	Main Line Takoradi to Kumasi 1.25% Kumasi to Takoradi 1.00% Dunkwa to Awaso 1.25% Awaso to Dunkwa 1.00% In the Station 0.33%
	The rate of changes in vertical curves per 100'	On summits: not more than 0.3% In sags: not more than 0.2%

(Source: GRCL Engineering Manual)

Table 2.2.5 Major Alignment Data (cont.)

<table>
<tr><th colspan="2">Item</th><th>Specification</th></tr>
<tr><td rowspan="3">Horizontal curves</td><td>Curvature (R)</td><td>1. Existing curvature
Takoradi – Sekondi - Kumasi 8°40’ (660’/201.2m)
Dunkwa – Awaso 6° (955’/291.1m)
In the station 12° (478’/145.7m)
2. In the future
Main line, first loop and important siding
6° (955’/291.1m)</td></tr>
<tr><td>Transition Curve</td><td>At the rate of 2’ of curvature per foot</td></tr>
<tr><td>Super elevation</td><td><table>
<tr><th>Curvature</th><th>25m.p.h. (40km/h)</th><th>35.m.p.h (56km/h)</th></tr>
<tr><td>1° (1746m)</td><td>1/2” (13mm)</td><td>1/2“ (13mm)</td></tr>
<tr><td>2° (873m)</td><td>1” (25mm)</td><td>1” (25mm)</td></tr>
<tr><td>3° (582m)</td><td>1” (25mm)</td><td>1” (25mm)</td></tr>
<tr><td>4° (437m)</td><td>1” (25mm)</td><td>1 1/2“ (38mm)</td></tr>
<tr><td>5° (349m)</td><td>1 1/2“ (38mm)</td><td>1” (25mm)</td></tr>
<tr><td>6° (291m)</td><td>2” (51mm)</td><td>2” 1/2” (64mm)</td></tr>
<tr><td>7° (249m)</td><td>2” (51mm)</td><td>3” (76mm)</td></tr>
<tr><td>8° (218m)</td><td>2 1/2“ (64mm)</td><td>3 1/2” (89mm)</td></tr>
<tr><td>8°40”(208m)</td><td>2 1/2“ (64mm)</td><td>3 1/2” (89mm)</td></tr>
<tr><td>9° (194m)</td><td>2 1/2“ (64mm)</td><td>3 1/2” (89mm)</td></tr>
<tr><td>10° (175m)</td><td>3” (76mm)</td><td></td></tr>
<tr><td>11° (159m)</td><td>3” (76mm)</td><td></td></tr>
<tr><td>12° and over (146m and below)</td><td>3 1/2” (89mm)</td><td></td></tr>
</table>Decrease on the transition at rate of 1/2” per rail length</td></tr>
<tr><td rowspan="2">Formation</td><td>Width (at sub-ballast top level)</td><td>Embankment single track: 15’ (4.57m))
double track: 29’6” (8.99m)
Cutting single track:14’6” (4.42m)
double track: 29’ (8.84m)
(Refer to Figure 2.2.3)</td></tr>
<tr><td>Slopes</td><td>Embankment: 1 : 1 1/2
Cutting: (depends on nature of the soil)</td></tr>
</table>

(Source: GRCL Engineering Manual)

Table 2.2.5 Major Alignment Data (cont.)

Item		Specification
Others	Min. Distance between Track Centers	In sections: 14'6" (4.420m) Within station: 16' (4.877m)
	Length of crossing tracks	Running loops: 1500'(457.2m) (between clearance limits) Other loops: 800'(243.8m)
	Turnout	1:8 1/2 and 1:12

(Source: GRCL Engineering Manual)

Table 2.2.6 Locations where Curve Radius is Smaller than the Minimum (201m)

Location (km)	Curve length (m)	Curve radius (m)	Remarks
70.054 - 70.245	191	195	
70.755 - 70.900	145	195	
100.985 - 101.133	148	195	
101.315 - 101.399	84	195	
101.911 - 102.018	148	195	
102.975 - 103.085	81	190-	
117.522 - 117.667	145	190	
117.898 - 117.945	47	190	
119.151 - 119.176	25	190	
120.138 - 120.191	53	190	
122.312 - 122.400	88	185	Minimum curve radius
124.505 - 124.625	120	195	
137.389 - 137.426	39	190	
146.967 - 146.152	185	195	
157.775 - 157.852	77	190	

(Source : DE Consul)

Table 2.2.7 Locations where the Gradient is Greater than the Maximum (1.25%)

Location (km)	Length (m)	Gradient (%)	Remarks
47.630 - 47.751	121	1.269	
49.849 - 49.904	55	1.402	
52.500 - 52.602	103	1.307	
70.472 - 70.562	90	2.172	
80.032 - 80.146	115	-1.465	Down grade toward the terminal (Kumasi)
94.592 - 94.773	182	1.343	
114.404 - 114.603	201	1.373	
119.950 - 120.163	91	3.155	Steepest gradient
153.517 - 153.753	237	1.369	

(Source: DE Consul)

2) Management Criteria (Grade and Period of Inspection etc.)

The Engineering Manual states that inspectors must get on a railcar or trolley and carry out investigations of the sections they are responsible for at least once a week. However, the Manual does not prescribe the content of the investigations or the intervals between investigations of track materials and irregularities.

The budget for track maintenance is insufficient, and investigation equipment is mostly damaged or defective and left unattended. Accordingly, track maintenance mainly consists of visual checks by an inspector, and repairs, if deemed necessary by the inspector, are requested in writing to the higher level of the organization. As there are no maintenance criteria, the judgment criteria differ among individual inspectors. This leads to failure in achieving uniform track management.

3) Management Criteria (Tolerance Limit of Maintenance etc.)

The Engineering Manual does not specify criteria for determining deficiencies of track materials (sleepers, fasteners) nor limits on track irregularities for maintenance. Therefore, the degree of irregularity necessitating replacement of materials or track repair work is not definite.

Established criteria are needed for making judgment on track materials and limits on track irregularity that would indicate the need for maintenance and repair work. Determining what kind of maintenance is needed will become easier once inspectors can grasp present conditions according to these criteria. They will be able to study conditions based on deviations from these criteria.

4) Operation and Maintenance Manuals for Track and Civil Structure Maintenance Equipment

It seems that there were operation and maintenance manuals for track and civil structure maintenance equipment at the time of purchase. But, most of those have been lost at present because of insufficient management.

5) Check List after Inspection and Maintenance Work

The Engineering Manual does not contain a check list for after investigation and maintenance of tracks and structures. Check lists play an important role in confirming that maintenance work has been properly executed. The safety of train operations is threatened when any portion of required maintenance is not performed and when defects are left uncorrected. It is essential to establish a check system for after maintenance work. This includes preparation of check lists.

6) Management Criteria for Equipment for Civil Structures and Track Maintenance

The machinery used for track maintenance, such as measuring instruments, high-speed rail cutters, and tie tampers, are often left in defective condition because replacement parts are unavailable due to the tight maintenance budget. Presently, track maintenance is done manually with simple tools (Photos 2.2.2, 2.2.3 and 2.2.4). There are no established control criteria for these machines.

(Source: JICA Study Team)

Photo 2.2.2 Track Investigation Tools Left in a Defective Condition

(Source: JICA Study Team)

Photo 2.2.3 Track Maintenance Equipment Left in a Defective Condition (in Wagon at Dunkwa Station Yard)

(Source: JICA Study Team)

Photo 2.2.4 Tools Used for Track Repair

(2) Rolling Stock

1) Regulations for Manufacturing and Maintenance of Rolling Stock

Loading gauge of the rolling stock is regulated by the Engineering Manual, but the existence of any other written regulation of rolling stock could not be confirmed through our survey.

2) Management Criteria for Rolling Stock Maintenance System

There are 7 types of scheduled maintenance for locomotives, namely daily, weekly, monthly, 3 monthly, 6 monthly, 9 monthly, and 12 monthly. Most of these maintenance operations are carried out at the Running Shed, but 12 monthly maintenance and special or accident repairs are done at the Location workshop. Currently due to non-availability of the required crane facility at the Running Shed both the 6 monthly and 12 monthly maintenance operations are done between the Running Shed and the Location Workshop.

For passenger cars and freight wagons, routine inspection and minor repairs are carried out at the Carriage & Wagon Depot and general inspection is carried out at the Location Workshop every two years.

It is considered that the maintenance system mentioned above is based on the regulations of GRCL and maintenance manuals from the manufacturer, but the written regulations of GRCL could not be confirmed through our survey.

3) Maintenance Criteria for Rolling Stock (Tolerance Limit of Maintenance etc.)

Maintenance Criteria for Rolling Stock is regulated by maintenance manuals from the manufacturer.

4) Operation and Maintenance Manuals for Rolling Stock and Maintenance Facilities

Operation and maintenance manuals for each rolling stock and maintenance facility are stored and used properly.

5) Check lists for Inspection and Maintenance Work

According to the maintenance manuals from the manufacturer, check lists are prepared and used for inspection and maintenance work. Deputy Chief Mech. & Elec. Engineer summarizes the records of the inspection and the maintenance and it is used for the Locomotive and Other Rolling Stock Maintenance Reports created quarterly.

GHANA RAILWAY COMPANY

CLASS 1661 MAINTENANCE SHEET

LOCO NO.	DAILY INSPECTION		STABLE		
HASLER Klms	DATE:	TIME:	SERVICE		
No.	**TASK (MECHANICAL)**	**Operation**	**Yes/No**	**INITIAL**	
1.	CHECK ENGINE OIL LEVEL. FILL IF REQUIRED.				
2.	CHECK EXPRESSOR COOLANT LEVEL. FILL IF REQUIRED.				
3.	CHECK ENGINE COOLANT LEVEL. FILL IF REQUIRED				
4	CHECK BRAKE BLOCK WEAR. CHANGE IF REQUIRED				
5.	CHECK EXPRESSOR AIR CUT IN / CUT OUT TIMES				
6.	CHECK AND FILL SAND BOXES IF REQUIRED.				
7.	START ENGINE AND PROVE SYSTEMS.				
8.	CHECK ENGINE OIL PRESSURE AT IDLING				
9.	CHECK ALL LEVELS AFTER ENGINE START.				
10.	CHECK ENGINE FOR LEAKS.				
11.	CHECK INDEPENDANT BRAKE APPLICATION AND RELEASE.				
12.	CHECK AUTOMATIC BRAKE APPLICATION AND RELEASE				
13.	CHECK VIGILANCE AND PENTALTY BRAKE APPLICATION				
14.	CHECK VACUUM SETTING.				
15.	CHECK OPERATION OF WARNING HORNS				
16.	CHECK OPERATION OF WINDOW WIPERS				
17.	CHECK FUEL LEVEL. TOP UP IF REQD. (Record Amount .....ltrs				

REMARKS/OBSERVATIONS. LOCO RELEASED:- YES/NO (Delete) TIME :-

Q A ENGINEER ..... SHED MTCE SUPERVISOR .....

(Source: GRCL)

Figure 2.2.4 One of the Check Lists for Locomotives

6) Number and Experience of Staff, Regulation of Qualification for Rolling Stock Maintenance

The number of GRCL maintenance personnel for rolling stock and structures will be described in the section dealing with the organization. There are also no established internal qualifications for engaging in rolling stock maintenance.

7) Management Criteria for Facilities and Equipment for Rolling Stock Maintenance

Maintenance of facilities and equipment for rolling stock is also based on the manuals from the manufacturer. However, the present condition is that only indispensable facilities are working now. Therefore, it is considered that the maintenance of facilities is hardly carried out due to the lack of budget.

2.2.3 Organization

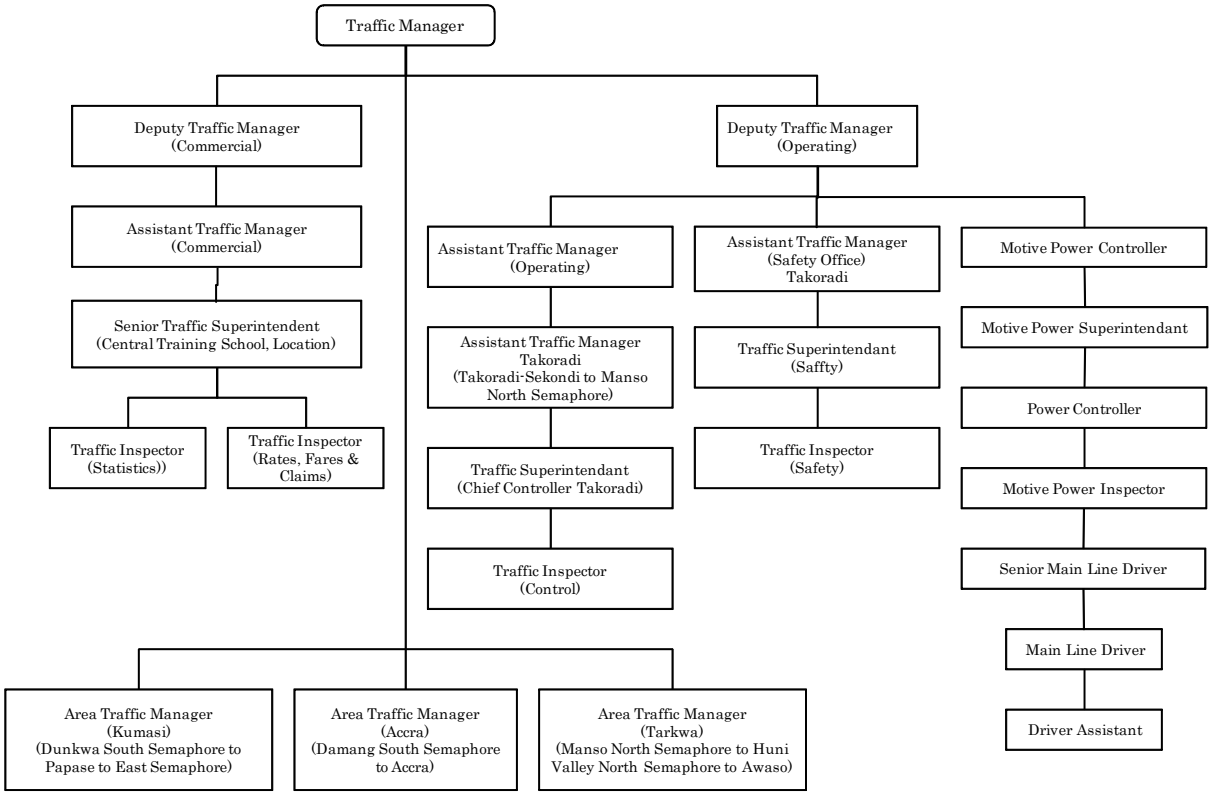
(1) Organization Chart of the Ghana Railway

The whole organization structure has already been described in the Chapter 1.

The following show the organization structure of each division (Traffic, Civil Engineering and Electrical and Mechanical Engineering).

1) Organization of Traffic Division

Train operation planning and management is carried out in the Traffic Division. Figure 2.2.5 shows the organization structure of the Traffic Division. The train operation between Takoradi and Manso is controlled at Takoradi station, and that between Manso and Awaso is controlled at Tarkwa station.



(Source: GRCL)

Figure 2.2.5 Organization Structure of Traffic Division

2) Organization of Civil Engineering Division

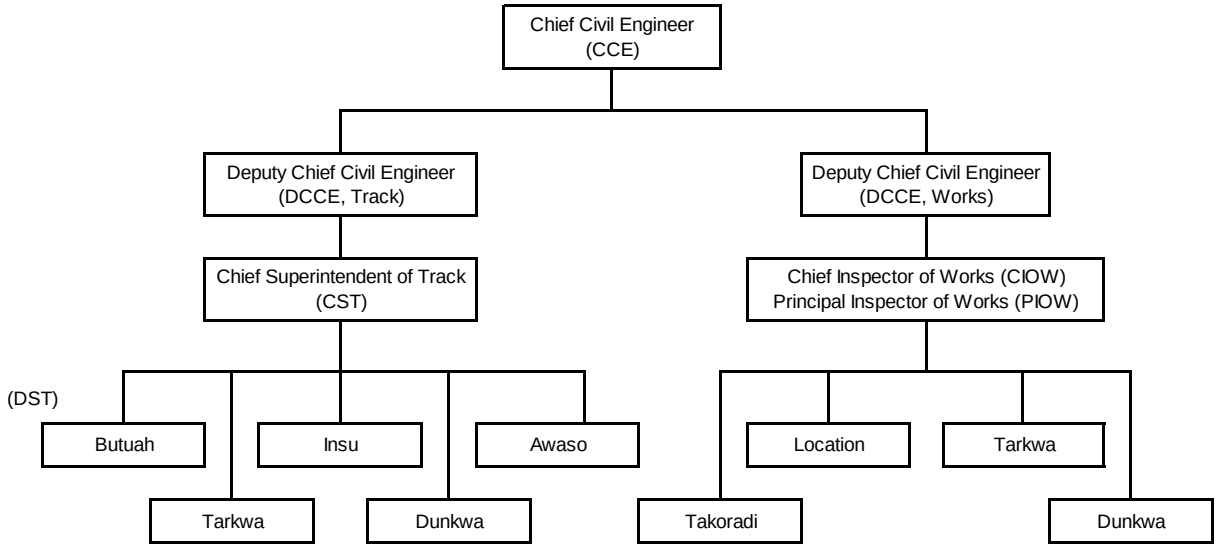
The track- and structure-related organizations of GRCL are shown in Figure 2.2.6.

The GRCL head-office organization includes one Chief Civil Engineer (CCE) who is fully in charge of track and structures and two Deputy Chief Civil Engineers (DCCE); one in charge of tracks and one in charge of works. For general field management, the Railway has a Chief Superintendent of Track (CST) for tracks, a Chief Inspector of Works (CIOW) for works and a Principal Inspector of Works (PIOW).

Persons in charge of field management of the Western Line (Takoradi – Dunkwa) and Awaso Branch Line are assigned to cover five sections and positioned at five locations, Butuah, Tarkwa, Insu, Dunkwa, and Awaso. Each section is headed by a District Superintendent of Track (DST), a Senior Superintendent of Track (SST), a Superintendent of Track (ST), a Track Overseer (TO) or an Inspector Track (IT), a Senior Length Man (SLM) and a Level Crossing Keeper (LCK).

As a rule, each TO or IT is in charge of a 6-km length, and an ST is in charge of track control covering three TO or IT lengths (18 km).

Those in charge of structures are assigned to four locations, Takoradi, Location, Tarkwa, and Dunkwa. Foremen and other specialized personnel headed by a Senior Inspector of Works (SIOW) work at each location.



(Source: GRCL)

Figure 2.2.6 Organization Structure of Civil Engineering Division

Table 2.2.8 Staff for Track Works (Western Line (Takoradi－Dunkwa) and Awaso Branch Line)

(As of October 2012)

DST	Mileage of DST (mile (km))	Length (km)	DST	SST	ST	IT	TO	SLM	LCK	Total	Note
Butuah	0 - 26 (0 - 41.8)	41.8	1	1	5	6	5	62	10	90	Takoradi - Benso
Tarkwa	26 - 42 (41.8 - 67.6)	25.8		1	2	6	1	41	4	55	Benso - Tarkwa
Insu	42 - 74 (67.6 - 119.1)	51.5			3	8	3	48	6	68	Tarkwa - Gyimakrom
Dunkwa	74 - 102 (119.1 - 164.1)	45.0			3	5	7	59	1	75	Gyimakrom - Dunkwa
Awaso	0 - 45 1/2 (0 - 73.2)	73.2			4	9	5	59	10	87	Dunkwa - Awaso
Total			1	2	17	34	21	269	31	375	

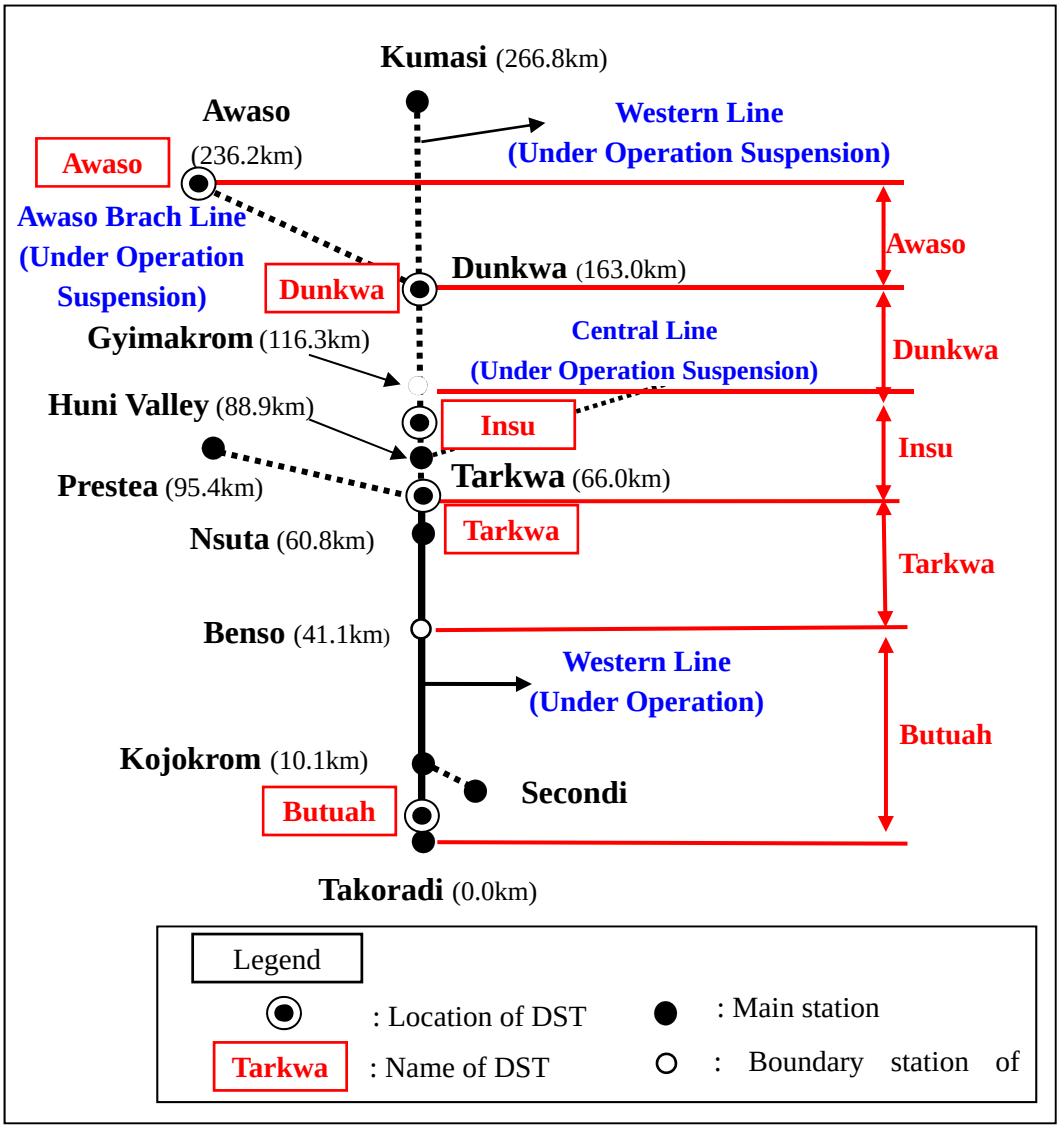
(Source: JICA Study Team)

Table 2.2.9 Staff for Structure Works (Western Line (Takoradi – Dunkwa) and Awaso Branch Line)

(As of October 2012)

Division	SIOW	IOW	Foreman	Others	Total
Takoradi	1		2	19	22
Location	1		3	19	23
Tarkwa				3	3
Dunkwa		1	1	4	6
Total	2	1	6	45	64

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 2.2.7 Locations and Sections of D.S.T.

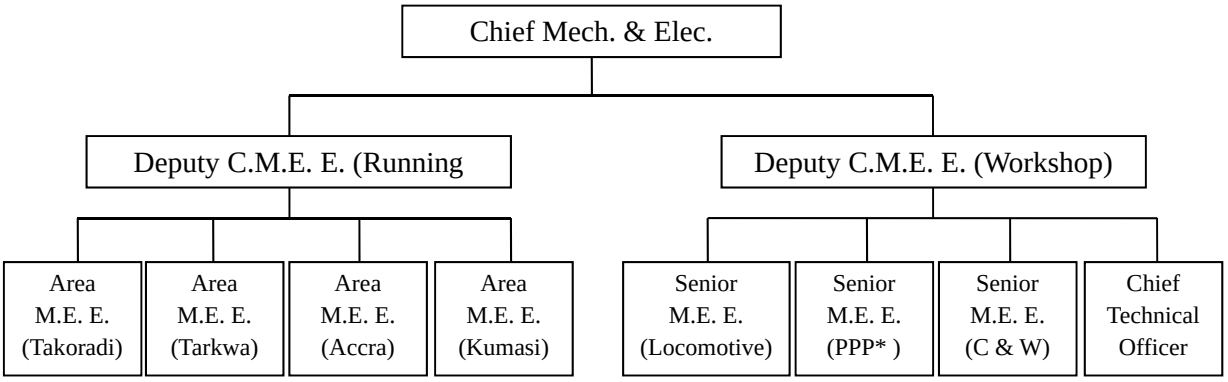
3) Organization of Electrical and Mechanical Eng. Division

The Organization Chart for Electrical & Mechanical Eng. Division of GRCL is shown in Figure 2.2.8. For the rolling stock maintenance purposes, there are one Workshop in Location, 4 Running Sheds, one Carriage & Wagon depot in Takoradi, and one DMU depot in Tema. Out of the 4 Running Sheds, only Takoradi and Tema Running Sheds are actually working now.

There are 7 types of scheduled maintenance for locomotives, namely daily, weekly, 1 monthly, 3 monthly, 6 monthly, 9 monthly and 12 monthly. Most of these maintenances are carried out at the Running Shed, but 12 monthly maintenance and special or accident repairs are done at the Location workshop. Currently due to non-availability of the required crane facility at the Running Shed both the 6 monthly and 12 monthly maintenances are done between the Running Shed and the Location Workshop.

For passenger cars and freight wagons, routine inspection and minor repairs are carried out at the Carriage & Wagon Depot and general inspection is carried out at the Location Workshop every two years.

The number of workers and engineers of the Mech. & Elec. department which is responsible for the rolling stock maintenance was 437 persons as of May, 2012.



* PPP：Production & Planning and Plant

(Source: GRCL)

Figure 2.2.8 Organization Chart for Mechanical & Electrical Eng. Department of GRCL

(2) Number of Personnel at Each Section and Their Years of Experience

Figure 2.2.9 shows the age composition of all employees of GRCL, and Figure 2.2.10 shows their years of experience.

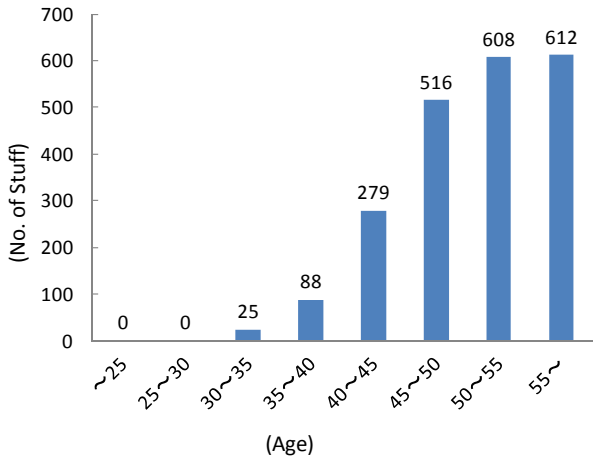
The total number of GRCL employees was 2,128 persons as of May 2012. As the Figure shows, those 45 years old or above account for about 80% of the employees. This indicates an aging of the staff.

Trains are currently operated only for the Takoradi-Nsuta (60.8km) section of the Western Line and the Accra-Nswam (40.5km) and Accra-Tema (about 34km) sections of the Eastern Line. In other words, extremely large numbers of employees are concentrated in the limited sections where trains are operated. This can be accounted for by the GRCL decision based on the need to prevent theft of materials and equipment even at sections where there is no train operation and transferring staff from the Eastern or Central Lines to the Western Line (Takoradi-Nsuta) will be costly.

It is said however that GRCL executives are ready to implement various plans in accordance with planning for the future of GRCL, including reduction of about 300 personnel—a reduction of 1/4. Since the union will try to protect the employees and accordingly new employment opportunities and retirement allowances must be secured for those to be laid off, it is not yet definite what plan will be applied in the future.

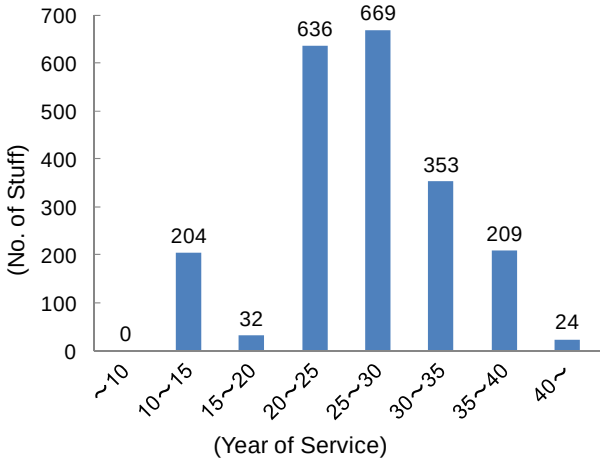
Moreover, for more than the past decade, no new employees, especially younger engineers, have been hired. GRCL recognizes the necessity of recruiting the younger engineers for technical

succession with the above-mentioned personnel reduction plan, considering the possibility that technical succession including the future cannot fully be carried out. But it has not yet been realized.



(Source: GRCL,JICA Study Team)

Figure 2.2.9 Age Composition of Employees GRCL as a Whole



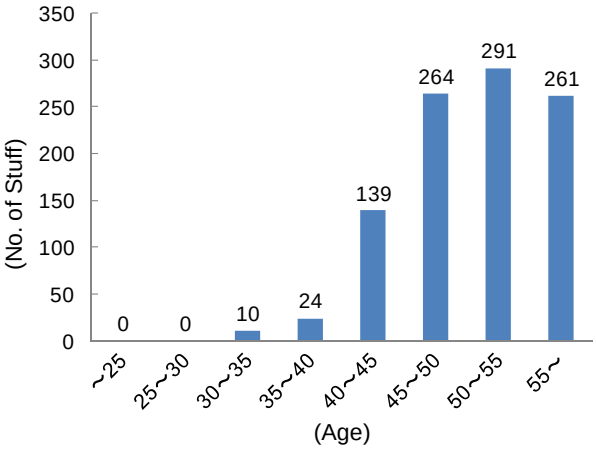
(Source: GRCL,JICA Study Team)

Figure 2.2.10 Years of Experience of Employees GRCL as a Whole

Figure 2.2.11 shows the age composition of employees of the civil engineering division, and Figure 2.2.12 shows the number of years of experience of employees in the same division.

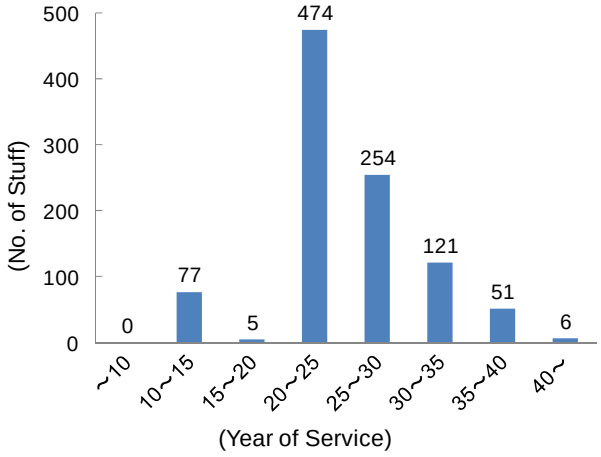
The civil engineering division has 989 employees, which is approximately one half the total number of CRCL employees.

The age composition is approximately the same rate as for GRCL as a whole; those 45 or more years old account for 80%. Many personnel have 20 to 30 years of experience. It is noteworthy that there were only three college graduates among the lot as of the year 2012.



(Source: GRCL,JICA Study Team)

Figure 2.2.11 Age Composition of Civil Engineering Division Employees

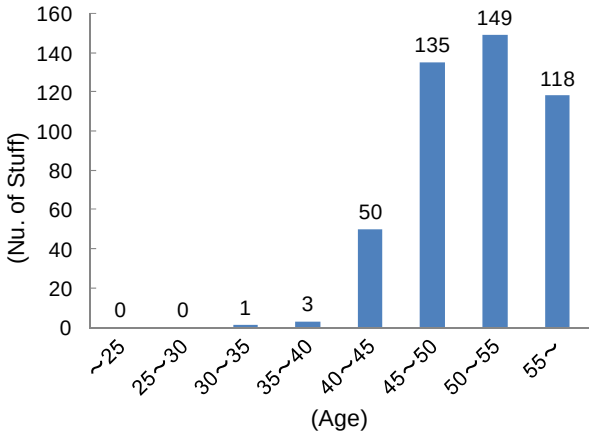


(Source: GRCL,JICA Study Team)

Figure 2.2.12 Years of Experience of Civil Engineering Division Employees

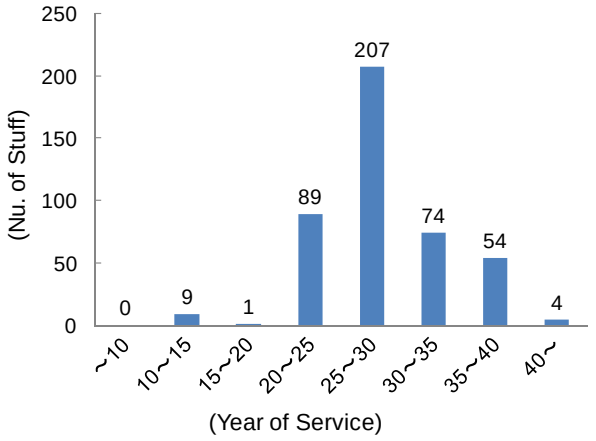
Figures 2.2.13 - 16 show, respectively, the age composition of employees of the Electrical & Mechanical (E & M) Division, the years of experience of the E & M Division employees, the age composition of employees of the Operation Division and the years of experience of Operation Division employees.

The age composition shows a similar trend to those of the Civil Engineering Division and GRCL as a whole. Characteristically, the Operation Division has a relatively high rate of backbone engineers with 10 to 15 years of experience.



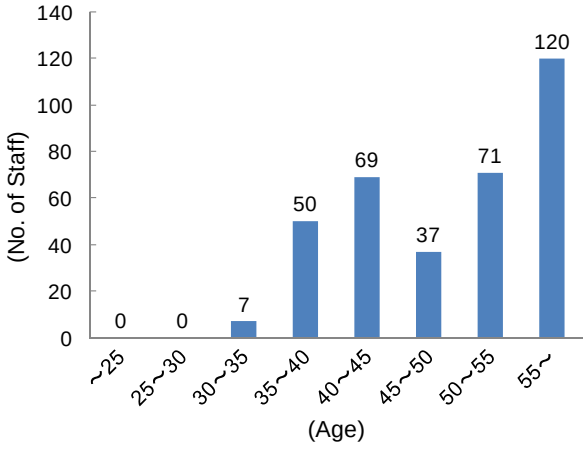
(Source: GRCL,JICA Study Team)

Figure 2.2.13 Age Composition of Employees of the E & M Division



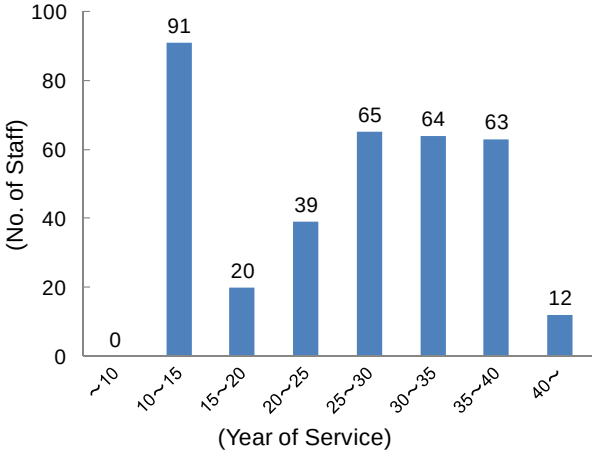
(Source: GRCL,JICA Study Team)

Figure 2.2.14 Years of Experience of Employees of the E & M Division



(Source: GRCL,JICA Study Team)

Figure 2.2.15 Age Composition of Employees of the Operation Division



(Source: GRCL,JICA Study Team)

Figure 2.2.16 Years of Experience of Employees of the Operation Division

(3) Qualifications, Experience, etc, Required by Each Service

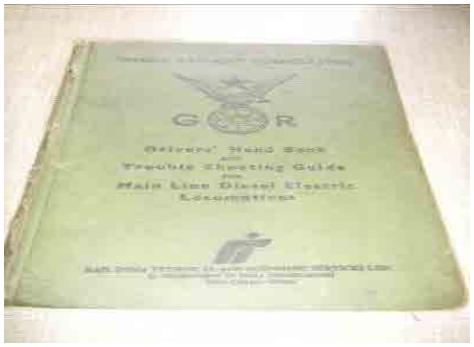
There is no established in-house system of necessary qualifications for tracks and structures.

(4) Training System

The running of the training school at the Location Station has virtually come to a close since December 2010 to reduce expenses. Though it appears that training for operating staff is conducted from time to time, it is not systematic. On-the-job training or hands-on training, are conducted as required.

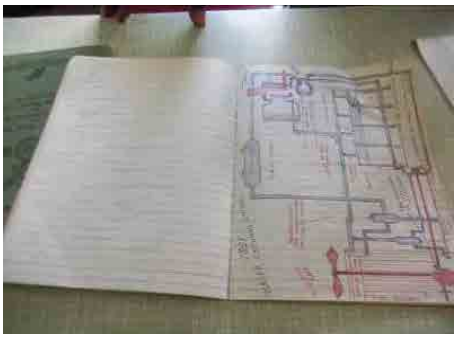
Personnel of the management and planning department related to train operation including the train operation control center (OCC), consist of ones who had stationmaster experience etc. Their aging is progressing, and the "Working Time Table", which is the train operation plan standard compiled with the technical cooperation of Japan, have not been revised since the new revised edition, No.12, in 1977. In the safety department, no engineers with technical knowledge necessary for accident investigation are engaged. So, sufficient accident investigation has not been performed. This makes it difficult for human resource development and technology transfer in the management and planning department.

Potential drivers first shall be qualified as an assistant driver through the basic education related to the locomotive and safety equipment, regulations and safe train operation. After acquiring 5-7 years of experience as assistant drivers, they will be promoted to train drivers in the main line by the supply and demand for train drivers. The driver's qualification is issued by GRCL, but there is no license issued by the Government. Regular training for 5-7 years of experience as assistant drivers is being carried out. Irregular training or instruction for drivers is also being carried out in accordance with the changing circumstance of the lines.



(Source: JICA Study Team)

Photo 2.2.5 Instruction Material for Drivers (1)



(Source: JICA Study Team)

Photo 2.2.6 Instruction Material for Drivers (2)

New hiring for rolling stock maintenance staff is also not carried out now. In the past, a training course for rolling stock maintenance in the training centre had been carried out, but the current training is OJT solely because the training center has been virtually closed due to budget shortfall.

(5) System of Reporting, Handling, and Taking Countermeasures for Accidents

When a derailment or major accident occurs, reporting and handling are arranged in the sequence shown in Figure 2.2.17.

a) The driver submits the first report of an accident to the Stationmaster of the nearest station as soon as possible after an accident occurs.

b) The station master transfers the first report to the Headquarters in the main office.

c) The first report is then sent on to the Managing Director, Deputy Managing Director, Traffic Manager, Chief Civil Engineer, and Chief Mechanical and Electric Engineer.

d) Instructions for investigation, investigation and restoration are given, respectively, from the Chief Civil Engineer to the Chief Superintendent of Track (CST) and the District Superintendent of Track (DST), from the Chief Electric Engineer to Deputy Mechanical Engineer (DME) (Chief of Running shed), and from the Transport Manager to the main station master where the operation can be handled.

e) The District Superintendent of Track (DST) in whose section the derailment accident occurred visits the site immediately and investigates the track material damage and track irregularities.

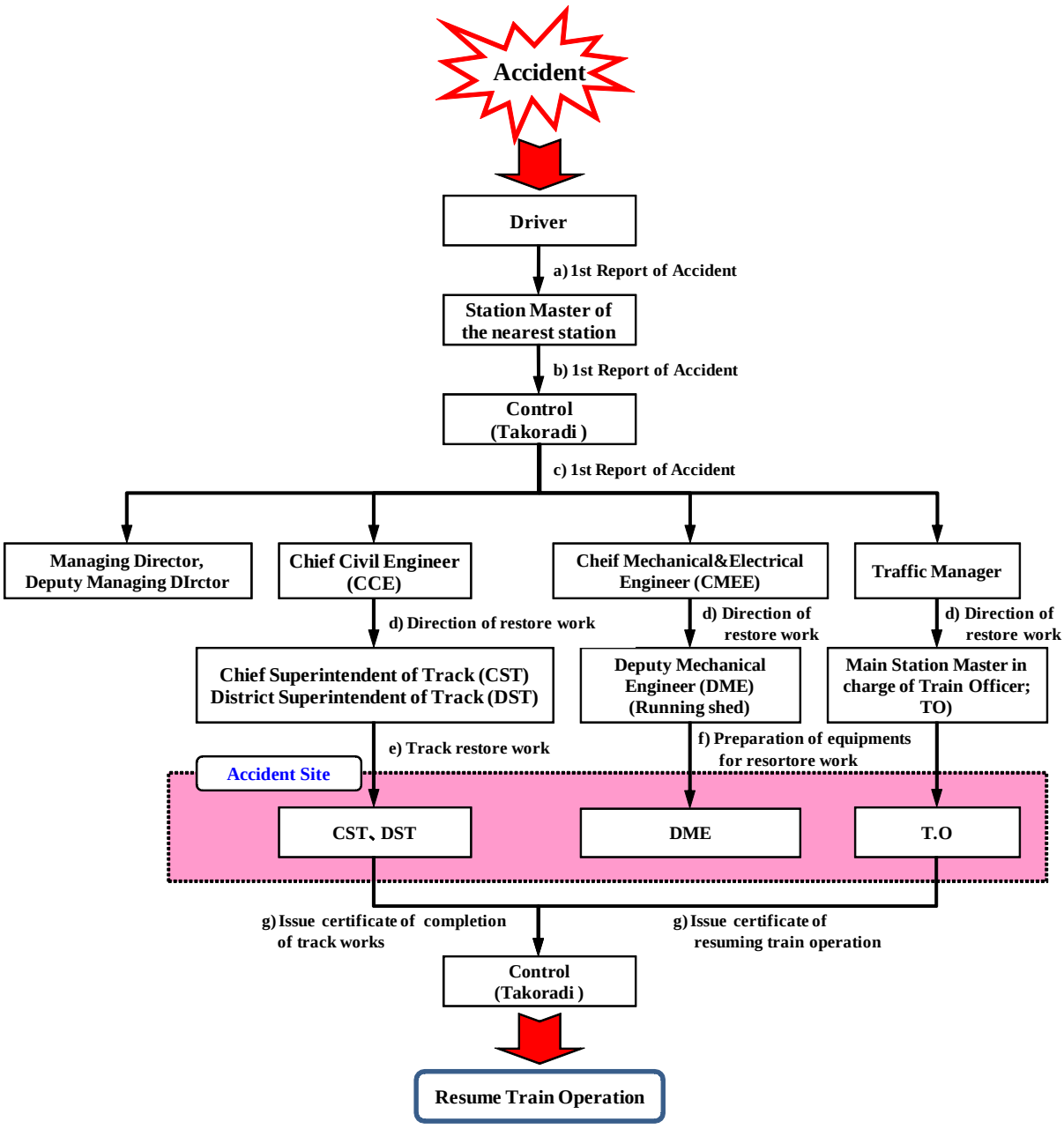
   Then, the DST checks the track materials needed for recovery, and the tools and the number of workers needed for track repair.

   Track repair work is started once the derailed vehicle is put back on track.

f) The Deputy Chief Mechanical Engineer (chief of the running shed) dispatches the breakdown train loaded with recovery equipment and materials and a crane to the site. (These vehicles are always prepared in the running shed.)

g) Upon completion and return to a normalcy, the District Superintendent of Track reports to the Headquarters on the end of work to return the track to normal condition, and the main station master reports to the Headquarters that there is no problem in resuming train operation.

h) Upon receiving these reports, the Headquarters transfers them to the Managing Director, Deputy Managing Director, Chief Civil Engineer, and Chief Mechanical and Electric Engineer and finally resumes operation after receiving the Managing Director’s approval.



(Source: GRCL)

Figure 2.2.17 Reporting and Recovery System in GRCL in Case of Derailment or Major Accident

(6) Budget for Maintenance Services

At the end of each fiscal year (December), each division submits a list of materials and equipment necessary for the next year to Controller of Supplies (COS). COS prepares an estimate on the basis of the submitted lists as a summary for the next-year budget.

The details for procurement of equipment and spare parts and inventory control are referred to in Chapter “1.2.6 (2)”.

(7) Inspection Results Feedback System:

In the Civil Engineering Division, the Track Overseer (TO) or the Inspector Track (IT) reports the results of the inspection of track or structure to the Superintendent of Track (ST). And these are reported in turn to the Senior Superintendent of Track (SST), District Superintendent of Track (DST) and the Chief Superintendent of Track (CST). Finally, the Chief Superintendent of Track (CST) reports it to the Chief Civil Engineer.

The equipment required on the site is also reported in the same procedure. The Chief Civil Engineer reports the requirements to the Controller of Supplies (COS). The procedure for equipment procurement is as described in the Chapter "1.2.6 (2)".

(8) Emergency Contact System

In an emergency, a contact system is established, as required, between authorities concerned on the basis of the recovery system after a derailment, as described in 5).

2.2.4 Others

(1) Records of Recent Meteorological Data (rainfall, wind speed, air temperature, humidity, earthquake)

Ghana Railway has not been conducting meteorological measurements — of rainfall, wind speed, air temperature, and humidity, earthquake, or river water levels— to ensure the safety of train operations against natural disasters.

(2) Train Operation Control by Meteorological Observation Data

As described above, Ghana Railway has not been conducting meteorological observations. During the wet season, the railway is often hit by very strong rainfall, and events that adversely affect train operation are frequent. This includes inflows of rainwater onto the tracks (Photo 2.2.7), cut slope failure, falling rocks (Photo 2.2.8 and Photo 2.2.9), and washout of ballast and roadbed (Photo 2.2.10).

Apart from the lack of an established meteorological observation system, facilities investigation system and operation regulations for times of heavy rain and storm have not been developed.

Considering the existence of sites as above described, establishing a good meteorological observation system is essential along with regulations on checking the facilities and operations in accordance with rainfall and wind speed.

(Source: JICA Study Team)

Photo 2.2.7 Station Yard in which Effluent Flows through the Track Areas like a River (Kojokrom Station area on the Western Line)

(Source: JICA Study Team)

Photo 2.2.8 Site with Rock Fall by the Side of the Track (Dunkwa-Buabin on the Western Line)

(Source: JICA Study Team)

Photo 2.2.9 Partial Failure of Nearly Vertical Slope (Maudaso-Ankwaso on the Awaso Branch line)

(Source: JICA Study Team)

Photo 2.2.10 Ballast and Roadbed Eroded by Water Flowing from a Residential Area (Maudaso-Ankwaso on the Awaso Branch line)

(3) Management of the Weight Condition

The Study Team implemented site surveys at the bauxite loading site at Awaso and the manganese loading site at Nsuta. Although there is a weighing bridge at Awaso, it has been out of order for many years. On the other hand, there is no weighing measurement in the manganese loading site at Nsuta. The operation of loading and offloading of the manganese ore are carried out by manganese company's staff. GRCL does not manage the weight condition of the wagon. The loading conditions on the wagon are different. This increases the danger due to causing the wagons to lean on a curve.

(4) Wayside Marker (Mile Post, Gradient Post, Curve Post etc.)

Along the track, there are mileage posts (mile posts and 1/4, 1/2, 3/4 mile posts) (Photo 2.2.11) and steel pipe piles (Photo 2.2.12) about every 60 meters, which indicate distances.

However, there are locations where mileage posts have deteriorated so much as to make the letters illegible, the post is lost, or overgrown grass covers the letters. Operators are often unable to identify the mileage posts with ease. Illegible letters must be repainted in white to ensure easy identification by those concerned with the railway (especially, the operator).

Curve posts and grade posts, which are normally indispensable for maintenance, are not provided along the Western Line covered by the study.

(Source: JICA Study Team)

Photo 2.2.11 Mileage Post Provided along the Track (four types of 0, 1/4, 1/2, and 3/4)

(Source: JICA Study Team)

Photo 2.2.12 Auxiliary Distance Pile

2.3 Confirmation of Deformation and Deficiencies of Railway Structures

2.3.1 Occurrence of Accidents

(1) The features of the Western Line

The climate is tropical. There are two seasons, rainy season and dry-season in a year. There are some places that are swamped by heavy downpours. There are some bridges which are damaged by flood. There are some sections with poor visibility by overgrown with weeds beside the tracks in the jungle. The development of the railway has a long history. There are many curves because the line ran parallel to the river on lowland to avoid constructing tunnels. The roadbeds are soft ground near ponds or rivers. Some cuts along the line are dangerous because the cliffs of the cuts are ready to collapse. It is easy for them to be eroded by rain water because the tracks are lower than the surroundings.

(Source: JICA Study Team)

Photo 2.3.1 Damage by Heavy Rain (1)

(Source: JICA Study Team)

Photo 2.3.2 Damage by Heavy Rain (2)

(Source: JICA Study Team)

Photo 2.3.3 Damage by Heavy Rain (3)

(Source: JICA Study Team)

Photo 2.3.4 Dangerous Cut

(2) Site Surveys at the Point where a Number of Derailments Had Occurred

The JICA Study Team (the Team) implemented site surveys at the points where a number of derailments had occurred selected from the accident records that were supplied by GRCL.

1) Sites Surveys

No.	Day	Location		Curve Radius etc.
1	April 27,2012	Nsuta - Bonsawire	35Mile from Takoradi	R=205,R=228
2	May 1, 2012	Buabin - Rubberkrom	91Mile from Takoradi	R=195
3	May 2, 2012	Buabin - Rubberkrom	91Mile 3/4 from Takoradi	R=240
4	May 22, 2012	Maudaso - Ankwaso	33Mile from Dunkwa	(unknown)
5	May 31, 2012	Angu - Kojokrom	13Mile 3/4 from Takoradi	Straight
6	October 18, 2012	Huni Valley - Kuranti	57Mile from Takoradi	(unknown)

2) The general Situation of the Sites

a) Nsuta - Bonsawire: 35Mile from Takoradi (Curve Radius =205,228)

The points where derailments had occurred are near the start point of a left curve heading towards Takoradi. The roadbed collapsed just below the edge of the sleepers. The left sides of the tracks are wetlands and flood is a danger in heavy rain.

The wreckage of the rolling stock still remains crushed into the bank on the left side of the track. The traces of the derailment show that the right wheel ran out. All around the site the condition of sleepers and rail fasteners are poor .The rail joints in particular are extremely poor, the rolling stocks tend to experience rolling whenever they pass such bad sections. The accident sites are mended temporarily. And the manganese train operations still continue. It is necessary to pay close attention when passing the section because the roadbed has collapsed just below the edge of the sleepers, so they are half way to failure.

(Source: JICA Study Team)

Photo 2.3.5 Trace of Derailment (1)

(Source: JICA Study Team)

Photo 2.3.6 Trace of Derailment (2)

(Source: JICA Study Team)

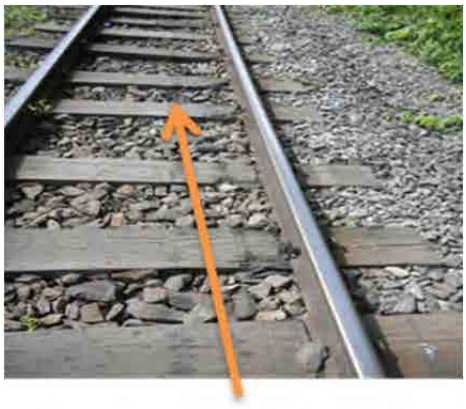
Photo 2.3.7 Trace of Recovery Work

(Source: JICA Study Team)

Photo 2.3.8 Ballast beside Sleepers

(Source: JICA Study Team)

Photo 2.3.9 Trace of Derailment (1)



(Source: JICA Study Team)

Photo 2.3.10 Trace of Derailment (2)

b) Buabin - Rubberkrom: 91Mile from Takoradi (Curve Radius =195)

On this site trains operations are stopped. The points where derailments had occurred are the middle point of a left curve heading towards Takoradi. The bauxite ore that fell out of the wagons by running impact is scattered around there. It seems that the point where a huge amount of the bauxite ore had accumulated is the derailment place. All around that site the conditions of sleepers and rail fasteners are poor .The rail joints in particular are extremely poor, the joints are set in different place on each tracks, and the rolling stocks tend to experience irregular rolling whenever they pass such bad sections. And the roadbeds are poor too. It is easy to see that the sleepers are unstable. The situations are similar to the site near Nsuta. The track heads towards the left side and that is same direction as the Nsuta site.

(Source: JICA Study Team)

Photo 2.3.11 Edge of Sleepers (1)

(Source: JICA Study Team)

Photo 2.3.12 Edge of Sleepers (2)

(Source: JICA Study Team)

Photo 2.3.13 Collapsed Roadbed (1)

(Source: JICA Study Team)

Photo 2.3.14 Collapsed Roadbed (2)

(Source: JICA Study Team)

Photo 2.3.15 Scattered Bauxite (1)

(Source: JICA Study Team)

Photo 2.3.16 Scattered Bauxite (2)

3) The Features of the Sites

The points where a number of derailments had occurred are mainly the middle or the end point of a curve including a sharp S curve with a gentle gradient, it is easily to generate resultant forces that lead to derailments, which are combined cross forces that are produced by the cant on the curve and impacts by rolling stock because they tend to experience irregular rolling whenever they pass inferior rail joints and the vertical forces due to break operation and impacts due to lack of brake force.

(3) Site Survey of the Operations for Recovery from Derailments

The Team implemented a site survey at the point where derailments have occurred between Benso - Esuaso on the 6th Jun 2012, to check the situation at the accident site and the operation for recovery from derailment.

The points where derailments had occurred are near the end point of a right curve heading towards Takoradi with a down gradient. The condition of the sleepers is poor and the trace of the wheel that flew off was recognized at the point where the sleepers are unstable. The point is similar to the other sites.

All the wheels of many wagons fell down into the tracks because the condition of the rail fastenings is poor, so the track gauge widened by the impact of the derailment. This exacerbated the damage from the derailment.

The recovery works are simple and use a heavy crane, locomotive power, wooden parts, and hydraulic jacks. It is desired to improve the efficiency and safety.

(Source: JICA Study Team)

Photo 2.3.17 Wagon Condition

(Source: JICA Study Team)

Photo 2.3.18 Over Width Gauge

(Source: JICA Study Team)

Photo 2.3.19 Condition of Fastenings

(Source: JICA Study Team)

Photo 2.3.20 Trace of Derailment

(Source: JICA Study Team)

Photo 2.3.21 Recovery Work (1)

(Source: JICA Study Team)

Photo 2.3.22 Recovery Work (2)

2.3.2 Civil Structures

(1) General

The study covered the Takoradi-Awaso section. A site survey was also conducted on the Takoradi – Nsuta section currently in service and around Huni Valley.

The results of the field survey of bridges are shown in Appendix-2.

A visual investigation was conducted of the railway tracks, track beds, subgrades, and embankments, cut portions, bridges, and drainage to determine the state of deformation/deficiencies. River bridges use steel upper-deck plate girders, steel through plate girders and steel through truss girders. As rust, corrosion, and sectional loss of parts of the members were observed due to time-dependent deterioration, it is possible to confirm that almost no operation and maintenance (O & M) has been undertaken since construction.

It is possible to confirm that, in the substructure, concrete members of abutments, piers and retaining walls to which wing plates are mounted and cross channels suffer from concrete

break-off and cracks in many locations.

The soil observed in Ghana and other African countries is so-called laterite, which is reddish soil containing large amounts of iron and aluminium. This soil becomes soft as ordinary soils do when wet. Once dried, laterite becomes extremely hard due to its iron content.

Accordingly, in countries of Africa and Asia, laterite soil in cut faces is sometimes left as it is without any slope protection because, once dried, the soil acts against collapse.

However, collapse of laterite soil is possible due to heavy rain or other causes. Due to lack of maintenance and repair work over a long period of time, certain sections indicate the risk of minor surface collapse in embankment sections as well as small-scale rock falls in cut sections. Though provided, drainage equipment with drainage systems made of concrete or steel are covered by soil, and do not function as intended.

(2) Issues with Structures

1) Issues with Superstructures

- All of the steel girders showed time-dependent deterioration, rust and corrosion due to high temperature and humidity. Also, cross sectional loss of members other than principal members has occurred in the course of the 60 to 110 years after construction.
- In particular, Bridges No.1 and No.7 have insufficient clearance over the rivers. Main girders are submerged when the level of flood waters is high.
- No specific cracks could be detected in the steel girders. Only corrosion and rust are problems.
- Loss of rivets and bolts are limited. Therefore this is not particularly a problem.
- In some bridges, the distance between the steel girder end and abutment is not secured, resulting in collapse of the parapet in certain locations.
- Considerable rotting of sleepers on the bridges was apparent, and the sleepers are not arranged at even distances. In addition, fasteners are lost in certain locations.

(Bridge No.4)

(Bridge No.2)

(Bridge No.6)

(Bridge No.5)

(Source: JICA Study Team)

Photo 2.3.23 Corrosion of Steel Girders

(Bridge No.1)

(Bridge No.1)

(Source: JICA Study Team)

Photo 2.3.24 Sectional Loss Observed in Stiffeners between Bridge Main Girders

(Bridge No.1)

(Bridge No.1)

(Source: JICA Study Team)

Photo 2.3.25 Insufficient Overhead Clearance

(Bridge No.4)

(Bridge No.1)

(Source: JICA Study Team)

Photo 2.3.26 Distance between the Bridge and Abutment

(Bridge No.6)

(Bridge No.3)

(Source: JICA Study Team)

Photo 2.3.27 Condition of Track (Rails/Sleepers)

2) Issues with Substructures (abutments and piers)

- The substructures are 60 to 110 years old. Many cracks were detected in the structures, and partial concrete break-off was observed.

- The parapet front and the widely exposed surface showed major horizontal cracks, which are considered to be due to dry shrinkage.
- Soil was found to have accumulated around the girder supports. This promotes corrosion and hinders proper functioning.
- The girder seat surfaces were narrow in certain locations. Though the initial design standard at the time of design is not known, provision of necessary equipment (jacks, etc.) is difficult during repair work.
- Honeycomb has developed in portions of the concrete surfaces. This is an indication of faulty concrete placement.

(a) Insufficient Edge Distance
(Bridge No.1)

(b) Collapse due to Lack of Edge Distance
(Bridge No.1)

(c) Accumulated Soil around Bearing
(Bridge No.1)

(d) Concrete Spalling at the Face of Bridge Seat
(Bridge No.1)

(Source: JICA Study Team)

Photo 2.3.28 Bridge Seat of Substructure

3) Issues with Earth-work

As a rule, the line is an earth-work section with track structures provided on embankments or cut subgrades.

Both embankment/cut sections are of laterite soil and finished without any additional measures. In particular, no protection is provided on the slopes. Due to a long time lack of maintenance work, slope collapse and collapsed slant surfaces of cut portions are observed. Although a drainage system plan along the route is apparent, proper drainage is not occurring because it is

covered by soil and waste. Actually, even minor rainfall causes flooding of the track, which hinders train operation. Along part of the route, simplified earth-retaining work was provided as a minimum emergency measure.


(a) Embankment Section (railway subgrade not clear)

(b) Emergency Earth-retaining Work

(c) Embankment Collapse on the Track Side


(d) Cut section (laterite soil cut and left as is)

(Source: JICA Study Team)

Photo 2.3.29 Earth-work Section

4) Issues with Earth-work

Maintenance of drainage systems by the side of the railway track is crucial to safe operation. In the drainage system, side ditches running parallel to the track are covered by soil. Under the track, concrete box culverts, arch structures, and pipe culverts (Armco pipe) were provided for cross drainage equipment (Photo 2.3.30). According to reference materials that the Ghana Railway has, there are 682 track-crossing culverts in the Takoradi-Awaso section and 218 in the

Takoradi-Nsuta section. However, some of these could not be actually seen on-site since they are covered with sediment, for example.

In the places where they are covered with sediment and their function as culverts or ditches is insufficient, water flows onto the track after heavy rain (Photo 2.3.33).

(a) Box Culvert

(b) Arch Culvert

(c) Pipe Culvert (Armco Pipe)

(Source: JICA Study Team)

Photo 2.3.30 Type of Culvert

(a) Spalling of the Concrete

(b) Culvert Covered with the Sediment

(Source: JICA Study Team)

Photo 2.3.31 Current Status of Culverts

(Source: JICA Study Team)

Photo 2.3.32 Culvert Filled with Garbage in Kojokrom Station

(Source: JICA Study Team)

Photo 2.3.33 Water and Soil Flowed onto the Track in Kojokrom Station

(3) Repair work on Existing Bridges

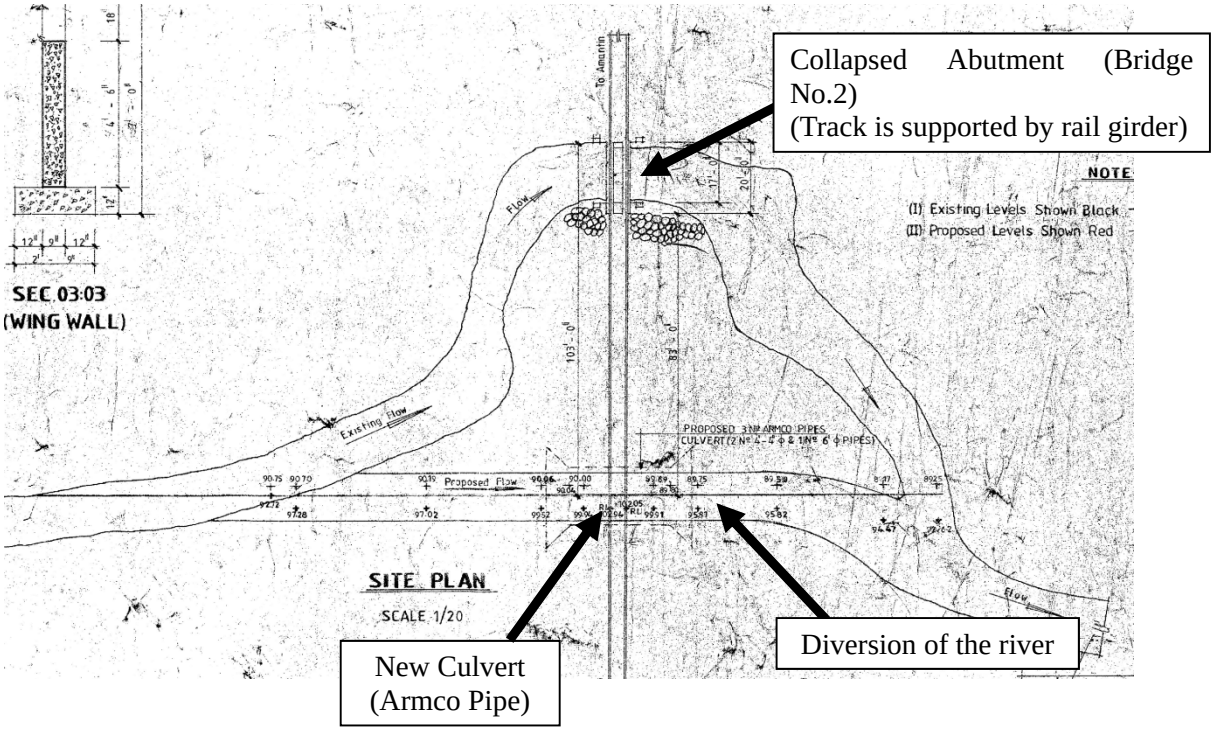
Emergency work was conducted for a steel upper-deck girder, No.2, because the Takoradi-side abutments to support girders had collapsed due to scour. The details of the work are shown below as an example of emergency repairs on-site.

- Three Armco Pipes were used to divert the river.
- The old bridge was modified by using wood sleepers as substructure
- Rail girders were used for protection of the rail on the bridge.
- Gabions were installed in order to protect from further scour

10 years have passed since this bridge collapsed, but drastic measures such as removal of the collapsed bridge have not taken place yet. Therefore, a 5mile/h (approx. 8km/h) speed restriction is provided in the section before and after this bridge.

In addition, the rail girder used for the protection of track at this bridge is also used at another bridge as an emergency work. Also in Japan, this is used as a temporary structure for the track protection by the track workers.

Figure 2.3.3 shows a drawing of track protection work used in the Western Line. And, this drawing describes the expiration date of the temporary bridge, "TEMPORARY BRIDGE STAY FOR 21 DAYS". The use of these temporary bridges involves speed restriction, and a week limit for expiration date. The removal of this by urgent repair work is desirable as soon as possible.

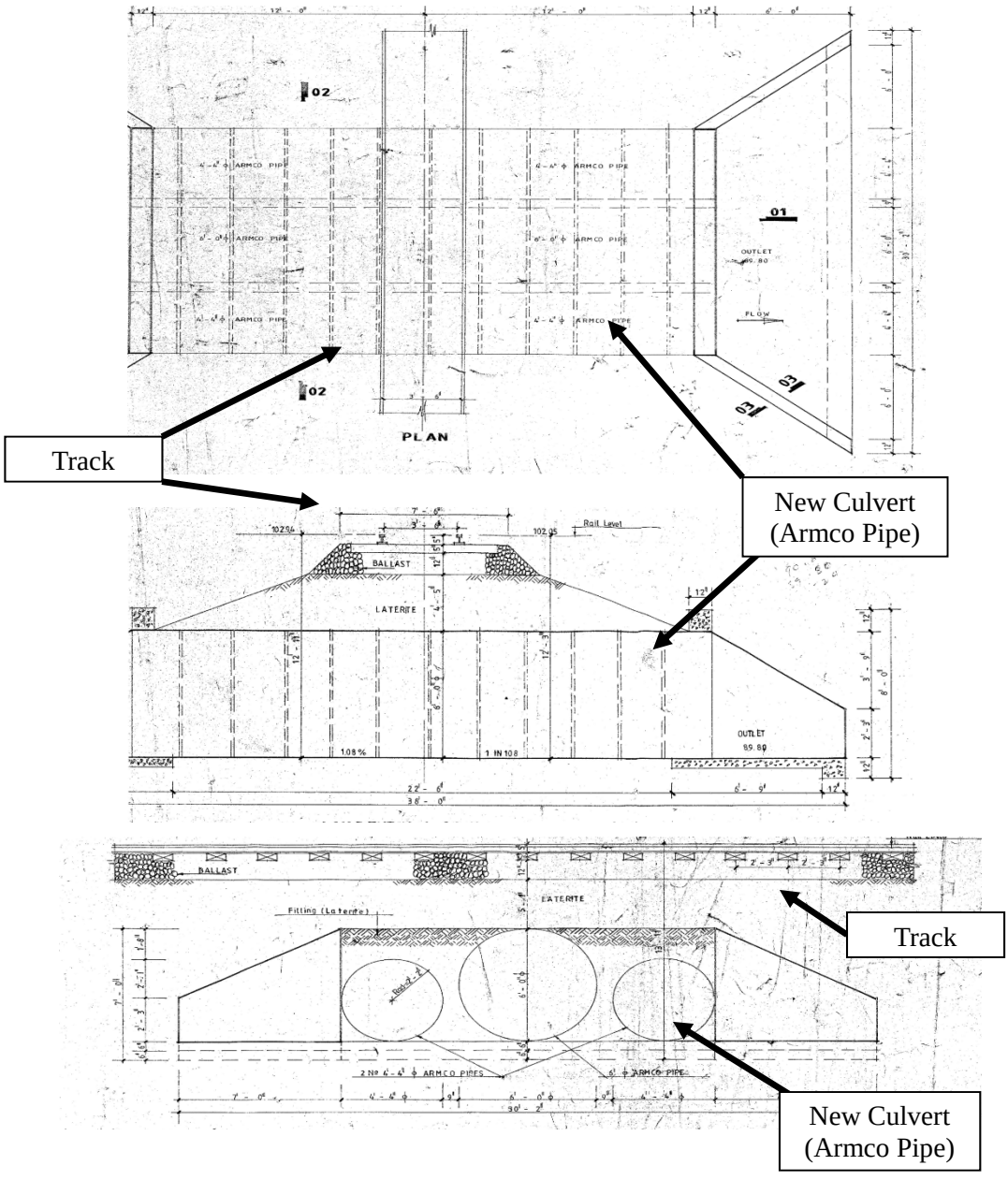


(Source: GRCL)

Figure 2.3.1 Urgent Repair Works for Bridge No.2

(Source: JICA Study Team)

Photo 2.3.34 Steel Girder Bridge Temporarily Supported by Sleepers



(Source: GRCL)

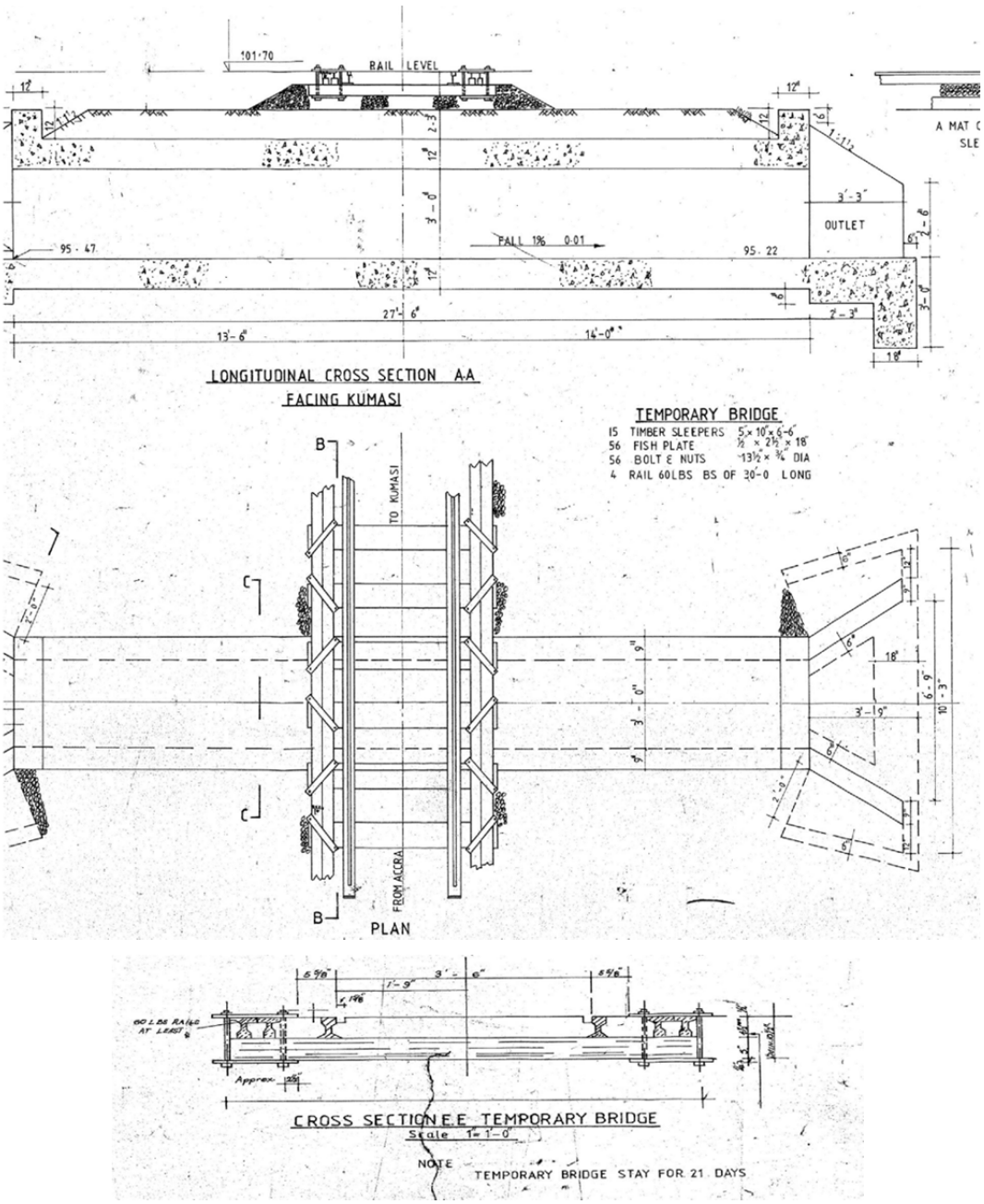
Figure 2.3.2 New Culvert (Armco Pipe)


(Source: JICA Study Team)

Photo 2.3.35 Diverted River and New Culvert


(Source: JICA Study Team)

Photo 2.3.36 Track Protection by Rail Girder



(Source: GRCL)

Figure 2.3.3 Track Protection Work by Rail Girder in the Western Line

(4) Cause Analysis of Deformation and Deficiencies

Shortage of maintenance budget, which can be considered as one of the causes of obsolescence of civil structures, is serious as mentioned above.

The rust of some steel girders is advanced affecting the whole girder because of deterioration of the coating. On some bridges, the lower part of the girder is soaked in water during a flood, and garbage or sediment is deposited around the bearing and the lower flange. As a result, it causes the corrosion of the lower members of the girder, and it leads to cross sectional loss or missing members. Regular removal of rust, repainting and removal of garbage or sediment can prevent

members from corrosion. However, such situation has been left because the maintenance regulations are not clear. Moreover, either cross-sectional loss or missing members have not been repaired because of shortage of maintenance budget.

In most culverts, garbage and sediment are deposited. Drainage function of such culverts is insufficient and in the some places, water overflows and enters onto the tracks at the time of heavy rain. Although the workers' motivation for daily maintenance work is sometimes far from high, it is the actual situation that the daily work cannot be carried out because there is a great deal of trouble with gang trolleys which transport staff and materials to the site.

In addition, the shortage of maintenance budget makes full-scale repair work or reconstruction of deteriorated bridges difficult. For many years, a bridge has been left in the situation that urgent countermeasures have been implemented. Such bridge has a restriction on train operation speed, and it affects safety and regular operation.

2.3.3 Track

(1) Site Investigation

Table 2.3.1 shows the number and locations of derailments from 2004 and 2010.

The JICA Study Team (the Team) has implemented an investigation of the track conditions and a measurement of the damaged sleepers and fastening devices as well as the track irregularities, e.g. track gauge, cross level, longitudinal, line, twist, etc. at the locations where many accidents have frequently occurred. The investigation and the measurement aim at identifying the cause of the accidents, such as derailment, and grasping the current track conditions.

The Team also carried out the same measurement at both ends of the section where the accidents had occurred but have been already been restored during the site survey by the Team.

Table 2.3.1 Locations and Number of Derailment Accidents

	No.	Station	Type of Station*	Mileage (mile)	Mileage (km)	Nos. of Accident 2004	2005	2006	2007	2008
Western Line	1	TAKORADI	◎	0.0	0.0					
	2	BUTUAH	○	1.61	2.6					
	3	NKWANTA	－	3.48	5.6					
	4	ADIEMBRA	－	4.22	6.8	3				
	5	KOJOKROM	◎	6.27	10.1					
	6	ANGU	○	13.48	21.7				2	
	7	MANSO	○	19.01	30.6			16		
	8	AMANTIN	○	20.99	33.8					
	9	BENSO	○	25.53	41.1					
	10	ESUASO	○	30.00	48.3			2	2	
	11	BONSAWIRE	○	33.48	53.9					
	12	NSUTA	○	37.76	60.8	3	4	3		
	13	TARKUWA	◎	40.99	66.0	2	3	4	3	
	14	ABOSO	○	46.27	74.5					
	15	WORKERS BRIGADE	－	48.51	78.1			2		
	16	BOMPIESO	○	51.74	83.3					
	17	HUNI VALLEY	◎	55.22	88.9					
	18	KURANTI	○	60.00	96.6					
	19	INSU	○	65.47	105.4					
	20	PENESO	－	68.01	109.5					2
	21	GYIMAKROM	○	72.24	116.3					
	22	OPON VALLEY	○	75.71	121.9					
	23	OPOKUKROM	－	80.00	128.8					
	24	TWIFUKYEBI	○	82.48	132.8					
	25	JERUSALEM	－	84.47	136.0	6	3			
	26	IMBRAIM	○	86.77	139.7					
	27	RUBBERKROM	－	89.01	143.3	12	13	8	4	
	28	BUABIN	○	91.99	148.1					
	29	SOBROSO	－	93.23	150.1	4	4	6	5	3
	30	MPEASEM	○	96.00	154.5		3	6	2	
	31	DUNKWA	◎	101.24	163.0	3	2	7	2	
				0.00	0.0					
Awaso Branch Line	32	WOMPAM	○	7.52	12.1		3			
	33	NKOTUMSO	－	11.24	18.1			4	4	
	34	DOMENASI	○	15.40	24.8					
	35	ANWIA	－	18.51	29.8	3		6	3	3
	36	ANANIKROM	○	23.23	37.4		7		6	2
	37	MAUDASO	○	32.24	51.9		14	5	3	2
	38	ANKWASO	－	36.27	58.4	3				
	39	ANKWASO	○	40.50	65.2		5	2	2	
	40	AWASO	◎	45.78	73.7					
			Total	147.02	236.7	39	66	71	38	12

(Source: JICA Study Team)

(Legend)

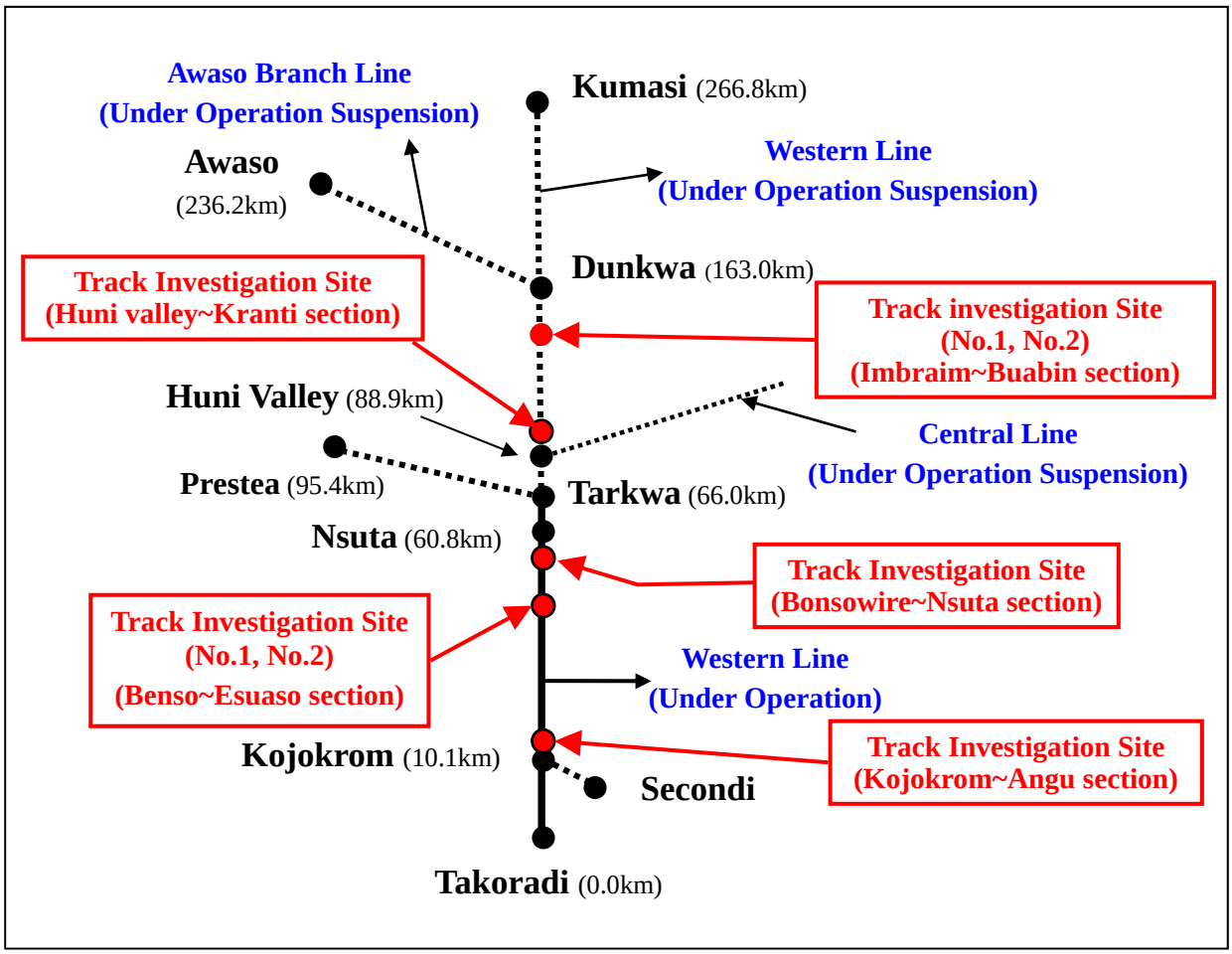
Type of station

◎: Main stations where other lines are connected.

○: Stations where platform is installed.

－: Stations where platform is not installed.

As shown in Figure 2.3.4, 7 locations were investigated, consisting of 4 locations between Takoradi and Nsuta as the operating section and 3 locations north of Nsuta where the train operation has been suspended.



(Source: JICA Study Team)

Figure 2.3.4 Locations of Site Investigations in the Western Line

(2) Establishment of standard for judgment of defective sleepers and fastening devices and criteria for maximum amount of rail irregularities

As there is no standard for judgment of defective sleepers and fastening devices or criteria for maximum amount of rail irregularities in Ghana Railway, the Team has established the provisional standard and criteria based on the Japanese Standard for this site investigation and measurement, which are shown in Tables 2.3.2 and 2.3.3.

Table 2.3.2 Provisional Standard for Judgment of Defective Fastening Devices and Sleepers

Sleepers: 1. Erosion in progress and not properly functioning 2. Broken due to derailment in the past and thus not properly functioning 3. Highly possibly hollow assumed by checking with hammer 4. Too Loose to firmly hold the fasting devices due to too large holes
Fastening Device: 1. Incorrectly positioned (or missing) 2. Not properly functioning due to uplift from the baseplate and thus 3. Easily removable by hand 4. Movable only by hitting with a hammer

(Source: JICA Study Team)

Table 2.3.3 Provisional Criteria for Rail Irregularities (Normal/ Urgent)

	Gauge	Level	Cross level	Alignment	Twist
Normal Maintenance	+6, -4	±9			―
Urgent Maintenance	+20, -10	―	±19		±18

(Source: JICA Study Team)

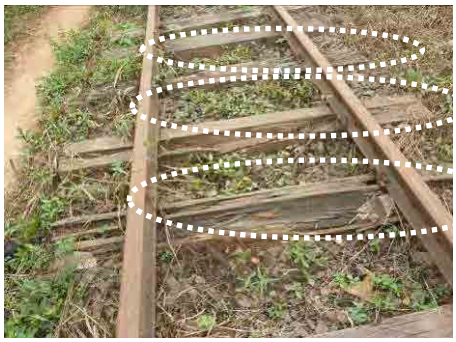
Third Class Track[1] in the Japanese Standard was used as the reference in the establishment of the provisional criteria for rail irregularities, considering the track conditions, e.g., axle load, passing tonnage, etc. of Ghana Railway. The "Emergency" values are designated to urge immediate repair as such condition may lead to a derailment, and thus the values shall be kept at zero at all times.

(3) Summary of site investigation

1) Sleepers

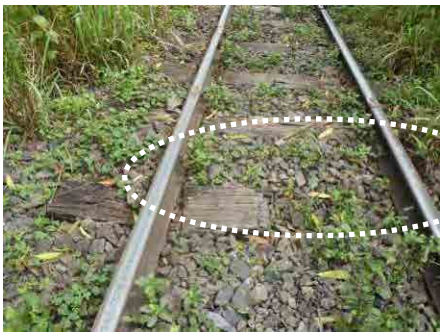
- It was observed that there are some sections where more than 3 sleepers in succession were damaged or broken (Photo 2.3.16 and 2.3.17)
- Figure 2.3.5 shows the status of sleepers, and 37 of 83 sleepers were damaged or broken.
- As shown in Table 2.3.4, the rates of defective sleepers range between 6% and 45%, which implies that the maintenance works might most probably have not been carried out thoroughly throughout the section.
- Japanese Standard regulates the rate of defective sleepers to be less than 7 %.

[1] *The classes of track are determined by calculating the power rate to destroy the track in accordance with the passing tonnage per year and train speed, and it is graded according to thickness of ballast, construction type and number of the sleepers. Axle load of first class track, second class track, third class track and fourth class track are: 18t, 17t, 15t and 14t. Maximum speed is limited by: 110km/h, 100km/h, 95km/h and 85km/h for each class as well.*



(Source: JICA Study Team)

Photo 2.3.37 Successive Sleepers Damaged



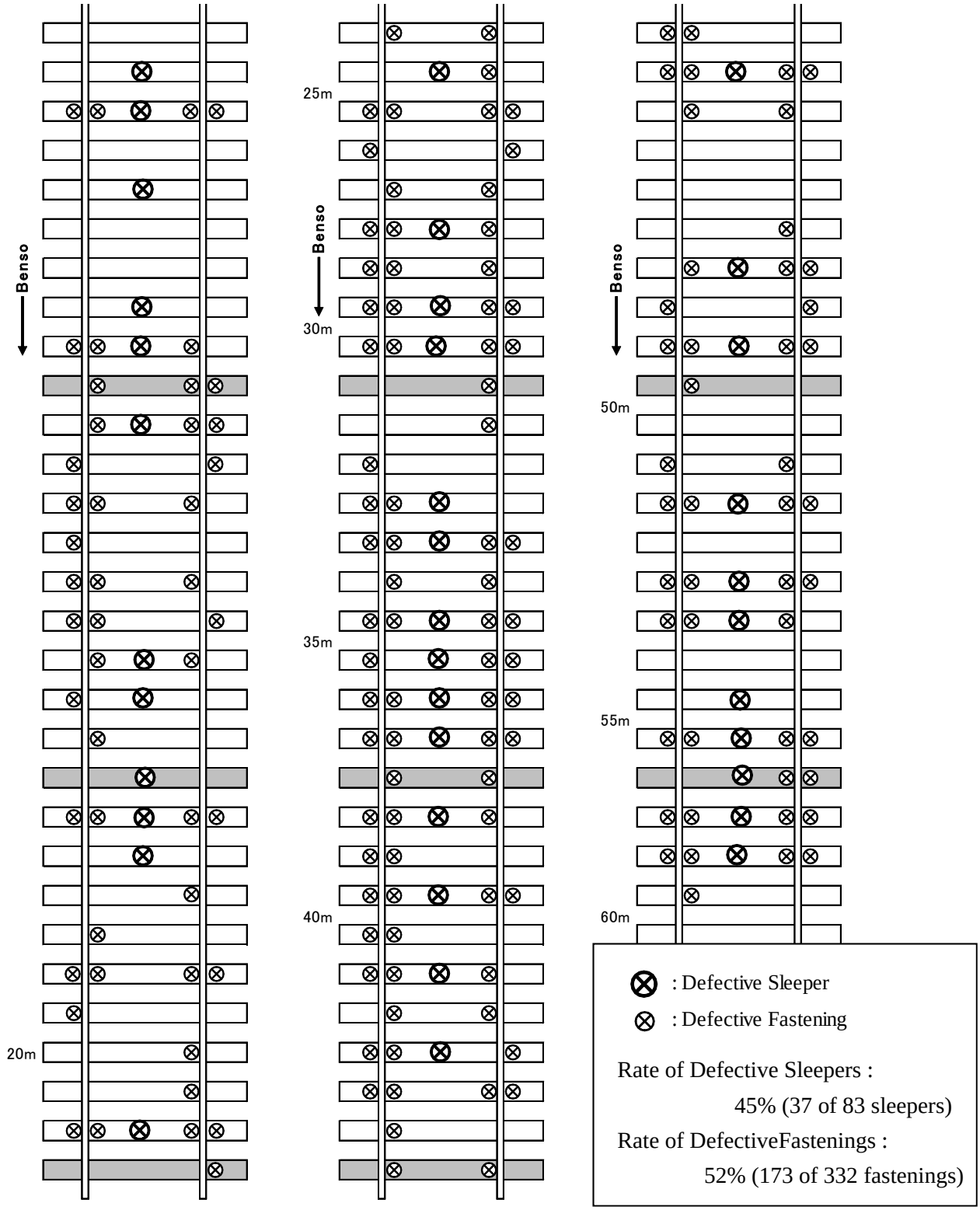
(Source: JICA Study Team)

Photo 2.3.38 Broken Sleeper (Due to Derailment)

Table 2.3.4 Measurement of the Rates of Defective Devices

	Section	Number of all Sleepers	Number of Defective Sleepers	Defective Rate (%)
Takoradi - Nsuta	Kojokrom - Angu	210	13	6
	Benso - Esuaso (No.1)	100	41	41
	Benso - Esuaso (No.2)	83	37	45
	Bonsawire - Nsuta	90	30	33
North of Nsuta	Huni Valley - Kuranti	140	26	19
	Imbraim - Buabin (No.1)	114	41	36
	Imbraim - Buabin (No.2)	153	19	12

(Source: JICA Study Team)

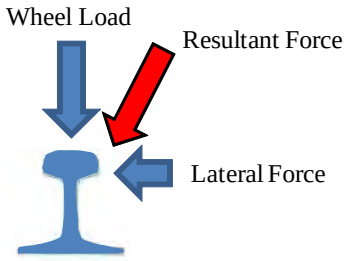


(Source: JICA Study Team)

Figure 2.3.5 The Status of Sleepers and Fastenings (Benso – Esuaso (No.2))

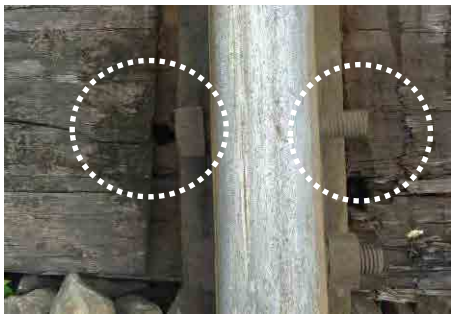
2) Fastening Devices

- There are many locations where fastening devices are missing (Photo 2.3.18).
- There are many locations with more than 3 successive defective fastenings.
- As shown in Table 2.3.5, the rates of defective devices range between 29% and 55%, which implies that the maintenance works might most probably have not been carried out thoroughly throughout the section.
- Japanese Standard regulates the rate of defective fasting devices to be less than 5 %.
- As shown in Photo 2.3.19, more than half of the defective devices are under the condition that the shank spike was uplifted from the sleeper and thus not properly functioning.
- Uplifted shank spikes have to be hammered down to the normal positions. However, hammering down the uplifted shank spikes cannot be done at the locations where the depth of the spike hole in the sleeper is not adequate and thus the shape of the bottom of the shank spike became rounded (Photo 2.3.20). In such a case, it is required to make the spike hole deep enough by auguring, and then hammer down the shank spike, or use dog spikes instead.
- As shown in Figure 2.3.6, the resultant force of the wheel load (16 ton / 2 = 8 ton) and the lateral force (approx. max. 6 tons at sharp curves) on the rails prevents the rails from moving outside of the normal position. A derailment would happen if the dynamic movement of the train increases due to the expansion of the track gauge. Therefore, it is recommended that the repair of the defective fasting devices throughout the entire sections be carried out immediately in case such are found.



(Source: JICA Study Team)

Figure 2.3.6 Forces Acting on the Rail

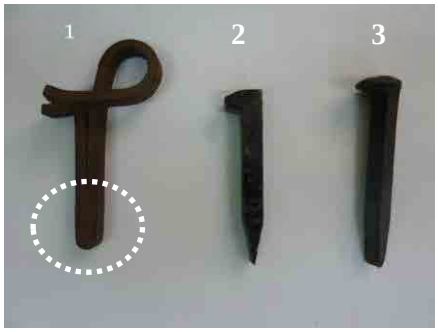


(Source: JICA Study Team)

Photo 2.3.39 Missing Fasting Devices

(Source: JICA Study Team)

Photo 2.3.40 Uplifted Shank Spike



1. Shank Spike
2. Dog Spike (Ghana)
3. Dog Spike (Japan)

(Source: JICA Study Team)

Photo 2.3.41 3 Types of Fasting Devices

Table 2.3.5 Result of Rate of Defective Fastening Devices

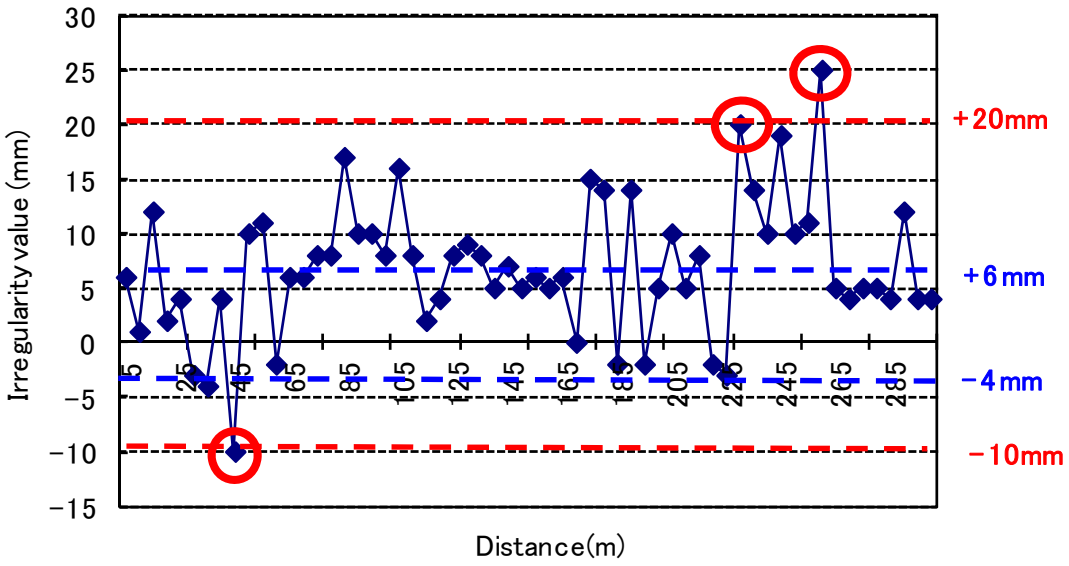
	Section	Number of total fastening devices	Number of defective fastening devices	Defective Rate (%)
Takoradi - Nsuta	Kojokrom - Angu	840	336	40
	Benso - Esuaso(No.1)	400	196	41
	Benso - Esuaso(No.2)	332	173	52
	Bonsawire - Nsuta	360	103	29
North of Nsuta	Huni Valley - Kuranti	560	194	40
	Imbraim - Buabin(No.1)	456	251	55
	Imbraim - Buabin(No.2)	612	238	39

(Source: JICA Study Team)

3) Gauge Irregularity

- Figure 2.3.6 shows the result of the investigation of gauge irregularity in the section Bonsawire – Nsuta, and that indicates that gauge tends to expand on the whole. This is a similar tendency in the other sections measured. Then, there are many points that exceed the normal maintenance limit, +6mm or -4mm and there are three points that exceed the urgent maintenance limit, +20mm or -10mm.

- Table 2.3.6 shows locations of measured gauge irregularity beyond the urgent maintenance limit, +20mm or -10mm.
- When the track gauge is reduced, it will reduce the tolerance relative to the wheel spacing of the rolling stock. When the track gauge is expanded, it will increase oscillation of the rolling stock. Because both cases increase the risk of derailment, track maintenance must be done with care.



(Source: JICA Study Team)

Figure 2.3.7 The Result of Gauge Irregularity Investigation (Bonsawire - Nsuta)

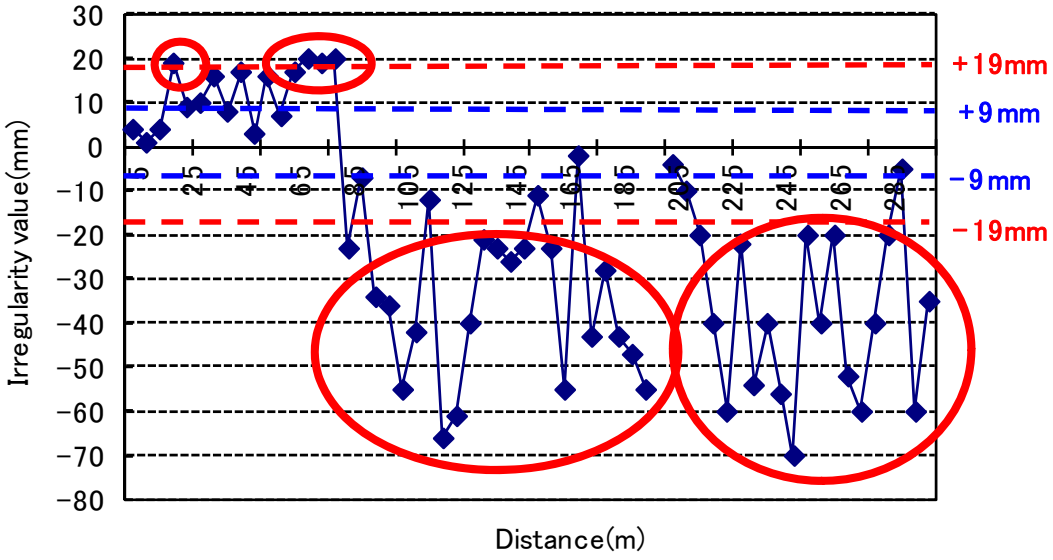
Table 2.3.6 The Result of Measurement of Track Deviation

	Section	investigation date	Track deviation(mm)	
			More than +20mm	More than -10mm
Takoradi - Nsuta	Kojokrom - Angu	25/May/2012	—	-22,-21, -12
	Benso - Esuaso (No.1)	1/Nov/2012	—	-17,-14, -13
	Benso - Esuaso (No.2)	〃	—	-22, -12
	Bonsowire - Nsuta	27/Apr/2012	25,20	-10
North of Nsuta	Huni Valley - Kuranti	18/Oct/2012	20	-10
	Imbraim - Buabin (No.1)	1/May/2012	24,20	—
	Imbraim - Buabin (No.2)	2/May/2012	22	—

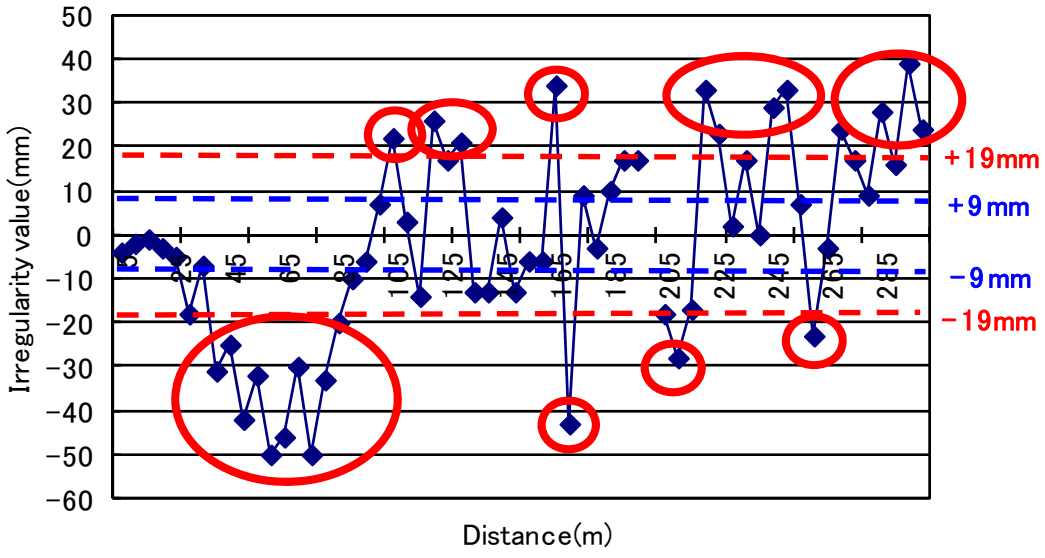
(Source: JICA Study Team)

4) Level, Cross Level, Alignment, Twist

- Figure 2.3.8 shows the result of the track irregularity investigation in the section Bonsawire – Nsuta, and there are many points that exceed the urgent maintenance limit, +19mm or -19mm.
- The numbers of the points which exceed the urgent maintenance limit are shown in the Table 2.3.7. Many points exceed the urgent maintenance limit in all the sections measured. The track repair work should be implemented immediately, considering the high possibility of accidents such as derailment.



(a) Rail Level Irregularity (Right-side Rail)



(b) Line Irregularity (Right-side Rail)

(Source: JICA Study Team)

Figure 2.3.8 The Result of Track Irregularity Investigation (Bonsawire – Nsuta)

Table 2.3.7 The Number of Points Exceeding the Urgent Maintenance Limit

	Section	Alignment (nos.)		Cross Level (nos.)		Twist (nos.)
		Left	Right	Left	Right	
Takoradi - Nsuta	Kojokrom - Angu	1	1	0	2	0
	Benso - Esuaso(No.1)	0	0	6	2	0
	Benso - Esuaso(No.2)	0	0	2	5	4
	Bonsowire - Nsuta	3	Over 20	1	Over 20	4
North of Nsuta	Huni Valley - Kuranti	0	0	1	1	0
	Imbraim - Buabi(No.1)	9	8	3	10	8
	Imbraim - Buabi(No.2)	2	6	7	Over 10	6

(Source: JICA Study Team)

5) Other Concerns

a) Wheel Burn

The train runs because the frictional force between the locomotive wheels and the rails transmits traction to the freight wagons. When the frictional force of the rails relative to the wheels of the freight wagon groups is greater than that relative to the locomotive wheels, the locomotive wheels slip and fail to roll forward. These slips are called “Wheel Slip”. When this occurs, it causes a change in the rail structure due to rapid heating and cooling of the rail head surface, resulting in wheel burn.

Wheel burns have occurred everywhere, and in certain locations, wheel burns were so large that the depression in the rail level was as much as about 3 mm as is shown in the photo. (See Photo 2.3.21.)

If left unattended, large wheel burns with a substantial dip in the rail, may soon develop into rail damage that could cause train derailment.

(Source: JICA Study Team)

Photo 2.3.42 Wheel Burn(Kojokrom - Angu)

b) Excessive Joint Gap

When a train runs and stops, the frictional force between the rails and sleepers and between the rails and rail fastenings resists the frictional force between the wheels and the rails. If excessive frictional force occurs between the wheels and the rails, the rails move in the direction, of motion which is called “Rail Creep.” This will always occur as long as the train is operated. Cumulative rail movement creates excessive joint gaps as shown in 2.3.22 and 2.3.23.

If left unattended, excessive joint gaps contribute to increased impacts due to wheels dropping. This leads to rail damage and finally to derailment. It is therefore essential to restore rail joints to specified levels.

(Source: JICA Study Team)

Photo 2.3.43 Excessive Joint Gap beyond 130mm (Kojokrom - Angu)

(Source: JICA Study Team)

Photo 2.3.44 Broken Rail End at the Joint (Kojokrom - Angu)

c) Extremely Short Rail

Photo 2.3.24 shows the fastening of the fish plate with bolts through bolt holes opened in the extremely short rail inserted into an excessive joint gap. The plate is fastened to the main rails with one bolt. Many fish plates are fastened in a similar manner. Since joints are weak spots, the normal practice is to design the fastening with a fish plate using four bolts to ensure safety.

The method shown in Photo 2.3.24 worsens the situation by further weakening the already weak joint structures. This can lead to damage to the rail or fish plate at the joints. It is essential to restore the normal joint structure as soon as possible.

d) Lack of Fish Bolt and Loosening Nuts

As shown in Photo 2.3.25, one fish bolt was missing from the outside rail and the nut for the fish bolt for the inside rail was loose. Similar defects were observed in many places and should be corrected to the normal joint structure as soon as possible.

(Source: JICA Study Team)

Photo 2.3.45 Extremely Short Rail in the Joint Gap (Dunkwa - Awaso)

(Source: JICA Study Team)

Photo 2.3.46 Lack of Fish Bolt and Loosening Nut (Kojokrom - Angu)

e) Mud Pumping

Where drainage is poor in the station yard, a phenomenon (called the mud pumping phenomenon) occurs in which roadbed soil is blown together with muddy water. This was observed in a few places.

(Source: JICA Study Team)

Photo 2.3.47 Mud Pumping (Manso Station)

6) Supporting Power of Track

In October, 2012, a driving test was conducted using new ore freight wagons imported from India. Damage to rails occurred in many cases in the course of the test. GRCL's analysis suggested that the damage occurred because deteriorated track could not withstand the use of the new freight wagons. Along with the study team, GRCL conducted a survey of track capacity with this situation in mind.

a) Prerequisite for the Calculation

A prerequisite for the site investigation is as follows:

- Type of Rail: 80lb (R), 40kg / m
- Distance between Sleepers: 720mm as an assumption from the result of the site investigation for defective sleepers (1380 sleepers / km)

- Thickness of ballast,: 30cm
- Specifications of Locomotive: Type 1670 as used for traction of new freight cars

b) Result of the Calculation

The calculation results showed no problem in terms of track capacity because the safety factor of the sleepers was 4.5 and that of the roadbed was 1.5.

The damage to the rails occurring during the test is considered to have been due to the following: At points where the rail gap was excessive, as shown in Photos 2.3.22 and 2.3.23, the wheels run down into the rail gaps directly with such impact as to damage the rail edges. Since the capacity of the sleepers and roadbed is satisfactory, the problem of damage to the rails may be removed if the rail gaps can be returned to the specified level (about 10 to 20 mm).

(4) Consideration of the Investigating: the Relationship of Gauge Irregularity to Derailment

The number of derailments occurring in each section between stations during the 2004 – 2008 period and the results of the site survey work described in 1) to 4) above are summarized in Table 2.3.8. It is difficult to derive a relationship between the track condition and derailments from the survey results because the site surveys could be done only for limited, short sections. Another difficulty in reaching a conclusion on the relationship as above described was GRCL's inability to identify the exact derailment points. They could only point out that past derailment sites were between stations.

In Japan, it has been said that derailment occurs due to composite factors. Judging from the high percent of defective of sleepers and fasteners and the fact that the emergency maintenance limit has been exceeded in a large number of locations, it can at least be said that the conditions are such that derailment can happen anytime on Ghana railways.

Table 2.3.8 Summary of Investigation

Section		Nos. of Derailments from 2003 to 2008	Defective Sleepers Rate (%)	Defective Fastenings Rate (%)	Nos. of Points beyond Urgent Maintenance Limit
Takoradi - Nsuta	Kojokrom - Angu	2	6	40	7
	Benso - Esuaso(No.1)	0	41	41	8
	Benso - Esuaso(No.2)		45	52	11
	Bonsowire - Nsuta	0	33	29	Over 40
North of Nsuta	Huni Valley - Kuranti	0	19	40	2
	Imbraim - Buabi(No.1)	38	36	55	38
	Imbraim - Buabi(No.2)		12	39	Over 30

(Source: JICA Study Team)

(5) Cause Analysis of Deformation and Deficiencies

Shortage of maintenance budget which can be considered as one of the causes of obsolescence of the track is serious as mentioned above regarding the civil structures.

Shortage of maintenance budget has greatly affected track maintenance works: e.g. it is difficult to purchase the required quantity of necessary materials such as rails, sleepers and others, and to repair tools/ equipment for track maintenance works such as cutting/welding rails, drilling sleepers and tamping ballast and gang trolleys to transport workers and materials/equipment to the site.

Track materials such as steel sleepers and shank spikes have been procured funded by an Indian loan. However, the quantity of procured steel sleeper is totally inadequate (9,600 sleepers for approx. 6km) and there are few sleepers which meet with the dimensions of the rails currently used. Therefore, those are only used for repair works of derailment accidents. In addition, although GRCL has approx. 3,000m^3 of ballast stock in Nsuta, the maintenance work cannot be implemented because the gang trolleys to transport ballast to the site are not in good condition, and tools and equipment are also broken as mentioned above. Thus, GRCL has various problems to implement the maintenance work.

2.3.4 Signals and Telecommunication

(1) Signals and Route control

There are the old semi-automatic block systems that were introduced in 1983. But they are out of order now. The points at the stations are controlled by mechanical devices.

(2) Communication System

There are old telecommunication systems by fixed line. But they are out of order now. The communication devices are mobile phones for officials now. The blockings are done by using mobile phone.

(3) Level Crossings

The level crossings are two types, manned and unmanned. There is no way to know of an approaching train, the level crossing staff notice the approaching trains by an alarm whistle and prevent the entry of the cars.

(Source: JICA Study Team)

Photo 2.3.48 Level Crossing (manned)

(Source: JICA Study Team)

Photo 2.3.49 Level Crossing (unmanned)

2.3.5 Rolling stock

(1) Deficiency Status

The current condition of rolling stock is described in Chapter 2.1.4.

The reasons for the deterioration in rolling stock, which are out of operation, are classified into 5 types below. Most types under D) are due to A), B) & C)

A) Consumable supplies not replaced

B) Parts worn out and torn

C) Breakage by an accident

D) Corrosion, rust and ruin by long-time neglect without usage

E) Incompatibility with track condition

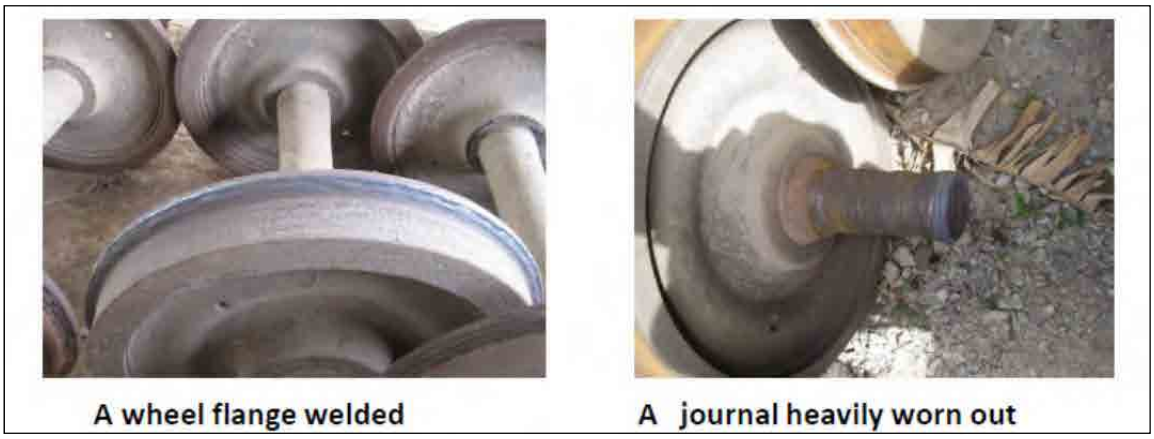
The cases such as C), D) and E) are caused by external factors. 2601 class locomotives are in the case of E) due to their heavy axle load. Freight cars, except mineral wagons and almost all passenger cars are in the case of D). Some rolling stocks are abandoned due to accident. They are in the case of C).

(Source: JICA Study Team)

Photo 2.3.50 Defective of Locomotives

For safe operation, rolling stock must possess at least three basic functions, power system to move, brake system to stop, and running gear to control movement. These are, so to speak, the key regions for safe train operation. Among them, the power system is equipped to locomotives only.

In the current situation of Ghana railway, wheels are key items for the operation of locomotives and break system, wheels and axles are those for freight wagons.



(Source: JICA Study Team)

Photo 2.3.51 Defective of Wagons

(2) Analysis of Cause

Considering maintenance as a production activity, the causes of rolling stock deterioration would be analysed from the viewpoint of **4M**, **Man**, **Machine**, **Material** and **Method**, which are 4 factors affecting production activity.

1) Man

There are no definite rules in GRCL which prescribe requirements, skill capacity, or training & education system of employees concerned. It was not noticed that any training was practiced. It may be because the lack of budget makes the training impossible. As far as appearances go, the employees have enough skill to provide proper maintenance work at this stage. However, aging of the employees is proceeding and the lack of budget and spare parts is reducing maintenance work. Skill retention will be a serious problem in the long term.

(Source: JICA Study Team)

Photo 2.3.52 Maintenance Work at Location W.S

2) Machine

There used to be a variety of maintenance equipment, including sophisticated machines. Most of the maintenance machines have been abandoned and only indispensable ones such as cranes, lathe and wheel lathe are maintained for use, but they are in bad condition.

Maintenance facilities should be kept in good condition so that they can be used whenever they need to be used. That is the reason preventive maintenance and daily maintenance systems should be adopted. However maintenance of the machines has rarely been practiced due to the lack of maintenance budget and severe shortage of consumable goods, even oil and grease. They are only just kept in operation.

(Source: JICA Study Team)

Photo 2.3.53 Maintenance Machines Working at Location W.S

3) Material

Rolling stock should normally be in a working state in comparison with civil facilities, the normal state of which is static. Consumable goods such as grease, filters and spare parts such as bearings and wheels, which are worn out while working are indispensable for rolling stock. Therefore a parts supply system composed of 2 stratums, stock in warehouse and stock on site, should be adopted. However an ex-post order system is necessary in GRCL due to the lack of a valid budget system. Many spare parts require a long time between order and a delivery, so the rolling stock must be out of service for a long time.

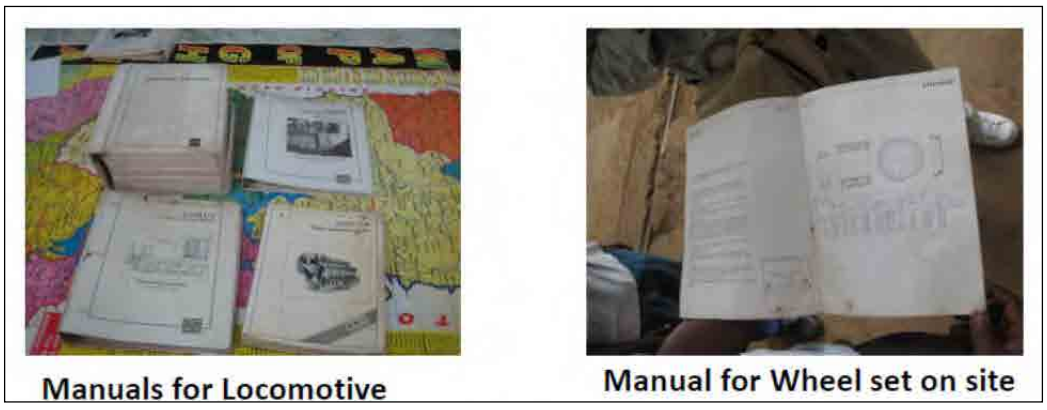
Material management has not only a quantity control function but also a quality control function. It is one of the important roles to keep stocks in good condition. As far as observing the shed of Tema line, quality control is poor and spare parts are placed on a dusty shelf.

(Source: JICA Study Team)

Photo 2.3.54 Current Status of Stock Parts

4) Method

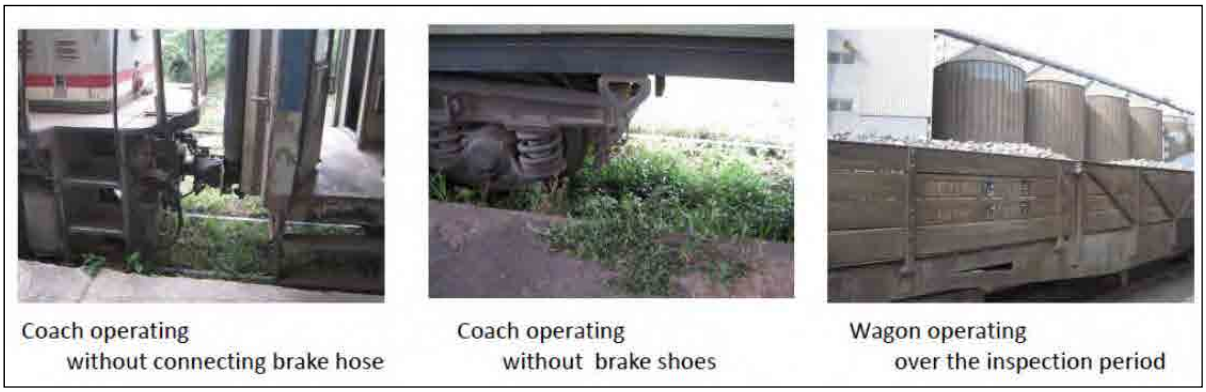
Method means establishment and implementation of a maintenance system, maintenance rules and manuals. Accidents and failures of Rolling stock might cause a fatal accident, so a preventive maintenance (PM) system is ordinarily adopted. GRCL has also established the rules that prescribed the maintenance system based on PM, composed of daily inspection, weekly inspection, monthly inspection and overhaul. The period between inspections, implementation site and responsibility seem to be prescribed in rules that the study team couldn't check. The maintenance manuals are provided from each supplier in the same way developing countries usually do.



(Source: JICA Study Team)

Photo 2.3.55 Examples of Maintenance Manuals

However implementation of PM is not sufficient due to the lack of budget and spare parts. Sometimes rolling stock and trains without brake hoses or brake shoes are operating beyond the maintenance period. In actual fact GRCL is obliged to accept break down maintenance against the rules.



(Source: JICA Study Team)

Photo 2.3.56 Examples against the Rule

Up to here, the analysis from the view point of 4M has been described and the absolute lack of budget expenditure is behind all these factors. Insufficient maintenance, which resulted from the lack of budget expenditure, causes frequent accidents, resulting in reduction of income and increase in expense. This is a vicious downward spiral. Deterioration of track accelerates wear and tear of wheels, and that of rolling stock accelerates that of track also. The relation between rolling stock and track has been trapped in another vicious cycle.

GRCL has been trapped in two types of vicious downward spirals. GRCL needs to eject from these vicious cycles.

Chapter 3 Setting Improvement Goal

3.1 Sharing the Recognition of the Present Situation and Challenges with GRDA/GRCL

The biggest issue is that many derailments occur and traffic volume of manganese and bauxite has decreased because the maintenance budget for procuring spare-parts and repairing equipment ran out and maintenance of railway assets is not sufficient.

GRCL still had approx. 2,200 employees in 2012, but fare revenue, GHC 4.5 million in 2011, doesn't cover their wages and salary, which is GHC 7.11 million. Then, GRCL received budgetary support from the Government, which is GHC 6.84 million and much of it is spent on wages and salary. As a result, budget for maintenance is not sufficient.

Due to deterioration of facilities and rolling stock and the occurrence of labour issues, annual traffic volume of manganese decreased from 1.2 million tons in the peak (2003 to 2006) to 65,000 tons in 2009. And bauxite transportation was suspended in May, 2011. Fare revenue decreased from GHC 82 billion1 (US$ 9.1 million) to GHC 1.7 million (US$ 1.2 million) in 2009. After 2009, since the labour issues were resolved and track material and wagons were procured using an Indian loan, manganese transportation recovered to 64,000 tons of traffic volume and to US$ 3.3 million of fare revenue in 2012. However, the condition of the facilities and rolling stock has not sufficiently improved, and traffic volume is only about half of the amount 10 years ago.

Both GRDA, the assets owner, and GRCL, the operation and maintenance entity, recognize that lack of maintenance budget is one of the causes of facilities and rolling stock deterioration and they are requesting for budgetary allocation for maintenance from the Government (Ministry of Transport and Ministry of Finance and Economic Planning).

This budgetary request is intended to increase annual traffic volume from 64 thousand tons in the present to 1.2 million tons through safe operation of the manganese trains between Takoradi and Nsuta in the Western Line. This can be considered an urgent and very important project for improvement of the financial status of GRCL and the economic development of Ghana. In addition, this project is expected to produce highly effective results with minimum cost.

Based on this situation, analysis of the current situation, issues and measures are shown as follows:

3.1.1 Organization

(1) Present Situation and Issues

1) Organization Structure

According to the Railway Act 2008 GRDA is the administrator of the railway assets and grants licenses, concessions and leases to Operators and the Operators carry out railway services. GRCL

[1] *Redenomination was carried out in 2007 and the new cedi was introduced. Exchange rate in 2005 was US$ 1.00 = GHC 9,020 (OANDA http://www.oanda.com/lang/ja/currency/converter/）.*

is the entity that has tentatively inherited the railway services until a private operator takes part in the railway services. Although GRCL is the official railway operator in Ghana, it is a non-registered entity that has not entered into a contract with GRDA.

2) Budget for Maintenance

Before 2008, revenue from manganese and bauxite transportation accounted for more than 70 % of GRCL revenue. Since that time, wages and salary for employees' accounts for nearly 50% of expenses and the amount for maintenance was only a few percent of the expenses. This trend has not changed since 2009 when GRCL began to receive the budgetary support from the Government. A chronic shortage of maintenance budget has also affected the repair of broken equipment and the procurement of spare parts.

3) Procurement Procedure for Maintenance Equipment and Spare Parts

Since GRCL is a public company and does not have sufficient budget, the Procurement Act has seldom been applied. Therefore, the Government authorities' approvals are required to procure equipment and spare parts. This approval process is complicated and takes much time. As a result, requests from each section of GRCL do not receive enough approval and appropriate maintenance cannot be carried out.

In addition, the Procurement Act was enforced in 2003, but it has not been revised after redenomination of the Ghana Cedi in 2007. So, there is also an issue that it is not based on the present currency values such as the amount of money for equipment and spare parts that GRCL can procure by the approval of itself self-settlement, which is less than GHC 5,000 (approx. US$2,500).

4) Personnel Composition

The total number of GRCL employees was 2,128 persons as of May 2012. 45 years old or above account for about 80% of the all employees. This indicates an aging staff. It is said however, that GRCL executives are ready to implement various plans for the reduction in personnel. Due to various factors, it is not yet definite what plan will be applied in the future. Moreover, for more than a decade, no new employees have been hired, and no reinforcement with younger workers has been made. As a result, there are no employees in their twenties. If this situation persists, the railway technologies and experiences of the current staff may not be satisfactorily passed on.

5) Motivation of Staff

Due to lack of maintenance budget, GRCL cannot repair equipment or carry out proper maintenance. On the other hand, there are some works using only man-power, such as excavation of drainage systems buried in the soil and cutting grass in the tracks. It is very important to undertake such daily work without using machines to maintain good condition of the facilities. But, the motivation of staff seems low and they don't seem to carry out these works positively.

1) Document Management

Each division of GRCL has a small number of computers and document management is implemented without much use of computers, but basically by conventional means. Since they don't have documentation manuals, the contents of documents may be different by the author and necessary matters may not be described.

Moreover, there are missing documents and drawings because no document management system has been established and the system for administration and storage of documents and drawings is not clear.

(2) Measures

1) Organization Structure

It is necessary that GRCL executes a contract with GRDA as an operator. By entering into a contract, ownership of assets and the role of maintenance will be clear and proper maintenance can be carried out.

2) Budget for Maintenance

GRCL should improve its financial structure in order to secure maintenance budget. For urgent maintenance work, it also requires support from the Government. In order to secure the budget from the Government, GRCL should make a concrete action plan and should proceed to consult with the relevant Ministries and GRDA.

3) Procurement Procedure for Maintenance Equipment and Spare Parts

By avoiding complicated procurement processes, GRCL should secure sufficient budget for maintenance in order to procure equipment and spare-parts in good time. For this purpose, we consider that GRCL should improve its earning capacity such as new business development in addition to manganese and bauxite transportation, and enter into partnership with other private organizations.

4) Document Management

It is desirable that GRCL establish a documentation manual and management system for the train operation records, the inspection record drawings and so on. At first, a unified format for train operation records, inspection records and accident records should be prepared, and a system to clarify the persons in charge and management representatives who cover each field should be reconstructed. At the time of reconstruction of the system, it is important to explain the system and provide training to the related division and person so that recording will be carried out continually.

5) Motivation of Staff

As one of the reasons that daily maintenance works have not been carried out, it seems that a maintenance manual hasn't been established yet. Therefore, it is required that the manuals showing the responsibility of each person in charge, timing and period of inspections are prepared. In the future, also it will be required to institute a program in which staff takes part in the maintenance works actively like an incentive such as a reward and commendation from top management.

3.1.2 Train Operation and Operation Regulation

(1) Analysis of the Present Situation and Issues

1) Speedometers

The most important matter of the train operation is speedometers being destroyed by the drivers.

This matter is described in DE-CONSUL's report in 1993. The Drivers destroyed the speedometers to conceal their incriminating records of stopping to pick up illegal passengers. This is a matter that has been admitted. All speedometers of all locomotives are left without being fixed. The maintenance of speedometers is required.

(Source: JICA Study Team)

Photo 3.1.1 Broken Speedometer (1)

(Source: JICA Study Team)

Photo 3.1.2 Broken Speedometer (2)

2) Management of the Weight Condition

The JICA Study Team implemented site surveys at the bauxite loading site at Awaso and the manganese loading site at Nsuta. There is a weighting bridge at Awaso, but it has been out of order for many years (Photo 3.1.3 and 3.1.4). There is no weighting bridge/equipment at the manganese loading site in Nsuta. The operation of loading and offloading of the manganese ore are done by manganese company's staff. GRCL does not manage the weight of the loaded wagons (Photo 3.1.5). The loading conditions on the wagons are different (Photo 3.1.6 to 3.1.8). This increases the danger of derailment due to the tilting of wagons in the curves.

(Source: JICA Study Team)

Photo 3.1.3 Bauxite Hopper (Awaso)

(Source: JICA Study Team)

Photo 3.1.4 Old Weigh Bridge (Awaso)

(Source: JICA Study Team)

Photo 3.1.5 Loading Manganese (Nsuta) (1)

(Source: JICA Study Team)

Photo 3.1.6 Loading Manganese (Nsuta) (2)

(Source: JICA Study Team)

Photo 3.1.7 Loading Manganese (3)

(Source: JICA Study Team)

Photo 3.1.8 Loading Manganese (4)

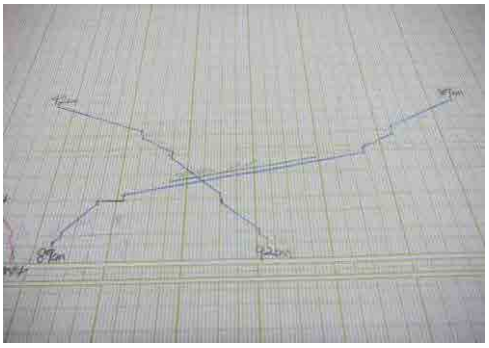
3) Wheel Slips

We were once on board a manganese train from Nsuta. We experienced wheel slips of the train as it had rained. And we saw many traces of the wheel slips during site surveys. Many wheel slips are caused by bad conditions of the track and the rolling stocks that reduce the frictional force that is ordinarily expected. When the Drivers experience wheel slips they try to recover for the delay by increasing speed and violating existing speed restrictions. And they operate the brakes excessively to decelerate. These operations increase the danger of derailment by irregular movement of the wagons and cause brake trouble too. The locos are provided with sand boxes,

but they were damaged. So, the drivers put many pebbles on the rail to generate the required frictional force (Photo 3.1.9). This causes an increase in the degradation of the tracks and the wheels and also reduces the friction force. It becomes a vicious spiral. The device that heats the sand in the running shed are left damaged as well as the sand box with the loco (Photo 3.1.14).

(Source: JICA Study Team)

Photo 3.1.9 Using Pebbles for Wheel Slips



(Source: JICA Study Team)

Photo 3.1.10 The Wheel Slip Record on the Actual Diagram

(Source: JICA Study Team)

Photo 3.1.11 Trace of the Wheel Slips on the Rail (1)

(Source: JICA Study Team)

Photo 3.1.12 Trace of the Wheel Slips on the Rail (2)

(Source: JICA Study Team)

Photo 3.1.13 Broken Sand Box

(Source: JICA Study Team)

Photo 3.1.14 Broken sand Heating Device

4) Credentials of the Drivers

There are some drivers who caused many accidents in the list handed out by GRCL. One of the reasons for the derailment is stopping to pick up illegal passengers and it also leads to delays. A national license for driving trains should be introduced in the future.

5) Inadequacy of the Accident Investigations

The condition of the tracks and rolling stocks is awful. So the causes of the accidents are easily attributed to defects in the tracks and the rolling stocks. The investigations into the causes of the accidents are inadequate because there are so many accidents and there is a shortfall in human resources in the safety section. It is hard to recommend real measures for prevention of accidents because the investigations do not reveal the background of the accidents.

3.1.3 Civil Structures

(1) Analysis of the Present Situation and Issues

All of the steel bridges between Takoradi and Awaso showed time-dependent deterioration, rust and corrosion due to high temperature and humidity. Also, cross sectional loss of members other than principal members occurred in the course of the 60 to 110 years after construction and some bridges have insufficient clearance above the river causing the main girder to be submerged when the level of flood water is high.

Emergency response work was conducted for a steel upper-deck girder close to Manso station because the abutment to support the girders on the Takoradi side had collapse due to scouring. As urgent repair work, the girder was modified by using wooden sleepers as a substructure and was reinforced by using rail girders. 10 years have passed since this bridge developed this situation, but adequate measures have not been taken yet. Therefore, a 5mile/h (approx. 8km/h) speed restriction is set up in the section before and after this bridge.

In addition, most of the ditches and some crossing culverts are in a poor state because of sedimentation. Therefore, the track is submerged after every heavy downpour.

(2) Measures

The above bridge should be adequately repaired as soon as possible. Although other bridges, embankments and cuts do not require urgent measures, GRCL should make preparations to carry out periodic inspections and repairs if necessary because of deterioration of the structures.

The ditches and culverts in which the drainage function is failing should have the sediment removed to allow free flow.

3.1.4 Tracks

(1) Analysis of the Present Situation and Issues

1) Sleepers and Fastenings

There are areas where corroded sleepers exist and there are a number of broken sleepers caused by derailment because replacement of poor sleepers has not been fully carried out. Japanese regulations provides that the ratio of poor sleepers is less than or equal to 7%. However, the ratio of poor sleepers is 6 to 45% in the sections of our site inspection. Moreover, there are a number of fastenings which are loose or missing. As a result of our site inspection, the ratio of poor fastenings is 29 to 45 %. It is not the state of a track which is maintained adequately.

2) Track Irregularities

GRCL doesn't have an elaborate maintenance reference for track irregularity (gauge, cross level, longitudinal, line and twist). However, it is important to note that if the Japanese regulations were to be applied to the result of the site inspection, places where the results exceed the urgent maintenance limit were abound. This situation indicates that a derailment could occur at any time.

3) Others

Many events that affect safe train operation can be seen, such as wheel burn on the top of the rail, excessive joint gap, extremely short rail inserted in the excessive joint gap, loosening and loss of bolts in the joints and mud pumping.

Since the condition of the gang trolleys is not good, patrols along the route and transportation of workers and equipment/materials for maintenance cannot be carried out sufficiently. Also, proper maintenance work cannot be carried out.

(2) Measures

One of the reasons that a derailment may occur at any time due to the very poor condition of the track is that maintenance regulations haven't been elaborately established. GRCL should adopt and publish an elaborate maintenance regulation that indicate the period of inspections, maintenance reference values and so on, and create a system to implement that.

In addition, GRCL should carry out realignment to proper alignment and replacement of very poor rails, sleepers, fastenings, and ballast, especially at the site where derailments have occurred frequently.

3.1.5 Rolling stock

(1) Analysis of the Current Status and Issues

As mentioned above, the key issue in performing safe operation of Ghana Railway is that regular maintenance has not been executed for a long term due to the lack of funding for maintenance works. As a result, many accidents and traffic suspensions have occurred, resulting in reducing the income and more deterioration in both rolling stock and track rails. GRCL has been trapped in a vicious downward spiral.

Additionally, deterioration of the track accelerates wear and tear of the wheels and that of the rolling stock accelerates that of the track also. The relation between rolling stock and track has been trapped in another vicious cycle.

In order to improve the current condition and resume safe operation, all parties concerned need to realize the importance of maintenance and enable GRCL to provide the minimum maintenance required. This is the only way to get out of the vicious cycles.

(2) Improvement Plan

GRCL does not have adequate income sources to provide proper maintenance, so GRCL needs to develop an effective maintenance strategy.

Considering stable income, competitiveness versus road transportation, mineral transportation, which is the only income source of GRCL now, should be given priority and maintenance should focus on the prevention of serious accidents.

3.2 Setting Goals for Safety Improvement and Enhancement of the System

GRCL has a target to transport 1.20 million tons of manganese a year as a short-term target in 2013. This target is at the same level as 10 years ago before the condition of the facilities and rolling stock had deteriorated. This target seems to be feasible to carry out early.

In the Study, we propose to develop goals for strengthening of the maintenance required for this target.

Improvement goals for each section are shown in the following:

3.2.1 Organization

Improvement goals for the organization structure are divided into short-term goals (2012 to 2013) and medium-term goals (2012 to 2015).

1) Short-Term Goals (2012 to 2013)

- To contract with GRDA as an operator
- To recruit younger professionals to take over from ageing staff the technical know-how of railway operation and maintenance
- To establish a report writing manual and document management system with the use of computers

2) Medium-Term Goals (2012 to 2015)

- To secure sufficient budget for maintenance with improvement of the finance structure
- To obtain support funding for maintenance from the Government

3.2.2 Civil Structures

Improvement goals for civil structures are shown as follows:

- To repair Manso Bridge promptly to eliminate the speed restriction
- To repair drainage systems
- To establish maintenance and inspection criteria for the soundness of structures that meet the condition of Ghana railways
- To inspect the current status of all structures between Takoradi and Nsuta and judge the soundness of the structures using the aforementioned maintenance and inspection criteria
- To repair the structures which are determined enough to require need repair promptly based on the maintenance and inspection criteria

3.2.3 Track

Replacement of rails, sleepers and ballast should be implemented in the sites that require urgent track repair works between Takoradi and Nsuta.

GRCL is planning urgent track repair works in the following sites:

Table 3.2.1 Site requiring Urgent Track Repair Works

No.	Mileage / Section	Item
1	Mile 8 - Mile 11 Angu – Kojokrom	a. Replacement of broken and rotten sleepers & old rails b. Ballasting, packing & lining c. Insertion and tightening of fasters d. Rail creep
2	Mile 34 - Mile 35 - Mile36 Bonsawaire - Nsuta	a. Replacing broken and rotten sleepers & old rails b. Ballasting, packing & lining c. Insertion and tightening of fasters
3	Kojokrom station limits	a. Desilting drains b. Replacing broken and rotten sleepers c. Track formation repairs d. Ballasting, packing & lining
4	Mile 2 - Mile 4 Takoradi - Kojokrom	a. Drainage improvement b. Replacing Broken and Rotten Sleepers
5	Mile 12 - Mile 18 Angu - Manso	a. Replacing broken and rotten sleepers b. Ballasting, packing & lining c. Insertion and tightening of fasters
6	Mile 23 - Mile 27 Amantin - Benso - Esuaso	a. Replacing broken and rotten sleepers b. Ballasting, packing & lining c. Insertion and tightening of fasters

(Source: GRCL)

In addition, the maintenance reference for tracks should be prepared by referring to Japanese regulations and a system to implement regular inspections and measurement of the tracks should be implemented. The measurement of track irregularity (gauge, cross level, longitudinal, line and twist) in the section between Takoradi and Nsuta will be carried out for the above-mentioned urgent repair works. After observing track irregularity by measurement 4 times a year, the criterion for track maintenance work will be made from the result of the measurement.

3.2.4 Rolling stock

(1) Setting Improvement Goal

The target is to maintain the minimum number of rolling stocks required in good condition in order to hold onto the manganese freight transport business which is essential for the survival of GRCL. The maintenance level is specified to prevent such fatal accidents as a derailment or a collision. Wheels, wheel sets and brake systems are selected as the target region and minimum inspections ensuring safety before the train operation should be focused on.

In the Action-plan that GRCL formulated, freight wagons with automatic air brake systems imported from India are planned to be used as much as possible and it is the first time to adopt this type of break system in GRCL. A trivial failure of this brake system would produce a lengthy traffic disruption, because it would halt train operations on the rail due to a fail-safe function in a reverse way that a failure of vacuum brake system results in an unstoppable case. That is the reason that GRCL require adequate training in examining automatic air brake systems.

(2) An Urgent Improvement Target

1) Objective

- Locomotives :9 Locos
  - 4 of the 1671 class, which are fitted with air brake systems.
  - 3 of the 1651/1661 class, which will be made available to run the 2 rakes with vacuum break wagons.
  - One 1651 class will earmarked for emergencies/ shunting duties.
  - One 1670 class will be used for offloading the manganese ore.
- Wagons: 5 rakes, 120 wagons
  - 70 new 40 ton wagons from India, which are fitted with air brake systems and will form 3 rakes.
  - 50 wagons from the existing wagons with vacuum brakes, which will form 2 rakes.

2) Selected Inspection Items :

Air brake system, Profile and Diameter of Wheel, Back gauge of Wheel set

- Air brake system:

  A failure of an air brake system would cause a derailment due to over-speed or a collision in an unstoppable case.

- Profile of wheel:

  Deterioration of wheel-profile would not only directly raise the probability of a derailment but can also cause wheel slip, skid and deterioration of the rails.

- Diameter of wheel:

  Too small wheel-diameter could cause breakage of the wheels and the use of wheels with different diameters might cause train-separation in conjunction with subsidence of the track.

- Back gauge of wheel set

  Defect of back gauge could not only directly cause a derailment but might cause a derailment in conjunction with a defect of track gauge.

3.3 Joint Workshop with Japan and India

In the Workshop on 27 September 2012, the Study Team members presented "Sharing the recognition of the present situation and challenges in GRDA/GRCL" and "Setting goals for safety improvement and enforcement systems" to share the recognition of the present situation and challenges for raising awareness among the stakeholders in Ghana. And then we confirmed the orientation to the target with them.

In addition, the Study Team invited two railway engineers from Indian Railways (RITES) into the Workshop. They presented the current situation of facilities and safety concept of Indian railways, and commented on Ghana railway from their point of view to help stakeholders understand the targeted railway technology level in Ghana for the time being.

Outline of the Workshop is shown in the following:

3.3.1 Purpose and Contents

(1) Purpose

1) Share the Information regarding the Current Situation and Issues with the Stakeholders

Based on the result of the 1st site survey, the Study Team shared the information regarding the current situation of facilities and rolling stock and related issues with stakeholders, namely GRDA, GRCL, GRDA, GRCL, the Ministry of Transport (MoT), Ministry of Finance and Economic Planning (MoFEP), and other authorities/organizations related to railway.

2) Setting Goals for Safety Improvement and Enhancement of the System

The Study Team set feasible goals which GRDA and GRCL can achieve and proposed enhancement of the maintenance management system.

(2) Contents

Outline of the presentation of the Workshop are as follows. The presentation materials of each field are shown in Appendix-4.

1) Current Situation and Issues of the Western Line (Takoradi - Tarkwa - Dunkwa - Awaso)

Current situation and issues of tracks/civil structures/rolling stock/operation, recording system of accidents/analysis of causes, organization/system of operation and management (including organization structure, budget, inventory control, development of regulations/manuals), etc.

2) Suggestions about Setting Goals for Safety Improvement and a Reinforcing System

Suggestions were given about setting goals which the Ghana Railway can actually reach such as

measures and numerical targets for reducing the number of accidents, and enforcement of operation and management systems (in terms of technical improvement, finance and organization.).

3) Introduction of Indian Railway System for Safe Operation

The methods employed in India for keeping train operation records and accident record management, system and method of analysis of railway accidents, maintenance system of tracks/civil structures/rolling stock, etc. were introduced. Main topics are as follows:

- Outline of Indian Railways
- Safety Organization and its role
- Key Drivers for Safety
- Concept of Preventive Maintenance for Diesel Locomotives, Wagons, Coaches
- Safety on Indian Railways (Civil, Track, Signalling and Telecom Infrastructure)
- Corporate Safety Plan on 2003-2013

Although frequent accidents have occurred in India once, but the accident rate has been declining sharply after the establishment of a positive maintenance plan and safety program. Therefore, in order to carry out safety train operation, the positive action by Ghana railway including the Government is required even in Ghana.

3.3.2 Participants

Participants in the Workshop were as follows:

- GRDA, Ministry of Transport (MoT) and Ministry of Finance and Economic Planning (MoFEP)
- GRCL
- Concerned authority and consultant: World Bank and Team Engineering
- Ghana Bauxite Company and Ghana Manganese Company

3.3.3 Schedule, Venue and Agenda of Workshop

Schedule, venue and agenda of the Workshop were as follows:

Table 3.3.1 Schedule of the Workshop

Date		27th September
AM	8	
	9	●9:00–9:05 Opening speech : JICA Ghana Office ●9:05–9:10 Opening speech : GRDA ●9:10–9:20 Outline of this Study ●9:20–9:50 Railway operation and organization
	10	●9:50–10:20 Train operation ●10:20–10:50 Short break
	11	●10:50–11:20 Track ●11:20–11:50 Civil structures/Bridges
	12	●11:50–12:20 Rolling stock ●12:20–13:20 Lunch break
PM	13	●13:20–13:30 Speech : JICA India office ●13:30–15:00 Introduction of Indian railway system on safety operation
	14	
	15	●15:00–15:30 Q&A ●15:30–15:40 Closing speech : JICA head office Tokyo ●15:40– Meeting with Ghana government
	16	
Site		JICA Ghana Office (Accra)

(Source: JICA Study Team)

3.3.4 Questions and Answers in the Workshop

Appendix-3 shows the Questions and Answers in the Workshop.

3.3.5 Stakeholder Meeting

After the Workshop, a stakeholder meeting was held with GRDA, GRCL, the Ministry of Transport (MoT), Ministry of Finance and Economic Planning (MoFEP), JICA Ghana Office and the JICA Study Team about maintenance budget for railway facilities and rolling stocks.

Appendix-4 shows the minutes of the stakeholder meeting.

(Source: JICA Ghana Office)

Photo 3.3.1 Mr Opoku, Ag. Chief Executive of GRDA and Mr. Inamura, Representative of JICA Ghana Office

(Source: JICA Ghana Office)

Photo 3.3.2 Participants of the Workshop (1)

(Source: JICA Ghana Office)

Photo 3.3.3 Mr. Nakamura, Team Leader of JICA Study Team

(Source: JICA Ghana Office)

Photo 3.3.4 Participants of the Workshop (2)

Chapter 4 Implementation of the Maintenance Training

4.1 Review of Action Plan (Draft Improvement Plan)

After the implementation of the Work Shop mentioned in Chapter 3, GRCL established the Action Plan; hereafter referred to as a "Draft Improvement Plan" for track maintenance and rolling stock maintenance. Contents of the Draft Improvement Plan and the results of the review by the Study Team are shown below. In addition, the Revised Improvement Plan prepared and finalized by the Study Team after reviewing the one originally prepared by GRCL, which was later submitted to GRCL, is enclosed in Appendix-5.

4.1.1 Track

(1) Contents of Draft Improvement Plan

1) Objective

Objective GRCL stated in the Draft Improvement Plan is to increase the volume of manganese ore transportation to 1,200,000 tonne in the year 2013. Various action plans required for the achievement of this objective are listed in the Draft Improvement Plan accordingly.

2) Necessary Equipment and Materials

GRCL has listed the following equipment and materials in the Draft Improvement Plan that are required for the track maintenance at highly prioritized 6 sections and the prevention against scouring of abutments at Manso Bridge.

Table 4.1.1 Equipment and Materials Listed in Draft Improvement Plan

No	Item	Quantity
1	Wooden sleeper	10,000
2	Shovel	20
3	Lease of Back Hoe	For 10 days
4	Cobblestones (8" – 10") and its transportation	60 m^3 4 trips
5	Repair of Gang Trolleys (Nos.1, 3 & 6)	3
6	Transportation of rails from Accra to Ketan Level Crossings (80A type rail)	40
7	Track Maintenance tools	1 set
8	Round logs for turnouts and bridge timber sleepers	200m^3

(Source: GRCL)

3) Method of Improvement

Implementation of track repair activities, specifically curve radius adjustment, replacement of defective sleepers, replacement of rails, replenishment of ballast as well as tamping and lining,

replacement and re-tightening of fasteners, adjustment of rail joint gap, is planned at Angu – Kojokrom section (ML8-11) that has great urgency as well as at other 5 sections.

For preventing the scouring of abutments at Manso Bridge, installation of cobblestones and gabion nets is planned.

4) Estimated Cost

The cost for the procurement of equipment and materials mentioned in 2) above is estimated at 412,280.00GHc, detailed breakdown of which is shown below:

Table 4.1.2 Estimated Cost for Procurement of Equipment and Materials

No.	Item	Quantity	UnitCost (GH¢)	Total Cost (GH¢)
1.	Wooden Sleeper	10,000 Nos.	16.00	160,000.00
2.	Shovel	20 Nos.	8.00	160.00
3.	Lease of Back Hoe	10 Days	1,000.00 (US$500.00)	10,000.00 (US$5,000.00)
4.	Cobblestones (8" – 10") Transportation cost (15m³/Trip)	60m³ 4 Trips	27.00 500.00	1,620.00 2,000.00
5.	Repair of Gang Trolleys (Nos.1, 3 & 6)	3 Nos.	4,500.00	13,500.00
6.	Transportation of Rails from Accra to Ketan Level Crossing (40 Nos. 80A)	2 Trips	-	5,000.00
7.	Track Tools	1 set (lump sum)	-	200,000.00
8.	Round logs for turnouts and bridge timber sleepers	200m^3	150.00	30,000.00
TOTAL				412,280.00

(Source: GRCL)

(2) Review of Draft Improvement Plan

Draft Maintenance Plan prepared by GRCL as the urgent action plan for maintenance activities is intended for actions at 7 specific sections. However, track conditions at entire sections between Takoradi St. and Nsuta St are in fact seriously poor and considered that urgent repair is required. Tracks are required to be maintained at uniform condition at entire sections, thus it is considered that repairing the specific sections included in the Draft Improvement Plan is not sufficient to reduce the number of derailment that have recently happened. Therefore, the Study Team recommends that the revised Improvement Plan prepared by the Study Team be adopted and the following action plans be strictly implemented:

1) Objective

Objective shall be to maintain uniform track conditions at entire sections between Takoradi St. and Nsuta St as much as possible. For this purpose, GRCL shall carry out the measurement of track irregularity and inspection of defective sleepers and fasteners between Takoradi St. and Nsuta St.

- Track irregularity : Establish a tentative track maintenance standard and repair portions where measured result exceeds the limit set in the standard
- Defective sleepers and fasteners : Carry out maintenance activities so as not to have defective sleepers and fasteners continuously for over 3 portions.

2) Equipment/Materials and Methods of Improvement

a) Implementation of Measurement of Track Irregularity and Inspection of Defective Sleepers and Fasteners

- Measurement and inspection of the section between Takoradi～Nsuta, where manganese trains are currently operating, shall be prioritized. Implementation of measurement and inspection at other sections shall be planned in consideration with the budgetary affordability and the result of measurement/inspection between Takoradi～Nsuta.
- 4 groups[1], comprising existing staff, shall be organized for the measurement of track irregularity and carry out measurement of respective sections.
- Standards for assessment of defective sleepers/fasters and track irregularity shall be established, where the standards set out by the Study Team be tentatively adopted and the standards be modified based on the result of measurement.
- For the measurement of distance between rails and track levels, 4 sets of measurement equipment procured by JICA for GRCL staff training shall be used.
- For the measurement of longitudinal level and alignment of tracks, measurement blocks made at GRCL for staff training purpose, with 10m threads shall be used. (5 sets were previously prepared for staff training.)
- It is assumed that GRCL will be able to grasp the conditions of defective sleepers and fasteners as well as the track irregularity condition by using these methods.
- Assuming that the efficiency of track measurement is roughly 250m/day per group, it can be estimated that the measurement between Takoradi St. and Nsuta St. having 70km distance can be achieved within 3 months, i.e. 70,000/(250m/day per group x 4 groups = 70 working days.
- As an alternative method, measurement can be completed within 1 week if a track measurement equipment called "Track Master" [2] widely used in every JR companies is used. If the budget can be secured, JICA Study Team recommends that GRCL carry out measurement of track irregularity periodically, say at least twice per year using the "Track Master".

[1] *There were 4 sets of available track measurement equipment provided by Study Team. 4 hand hammers for checking defective materials were prepared for the GRCL staff training class by the JICA Study Team.*

[2] *Measurement of track irregularity can be done by one staff by pushing the equipment by hand, where measurement of 10km per day is achievable. The cost of the equipment in Japan is 2,800,000 Japanese Yen.*

b) Results of Analysis of Defect Materials and Track Irregularity and Establishment of Improvement Plan with Priority

- List of defective sleepers and fasteners shall be prepared. As a tentative solution, the list showing the portions for replacement shall be prepared in such a way that one sleeper or fastener be added in portions where there are 3 continuous defective sleepers or fasteners, and two sleepers or fasteners be added where there are 5 continuous defective sleepers or fasteners, so that there will be no portion with 3 continuous defective sleepers or fasteners.
- In the analysis of track irregularity, it is necessary to set out the standards for tolerance for portions that require urgent track maintenance. Therefore, the standards for tolerance applied in Japan Railway Companies shall be used for the time being. It is highly recommended that the standards for tolerance be revised after GRCL has carried out sufficient period for measurement and inspection in future.
- Track irregularity shall be shown in graph, so that portions that exceed the limit of tolerance can be easily recognized. Prioritization shall be made based on the potions with higher deviation of twist in track irregularity and also portions with higher deviation in longitudinal level and alignment.
- Results obtained from the above analysis shall be reported to and approved by the Chief Civil Engineer.

c) Implementation of Actions in Accordance with Prioritization in Improvement Plan

- Sleepers not in use in the siding tracks at stations but with sufficient condition shall be selected and used to replace defective sleepers on mainline, since securing budget for wooden sleepers is difficult.
- Replacement of defective fasteners shall be implemented in such a way that there will be no sections with more than 3 defective fasteners.
- Dog spike instead of shank-type spring spikes currently used at many portions shall be used. This is because use of shank-type spring spikes induces up-lift force on ballasted tracks with elasticity when train passes, resulting sink at portions with wheels and rise at portions both sides with wheels. Accordingly, shank-spikes are detached upwards from rail base, which have been frequently observed at many portions on mainline. Due to this characteristic, shank-type spring spikes have not been used in Japan.
- After carrying out track repair works at portions with high priority, track irregularity shall be measured, result of which shall be reported to and approved by the Chief Civil Engineer.

3) Estimated Cost

Although the use of tie-tamper increases the workability and progress rate of track repair works described in Clause 2) above, additional budget needs to be secured for procurement of generators[3], etc. In case the budget does not allow such procurement, track repair works can be done by crowbars, hammers and beaters although the efficiency becomes lower.

4) Conclusion and Recommendation

It is observed that GRCL management staffs tend to think that nothing can be done due to budget limitation. However, as mentioned above, certain track repair works can be done with limited budget. GRCL shall make every effort to enable safe and stable train operations under the limited and tight budget situation.

4.1.2 Rolling Stock

(1) Contents of Draft Improvement Plan

1) Objective

About 60km haulage of manganese ore between Nsuta – Takoradi harbour is currently the only traffic in the GRCL freight transportation. It is expected that the traffic volume of manganese ore is increased to 1,200,000 tons in 2013, from 637,000 tons in 2012. The poor performance had been due to the frequent accidents caused by poor condition of tracks and rolling stocks as well as shortage of serviceable rolling stocks.

2) Required Number of Rolling Stocks

In order to achieve the above-mentioned objective, it is required to maintain the following number of rolling stocks in serviceable condition.

Locomotives: 9 Nos.	4 of Class 1671 (Air Brake type)
	3 of Class 1651/1661 (Vacuum Brake type)
	1 of Class 1671 and 1 of 1651 (for shunting or stand-by)
Wagons: 120 Nos. (5 rakes)	
	New wagons from India (Air Brake) 70 wagons (3 rakes)
	Conventional wagons (Vacuum Brake) 50 wagons (2 rakes)

3) Measures for Improvement

In order to achieve the above-mentioned objective, the following actions shall be taken to consistently maintain the necessary number of rolling stocks:

[3] *The price of 1 Generator and 4 tie-tampers as one set is approx.. 1,000,000 Japanese Yen.*

- Purchase necessary spare parts for locomotives and repair as and when required.
- Periodically repair wagons procured from India with the spare parts already available with sufficient quantities.
- Purchase spare parts for conventional wagons and repair as and when required.

4) Estimated Cost

(USD 1= GH¢ 2)

Item		Cost	
		GH¢	USD
Locomotive	Short Term (1 year)	1,662,643	831,321
	Medium Term (2-3 years)	615,997	307,998
	Long Term (3 years)	866,840	433,420
	Sub Total	3,145,480	1,572,740
Wagon		1,100,042	1,100,042
Total		4,245,523	4,245,523

(Source: GRCL)

(2) Review of Draft Improvement Plan

1) Objective

The annual traffic volume of 1,200,000 tons stated in the Draft Improvement Plan as an object seems to be practically achievable considering that this volume is nearly the same as the actual traffic volume of manganese ore in the period from 2003 to 2006.

2) Required Number of Rolling Stocks

In the Draft Improvement Plan, it is mentioned that 5 rakes of wagons are required to achieve the target volume based on the assumption as operating days of 284 days/year, average load of 30t/wagon and the number of wagons per train of 23 wagons. Train operation of 6.12 round trips per day will be needed to achieve the target volume under these assumptions. As 0.8 day is required for one round trip, 6.25 round trips/day will be enabled with 5 rakes of wagons. Therefore, 5 rakes as the required number to achieve the objective can be considered appropriate. In fact, it was found during the site survey that the actual number of manganese trains operated per day on days with smooth operation was 13 (6.5 round trips), which justifies the recommended number of trains at 5 rakes.

Meanwhile, the current available number of rolling stocks is 2 locomotives in shortage compared to the required number. (The number of locomotives currently available is 9, but 1 of those is in operation in Accra and another is dedicated for shunting inside depot.) This shortage of 2 locomotives can be secured if repair works will be done according to the Draft Improvement Plan. As to the wagons, it will be possible to secure the required number of wagons by utilizing the wagons procured from India.

3) Method of Improvement

Although the details of the parts list in the Draft Improvement Plan are unclear, it is observed that most of the parts required to be procured are consumables, which are indispensable for realization of safe and stable operation. The quantity of the parts mentioned in the parts list also seems to be appropriate.

However, it shall be noted that oil and grease, such as lubricating oil, and gas required for welding works are not included in the parts list, thus these shall be additionally procured for the actual implementation of repair works.

If these parts, e.g. oil, grease, and gas, can be procured, it can be considered that GRCL has sufficient capability to implement repair works of rolling stocks.

4) Estimated Cost

Cost estimate of the rolling stocks in the Draft Improvement Plan was made based on the quotations GRCL had actually obtained. Although costs for locomotive parts are classified into three categories, i.e. Short Term, Medium Term, and Long Term, classification of each part could not be made clear.

Locomotive parts cost is estimated to be approximately USD 175,000 per locomotive, which is almost equivalent to the parts cost in case of overall inspection of locomotive in Japan. Therefore, it is considered appropriate considering the current conditions of GRCL locomotives. Parts cost of wagons per car is estimated at USD 11,000, which seems appropriate.

5) Conclusion and Recommendation

Under the severe condition of railways in Ghana, it is observed that the manganese transportation is the only sustainable operation. Plans for rolling stocks proposed in the Draft Improvement Plan seem to be minimum requirement for maintaining track. Moreover, for the actual implementation of repair works, oil, grease, and gas must be procured in addition to the realization of above-mentioned plans.

However, not only the procurement of these parts, safe and stable operations cannot be achieved without adequate daily maintenance, such as “cleaning”, “lubrication (oil & grease)”, “re-tightening of bolts”, “exchange of consumables”, etc.

In conclusion, it is absolutely necessary to secure not only the transient budget as mentioned in the Draft Improvement Plan, but also necessary annual budget for the implementation of preventive maintenance activities in the defined period. Unless the above cannot be realized, the same situation, namely new rolling stocks procured with support of donor countries becoming unusable in a short time, will continue.

4.2 Maintenance Training Activities

The maintenance training activities and lectures have implemented on March 2014, aims to achieve the goal established at the Work Shop with all of participants.

The training program consists of the basic maintenance activities to improve the current condition and situation of Ghana Railway. The program contents and lecture contents are based on the review result of the draft Improvement Plan hereafter referred to as "Improvement Plan" mentioned 4.1 above, and the comments from GRDA and GRCL were referred to the contents also.

The detail of the maintenance training and lectures are stated below.

4.1.1 Organization Structure

(1) Objectives and Outline

Railway privatization and non-rail business models were presented to MOT, GRDA, and GRCL in the part of organization structure at the seminar. Vertical separation of the railway organization was adapted in 2008 in Ghana Railway, and GRDA, which owns railway asset and implements construction projects, was established at that time. On the other hand, a tender for the selection of railway operation and maintenance was implemented among private companies, but no company showed interest to participate in the tender. Therefore, for the meantime, GRCL continues to carry out operation and maintenance activities of the railway. This means that the true privatization of railway section has not been realized yet.

Considering such situation, past experiences in Japan were introduced at the seminar to help representatives of Ghana railway understand the basis of railway privatization, non-rail business, and land development along railway corridor.

1) Railway Privatization

Former Japanese National Railway had many issues, such as excessive number of personnel, huge debt, many accidents, and poor service to railway users. Such situation is similar to the present situation of Ghana railway.

In the seminar, issues, process, solution, finance, service level, result of privatization experience in Japan and other countries were introduced and exchange of the opinions among participant were vigorously worked out. Each country has had a unique railway privatization scheme and the case studies were very much useful for future privatization implementation in Ghana.

2) Non-Rail Business

Income of Ghana Railway largely depends on revenue from manganese transportation at the moment. However, it does not cover costs of operation and maintenance of railway operations including passenger trains, and consequently GRCL relies on subsidy from Government to compensate the deficiency for maintaining railway operations.

Since non-rail business model is very helpful for increasing income to railway operators, some cases in Japan were introduced to GRCL, and discussions were made to seek possibility of such non-rail business in Ghana railway to reform its financial structure.

3) Development along Railway Corridor

Development along railway corridor is expected to contribute to increase in revenue from railway operations due to increased ridership. Cases of development along railway corridor together with development of railway itself by some Japanese railway operators were introduced to GRCL. In addition, applicability to Ghana railway was discussed among participants, and JICA Study Team made suggestions to GRCL regarding measures in urban railway development in Ghana.

(2) Participant

A list of participants in the training is described as below.

	NAME	POSITION
1	ALEX N. BOATENG	TRAFFIC CONTROL (GRCL)
2	ALEX K. LAMPTEY	AREA MECH./ELEC.ENG (GRCL)
3	ARTHUR-MENDS ANTHONY	ASST.TRAFFIC MANAGER (GRCL)
4	IBRAHM NII-DJANIE KOTEY	SGNAL&TELECOMS ENG. (GRCL)
5	A.A.SADIQUE	CHIEF EXECUTIVE (GRDA)
6	KOBINA GRANT BINEY	P.A.M. (GRCL)
7	LORD L.QUANSAH	DIRECTOR (R&A) (GRDA)
8	FRANCIS E.QUAGRAINE	AREA MANAGER, ACCRA (GRCL)
9	A.A.PREMPEH	MOT
10	EMMANUEL KWASHIE HULEPOUTI	GRCL
11	WILLIAMS K.AGYEMANG	SENIOR I.T OFFICER (GRDA)

(3) Training Schedule

Although trainings were originally planned 3 times in Accra and 2 times in Takoradi, only once at each city was finally carried out because of participants' reasons.

- March 14, 2014 (Fri) 9:00～10:30 Takoradi（GRCL Boardroom）
- March 19, 2014 (Wed) 10:00～11:30 Accra（GRDA Meeting Room）

(4) Training Contents

1. Railway Privatization

- Outline of railway privatization (objectives, advantages/disadvantages, experienced countries, implementation scheme, etc.)
- Experience in Japan (situation before privatization, basic policy of reform, outcome from privatization)

2. Non-Railway Business

- Objectives, business models, share of non-railway business in overall operation,etc.
- Cases in JR East (background, in-station business, internet-order business)
- Issues and concerns in non-railway business

3. Development along Railway Corridor

- Cases in Japan (Hankyu Railway)
- Policies in development along railway corridor (Tsukuba Express)

4. Possibility of Non-Railway Business in Ghana Railway

- Applicability of non-railway business in Ghana Railway (utilization of land and human resources)

(Source: JICA Study Team)

Photo 4.2.1 Seminar in GRCL Boardroom at Takoradi

(5) Training Result

The seminar was not directly related to safety operation of railway and the subjects presented in the seminar were not those that could be easily implemented in Ghana Railway. However, it seemed participants from Ghana Railway had serious concerns on the measures to improve present poor condition.

Majority of topics in the seminar was the introduction of cases in Japanese Railways upon request from GRDA. Considering high interests of participants this time, seminars, such as group discussions about how non-railway business and/or development along railway corridor could be implemented in Ghana Railway, overseas training in Japan, etc., may be considered as a further step.

Many questions about process in railway privatization were asked to lecturer, which implies that those in Ghana Railway were fully aware of the necessity of organizational reform as well as

financial improvement including policy and scheme on subsidy, development of laws and regulations. It is hoped that the issues presented and discussions made in the seminar could be a trigger to start studying how the current situation and organizational structure of Ghana Railway should be improved.

(6) Issues and Recommendations

GRCL largely depends on income from manganese transportation besides subsidy from the government. Such vulnerable financial situation shall be urgently improved by taking necessary measures. Reliable and efficient railway operation, railway privatization, non-railway business and development along railway corridor could be the options for such measures.

1) Reliable and Efficient Railway Operation

Present railway system has not enough capacity for demand of freight transportation especially for manganese because of frequent derailment and rolling stock trouble. Furthermore staffs of un-operated station are still working for security of station. It is a burden to GRCL financially. Revitalization is one of the solutions but it takes time. Therefore proper budget or subsidy should be secured for railway operation and maintenance continuously and employment adjustment should be moved into action for reliable freight train operation. Change for sound railway management is very urgent and absolutely necessary.

2) Railway Privatization

When GRDA was established in 2008, the number of staff was only five, and since then, the number has increased gradually. In addition, a study regarding organization reform is being carried out by the World Bank. Therefore, GRDA is expected to be the regulator of railway sector in Ghana in near future.

On the other hand, fact finding survey of GRCL employees was implemented by MOT in March 2014 and GRCL is also expected to start its reform shortly.

Although such organization reform has been proceeding step by step, superannuated railway facilities keep private sector difficult in participation in railway business. Therefore, rehabilitation of existing facilities, to increase transportation capacity is indispensable and very urgent for the realization of railway privatization.

The government should understand that the railway privatization would increase profit of the railway business, thus resulting in the reduction of subsidy from the government. Therefore, pro-active investment on railway facilities, e.g. infrastructure, rehabilitation of rolling stocks, etc., should be made.

Involvement of private sector shall not be limited to take care of not only the operation but maintenance of railway. The government should prepare legal frame for the involvement of

private sector in the field that does not influence the current implementation and organization scheme, e.g. non-railway business.

3) Non-Railway Business

Big issue of Non-Railway Business in Ghana is that the number of passengers to use is minimal. Apart from real estate business, non-railway business is intended to increase the income of railway operator by having increased railway passengers living along the railway and making profit from in-station and around-station commercial facilities at origin and destination stations of railway passengers. This means that overall income from both railway and non-railway business operation depends on the volume of railway passengers.

Another concern is how the budget can be secured for the implementation of non-railway business under the situation that the current income mainly comes from manganese transportation which does not cover the costs of overall railway operation. Therefore, securing budget for non-railway business from the current income from railway operation is not possible.

One of the options is that the government provides a fund to GRDA or GRCL for non-railway business at the beginning. However, possible schemes for start-up of small-scale non-railway business plan that can make profit to some extent shall be studied among GRDA and GRCL. Accra station is located nearby market where many people gather, thus the station has big potential for the development of commercial facilities under PPP scheme.

JR East can be a good example to Ghana Railway since non-railway business of JR East was started with minimum volume but has been gradually increased to now become one of the biggest incomes for JR East.

4) Development along Railway Corridor

As mentioned above, increasing railway passenger volume is a significant factor to increase income from non-railway business. Extension to residential area of Tema Line as a commuter line to Accra was completed last year and track rehabilitation is currently being implemented in the section of Takoradi～Kojokrom～Secondi not only for freight transportation but passenger transportation. Taking this opportunity, development along railway corridor, such as housing and commercial facilities, shall be implemented to increase railway passenger volume in this section.

Development along railway corridor cannot be made by railway operator without cooperation and collaboration with the central and local governments. Attracting the development of housing, shopping malls, factories, schools, hospitals and entertainment facilities is considered as the measure for increasing railway passenger volume. A scheme giving development rights with share of profit would attract private firms to invest in development of above mentioned facilities.

Lease of unused public land to private firms for construction and operation of commercial facilities would also enable the implementation of non-railway business without budget of railway operator.

Along with the development and operation of non-railway business, the railway operator should increase the number of train operation for convenience of users of railway and non-railway facilities. As the procurement of new rolling stocks is costly, sharing such procurement cost by both railway operator and non-railway business developers would also be a good idea.

Development along railway corridor also creates land acquisition and resettlement issues. Therefore, development of legal framework and necessary regulations is also required for efficient implementation of railway and non-railway business development at the same time, which was emphasized in the seminar.

4.1.2 Regulation for Train Operation

(1) Purpose and Outline

As a summary of the project activities, seminars related to "safe train operation" were held for railway staff in Ghana. It was intended to enhance the awareness of the necessity of safety by introducing approaches for safe and stable railway operation by railway companies in Japan.

(2) Participants

A list of participants in the training is described as below.

	NAME	POSITION
1	ALEX N. BOATENG	TRAFFIC CONTROL (GRCL)
2	STEPHEN NIMOH	SENIOR MAINLINE DRIVER (GRCL)
3	YAW TECHIE BOATENG	TRAFFIC INSPECTOR (SAFETY) (GRCL)
4	ARTHUR-MENDS ANTHONY	ASST.TRAFFIC MANAGER (GRCL)
5	IBRAHM NII-DJANIE KOTEY	SGNAL&TELECOMS ENG. (GRCL)
6	ALEX K. LAMPTEY	AREA MECH./ELEC.ENG (GRCL)
7	FREDERICK K. MENSAH	CHIEF WORKSHOP SUPERVISOR (GRCL)
8	EMMANUEL ARYEH	YARD MASTER (GRCL)
9	ANTHONY KEVIN YANFUL	WORKSHOP SUPERVISOR (GRCL)
10	SAMUEL APPIAH	CHIEF WORKSHOP SUPERVISOR (GRCL)
11	J.W.YANKSON	TRAFFIC INSPECTOR (GRCL)
12	ALBERT BONKU	LOCOMOTIVE DRIVER (GRCL)
13	T.K.DZEBU	SUPERVISOR (GRCL)
14	SOLOMON SACKEY	SIGNAL TECHNICIAN (GRCL)
15	JOHN CECIL MENSAH	SUPERVISOR (GRCL)
16	BENJAMIN B. MENSAH	SUPERVISOR (GRCL)
17	S'HAIK IDDRISU	SUPERVISOR (GRCL)
18	MOHAMMED ALI FUSEINI	STATION MANAGER (GRCL)
19	QUANSAH REYNOLDS	STATION MANAGER (GRCL)
20	THEOPHILUS TETTEH	LOCOMOTIVE DRIVER (GRCL)
21	WILLIAMS K.AGYEMANG	SENIOR I.T. OFFICER (GRCL)
22	LORD L.QUANSAH	DIRECTOR (R&A) (GRDA)

(3) Training Schedule

Seminars have held in Accra and Tackradi as shown in Table 4.2.3.

Table 4.2.1 Seminar Schedule and Number of Participants

Date	Location	Number of participant
March 20th 10:00-12:00	GRDA Meeting Room in Accra	12 people
March 21st 10:00-12:00		11 people
March 22nd 9:00-12:00	GRCL Board Room in Tackradi	14 people
March 23rd 9:00-12:00		17 people
March 24th 9:00-12:00		4 people

(Source: Study Team)

(4) Training Contents

Main subjects in the seminars are as follows. Presentation slides are attached in"Appendix-5".

- Legal frame and regulators in Japan as well as relationship among government, railway operators and railway systems manufacturers.
- Training program for train drivers in Japan
- Analysis of accident（utilization of simplified "Excel" based accident database）

(5) Result of Seminars

In every sessions in the seminars, lecturers has emphasized on "Lessons learned from past accidents, never again the same mistakes." Participants repeated these phrases to memorize them. Although similar seminars have been held several times, not only in Japan but also in other countries, such positive reaction was very rare.

Some typical questions were as follows.

Question) How does GRCL deal with those who has driver license but has failed to pass the examination?

Answer) They were employed as employees of the railway company, not exclusively as train drivers. Therefore, such persons are assigned to other workplaces where their capabilities can be fully utilized.

Question) How do you think about privatization of Ghana Railway now?

Answer) There are many problems in assets, such as track facilities and rolling stocks, that are far beyond the consideration of railway privatization. Railway operator shall make every effort to maintain stable business operation with subsidy from the government.

(Source: JICA Study Team)

Photo 4.2.2 Lecture at Accra (1)

(Source: JICA Study Team)

Photo 4.2.3 Lecture at Accra (2)

(Source: JICA Study Team)

Photo 4.2.4 Lecture and Practice with PC at Takoradi (1)

(Source: JICA Study Team)

Photo 4.2.5 Lecture and Practice with PC at Tacokadi (2)

(6) Issues and Recommendations

1) Accident Records

A method was presented to comprehensively control accident records using Excel, which is currently stored and managed by each department, was presented in the seminar. This can be easily done with the available resources without introducing database software. It is expected that persons in charge shall start reform activities with available resources.

At present, all accident records of GRCL are stored only in hardcopies. Partially due to this, some of them are unreadable due to deterioration, or some serious accidents are not properly recorded. Previous accidents have indicated the weakness of West Line, thus proper maintenance of accident records is mandatory and urgent issue for enabling safe railway operation.

2) Regulations for Drivers

In order to maintain and ensure certain level of quality of train drivers and to make them take pride in their works, it is necessary for GRDA and GRCL to consider the introduction of driver license system, which needs to be updated every three years. Since there is a tendency for some drivers to cause more accidents than others, a monitoring of drivers' quality by official license system should be made. In order to raise awareness of workplace discipline, it is important not only to establish rules and regulations, such as work rules, but also to require the wear of uniforms for the staff. Considering the fact that the willingness of trainees during the training was increased by providing protection accessories, it is anticipated that the introduction of uniforms would be worthwhile.

Study Team suggests that a model line be designated, where highly skilled and motivated staffs as model staffs are selected among all employees and assigned to work in the designated line, nominate the line as an ideal line, propagandize the maintenance activities in that line with support of mass media, so that the reputation of GRCL could be increased among public with understanding of proactive actions for reforms. Then, by moving such model staff to other lines, improvement could be spread over entire lines. The Tema Line would be considered appropriate as a part of ground facilities were recently renewed in the Tema Line.

3) Prevention of Accidents at Level Crossing and Measures to Prevent Intrusion of Pedestrians into Railway Right of Way

Next, the prevention of accidents at level crossing and measures to prevent intrusion of pedestrians into railway right of way is suggested. The above 2 improvements are essential for increasing the number of train operations and train speed in near future. As the achievement of such objectives cannot be only made by the railway operator, cooperation and collaboration with traffic police, road administrator and the governmental education institutions will be required.

(Source: JICA Study Team)

Photo 4.2.6 Level Crossing over Tema Line

(Source: JICA Study Team)

Photo 4.2.7 Illegal Market in the Accra Station

5) Recommendation for "Reformation Program"

It was observed in the seminars that the participants were eager to learn a lot of things presented in the seminars, thus the atmosphere of the seminars was all good. Motivation of each participant was sufficiently high and that can be fully utilized as the basis for structural reform. Motivation of employees on top of the management policies and strategies is indispensable for the realization of safe and stable railway operation. As it seems the potential for the structural reforms is high enough, showing an appropriate reform program by the management to employees is a key for success of Ghana railway.

4.2.2 Civil Structures

(1) Purpose and Outline

Ghana railway has not carried out proper maintenance of structures and also training of engineers for maintenance activities due to continuous shortage of budget for maintenance and obsolescence in technical improvement. As a result, there has been many unsafe and insufficient structures, e.g. fallen abutments, corroded metal bridges, concrete structures with cracks, etc, which impedes safe operation of railway.

The training was intended to teach basic knowledge needed for maintenance activities under urgent situation and to show method of daily inspection and measurement as well as its recording at site. Major topics can be summarized into following 3 points.

- To learn knowledge about and method of maintenance of structures.
- To learn basic knowledge of structures
- To make participants aware of the possibility of maintenance of structures on its own if all participants proactively take actions

(2) Participant

The following tables show the list of trainees and the 5 teams-structure.

CIVIL ENGINEERING DEPARTMENT			
S/N	**STAFF NO.**	**NAME**	**STATION**
1	294256	Joseph Amanfi	Kojokom
2	292333	C.E. Acquah	Kojokom
3	291715	Thomas Quarm	Angu
4	294294	Yahaya Lakaine	Butuah
5	292157	James Afamalor	Benso
6	294152	Anthony Kojo Bissue	Harbour
7	294009	Sampson Nyame	Aboso
8	291982	Francis Baidoo	Tarkwa
9	294418	Thomas Anafo	Manso
10	292397	James Cobbinah	Accra
11	294227	Joseph Arthur	Bonsawire
12	291917	Joseph Sam	Tarkwa
13	294539	Efia Dadzie	Takoradi
14	294079	Kwame Abogye	Benso
15	291397	Richard Adama	Nsuta
16	292194	Esther Andoh	Takoradi
17	294846	Patrick Mensah	Accra
18	220097	John Mensah	Takoradi
19	292233	Anopong Sarfie	Angu
20	292116	Sylvester Banson	
21	294849	John Apagya Quayson	
22	294259	James Kofie	
23	294049	Kwame Abrugye	Benso
24	294258	Albert Andrews	Takoradi
25	294451	Emmanuel Imbeah	Accra
26	294509	J.P. Mensah	Kumasi
27	294450	Seth Amissah	Accra
28	210084	John Quaicoe	Dunkwa
29	294845	Dorothy Turkson	Kumasi
30	294387	G. Donkor	Accra

(Source: GRCL)

GROUP A

LEADER - JOHN MENSAH

ANTHONY KOJO BISSUE
ERIC DADZIE
RICHARD ADAMA
DOROTHY TURKSON

GROUP B

LEADER - JOHN A. QUAYSON

JOSEPH AMANFI
THOMAS QUARM
YAHYA ZAKARI
JOSEPH SAM (FLAG)

GROUP C

LEADER - SYLVESTER BANSON

C.E. ACQUAH
JAMES COBBINAH
JAMES AFAMALOR
THOMAS ANAFO

GROUP D

LEADER - JACOB SWANZY BAIDOO
EMMANUEL K. IMBEAH
KWAME ABOAGYE
JAMES KOFIE
ALBERT ANDREWS
S. AMISSAH
J.P. MENSAH

GROUP E

LEADER - PATRICK MENSAH
FRANCIS BAIDOO
JOSEPH ARTHUR
S. A. NYAME
G. DONKOR
A. SARFIE

(3) Training Schedule

Training Plan			12/3/2014 MIYAMOTO and OHKAWA	
		Bridge training	Track training	Remarks
March 14 (Fri)	Morning	Present conditions explanation of the Ghana and Japan bridge		Conference room
	Afternoon		Present condition of GRCL track,Temporaly criteria of defective fastening and sleeper, Measuring method of track irregularity, Track mentenance method, Track irregularity measurement training at Takoradi St.	〃
3/15(Sat)				
3/16(Sun)				
March 17 (Mon)	Morning	Team A,B,C: Field exploration,Basic Knowledge of Bridge	Team D, E : Carrying out of track irregularity measurement and inspection of defective sleepers at site	(Bridge and Track team) Neighborhood of Butuah St.
	Afternoon	Team A,B,C: Field exploration,Point and Method of Bridge Inspection	Team D, E: Ditto	〃
March 18 (Tue)	Morning	Team D,E: Field exploration,Basic Knowledge of Bridge	Team A, B,C: Carrying out of track irregularity measurement and inspection of defective sleepers at site	〃
	Afternoon	Team D,E: Field exploration,Point and Method of Bridge Inspection	Team A, B,C: Ditto	〃
March 19 (Wed)	Morning	Team A,B,C: Field exploration,Point and Method of Bridge Inspection	Team D,E : Arrangement of measured data. Picking up the section which is over the tolerable limit of urgency, Decision of the priority order of track maintenance work	(Bridge team) Neighborhood of Butuah St. (Track team) Conference room
	Afternoon	Team D,E: Field exploration,Point and Method of Bridge Inspection	Team A,B,C : Ditto	〃
March 20 (Thu)	Morning	Making of Ledger (use PC)		Conference room
	Afternoon		Arrangement of measured data. Picking up the section which is over the tolerable limit of urgency, Decision of the priority order of track maintenance work	〃
March 21 (Fri)	Morning	Team A,B,C: Field exploration,Basic Knowledge of Bridge	Team D,E : Carrying out of sleeper renewal work and tamping work at priority section and track irregularity measurement after finishing trackmaintenance work	(Bridge team) Neighborhood of Manso St. (Track team) Neighborhood of Butuah St.
	Afternoon	Team A,B,C: Field exploration,Point and Method of Bridge Inspection	Team D,E : Ditto	〃
3/22(Sat)				
3/23(Sun)				
March 24 (Mon)	Morning	Team D,E: Field exploration,Basic Knowledge of Bridge	Team A,B,C : Carrying out of sleeper renewal work and tamping work at priority section and track irregularity measurement after finishing trackmaintenance work	(Bridge team) Neighborhood of Manso St. (Track team) Neighborhood of Butuah St.
	Afternoon	Team D,E: Field exploration,Point and Method of Bridge Inspection	Team A,B,C : Ditto	〃
March 25 (Thu)	Morning	Team A,B,C: Field exploration,Point and Method of Bridge Inspection	Team D,E : Carrying out of sleeper renewal work and tamping work at priority section and track irregularity measurement after finishing trackmaintenance work	〃
	Afternoon	Team D,E: Ditto	Team A,B,C : Ditto	〃
March 26 (Wed)	Morning	About Standard design of Japan		Conference room
	Afternoon		Arrangement of measured data.	〃
March 27 (Thu)	Morning	Discussion		〃
	Afternoon	Presenting the certification to all trainees		〃

Note: 1. March 13(Thu) preparation of conference room.

2.The Class consists of 5 groups (Team A, B, C, D, E)

(Source: JICA Study Team)

(4) Training Contents

Training activities were held at Busua Bridge, Manso Bridge and conference room of GRCL Head Office in Takoradi. Participants to the training were divided into 5 teams, namely A, B, C, D and E based on their technical level, so that all participants could take both of in-room and on-site lessons in the morning and afternoon. Contents of the training are as follows.

1) Hitting Inspection of Concrete

Hitting inspection of concrete by use of inspection hammer was instructed.

- Hold hammer handle at its middle part, continuously hit narrow areas of concrete surface lightly using wrist, and hear if the sound is high or low, where high sound indicates normal condition and low sound indicates possibility of deformation.
- Mark deformed portions by chalk, measure dimensions in mm by scale and take photos with camera.
- Instruct in case there are any concrete that has possibility of detachment

(Source: JICA Study Team)

Photo 4.2.8 Hitting Inspection (1)

(Source: JICA Study Team)

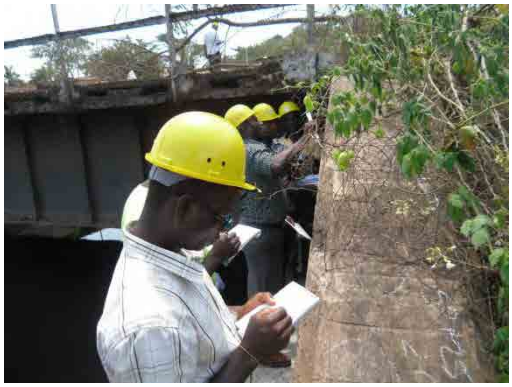
Photo 4.2.9 Hitting Inspection (2)

(Source: JICA Study Team)

Photo 4.2.10 Marking (1)

(Source: JICA Study Team)

Photo 4.2.11 Marking (2)



(Source: JICA Study Team)

Photo 4.2.12 Recode of Inspection Result (1)

(Source: JICA Study Team)

Photo 4.2.13 Recode of Inspection Result (2)

2) Measurement of Cracks

Method of measurement of cracks in width and length using crack gauge and scale was instructed.

- Write crack line by chalk and measure crack width by crack gauge in mm, then take photos with camera

(Source: JICA Study Team)

Photo 4.2.14 Measurement by Crack Gauge (1)

(Source: JICA Study Team)

Photo 4.2.15 Measurement by Crack Gauge (2)

(Source: JICA Study Team)

Photo 4.2.16 Measurement of Beam Height

(Source: JICA Study Team)

Photo 4.2.17 Record of Measurement of Beam Height

3) Measurement of Steel Beam Thickness

Method of measurement of thickness of steel beam using caliper was instructed.

(Source: JICA Study Team)

Photo 4.2.18 Thickness Measurement by Caliper (1)

(Source: JICA Study Team)

Photo 4.2.19 Thickness Measurement by Caliper (2)

(Source: JICA Study Team)

Photo 4.2.20 Lecture of Usage of Caliper (1)

(Source: JICA Study Team)

Photo 4.2.21 Lecture of Usage of Caliper (2)

4) Measurement of Span Length and Beam Height of Superstructure

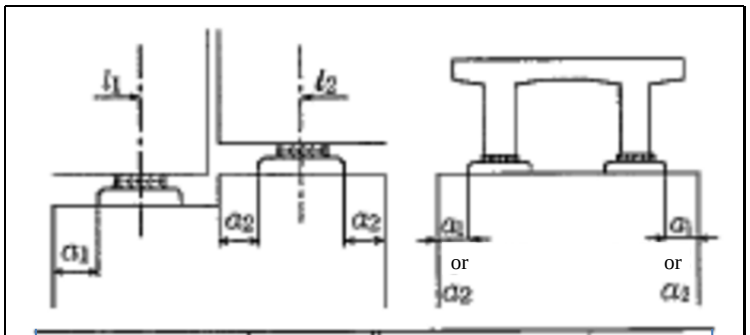
It was found at the beginning that there are some participants who did not have basic understanding of bridge structure, e.g. the definition of span length, beam height, etc. During the training, method of measurement of span length to obtain width of bearing is trained.

(Source: JICA Study Team)

Photo 4.2.22 Measurement of Span Length

(Source: JICA Study Team)

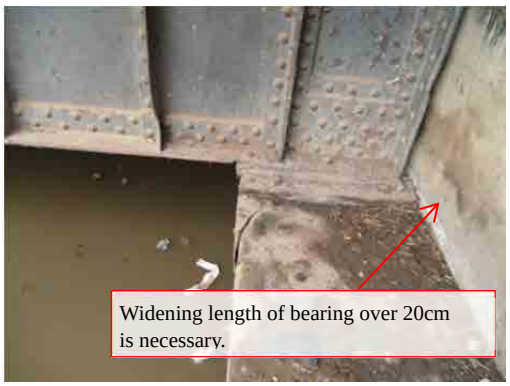
Photo 4.2.23 Measurement of Beam Height



span l_1(m)	a_1(mm)	span l_2(m)	a_2(mm)
$l_1 < 15$	150	$l_2 < 15$	150
$15 \leqq l_1 < 20$	200	$15 \leqq l_2 < 20$	200
$20 \leqq l_1 < 30$	250	$20 \leqq l_2 < 30$	250
$30 \leqq l_1 < 40$	350	$30 \leqq l_2 < 40$	350
$l_1 \geqq 40$	400	$l_2 \geqq 40$	400

Figure 4.2.1 Distance from Most Outside Line of Support to Bearing End

It was explained that width of bearing over 20cm is necessary because span length of Busua bridge is 15cm , which is in the range of l1<20 shown in the table.



(Source: JICA Study Team)

Photo 4.2.24 Busua Bridge

5) Safety Management during Site Training

Trainees wore helmet, safe vest, long sleeves shirt, clodhopper and working gloves while working at site.

(Source: JICA Study Team)

Photo 4.2.25 Lecture of the Need to Take on Helmet

It was instructed to trainees that one person should always hold the ladder when another climbs up and down

(Source: JICA Study Team)

Photo 4.2.26 Teaching of Safety Keeping

6) Presentation among Group Members

Trainees who have already learned the method of measurement of structures have provided training to those who did not in order to enhance mutual understanding.

(Source: JICA Study Team)

Photo 4.2.27 Training with Trainee Each Other (1)

(Source: JICA Study Team)

Photo 4.2.28 Training with Trainee Each Other (2)

(Source: JICA Study Team)

Photo 4.2.29 Training with Trainee Each Other (3)

(Source: JICA Study Team)

Photo 4.2.30 Training with Trainee Each Other (4)

7) Introduction of Japanese Cases and Comparison with Current Situation of Ghana Railway

In Ghana, progress ion of corrosion of steel bridge has been a serious situation due to lack of maintenance for a long period.

(Source: JICA Study Team)

Photo 4.2.31 Steel Beam of Busua Bridge

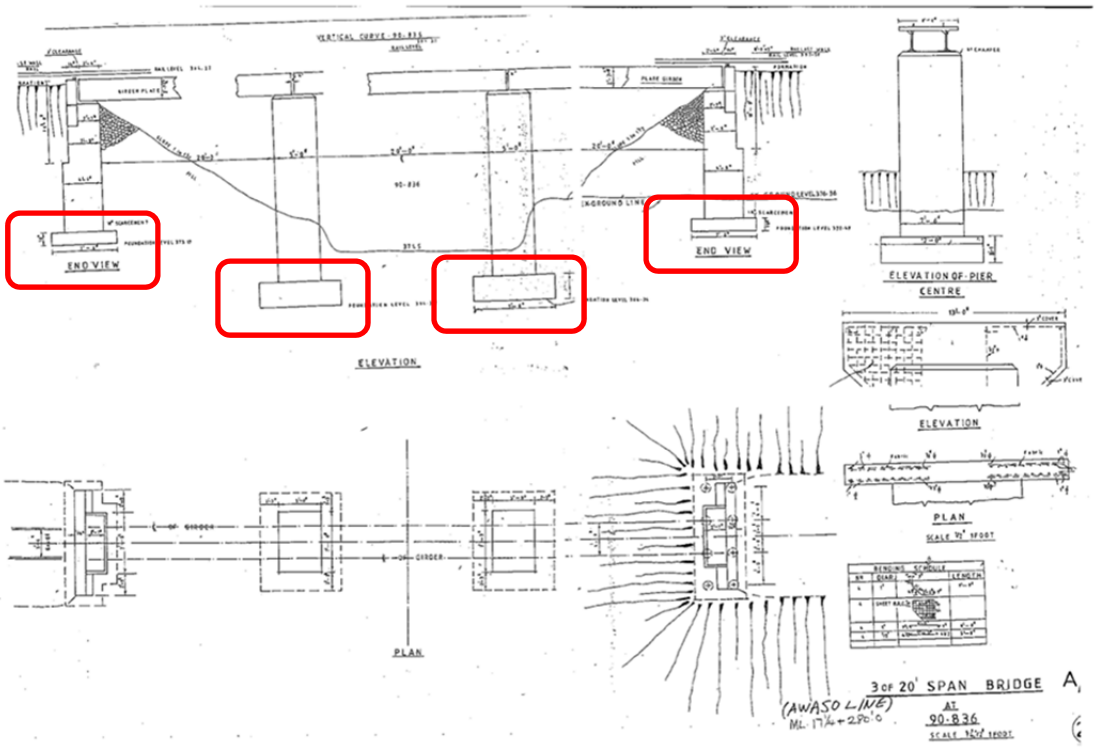
(Source: JICA Study Team)

Photo 4.2.32 Steel Beam of Busua Bridge

(Source: JICA Study Team)

Photo 4.2.33 Japanese Bridge

Japanese steel bridges are regularly painted, which results in maintaining healthy condition. This implies how important regular inspection and continuous maintenance is. It was found out from design drawings of bridge structures in Ghana that the width of foundations tends to be narrow compared to the height of structure, which could be considered unstable for fall, sliding and subsidence.



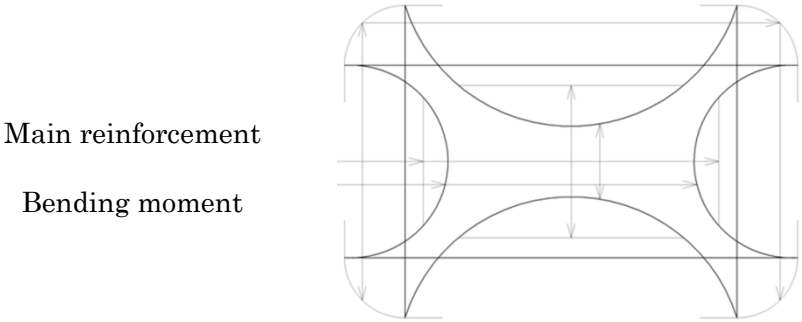
(Source: GRCL)

Figure 4.2.2 Design of Bridge in Ghana

Taking an example of the box culvert nearby Busua Station, explanation was made regarding the relation of positions of tension side and compression side. It is necessary to arrange many steel bars at tension side because concrete is weaker in tension but steel bars are stronger in tension. It was also explained that substructure consisted of plane concrete and structurally weak.

(Source: JICA Study Team)

Photo 4.2.34 Box Culvert in the Suburbs of Busua



(Source: JICA Study Team)

Figure 4.2.3 Main Reinforcement and Bending Moment

Next, temporary structures for inspection in Japan were introduced, then trainees were asked to come up with suitable temporary structures for railways in Ghana.

(Source: JICA Study Team)

Photo 4.2.35 Stage in Japan (1)

(Source: JICA Study Team)

Photo 4.2.36 Stage in Japan (2)

(Source: JICA Study Team)

Photo 4.2.37 Retaining Wall Foundation be Scoured in Ghana

(Source: JICA Study Team)

Photo 4.2.38 Japanese Bridge be Foot Protected

8) Basic Knowledge of Bridge Structure

As mentioned above, there were some participants who did not sufficient basic knowledge of bridge structure. Therefore, basic knowledge of bridge structures was lectured. Below are the contents of the lecture :

- A bridge consists of superstructure and substructure.
- There are various types in superstructure, such as steel girder, PC girder and RC girder.
- Substructure consists of pier and abutment, where foundation structure could be pile foundation, caisson foundation or spread foundation.
- Length in bridge structures, e.g. bridge length, effective span length etc.
- Names and function of each part of superstructure and substructure.

Following points were explained in bridge inspection.

- Management of bridge is to secure safety and smooth traffic, to secure structural durability and strength etc., and to prevent from accidents and damages to third-party
- It is important to detect dangerous portions at early stage by carrying out regular inspection and repair works.
- Checkpoints in each part of bridge structures were explained.

(Source: JICA Study Team)

Photo 4.2.39 Lecture's Look at Conference Room

9) Maintenance Works

As a result of the inspection at Manso Bridge, it was confirmed that sleepers piled up to support the superstructure was subsided and thus not actually supporting it. The substructure that was built by plain concrete has collapsed due to narrow foundation width and has lost stability by scouring, etc. As trainees could not understand the reason of collapse, explanation was made about working load (train load, earth pressure, water pressure, earthquake load) and strut method as an appropriate measure.

(Source: JICA Study Team)

Photo 4.2.40 The state of the sleeper were piled up don't support upper structure (1)

(Source: JICA Study Team)

Photo 4.2.41 The state of the sleeper were piled up don't support upper structure (2)

(Source: JICA Study Team)

Photo 4.2.42 The State of the Collapsed A1 abutment (1)

(Source: JICA Study Team)

Photo 4.2.43 The State of the Collapsed A1 abutment (2)

(Source: JICA Study Team)

Photo 4.2.44 Explain about Strut Method and Training (1)

(Source: JICA Study Team)

Photo 4.2.45 Explain about Strut Method and Training (2)

10) Original Maintenance Method of Structures by Ghana Railway

As an option for carrying out maintenance activities by Ghana's original method, how hitting inspection at the height of 2.5m using hammer, scale and choke can be made, after suggesting that solutions could be found with knowledge of all persons concerned even though sufficient

budget and resources for maintenance are not available and not all of persons concerned have high skills of maintenance. One trainee said he could not come up with good idea, another trainee said jumping could be the method, and the other trainee proposed to inspect by one riding on other's shoulder.

(Source: JICA Study Team)

Photo 4.2.46 Hitting Inspection of Shoulders

(Source: JICA Study Team)

Photo 4.2.47 Hitting Inspection of Concrete on His Concrete by Use a Ladder

11) Presentation after Training

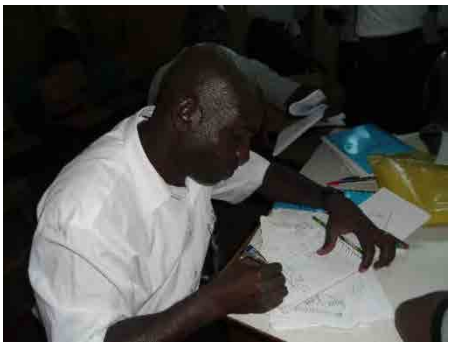
Finally, trainees made presentations positively and enthusiastically about bridge knowledge and skills they learned from the training activities.

(Source: JICA Study Team)

Photo 4.2.48 The State of Announcement

(Source: JICA Study Team)

Photo 4.2.49 The state of the sleeper were piled up don't support upper structure (2)



(Source: JICA Study Team)

Photo 4.2.50 Trainee take note earnestly

(Source: JICA Study Team)

Photo 4.2.51 Input Work by PC

(Source: JICA Study Team)

Photo 4.2.52 Group Discussion

(Source: JICA Study Team)

Photo 4.2.53 Group Announcement

12) Award of Certificate

At the completion of the training, certificates were awarded to all trainees as shown below.

(Source: JICA Study Team)

Photo 4.2.54 State of Presentation of Certificate

(Source: JICA Study Team)

Photo 4.2.55 Gathering Photograph

(5) Result of Training Activities

1) Preparation of Bridge Record Book

A method for the preparation of bridge record book, including the items to be included, was explained in consideration of the current situation in Ghana railway. Input of measured data was made using 1 computer for 1 group consisting of 5 participants.

2) Presentation about Skills Learned

Leaders selected among each group made presentations about skills learned from the training activities, then each group prepared and presented answers to 12 questions prepared in advance. Following shows questions made and some of the answers made by the participants:

- Answers of Participants

1. *How do you think about the present conditions of steel bridge?*

   Write your way of thinking how to paint and place of steel bridge.

   ・Condition is very bad because of insufficient maintenance. Painting should be done at span center where bending moment is the largest.

   ・Due to lack of maintenance budget, the bridges could not be painted and that led to the corrosion.

   ・Portions at span center should be painted by use of ladder and wood plate.

2. *Write present conditions and measures of the A part indicated in the training paper..*

   ・It should be reinforced by concrete and steel bars where there are large cracks that may cause serious problem.

3. *Write that you learned about width of foundation.*

   ・We learned that the foundation width is narrow compared to the height of abutment and pier , thus the structure is unstable. Width of the foundation should be widened.

   ・The width of the foundation should be widened because it becomes unstable by scouring.

4. *Write that you learned about bowling data.*

   ・Bowling data is necessary to know the condition of geology and essential for design.

5. *How do you think about Japanese mobile lift?*

   ・It is wonderful because it enables maintenance of bridge structures freely.

   ・It is very difficult to reach the bottom of the bridge without mobile lift.

6. *Write that you felt it to see figure 6 and 7. (About scouring of retaining wall)*

   ・Retaining wall is in a very bad condition by scouring as shown in Figure 6. Scouring is not easily made if the foundation is protected as shown in Figure 7.

7. *Write that you learned about MANSO bridge.*

   ・A1 abutment has collapsed because of soil pressure, water pressure, train load, scouring and narrow foundation width as well as no regular maintenance.

   ・We confirmed that the subsidence of piled up sleepers that supported superstructure has occurred and thus sleepers did not support it.

   ・Substructure that was built by plain concrete and the foundation width was narrow. As concrete is weak for tension, it must be changed to reinforced concrete.

   ・It is considered effective to use H-steel as strut to prevent collapse of A1 abutment.

8. *Did you understand a record method of deformation?*

   ・Hammers, crack gauges, calipers and cameras are required to keep record of deformation portions of bridges.

   ・Low sound portions are considered that the condition of concrete is not good, thus the portions should be marked by chalk.

9. *Others*

   ・All topics in the seminars were very useful.

   ・We learned many things about bridge maintenance.

   ・We learned methods of new tools.

3) Outcome of Training

The main outcomes of the training program were not only the transfer of knowledge on basic maintenance and bridge concepts, methods of maintenance, but also the realization by the participants that the life span of bridge structures can be considerably extended by carrying out proper maintenance, even under circumstances where no spare parts are available. It was understood that maintenance can be done by own means with technical knowledge and invention, and that will improve the safety levels of Ghana railways.

Almost all trainees were able to master the use of inspection tools due to more time spent on practical training, mainly at the Manso and Busua bridges. It was impressive that those who has already learned the skills were proactively teaching those who has not, which increased the overall understanding of participants.

(6) Issues and Recommendations

1) Issues

Aging of bridge and sub-base course are remarkable, thus they need to be repaired or re-built at an early stage. However, the most significant issue is how to secure the budget. It would be preferable that MOT and MOFEP understand the current situation of Ghana railway fully and correctly, and secure appropriate budget. Also, assuming that the West Line rehabilitation project and the new line construction project by CBD will be carried out in accordance with the original schedule, it is very important that GRCL should secure necessary budget for maintenance and continue proper maintenance by making use of the knowledge acquired in the training.

2) Maintenance Manual (Method of Recording, Capital Investment Plan, etc.)

Maintenance manual is essential to maintenance of railway facilities. However, due to poor maintenance of railway facilities in Ghana, most of bridges need re-building. Nevertheless, it is important to make efforts in maintaining the present conditions by continuously carrying out minimum level of regular inspections and early detection of deformation etc. that could prevent safe operation of railways.

Therefore, it is suggested that bridge record books presented in the training be used to control and manage results of inspections. The bridge record book is included in Appendix-6 together with training materials.

3) Drawings for Maintenance, e.g. track layout plans and schematic track plans

Rehabilitation project between Takoradi～Awaso～Kumasi and new line construction project are planned by CBD and re-building of some bridges is included in the rehabilitation project. Therefore, the drawings for maintenance should be finalized after the movement of CBD to the projects.

On the other hand, it is recommended that existing drawings and hand-written documentats in storage rooms of GRCL Head Office be scanned and stored in an electronic format. Documents created in the future for maintenance purpose also need to be stored in and controlled by electronic format, utilizing PC and Scanner to be provided under the JICA Study.

4) Recommendation

Most of participants (trainees) were at the age of 40's and 50's, and all with engineering background. Despite the short period of training with only 10 days, most of the trainees were able to acquire basic knowledge on inspection and maintenance. Therefore, their potential capability for the works was recognized very high, supported by the fact that trainees made their presentations during the seminar with confidence and passion. As the next step, it is important to carry on minimum maintenance activities in accordance with the training program with inspection tools used during the training. Also, a maintenance management system should be established to record inspection results. The Study Team expects that GRDA and GRCL will work together to establish a maintenance plan and implement accordingly for sustainable train operations in Ghana.

Situation would be largely changed once West Line rehabilitation project and new line construction project with CDB financial assistance are completed. However, structures and facilities, e.g. sub-base course, bridge etc., need urgent repair as such conditions would cause serious accidents.

Finally, it is desirable that the management of MOT and/or MOFEP understand the significance and need of maintenance activities, and that GRDA and GRCL jointly request necessary budget for maintenance activities to the government.

4.2.3 Track

(1) Objective and Outline

The main objective of the training was to make young and excellent staff of GRCL acquire knowledge and skills of overall track maintenance, so that such staffs would become able to both instruct other staffs of the knowledge and skills acquired and eventually implement and transfer track maintenance technology to younger generations. The training courses have focused on the following subjects:

1. Method of measurement of track irregularity and inspection of track materials.
2. Establishment of track maintenance plan with prioritization in accordance with the results of track inspections.
3. Basic actions in track maintenance works.
4. Implementation of track maintenance works.
5. Review and evaluation of performance of track maintenance works.

(2) Participants

The JICA Study Team have divided 32 participants into 5 groups as per the following Table 4.2.2, and nominated staff members who possessed basic computer literacy as leaders of each group.

Table 4.2.2 Participants of Training and Group Classification

Group	A	B	C	D	E
Group Leader	**John Mensah**	**Thou A. Quayson**	**Sylvester Banson**	**Jakob Swanzg Baidoo**	**Patrick Mensah**
	Anthony Kojo Bissue	Joseph Amanfi	C.E.Acquah	Emmanuel K. Imbeah	Francis Baidoo
	Eric Dadzie	Thomas Quarm	James Cobbinah	Kwame Aboagye	Joseph Arthur
	Richard Adaruq	Yahya Zakari	James Afamalor	James Kofie	S.A. Nyame
	Dorothy Turkson	Joseph Sam	Thomas Anafo	Arbert Andrews	G. Donkor
				S. Amissah	A. Sarfie
				JP Mensah	

(Source: JICA Study Team)

(3) Training Schedule

At first, the JICA Study Team prepared two separate training courses, where one focused on track maintenance and another on roadbed and bridge, each comprising 2 weeks program. However, as the MOT has been carrying out an unexpected survey of all GRCL staffs at the beginning of March 2014, training schedule was required to be postponed, resulting in the necessity to combine two training courses into one comprehensive class. The training schedule after the said change is shown in the following table:

Table 4.2.3 Training Schedule

		Bridge training	Track training	Remarks
March 14 (Fri)	Morning	General explanation of the present conditions of bridges in Ghana and Japan		Conference room
	Afternoom		Present condition of GRCL tracks, temporary criteria for defective fastening and sleeper. Measuring method of track irregularity, Track maintenance method, Track irregularity measurement training at Takoradi St.	Ditto
March 15 (Sut)				
March 16 (Sun)				
March 17(Mon)	Morning	Team A,B: Field exploration, Basic Knowledge of Bridges	Team C, D : Carrying out track irregularity measurements and inspection of defective sleepers at site	(Bridge and Track team) Neighborhood of Busuah St.
	Afternoom	Team A,B: Field exploration, Point and Method of Bridge Inspection	Team C, D: Ditto	Ditto
March 18(Tues)	Morning	Team C,D: Field exploration, Basic Knowledge of Bridges	Team A, B: Carrying out track irregularity measurements and inspection of defective sleepers at site	Ditto
	Afternoom	Team C,D: Field exploration ,Point and Method of Bridge Inspection	Team A, B: Ditto	Ditto
March 19(Wed)	Morning	Team A,B: Field exploration, Point and Method of Bridge Inspection	Team C,D : Arrangement of measured data. Designating sections which significantly deviate from the irregularity standard. Decision of the priority order of track maintenance work	(Bridge team) Neighborhood of Busuah St. (Track team) Conference room
	Afternoom	Team C,D: Field exploration, Point and Method of Bridge Inspection	Team A,B : Ditto	Ditto
March20(Thur)	Morning	Making of Ledger (using PC)		Conference room
	Afternoon		Arrangement of measured data. Designating sections which significantly deviate from the irregularity standard, Decision of the priority order of track maintenance work	Ditto

		Bridge training	Track training	Remarks
March21(Fri)	Morning	Team A,B: Field exploration, Basic Knowledge of Bridge	Team C,D : Carrying out of sleeper renewal work and tamping work at priority section and track irregularity measurement after finishing track maintenance work	(Bridge team) Neighborhood of Manso St. (Track team) Neighborhood of Busuah St.
	Afternoon	Team A,B: Field exploration, Point and Method of Bridge Inspection	Team C,D : Ditto	Ditto
March22(Sut)				
March23(Sun)				
March24(Mon)	Morning	Team C,D: Field exploration, Basic Knowledge of Bridge	Team A,B : Carrying out sleeper renewal work, tamping work at priority sections and additional track irregularity measurement after finishing the track maintenance work	(Bridge team) Neighborhood of Manso St. (Track team) Neighborhood of Busuah St.
	Afternoon	Team C,D: Field exploration, Point and Method of Bridge Inspection	Team A,B : Ditto	Ditto
March25(Tues)	Morning	Team A,B: Field exploration, Point and Method of Bridge Inspection	Team C,D : Carrying out sleeper renewal work, tamping work at priority sections and additional track irregularity measurement after finishing track maintenance work	Ditto
	Afternoon	Team C,D: Ditto	Team A,B : Ditto	Ditto
March26(Wed)	Morning	About Standard design of Japan		Conference roo
	Afternoon		Arrangement of measured data.	Ditto
March27(Thu)	Morning	Discussion		Ditto
	Afternoon	Presenting the certification to all trainees		Ditto

(Source: JICA Study Team)

(4) Contents of Training

The Study Team has prepared Power Point slides showing results from our 1st and 2nd site surveys, in a way that trainees could understand the subjects clearly and easily.

The main topics presented are as follows.

- Explanation of the present condition of Ghana railways
- Explanation regarding the establishment of methods of temporally standards for judgments of defective sleepers, fasteners and track irregularity
- Explanation of actual methods of these judgments and the forms to record the result of inspection.
- Explanation of analysis method of inspection results.

With respect to basic movements of track maintenance works, the training was conducted using PowerPoint slides with illustrations to explain the following:

- change of sleepers
- Driving and pulling up dog spikes
- Method of leveling check at rail surfaces.
- Rail lifting by track jack and tamping of ballast under the sleepers by beater.
- Rail lifting by track jack and tamping of ballast under the sleepers by tie tampers
- Basic actions in adjustment of track alignment
- Advices for carrying out works safely

Each of 5 groups had the opportunity to experience evaluation of defective sleepers, measurement of track irregularity, change of damaged sleepers, tamping works by beaters and measurement of track irregularity after the completion of track maintenance works on the main line at Busuah St. yard[4].

[4] *Ghana railways prepared materials and tools for carrying out the track maintenance work by trainees. (Wooden sleeper: 10 nos., Dog spike: 50 nos., Crowbar: 10 nos., Beater: 10 nos., Hammer: 4 nos., Track jack: 4 nos., Auger: 4 nos., Fork: 4nos., Shovel: 4 nos., Trolley: 1 no.)*

(Source: JICA Study Team)

Photo 4.2.56 There are many big track irregularity spots (Butuah St. Yard)

(Source: JICA Study Team)

Photo 4.2.57 The manganese ore train is passing through on the Fig.4.2.56 track (Butuah St. Yard)

(Source: JICA Study Team)

Photo 4.2.58 Each group is measuring the track irregularity

(Source: JICA Study Team)

Photo 4.2.59 Trainees are measuring the longitudinal level of the rail surface by using the level measuring equipment

(Source: JICA Study Team)

Photo 4.2.60 The Trainees are analyzing the measured data and making the maintenance work plan with the priority order

(Source: JICA Study Team)

Photo 4.2.61 Every group tried to change rotten sleepers

(Source: JICA Study Team)

Photo 4.2.62 The rotten sleepers are worn out (This fact means that these sleepers are left as they are rotten for a long time)

(Source: JICA Study Team)

Photo 4.2.63 Trainees are removing the ballast in order to insert the sleeper

(Source: JICA Study Team)

Photo 4.2.64 Trainees are inserting the used sleeper

(Source: JICA Study Team)

Photo 4.2.65 Trainee is drilling the hole into the sleeper by auger

(Source: JICA Study Team)

Photo 4.2.66 The Trainees are driving the dog spike into the sleeper

(Source: JICA Study Team)

Photo 4.2.67 The Trainees are transporting the sleeper on the trolley.

(Source: JICA Study Team)

Photo 4.2.68 The Trainees are lifting the low joint by the track jack

(Source: JICA Study Team)

Photo 4.2.69 The Trainees are tamping the ballast under the sleeper

(Source: JICA Study Team)

Photo 4.2.70 The Trainees are checking the irregularity of rail low joint

(Source: JICA Study Team)

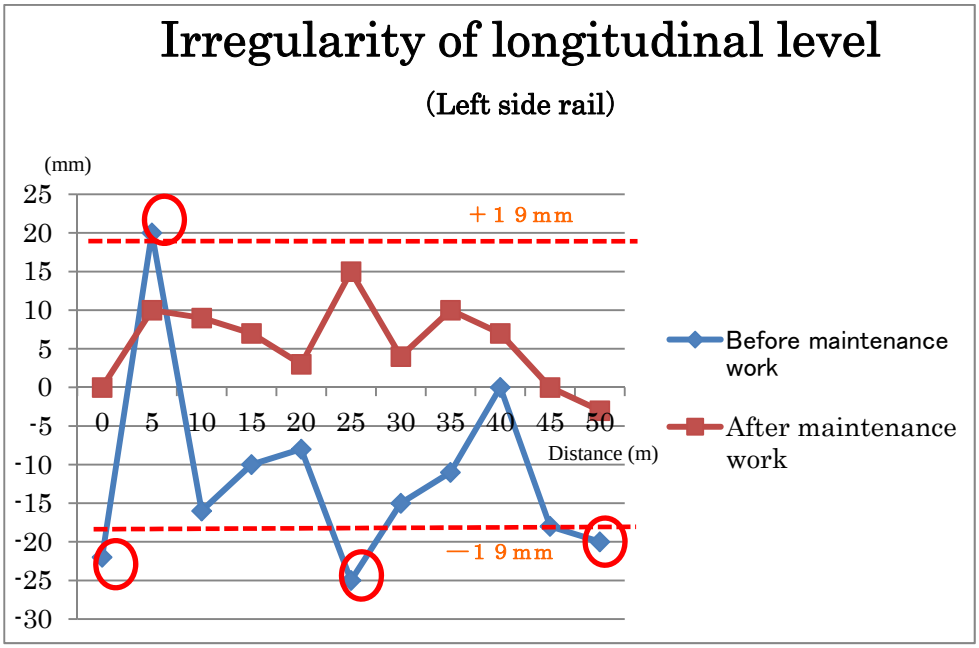
Photo 4.2.71 The Trainees are caring out the alignment work

(Source: JICA Study Team)

Photo 4.2.72 The Trainees are measuring the track irregularity after finishing the maintenance work

(5) Result of Training

Each group has shown in graph the results of the track irregularity before and after the repair of tracks, then compared among groups. All groups have confirmed that the track condition was improved after the repair works. Following shows the result of inspections of track irregularity.



(Note: As at initial maintenance work, there were 4 spots were over the tolerable limit for urgency. However, irregularity values of whole of section including the of these over limit spots have became within the limit for urgency after the maintenance work.)

(Source: JICA Study Team)

It was confirmed from the result of questionnaires conducted and obtained after the training that participants were satisfied with all training program, particularly track measurement activities at site. In addition, it was found out that majority of participants have serious concerns in the necessity of proper maintenance under the current condition of Ghana railway. All participants were eager to learn and acquire maintenance skills and had large expectation to the contribution by Japan for the transfer of railway technology. Figure 4.2.2 shows the contents of questionnaires, whereas the results were shown in Figure 4.2.5

Summary of trainee's answer is below.

1) The trainee satisfies all of training contents and it was very useful.
2) Measurement activities for track maintenance and inspection activities for defective sleepers and fastenings have became popular with trainees.
3) Almost trainees have recognized that they should carry on the suitable track maintenance which is needed for sustainable operation of Ghana Railway.
4) All trainees want to acquire knowledge of track maintenance method and activities.
5) All trainees have a big expectation for the technical cooperation of Japanese Railways

Date _____

Division _____

Name _____

Describe your impressions after the track and structure maintenance training.

1. Which contents of this training program was more useful for you?

2. Which contents of the site training program was more useful for you?

3. Describe your impressions of "Kaizen (improving) Point" of GRCL's daily track and structure maintenance.

4. Describe your request for Japanese technical assistance.
Ex. What kind of skills do you want to learn?

(Source: JICA Study Team)

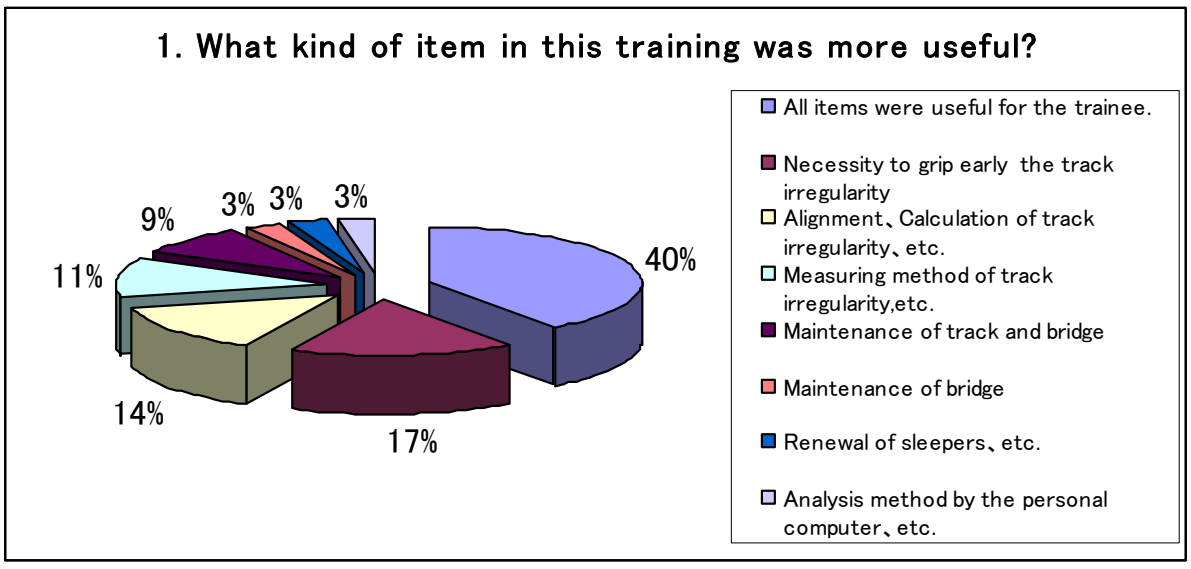
Figure 4.2.4 Questionnaire

The results of the questionnaire are shown in the Figure 4.2.5 to Figure 4.2.8 below;

1. Which maintenance training activities were the most of useful for you?

	Subjects in Training	Quantity	Remarks
1	All subjects were very useful.	14	As each trainee answered to several items, the total of quantity doest not correspond to the number of trainees.
2	Necessity of early inspection of track irregularity and track damages in order to prevent further serious track damages	6	
3	Alignment of tracks, calculation of track irregularity, track lifting, tamping of ballast, and twist irregularity	5	
4	Method of measurement of track irregularity and basis of track maintenance	4	
5	Maintenance of tracks and bridges	3	
6	Maintenance of bridges	1	
7	Renewal of sleepers, measurement of track irregularity by use of gauge	1	
8	Analysis by computers, lifting and tamping of tracks	1	
Total		35	

(Source: JICA Study Team)



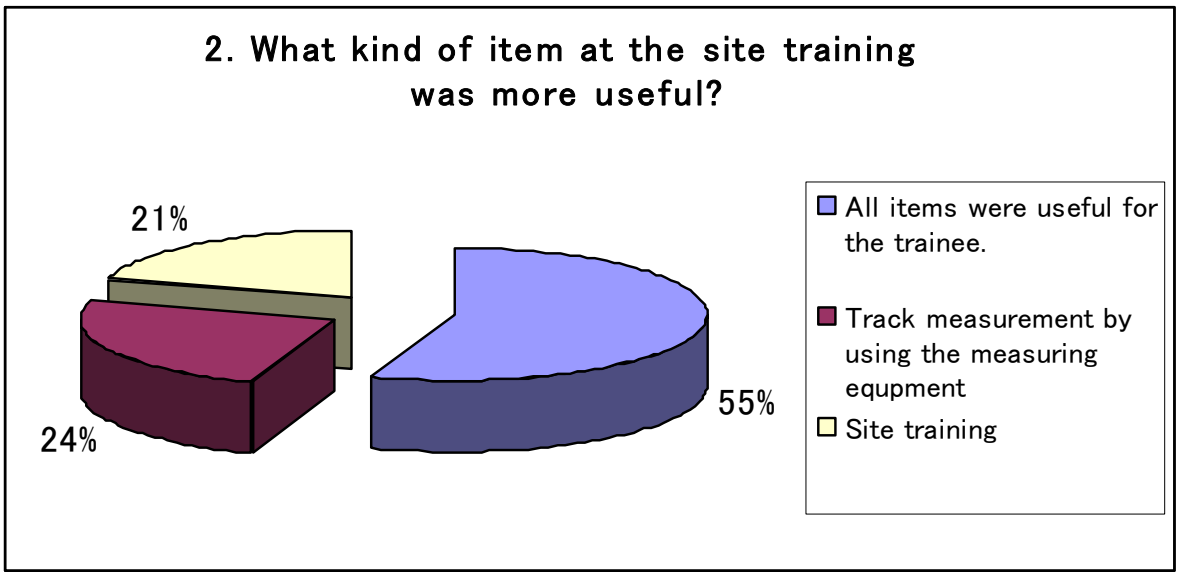
(Source: JICA Study Team)

Figure 4.2.5 Result of the Questionnaire (1)

2. What kind of item at the site training program was more useful for you?

	Subjects of Training at Site	Quantity	Remarks
1	All subjects were useful.	16	As each trainee answered to several items, the total of quantity doest not correspond to the number of trainees.
2	Track measurement by use of measuring equipment	7	
3	Site training	6	
Total		29	29

(Source: JICA Study Team)



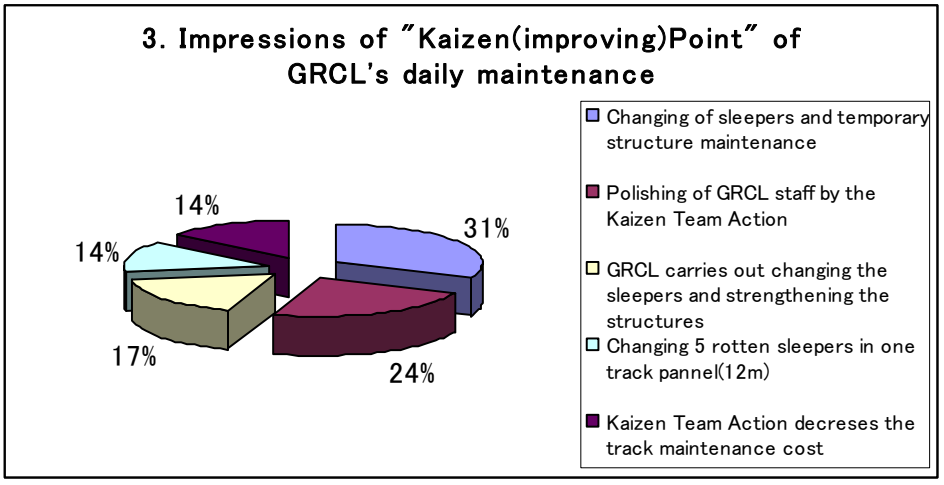
(Source: JICA Study Team)

Figure 4.2.6 Result of the Questionnaire (2)

3. Describe your impressions "Kaizen (improving) Point" of GRCL's daily maintenance work for track and civil structures

	Areas of Track Maintenance which GRCL shall improve	Quantity	Remarks
1	Track maintenance has been made by changing several rotten sleepers to used sleepers, but maintenance of structures has not been carried out except temporary repair for defective portions.	9	As the trainees answer several items for questionnaire, total of the quantity don't correspond with the numberof trainees.
2	Activities in line with "Kaizen Team"[5]has been helpful in the improvement of skills and knowledge by daily recording of site conditions, improvement of maintenance of tracks and structures and improvement of operation system.	7	
3	Changing of sleepers and reinforcement of structures.	5	
4	Maintenance of track gauge by change of 5 rotten sleepers to used sleepers in one track panel (12m) by "Kaizen Team".	4	
5	Decrease in track and structure maintenance cost by "Kaizen Team" activities	4	
Total		29	

(Source: JICA Study Team)



(Source: JICA Study Team)

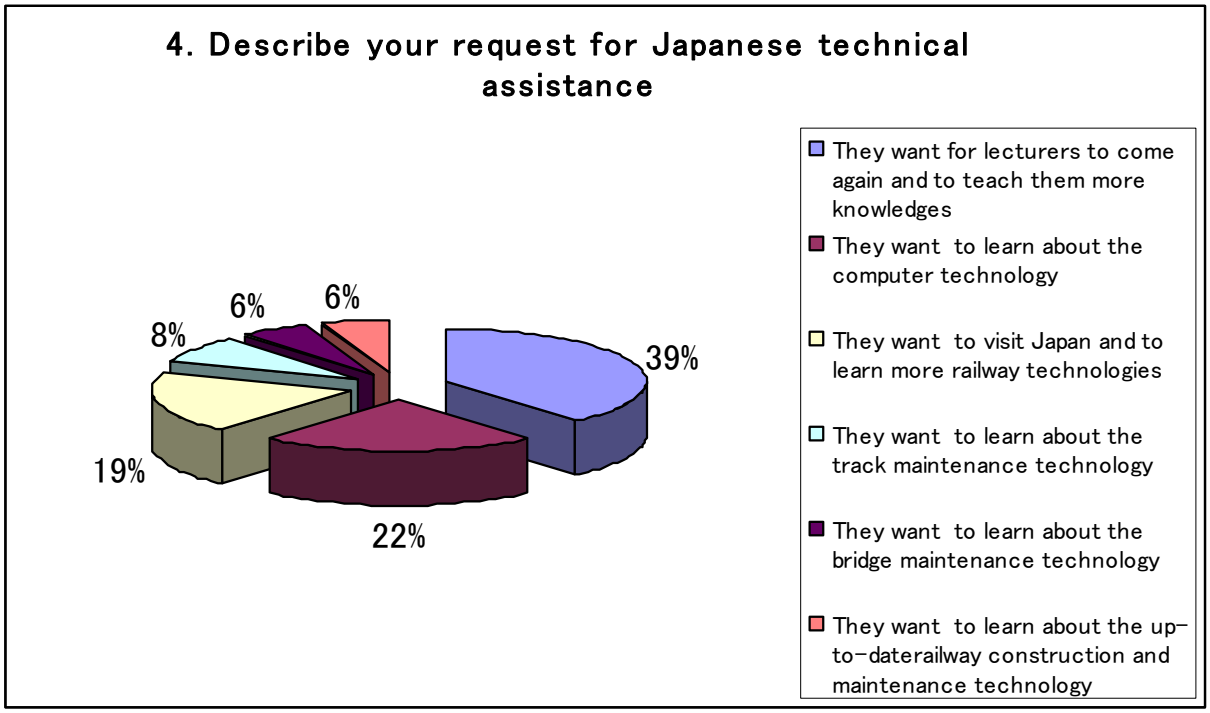
Figure 4.2.7 Result of the Questionnaire (3)

[5] *The "Transportation Reinforcement of Ghana Railway Project" was implemented from March 1994 to July 2000 as a JICA ODA Project. As part of the Project, Mr Sankah (former Deputy Managing Director, GRCL) visited Japan as a trainee and was impressed with the "Kaizen Team" movement, which was carried out by Japan National Railways and many other private Japanese companies at that time. After the training, he decided to formulate a "Kaizen Team" at Ghana Railway in order to raise their motivations and listen to staff opinions working at site. The GRCL commended the work team, which achieved good results from the "Kaizen Team" activity. For example, in the Hani Valley Station, there is a certificate of commendation, provided by the GRCL, hanging on the wall. Nowadays, the "Kaizen Team" movement spirit seems to have disappeared, however some staff, who experienced the "Kaizen Team" movement, still have a strong and positive impression of it.*

4. Describe your request for Japanese technical assistance.
Ex. What kind of track maintenance skills do you want to learn?

	Items of Railway Technology Desired from Japan	Quantity	Remarks
1	More lectures in Ghana for further improvement of knowledge about tracks and bridges.	14	As each trainee answered to several items, the total of quantity doest not correspond to the number of trainees.
2	Computer technology	8	
3	Visit Japan and learn more railway technologies	7	
4	Track maintenance technology	3	
5	Bridge maintenance technology	2	
6	Railway construction and maintenance methods based on latest standards and criteria.	2	
Total		36	

(Source: JICA Study Team)



(Source: JICA Study Team)

Figure 4.2.8 Result of the Questionnaire (4)

(6) Issues and Recommendations

1) Issues

Lately, the railway facilities of GRCL have become overage, which has led accidents, such as derailment, frequently. Also, the sections where trains are in operation have been decreasing and it now became only approximately 120km of the entire sections in Ghana. It is assumed that one of the causes is insufficient assistance, guidance and support from the government (MOT) after the privation and the establishment of GRDA.

It is essential that the government stimulates the growth of railway sector in Ghana, comes up with measures to make use of railway assets and operation skills to maximize the railway characteristics, such as mass transportation, accurate and low-cost freight transportation, etc., and finally develops the system for supporting GRDA and GRCL as the central government and for properly instructing and managing them.

2) Maintenance Manual

Concerning the insufficient maintenance budget for the procurement of maintenance equipment and materials, it is recommended that the urgent track maintenance works continuously using available resources be carried out. Having and referring to the urgent maintenance activities and methods included in the temporary standards presented in the training program will be valuable for the implementation of urgent maintenance works by GRCL.

The Study Team has established a “temporary standards” for track maintenance in order to evaluate the inspection results in proper data recording forms. Such temporary standards were those adopted and used during the during1stto the 3rd site surveys. Temporary standards shall be improved and revised by GRCL after having carried out certain period of maintenance activities using the temporary standards. Temporary Standards established by the Study Team are as shown below.

- **Standard for Judgment of Defective Sleepers and Fasteners**

Sleepers (Wooden):

1. Sleepers not properly functioning because of corrosion.
2. Broken sleepers or sleepers not properly functioning because of past derailments or .
3. Sleepers with voids inside inspected by hitting with hand hammer.
4. Sleepers with enlarged holes of dog spikes, causing insufficient supporting force

Fasteners:

1. Missing fasteners
2. Fasteners lifted up from the base plate and not functioning as connectors between rails and sleepers.
3. Fasteners that can be easily pulled out by hand

(Source: JICA Study Team)

- **Tolerable Limit for Regular Maintenance and Tolerable Limit for Urgency**

Type of irregularity	Kind of irregularity	gauge	Level	Longi-tudinal Level	Align-ment	Cross Level variation
Tolerable Limit in Regular maintenance	Tolerable Limit For Regular maintenance	+6 - 4	±9			———
Tolerable Limit in case of emergency	Tolerable Limit for Urgency	+20 -10	———	±19		±18

(Source: JICA Study Team)

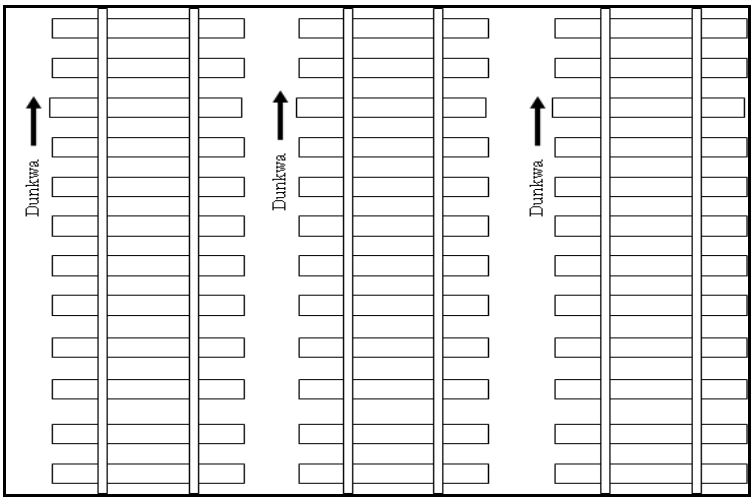
- **Various Forms**

1) Forms of defective sleepers and fastenings

Date Day Month Year

Location mile

Name in Charge

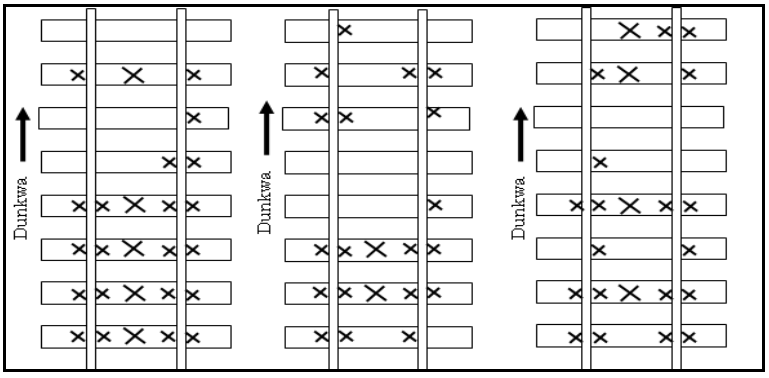


Form example of defective sleepers and fastenings

Date Day Month Year

Location mil**e**

Name in Charge



(Source: JICA Study Team)

2) Form of track irregularity

Date Day Month Year

Location mile

Name in Charge

No. (5m interval)	Track irregularity values(mm)							Remark
	Gauge	Level	Left side rail		Right side rail		Twist	
			L.L	A	L.L	A		
1								L.L=Longitudinal level A=Alignment
2								
3								
4								
・・・								
・・・								
・・・								

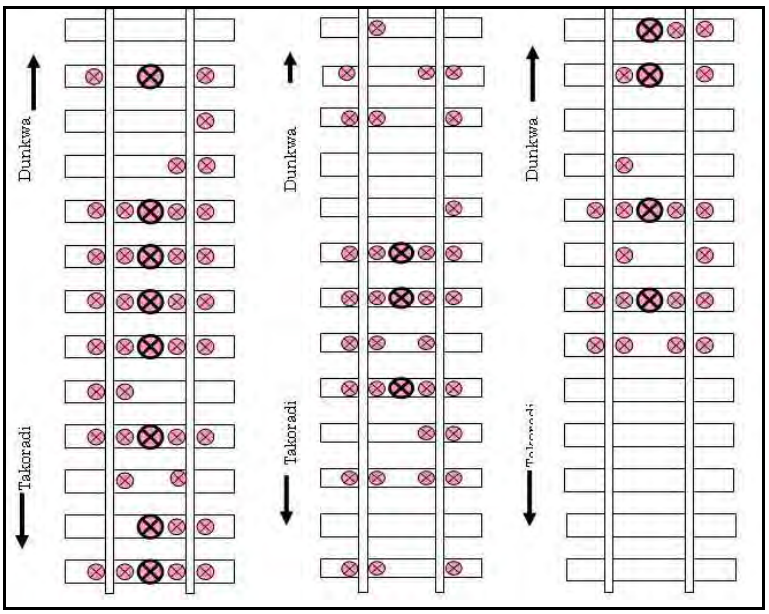
(Source: JICA Study Team)

3) Form example of defective sleepers and fastenings

Date Day Month Year

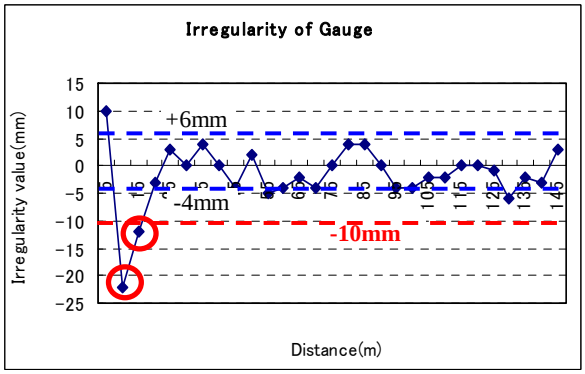
Location mile

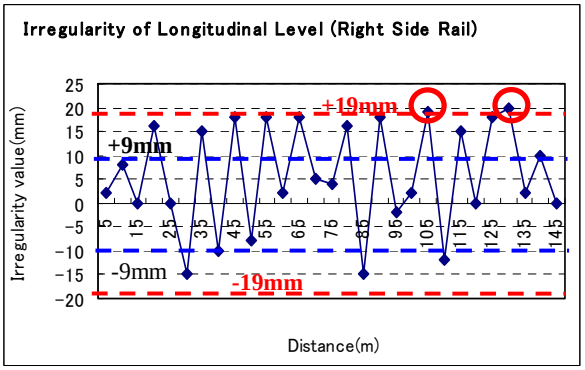
Name in Charge

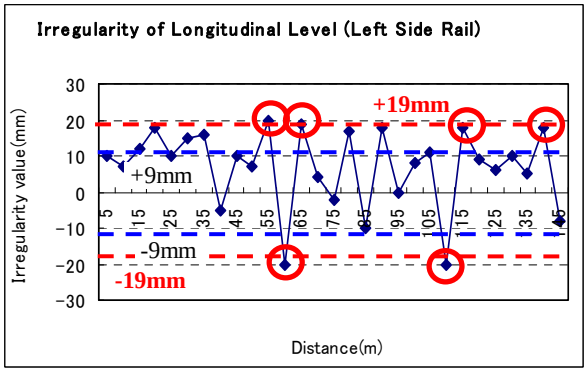


(Source: JICA Study Team)

4) Drawing examples of track irregularity over the tolerable limit for urgent







(Source: JICA Study Team)

5) Table of the spots needed the urgent track maintenance work

Date Day Month Year

Location mile

Name in Charge

Priority order	Date measured	Section over the limit of criteria		Track irregularity value (mm)						Remark
				Gauge	Left side rail		Right side rail		Twist	
		From	To		L. L	A	L. L	A		
1										L.L=Longitudinal level A=Alignment
2										
3										
4										
・・・										
・・・										
・・・										

(Source: JICA Study Team)

6) Form of Track irregularity data after finishing the urgent track maintenance work

Date Day Month Year

Location mile

Name in Charge

Date of maintenance work	Priority order	Location		Track irregularity data after finishing the urgent track maintenance work(mm)						Remark
				Gauge	Left side rail		Right side rail		Twist	
		From	To		L. L	A	L. L	A		
										L.L=Longitudinal level A=Alignment

(Source: JICA Study Team)

3) Drawings for Maintenance

Rehabilitation project between Takoradi～Awaso and new line construction project are planned with finance from CBD, which include improvement of curve sections and track layouts inside stations. Therefore, drawings for maintenance, e.g. track layout plans and schematic drawings, etc., shall be finalized after obtaining outcomes of the CDB financing projects.

4) Recommendation (Measures for Prevention of Accidents)

The training program was successfully carried out and completed with participation of approx. 30 staffs, mainly comprising of young generation. It is highly hoped and expected that staffs who attended the training activities teach and transfer to others. Under the severe financial condition, many staffs in railway sector have thought “As the budget is not sufficient, nothing can be done”. However, they must have learned through various activities in the training program that certain level of track maintenance works can be done to within limited budget. Young generation staffs who attended the training program and acquired knowledge and skills of track maintenance are expected lead to the realization of proper track maintenance works between Takoradi St. and Nsuta St. and the safe and stable operation of railway in near future, improved from the current situation where derailments have happened at a frequency of once a week,

4.2.4 Rolling Stock

(1) Objectives and Outline

1) Objectives

GRCL does not have its own maintenance manuals and record books for rolling stocks, but

utilizes those provided by rolling stocks suppliers in the maintenance of rolling stocks. The manuals and record books are stored in the administration section and also in depot. Maintenance of rolling stocks has been carried out in accordance with them as much as budget allows. Failure and inspection records have been reported to Chief Mechanical Engineer in daily, monthly and quarterly reports. Based on such situation and considering the objectives stated in Chapter 3, the training activities were implemented focusing on the following issues:

- Achievement of stable operation of manganese transportation
- Prevention of major accidents during train operations
- Inspections of functionality prior to operation on wheels, wheel sets and braking systems, particularly freight cars with automatic air break system newly introduced from India recently.

2) Outline

Training of inspection of wheels and wheel sets as well as automatic air brake system was carried out, including demonstrations and trials by the trainees at site. Trainees were divided into two groups and one-day training program was provided to each group on 24 and 25 March..

Training was implemented at 'Carriage & Wagon', where the actual maintenance of freight cars is carried out by GRCL, using one freight car and one bogie imported from India.

(Source: JICA Study Team)

Photo 4.2.73 Freight Car Used in Training

(Source: JICA Study Team)

Photo 4.2.74 Bogie Used in Training

➢ Inspection of wheels and wheel sets

- Definition of inspection criteria for wheels and wheel sets (lecture)
- Inspection method for wheels and wheel sets (demonstration and practical training) (Back-gauge, wheel diameter measurement device, flange measurement device, wheel tread measurement device)

- Inspection of automatic brake system
  - Inspection method for automatic brake system (lecture)
  - Inspection method for automatic brake system (and practical training)

(2) Participants

1st training (March 24th)

No	Name	Remarks
1	Isaac Anaman	Engineer
2	W.K. Arthur	Engineer
3	S. Baffoe-Matthews	Engineer
4	Rex A. Mensah	Technical Person
5	Nat Otoo	Technical Person
6	Paul Mensah	Technical Person
7	Joseph Annan	Technical Person
8	Edward Walden	Technical Person
9	M.K. Agyeman	Technical Person
10	Ishmael Quansah	Technical Person
11	Kobina Sarsah	Technical Person
12	Joseph Mbiah	Technical Person
13	Albert Quansah	Technical Person
14	Enmanuel Mensal	Technical Person

2nd training (March 25th)

No	Name	Remarks
1	S.E. Ali	Engineer
2	Fredrick Barnes	Technical Person
3	Michael Mottey	Technical Person
4	R. Lamptey	Technical Person
5	J. Encher	Technical Person
6	J.A. Arthur	Technical Person
7	K.T. Ankrah	Technical Person
8	S. Akumanyi	Technical Person
9	W.K. Arthur	Technical Person
10	C. Baidoo	Technical Person
11	J. Chinebuah	Technical Person
12	Anthony Abban	Technical Person
Observation	Hamlet V. Cromwell	Senior Mechanical Engineer

(Source: GRCL)

(3) Training Schedule

- March 18 (Tues.):
  Preparation and confirmation of training equipment and purchase of any additional equipment required
- March 19 (Wed.):
  Meeting with the Chief Mechanical Engineer regarding training venues and schedule, and the assembling of air brake test equipment
- March 20 (Thur.):
  Assembly of air brake test equipment and arrangement of freight car and bogie to be used during the training
- March 21 (Fri.):
  Rehearsal of break test and repair of freight car brake pipes for air leakage, etc.
- March 24 (Mon.):
  The 1st course (14 trainees)
- March 24 (Tues.):
  The 2nd course (12 trainees)
- March 25 (Wed.):
  Clean up, maintenance and storage of equipment used in the training
- March 26 (Thur.):
  Confirmation of equipment by GRCL staff)

(4) Contents of Training

1) Confirmation of Equipment Check

Confirmation of the measurement and test equipment brought from Japan as well as those purchased in Ghana was checked in advance of the training. Since the external shape of the air hoses purchased in Ghana was compatible to the test equipment to be used, bands to fasten the hoses and ancillary equipment were additionally purchased.

(Source: JICA Study Team)

Photo 4.2.75 Back Gauge

(Source: JICA Study Team)

Photo 4.2.76 Back Gauge (an enlarged photo)

(Source: JICA Study Team)

Photo 4.2.77 Wheel Diameter Measurement Device

(Source: JICA Study Team)

Photo 4.2.78 Flange Measurement Device

(Source: JICA Study Team)

Photo 4.2.79 Wheel Tread Profile Measurement Device

(Source: JICA Study Team)

Photo 4.2.80 Slide Calliper

(Source: JICA Study Team)

Photo 4.2.81 Brake Test Equipment Main Body

(Source: JICA Study Team)

Photo 4.2.82 Brake Test Equipment Components (Brought from Japan)

(Source: JICA Study Team)

Photo 4.2.83 Brake Test Equipment Components (Compressor purchased in Ghana)

(Source: JICA Study Team)

Photo 4.2.84 Brake Test Equipment Components (Air hoses purchased in Ghana)

2) Assembly of Brake Test Equipment

With the cooperation of GRCL staff, the brake test equipment was assembled utilizing test equipment brought from Japan and a compressor purchased in Ghana.

(Source: JICA Study Team)

Photo 4.2.85 Brake Test Equipment Components (Compressor purchased in Ghana)

(Source: JICA Study Team)

Photo 4.2.86 Brake Test Equipment Components (Assembling air hose joints purchased in Ghana)

(Source: JICA Study Team)

Photo 4.2.87 Assembly of Brake Test Equipment (Preparation of connection hose)

(Source: JICA Study Team)

Photo 4.2.88 Assembly by Brake Test Equipment (Connecting the test equipment with the hose)

(Source: JICA Study Team)

Photo 4.2.89 Completed Brake Test Equipment

(Source: JICA Study Team)

Photo 4.2.90 Completed Equipment and Assistant in Assembly

3) Rehearsal of Brake Test

Using a freight car purchased from India, functions of the assembled brake test equipment were checked and confirmed. Though it was only a year and a half old, the brakes did not properly work due to insufficient daily cleaning and lubrication, which has resulted in air leakage from the brake pipe and sticking of the foundation brake system. Therefore, the freight car was repaired in advance jointly with GRCL employees.

Training preparations and rehearsals such as the check repair of the freight car, check of air leakage, and confirmation of the functionality of brakes, compression of air by brake test equipment and confirmation of time of air discharge were conducted.

(Source: JICA Study Team)

Photo 4.2.91 Delivery of Freight Car to Training Site

(Source: JICA Study Team)

Photo 4.2.92 Positioning of Freight Car at Training Site

(Source: JICA Study Team)

Photo 4.2.93 Installation of the Brake Test Equipment

(Source: JICA Study Team)

Photo 4.2.94 Repair of Brake Pipe from Air Leakage

(Source: JICA Study Team)

Photo 4.2.95 Repair of the Brake Pipe from Air Leakage

(Source: JICA Study Team)

Photo 4.2.96 Non-movable Brake System which does not Move due to Sticking

(Source: JICA Study Team)

Photo 4.2.97 Check of Functionality under Brake Cylinder Released Status

(Source: JICA Study Team)

Photo 4.2.98 Check of Functionality of Brake Cylinder Lever

(Source: JICA Study Team)

Photo 4.2.99 Assistants from GRCL for Testing and Repair

(Source: JICA Study Team)

Photo 4.2.100 Assistants from GRCL for Testing and Repair

4) Training

a) Participants

(Source: JICA Study Team)

Photo 4.2.101 Participants of Day 1 Training (Mar. 24th)

(Source: JICA Study Team)

Photo 4.2.102 Participants of Day 2 Training (Mar. 25th)

b) Inspections of Wheels and Wheel Sets

The first part of the training covered method of inspection of wheels & wheel sets, e.g. parts to be inspected, criteria applied, etc., whereas demonstrations of inspection as well as practical training by the participants were carried out in the second part.

It seemed that participants were particularly interested in the following issues:

- Background of Japanese inspection standards and criteria
- Relationships between standards for wheels and rails
- Limits in case of abrasion

There happened to have a situation that the Senior Mechanical Engineer who was in the training called upon a staff in charge of wheel set maintenance to participate in the practical training.

(Source: JICA Study Team)

Photo 4.2.103 Lectures

(Source: JICA Study Team)

Photo 4.2.104 Lectures

(Source: JICA Study Team)

Photo 4.2.105 Measurement of Back Gauge

(Source: JICA Study Team)

Photo 4.2.106 Measurement of Back Gauge

(Source: JICA Study Team)

Photo 4.2.107 Measurement of Wheel Diameter

(Source: JICA Study Team)

Photo 4.2.108 Measurement of Wheel Thickness

(Source: JICA Study Team)

Photo 4.2.109 Measurement of Wheel Flange Measurement

(Source: JICA Study Team)

Photo 4.2.110 Old-type Flange Measurement Device Used in Ghana

(Source: JICA Study Team)

Photo 4.2.111 Measurement of Wheel Tread (Demonstration)

(Source: JICA Study Team)

Photo 4.2.112 Measurement of Wheel Tread (Practical training)

c) Inspection of Automatic Air Brake System

Inspection criteria for brake systems in Japan, inspection cycle and method of measurement by the brake test equipment were first explained in the classroom. At the site, demonstrations were made by the trainer, and then practical training by the participants was carried out, especially to those in charge of the maintenance of brake system.

Participants showed their interests in the following issues, for which answers were given by the trainer of the Study Team:

- Relationship between the air compression speed and air pressure
- Impact in case of excessive air pressure

During the practical training, all participants worked well together and those who learned the skills more quickly assisted the others.

(Source: JICA Study Team)

Photo 4.2.113 Lectures

(Source: JICA Study Team)

Photo 4.2.114 Lectures

(Source: JICA Study Team)

Photo 4.2.115 Demonstrations

(Source: JICA Study Team)

Photo 4.2.116 Demonstrations

(Source: JICA Study Team)

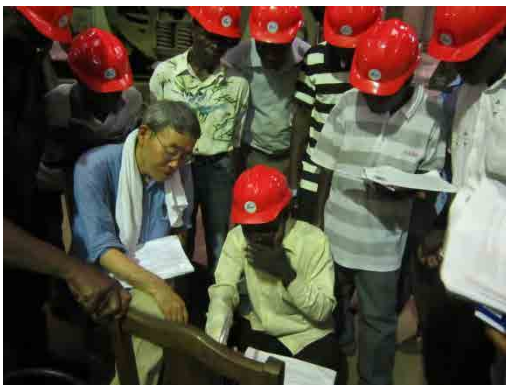
Photo 4.2.117 Taking Questions (during demonstration)

(Source: JICA Study Team)

Photo 4.2.118 Answer to Questions (during demonstration)

(Source: JICA Study Team)

Photo 4.2.119 Practical Training by Trainees



(Source: JICA Study Team)

Photo 4.2.120 Practical Training by Trainees

(Source: JICA Study Team)

Photo 4.2.121 Practical Training by Trainees

(Source: JICA Study Team)

Photo 4.2.122 Practical Training by Trainees

(Source: JICA Study Team)

Photo 4.2.123 Check of Brake Function

(Source: JICA Study Team)

Photo 4.2.124 Check of Function under Active Brake Cylinder

d) Special Topic: KAIZEN with 5”S”s

Importance of daily inspections and maintenance works of rolling stocks, such as cleaning, lubrication, etc., were explained by the Study Team as a summary of the training program. Mr. Cromwell (Senior Mechanical Engineer), who was attending the training as an observer, requested to the Study Team a brief explanation regarding KAIZEN in Japan. In response, the outline of ”KAIZEN” with 5”S”s were explained.

Participants showed their interests in the fundamental principles of KAIZEN, i.e., improvements through the gathering of knowledge by all concerned and the importance of being organized and clean.

(Source: JICA Study Team)

Photo 4.2.125 Scene from Lecture (about 5"S"s)

(Source: JICA Study Team)

Photo 4.2.126 Participants during Lecture

e) Closing of the training

(Source: JICA Study Team)

Photo 4.2.127 Closing of Day 1 Training Session (Mar. 24th)

(Source: JICA Study Team)

Photo 4.2.128 Closing of Day 2 Training Session (Mar. 25th)

(Source: JICA Study Team)

Photo 4.2.129 Certificates Giving Ceremony for Completion of Training (jointly, Mar. 25th)

(Source: JICA Study Team)

Photo 4.2.130 Certificates Giving Ceremony for Completion of Training (jointly, Mar. 25th)

(5) Results of the Training

As previously mentioned several times, insufficient budge for maintenance has put the Ghana railways and the condition of rolling stocks in a critical situation with numerous issues to be resolved. Therefore, the training program was aimed at the prevention of derailments and crashes, which are two most serious railway accidents, and thus focused on the inspection of wheels, wheel sets and brake systems (especially the automatic air brake system recently introduced to Ghana railways) , which are often the major cause of derailments and crashes.

Participants of the training were mainly core staffs of 'Carriage & Wagon' and 'Location', where maintenance of rolling stocks of GRCL are carried out. Since the subjects of the training were closely related to their daily works, the participants were industrious during the training all the times. It is hoped and assumed that the participants acquired the skills and technologies originally expected by the Study Team. Importance of the training to GRCL could be recognized from the fact that the Senior Mechanical Engineer called a staff in charge of the subject being lectured to come and attend the training.

(6) Issues and Recommendations

Necessity methods of inspection for wheels, wheel sets and air brake system were explained in the training program, based on and referring to the test equipment and methods being used in Japan as well as Japanese standards and criteria. It was observed during the training that the participants were satisfied with the subjects of the training program and were able to learn and acquire the skills and technologies presented in the training. However, railway facilities and rolling stocks in Ghana railways are in an extremely poor condition which can be even confirmed without using them, owing to insufficient daily maintenance including wheels, wheel sets and brake system. Therefore, Japanese standards and criteria cannot be simply applied to Ghana railways.

The freight car for manganese transportation imported from India a year and a half ago was used in the training for air brake system. Although this was the latest freight car in Ghana, its condition was in a very poor condition, where movable parts of the brake cylinders and link devices were not properly functioning and air was leaking from the brake pipes.

At the closing of the training program, following points are addressed as issues to be resolved and recommendations, considering the current situation of Ghana railways.

1) Enhancement of Daily Maintenance

- It is important to continue operating rolling stocks no matter what. For this, daily maintenance is considered more important than overhaul maintenance conducted every couple of years.
- Fundamental daily maintenance includes cleaning, lubrication (oil and grease), fastening of loosened bolts, and replacement of consumables.

- Even though expensive and highly functional rolling stocks are introduced, they will become inoperable and be decommissioned in a short period of time if proper daily maintenance is not carried out. On the other hand, rolling stocks with proper daily maintenance can be maintained operable for quite a long time without extensive repair requiring high cost.
- A huge cost will be required when rolling stocks that have been suspended from operation are resumed for operation again. Considering the current budgetary situation of Ghana railways, the possibility of resuming operations of once suspended rolling stocks is very unlikely.
- For the time being, Ghana railways shall strive to secure the minimum budget required, and, with efforts of all staffs, to maintain the train operations by the implementation of minimum maintenance, e.g. cleaning, lubrication (oil and grease), fastening of loosened bolts, and replacement of consumables.

2) Understanding of Necessity of Inspection Standards/Criteria and Establishment of Own Standards/Criteria

- Inspection standards/criteria of railways are formulated through a consideration of particularities of each country and railway. In addition, in the same way as the relationship between tracks and wheels, the standards/criteria and such particularities are closely and mutually related.
- Standards/criteria of other countries with different conditions and environment may not be applicable to other railways.
- All standards/criteria have their own meaning and objectives.

Accordingly, Ghana railways shall try to establish their own standards and criteria by understanding their meanings and considering their situation, not simply applying those of other countries.

(Source: JICA Study Team)

Photo 4.2.131 Wheels with Vertical Wear at Tire Flange that can be Confirmed at a Glance

(Source: JICA Study Team)

Photo 4.2.132 Brake Valve Covered with Dust

(Source: JICA Study Team)

Photo 4.2.133 Unlubricated Brake Lever

(Source: JICA Study Team)

Photo 4.2.134 Brake Cylinder and Lever (with scoring traits)

4.3 Procurement of Training Equipment

Equipments shown in the table below were procured for the training regarding maintenance*

Table 4.3.1 Instruments List for the training

No.	Items	Qty.	Serial. No.	Model	Descriptions
1	PC and peripheral equipment	1	SGH127R6LS	-	Office eqipment
	BLUTEK 850VA UPS	10	-	-	-
	D-LINK WIRELESS N300 ROUTER	1	-	-	-
	RJ 45 CONNECTOR	10	-	-	-
	CAT5 CABLE 100FT	1	-	-	-
2	HP Officejet 7500A	1	MY24O310P1	-	Office eqipment
3	Canon IR 2320 COPIER	1	F190600	-	Office eqipment
4	Fiber-Reinforced Plastic Standard Gage for 1,067mm	1	3492	KS5300B	Mesurement for track irregurality
5	Measurement for Leveling Defect (Coma)	1	-	KS560A	Mesurement for track irregurality
6	Constant Tension Device for Level Measurement (yam tension)	1	-	KS615A－1	Mesurement for track irregurality
7	Digital Tyre Measuring Instrument	1	1600	TDD-400	Basic maintenance for Rooling stock
8	Back Gauge	1	1745	SA41022	Mesurement for back side distance
9	Wheel Diameter Measuring Instrument	1	1109	TY-50	Mesurement for wheel diameter
10	Wheel Tread Wear Measuring Instrument (1)	1	1108	TS-3D	Mesurment for wheel tread wear
11	Wheel Tread Wear Measuring Instrument (2)	1	1109	TS-3D	Mesurment for wheel tread wear
12	Wheel Tread Wear Measuring Instrument (3)	1	1110	TS-3D	Mesurment for wheel tread wear
13	Fiber-Reinforced Plastic Standerd Gage for 1,067mm (	1	3856	KS5300B	Mesurement for track irregurality
14	Fiber-Reinforced Plastic Standerd Gage for 1,067mm (	1	3857	KS5300B	Mesurement for track irregurality
15	Fiber-Reinforced Plastic Standerd Gage for 1,067mm (	1	3858	KS5300B	Mesurement for track irregurality
16	Portable type brake tester for signal car (1)	1	130001	1009-3199256-01	Air breae tester for 2-shaft freight car
17	Portable type brake tester for signal car (2)	1	130002	1009-3199256-01	Air breae tester for 2-shaft freight car
18	Compressor (1)	1	157047 0003	B2800B / 100 CM3 V230 CE NUAIR	For the training of air brake tast.
19	Compressor (2)	1	156070 0007	B2800B / 100 CM3 V230 CE NUAIR	For the training of air brake tast.
20	365MM Cut-off machine (1)	1	-	-	For the training of air brake tast.
21	365MM Cut-off machine (2)	1	-	-	For the training of air brake tast.
22	Auger Drill (1)	1	-	GBH 2-26 DRE Professional	For the training of air brake tast.
23	Auger Drill (2)	1	-	GBH 2-26 DRE Professional	For the training of air brake tast.
24	Generator	1	131200600593	TG1700 - TG6700	For the training of air brake tast.
25	Desktop Computer (1)	1	TRF344095X	HP PRO 3500SERIES MT	For the reporting inspection result of track maitenance training.
26	Desktop Computer (2)	1	-	-	-
27	Desktop Computer (3)	1	-	-	-
28	Laptop (1)	1	5CG33836NQ	250-G1U32328MOX320NXNC04Da	For the saffety operation lecture.
29	Laptop (2)	1	5CG33837HV	2250-G1U32328MOX320NXNC04D	For the saffety operation lecture.
30	HP Multipul Printer	1	CND8F478CP	BOISB - 1104 - 02	For the saffety operation lecture.
31	D - Link Projector	1	MAC ID: 5CD99860DE03	-	For the lectur training.
32	Acer Projector	1	MRJFH11001244004A18401	No. Q5V1106	For the lectur training.
33	Screen	1	-	-	For the lecture training.
34	CANON Video Camera (1)	1	S / N 323272004004	Legria FS406 e	For the recording of site survey and training.
35	SUMSUNG Video Camera (2)	1	S / N ASM1CN208000QV	HMX-F908P/MEA	For the recording of site survey and training.

(Source: JICA Study Team)

APPENDIX 1

Site Survey of the Train Operation and Track Condition

APPENDIX 1 Site Survey of the Train Operation Condition

The JICA Study Team carried out a Site Survey of the Train Operation Condition in the following sections.

Table Site Survey of the Train Operation Condition

	Day	Section	Item of Survey
1	9 April 2012	Awaso – Dunkwa (73.2km)	Conditions of Awaso station, the bauxite mine in Awaso and the section between Awaso and Dunkwa in which train operation has been suspending
2	10 April 2012	Takoradi – Tarkwa (66km)	Conditions of track, civil structure and train operation in the section between Takoradi and Tarkwa by the inspection train
3	2 June 2012	Nsuta – Takoradi (60.8km)	Conditions of train inspection, loading state of manganese and state of train running by riding on the manganese train

The detailed results of each survey are shown in the following pages:

1. Site Survey 1

Date: 9th April2012

Place: Dunkwa-Awaso

We implemented site surveys where there was easy to access by car between Awaso to Dunkwa and Awaso station and the loading site of bauxite ore that is mainly good on the west line at the bauxite company.

(1) Current conditions of the facilities and the equipment in the train suspension section from Tarkwa to Awaso

- Tracks

There are many rotten sleepers, unstable rails and fasteners everywhere. And it is notable that the conditions of the rail joints and roadbed are extremely poor. At a level crossing the tracks are buried under the ground.

Photo 1 Track at level crossing

Photo 2 Track condition in the section where Train operations are stopped

- Stations

We visited at Dominasi station and Dunkwa station. There are two stationmasters at the station though the train operations had been suspended now. They manage the facilities at the station by rotation. The stationmaster secures the blocking from his station to the next station along with order to depart or approach. Some manuals and documents are recognized at the stations. There is a sub-depot in the Dunkwa station. The traces of the derailment are recognized on the turnout at Dunkwa station.

Photo 3　Dominasi station

Photo 4　Dunkwa station

Photo 5　Old Blocking System

Photo 6　Manuals

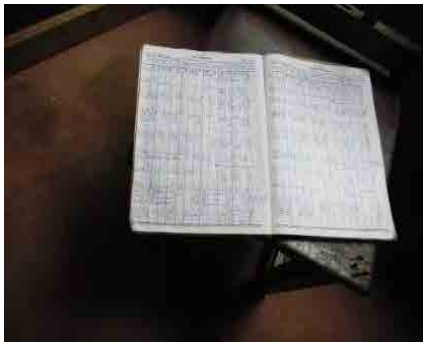


Photo 7　Train operations records

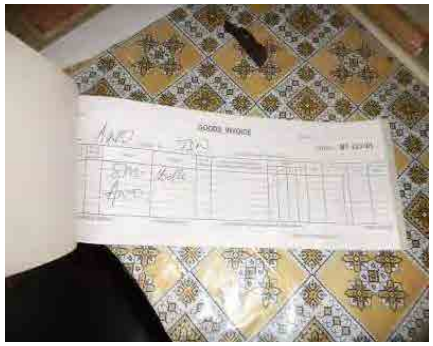


Photo.8　Invoice records

Photo 9　Divergence point to Awaso (Dunkwa)

Photo 10　Trace of derailment (Dunkwa)

- Level crossing

There are some boxes for guards at level crossing on the main road. But no crossing bars, security alarms or roadblocks are provided.

Photo 11 Level crossing at Main road

Photo 12 Level crossing at Dominasi station

- Signal and Route control

There are old semi-automatic block systems that were introduced in 1983. But they are out of order now. The points at the stations are controlled by mechanical devices.

Photo 13 Old type starting signal (3aspect)

Photo 14 Old type home signal (2aspect)

Photo 15 Old Blocking system

Photo.16 Old Blocking control device

Photo 17 Old battery for Blocking system

Photo 18 Old signal detector

Photo 19 Point machine at Dominasi station

Photo 20 Transmission at station

- Communication system

There is an old type of telecommunication system using a fixed line, but it is out of order now. The communication devices are mobile phones for officials now. The mobile phones are used for the blocking.

Photo 21 Old telecommunication device (1)

Photo 22 Old telecommunication device (2)

Photo 23 Old control device

Photo 24 Official mobile phone

(2) Awaso station and the bauxite loading site

Many big bauxite trucks run on the main dirt road towards Takoradi.

There is a sub-depot in the Awaso station too. The tracks that lead to the bauxite mine and in the mine are buried under the ground. There is a weight bridge in the bauxite loading site, but that has been out of order for many years.

Photo 25 Awaso station

Photo 26 Sub depot at Awaso

Photo 27 Track condition leading to Bauxite mine

Photo 28 Track condition at loading site

Photo 29 Bauxite mine

Photo 30 Bauxite Loading base

Photo 31 Loading hopper

Photo 32 Old weigh bridge

1. Site Survey 2

Date: 10th April2012

Section: Takoradi-Tarkwa (66km)

We ride a special train from Takoradi to Tarkwa for checking track condition and train operation method. Current train services in this section are one round trip of a passenger train from Takoradi to Kojokrom every morning and evening and 4 or 5 manganese trains from Nsuta to Takoradi.

Photo 33 Locomotive for passengers

Photo 34 Passenger coach

(Reference)

Western Line (Takoradi—Kumasi)	13 Sep. 2007	Suspension of inter-city train
	13 Mar. 2009	Suspension of bauxite and timber transportation
	May 2011	Suspension of the Tarkwa—Kumasi /Awaso section
Eastern Line (Accra—Kumasi)	13 Mar. 2002	Suspension of train operation
Central Line (Huni Valley—Kotoku)	1 Dec. 2002	Suspension of train operation

(1) Takoradi Station

There is a train control center (OCC) at Takoradi station on the second floor. The dispatchers control the train and record the departure and arrival times of the trains that are reported to each station master on the actual train diagram. The communication devices are mobile phones for each stationmaster now.

Photo 35 Takoradi Station

Photo 36 Train operation control center

Photo 37 Train dispatcher

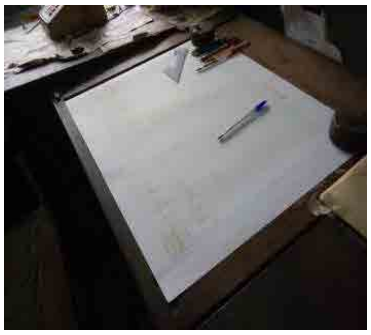


Photo 38 Actual train diagram

Photo 39 Old telecommunication device

Photo 40 Condition of management Documents

(2) The signal cabin

We made an inspection of the signal cabins at Takoradi station and Tarkwa station. The points at both stations are controlled by mechanical devices. There are the old blocking system and the old telecommunication devices, but they are out of order. The mobile phones are used for the blocking.

Photo 41 Takoradi signal cabin

Photo 42 Point machine at Takoradi

Photo 43 Tarkwa signal cabin

Photo 44 Point machine at Tarkwa station

(3) The inspection in the driver's cabin (Takoradi-Tarkwa)

We rode the special train in the driver's cabin and made an inspection of the condition of the tracks, the condition of the train driving, and the method of the train operations.

- The blocking system

The present train blocking system is a staff and ticket block system. The stationmaster who orders departure to the driver from his station calls the stationmaster who is in the end station of the blocking section to make sure that the last train has already left the station using a mobile phone before departure. When it is confirmed that the last train has already left, the stationmaster passes the ticket, LINECLEAR CERTIFICATE, to the driver in order to give approval for the departure. The blocking sections are not a single section, but include 2 or 3 sections. The driver records the departure time in his note book.

Operation notification: In sections where track conditions are so extremely poor that the running speeds need to be restricted, the station master directs the driver to restrict the running speed, which is given in a Caution Order.

- The driving condition

Generally the track conditions are very poor, so the driver is ordered to keep the running speed under

25km/h by the stationmaster. When the train runs into an extremely poor section with an up gradient which causes the train to run at a very low speed, the driver uses a blower to protect the motor from overheating.

In the sections where there are few crossing guardrails, the driver always used the whistle for attention because there are no boundary facilities and the trains operate infrequently, so the public or animals can easily enter the railway area, a level crossing guard stopped the cars by waving a red flag at the level crossings that many people use or that are in a town. There are some level crossings that provide crossing bars. There are many level crossings that don't provide any device for safety in a section with poor visibility. The indicator C that means that a station is near. Mile posts from Takoradi, quarter mile posts and speed limit indicators are provided beside the track.

Photo 45 Locomotive cabin

Photo 46 Broken speedometer

Photo 47 Certification delivered

Photo 48 Put on record

Photo 49 Driver's Document note

Photo 50 Line clear certificate

Photo 51 Notice by stationmaster

Photo 52 Caution Order

Photo 53 Speed limit indicator (1)

Photo 54 Speed limit indicator (2)

Photo 55 Speed limit indicator (3)

Photo 56 Station approach indicator

Photo 57 Speed limit indicator (4)

Photo 58 Speed limit cancel indicator

Photo 59 Mile post

Photo 60 Quarter mile post

Photo 61 Extremely bad track (1)

Photo 62 Extremely bad track (2)

1. Site Survey 3

Date: 2 Jun 2012

Section: Takoradi-Nsuta (60.8km)

We rode the actual manganese train in the driver's cabin from Nsuta to Takoradi and made an inspection of the condition of the Loading wagon, the condition of the train driving, and the method of train inspection.

(1) The situation of the train inspection

The shunter, the driver and the wagon inspector inspected the condition of the train. The certificate of inspection was delivered from the inspector to the driver after inspection. The composition of the train is 25 wagons, and the brakes of two wagons in the rear are out of order.

Photo 63 Inspection by shunter

Photo 64 Inspection by driver

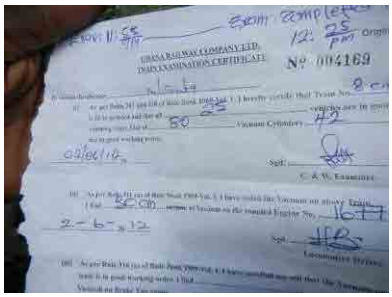


Photo 65 Certificate of inspection

Photo 66 Defective brake hose

Photo 67 Brake inspection (1)

Photo 68 Brake inspection (2)

(2) The loading and unloading

- Loading

The train was divided from 25 wagons into 12 wagons and 13 wagons because the effective length for loading is 13 wagons at the loading site and manganese ore was loaded on the wagons by manganese company staff at the site. For loading to the first composition they used one big wheel loader, then for the next composition they used two. Two buckets of manganese ore were loaded into one wagon. It is dangerous to load goods the on center of the wagon because the load concentrates on the center, so the manganese ore was loaded as two parts longitudinally on the wagon. It is obvious that the load stress for the tracks and wheels increase in the curves due to car body displacement because the wagon length is longer than the Ore car's, which is 8 - 10m, that are commonly used for heavy goods. And the loads tend to lean to the right side because the goods are loaded from the left side toward Takoradi at the site. The wagons were usually used for bauxite, but the bauxite train operations have stopped, so they used for manganese instead. The manganese ore was collected in each wagon. There is no weight measurement at the site. The invoice including information of the weight that was estimated from sampling of manganese ore was delivered by the manganese company staff to the driver. The total loading time was about two hours including shunting. The drivers who drove up in empty trains were in charge of the loading operation.

Photo 69 Loading manganese (1)

Photo 70 Loading Manganese (2)

- Unloading

The length of the rotary car dumper that is used for unloading corresponds to one wagon.

Maximum length of the wagon for manganese is 13.4m. Bauxite wagons are shorter than that, so they are used instead. It seems that the wagon's length can be shorter than existing wagons.

Photo 71 Unloading facility in Takoradi Port (1)

Photo 72 Unloading facility in Takoradi Port (2)

(3) The driving condition

After finishing loading, the driver and the assistant driver changed. The new drivers are in charge of driving from Nsuta to the Takoradi marshalling yard. The unloading operations are done by the manganese company staff. When the train passed the points where a number of derailments had occurred between Nsuta and Esuaso, the wagon's irregular rolling was recognized whenever the train passed rail joints, which is in the middle of an S curve with down gradient and hard cant.

The section between Esuaso and Benso is dangerous because of poor visibility due to being overgrown with weeds beside the tracks in the jungle. The driver checked the condition of the edge of the sleepers when the train passed through the dangerous section where the conditions of the roadbed and sleepers are extreme poor. When the train ran between Benso and Amantin, wheel slip occurred because of rain at the start of the curve with an up gradient. The driver and assistant driver tried to start on the steep grade by using pebbles, but it was impossible. So finally a relief locomotive was connected at the rear and the train advanced to Amantin by being pushed.

From Manso, there are many straight lines and the driver tried to recover the lost time, so the train ran at high speed, but the running speed is unknown because speedometer is broken. The wagon's rolling movement is recognized on the straight line because track conditions are very poor here too.

Photo 73 Broken speedometer

Photo 74 Checking the track condition

Photo 75 Wheel slip (1)

Photo 76 Wheel slip (2)

Photo 77 Wagon condition at curve

Photo 78 Wagon condition at straight