

Republic of Zambia  
Road Development Agency  
(RDA)

Republic of Zambia  
Bridge Maintenance Capacity Building Project  
FINAL REPORT

August 2017

Japan International Cooperation Agency  
Nippon Engineering Consultants Co., Ltd.  
West Nippon Expressway Company Limited

EI
JR
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Location Map (Republic of Zambia)

# Abbreviations

BIV	:	Bridge Inspection Vehicle
BMS	:	Bridge Management System
CM	:	Coordination Meeting
C/P	:	Counterpart
DAC	:	Development Assistance Committee (OECD)
DPWH	:	Department of Public Works and Highway
JCC	:	Joint Coordination Committee
JICA	:	Japan International Cooperation Agency
KIC	:	Kansai International Center
M/M	:	Minutes of Meeting
MoTWSC	:	Ministry of Transport, Works, Supply and Communications
MoTC	:	Ministry of Transport and Communications
MoWS	:	Ministry of Works and Supply
NCC	:	National Council for Construction
NDT	:	Non-Destructive Testing
OJT	:	On-the-Job Training
PDM	:	Project Design Matrix
R/D	:	Record of Discussion
RDA	:	Road Development Agency
RO	:	Regional Office
SANRAL	:	South Africa National Road Authority Limited
SATCC	:	Southern Africa Transport and Communication Committee
TIC	:	Tokyo International Center
TWG	:	Technical Working Group

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### **III RESULTS OF JOINT REVIEW**

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## **Executive Summary**

The Road Development Agency, hereinafter referred to as the RDA, is the highest administrative agency responsible for the construction and maintenance/management of national roads, bridges in the Republic of Zambia.

1. In the first part of the Final Report, is the Outline of the Project on “Bridge Maintenance Capacity Building”. The duration of the project starts from February 16, 2015 – February 17, 2017 with an extension of six (6) months up to August 31, 2017 due to implementation of the pilot project that needs technical assistance from the experts. The overall goal of the project is the bridge maintenance activities were regularly implemented by the agency and its purpose is to institutionalize the capacity of engineers and to strengthen the bridge maintenance planning and operational management which includes the outsourcing contract.
2. In the second part of the report, contains the Results of the Project, under which are the Input by the Japanese Side, Inputs by the Zambian Side and Activities. There are a total of eight (8) experts dispatched.

The tools and materials has also been provided for the bridge inspection and for office operational.

The agency provided an office space and a total of thirteen (13) counterparts involving some regional engineers to achieve its purpose.

### 3. Activities

#### 3.1 Routine Maintenance

Seminar and on-the-job trainings for Bridge Routine Maintenance were held two (2) times and

three (3) times, respectively. The field training for pilot project were also conducted three (3) times showing the actual and proper application of materials used for maintenance.

The Bridge Routine Maintenance Guidelines was developed.

#### 3.2 Bridge Inspection

Reviewing of Bridge Inspection data were conducted in fifty three (53) bridges.

On-the-job training for Bridge Inspection were done two (2) times using the Non-Destructive Testing equipment to acquire knowledge and techniques using these technologies. The Bridge Inspection Guidebook was developed.

### 3.3 Bridge Repair

Knowledge on Bridge Repair with its technology were enhanced through training in Japan three (3) times and exposure on bridge repair works to third countries in South Africa and the Philippines.

The purpose of the training is to understand the importance of bridge maintenance. Develop an implementation plan of repair and/or replacement of bridges based on the condition inspection data. The Bridge Repair Guidebook was developed.

### 3.4 Outsourcing Contract

Develop contract templates and technical specifications for Bridge Routine Maintenance outsourcing. This outsourcing contract was develop to introduce minor works such as vegetation, cleaning of the road facilities and small scale of repair works including road surface and drain structures. RDA has not enough numbers of staffs to do these work activities by themselves and would be outsourced to contractors.

For the outsourcing on Bridge Repair, its purpose is very important in recovering the function of damaged bridges and for preventing further deterioration.

Examination of draft contract, technical specification, bill of quantities, drawings and cost estimates were prepared. A concept paper of pilot project for bridge repair was also prepared. It includes the general idea of the pilot project and shows the outline of the project.

## 4. Monitoring/Evaluation

The progress of the project was based on the Project Design Matrix (PDM) with verification of project performance and was assessed with reference verifiable indicators stated in the said PDM. The five criteria for evaluating the project were the relevance which were assessed as “high”, effectiveness as “relatively high”, efficiency as “moderate”, impact as “relatively high”, and sustainability as “relatively high”.

The third part are the Results of Joint Review based on Development Assistance Committee (DAC) Evaluation Criteria. It was confirmed that the implementation of the field training for pilot bridge routine maintenance was delayed that the project has been extended by six (6) months until August 2017.

There are some Key Factors Affecting the implementation and outcomes of the project. The following were considered reasons: procedural delay of outsourcing for the pilot project, delay of payment of travel expenses, partial absence of RDA counterparts and engineers in the meetings/OJTs due to their other assignments and frequent personnel change.

Lesson Learnt from the project was the delay of procedural outsourcing that could not accommodate the planned activities resulting to time extension.

#### 5. Achievement

The project objective was achieved by the individual achievements of the activities particularly on bridge management cycle related to routine maintenance, bridge inspection and bridge repair.

Through the activities implemented in the project, RDA engineers and those from contractors and consultants who participated in the activities could strengthen sufficiently their understanding on bridge maintenance such as the necessity of bridge routine maintenance and the concept of maintenance management cycle. It is expected that the overall goal of the project can be achieved within 3-5 years after the project termination.

6. Recommendations were suggested to the recipient agency to strengthen the organization for Bridge Maintenance Management, to secure the necessary budget, develop human resources and to guide the capacity of contractors and local consultants through implementation of bridge maintenance.

## I OUTLINE OF THE PROJECT

### 1 Outline of the Project

1.1 Country : The Republic of Zambia

1.2 Title of the Project : The Bridge Maintenance Capacity Building Project in Zambia

1.3 Duration of the Project : February 16, 2015 – August 31, 2017

### 1.4 Background

The Road Development Agency, hereinafter referred to as RDA, is the highest administrative agency responsible for the construction and maintenance/management of national roads, bridges in the Republic of Zambia. The present total length of national road network in Zambia is about 67,000 km and about 39,800km of those are maintained by RDA. There are over 460 bridges along national roads. However, since constructed in the early seventies and or even much earlier, many of these bridges received poor or even no maintenance. About 15% of these structures were reportedly in bad condition wherein urgent maintenance and repair work is needed. On the other hand, the government has a plan to construct 144 new bridges over the rivers crossing selected roads by the end of 2015 together with the replacement of all pontoons by bridges.

New structures need to be maintained well to prolong their life spans. In order to address these challenges, the government set up a bridge unit in RDA specialized in planning and management of bridge construction, inspections and maintenance. As in the case for a newly established entity, there is a need for the bridge unit to strengthen its capacity to manage implementation of RDA's bridge inspection and maintenance programs due to its limited financial, manpower and knowledge resources.

Considering the above-mentioned background, the framework of the project was agreed and it includes activities in RDA Head Office and the regional offices for bridge maintenance capacity building of RDA engineers.

### 1.5 Overall Goal and Project Purpose

#### (1) Overall Goal

Bridge maintenance activities are regularly implemented by Road Development Agency (RDA).

#### (2) Project Purpose

The institutional capacity of RDA is strengthened for bridge maintenance planning and operational management, which includes improvement of outsourcing contract management.

#### (3) Outputs

Output-1: RDA engineers understand the management cycle of routine maintenance and undertake supervision of routine maintenance activities.

Output-2: RDA engineers utilize bridge condition inspection data for further investigation and planning of repair or replacement of bridges.

Output-3: The knowledge on bridge repair technology of RDA engineers are enhanced and RDA engineers are able to prepare a bridge repair plan for pilot bridges using the data from condition inspection and Bridge Management System.

Output-4: The capacity of RDA for contract management is improved in the field of routine maintenance and repair on bridges.



## II RESULTS OF THE PROJECT

### 1 Results of the Project

#### 1.1 Input by the Japanese Side (Planned and Actual)

##### 1.1.1 Dispatch of Experts

Table II-1 Dispatch of Experts (Planned and Actual)

Expert	Name	Plan MM		Actual MM	
		Field	Japan	Field	Japan
Team Leader/Bridge Maintenance Management	NAGAO, Hideo	8.00	0.40	11.33	0.75
Bridge Inspection	KANGAWA, Masaki	7.00	0.35	6.67	0.35
Bridge Repair	TERAI, Kokichi	8.00	0.50	8.00	1.00
Bridge Routine Maintenance	SAGAWA, Nobuyuki	8.00	—	13.73	—
Bridge Maintenance Outsourcing	KASAMATSU, Hiroji	7.00	—	7.77	—
Project Coordinator/Asst. for Bridge Inspection/Training	ESTUDILLO, Cherri	7.00	0.50	10.17	1.00
Bridge Maintenance	HARASAKI, Ikuo	—	—	0.43	—
Monitoring	MINAGAWA Yasunori	—	—	0.70	0.80
<b>Total</b>		45.00	1.75	58.80	3.90

##### 1.1.2 Tools/Materials Supply

Table II-2 Procurement of Tools/Materials (1/2)

Tools Name	Quantity	Specification	Remarks
Concrete Rebound Hammer	1	Proceq Original Schmidt, Type N	Use for condition inspection (Measurement of concrete compressive strength)
Testing Anvil for Concrete Rebound Hammer	1	Proceq Anvil, Type N	Use for condition inspection (Calibration of the above hammer)
Reinforced Concrete Rebar Detector (Radar Type)	1	Japan Radio Company (JRC) NJJ-105 Handy Search	Use for condition inspection (Survey of cover and reinforcement bar of concrete structure)
Ultrasonic Metal Thickness Gauge	1	Checkline T1-007	Use for condition inspection (Measurement of steel plate thickness)
Portable Water Pressure Washer	3	KARCHER K4640	Portable bridge washer with high pressure water
Generator	3	Ryobi RG-2700 Rated power-2000W	Generator for the above tools
Paint Thickness Gauge	4	Laserliner	Use for condition inspection (Measurement of paint thickness)

Table II-3 Procurement of Tools/Materials (2/2)

Hand-carry Tools	Quantity	Specification	Remarks
Projector	1	Canon LV-X300	Office tools
Video Camera	1	Canon F506	
Copier Machine	1	Canon IR2525	
Digital Camera	4	Canon	
Laptop Computer	4	HP Pro Book 450 G1	
Desktop Computer	1	HP MT 3500 G2	
Color Printer	1	HP PRO 400 M401	
Hard Hat	30		OJT tools
Safety Vest	30		
Safety Belt	30		
Distance Meter	4	HILTI Laser Range Meter PD5	
Global Positioning System (GPS)	4	Garmin Navigator ETREX 10	
Binocular	4	Nikon 8×2	

### 1.1.3 Expenses

Excerpted from the 3rd contract modification documentation.

Table II-4 Expenses of the Project (Japan side)

Items	Amount (Yen)
I Project Cost	216,945,000
1 Direct Cost	117,699,000
(1) Travel Cost (Air tariff)	40,736,000
(2) Travel Cost (Others)	26,539,000
(3) General business expenses	35,488,000
(4) Products creation cost	368,000
(5) Equipment cost	8,124,000
(6) Re-entrust cost	0
(7) Training cost in foreign countries	6,444,000
2 Direct manpower cost	45,112,000
3 Other cost	54,134,000
II Administrative expenses	39,698,000
III Total	256,643,000
Total amount of consumption tax and local consumption tax ( Calculated at the tax rates that are determined by the laws and regulations )	20,531,440
IV Grand Total	277,174,440

## 1.2 Input by the Zambian Side (Planned and Actual)

## 1.2.1 Counterparts

Table II-5 Counterparts

Counterparts		Planning	Implementation
Project Director	CEO	Eng. Elias Mwape- Acting Director & CEO	Eng. Elias Mwape (Eng. Kanyuka Mumba) (Eng. Bernard Mwape Chiwala)
Project Manager	Director, Planning & Design	Eng. Dickson Ndhlovu-Acting Director, Planning & Design	Eng. Dickson Ndhlovu (Eng. Elias Mwape) (Eng. William K Mulusa)
Project Coordinator	Senior Manager Bridges	Eng. Stephen Sondashi (Eng. Mubuyaeta Kapinda) (Eng. Lazarous Nyawali)	Eng. Stephen Sondashi (Eng. Mubuyaeta Kapinda) (Eng. Lazarous Nyawali)
Counterpart Assistant Project Coordinator/ Bridge Inspection	Principal Engineer-Structures	Eng. Habeene Habeenzu	Eng. Habeene Habeenzu
Counterpart Bridge Repair	Senior Manager Bridges Maintenance	-	Mr. Mubuyaeta Kapinda
Counterpart Bridge Repair	Principal Engineer-Bridge Maintenance	Eng. Chapwe Tumelo	Eng. Chapwe Tumelo
Counterpart Bridge Routine Maintenance	Principal Engineer-Emergencies	Eng. Gerald Phiri	Eng. Gerald Phiri
Counterpart Bridge Maintenance Outsourcing	Engineer Hydrologist Planning & Design	Eng. Mwape Phiri	Eng. Mwape Phiri
Counterpart	Principal Engineer- Bridge	-	Eng. Muyunda Maketo
Counterpart	Engineer Planning & Design	-	Eng. Bornwell Siakanomba
Counterpart Pilot Project on Bridge Routine Maintenance	Lusaka Regional Office Regional Manager	-	Eng. Chabala Pandeki (Eng. Joseph Mwinga)
Counterpart Pilot Project on Bridge Routine Maintenance	Lusaka Regional Office Senior Engineer	-	Eng. Main Chama (Eng. George Chitonena)
Counterpart Pilot Project on Bridge Routine Maintenance	Lusaka Regional Office Planning	-	Eng. Victor Miti

## 1.2.2 Regional Office Staff

- a. RDA were able to Review the Bridge Inspection of Trunk Road (T-1, 2, 3, 4) with the participation from Lusaka, Copperbelt, Central, Southern, and Eastern Regional engineers.

- b. RDA and JICA team completed the On-the-Job Training on Routine Maintenance in three (3) clusters at Copperbelt, Lusaka and Muchinga with regional attendants of 10, 15 and 5 engineers, respectively.
- c. Japan training accommodated three (3) batches of RDA engineers from provinces of: Muchinga (1), Western (1), North West (1), Northern (1), Lusaka (2), Copperbelt (1), and Kasama (1).
- d. Seminars were conducted in two different venues with a total number of RDA participants from headquarters of six (6) and regional offices of fourteen (14).
- e. On-the-Job Training on Bridge Inspection were conducted two (2) times at the same bridge site to give engineers initial inspection methodology for budget planning and preparation and Transfer Of Technology using Non Destructive Testing equipment with the help of Bridge Inspection Vehicle (BIV) in accessing the bottom parts of the bridge.

### 1.2.3 Office Facilities

RDA provided an office to the team in Alick Nkhata Road with facilities such as tables (8), cabinets (2) and chairs (8). Internet were provided but with intermittent connections since Zambian Government is experiencing power shortage. On March of 2016, RDA in Alick Nkhata was transferred and merged with RDA in Government Fairley Road with the JICA team transferred at the same time.

## 1.2.4 Budget (RDA)

Table II-6 Budget of the Project (RDA)

<b>1. EVENTS</b>	<b>Cost (ZMW)</b>
1st Seminar on Bridge Routine Maintenance	26,814.50
1st Japan Training	119,700.00
OJT on Bridge Routine Maintenance Kafue	31,019.00
OJT on Bridge Routine Maintenance Kitwe	31,019.00
OJT on Bridge Routine Maintenance Mpika	31,019.00
2nd Japan training	119,700.00
2nd Seminar on Bridge Routine Maintenance	24,689.28
Dry Run 1	3,040.30
Third Country Training	-
1st OJT On Bridge condition Inspection, Kafue	15,000.00
Dry Run 2	3,040.30
Fourth Country Training	68,400.00
2nd OJT On Bridge condition Inspection, Kafue	32,874.33
1st Field Training on Bridge Routine Maintenance	13,365.55
2nd Field Training on Bridge Routine Maintenance	16,982.97
3rd Japan training	118,020.00
3rd Field Training on Bridge Routine Maintenance	29,644.04
Bridge Inspections	12,000.00
<b>TOTAL</b>	<b>696,328.23</b>
<b>2. Counterpart Personnel time inputs</b>	
Director & CEO Project Director, Director P&D Project Manager, Project Coordinator, Counterpart	150,492.59
<b>TOTAL</b>	<b>150,492.59</b>
<b>3. Pilot Project on Bridge Routine Maintenance</b>	<b>5,200,572.72</b>
<b>GRAND TOTAL</b>	<b>6,047,393.54</b>

1.3 Activities (Planned and Actual)

1.3.1 Enhancement of Routine Maintenance for Bridges

1.3.1.1 Develop a Guideline for Routine Maintenance of Bridges

The purpose of this activity is to prepare a guideline that contains all the essential items for the use of RDA engineers and other involved engineers in starting the bridge routine maintenance operations in Zambia.

Basically, on the assumption that the bridge routine maintenance operations are carried out through outsourcing, the routine inspection procedures, that is, the inspection items, the places to be inspected, how to record the data, etc. should be established. The work items, the key points, the matters to keep in mind and the repairing methods for bridge routine maintenance operations should be also explained. In addition, photos and illustrations should be provided for easy comprehension.

The flowchart for developing the routine maintenance of bridge guideline is shown in Figure II-1. On-the-Job-Trainings will be conducted using the draft of these guidelines, which will be corrected and revised to be finalized through the feedback of such accomplishments.

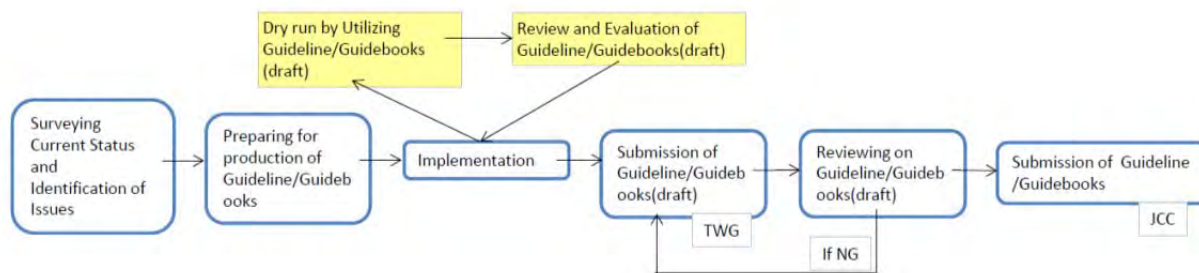


Figure II-1 Flowchart for developing the Routine Maintenance of Bridge Guideline

(1) Points to consider in the preparation of the Guideline

For the preparation of the Guidelines, the work items and the work procedures to be included in the routine maintenance contract should be reviewed in advance. Although these matters will be also discussed in the preparation of the outsourcing documents, a comprehensive consideration is important because of many mutually related factors. Without a precise definition of routine maintenance, the scope of operation of each road administrative body would generally differ. In such case, the capacity of contractor and the availability of materials and equipment are the important points to consider.

a. Capacity and qualification of contractor

While the qualification for road routine maintenance is the Grade 5th or 6th, it is determined that a higher capacity by one rank, that is, the Grade 3rd or 4th, is required for the bridge routine maintenance, even though the target is a local contractor; the National Council for Construction, NCC is responsible for the registration and qualification of contractors.

For this purpose, the contract package should be separate from road routine maintenance and of appropriate size; grouping in the unit of province or route may be a possible approach.

b. Procurement of materials and equipment

Considering the wide variety of construction conditions, various kinds of repair materials should be used in bridge repair works. Regarding the availability of such materials

in Zambia, inquiries to several repair material suppliers were conducted.

As for the equipment for bridge repair works, the bridge inspection vehicle owned by RDA can be used effectively not only for inspection activities as its main purpose but also for bridge maintenance operations as a movable scaffolding. For this reason, it has been requested for use in this project.

The inquiries to several suppliers were held to examine the market availability and the handling conditions of various repair materials such as concrete sealer and paints. Although an inquiry about such suppliers was made to the NCC office which is responsible for the contractor registration, the information obtained was insufficient. It is apparent that the experience of bridge repairs in Zambia is insufficient and the industries dealing with the materials and equipment related to bridge maintenance have yet to be developed. Moreover, when such repair materials are applied on site, the suppliers should provide a significant amount of on-site technical assistance from the manufacturer's aspect. As a result, it has been reconfirmed that not only improving the capacity of contractors, but also raising the technological knowledge and skills of the related industries, especially of repair material suppliers, is indispensable for future bridge maintenance operations.

- Information gathered from the suppliers of repair materials -

Firm A: This is a supplier of construction materials which is dealing in the products of European chemical manufacturer mainly with mining firms in the northern regions. They have a general lineup of products but it is not sufficient for various bridge repair operations.

Firm B: This is a South African paint maker which has capital ties with Japanese paint maker. They have a paint factory in Zambia and also deal in wide range of products. They say confidently that the products from South Africa can be delivered for about two weeks.

Firm C: This is a European cement maker, the largest company of this kind, which also operates cement plants in Zambia. However, their domestic transaction is limited to cement; though they have the group companies who are developing and producing concrete repair materials, they have not embarked on such business so far here in Zambia.

c. Work process and routine inspection

Regarding the work process of bridge routine maintenance contract including routine inspection, after the completion of routine inspection, the contractor submits the inspection report to RDA regional office and then the regional office reviews it in detail, and finally reports it to RDA headquarters. Based on the inspection results, RDA side provides the contractor with the instructions of starting work for the Day Work items; while for large-scale or more serious defects, separate major repair works should be considered for outsourcing.

It is determined that the routine inspection should be conducted every 3 months as the performance based item in addition to cleaning and vegetation control activities.

In a series of the procedures including routine inspection, defect evaluation, instruction of repair works, and data record, report forms to be used therein should be prepared so as not to conflict with the existing administrative procedures of RDA. Therefore, a close check was requested to the counterparts.

(2) Framework and Contents of the Guideline

This Guideline is consisted of Chapter 1 "General", Chapter 2 "Routine Inspection", Chapter 3 "Routine Maintenance", and Chapter 4 "Routine Maintenance and Repair Method".

In Chapter 1 "General", the general outline of bridge routine maintenance and the positioning therein of the routine maintenance operations are explained. The establishment of integrated system with the following key concepts: "Bridge Maintenance Management Cycle" and "Preventive Maintenance" is emphasized.

In Chapter 2 "Routine Inspection", when conducting the routine inspection, the details should be understood in connection with the maintenance management cycle which is composed of inspection, defect evaluation, repair work, and data record. For this purpose, the flowchart of the RDA operations including the inspection is provided together with the inspection items, defect evaluation/judgement skill, and record forms are attached, including some explanations.

In Chapter 3 "Routine Maintenance", following Chapter 1 "General", the roles of routine maintenance are explained in detail, and the standard activity list indicating the actual work items targeted by the routine maintenance operation is provided. On the assumption that this operation is conducted by outsourcing, the dual system of measurement/payment by the combination of performance based system and achievement based system is applied, in which contractual demarcation is indicated in the list concerned; the former is applicable to regular and standard activities and the latter is applicable to minor repairs according to circumstances.

In Chapter 4 "Routine Maintenance and Repair Method", regarding the maintenance activities and minor repairs which are prescribed as the routine maintenance items in the previous chapter, the actual application criteria, the work procedures, and the required materials and tools/equipment are indicated per individual activity together with some explanations.

(3) Submission of the draft to the 1st TWG Meeting on July 31st, 2015

The draft of Bridge Routine Maintenance Guidelines was submitted to the TWG Meeting held on July 31<sup>st</sup>, 2015 so as to be discussed among the TWG members. Although the Guidelines should be finalized by the necessary touch-up and correction of the descriptions based on the experiences from the OJTs, seminars and the accomplishments of the pilot project to be mentioned hereafter, the basic parts of the Guidelines were approved in this TWG Meeting.

(4) Submission of the final draft to the 4th TWG Meeting on October 28th, 2016

Reflecting the achievements obtained from every activity of this project, the draft initially approved in the 1st TWG meeting had been finalized with the necessary touch-up and correction.

As for the main revision, the Chapter 4 "Routine Maintenance and Repair Method" was revised based on the experiences and accomplishments of the on-site demonstrations in the OJTs and the implementation of the pilot project. The final draft had been completed through the discussion in the 4<sup>th</sup> TWG meeting and the comments were afterward collected from the counterparts.



Exchange of views on the Guidelines draft with the counterpart



B firm: South African paint maker which has capital ties with Japanese paint maker

Figure II-2 Developing the Guideline for Bridge Routine Maintenance



### 1.3.1.2 Conduct Seminar on Routine Maintenance for Bridges

Since this is the first project in Zambia to establish the full-scale bridge maintenance operations, the maintenance methodologies on the basis of the importance of maintenance management cycle and the principle of preventive maintenance will be presented in this seminar together with the introduction of examples in other countries. The Bridge Routine Maintenance Guideline will be explained to understand the individual activities of the routine maintenance operations from the standpoint of preventive maintenance of bridges.

#### (1) Conduct the 1st Seminar on Routine Maintenance for Bridge

The 1st Seminar on Bridge Routine Maintenance was held at the Government Complex on August 11<sup>th</sup>, 2015 with a total of 72 participants (including the counterparts) from RDA headquarters, RDA regional offices, related organizations, and private contractors. The whole program had progressed almost on schedule; in the question-and-answer session, a lot of lively and spirited discussions arose.

Table II-7 Program of the 1st Seminar on Routine Maintenance for Bridge

THE 1ST SEMINAR PROGRAM on Conceptual Framework of Routine Maintenance on Bridge

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: August 11 <sup>th</sup> , 2015 (Tuesday)/Government Complex in Lusaka		
08:30 - 09:00	Registration/Conference Room	Supporting Staff
09:00 - 09:15	Opening Remarks	Mr. Mumba Kanyuka CEO, RDA
09:15 - 09:30	Speech by JICA	Mr. Hisanao Noda Chief Rep., JICA
09:30 - 09:45	Speech by MOT	Mr. Joe Kapembwa Director (P&M), MOT
09:45 - 10:30	Bridge Maintenance Management	Mr. Hideo Nagao, JICA Team Leader
Break		
10:45 - 11:30	Overview of Road Administration in Zambia	Mr. Mubuyaeta Kapinda Senior Manager-Br. RDA
11:30 - 12:15	Introduction of Bridge Repair Technology in Japan	Mr. Katsuo Ochi Shimizu Corporation
Lunch Break		
13:15 - 13:35	Video Show (Maintenance of Akashi Bridge)	Mr. Hideo Nagao, JICA Team Leader
13:35 - 14:20	Presentation on Bridge Routine Maintenance	Mr. Nobuyuki Sagawa JICA Expert
14:20 - 15:05	Outlook on Bridge Maintenance in Zambia (undecided)	Mr. Emmanuel Kaunda Director Maint, RDA
15:05 - 15:20	Closing Remarks	Mr. Willam Mulusa Director PL, RDA



Total of 72 participants at Government Complex on August 11<sup>th</sup>

High level of interest among contractor participants who exchanged views spiritedly

Figure II-3 The 1st Seminar on Routine Maintenance for Bridge

(2) Conduct the 2nd Seminar on Routine Maintenance for Bridge

The 2nd Seminar on Bridge Routine Maintenance was held at a hotel in Lusaka on June 14th, 2016 with a total of 81 participants (including the counterparts) from RDA headquarters, RDA regional offices, related organizations, and private contractors. The program were diversified by the presentation of Japanese up-to-date technologies of bridge maintenance by Mr. Harasaki, a short-term expert, and the practical explanation based on the first year's achievements such as the OJTs on site. On the counterpart side, the presentation of their future bridge maintenance operations with technological topics was provided by Lusaka R/O who is in-charge of the pilot project and the executive officers from the Ministry and RDA headquarters who devotedly joined the discussion to the end where various opinions were exchanged proactively. Several women entrepreneurs from the Zambia Association of Women in Construction also joined the seminar with their diverse opinions that activated the discussion. Compared with the 1st seminar, the discussion included more high-level technological matters which implies an improvement in understanding and recognition of bridge maintenance.

Table II-8 Program of the 2nd Seminar on Routine Maintenance for Bridge (1/2)  
THE 2<sup>nd</sup> SEMINAR PROGRAM on Conceptual Framework of Routine Maintenance on Bridge

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: June 14 <sup>th</sup> , 2016 (Tuesday)/Golden Zambezi Lodge		
08:30 - 09:00	Registration/Conference Room	Supporting Staff
09:00 - 09:15	Opening Remarks	Mr. Kanyuka Mumba CEO, RDA
09:15 - 09:30	Speech by JICA	Mr. Hisanao Noda Chief Rep., JICA
09:30 - 09:45	Speech by MoWS	Mr. Joe Kapembwa Director (P&M), MoWS
09:45 - 10:30	Bridge Maintenance Management	Mr. Hideo Nagao, JICA Team Leader
Break (15 minutes)		

Table II-9 Program of the 2nd Seminar on Routine Maintenance for Bridge (2/2)

DATE/TIME	ACTIVITIES	IN-CHARGE
10:45-11:10	Pilot Project on Bridge Routine Maintenance	Regional Manager Lusaka Region
11:10 - 11:50	Overview of Road Administration in Zambia	Mr. Elias Mwape Director P&D, RDA
11:50 - 13:00	Maintenance Management of Road Bridges in Japan	Mr. Ikuo Harazaki Japan Bridge Engineering Center
Lunch Break (13:00-14:00)		
14:00 - 14:20	Video Show (Maintenance of Akashi Bridge)	Mr. Hideo Nagao JICA Team Leader
14:20 - 15:05	Bridge Routine Maintenance (Explanation of Guidelines)	Mr. Nobuyuki Sagawa JICA Expert: Routine Maintenance
15:05 – 16:00	Questionnaire/Discussion	RDA,JICA
16:00 - 16:15	Closing Remarks	Mr. William Mulusa Director Maint., RDA



Total of 81 participants; presentation on the overall project by Mr. Nagao, Team Leader



Presentation about technical details of the pilot project and others by Lusaka Regional Office



Introduction of Japanese latest bridge maintenance technologies by Mr. Harasaki, Short-term Expert



Participants from contractors; several women entrepreneurs participated in this seminar.

Figure II-4 The 2nd Seminar on Routine Maintenance for Bridge

(3) Results of questionnaire; mainly on comparison between the 1st and 2nd seminars

- Have you ever experienced bridge preservation activities?

Table II-10 Experience with Bridge Preservation Activities

	1 <sup>st</sup> Seminar	2 <sup>nd</sup> Seminar
Yes	33%	47%
No	65%	51%

The reason why the participants with experience had increased is supposedly because the contractors invited to the 2nd seminar were limited to those with a qualification that has a possibility in getting involved in such bridge maintenance business in future.

Although the said experience is limited mainly to cleaning, vegetation control and repairs to bridge appurtenances, many of the participants in the 2nd seminar mentioned the actual project names and the details of repair methods which reflects their higher expertise.

- Level of difficulty and seminar improvement proposals

The level of difficulty was recognized to be appropriate for both the 1st and 2nd seminars. As for the proposals of improvement, the request of upgrading the seminar program such as extension of the seminar schedule was same in both seminars. However in the 2nd seminar, the requests and proposals were more noticeably deepened; the detailed explanation of the repair methods for individual defects and the allocation of enough time for exchange of views were requested.

- The most necessary/interesting technologies and the usefulness of the seminar

In the 1st seminar, many participants mentioned general topics such as preventive maintenance and deterioration forecast technique. On the other hand, in the 2nd seminar some added more specific topics such as repair skill using epoxy resin, crack repair skill, and evaluation technique of bridge maintenance; this implies that the understanding of bridge maintenance operations had been widened and deepened considerably. As for the comments about the seminars, there were some requests for further improvement to meet the necessity of learning more practical technologies to be applied on site although the seminars were recognized as very useful to beginners.

The enhancement and improvement of the understandings of bridge maintenance operations was identified through the comparison between the 1st seminar and the 2nd seminar, in which RDA officers including the counterparts had played an important role.

- The most important requirement to establish bridge maintenance system in Zambia

There were many comments pointing out the improvement of policy framework, financial resources, human resource, materials/equipment in both seminars, and some mentioned the necessity of soft technology such as recording various data from construction that should be updated continually by the regional office. This gives an impression of improvement of the understanding and recognition of bridge maintenance among the attendees.

- Opinions on overall bridge preservation in Zambia

Most participants had the opinion that the bridge maintenance operation in Zambia is being performed insufficiently and should be enhanced for the future. Examining in details, wider views were confirmed such as, priority should be given to the bridge maintenance on policy level and the contractors with higher expertise should be brought up to carry out repair operations using up-to-date materials and construction methods.

1.3.1.3 Conduct On-the-Job Training for Routine Maintenance of Bridges

The purpose of this OJT is to facilitate understanding of the contents of the Bridge Routine Maintenance Guideline by conducting actual individual routine maintenance activities at the bridge sites in accordance with the draft of the Guideline. The program of the OJT is composed of the lectures for the first day and the field trainings for the second day. The targeted participants were the counterparts, the engineers of regional offices and the engineers of private contractors; the active participation of engineers from private contractors was particularly demanded because the bridge maintenance operation in Zambia will be performed mainly by such engineers.

(1) Conduct a Dry-Run in Copperbelt Province

The repair technologies to be adopted in the Guideline should be checked from the aspect of adaptability by performing a dry-run because of the limited availability of materials and equipment in Zambia. RDA approved the proposal that several basic activities including touch-up paint, concrete patching and repair of slope protection around abutment should be tried by a such dry-run prior to the upcoming OJTs. The reasons why Copperbelt province was selected are because there are many damaged bridges to be repaired due to the heavy traffic of large vehicles and the materials and equipment can be procured relatively easy in the integrated market of mining industries.

In addition, the project activities conducted on site including the OJTs were supposed to have been carried out in the pilot project which should have been outsourced in advance by RDA, but actually, due to the delay of RDA's procurement process, these pilot activities were conducted under the direct management of RDA using the workers employed by the regional office. What was revealed in this dry-run is that it unexpectedly took much time to complete the preparation due to the lack of experience of the supervisors and the workmen and that the technical assistance provided by the material suppliers were indispensable in mastering the of use such repair materials.



Dry-run at steel bridge on T3 Road over Kafue River. Traffic regulation completed.



Concrete patching with polymer cement application. Pour and finish by trowel.

Figure II-5 Conduct a Dry-Run in Copperbelt Province (1/2)





Applying epoxy primer; after drying, finish with polyurethane topcoat.



Cleaning expansion joint with high-pressed water cleaner.

Figure II-6 Conduct a Dry-Run in Copperbelt Province (2/2)

(2) Preparation to conduct OJT for bridge routine maintenance

Based on the achievement of the dry-run as described previously, every preparation including the selection of bridge site and venue for the OJT was started in addition to preparing the OJT program. Copperbelt Province, Lusaka Province and Muchinga Province were selected as the venue for the OJT so as to accommodate all the participants efficiently from the 10 provinces all over the country. Aside from arranging the venues, RDA was requested to firmly secure the budget particularly the items to be financed by RDA including travel allowance of participants and labor cost of workers for conducting site training. Various kinds of activities were incorporated in the OJT program: the report of the participants about their training in Japan, the group discussion among participants, the presentation of repair materials suppliers, etc. Moreover, in the on-site demonstration of repair works scheduled for the second day, preparations such as the selection of repair locations, the procurement of materials/equipment and the allocation of workers were required. Such arrangements were carefully done in coordination with the repair material suppliers.



Repaired concrete member at a guardrail post base in the dry-run held on August



Repainted guardrail in the dry-run; unfortunately, many graffiti were already on it

Figure II-7 Preparation to Conduct OJT for Bridge Routine Maintenance

(3) The 1st OJT in Kitwe of Copperbelt Province

On the first day, the training lecture was conducted in a venue in Kitwe with a total of 23 participants: 13 from RDA and 10 from private contractors. The program contained several presentations by the engineers who were dispatched by the material suppliers from

South Africa. On the field training of the second day, the venue was a continuous steel girder bridge over the Kafue River which had been used previously for the Dry-Run. While the activities in the dry-run had been limited to those on the bridge deck due to insufficient preparation, during the OJT, the activities were carried out around the bearings and at the end part of girders by building up a scaffolding in front of the abutment. In addition, the drain extension up to the girder bottom and the indication of bridge name that the JICA team had previously proposed were completed in advance so as to be exhibited to the participants. Because the staff of the regional office had already experienced the dry-run the last August, the preparatory works such as building of scaffolding had been efficiently completed, hence the site training of the second day went very smoothly. Afterward, in the group discussion session, the active discussion brought significant results wherein RDA executives took part in as well.

Table II-11 Program of the 1st OJT on Routine Maintenance for Bridge (1/2)

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: November 25 <sup>th</sup> , 2015 (Wednesday)/Sherbourne Lodge in Kitwe		
08:30 - 09:00	Registration/Conference Room	Supporting Staff
09:00 - 09:10	Opening Remarks	Mr. Kayuka Mumba CEO, RDA
09:10- 09:25	Introduction of TCP	Mr. Hideo Nagao, JICA Team Leader
09:25- 09:40	Bridge Maintenance Management	Mr. Hideo Nagao, JICA Team Leader
09:40- 10:00	Introduction of Japan Training	Mr. Tyson Mwale Senior Eng.-North Western
Break		
10:15 - 10:30	Pre-evaluation Questionnaire	Supporting Staff
10:30 - 10:50	Bridge Maintenance in Zambia	Mr. Mubuyaeta Kapinda Senior Manager-Br
10:50 - 12:30	Bridge Routine Maintenance - Explanation on the Guidelines -	Mr. Nobuyuki Sagawa JICA Expert
Lunch Break		
14:00 - 14:20	VIDEO show	
14:20 - 14:55	Concrete Structure Repairs	Mr. Manfredi P.Brunelli BASF (Brunelli Store)
14:55 - 15:30	Protective Coating for Steel	Mr. Brian Malandu Kansai PLASCON
Break		
15:45 - 16:30	Briefing on Field Training	Mr. Nobuyuki Sagawa JICA Expert

**Table II-12 Program of the 1st OJT on Routine Maintenance for Bridge (2/2)**

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: November 26 <sup>th</sup> , 2015 (Thursday)/ Steel bridge on T3 Road over Kafue River near Kitwe		
08:30 - 09:00	Assembling and Travel to Bridge Site	
09:00 - 12:00	Field Training Inspection, Concrete Patching, Touch-up Painting, Cleaning, Vegetation Control, etc.	Mr. Nobuyuki Sagawa JICA Expert Mr. Gerald Phiri Principal Engr, RDA BASF (Brunelli Store) Kansai PLASCON
Lunch Break		
13:00 - 14:00	Continuation of Field Training	ditto
14:00 - 14:30	Back to Conference Room	
Break		
14:45 - 15:45	Group Discussion	All Participants (into 4 groups)
15:45 - 16:15	Group Presentation	ditto
16:15 - 16:30	Post-evaluation Questionnaire	Supporting Staff
16:30 - 16:50	Issuance of Certificates	Mr. Willam Mulusa, PM. Director PL, RDA /RM/NAGAO/SAGAWA
16:50 - 17:00	Closing Remarks	Mr. Ziko Banda Regional Manager, RDA



Opening of OJT; Mr. William Mulusa and Mr. Ziko Banda attended from RDA.



Presentation on introduction of latest technologies of concrete repair by material supplier

**Figure II-8 The 1st OJT in Kitwe of Copperbelt Province (1/2)**





Site training: technical instruction for partial painting on the scaffolding built in front of abutment



Concrete patching work using polymer cement mortar produced by chemical maker



Indication of bridge name proposed in the project; naming Luanga Bridge T-003



Another proposal; drain extension up to bottom flange with fabricated VP pipe and metal fitting



Group Discussion; each group discussed a topic of their choice and afterwards made a presentation.



Mr. Mulusa handed the attendance certificate to the participants one by one.

Figure II-9 The 1st OJT in Kitwe of Copperbelt Province (2/2)

(4) The 2nd OJT in Kafue of Lusaka Province

On the first day, the training lecture was conducted in the venue arranged on the Kafue River with a total of 24 participants: 10 from the RDA and 14 from private contractors. On the second day, the site training was conducted in the girder bridge of T2 road passing over the Manlengo River located in the middle of Kafue and Chirundu. There were many medium degree defects in this bridge and the access to repair areas was relatively easy because of its low clearance; that is why this bridge was selected for the OJT site. For the individual repair works, some technical instructions were provided by the material suppliers, where some inconsistencies in the technical procedures were revealed and such inconsistencies should be corrected in the implementation stage of the pilot project. Several contractors participated in this OJT where they posed many questions actively, a proof of their great interest in the RDA's outsourcing of bridge routine maintenance.

Table II-13 Program of the 2nd OJT on Routine Maintenance for Bridge (1/3)

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: December 2 <sup>nd</sup> , 2015 (Wednesday)/Chita Lodge near Kafue River		
08:30 - 09:00	Registration/Conference Room	Supporting Staff
09:00 - 09:10	Opening Remarks	Mr. Willam Mulusa PM. Director PL, RDA
09:10- 09:25	Introduction of TCP	Mr. Hideo Nagao, JICA Team Leader
09:25- 09:40	Bridge Maintenance Management	Mr. Hideo Nagao, JICA Team Leader
09:40- 10:00	Introduction of Japan Training	Mr. Bernard Zulu Senior Eng.-Western
Break		
10:15 - 10:30	Pre-evaluation Questionnaire	Supporting Staff
10:30 - 10:50	Bridge Maintenance in Zambia	Mr. Mubuyaeta Kapinda Senior Manager-Br
10:50 - 12:30	Bridge Routine Maintenance - Explanation on the Guidelines -	Mr. Nobuyuki Sagawa JICA Expert
Lunch Break		
14:00 - 14:20	VIDEO show	
14:20 - 14:55	Protective Coating for Steel	Mr. Palghat Mohan Kansai PLASCON
14:55 - 15:30	Concrete Structure Repairs	Mr. Stephen de-Klerk BASF (South Africa)
Break		
15:45 - 16:30	Briefing on Field Training	Mr. Nobuyuki Sagawa JICA Expert

Table II-14 Program of the 2nd OJT on Routine Maintenance for Bridge (2/3)

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: December 3 <sup>rd</sup> , 2015 (Thursday)/Steel bridge on T2 Road over Manlengo River		
08:30 - 09:00	Assembling and Travel to Bridge Site	
09:00 - 12:00	Field Training Inspection, Concrete Patching, Touch-up Painting, Cleaning, Vegetation Control, etc.	Mr. Nobuyuki Sagawa JICA Expert Mr. Gerald Phiri Principal Engr, RDA BASF (Brunelli Store) Kansai PLASCON
Lunch Break		
13:00 - 14:00	Continuation of Field Training	ditto
14:00 - 14:30	Back to Conference Room	
Break		

Table II-15 Program of the 2nd OJT on Routine Maintenance for Bridge (3/3)

DATE/TIME	ACTIVITIES	IN-CHARGE
14:45 - 15:45	Group Discussion	All Participants (into 4 groups)
15:45 - 16:25	Group Presentation	ditto
16:25 - 16:40	Post-evaluation Questionnaire	Supporting Staff
16:40 – 17:00	Issuance of Certificates	Mr. Willam Mulusa, PM. Director PL, RDA /RM/ NAGAO/SAGAWA
17:00 - 17:10	Closing Remarks	Mr. Joseph Mwinga Regional Manager, RDA



Opening speech by a staff in charge of Lusaka Regional Office



OJT lecture by a dispatch engineer of material supplier from South Africa



Preparation for Site training: primer application on lower flange of girder for touch-up paint



Participants who listened attentively to the explanation about paint application by a JICA expert



Technical instruction on routine inspection; settlement of abutment damages expansion joint.



Technical instruction on concrete patching; mixing polymer cement with water

Figure II-10 The 2nd OJT in Kafue of Lusaka Province

(5) The 3rd OJT in Mpika of Muchinga Province

On the first day, the training lecture was conducted in a venue set in Mpika with a total of 21 participants: 5 from RDA and 16 from private contractors. On the second day, the steel girder bridge of M1 road over the Lwitikila River was selected as the OJT training site. The defects such as corrosion on the lower surface of flange were observed from under the bridge. However, the demonstration activities were necessitated to be limited to the bridge deck upon the condition that the height of abutment is approximately 7m to 8m thus building a scaffolding there is difficult due to the soft ground on the riverbank. Since there are few contractors in the three provinces covered by this OJT, securing the number of participants had been a concern but unexpectedly, a considerable number of contractors who have a branch in this region had participated.

Table II-16 Program of the 3rd OJT on Routine Maintenance for Bridge (1/2)

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: December 9 <sup>th</sup> , 2015 (Wednesday)/Mango Grove Lodge in Mpika		
08:30 - 09:00	Registration/Conference Room	Supporting Staff
09:00 - 09:10	Opening Remarks	Mr. Willam Mulusa PM. Director PL, RDA
09:10- 09:25	Introduction of TCP	Mr. Hideo Nagao, JICA Team Leader
09:25- 09:40	Bridge Maintenance Management	Mr. Hideo Nagao, JICA Team Leader
09:40- 10:00	Introduction of Japan Training	Mr. Wanzi Zulu Ag Senior Eng.-Muchinga
Break		
10:15 - 10:30	Pre-evaluation Questionnaire	Supporting Staff
10:30 - 10:50	Bridge Maintenance in Zambia	Mr. Mubuyaeta Kapinda Senior Manager-Br
10:50 - 12:30	Bridge Routine Maintenance - Explanation on the Guidelines -	Mr. Nobuyuki Sagawa JICA Expert
Lunch Break		
14:00 - 14:20	VIDEO show	
	Concrete Structure Repairs	Mr. Terence Shortall BASF (Brunelli Store)
14:55 - 15:30	Protective Coating for Steel	Mr. Palghat Mohan Kansai PLASCON
Break		
15:45 - 16:30	Briefing on Field Training	Mr. Nobuyuki Sagawa JICA Expert



Table II-17 Program of the 3rd OJT on Routine Maintenance for Bridge (2/2)

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: December 10 <sup>th</sup> , 2015 (Thursday)/Steel Bridge on M1 Road over Lwitikila River near Mpika		
08:30 - 09:00	Assembling and Travel to Bridge Site	
09:00 - 12:00	Field Training Inspection, Concrete Patching, Touch-up Painting, Cleaning, Vegetation Control, etc.	Mr. Nobuyuki Sagawa JICA Expert Mr. Gerald Phiri Principal Engr, RDA BASF (Brunelli Store) Kansai PLASCON
Lunch Break		
13:00 - 14:00	Continuation of Field Training	ditto
14:00 - 14:30	Back to Conference Room	
Break		
14:45 - 15:45	Group Discussion	All Participants (into 4 groups)
15:45 - 16:15	Group Presentation	ditto
16:15 - 16:30	Post-evaluation Questionnaire	Supporting Staff
16:30 - 16:50	Issuance of Certificates	Mr. Willam Mulusa, PM. Director PL, RDA/RM/ NAGAO/SAGAWA
16:50 - 17:00	Closing Remarks	Mr. Samuel Twasa Regional Manager, RDA



Presentation including a report on the Japan training by one of its attendees



Preparatory work for concrete patching; anticorrosive agent already applied to rebars



Surface preparation using electric grinder for repainting guardrail



Participant experienced demonstration of expansion joint cleaning by high-pressed water

Figure II-11 The 3rd OJT in Mpika of Muchinga Province (1/2)



Explanation on routine inspection; defects in concrete deck already progressed considerably



Wrap-up presentation after group discussion; participants' high interest in bridge maintenance

Figure II-12 The 3rd OJT in Mpika of Muchinga Province (2/2)

#### (6) Assistance for the Implementation of Routine Maintenance Contract

As Lusaka R/O was designated as the model office, the procurement of the outsourcing contract concerned proceeded as the pilot project of the bridge routine maintenance since the public announcement of tendering on December 15th, 2015; it finally came to contract signing on July 19th, 2016.

In this contract, each maintenance work should be carried out based on the contract documents concerned and the Bridge Routine Maintenance Guidelines; a mindful technical assistance was required because RDA and the contractor should conduct the supervision or management without such experiences or achievements in the past. On the other hand, there was also a possibility that what was not prescribed in the procurement documents or the Guidelines would happen, and the matters to be improved for the future would be discovered; such matters should be properly dealt with by Variation Order, etc.; furthermore, the feedback should be provided to the future procurement documents or the revision of Guidelines.

#### (7) Conduction of On-site OJT

For the smooth progress and proper work procedure of the pilot project proceeding construction, the on-site OJTs which are intended for the RDA officers and the contractor's engineers/technicians were conducted.

##### a. The OJT of Routine Inspection, Cleaning and Vegetation Control

For the routine inspection and the cleaning of deck surface and drainage, an OJT was conducted in the bridge, T02-92, on June 29th, 2016. For the routine inspection, areas, items and procedures of the inspection were explained, and regarding how to record the inspection data and to prepare the inspection report, the formalities prescribed in the Guidelines were explained. For cleaning, the operations with using high pressure water were demonstrated in the areas to be particularly paid attention: e.g., in drain equipment and around bearings.



Cleaning activity using high pressure water; checking work procedures and necessary equipment



Technical guidance of routine inspection; instructing inspector in the points in conducting inspection

Figure II-13 The OJT of Routine Inspection, Cleaning and Vegetation Control

b. The OJT of Concrete Repairs

In the OJT of concrete repairs, the repair works of concrete spalling areas, the restoration works of damaged concrete supports of guardrail and the restoration works of pedestrian handrail were chosen for the demonstration in the OJT, which was held in the bridges of T04-01 and C01049 inside Lusaka City during the three days from September 14th to September 16th, 2016. The work procedures consist of chipping off damaged concrete, removing the rust of exposed reinforcement, applying anti-corrosion paint, filling with polymer cement mortar, and finally applying waterproof coating. With the cooperation of the material supplier's engineer invited from South Africa, those work procedures and quality control were explained enough so as to be thoroughly understood by the related engineers/technicians mainly of the contractor. When chipping off damaged areas, deterioration that has progressed unexpectedly is frequently revealed and is ought to result in large-scale repair works.

Thin concrete cover for reinforcement, poor quality of existing concrete, etc. are considered to be the potential problems.





Technical instruction on site of concrete repairs; explaining the details of work procedures



Checking the consistency of polymer cement mortar with bare hands; only in on-site OJT



Concrete patching, applying polymer cement mortar using metal trowel



Restoration of guardrail pillars using concrete; application of coating for durability

Figure II-14 The OJT of Concrete Repairs

c. The OJT of Re-painting of Steel Bridge

In the OJT of re-painting of steel bridge, partial re-painting was carried out in the 2 m section of the end of girders on the Chirundu side in the bridge T02-92, which was held for two days, September 20th and September 21st, 2016. The work details are composed of cleaning the girders and the surroundings of bearings, surface preparation, applying primer using epoxy resin aluminum paint, and applying topcoat using polyurethane resin paint. With the cooperation of the paint manufacturer's engineer from South Africa, the quality control was explained enough so as to be thoroughly understood by the involved engineers/technicians. Since the existing coat still remains in a sound condition in the whole of this bridge, this kind of partial re-painting is thought to be an effective measure. Considering that the drain water from expansion joint will damage directly the end girders and that the corrosion has considerably progressed because of the structural features that mud and soil can accumulate easily, some radical measures or continuous maintenance activities for such girder end areas are mandatory.





On-site technical instruction on application details and quality control by manufacturer engineer



Applying epoxy primer coat using paint roller and brush with the installation of scaffolding

Figure II-15 The OJT of Re-painting of Steel Bridge

(8) Implementation of the Pilot Project

During the first quarter, from July to October, after starting work, the regular activities of the performance based items such as routine inspection, cleaning and vegetation control were mainly carried out. The JICA team provided with a thoughtful support to their comprehensive understanding of the assessment method of defects and the flowchart of procedures up to repair work as prescribed in the Guidelines.

And it was determined to hold the Weekly Meeting at Lusaka R/O once a week to share the understandings on work schedule and pending issues in the pilot project among the people concerned. To grasp the site situations, it was also determined to make discussion after visiting the sites once a month. Since there are many first experimental attempts in the pilot project, close cooperation between an employer and a contractor is strongly required. Such regular meetings were very useful to carry out the pilot project effectively.



Discussion in Weekly Meeting at Lusaka Regional Office of RDA



Cleaning girders using BIV at Monthly Site Visit Meeting

Figure II-16 Implementation of the Pilot Project

Difficult cash-flow management of the contractor was one of most serious problems for progressing the project smoothly. While only the works by workmen could be proceeded at a relatively steady rate, it was recognized that repair works using expensive materials and cleaning girders using the bridge inspection vehicle were largely delayed to be fully started because required equipment and materials could not be procured due to insufficient funds of the contractor. On the other hand, regarding the payments by employer’s side, the payments

by the National Road Fund Agency, NRFA to many road projects became due at the same time which caused the delay of payments to contractors. For this pilot project, advance payment was paid at the end of February when more than the half of contract term had passed, which caused the difficulty of cash-flow management for the site and consequently delay of the whole project schedule.

#### (9) Conduction of the Field Training

For a technical transfer to establish the bridge maintenance system, the activities of this project were intended to enhance the implementation capacity mainly of RDA counterparts by building the integral system of the maintenance cycle consisting of inspection, diagnosis, implementation, and record, and, by providing them with knowledge and know-how related to the individual elemental technologies.

On the other hand, to actually carrying out repair works, it is necessary to provide site instructions in detail on work procedures to secure their quality. Since peculiar synthetic materials and devices are frequently used in repair technologies due to restricted site conditions, there are a wider variety of technical problems even as compared with those in new construction projects. For such detailed instructions, the existence of site engineer who is familiar with the application of these materials and devices is inevitable. In Zambia, however, since actual bridge repair works have been seldom experienced, there find very few contractors and suppliers who have such competent site engineers.

Since the RDA is planning to roll out bridge routine maintenance operations all over the country, it is necessary to facilitate the understandings on and to enhance the supervision capacity for repair technologies of the RDA engineers, particularly, R/O engineers who provide directly technical instructions during supervising those repair projects. For these purposes, we conducted the field trainings targeting the RDA engineers and the possible contractors who will join these operations in the future.

##### a. The 1st Field Training held for 2 days of February 22nd and 23rd

The participants were as follows: 11 persons from RDA HQ and Lusaka R/O, 4 persons from target R/Os, 5 persons from contractors, 6 persons from others, 26 persons in total.

Unlike the seminars and the OJTs conducted previously, in the Field Training this time, as considering the rollout all over the country, JICA experts provided only a limited assistance behind and the counterparts of this project independently instructed the engineers of the target R/Os and the contractors. The presentations of the Guidelines/Guidebooks were conducted by the counterparts themselves, the contents of which were recognized as appropriate with keeping a grasp on the points. The improvement of capacity of the counterparts could be surely assessed.

As for the site demonstration, concrete repairs of patching, coating and crack injection were taken up at C01049 bridge where the on-site OJT had been held in the previous year. It was assumed that technical instructions on individual repair methods were easy to understand with reviewing the areas repaired in the previous on-site OJT. In crack injection, however, the injection of epoxy resin was failed due to the malfunction of grout pump; it was determined to be tried again in the coming field training.

The program of the 1st Field Training is shown below; those of the 2nd and the 3rd are not attached because of their almost same contents.

Table II-18 Program of the 1st Field Training on Routine Maintenance for Bridge

DATE/TIME	ACTIVITIES	IN-CHARGE
Date: February 22 <sup>nd</sup> , 2017 (Wednesday)/Best Western Plus/Great East Road		
09:30 - 09:45	Opening Remarks	Mr. William K. Mulusa Director-Maintenance
09:45 - 10:15	Introduction of Technical Cooperation Project	Mr. Chapwe Tumelo Principal Eng-Br Maintenance
Break		
10:35 - 11:20	Strategic Plan on Bridge Maintenance in RDA/ Bridge Maintenance Activity Plan	Mr. Mubuyaeta Kapinda Senior Manager-Bridges
11:20 - 11:50	Questions and Answers	
11:50 - 12:20	Explanation on Bridge Routine Maintenance Guidelines	Mr. Gerald Phiri Principal Eng-Emergencies
Lunch Break		
DATE/TIME	ACTIVITIES	IN-CHARGE
14:00 - 14:30	Implementation of the Pilot Project in Lusaka Province	Mr. Main Chama Senior Eng Lusaka R/O
14:30 - 15:00	Explanation on Bridge Inspection Guidebook	Mr. Habeene Habeenzu Principal Eng - Structure
15:00 - 15:30	Explanation on Bridge Repair Guidebook	Mr. Chapwe Tumelo Principal Eng - Br Maint
15:30 - 16:30	Repair Techniques applied in Field Training	Mr. Warren Trew BASF (South Africa)
DATE/TIME	ACTIVITIES	IN-CHARGE
Date: February 23 <sup>rd</sup> , 2017 (Thursday)/C01049 Bridge in Lusaka City		
08:30 - 09:00	Assembling and Travel to Bridge Site	
09:00 - 12:00	Field Training: Concrete Patching, Concrete Coating, Crack Injection	TechPride, BASF
Lunch Break		
14:00 - 15:00	Group Discussion/Exchange of Views	All participants (into 4 groups)
15:00 - 15:40	Group Presentation	Ditto
15:40 - 16:00	Closing Remarks	Mr. Mubuyaeta Kapinda Senior Manager-Br

	
<p>Mr. Tumelo, counterpart of this project, presents the outline of this project in the first day's program.</p>	<p>Explain to participants how to handle repair materials in the site demonstration</p>
	
<p>Demonstration of patching; filling with relatively hard mixture of polymer cement by hand</p>	<p>Application of acrylic waterproof coating to improve further durability</p>

Figure II-17 The 1st Field Training on Routine Maintenance for Bridge

b. The 2nd Field Training held for 2 days of April 26th and 27th

The participants were as follows: 8 persons from RDA HQ and Lusaka R/O, 5 persons from target R/Os, 2 persons from NCC and Lusaka City, 7 persons from contractors, 7 persons from others, 29 persons in total.

Although the program was almost same with the 1st Field Training, it had been enriched by adding the programs such as the presentation by the contractor to report the site situation of the pilot project and the introduction by JICA team on the pioneering case in other countries. An attendance was also requested to the officers of the National Construction Council, NCC, and Lusaka City Hall to disseminate the understandings on the activities of this project.

As for the site demonstration, re-painting on steel member, guardrail, and, technical instruction on measuring film thickness with thickness gauge using bridge inspection vehicle were conducted in T04-02 bridge. In T04-03 bridge, crack injection was taken up, and the demonstration of concrete repairs of patching and coating was conducted in C01049 bridge. Regarding crack injection, there still left the problem to be solved such as resin was leaked from the area sealed beforehand.





Contractor’s presentation using equipment and materials for repair works; easy to understand



Training of quality control; measuring film thickness with thickness gauge using BIV



Site demonstration of re-painting on guardrail in T04-02 bridge



Site demonstration of crack injection on abutment wall in T04-03 bridge

Figure II-18 The 2nd Field Training on Routine Maintenance for Bridge

c. The 3rd Field Training held for 2 days of July 6th and 7th

The participants were as follows: 10 persons from RDA HQ and Lusaka R/O, 5 persons from target R/Os, 2 persons from Lusaka City, 21 persons from contractors, 4 persons from others, 42 persons in total.

Although the program was almost same with the 1st and the 2nd Field Trainings, the program of the demonstration of repair works on site was shortened into one day program in total. That was because the pilot project contractor had suffered some financial difficulty in the site operation and thereby there had been a risk that the arrangements of materials and workers for the Field Training might not be prepared sufficiently.

As for the reason that more number of participants from contractors attended in this Field Training than those of the previous two times, it is supposed that the recognition of this project was spread widely by word of mouth and, as a result, more contractors have come to be interested in the activities of this project.

In the lectures, judging from the fact that the counterparts ventured their presentation on the other topic than that in one’s own charge to end successfully, it is recognized that the not only the individual capacity of counterparts but also the institutional capacity of the bridge unit of the RDA has been greatly enhanced.

While only a concrete patching was carried out as a site demonstration, the series of repair work process could be sufficiently grasped by the participants through the explanations provided with observing the repair works so far completed and the defective areas to be repaired. In addition, separately from this program, to improve individual technical issues such as the trouble of crack injection, the site instructions were also conducted in detail to the related persons.



Many participants from private contractors attended the lectures at the hotel conference room.



Participants learned various knowledges through the field trainings in spite of short time at C010149 bridge in Lusaka.

Figure II-19 The 3rd Field Training on Routine Maintenance for Bridge

(10) Progress and Achievement of the Pilot Project

Among the work items of the pilot project, the regular activities, the performance based items by quarterly progress payment, such as routine inspection, cleaning and vegetation control were progressed relatively smooth thanks to the effective technical assistance through the OJTs and others.

On the other hand, regarding minor repair works, originally, considerable skills were required to master repair techniques on site. In addition, different from the regular activities, the measurement based payment was applied in which the work details of each repair area should be instructed by the RDA. Depending on the situations of deterioration or defect, the addition and alteration of repair methods, areas, and others might be occasionally necessary against the original contract. Unfortunately due to the unfamiliarity of the persons in charge, it took unexpectedly much time to complete the contractual procedure such as variation orders. As a result, the extension of contract term by three months was determined to complete all the minor repair works.

As for the achievements of the implementation of the pilot project, in particular, for the basic technologies such as the touch-up, partial re-painting, for deteriorated coating on steel surface and the patching for spalling and delamination in concrete members, the sufficient techniques and skills including the quality control have been mastered through the OJTs and the actual works. On the other hand, for some other technologies such as crack injections and expansion joint repairs, there still remains the issues to be improved for future because much higher skills are required for them on site and the procurement of required tools and materials is difficult.



Patch repair to collision damage in concrete girders; close attention should be paid to the traffic under.



The situation in Kafue River half year later after the removal prior to rainy season; activity frequency should be reconsidered.

Figure II-20 Progress and Achievement of the Pilot Project

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### (11) Issues for Future and Recommendations

Issues that have been revealed through the implementation of the pilot project are described below:

a. Normalization of Payment: advance payment, quarterly payment, etc.

In this pilot project, the schedule of repair works was largely delayed because the required equipment and materials could not be procured due to the difficulty of cash-flow management of the contractor. One of the causes for the aggravation of the contractor's cash-flow was the delay in payment from the employer, the NRFA. For example, in spite of the application for advance payment by the contractor in October, the actual payment came at the end of February. And the quarterly payment was also largely delayed. The payment of contract amount is a crucial financial source to manage firmly their project in site for ordinary local contractors without ample funds. Therefore, improvement of such present situations is strongly required.

b. Speeding up of Variation Order Process

For minor repair works in the bridge routine maintenance, the procedural flow that the defects to be repaired and method to be applied, and the extents to be treated should be determined based on the routine inspection results has been established. Therefore, flexible changes in the repair methods and the quantities prescribed in the original contract are inevitable. But actually, as contractual procedure, the approval and instruction of variation order were largely delayed. Consequently, together with the aforementioned influence by the difficulty of cash flow, the whole project schedule had been delayed and it was determined to extend the contract term by three months to complete all the repair works.

c. Revision of the Bridge Routine Maintenance Guidelines

Regarding the regular activities, performance based items, such as cleaning and vegetation control, in the pilot project contract, these items are divided into two groups by frequency: quarterly and once during contract term; there is a possibility that the frequency of such activity can be reviewed properly based on the experiences in the pilot project. For example, while the frequency of cleaning girders can be lowered, it seems appropriate that the removal of driftwoods/plants around the piers in river should be carried out more frequently.

As for minor repair works, there is a possibility that the demarcation between bridge routine maintenance contract and other bridge repair project contract to be outsourced separately might be revised based on the achievements by this pilot project and others. For example, it seems appropriate that the repairs to simple expansion joints should be handled in the routine maintenance contract though it had not been tried in the pilot project this time.

d. Revision of Unit Prices reflecting the Experiences of the Pilot Projects

Since this was the first trial for the RDA to tender this sort of bridge maintenance project, the unit prices were estimated based on similar cases overseas and assumptions of the engineer in charge. During the implementation of the pilot project, the actual inputs of labors, equipment and materials have been recorded and stored. It may be also considered that the unit prices should be revised to further proper ones based on the achievements and those data. In particular, for minor repair works, the labor content and material usage will fluctuate greatly depending on the construction conditions on site, for which appropriate and flexible considerations should be taken.

1.3.2 Improvement of Bridge Condition Inspection

RDA have conducted an outsourcing for development of BMS in 2011 but rarely experienced bridge inspection so far.

For this reason, RDA don't have an accumulated knowledge about bridge inspection. Therefore, RDA's improvement of bridge inspection skill is necessary for the continual execution of bridge inspection.

1.3.2.1 Review Bridge Inspection Data

(1) Procedure

In order to improve the bridge inspection skill, a review of the previous inspection data is necessary. The procedure for review is shown in the following chart.

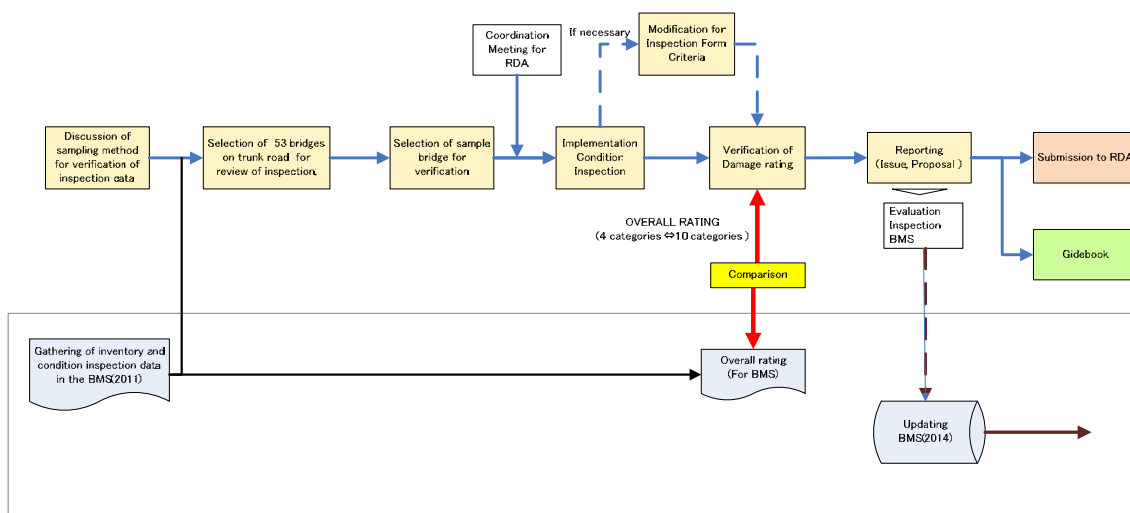


Figure II-21 Procedure of the Review of Bridge Inspection Data in BMS (2011)



(2) Location Map of the Selected Bridges

53 Bridges were selected from trunk roads considering the importance of each bridge.

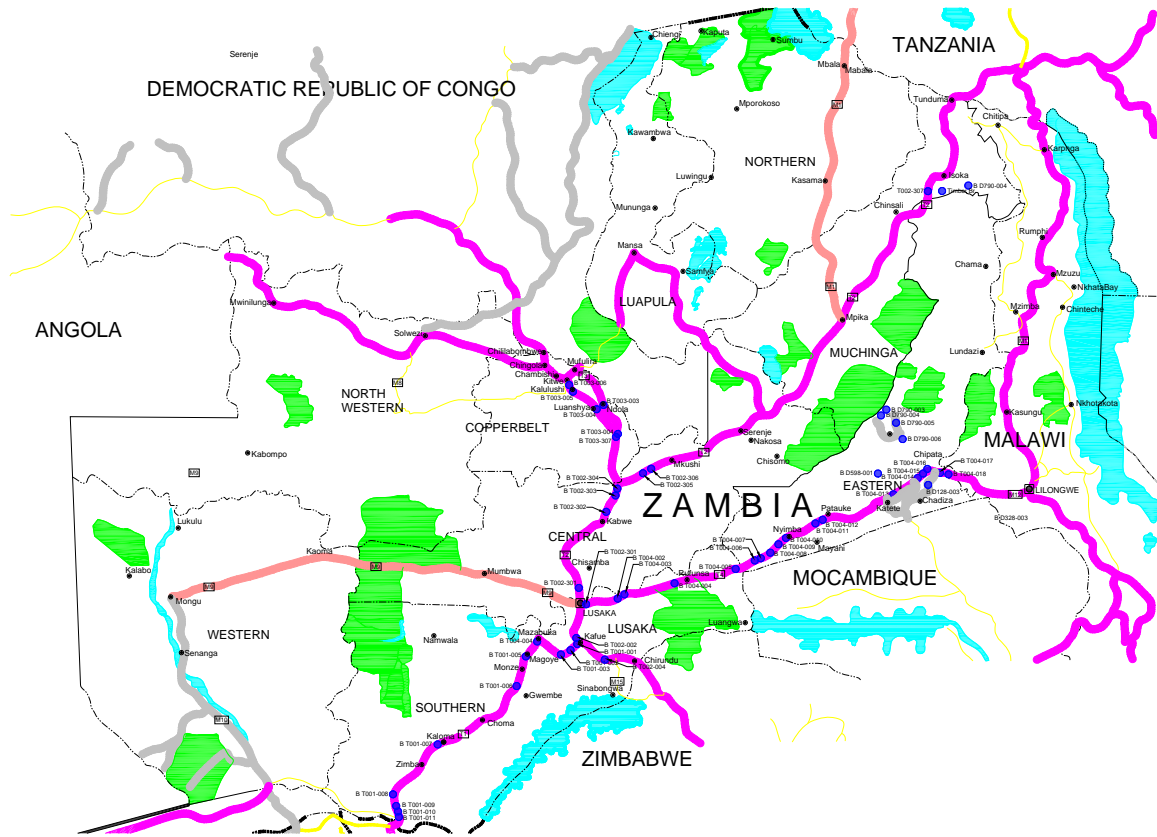


Figure II-22 Location Map of the Selected 53 Bridges

(3) Inspection Schedule

Periodic Inspections of the selected 53 bridges were conducted from May 2015 to January 2016.

Table II-19 Bridge Periodic Inspection Schedule

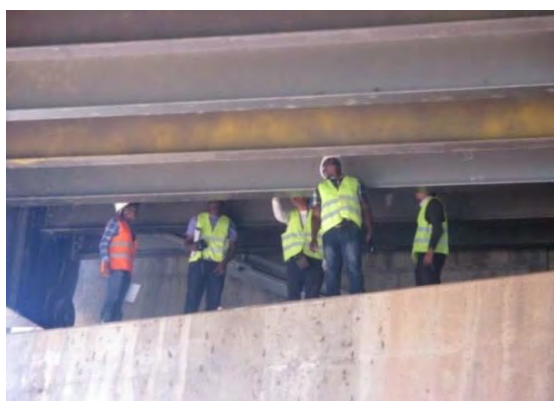
Road Name	Area	Number of Bridges	Date
Trunk Road - 1	Lusaka~Livingstone	11	20-21,May22-25,June
Trunk Road - 2	Lusaka~Mkushi	9	27-28,May 26 Jan
Trunk Road - 3	Kapiri Mposhi~Chamboli	7	1-3,Jun 6,Oct
Trunk Road - 4	Lusaka~Cipata (Nacala Corridor)	18	15,18 May9-16,Jun
District Road D790	Muchinga Province	1	6, Oct
District Road RD025-001	Muchinga Province	1	6, Oct
District Road D791	Eastern Province	4	11,Jun
District Road D598	Eastern Province	1	12,Jun
District Road D128	Eastern Province	1	10,Jun



Inspection Activities with counterparts in RDA HQ (Trunk Road 1 Br No.306)



Inspection Activities in Central Province (Trunk Road 2 Br No.304)



Inspection Activities in Eastern Province (Trunk Road 4 Br No.5)



Inspection Activities in Eastern Province (Trunk Road 4 Br No.18)

Figure II-23 Inspection Activities

(4) Inspection Forms

The following forms with the photographs and sketches of damage were used in the inspection.

CONDITION INSPECTION FORM (INVENTORY)

Bridge ID/ T004-0010 Filled in by/ Kangawa  
 Bridge Name/ H-1008A Inspector/ Kangawa  
 Date(ddmmyyy)

Bridge Type		Simply supported span		Crossing	
Superstructure		Road		Road	
Substructure		Railway		Railway	
Foundation		River		10 NYMBA	
A number of Span		1		Still There? Service Damaged?	
Bridge Length		31.7		Yes No Yes No	
Location		Abutment 1		Services	
		GPS: S 13° 33.654' E 93° 48.758'			
Abutment 2		GPS: S 13° 36.477' E 93° 46.730'		Telephone	
		GPS: S 13° 36.477' E 93° 46.730'		Electricity	
Bridge Width		Full-width		Still There? Service Damaged?	
		Effective width		Yes No Yes No	
Sidelwalk		Sidelwalk		Signs	
		Felloe guard		Signs	
Notes					
- W Corrosion on girder is as a result of water leakage from the scap holes with delamination					
- minor repairs to be done					

Bridge Number	Span

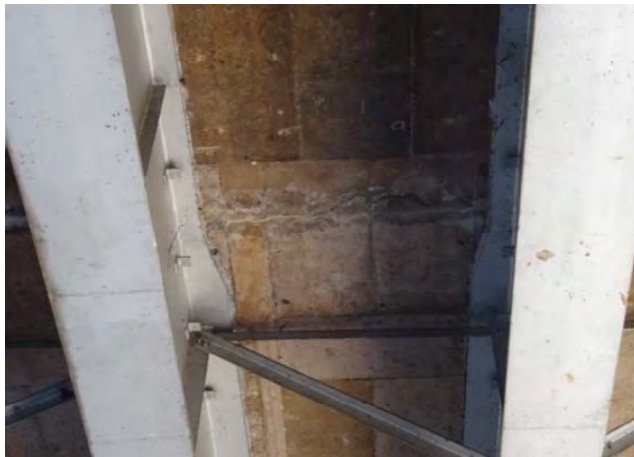
Component	Type	Defect Found	Rating				Comment
			Good	Fair	Poor	Bad	
Concrete Deck	Cracking						
	Spalling/scaling/disintegration						
	Delamination					200mm	
	Rebar exposure/corrosion					200mm	
	Honeycomb						
	Water leakage						
Steel Girder	Abnormal Vibration						
	Corrosion					20%	
	Cracking					200x20mm	
	Deformation/Buckling						
	Abnormal vibration						
	Loose connection						
Abutment	Paint peeling off					50%	
	Cracking						
	Spalling/scaling/disintegration					600x0.5mm	
	Rebar exposure/corrosion					150mm	
	Delamination						
	Honeycomb						
Tilt/Settlement							

Figure II-24 Bridge Inspection Forms

(5) Inspection Result

The damages confirmed in the recent inspection are as follows:

a. Damage on Concrete Slab



Crack due to heavy traffic



Deteriorated concrete surface

Figure II-25 Damage on Concrete Slab

b. Corrosion of Steel Girder



Corrosion due to water leakage

Figure II-26 Corrosion of Steel Girder

- In trunk road 3 and trunk road 4, several steel girders have been corroded at the end girders or lower flanges due to water leakage caused by the damaged expansion joints and insufficient or deteriorated drainage system.



c. Corrosion of Steel Truss Bridge



Severe paint peel-off and worsening corrosion on steel truss bridge in Mutinga province.

Figure II-27 Corrosion of Steel Truss Bridge

d. Damage on Concrete Girder



Cracks along the rebar due to insufficient cover



Spalling on bottom surface of concrete girder

Figure II-28 Damage on Concrete Girder

e. Damage on Concrete Slab



Honeycomb due to poor construction



Shear crack near the pier

Figure II-29 Damage on Concrete Slab

f. Damage on Substructure



Vertical crack on the wall type pier



Vertical crack on front abutment

Figure II-30 Damage on Substructure

g. Damage on Foundation



Scouring due to outflow of water or sand



Damage on slope protection due to flood

Figure II-31 Damage on Foundation

h. Damage on Expansion Joint



Damage on finger plate due to heavy traffic



Water leakage from expansion joint

Figure II-32 Damage on Expansion Joint



i. Damage on Railing



Damage due to car accident



Paint peel-off and corrosion

Figure II-33 Damage on Railing

j. Damage on Asphalt Wearing Surface



Potholes



Cracking

Figure II-34 Damage on Asphalt Wearing Surface

(6) Comparison of Evaluation Results with the 2011 BMS

The following tables show the comparison of evaluation of the 2011 BMS and this review.

The 2011 BMS has four ‘Poor’ or ‘Bad’ evaluation, while this review has 19 ‘Bad’ ratings.

Aging from 2011 to 2015 is certainly one of the factors that affected the evaluation but probably the main factor is the difference in the rating procedure.

	BMS(2011)	REVIEW(2015)
T1-1	Good	Fair
T1-2	Satisfactory	Bad
T1-3	Good	Fair
T1-4	Good	Poor
T1-5	Good	Bad
T1-6	Good	Bad
T1-7	Good	Bad
T1-8	Good	Poor
T1-9	Good	Fair
T1-10	Good	Fair
T1-11	Good	Good

	BMS(2011)	REVIEW(2015)
T2-2	Good	Fair
T2-4	Good	Bad
T2-301	Satisfactory	Fair
T2-302	Satisfactory	Fair
T2-303	Marginal	Fair
T2-304	Marginal	Bad
T2-305	Marginal	Bad
T2-306	Good	Fair
T2-307	Marginal	Poor

	BMS(2011)	REVIEW(2015)
T3-301	Satisfactory	Bad
T3-302	Satisfactory	Bad
T3-303	Good	Fair
T3-304	Satisfactory	Fair
T3-305	Satisfactory	Fair
T3-306	Satisfactory	Bad
T3-307	Satisfactory	Bad

	BMS(2011)	REVIEW(2015)
D128-003	Good	Fair
D598-001	Good	Fair
D791-3	Satisfactory	Bad
D791-4	Poor	Bad
D791-5	Good	Bad
D791-6	Good	Poor
D790-4	Good	Bad

	BMS(2011)	REVIEW(2015)
T4-1	Good	Fair
T4-2	Good	Fair
T4-3	Satisfactory	Fair
T4-4	Good	Good
T4-5	Marginal	Bad
T4-6	Satisfactory	Poor
T4-7	Poor	Bad
T4-8	Satisfactory	Fair
T4-9	Marginal	Poor
T4-10	Poor	Bad
T4-11	Good	-
T4-12	Marginal	-
T4-13	Satisfactory	Bad
T4-14	Poor	-
T4-15	Marginal	-
T4-16	Marginal	Fair
T4-17	Marginal	-
T4-18	Marginal	Fair

Figure II-35 Comparison of Overall Rating with BMS (2011)

(7) Comparison of Rating Procedure

a. Evaluation Components

The 2011 BMS had evaluated five components. But in this review, twelve components had been evaluated as shown in Table II-20

Table II-20 Evaluation Components

	Number of Components	Component
2011 BMS	5	Approaches, Waterway, Superstructure, Substructure, Roadway
2015 Review	12	Deck, Girder, Abutment, Pier, Foundation, Expansion Joint, Bearing, Railing, wing wall, Slope protection, Asphalt wearing surface, Approach

b. Damage Rating

As shown below, the 2011 BMS used 9 grades of rating system which were integrated into 5 grades. On the other hand, this review used 4 grades which originated in Japan and being adopted by other countries.



Table II-21 Rating Criteria

	10 Grade	5 Grade	4 Grade
0	Beyond Repair	Critical	Bad
1	Critical		
2	Very Poor	Poor	Poor
3	Poor		
4	Marginal	Marginal	Fair
5	Fair		
6	Satisfactory	Satisfactory	
7	Good	Good	Good
8	Very Good		
9	Excellent		
	BMS 2011		JICA

c. Rating Criteria

In the 2011 BMS, there were only 5 components for evaluation and both concrete bridges and steel bridges had the same criterion in their structural components. Moreover, the superstructure and substructure were not distinguished.

On the other hand, in the criteria of this review, concrete and steel bridges were distinguished and further been divided into individual bridge component.

Table II-23 Rating Criteria at This Review

Table II-22 Rating Criteria at the BMS in 2011

TABLE 4.3: CONDITION RATING FOR STRUCTURAL ELEMENTS

RATING	GUIDELINES
9 EXCELLENT	New condition
8 VERY GOOD	No signs of distress or deterioration. Possibly some minor shrinkage or temperature cracks in concrete. No rust on steel members.
7 GOOD	Some minor problems. Non-structural cracks in concrete. Light spalling. No rust stains through cracks. Some light rust formation on steel members, pitting the paint surface.
6 SATISFACTORY	Structural elements show some minor deterioration. More significant non-structural cracks in concrete. Moderate spalling. No rust stains visible. Moderate rust formation on steel members. No measurable section loss.
5 FAIR	Structural elements are sound but have some section loss due to deterioration, spalling or scour. Structural cracks with light rust staining. Stratified rust flakes with some measurable section loss for steel members.
4 MARGINAL	More general section loss due to deterioration, spalling or scour. Structural cracks with moderate rust staining visible. Heavy stratified rusting resulting in advanced section loss for steel members.
3 POOR	Advanced deterioration, spalling or scour, exposing reinforcing steel. Structural cracks with severe rust staining. Rust has caused holes in structural steel members. Loose connections, buckled or bowed steel members.
2 VERY POOR	Advanced deterioration of structural elements. Significant structural cracks visible. Reinforcing exposed and rusted. Holes rusted through steel members. Fatigue cracks. Scour has severely undermined supports. Unless closely monitored, bridge should be closed.
1 CRITICAL	Bridge closed. Study required to determine the feasibility of repairs.
0 BEYOND REPAIR	Permanently closed till replaced.

Structural Elements



BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT		SPAN	BRIDGE ATTRIBUTE	DECK (1/2)
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
CONCRETE	0 - Good	1 Cracking	Hairline crack or no crack	
		2 Spalling	Affected area is <= 150mm wide in any direction, or depth is less than 25mm	
		3 Delamination	Delaminated area measuring <= 150mm in any direction	
		4 Rebar exposure/corrosion	No damage	
		5 Honeycomb	Affected area is <= 150mm wide in any direction	
		6 Water leakage	Not visible	
		7 Abnormal Vibration	Not detected	
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm	
		2 Spalling	Affected area is > 150mm to <= 300mm wide in any direction, or depth is 25mm to 50mm	
		3 Delamination	Delaminated area measuring >150mm to <=300mm wide in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is <=500mm wide, corroded or flaking only	
		5 Honeycomb	Affected area is > 150mm to <= 300mm wide in any direction	
		6 Water leakage	Water leak in 1 spot has an area of <= 200mm wide	
		7 Abnormal Vibration	Not detected	
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, 2 directions, spacing is <500mm to >= 2000mm	
		2 Spalling	Affected area is > 300mm to <= 600mm wide in any direction, or depth is 50mm to 100mm	
		3 Delamination	Delaminated area measuring >300mm to <=600mm in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is >1500mm to <=1000mm wide, corroded	
		5 Honeycomb	Affected area is >300mm to <= 600mm wide in any direction	
		6 Water leakage	Water leak in 1 spot has an area of > 200mm to <= 500mm wide	
		7 Abnormal Vibration	Not detected	
3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm		
	2 Spalling	Affected area is > 600mm wide in any direction, or depth is more than 100mm		
	3 Delamination	Delaminated area measuring >600mm in any direction		
	4 Rebar exposure/corrosion	Main rebar exposed is >1000mm wide and corroded		
	5 Honeycomb	Affected area is >600mm wide in any direction		
	6 Water leakage	Water leak in 1 spot has an area of > 500mm wide		
	7 Abnormal Vibration	Detected		

BRIDGE ELEMENT		SPAN	BRIDGE ATTRIBUTE	MAIN/SECONDARY MEMBER(2/3)
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
STEEL	0 - Good	1 Corrosion	Loose rust formation and pitting in the paint surface, no section loss	
		2 Cracking	No cracks	
		3 Deformation/Buckling	No deformation on bridge components	
		4 Abnormal vibration	Not detected	
		5 Loose connection	No bolts missing, <= 10% of fasteners loose	
		6 Paint peel off	Surface area affected is <= 10% in a member	
	1 - Fair	1 Corrosion	Loose rust formation with scales/flakes, <= 10% section loss	
		2 Cracking	Spot cracking on secondary members only	
		3 Deformation/Buckling	Partial deformation on secondary members only	
		4 Abnormal vibration	Not detected	
		5 Loose connection	Loose fasteners is > 10% to <= 20%, falling out of bolts in > 1 pc. on joints	
		6 Paint peel off	Surface area affected is >10% to <= 20% in a member	
	2 - Poor	1 Corrosion	Stratified rust with pitting of metal surface, >10% to <=20% section loss	
		2 Cracking	Cracking on secondary members of bridges is severe	
		3 Deformation/Buckling	Partial deformation on primary members	
		4 Abnormal vibration	Not detected	
		5 Loose connection	Loose fasteners >20% <=30%, bolts fall out in > 3pc on sec. mem. joints	
		6 Paint peel off	Surface area affected is > 20% to <= 30% in a member	
3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/flaking through > 20% section loss		
	2 Cracking	Cracking on primary members, especially in welded parts		
	3 Deformation/Buckling	Outstanding deformation due to buckling or partial yielding		
	4 Abnormal vibration	Detected		
	5 Loose connection	> 30% fasteners loose, bolts fall out in > 3pc. on primary member joints		
	6 Paint peel off	Surface area affected is > 30% in a member		

BRIDGE ELEMENT		SPAN	BRIDGE ATTRIBUTE	MAIN/SECONDARY MEMBER(1/3)
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
CONCRETE	0 - Good	1 Cracking	Hairline crack or no crack	
		2 Spalling	Affected area is <= 150mm wide in any direction, or depth is less than 25mm	
		3 Delamination	Delaminated area measuring <= 150mm in any direction	
		4 Rebar exposure/corrosion	No damage	
		5 Honeycomb	Affected area is <= 150mm wide in any direction	
		6 Water Leakage	Not visible	
		7 Abnormal Vibration	<= 0.3mm, 1 direction, spacing > 500mm	
	1 - Fair	1 Cracking	Affected area is > 150mm to <= 300mm wide in any direction, or depth is 25mm to 50mm	
		2 Spalling	Affected area is > 150mm to <= 300mm wide in any direction, or depth is 25mm to 50mm	
		3 Delamination	Delaminated area measuring >150mm to <= 300mm wide in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is <= 50 mm wide, corroded or flaking only	
		5 Honeycomb	Affected area is > 150mm to <= 300mm wide in any direction	
		6 Water Leakage	Water leak in 1 spot has an area of <= 200mm wide	
		7 Abnormal Vibration	> 0.3mm to <= 1.0mm, spacing is <500mm to >= 2000mm	
	2 - Poor	1 Cracking	Affected area is > 300mm to <= 600mm wide in any direction, or depth is 50mm to 100mm	
		2 Spalling	Affected area is > 300mm to <= 600mm wide in any direction, or depth is 50mm to 100mm	
		3 Delamination	Delaminated area measuring >300mm to <= 600mm in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is >500mm to <=1000mm wide, corroded	
		5 Honeycomb	Affected area is >300mm to <= 600mm wide in any direction	
		6 Water Leakage	Water leak in 1 spot has an area of > 200mm to <= 500mm wide	
		7 Abnormal Vibration	> 1.0mm, 2 directions, spacing is < 200mm	
3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm		
	2 Spalling	Affected area is > 600mm wide in any direction, or depth is more than 100mm		
	3 Delamination	Delaminated area measuring > 600mm in any direction		
	4 Rebar exposure/corrosion	Main rebar exposed is > 1000mm wide and corroded		
	5 Honeycomb	Affected area is >600mm wide in any direction		
	6 Water Leakage	Water leak in 1 spot has an area of > 500mm wide		
	7 Abnormal Vibration	Detected		

d. Soundness of the Bridge as a Whole

At the 2011 BMS, the soundness of the whole bridge was calculated by using the weighted factor of each component. Table II-24 shows the weighted factor used in the calculation.

Table II-24 Weighted Factor at the BMS in 2011

	Approaches	Waterway	Substructure	Superstructure	Roadway
0	6	8	8	8	6
1	6	8	8	8	6
2	6	8	8	8	6
3	2	2	4	4	2
4	2	2	4	4	2
5	0.25	1	2	2	0.5
6	0.25	1	2	2	0.5
7	0.25	1	2	2	0.5
8	0.25	1	2	2	0.5
9	0.25	1	2	2	0.5

In this review, the evaluation of bridge was done in five stages as shown. The soundness of the whole bridge was decided by selecting the worst state of a primary component and a secondary component that affected the structural performance.

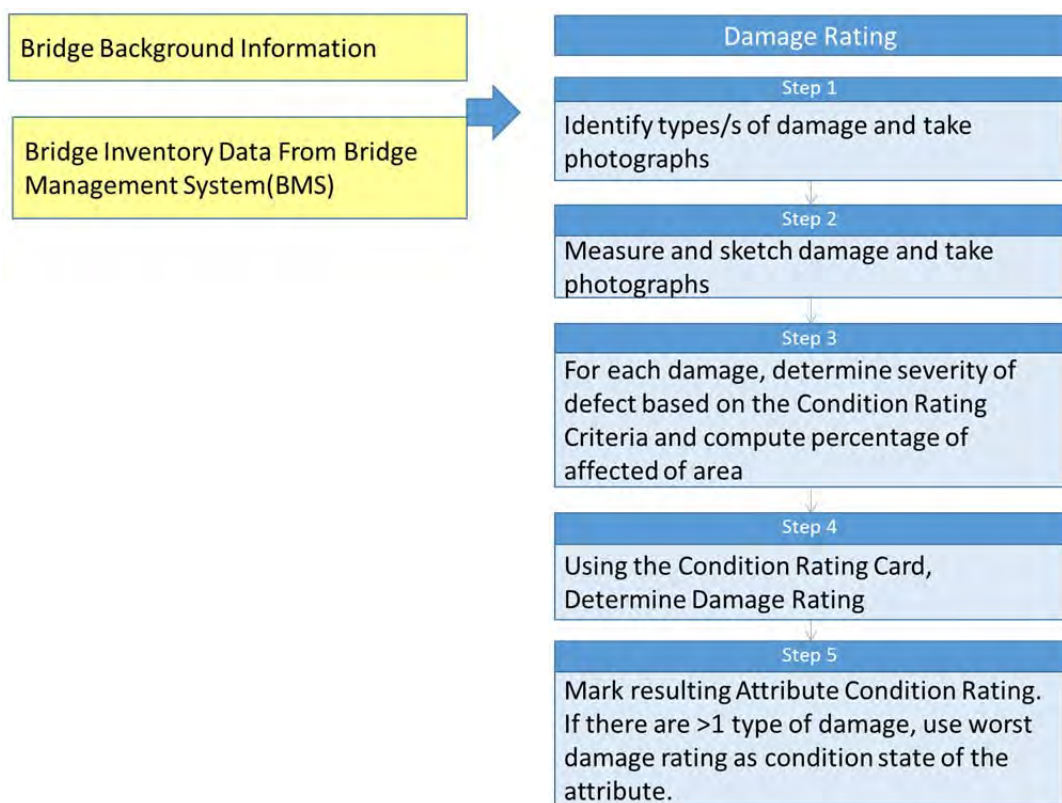


Figure II-36 Flow Chart of the Soundness of the Bridge as a Whole

In addition, during the soundness evaluation, the damage extent of every member was reflected using the Condition Rating Card (CRC) as shown below.

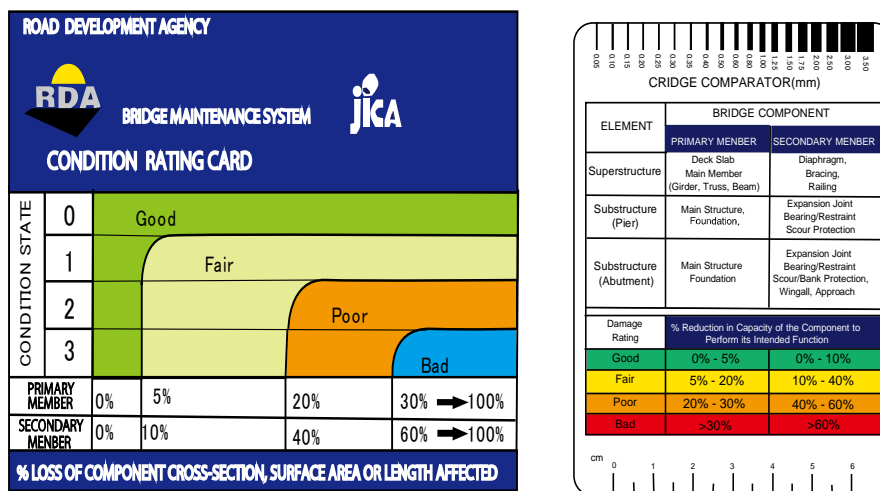


Figure II-37 Condition Rating Card

(8) Recommendation for Revision to the BMS in 2011

BMS is going to be revised by RDA from 2016, therefore some recommendations are listed as follows.

a. Condition Rating Criteria

Criteria of ‘STRUCTURAL ELEMENT’ should be classified into concrete and steel types, and divided into each component.

b. Inspection Record

Damage drawing and photographs are necessary for future maintenance strategy. When it comes to inspection, sketch, take pictures and record them.

c. The conduct of OJT

On-the-Job-Training, OJT is necessary to prevent variation of each inspector.

1.3.2.2 Creation of a Bridge Inspection Guidebook

BMS was developed by RDA in 2011 as a bridge asset management system. The BMS includes some bridge inspection forms.

However these inspection forms did not contain a practical inspection method and other significant matters, RDA engineers needed to practically understand the technical contents in order to outsource bridge inspection works.

The bridge inspection guidebook describes the basics of inspection (purpose, type, inspection items etc.) and the techniques for the appropriate diagnosis of inspection results for the smooth assessment of bridge damages and its causes.

The Contents of the Guidebook are:

- Chapter 1 Introduction
- Chapter 2 General Requirement for Bridge Inspection
- Chapter 3 Bridge Inventory
- Chapter 4 Inventory Inspection
- Chapter 5 Periodic Inspection,
- Chapter 6 Detailed Inspection
- Chapter 7 Emergency Inspection
- Chapter 8 Types of Damages and Cause of Damages

(1) Activity Procedure

The activity proceeded according to the following chart:

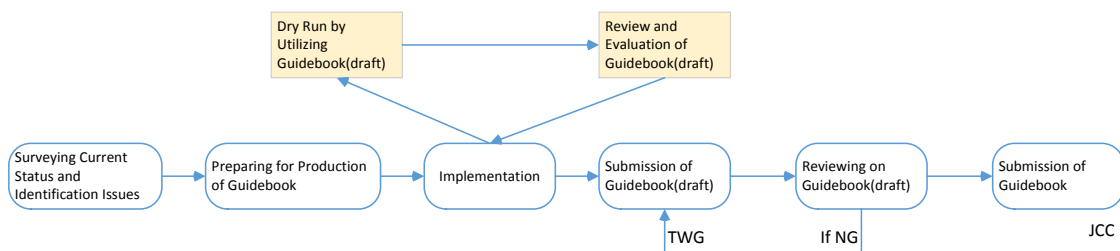


Figure II-38 Flowchart for the development Bridge Inspection Guidebook

### 1.3.2.3 Conduct On-the-Job Training of Bridge Periodic Inspection

In order to deepen the understanding of the guidebook and to be of help in the bridge inspection works of RDA, a Bridge Inspection OJT was conducted.

In addition to the lecture about bridge inspection guidebook, field training and group discussion had been conducted. In the field training, RDA engineers carried out periodic inspection by visual observation, Non-Destructive Testing, palpation, hammer testing using bridge inspection vehicle directly. Moreover, a group presentation and discussion of the soundness of the whole bridge had been conducted.

#### (1) Conduct OJT for Bridge Inspection

The OJT for RDA engineers and consultants, were conducted on the ff. schedule:

Table II-25 Schedule of the Bridge Inspection OJT (1/2)

Venue:	Conference Room, Chita Lodge Kafue River	
Date:	1 <sup>st</sup> OJT	July 26 <sup>th</sup> – July 28 <sup>th</sup>
	2 <sup>nd</sup> OJT	October 11 <sup>th</sup> – October 13 <sup>th</sup>

COURSE CONTENT/SCHEDULE OF ACTIVITIES		
DATE/TIME	TOPIC/ACTIVITIES	OFFICIAL IN-CHARGE
<b>1<sup>st</sup> Day: Periodic Inspection Guidebook Lecture</b>		
8:00-8:30 AM	Registration of Participants	Supporting Staff
8:30-8:45 AM	Opening Remarks	Mr. Elias Mwape PM. Director P & D, RDA
8:45-9:00 AM	Introduction of TCP	Hideo NAGAO JICA Team Leader
9:00-9:15 AM	Bridge Inspection(General)	Mr. Hideo Nagao, JICA Team Leader
9:15-9:45 AM	Introduction of Japan Training	C/P(Mr Habeene Habeenzu)
Break		
10:00-10:15 AM	Pre-evaluation Questionnaire	Supporting Staff
10:15-10:45 AM	Review of BMS in 2011	JICA Expert(Kangawa)
10:45-11:30 AM	Explanation on the Bridge Inspection Guidebook (Chapter-1~Chapter-4)	JICA Expert(Nagao)
11:30-12:30 PM	Explanation on the Bridge Inspection Guidebook (Chapter-5)	JICA Expert(Kangawa)
Lunch Break		
1:30-2:45 PM	Explanation on the Bridge Inspection Guidebook (Chapter-6 ~Chapter-8)	JICA Expert(Nagao)
Break		
3:00-3:45 PM	Explanation on Non Detective Equipment	JICA Expert(Nagao)
3:45-4:30 PM	Explanation on the Bridge Inspection Guidebook (Example)	JICA Expert(Kangawa)
4:30-5:00 PM	Briefing on Field Training	

Table II-26 Schedule of the Bridge Inspection OJT (2/2)

<b>DATE/TIME</b>	<b>TOPIC/ACTIVITIES</b>	<b>OFFICIAL IN-CHARGE</b>
<b>2<sup>nd</sup> Day: Field Training</b>		
8:30-9:00 AM	Assembling and Travel to Bridge Site	
9:00-12:00 AM	Group A <ul style="list-style-type: none"> <li>➤ Inventory Inspection</li> <li>(1) Distance Meter</li> <li>➤ Periodic Inspection</li> </ul>	Group B <ul style="list-style-type: none"> <li>➤ BIV Training</li> <li>➤ Use of NDT Equipment</li> <li>(1)Metal Thickness Test</li> <li>(2)Rebound Hammer Test</li> <li>(3)Rebar Detective Test</li> </ul>
Lunch Break		
13:00-16:00 PM	Group A <ul style="list-style-type: none"> <li>➤ BIV Training</li> <li>➤ Use of NDT Equipment</li> <li>(1)Metal Thickness Test</li> <li>(2)Rebound Hammer Test</li> <li>(3)Rebar Detective Test</li> </ul>	Group B <ul style="list-style-type: none"> <li>➤ Inventory Inspection</li> <li>(2) Distance Meter</li> <li>➤ Periodic Inspection</li> </ul>
<b>3<sup>rd</sup> Day: Group Discussion</b>		
8:30-10:00 AM	Review of Field Training	All Participants
Break		
10:00 -12:00 AM	Group Discussion	All Participants
Lunch Break		
1:00-3:00 PM	Presentation	All Participants
Break		
3:15-3:30 PM	Post-evaluation Questionnaire	Supporting Staff
3:30-3:45 PM	Closing Remark	Eng. Mr. Elias Mwape PM. Director P & D, RDA



(2) The 1st Bridge Inspection OJT

a. Lecture (Bridge Inspection Guidebook)



Opening Remarks by Mr. Sondashi, Planning Section Senior Manager



Presentation of Training in Japan by Mr. Habeenzu, Principal Engineer - Structures



Explanation of Bridge Inspection Guidebook by a JICA Expert



Explanation of Bridge Inspection Guidebook by a JICA Expert



Attendance at a lecture



Closing Remarks on the First day by Mr.Kapinda, Bridge Maintenance Senior Manager

Figure II-39 The 1st OJT on Bridge Inspection Guidebook (Lecture)



b. Field Training



Inspection by BIV



Inventory Inspection Drill



Periodic Inspection Drill



NDT(Rebound Hammer) Drill



NDT(Rebar Detective Test) Drill



NDT(Metal Thickness Test) Drill

Figure II-40 The 1st OJT on Bridge Inspection Guidebook (Field Training)



c. Group Discussion



Group Discussion(1)



Group Discussion(2)



Presentation(A2Group)



Presentation(B1Group)



Exchange of opinions between participants



Participants of 1<sup>st</sup> OJT

Figure II-41 The 1st OJT on Bridge Inspection Guidebook (Group Discussion)



(3) The 2nd Bridge Inspection OJT

a. Lecture(Bridge Inspection Guidebook)



Explanation of Bridge Inspection Guidebook by a JICA Expert(1)



Explanation of Bridge Inspection Guidebook by a JICA Expert(2)

Figure II-42 The 2nd OJT on Bridge Inspection Guidebook (Lecture)

b. Field Training



Inspection by BIV



Periodic Inspection Drill



NDT(Rebar Detective Test) Drill



NDT(Rebound Hammer) Drill

Figure II-43 The 2nd OJT on Bridge Inspection Guidebook (Field Training)



c. Group Discussion



Group Discussion(1)



Group Discussion(2)



Group Presentation(1)



Group Presentation(2)



Closing Remark by the Communications and Corporate Director



Participants of 2<sup>nd</sup> OJT

Figure II-44 The 2nd OJT on Bridge Inspection Guidebook (Group Discussion)

## (4) Feedback on Bridge Inspection Guidebook

Participants had various questions and ideas during the OJT and these were discussed among the counterparts. The comments were written as feedback in the Bridge Inspection Guidebook as follows:

Table II-27 Feedback to Bridge Inspection Guidebook

Items	Comments in OJT	Final Agreement
Timber Bridges and a Masonry Arch	Proposed to be kept as a historical heritage and be deleted from the guidebook since it is not included in the design due to its low traffic volume. In Zambia, these types of bridges connects districts and plays an important role in maintaining the community even now.	RDA still has to maintain these type of bridges, therefore timber bridges and a masonry arch should be remain in the guidebook.
Waterway	Flood affected to the bridges in the previous rainy season in Zambia. In conclusion, a waterway should be added in the condition criteria.	Waterway is added in the condition criteria.
Bridge Approach	To add other damages aside from depression/dent.	Other damages such as crack, embankment erosion, should be inspected by the road maintenance. Bridge approach is assumed to be 6m from the abutment.
Slope Protection	To revise criteria of Gabion Mattresses for slope protection. Material loss/disintegration doesn't depend only on the depth.	Delete the material loss/disintegration criteria because it is included in the damage types of 'Bank erosion' and 'Slope erosion`.

### 1.3.3 Improvement of Planning and Enhancement of Knowledge on Bridge Repair Technology

#### 1.3.3.1 Develop an Implementation Plan of Repair and/or Replacement for selected Bridges based on the Condition Inspection Data and the Data in the Bridge Management System

##### (1) Purpose of Activity

After the bridge condition inspection is conducted, RDA shall register the data to the BMS and shall proceed with the countermeasures for damaged/deteriorated bridges whether monitoring, repair or bridge replacement. In order to determine the countermeasures for damaged bridges, an implementation plan considering the damage degree, functionality, priority, cost and others shall be prepared.

It is necessary for RDA to prepare a plan of bridge repair and/or replacement prior to implementation. This aims to enhance the capability of RDA counterparts to implement bridge repair projects using the bridge repair guidebook.

##### (2) Activity Procedure

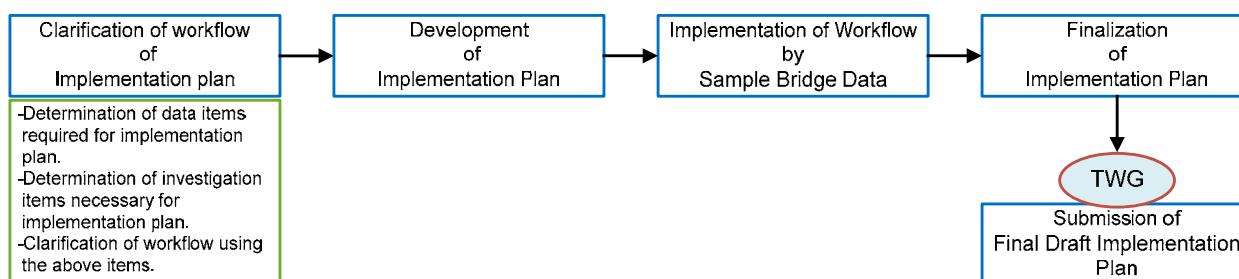


Figure II-45 Creation of Implementation Plan Flowchart

#### a. Clarification of workflow of implementation plan for bridge repair and/or replacement

- i. The data items which should be required for the implementation plan were determined as follows:
  - Bridge inventory data
  - Road classification
  - Traffic condition
  - Presence of functional problems
  - Planning of grade-up of bridge
  - Bridge condition inspection data and BMS data
  -
- ii. The investigation items necessary for the implementation plan were determined to be as follows:
  - Detailed inspection
  - Repair method and cost
  - Bridge type for replacement and construction cost

#### b. Development of the implementation plan

A workflow of implementation plan was proposed by the JICA bridge repair experts in consideration of the above items and was explained to the counterparts. The workflow was developed by repetitive discussion with JICA experts and the counterparts.

#### c. Implementation of the workflow by an existing bridge data as a sample

Trial judgement of either repair or replacement was done using the sample bridge data

in accordance with the workflow of the implementation plan.

d. Finalization of the implementation plan

The draft implementation plan was finalized after several discussions.

e. Submission to 3<sup>rd</sup> TWG meeting

The final draft implementation plan was submitted to 3<sup>rd</sup> TWG meeting and approved after discussion.



(3) Flowchart of implementation plan

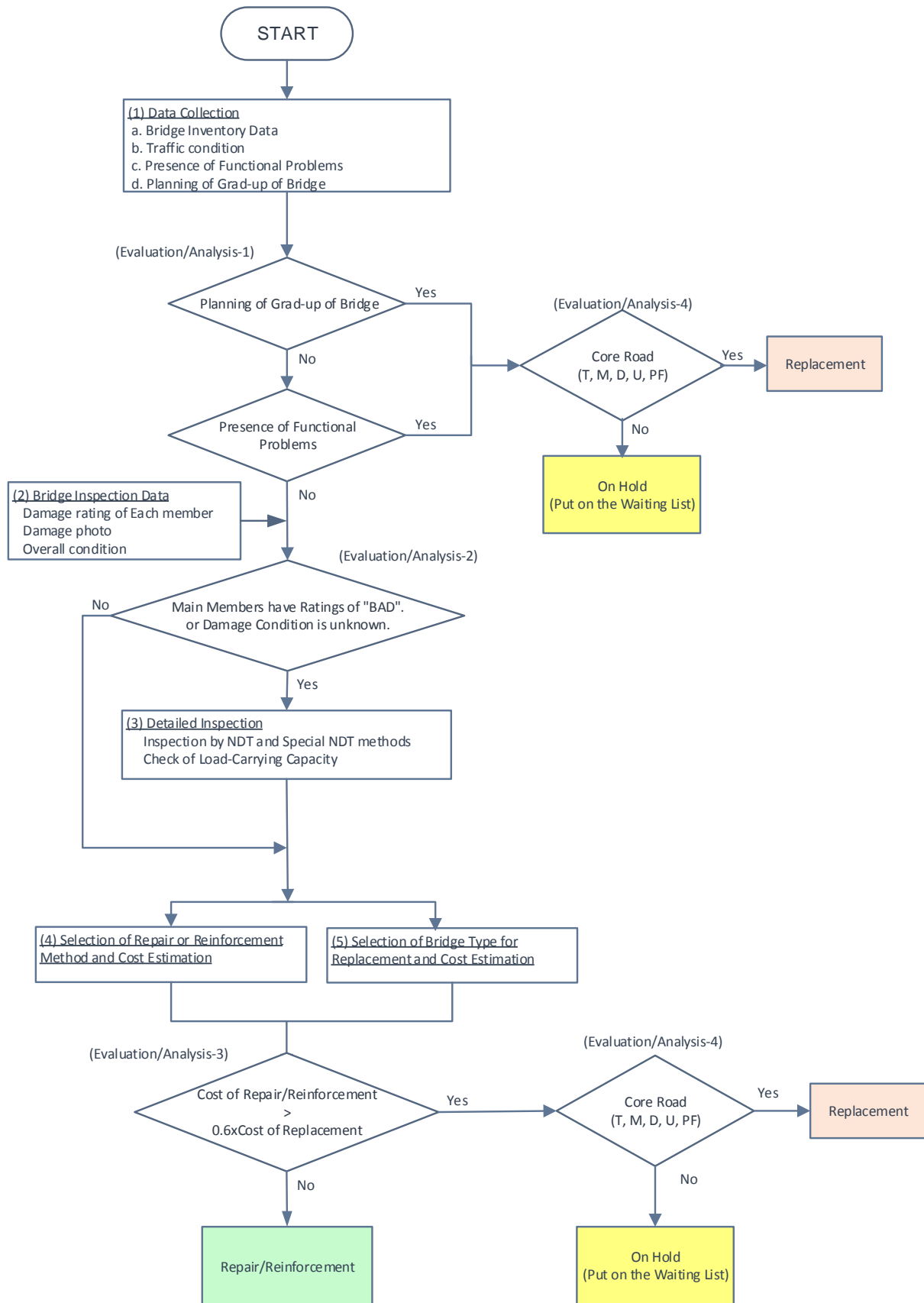


Figure II-46 Flowchart of Implementation Plan of Bridge Repair or Replacement

### 1.3.3.2 Develop a Bridge Repair Guidebook

#### (1) Purpose of Activity

So far, RDA have not executed any bridge repair project. Due to this, many bridges are not in good condition now. Recently, RDA became eager to implement the bridge repair projects in Zambia.

Furthermore, RDA do not yet have the technological capacity with bridge repair. For this reason, RDA engineers need to learn the know-how on the technological procedures for the implementation of bridge repairs.

This activity aims to prepare a guidebook in response to the above-mentioned.

In order to effectively manage the activities, there is a need to create a user-friendly guidebook to serve as a guide for the use of maintenance engineers as well as contractors, consultant engineers and practitioners in RDA. The Guidebook containing the most common information of bridge repair includes the following items;

- Overall procedure of bridge repair
- Procedure for selecting repair method
- Consideration on bridge repair activities
- Repair method for each structure

#### (2) Activity Procedure

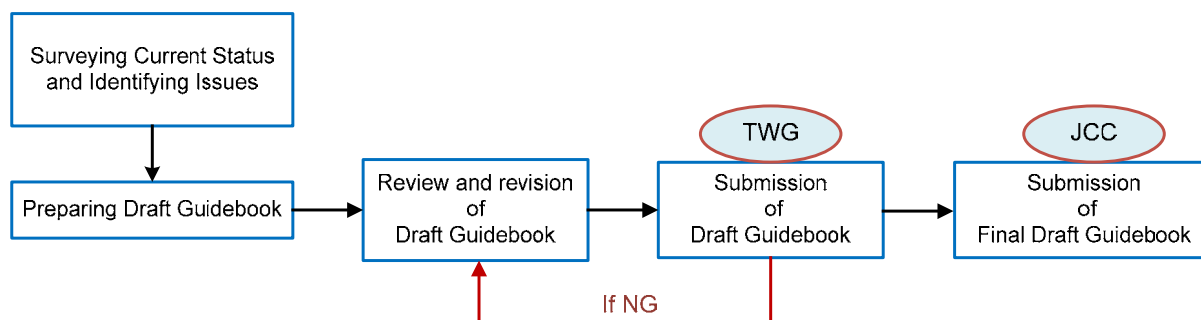


Figure II-47 Flowchart of the Creation of Bridge Repair Guidebook

##### a. Surveying current status

JICA team and Counterparts had conducted survey on the current status of the existing bridge conditions.

Specifically, the team understood the types and extents of damages of the existing bridges by reviewing the inspection data from BMS and by conducting the condition inspection for several bridges along the trunk roads.

##### b. Preparing the draft guidebook

JICA team and Counterparts had periodically met and discussed the details of the guidebook such as contents, procedure, etc.

Then, the 1st draft of the Bridge Repair Guidebook was submitted to the Technical Working Group (1<sup>st</sup> TWG meeting) on July 31, 2015 and the outline of the guidebook was explained.

##### c. Review and Revision of the draft guidebook

The 1st draft of the guidebook was carefully reviewed and revised considering the damage situation, repair material and construction capacity in Zambia. Then, the 2nd draft of the guidebook was submitted to 2<sup>nd</sup> TWG meeting on December 14, 2015. On the 2<sup>nd</sup> TWG meeting, it was required to add the specification of the repair materials in the guidebook. Then, the final draft guidebook was carefully prepared with the specification of repair materials.

d. Submission to 2<sup>nd</sup> JCC meeting

The final draft of the guidebook was submitted to the 2<sup>nd</sup> Joint Coordination Committee (JCC) meeting and had been approved.

(3) Main contents of the final draft guidebook

The main contents of the final draft guidebook are as follows;

Chapter 1 INTRODUCTION

Chapter 2 MAJOR MAINTENANCE REPAIR

Chapter 3 REPAIR OF CONCRETE DECK SLAB

Chapter 4 REPAIR OF CONCRETE BRIDGE SUPERSTRUCTURE

Chapter 5 REPAIR OF STEEL BRIDGE SUPERSTRUCTURE

Chapter 6 REPAIR OF CONCRETE/STEEL BRIDGE SUBSTRUCTURE

Chapter 7 REPAIR OF BRIDGE EXPANSION JOINT

Chapter 8 REPAIR OF BRIDGE BEARING

Chapter 9 PROTECTION WORKS

Chapter 10 REPAIR EXAMPLES FOR SPECIAL BRIDGES

APPENDIX: SPECIFICATIONS

1.3.3.3 Information Survey of Bridge Repair in Japan and in South Africa

(1) Survey in Japan

a. Purpose

The purpose of the survey is to understand the status of bridge repair technology in Japan (repair materials, repair methods, etc.) and to reflect the information obtained to the bridge repair guidebook.

The survey was performed in two weeks from October 9, 2015 to 23.

The main survey items are as follows:

- i. Visit of the bridge repair work site and obtaining of the data,
- ii. Interview with academically experienced person,
- iii. Interview with repair material supplier and collection of the material data,
- iv. Collection of documents which is related to bridge repair and
- v. Collection of documents of special bridge repair examples.

b. Survey Items and Contents

Table II-28 shows the survey items and their contents:

Table II-28 Survey Items and Their Contents

1. Visit of the bridge repair work site and obtaining of the data		
i. Tamamo Bridge Viaduct	Seismic reinforcement of the piers (Increase of wall thickness by the splaying method)	
ii. Metropolitan Expressway No. 3 route, Tanimachi JCT	Reinforcement of concrete slab, Replacement of bearings, etc.	
iii. Metropolitan Expressway No. 4 route, Vicinity of Sendagaya	Reinforcement of concrete slab, Improvement of girder hinge portion, etc.	
2. Interview with academically experienced person		
i. Professor Takuyo Konishi, Tokyo City University	Current situation of the bridge repair, and its problems	
ii. Professor Ichiro Iwaki, Nihon University	Ideal way of bridge maintenance in developing countries	
3. Interview with repair material supplier and collection of the material data		
i. Kansai Paint	Data sheets of paint specifications for steel bridge	
ii. BASF Japan	Data sheets of concrete repair materials	
iii. Sika Ltd.	Data sheets of concrete repair materials and waterproofing materials of deck slab	
4. Collection of documents which is related to bridge repair		
i. Diagnostic technology of concrete structures 2002	Japan Concrete Institute	
ii. Repair and reinforcement of concrete bridges	Japan Society of Civil Engineers	
iii. Concrete repair course	Nikkei Business Publications, Inc.	
iv. Text of technology workshop for road bridge inspector	Japan Bridge Engineering Center	
v. Bridge Repair Method (Alpha Method)	Alpha Kogyo K.K.	
vi. Bridge Repair Materials	Taiheiyo Materials Corporation	
vii. Materials of Expansion Joint (MM Joint)	MM Joint Japan Association	
viii. Materials of Expansion Joint (ThormaJoint)	Yokohama Rubber Co.,Ltd.	
5. Collection of documents of special bridge repair examples		
i. PC Box Girder Bridge	<ul style="list-style-type: none"> <li>• Cracks on the underside of PC box girder</li> <li>• Deterioration due to grout filling shortages and salt damage</li> </ul>	
ii. Steel Truss Through Bridge	<ul style="list-style-type: none"> <li>• Fatigue damage of truss diagonal member</li> <li>• Corrosion of truss lower chord member, etc.</li> </ul>	
iii. Steel Truss Deck Bridge	<ul style="list-style-type: none"> <li>• Corrosion of truss members (weathering steel)</li> </ul>	
iv. Steel Arch Deck Bridge	<ul style="list-style-type: none"> <li>• Fatigue damage of hinge part of arch bridge</li> <li>• Fatigue damage of vertical member mounting portion of arch bridge</li> </ul>	
v. Steel Cable-Stayed Bridge	<ul style="list-style-type: none"> <li>• Damage to the shock absorber of cable folding portion</li> <li>• Protrusion of sliding plate of vertical bearing, etc.</li> </ul>	

c. Activity Photos



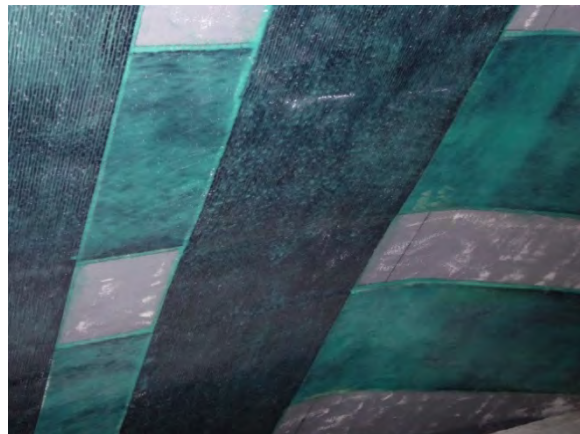
Increase of Wall Thickness by Spray Method  
(Tamamo Bridge Viaduct)



Construction Equipment of Spray Method  
(Tamamo Bridge Viaduct)



Carbon Fiber Sheet on Lower Surface of Slab  
(Metropolitan Expressway No.3 Route)



Carbon Fiber Sheet inside Box Girder  
(Metropolitan Expressway No.3 Route)



Replacement of Bearing (Existing)  
(Metropolitan Expressway No.4 Route)



Replacement of Bearing (New)  
(Metropolitan Expressway No.4 Route)

Figure II-48 Survey of Bridge Repair in Japan

## (2) Survey in South Africa

## a. Activity Purpose and Content

Information collection regarding the bridge repair materials and bridge repair companies was performed in Johannesburg of South Africa from November 16 to 19. Schedule of the survey is shown in Table II-29. BASF SA and SIKA SA are suppliers of the concrete repair materials. KANSAI PLASCON is a supplier of the paint materials for steel. And, Stefanutti Stocks Civils is a leading construction company with bridge repair achievements. Information of the materials which are suitable for the bridge repair in Zambia and available in Zambia was given by the suppliers. From the construction company, the achievements of the bridge repair works and the intention of the participation of the repair work in Zambia were confirmed.

Table II-29 Schedule of Market Survey in South Africa

	AM	PM
November 16 (Mon)	9:00 Lusaka- 11:05 Johannesburg	14:00 BASF SA (Supplier: Concrete repair material )
November 17 (Tue)	11:00 KANSAI PLASCON (Supplier: Paint for Steel)	
November 18 (Wed)	9:00 Stefanutti Stock Civils (Construction Company)	13:30 BASF SA (for sample materials observation)
November 19 (Thu)	9:00 SIKA SA (Supplier: Concrete repair material )	15:45 Johannesburg-17:40 Lusaka

Data obtained by the survey is shown in Table II-30.

Table II-30 Data Obtained by Market Survey in South Africa

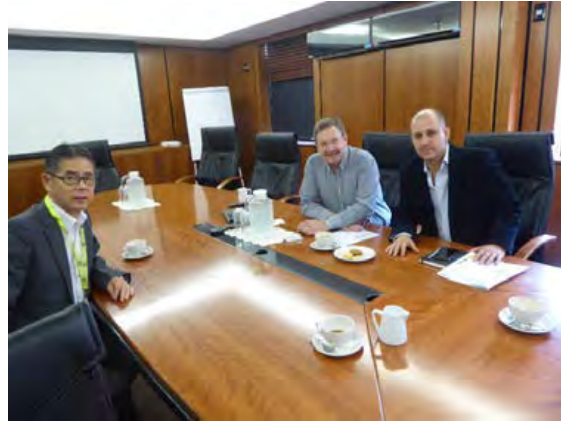
Company Name	Data
BASF SA	(1) Summary of BASF Products for Concrete Repair (2) Data Sheets of BASF Products for Concrete Repair (3) Solutions for Concrete Repair and Protection (4) MasterFlow – Solutions for Industrial Grouting
SIKA SA	(1) Summary of Sika Products for Concrete Repair (2) Data Sheets and Method Statements of Sika Products for Concrete Repair
KANSAI PLASCON	(1) Patch Repair Specification and Data Sheets (2) Full Maintenance Specification and Data Sheets (3) Presentation-Bridge Maintenance Zambia
Stefanutti Stocks Civils	(1) Brochure of company and Structural Concrete – Repair and Rehabilitation (2) Benchmark Volume 13 (May 2015) (3) Current and Completed Bridge Repair Projects (4) Contact List of Bridge Bearing and Joint Suppliers



b. Activity Photos



Meeting with Supplier



Interview with Construction Company



Damages of Bridge in Johannesburg City (Cracks, Water leakage, etc.)



Damages of Bridge in Johannesburg City (Cracks, Water leakage, etc.)



Repair Demonstration of Patching in BASF (Mixing of Material)



Repair Demonstration of Patching in BASF (Trowel finishing)

Figure II-49 Survey of Bridge Repair in South Africa



1.3.3.4 Provide Opportunities for Counterparts to get exposed to Bridge Repair Works through Actual Projects

(1) Counterpart Training in Japan

a. Purpose of Training

Training in Japan is carried out three times in this technical cooperation project period (February 2015 to August 2017). The training was held with the theme "bridge maintenance management skills".

The purpose of the training is for the trainees to understand the importance of bridge maintenance, learn the basic inspection and repair method of bridge.

The Training items are as follows:

- i. Bridge maintenance technology;
- ii. Bridge inspection technology;
- iii. Bridge repair technology/material;
- iv. Maintenance technology for Long span bridge;
- v. Damage of bridge, and its causes.

The detail program are described "4.4 Japan Training"

(2) The Third Country Training

In order to obtain the bridge repair technology, the third country training were conducted in South Africa and Philippines. The detail program are described "4.5 the third country training".

a. Counterpart Training in South Africa

Schedule of the training is shown in Table II-31.

Table II-31 Schedule of Training in South Africa

Month/Day	Day of Week	Contents of Training	Place of Training
7/18	Mon.	• Arrived at Johannesburg • Courtesy call to South Africa National Road Agency	South Africa National Road Agency
7/19	Tue.	• Move to Upington • Site visit, Bridge repair project (on-going) • Move to Johannesburg	South Africa National Road Agency
7/20	Wed.	• Site visit, Bridge repair project (Concrete bridges) • Site visit, Bridge repair project (Steel bridges, Repainting)	BASF Kansai-Plascon
7/21	Thu.	• Visit BASF (Supplier of bridge repair materials) - Discussion on bridge repair materials - Observation of demonstration of bridge repair works	BASF
7/22	Fri.	• Departure from Johannesburg	



Discussion with SANRAL Members



Bridge Repair Project Site in Upington



Damages on Wing of Bridge Abutment (Delamination of Concrete, Exposed Rebars)



At the Repair Bridge (Counterparts and SANRAL Members)



At the Silo Repair Project Site



On-going Silo Repair Project Site



Attending Test of the Concrete repair material



Discussion about the Repair Materials

Figure II-50 The Third Country Training in South Africa

b. Counterpart Training in the Philippines  
 Schedule of the training is shown in Table II-32.

Table II-32 Schedule of Training in the Philippines

Month/Day	Day of Week	Contents of Training	Place of Training
8/17	Wed.	Arrived at Manila	
8/18	Thu.	<ul style="list-style-type: none"> <li>• Courtesy call to Mr. Raul C. Asis, Undersecretary</li> <li>• Attend at monthly meeting of TCP-III, perform speech and presentation (DPWH Head)</li> <li>• Site visit, Completed repair project (Naic Diversion Bridge, Region IV-A, Cavite)</li> </ul>	Manila (Region IV-A)
8/19	Fri.	<ul style="list-style-type: none"> <li>• Attend at OJT for Bridge repair (Region IV-A Office)</li> <li>• Site visit, On-going repair project (Teresa Bridge, Region IV-A, Antipolo)</li> </ul>	Manila (Region IV-A)
8/20	Sat.	<ul style="list-style-type: none"> <li>• Site visit, Marcel Ferman Bridge (2nd Mactan Bridge, Extradosed Bridge, Region VII)</li> <li>• Site visit, 1st Mactan bridge (Steel Truss Bridge, Region VII)</li> </ul>	Cebu (Region VII)
8/21	Sun.	• Cebu to Manila	
8/22	Mon.	<ul style="list-style-type: none"> <li>• Site visit, Completed repair projects (Colorado Bridge and Camp4 Bridge, Region CAR)</li> <li>• Courtesy call to Mr. Gahid (Assistant Regional Director, DPWH Region CAR)</li> <li>• Site visit, Completed repair project (Loakan Bridge, Region CAR)</li> <li>• Visit Laboratory (Region Car)</li> </ul>	Baguio (Region CAR)
8/23	Tue.	• Site visit, Bamban Bridge (Steel Nielsen-Lohse Bridge, Region III)	Tarlac (Region III)
8/24	Wed.	<ul style="list-style-type: none"> <li>• Courtesy call to Ms. Nenita R. Jimenez (Deputy Project Manager, JICA TCP-III)</li> <li>• Departure from Manila</li> </ul>	Manila (DPWH Head)



Courtesy call to Mr. Raul C. Asis, Undersecretary



Perform presentation at monthly meeting of TCP-III (DPWH Head)

Figure II-51 The Third Country Training in the Philippines (1/3)





Attend at OJT for Bridge repair  
(Region IV-A Office)



Site visit: Naic Diversion Bridge  
(Region IV-A, Cavite)



Site visit: Teresa Bridge  
(Region IV-A, Antipolo)



Site visit: Marcel Ferman Bridge  
(Extradosed Bridge, Region VII)



Site visit: Marcel Ferman Bridge  
(Extradosed Bridge, Region VII)



Site visit: Colorado Bridge  
(Region CAR)

Figure II-52 The Third Country Training in the Philippines (2/3)



Site visit: Camp 4 Bridge (Region CAR)



Site visit: Loakan Bridge (Region CAR)



Courtesy call to Mr. Gahid  
(Assistant Regional Director, Region CAR)



Visit Laboratory: Explanation of Non-destructive testing equipment (Region CAR)



Site visit: Bamban Bridge  
(Steel Nielsen-Lohse Bridge, Region III)



Courtesy call to Ms. Nenita R. Jimenez  
(Deputy Project Manager, JICA TCP-III)

Figure II-53 The Third Country Training in the Philippines (3/3)



1.3.3.5 Preparing a Bridge Repair Plan for Pilot Bridges using Condition Inspection Data

(1) Purpose of Activity

RDA counterparts in cooperation with JICA experts devise and prepare the repair plan of the damaged bridges by using the inspection results.

(2) Activity Procedure

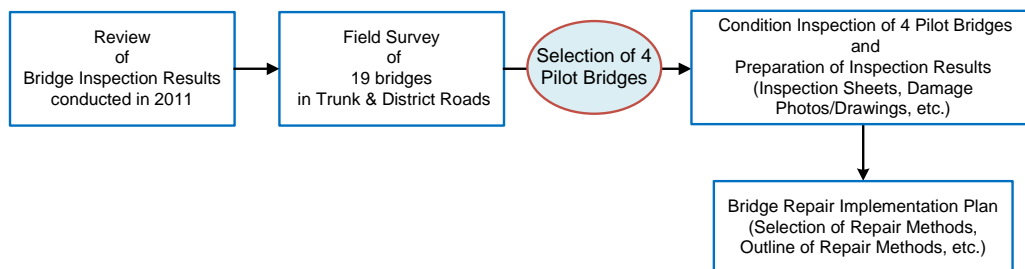


Figure II-54 Activity Procedure

RDA counterparts and JICA experts reviewed the results of the bridge inspection which had been implemented in 2011, and conducted the site survey about 19 bridges of the inspected bridges. Then, they selected the 4 bridges which had big damages from the 19 bridges as the pilot bridges, and carried out the condition inspection of those bridges.

After the condition inspection of the 4 pilot bridges, they prepared the inspection sheets, damage drawings and damage photos. And then, they selected the repair methods against the bridge damages with reference to the bridge repair guidebook and finalized the outline of the bridge repair method.

(3) Selection of Pilot Bridges

19 surveyed bridges and selected 4 pilot bridges are listed in the Table II-33.

Table II-33 19 Surveyed Bridges and Selected 4 Pilot bridges

	Bridge ID	Material of Main Member	Bridge Length (m)	Regional Office	Distance from Lusaka (km)	Main Defects
1	T1-2	Concrete	7	Southern	80	Cracking, Rebar expose
2	T1-5	Steel	36	Southern	160	Cracking, Corrosion
3	T1-6	Concrete	58	Southern	200	Scouring, Spalling
4	T1-7	Concrete	78	Southern	360	Cracking, Delamination
5	T2-304	Concrete	9	Central	190	Cracking
6	T2-305	Steel	20	Central	230	Paint peel off, Delamination
7	T2-4	Steel	24	Lusaka	100	Paint peel off, Delamination
8	T3-301	Steel	11	Copperbelt	270	Cracking
9	T3-302	Concrete	6	Copperbelt	280	Cracking, Rebar expose
10	T3-306	Concrete	9	Copperbelt	360	Spalling
11	T3-307	Steel	107	Copperbelt	380	Paint peel off, Corrosion
12	D790-4	Steel	124	Eastern	910	Paint peel off, Corrosion
13	D791-3	Steel	44	Eastern	670	Cracking
14	D791-4	Steel	37	Eastern	640	Paint peel off, Corrosion
15	D791-5	Steel	61	Eastern	600	Paint peel off, Corrosion
16	T4-5	Steel	303	Eastern	220	Deformation, Abnormal Vibration
17	T4-7	Concrete	16	Eastern	250	Cracking, Spalling
18	T4-10	Steel	32	Eastern	330	Paint peel off, Corrosion
19	T4-13	Concrete	8	Eastern	490	Honeycomb

\*T1-2, 5, 6 and T2-4 are pilot bridges.



(4) Damage Drawings and Outline of Repair Method

The examples of the damage drawings and the outline of repair method are shown in Figure II-55 to II-57.

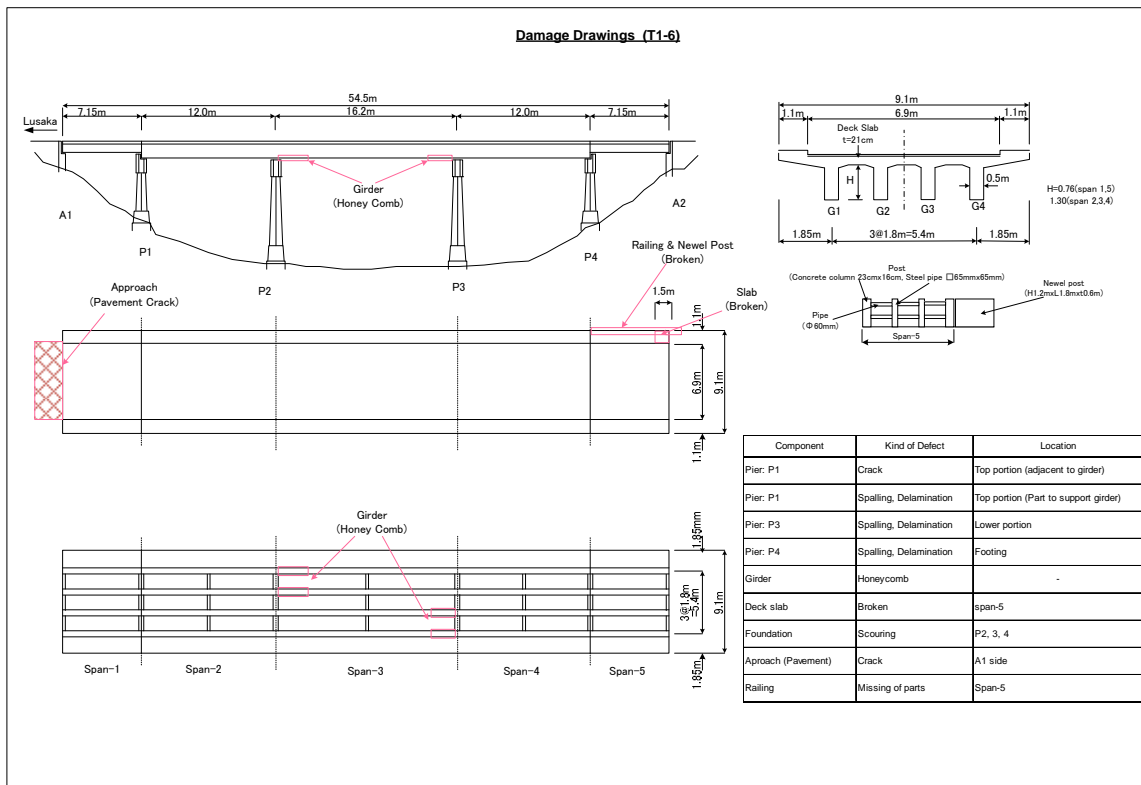


Figure II-55 Example of Damage Drawing (T1-6 Bridge)

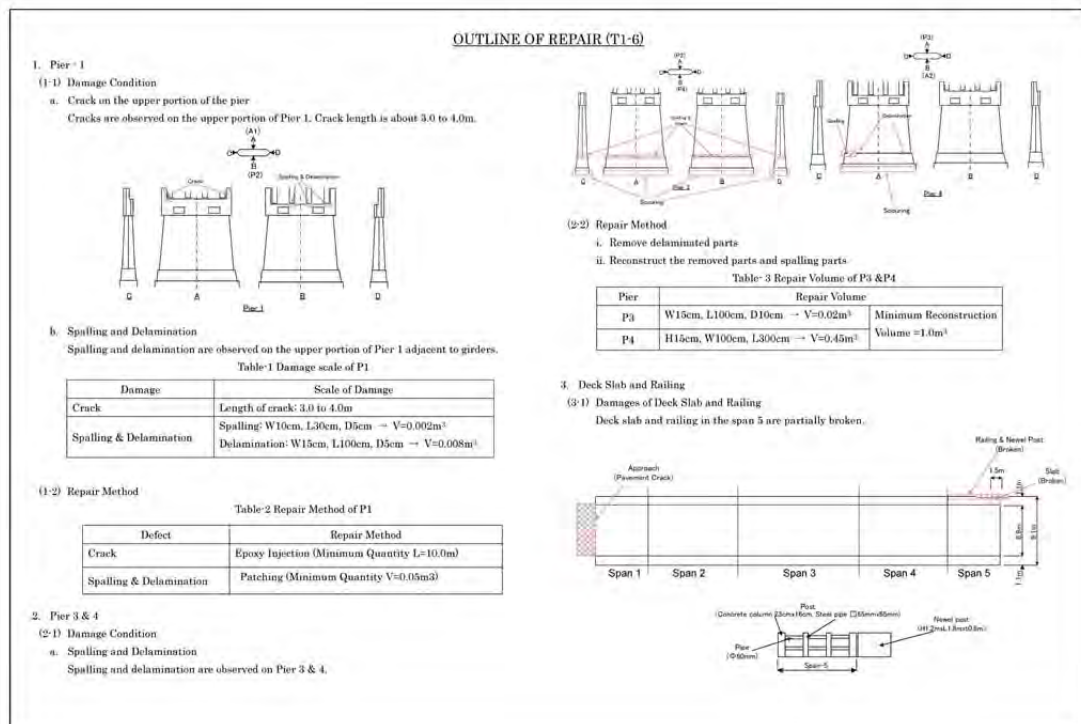


Figure II-56 Example of Outline of Repair Method (T1-6, 1/2)

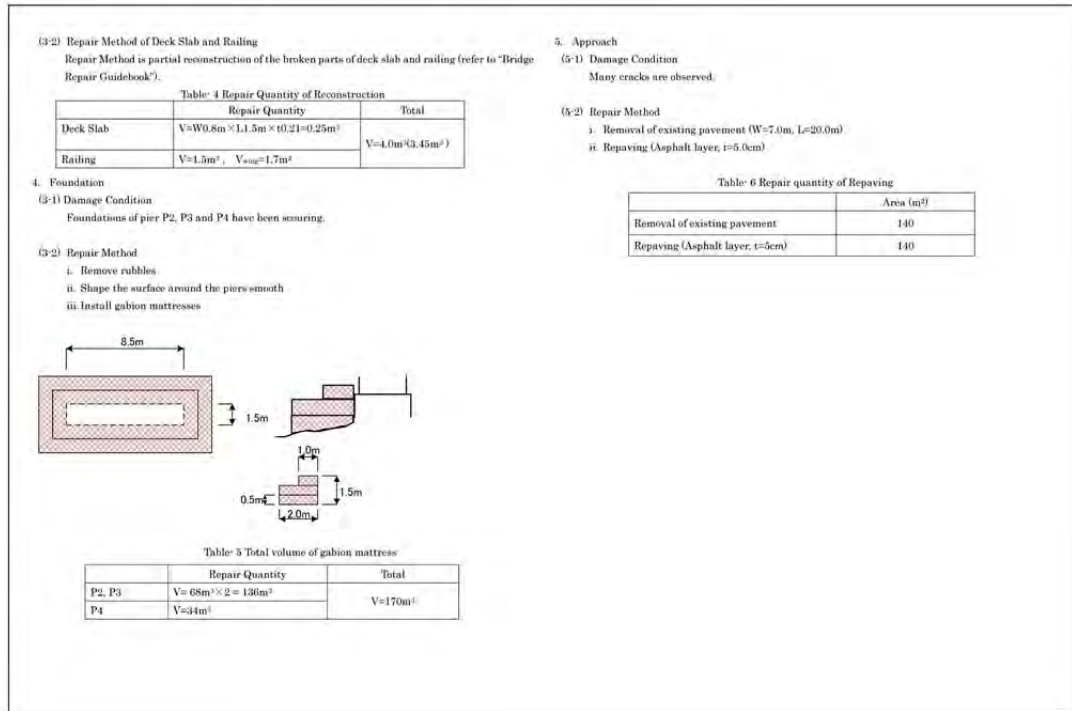


Figure II-57 Example of Outline of Repair Method (T1-6, 2/2)

(5) Activity Photos



Pilot Bridge (T1-2)



Pilot Bridge (T1-5)

Figure II-58 Pilot Bridges for Bridge Repair (1/2)





Pilot Bridge (T1-6)



Pilot Bridge (T2-4)



Inspection Scenes



Discussion Scenes

Figure II-59 Pilot Bridges for Bridge Repair (2/2)

1.3.4 Improvement of the Capacity of RDA for Contract Management

1.3.4.1 Develop Contract Templates and Technical Specifications required for Bridge Routine Maintenance Outsourcing

(1) Purpose of the activities

The road routine maintenance contract has been introduced in RDA for vegetation, cleaning of the road facilities and small repair works including road surface and drain structures. On the other hand, the routine maintenance of the bridge structures including inspection and cleaning works has not been introduced. In some bridge, re-bars in the concrete are exposed and steel girders are developing rust. These bridges must be repaired as soon as possible for preventing further damages. Because RDA has not enough numbers of staffs for executing these bridge routine works by themselves, the bridge routine works shall be outsourced to contractors.

The pilot project of bridge routine maintenance was planned to be outsourced by RDA. Issues and improvement matters for bridge routine maintenance works shall be identified in the pilot project before the expansion of bridge routine maintenance works to the whole country. Templates of contract documents and technical specification were prepared by counterparts of RDA and JICA experts. Assistance was provided in the process of evaluation of bids and contract award and construction management of bridge routine maintenance to improve construction management capacity of RDA.

(2) Activity Procedure

a. Develop contract templates and technical specification

i. Examination of outsourcing

At first, examination and planning of outsourcing of bridge routine maintenance was conducted. After confirmation of the issues of current bridge maintenance of RDA, works for the bridge routine maintenance contract were identified.

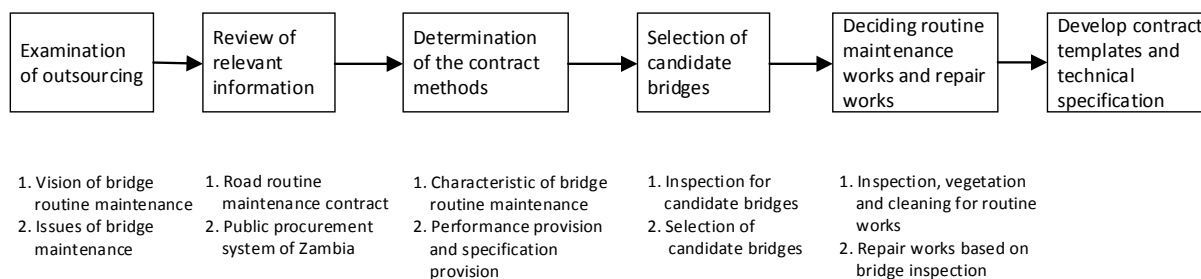


Figure II-60 Flowchart of Working Process of Bridge Routine Maintenance Outsourcing (1)

ii. Review of relevant information

The road routine maintenance contract has been widely outsourced in the country. These road routine maintenance contract documents were scrutinized and the characteristics and methods were understood. The public procurement system of Zambia was also examined by reviewing the “Procurement Acts of Zambia” to identify the matters to be applied to the bridge routine maintenance contract.

iii. Determination of contract methods

In the road routine maintenance, performance provisions and specification provisions are being used depending on the characteristics of the works. In the bridge routine maintenance contract, each work was classified into performance works and specification works based on the characteristics of the works.

iv. Selection of candidate bridges

Site visits with RDA counterparts were conducted for the selection of bridges that shall

be included in the contract. The selection was made considering the accessibility, environment and contract costs. To secure the Technology Transfer to RDA, the frequent participation of RDA staffs to the construction management site activities shall be ensured. Bridges in the city center areas were avoided because of the environment in which many pedestrians and shops were there, and the cost of the project which is high enough to attract a competent contractor was considered.

v. Deciding the routine maintenance works and repair works

Based on “Bridge Routine Maintenance Guidebook”, bridge routine maintenance work items that should be included in the contract were chosen. Damages of bridges were identified through site inspections. Small-scale and urgent repair works were chosen to be included in the contract considering the work capacity of the contractors.



Rusting girders



Damaged columns



Rusting guardpipes



Spalling and re-bars exposures

Figure II-61 Damages of Bridges

vi. Develop contract templates and technical specification

Based on the above examinations, draft of (1) contract documents, (2) technical specification, (3) bill of quantities and (4) cost estimates of the project were prepared with the cooperation of counterparts of headquarter and regional office of RDA. Coordination meetings were held periodically by the counterparts of RDA including discussions on how to make appropriate and reasonable bid documents of bridge routine maintenance contract. The final draft of contract templates and technical specification were submitted to the planning department of RDA on 7<sup>th</sup> December 2015. On 15<sup>th</sup> December 2015, an “Invitation for bids of bridge routine maintenance contract in Lusaka Province” was announced to the public by the procurement department of RDA. On 29<sup>th</sup> December 2015, “Pre-bid site visits” was conducted with more than 100 companies’ attendances. Domestic contractors have a lot of expectations for starting the bridge routine maintenance project.

b. Assistance for procurement and construction management

i. Assisting bid evaluation committee

After the bid opening, the evaluation committee was established in Lusaka regional office of RDA to evaluate the bids submitted by contractors. JICA experts attended the committee to observe and assist the evaluation process. At the committee, the whole bid documents were examined whether the requirements were satisfied.



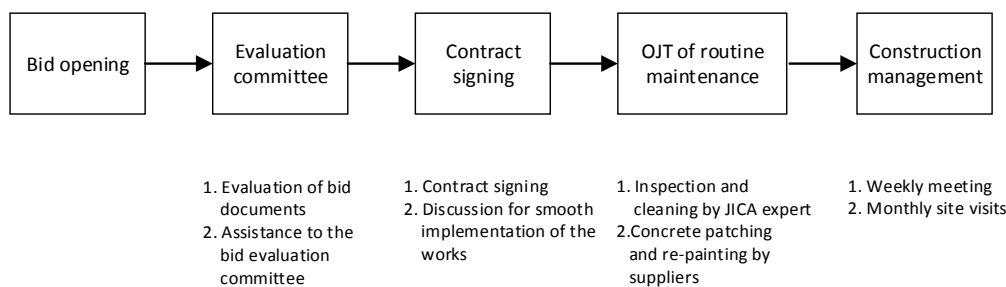


Figure II-62 Flowchart of Working Process for Bridge Routine Maintenance Outsourcing (2)



Pre-bid site visits



Bid evaluation committee

Figure II-63 Bid Related Activities

Some issues arising from the bid documents were examined considering the public procurement system in Zambia and the purpose of this project.

ii. Contract Signing

JICA experts witnessed the signing ceremony of the bridge routine maintenance contract. JICA experts discussed with RDA and the Contractors about the pilot project's objective and procedures and facilitated the communication of the four stakeholders (RDA headquarters, RDA regional office, Contractor and JICA experts) during the project. Followings matters were decided.

- ✓ Weekly meetings shall be held every week by the attendance of RDA head quarter, Regional Office, the Contractor and JICA expert
- ✓ The Contractor shall submit weekly reports which describe the resources which were consumed in the week, such as labors, equipment and machines.
- ✓ The Contractor shall submit weekly schedule for the next week before the end of the week and monthly schedule for the next month before the end of the month

Above matters shall be reviewed after one month later, whether these are heavy burdens for the participants.

iii. OJT of bridge routine maintenance

Because the Contractor have not enough knowledges of bridge routine maintenance, OJT of bridge inspection, bridge cleaning, concrete patching and re-painting works were conducted with the participation of the Contractor, RDA and JICA experts. At the OJT of "concrete patching" and "bridge painting", the technical experts from the suppliers of South Africa also attended and provided precise technical knowledge on the implementation of these repair works.

Aside from the above, OJT of bridge inspection vehicle (BIV) operation was also conducted. The BIV was procured through the World Bank fund in the previous year and RDA was not familiar with the operation of this BIV. OJT was conducted at the bridge of Trunk Road No.4 near Chongwe for the operation of traffic regulation, procedure of parking of the BIV on the bridge and operation of ladder of the BIV.





Operation of the ladder of BIV

Inspection using the ladder of BIV

Figure II-64 OJT of Operation of BIV at the Site

Based on the results of the OJT, the operation of traffic regulation, safety measures such as prevention of operators falling from BIV and the indication of maximum weights on the ladder of BIV was proposed. In the bridge routine maintenance contract, the applicability of BIV in the bridge routine maintenance works shall be verified at each bridge and the corresponding repair works using BIV shall be identified.

iv. Assist the construction management

For the project to proceed smoothly, weekly meetings between the Contractor, RDA and JICA expert continued after one month from the start of the work. In the weekly meetings, work progress, work schedule and issues about the implementation of works were discussed. In addition to weekly meetings, once a month, site visits were held by the Contractors, RDA and JICA experts together for identifying the issues of the sites and finding countermeasures.



Works of concrete patching



Works of painting

Figure II-65 Repair Works of the Pilot Project



Monthly site visit



Meeting after monthly site visit



Weekly meeting

Figure II-66 Meetings of the Contractor, RDA and JICA Experts

1.3.4.2 Prepare Technical Specifications of Bridge Repair Contracts

(1) Purpose of Activity

Same as bridge routine maintenance, bridge repair works have not been introduced in RDA. Bridge repair works are important in recovering the function of damaged bridges and for preventing further damages.

RDA decided to outsource the bridge repair works and implement a pilot project of bridge repair works. Through the pilot project, issues of the development of the repair works nationwide shall be identified. JICA team provides proper support to the counterparts, especially for selection of repair methods and preparation of technical specification of contract to improve contract management ability of the counterpart.

(2) Activity Procedure

a. Examination of outsourcing

At first, examination of outsourcing of bridge repair works was conducted. Based on “bridge Inspection Report” and “Bridge Repair Guidebook”, damages of bridges and repair methods were examined. The information of bridge repair materials in South Africa was also examined to determine which repair methods shall be applied to the damages.

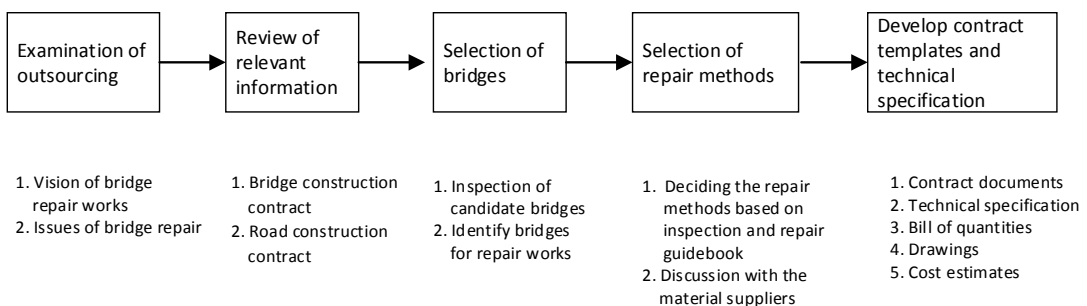


Figure II-67 Flowchart of the Outsourcing of Bridge Repair Project

b. Review of relevant information

Contract of the recent construction projects were reviewed. The specification of Southern Africa Transport and Communications Commission (SATCC) was reviewed because it is widely applied to the construction and repair contracts of RDA projects. The scope and range of the SATCC specification which shall be applied to the bridge repair contract were examined.

c. Selection of the bridges

Based on the bridge inspection, bridges damaged enough to be repaired and accessible from Lusaka city were selected as candidates of bridge repair contract.

d. Selection of repair location and methods

After conducting bridge inspection, repair location and methods were examined. Repair methods were determined based on “Bridge Repair Guidebook”, specification of repair materials from suppliers.

e. Preparing the contract templates and technical specification

Based on the above examinations, draft of contract, technical specification, bill of quantities, drawings and cost estimates were prepared with the cooperation of counterparts of RDA. A concept paper of pilot project for bridge repair was also prepared. It includes the general idea of the pilot project and shows the outline of the project.

For the contract documents, information about qualification of contractors from the procurement department of RDA was utilized. Especially, financial aspects of qualification were considered seriously based on the experiences of the bridge routine maintenance project.

For the cost estimates, the unit prices of work items were obtained from the quantity surveyors of RDA. The quantity surveyors can estimate unit price based on the past records of RDA’s past projects. As for the items, which were not available from the past projects, unit price from the material suppliers and unit price using the productivities of the Department of Public Works of Philippine were examined.

On 21th October 2016, the coordination meeting was held and discussed with RDA counterparts about the contract templates and technical specification of pilot project for bridge repair. On 30<sup>th</sup> January 2017, in the TWG meeting, the final reports which was revised considering the opinions of RDA counterparts was submitted.

Damages and repair methods for repair works are shown in the next figures.











Damages	Repair methods
	
Crack	Epoxy injection
	
Spalling & delamination	Patching with polymer cement mortal
	
Slab concrete broken	Slab partial recasting
	
Rusting girders	Re-painting

Figure II-68 Damages and Repair Methods (1/3)




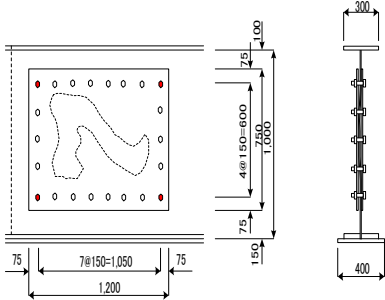




Damages	Repair methods
	
<p>Rusting near drain pipe</p>	<p>Extension of drain pipe</p>
	
<p>Deformation of girder</p>	<p>Steel plate adding</p>
	
<p>Damaged pavement</p>	<p>Waterproofing and re-pavement</p>
	
<p>Damaged joint</p>	<p>Install asphalt plug joint</p>

Figure II-69 Damages and Repair Methods (2/3)










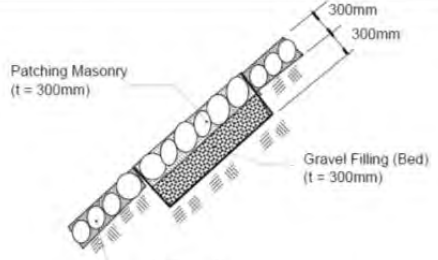
Damages	Repair methods
	
Scouring of foundation	Install gabion mattress
	
Damaged guardrail near bridge	Install steel guardrail
	
Concrete rail damaged	Re-install concrete rail
	
Slope of abutment partially collapsed	Cement-mortared masonry

Figure II-70 Damages and Repair Methods (3/3)

## 2 Achievement of the Project

### 2.1 Outputs and Indicators

#### 2.1.1 RDA Engineers understand the Management Cycle of Routine Maintenance and undertake Supervision of Routine Maintenance Activities

##### (1) Creation of Guideline for Routine Maintenance on Bridge

Considering that it is RDA's first standard related to bridge maintenance, an investigation of the actual organization of RDA and the present condition of bridges was thoroughly conducted and the opinions of RDA staffs and private contractors about the problems as well as the recognized actual condition based on the investigation result were gathered and reflected in the guideline.

As a result, the procurement and implementation of the bridge routine maintenance pilot project that was based on the draft of the Guideline went well without serious inconvenience. It can be concluded that the Guidelines effectively functions with proper use.

Through the seminars and OJTs to be described later, the principal concepts of the Guideline such as "Bridge Maintenance Management Cycle" and "Preventive Maintenance", and the details including the roles, workflow and individual activity items were comprehended by RDA officers, the counterparts and the contractor's engineers who will be engaged in the actual business in the future.

Although such technical standards are created usually by applying practical techniques based on the experience and achievements of road administrative agencies, RDA has no such experience and achievement at this point. Under this circumstance, some items were reviewed on site through OJT demonstrations and pilot project implementation, but in most items, the materials and equipment to be applied and the detail of work procedure still has to be checked on site. Therefore, some items may be continually revised based on the feedback of the results and the achievements to be obtained through the completion of the pilot project and the nationwide deployment of the bridge routine maintenance operations in order to establish a more practical standard reflecting local circumstances in Zambia.

##### (2) Conduction of Seminar on Routine Maintenance for Bridge

In the section 1.3.1.2 (3) "Results of questionnaire", the results of the questionnaire conducted in the 1st and 2nd seminar were compared and summarized. From this, the following conclusions are presumed as the achievements of this project and the issues to be posed for the future.

Since the bridge maintenance operations were rarely conducted in Zambia, in the aspect of road infrastructure preservation, a competent institution and organization should be established for the future. Such awareness have been substantially deepened among the related organizations in this project.

Moreover, the understanding of the importance of maintenance management cycle and the knowledge about the components of individual technologies have been fairly well spread inside the RDA. However, the on-site implementation experience of the related parties including the contractors is practically nothing. Therefore, it is essential to accumulate experiences and learn the know-hows through the implementation of the pilot project and to reflect the feedback of such improvements and amendments in the Guideline and the procurement documents. Furthermore, it is an indispensable process to continue such unremitting trials and efforts for a considerable period in order to establish and maintain a firm and sustainable system of bridge maintenance management.

##### (3) Conduction of On-the-Job Training for Routine Maintenance for Bridge

- Conduction of On-the-Job Training - 3 venues

Regarding the achievements obtained through the On-the-Job-Trainings held in the three venues, it can be mentioned that the participants could acquire specific and practical knowledge and know-how regarding the work procedures and the quality control through the demonstrations in the actual bridge sites. In addition, the issues such as the work procedures to be improved and the materials and equipment hard to obtain could be revealed. As the results of those achievements, it is considered that it allows the engineers to devise repair methods more specifically for individual defective areas. It was worthwhile to widely share those specific knowledge and knowhow among not only the counterparts but also RDA R/O engineers and the private contractors who participated in the OJT.

- Assistance in Implementation of the Pilot Project

Regarding the achievements obtained through the implementation of the pilot project, it can be mentioned that the shared awareness and understandings on the work procedures and the quality control through actual activities and experiences on site have been deepened in both the RDA and the contractor. In routine maintenance operation, particularly, all the components of maintenance cycle, inspection, diagnosis, implementation and record, are included in spite of its minimum size. It was meaningful to experience and master such actual activity flow and recognize the issues to be solved.

And furthermore through the implementation of the Field Training, it was very useful to enhance the individual repair skills and to share these knowledge and knowhow with the RDA R/O engineers and the private contractors who are engaged in the bridge routine maintenance operations planned for the rollout all over the country after the coming year.

In addition, it is supposed that a great contribution was given to those achievements with the cooperation of material manufacturer engineers who are well acquainted with their products and usages. For proper and steady bridge routine maintenance operations, it is crucial for the future to develop these sorts of related supportive industries in addition to the contractors directly taking on them.

## 2.1.2 RDA Engineers Utilize Bridge Condition Inspection Data for Further Investigation and Planning of Repair or Replacement of Bridges

### (1) Review of Bridge Inspection Data

The reviewed inspection records of the 53 bridges can be reflected in the proposal in the BMS update. Sample writings on bridge maintenance plan based on the inspection data can be utilized for RDA's bridge repair and renovation strategy.

### (2) Creation of Bridge Inspection Guidebook

The guidebook includes Inventory Inspection, Periodic Inspection and the basics of Non-Destructive Testing that are useful for the bridge inspections to be conducted by RDA later on.

It had been possible to reflect in the Guidebook the bridge types as well as the bridge damages that are common in Zambia because RDA engineers were engaged in the creation of the Guidebook,

### (3) Comprehension Survey on the On-The-Job Training (OJT)

As a result of analyzing the before-and-after OJT evaluation sheets filled-in by the trainees, the understanding of the guidebook was enhanced after OJT as shown in the following charts.

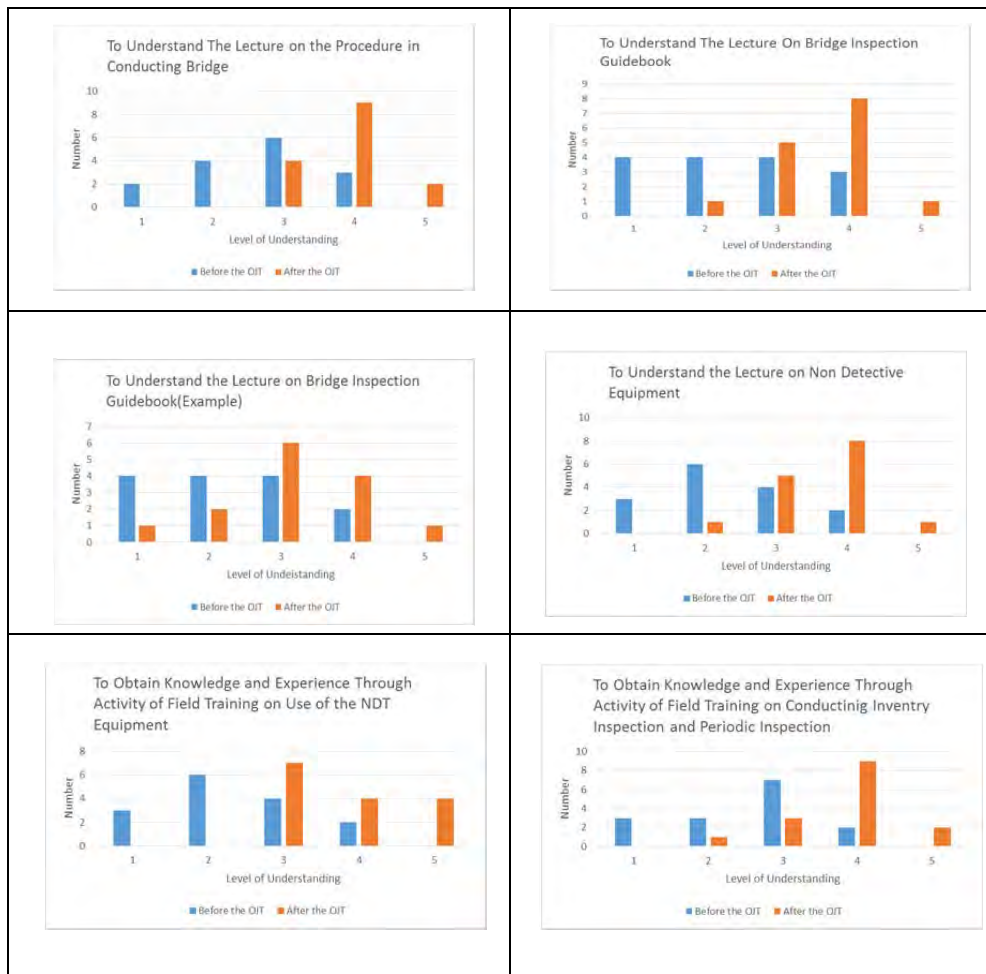


Figure II-71 Analyzed Evaluation Sheet



### 2.1.3 The Knowledge on Bridge Repair Technology of RDA Engineers are enhanced and RDA Engineers are able to prepare a Bridge Repair Plan for Pilot Bridges using the Data from Condition Inspection

#### (1) Enhancement of the Knowledge on Bridge Repair Technology of RDA Engineers

The knowledge on bridge repair technology of RDA engineers has been enhanced through the training in Japan and third countries (South Africa, Philippines).

In Japan, RDA engineers were able to learn the bridge repair technology by attending the lectures and by visiting the actual repair work sites. In the Philippines, RDA engineers gained valuable knowledge for the future implementation of bridge maintenance by visiting the repair work sites of JICA technical cooperation project, phase III and also by the technical intercourses with the DPWH counterparts. In South Africa, RDA engineers visited the bridge repair sites and the repair material suppliers, and have confirmed that the repair methods and the repair materials which they inspected were applicable in Zambia.

#### (2) Preparation of the Bridge Repair Guidebook

JICA experts and RDA counterparts conducted the following investigations:

- i. Damaged condition of the bridges in Zambia;
- ii. Repair materials that can be purchased in Zambia;
- iii. Contractors who have the experience of the bridge repair project, etc.

The group learned the bridge repair technology on site by training in Japan and third countries (South Africa, Philippines). Thereafter, referring to the above investigation and training results, the bridge repair guidebook that is suitable in Zambia was created.

#### (3) Preparation of the Implementation Plan of Repair and/or Replacement

At first, a workflow of the implementation plan was proposed by JICA experts considering the necessary data and investigation items and was further developed by repetitive discussions with JICA experts and RDA counterparts. Using the sample bridge data, a trial judgement of repair or replacement was done by using the workflow of the implementation plan. After the trial, the validity of the implementation plan was confirmed.

#### (4) Planning/Preparation of the Repair Plan of the Damaged Bridges by using the Inspection Results

RDA counterparts and JICA experts reviewed the results of the bridge inspection which had been implemented in 2011 and conducted the site surveys of about 19 out of the inspected bridges. Thereafter, the group selected 4 bridges which had big damages out of the 19 bridges as the pilot bridges and then carried out its condition inspection. After the condition inspection of the 4 pilot bridges, the group prepared the inspection sheets, damage drawings and damage photos and chose the repair methods suitable for the bridge damages referring to the bridge repair guidebook and then finalized the bridge repair plan (Outline of bridge repair methods).

#### 2.1.4 The Capacity of RDA for Contract Management is improved in the Field of Routine Maintenance and Repair on Bridges

##### (1) Contracting management

The activities described in 1.3.4 aimed to improve RDA counterpart's contract management skills related to outsourcing bridge maintenance and bridge repair works. Templates of the bidding documents for bridge routine maintenance and bridge repair works are prepared based on the concepts of "Bridge routine maintenance guideline" and "Bridge repair guidebook", considering the situation of each bridge. These templates of the contracts shall be utilized to developing the projects for other regions of RDA.

As for the bridge routine maintenance project, the "Pre-bid site visits", "Bid opening" and "Bid evaluation" were conducted by the regional office. Based on these procedures, the counterparts of regional office understand the process and identify the issues of bidding documents which shall be modified in the future.

Now, RDA headquarter and regional offices are preparing to expand the bridge routine maintenance contract to whole regions of RDA. Based on the results of the pilot project of bridge routine maintenance project, more effective and efficient bridge routine maintenance project shall be expected to be planned

##### (2) Construction management

After signing the contract, weekly meeting was held periodically between the Contractors, RDA staffs and JICA experts. In order to expedite the maintenance work, the timely decision making and issue of appropriate instructions from RDA is essential because the project period is only for one year. At first, the RDA staffs and the Contractor seemed to be reluctant to hold meeting every week because of time consuming, but gradually they tried to utilize the meetings for moving forward the project efficiently.

At the weekly meetings, the importance of monitoring and the schedule of the project was emphasized. The contractor was asked to submit weekly and monthly schedule and checked these schedule thoroughly. Due to this, RDA and the Contractor became to recognize the importance of the schedule management.

The monthly site visits by the Contractor, RDA staffs and JICA expert were held periodically to understand the work procedure and quality management at the site, and identify the issues for proceeding of works smoothly.

Due to the contractor's late acquisition of bond from the bank, and the lack of adequate financial resources of National Road Fund Agency, the payment of advance payment to the contractors was delayed for more than 6 months, The Contractor was forced to stop the repair works for a while because of unavailability of materials. RDA realized the importance of selecting competent contractor for financial aspects also at the contractor selecting process.

## 2.2 Project Purpose and Indicators

The institutional capacity of RDA is strengthened for bridge maintenance planning and operational management, which includes improvement of outsourcing contract management.

In order to archive the project purpose, a baseline survey was conducted by JICA team and C/P in March 2015 at RDA Headquarters, Eastern Regional Office, Lusaka Regional Office and Southern Regional Office.

The results of survey are as follows;

- (1) Issues about the Contract of Road Routine Maintenance that is already being implemented were confirmed. The issues are the following:

- Since the Contractor selection criteria were categories (R)-5 and 6, the ability was low.
- It is difficult to secure workers due to the area.
- Delay of payment for contractor due to lack of budget of RDA.

Therefore, JICA project team should consider ranking of contractors, selection of work scope, countermeasures for delayed payment in RDA.

#### (2) Status of Regional Office

Lusaka Regional Office is one of the biggest regional office in RDA but there are only four (4) Engineers: Regional Manager, Senior Engineer, Contract Engineer, Planning Engineer and two (2) technicians. The inspection is conducted by Contract Engineers and Planning Engineers.

#### (3) Others

Regional Engineers were eager to have the bridge maintenance guideline, bridge inspection guidebook and bridge repair guidebook which are developed by TCP due to its effectiveness in the Regional Offices.

Based on the base line survey results, project purpose is verified to be valid. The achievement of the project purpose shall be verified by three (3) indicators.

### 2.2.1 Objectively Verifiable Indicators

There are three verifiable indicators as follows;

- Indicator 1. The number of bridges that are regularly maintained according to the created guidelines etc.
- Indicator 2. The number of bridge repair conducted as planned
- Indicator 3. The prepared technical specifications are used to award outsourcing contract

Verification of Indicators are as follows;

#### Indicator 1.

Three (3) bridges for OJT on bridge routine maintenance and nine (9) bridges for pilot project on bridge routine maintenance were maintained according to the created bridge routine maintenance guideline and sample contract which were provided by JICA team.

#### Indicator 2.

Based on the review of the 2011 Bridge Inspection Data, 19 out of 53 bridges were evaluated to be in BAD condition. Four (4) bridges among of the said 19 bridges were planned for bridge repair project. Contract material such as repair method, cost and specifications were prepared by JICA team.

#### Indicator 3.

The technical specifications, sample of outsourcing contract and cost estimation which were provided by JICA team were utilized in awarding outsourcing contract.

### 2.2.2 Level of Achievement

The institutional capacity of RDA is strengthened for bridge maintenance planning and operational management was achieved by the individual achievements of the activities listed below. RDA's lack of ability particularly on bridge management cycle related to routine maintenance, bridge inspection and bridge repair had been improved.

### (1) Outsourcing Contract

Bridge Unit has been organized in RDA Headquarters to carry out bridge maintenance. However, the bridge unit has few engineers and did not have enough experience and the ability in bridge maintenance. Due to this matter, JICA team carried out activities such as bridge routine maintenance, bridge inspection and bridge repair on outsourcing premise.

Moreover, private contractors and consultant engineers also do not have enough capacity regarding bridge maintenance. Therefore, in terms of capacity building in bridge maintenance, it was confirmed that the engineers of both sectors should be involved in the capacity building in this project. A framework of activities was necessary for the improvement of bridge maintenance.

Activities of outsourcing contract were carried out through the assistance of preparation of contracts and specifications. JICA Team also provided samples of outsourcing contract of bridge repair projects.

Even though RDA engineers have knowledge of bridge maintenance, they do not have experiences of actual bridge maintenance. Due to this, JICA team invited private sector engineers for enhancing the ability of bridge maintenance.

Not only RDA engineers but also private contractor engineers and consultant engineers attended the OJTs on bridge routine maintenance and bridge inspection which were conducted by JICA team. The activities of enhancement of outsourcing contract on bridge maintenance were successfully completed. However, regarding the outsourcing of bridge repair projects, RDA engineers gained knowledge but no experience yet since there is no repair project in RDA.

### (2) Improvement of bridge routine maintenance by outsourcing contract

Routine maintenance management is a basic requirement in maintaining sound roads and bridges. It is consisted of routine inspection (patrol) and maintenance works (minor repairs).

In order to execute the said tasks, the only option was to outsource private contractors. Since these private contractors has conducted road maintenance but not on bridge structures, an OJT of small scale routine maintenance was conducted on site for the Technology Transfer to RDA engineers and contractors of the country. Field Training were also conducted on pilot project site 3 times for technology transfer.

Some of minor repairs technology and finalization of contract procedure were not transferred due to extension of contract. However, The Technology Transfer of bridge routine maintenance was mainly accomplished through the said activities.

### (3) Enhancement of bridge repair technology

Since there were no previous bridge maintenance operation in Zambia, there were insufficient bridge repair technologies. Therefore, JICA team provided the opportunity of training for bridge repair technology in Japan and third countries. As a result, the participants obtained knowledge of bridge repair technology through the training. In addition, a bridge repair guidebook was developed for RDA by JICA team.

Through the said activities, the Technology Transfer of bridge repair which is the objective of the activities was successfully accomplished. However, the continuous Technology Transfer relating to bridge repair is necessary so as to support RDA in actual bridge repair projects.

### (4) Improvement of bridge inspection technology

JICA and C/P reviewed the 2011 BMS bridge inspection data that was conducted by RDA and had a Technology Transfer.

Since the bridge periodic inspection will be outsourced, an OJT for both RDA and

consultant engineers were conducted twice by utilizing the Bridge Inspection Guidebook.

Through the OJT, RDA engineers have learned to self-assess the data, analysis results and bridge soundness as managers and moreover have come to give appropriate instructions to the outsourced Contractors.

The objective that is the Technical Transfer of bridge inspection was successfully accomplished through the above mentioned activities.



### 3 History of PDM Modification

A table below shows the history of the PDM Modification based on the Monitoring Sheets submitted to RDA by the Project Team.

Table II-34 History of PDM Modification

No.	Submission Date of Monitoring Sheets	PDM Modification	Version No. of the PDM
1	Mar. 20, 2015 (No.1 JCC)	• Original	0
2	Mar. 20, 2015 (No.1 JCC)	• Modification of Objectively Verifiable Indicators and means of Verification (More specifically described)	1
3	July 30, 2015	• None	1
4	Dec. 14, 2015	• None	1
5	Feb. 18, 2016 (No.2 JCC)	• Addition of third country trainings ( South Africa and the Philippines) into Overseas training courses of Inputs from Japanese side	1
6	June 30, 2016	• Modification of 2-1 Indicator; the target number of bridge was changed from 45 to 53.	1
7	Feb.1, 2017 (No.3 JCC)	<ul style="list-style-type: none"> <li>• Extension of cooperation period of the Project from Mar. 2015 to Aug. 2017 for 6 months</li> <li>• Added “and to assist implementation of pilot project of routine maintenance on bridge” into Activity 1-3.</li> <li>• Added Monitoring/Evaluation into the list of experts to be dispatched.</li> <li>• Added one more training course in Japan, 3 times in total.</li> </ul>	2

4 Administration of the Project

4.1 Record of Joint Coordinating Committee (JCC) Meeting

Table II-35 Joint Coordinating Committee (JCC) Meeting (1/2)

No./Date	Attendant	Topic/Discussions
1 <sup>st</sup> JCC-20 Mar. 2015	MoTWS: Mr. Sydney Tembo MT. Simbuwa RDA: Eng. Emmanuel Kaunda Eng. William K. Mulusa Eng. Mubuyaeta Kapinda Eng. Gerald Phiri, Eng. Habeene Habeenzu JICA: Mr. NODA, Hisanao Mr. KAWASE, Junichi Mr. SUNOHARA, Takumi Ms. MWILA, Njaame Mr. NAGAO, Hideo Mr. SAGAWA, Nobuyuki Ms. ESTUDILLO, Cherri	1. Presentation of RDA on the Status of Bridges in Zambia 2. Presentation of JICA on the Outline of Work Plan/ Monitoring Sheet 3. Approval of Work Plan/ Monitoring Sheet
2 <sup>nd</sup> JCC-18 Feb. 2016	MoTC: Mr. Mwata Sekeseke Mr. Chalwe Mwamba RDA: Eng. Titus Chansa Eng. Elias Mwape Eng. William Mulusa Eng. Mubuyaeta Kapinda Eng. Habeene Habeenzu Eng. Gerald Phiri Eng. Musonda Mwale Eng. Muyunda Maketo JICA: Mr. NODA, Hisanao Mr. SUNOHARA, Takumi Ms. MWILA, Njaame Kalililo Mr. NAGAO, Hideo Mr. TERAI, Kokichi Mr. KASAMATSU, Hiroji Mr. KANGAWA, Masaki Ms. ESTUDILLO, Cherri	1. Presentation of accomplishment - Annual accomplishment (2015-2016 implementation) - Report of Bridge Inspection - Introduction of Bridge Repair Guidebook - Introduction of Pilot Project on Routine Maintenance 2. Presentation of JICA Team - Annual Work Plan (2016-2017) & Monitoring Sheet 3. Approval of Annual Work Plan & Monitoring Sheet
3 <sup>rd</sup> JCC-1 Feb. 2016	MHID: Mr. Chembo Mbula Mr. Danny Mfunu RDA: Eng. Elias Mwape Eng. Dickson Ndhlovu Eng. William Mulusa Eng. Stephen Sondashi Eng. Mubuyaeta Kapinda Eng. Habeene Habeenzu Eng. Chapwe Tumelo Eng. Mwape Phiri Eng. Bornwell Siakanomba Eng. Main Chama JICA: Mr. NODA Hisanao Mr. HANSAKI, Takashi Ms. Njaame Kalililo-Mwila Mr. NAGAO, Hideo Mr. KASAMATSU, Hiroji Ms. ESTUDILLO, Cherri	1. Presentation of accomplishment - Annual accomplishment of TCP in 2016 - Introduction of Outsourcing contract of Pilot Project on Bridge Repair 2. Outcome of the project by RDA Counterparts 3. Monitoring/Evaluation of Project & Monitoring Sheet 4. Presentation of JICA Team - The 3rd term Work Plan (Feb- Aug, 2017) 5. Approval of 3 <sup>rd</sup> term Work Plan & Monitoring Sheet

Table II-36 Joint Coordinating Committee (JCC) Meeting (2/2)

No./Date	Attendant	Topic/Discussions
4 <sup>th</sup> JCC -8 Aug 2017	MHID: Eng. Charles Mweshi Eng. Clive Khan RDA: Eng. Elias Mwape Eng. Dickson Ndhlovu Eng. William Mulusa Eng. Mubuyaeta Kapinda Eng. Habeene Habeenzu Eng. Chapwe Tumelo Eng. Gerald Phiri Eng. Muyunda Maketo Eng. Bornwell Siakanomba Eng. Chabala Pandeki Eng. Main Chama Eng. Victor Miti Eng. Musonda Mwale Mr. John Kapenda JICA: Mr. HANAI, Junichi Mr. HANSAKI, Takashi Ms. Mwape Kapumpa Mr. KANENAWA, Tomoki Ms. KUMAZAWA, Yukie Mr. NAGAO, Hideo Mr. SAGAWA, Nobuyuki Mr. MINAGAWA, Yasunori Ms. ESTUDILLO, Cherri	1. Presentation of: - Implementation of Pilot Project on Bridge Routine Maintenance - Accomplishment of project (Draft Final Report) 2. Final Evaluation of the Project 3. Outcome of the project by RDA Counterparts 4. Approval of Guidebooks and Guidelines

4.2 Record of Technical Working Group (TWG) Meeting

Table II-37 Technical Working Group (TWG) Meeting

No./Date	Attendant	Topic/Discussions
1 <sup>st</sup> TWG (31 July 2015)	RDA: Eng. Mubuyaeta Kapinda, Eng. Phillimon Goma, Eng. Mwape Phiri JICA: Mr. Nagao, Mr. Sagawa, Mr. Kasamatsu, Mr. Terai, Ms. Cherri	<ul style="list-style-type: none"> <li>• Draft of Bridge Routine Maintenance Guideline</li> <li>• Table of Contents on Bridge Repair Guidebook</li> <li>• Other Matters</li> </ul>
2 <sup>nd</sup> TWG (14 Dec. 2015)	RDA: Eng. Mubuyaeta Kapinda, Eng. Chapwe Tumelo, Eng. Gerald Phiri, Eng. Phillimon Goma, Eng. Mwape Phiri JICA: Mr. Nagao, Mr. Kasamatsu, Mr. Terai, Ms. Cherri	<ul style="list-style-type: none"> <li>• Draft of Bridge Routine Maintenance Guideline (2<sup>nd</sup> Draft)</li> <li>• Report on Sample of outsourcing contract of Pilot Project on Bridge Routine Maintenance/Implementation of Pilot Project</li> <li>• Other Matters                             <ul style="list-style-type: none"> <li>- involvement of counterparts in all activities of the project</li> <li>- Handover Certificate</li> </ul> </li> <li>• Schedule of 2<sup>nd</sup> JCC</li> <li>• Schedule of JICA Experts (Jan. and Feb.)</li> </ul>
3 <sup>rd</sup> TWG (29 July 2016)	RDA: Eng. Mubuyaeta Kapinda, Eng. Stephen Sondashi, Eng. Gerald Phiri, Eng. Habeene Habeenzu JICA: Mr. Nagao, Mr. Kangawa, Mr. Terai, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Introduction of implementation Plan of repair and /or replacement</li> <li>• Discussion of Bridge Inspection Guidebook (2<sup>nd</sup> Draft)</li> </ul>
4 <sup>th</sup> TWG (28 Oct. 2016)	RDA: Eng. Dickson Ndhlovu, Eng. Stephen Sondashi, Eng. Muyunda Maketo, Eng. Chapwe Tumelo, Eng. Habeene Habeenzu, Eng. Bornwell Siakanomba JICA: Mr. Nagao, Mr. Kangawa, Mr. Sagawa, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Approval of Bridge Inspection Guidebook(Final Draft)</li> <li>• Approval of Bridge Routine Maintenance Guidelines(Final Draft)</li> </ul>
5 <sup>th</sup> TWG (30 Jan. 2017)	RDA: Eng. Dickson Ndhlovu, Eng. Stephen Sondashi, Eng. Mubuyaeta Kapinda, Eng. Gerald Phipi, Eng. Chapwe Tumelo, Eng. Habeene Habeenzu, Eng. Bornwell Siakanomba JICA: Mr. Nagao, Mr. Kasamatsu, Ms. Cherri, Mr. Minagawa	<ul style="list-style-type: none"> <li>• Discussion of development of specification of bridge repair contract</li> <li>• Report Monitoring Sheet (Jan 2017)</li> <li>• Discussion of Monitoring and Evaluation of project</li> <li>• Other matters</li> </ul>

## 4.3 Record of Coordination Meeting (CM)

Table II-38 Coordination Meeting (CM) (1/4)

No./Date	Attendant	Topic/Discussions
1st CM/ 10 Mar. 2015	RDA: Eng. M. Kapinda, Eng. G. Phiri, Eng. C. Tumelo, Eng. H. Hebeenzu JICA: Mr. Nagao, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of Project</li> <li>• Introduction of Work plan</li> <li>• Introduction of Monitoring Sheet (Ver.1)</li> </ul>
2nd CM/ 09 Apr. 2015	RDA: Eng. M. Kapinda, Eng. G. Phiri JICA: Mr. Sagawa	<ul style="list-style-type: none"> <li>• Discussion of Bridge Routine Maintenance Guideline (Draft)</li> </ul>
3rd CM/ 29 Apr. 2015	RDA: Eng. M. Kapinda, Eng. G. Phiri JICA: Mr. Sagawa	<ul style="list-style-type: none"> <li>• Discussion of Contents of Bridge Routine Maintenance Guideline</li> </ul>
4th CM/ 11 May 2015	RDA: Eng. M. Kapinda, JICA: Mr. Kangawa	<ul style="list-style-type: none"> <li>• Discussion of reviewing procedure of bridge condition inspection</li> <li>• JICA Expert train bridge inspection procedure and evaluate damage condition to C/P and or regional engineers should participate during reviewing of bridge inspection data on site.</li> </ul>
5th CM/ 19 May 2015	RDA: Eng. M. Kapinda, Eng. G. Phiri JICA: Eng. Sagawa	<ul style="list-style-type: none"> <li>• Approval of proposal of implementation of pilot project on bridge routine maintenance by guideline.</li> </ul>
6th CM/ 18 June 2015	RDA: Eng. M. Kapinda, JICA: Mr. Kangawa	<ul style="list-style-type: none"> <li>• Report of reviewing of bridge condition inspection data.</li> <li>• Introduction of project activities.</li> </ul>
7th CM/ 03 July 2015	RDA: Eng. M. Kapinda, Eng. G. Phiri, Eng. H. Hebeenzu, Eng. C. Tumelo JICA: Mr. Terai, Mr. Kangawa	<ul style="list-style-type: none"> <li>• Report of result of reviewing of bridge condition inspection data</li> <li>• Discussion of contents of bridge repair guidebook (Draft)</li> </ul>
8th CM/ 20 July 2015	RDA: Eng. M. Kapinda, Eng. H. Hebeenzu, Eng. C. Tumelo, Eng. M. Phiri JICA: Mr. Nagao, Mr. Terai, Mr. Sagawa, Mr. Kasamatsu, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of project activities and experts assignment.</li> <li>• Discussion of program of 1st OJT on bridge routine maintenance.</li> <li>• Discussion of Monitoring Sheet</li> <li>• Introduction of procurement of equipment.</li> </ul>
9th CM/ 04 Aug. 2015	RDA: Eng. M. Phiri, Eng. C. Tumelo, Eng. H. Hebeenzu JICA: Mr. Kasamatsu, Mr. Terai	<ul style="list-style-type: none"> <li>• Report of actual bridge damaged condition for development of bridge repair guidebook</li> <li>• Introduction of selection method of contractor</li> <li>• Discussion of candidate of pilot project on bridge repair.</li> </ul>



Table II-39 Coordination Meeting (CM) (2/4)

10th CM/ 27 Aug. 2015	RDA: Eng. G. Phiri, Eng. C. Tumelo, Eng. M. Phiri JICA: Mr. Terai, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Report of inspection result of candidate bridges</li> <li>• Revision of bridge repair guidebook (1st draft)</li> <li>• Discussion of contract of pilot project on bridge routine maintenance</li> </ul>
11th CM/ 10 Sep. 2015	RDA: Eng. H. Habeenzu, Eng.P. Goma, Eng. M. Phiri JICA: Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Discussion of contract of pilot project on bridge routine maintenance</li> </ul>
12th CM/ 18 Sep. 2015	RDA: Eng. H. Habeenzu JICA: Mr. Kangawa	<ul style="list-style-type: none"> <li>• Discussion of reviewing of bridge inspection data 2011 in BMS</li> </ul>
13th CM/ 09 Oct. 2015	RDA: Eng. H. Habeenzu JICA: Mr. Kangawa	<ul style="list-style-type: none"> <li>• Discussion of table contents of bridge inspection guidebook</li> </ul>
14th CM/ 20 Nov. 2015	RDA: Eng. C. Tumelo, Eng. M. Phiri, Eng. P. Goma JICA: Mr. Nagao, Mr. Terai, Mr. Sagawa, Mr. Kasamatsu, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of OJT on bridge routine maintenance (1<sup>st</sup> – 3<sup>rd</sup>) program.</li> <li>• Discussion of draft of contract of pilot project on bridge routine maintenance</li> <li>• Report of marketing research of bridge repair material in South Africa</li> <li>• Discussion of Monitoring Sheet (2<sup>nd</sup> Edition)</li> <li>• Discussion of schedule of donation of equipment</li> </ul>
15th CM/ 25 Jan. 2016	RDA: Eng. M. Kapinda, Eng. M. Maketo, Eng. C. Tumelo, Eng. M. Phiri JICA: Mr. Nagao, Mr. Kangawa, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Introduction of schedule of activities</li> <li>• Introduction of bridge inspection guidebook (1st draft)</li> <li>• Discussion of Implementation schedule of procurement of pilot project on bridge routine maintenance</li> <li>• Introduction of schedule of 2<sup>nd</sup> JCC</li> <li>• Introduction of schedule of Japan training</li> <li>• Approval of program on 2nd bridge routine maintenance seminar</li> <li>• Discussion of bridge repair guidebook (2<sup>nd</sup> Draft)</li> </ul>
16th CM/ 10 Feb. 2016	RDA: Eng. M. Kapinda, Eng. M. Maketo, Eng. G. Phiri, Eng. C. Tumelo, Eng. M. Phiri Eng. H. Habeenzu JICA: Mr. Nagao, Mr. Kasamatsu, Mr. Kangawa, Mr. Terai, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of schedule of activities</li> <li>• Discussion of bridge inspection guidebook(1st Draft)</li> <li>• Approval of OJT program on bridge inspection</li> <li>• Report training of BIV</li> <li>• Discussion of OJT program of pilot project on bridge routine maintenance</li> <li>• Approval of selection of bridges for pilot project on bridge repair</li> <li>• Discussion of Implementation Plan of repair and /or Replacement</li> <li>• Approval of third country Program</li> <li>• Approval of 2<sup>nd</sup> bridge maintenance seminar program</li> </ul>

Table II-40 Coordination Meeting (CM) (3/4)

17th CM/ 26 May 2016	RDA: Eng. M. Kapinda, Eng. L. Nyawali, Eng. M. Maketo, Eng. G. Phiri, Eng. M. Phiri, Eng. B. Siakanomba JICA: Mr. Sagawa	<ul style="list-style-type: none"> <li>• Discussion of preparation of 2nd seminar</li> <li>• Request procurement of pilot project on bridge routine maintenance as soon as possible</li> </ul>
18th CM/ 07 June 2016	RDA: Eng. M. Kapinda, Eng. L. Nyawali, Eng. H. Habeenzu, Eng. C. Tumelo, Eng. G. Phiri, Eng. B. Siakanomba, Eng. G. Chitonena JICA: Mr. Nagao, Mr. Sagawa, Mr. Terai, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of schedule of activities and assignment of experts</li> <li>• Discussion of 2nd bridge maintenance seminar program</li> <li>• Approval 1st OJT program on bridge inspection</li> <li>• Approval of bridge repair guidebook (final draft)</li> <li>• Introduction of third country training program.</li> </ul>
19th CM/ 30 June 2016	RDA: Eng. L. Nyawali, Eng. M. Maketo, Eng. Gerald Phiri, Eng. C. Tumelo, Eng. M. Phiri, Eng. H. Habeenzu JICA: Mr. Nagao, Mr. Sagawa, Mr. Terai, Mr. Kangawa, Ms. Cherri	<ul style="list-style-type: none"> <li>• Report 2<sup>nd</sup> bridge maintenance seminar</li> <li>• Discussion of Monitoring Sheet (June 30.2016)</li> <li>• Introduction of schedule of Activities</li> <li>• Introduction of OJT program for pilot project on bridge routine maintenance</li> <li>• Report of 1<sup>st</sup> OJT on bridge inspection</li> </ul>
20th CM/ 25 July 2016	RDA: Eng. S. Sondashi, Eng. M. Kapinda, Eng. G. Chitonena JICA: Mr. Nagao, Mr. Terai, Mr. Kangawa, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Introduction of schedule of Activities</li> <li>• Approval of preparation of sample contract of pilot project on bridge repair</li> <li>• Discussion of candidate bridges and repair method for pilot project on bridge repair</li> </ul>
21st CM/ 26 Sep. 2016	RDA: Eng. S. Sondashi, Eng. H. Habeenzu, Eng. J. Mwinga JICA: Mr. Sagawa, Mr. Kasamatsu	<ul style="list-style-type: none"> <li>• Report of OJT on pilot project on bridge routine maintenance</li> <li>• Discussion of issues of pilot project on bridge routine maintenance</li> <li>• Approval of venue and participants of Weekly meeting</li> </ul>
22nd CM/ 07 Oct. 2016	RDA: Eng. G. Phiri, Eng. H. Habeenzu, Eng. C. Tumelo JICA: Mr. Nagao, Mr. Kangawa, Mr. Kasamatsu, Ms. Cherri	<ul style="list-style-type: none"> <li>• Approval of schedule and program of 2<sup>nd</sup> OJT on bridge inspection</li> <li>• Discussion comment of 1st OJT on bridge inspection</li> <li>• Report of progress of pilot project on bridge routine maintenance and weekly meeting</li> <li>• Introduction of schedule of activities</li> </ul>
23rd CM/ 21 Oct. 2016	RDA: Eng. G. Phiri, Eng. H. Habeenzu, Eng. C. Tumelo, Eng. Maketo JICA: Mr. Nagao, Mr. Kangawa, Mr. Kasamatsu, Ms. Cherri	<ul style="list-style-type: none"> <li>• Introduction of the OJT comments regarding the Bridge Inspection Guidebook</li> <li>• Explanation of the contract documents of the bridge repair work outsourcing</li> <li>• Introduction of schedule of the future activities</li> </ul>

Table II-41 Coordination Meeting (CM) (4/4)

<p>24<sup>th</sup> CM/ 9 Jan.2017</p>	<p>RDA: Eng. S. Sondashi, Eng. M. Kapinda, Eng. M. Maketo, Eng. Gerald Phiri, Eng. C. Tumelo, Eng. B. Siakanomba JICA: Mr. Nagao, Mr. Kasamatsu, Ms. Cherri</p>	<ul style="list-style-type: none"> <li>• Introduction of Schedule of Project (Nagao)</li> <li>• Discussion of Agenda of 3<sup>rd</sup> JCC meeting (Nagao)</li> <li>• Introduction of Monitoring/Evaluation of Project (Nagao)</li> <li>• Discussion of Field Training Program on Bridge Routine Maintenance Pilot Project (Nagao)</li> <li>• Other Issues</li> </ul>
<p>25<sup>th</sup> CM 10 Mar. 2017</p>	<p>RDA: Eng. S. Sondashi, Eng. M. Phiri, Eng. B. Siakanomba JICA: Mr. Sagawa</p>	<ul style="list-style-type: none"> <li>• Field Training: <ul style="list-style-type: none"> <li>- 2<sup>nd</sup>: April 26, 27</li> <li>- 3<sup>rd</sup>: July 6, 7</li> </ul> </li> <li>• Japan Training: <ul style="list-style-type: none"> <li>- May 8 – May 21</li> </ul> </li> <li>• Expert Assignment: <ul style="list-style-type: none"> <li>Nagao: April 1 – April 30</li> <li>Sagawa: April 18 – May 12</li> <li>Cherri: April 4 – April 30</li> </ul> </li> <li>• Field Training <ul style="list-style-type: none"> <li>- Demonstration of repair works in 2<sup>nd</sup> and 3<sup>rd</sup> Field Training</li> <li>- Reflection and improvement</li> </ul> </li> <li>• Others</li> </ul>
<p>26<sup>th</sup> 17 Apr.2017</p>	<p>RDA: Eng. S. Sondashi, Eng. H. Habeenzu, Eng. M. Maketo, Eng. C. Tumelo, Eng. M. Mwale, Eng. B. Siakanomba, Eng. V. Miti JICA: Mr. NAGAO</p>	<ul style="list-style-type: none"> <li>• Introduction of Schedule of Project</li> <li>• Discussion of 2<sup>nd</sup> Field Training Program on Bridge Routine Maintenance Pilot Project</li> <li>• Introduction of Bridge Inspection by Drone</li> <li>• Other Issues</li> </ul>
<p>27<sup>th</sup> 9 June 2017</p>	<p>RDA: Eng. S. Sondashi, Eng. H. Habeenzu, Eng. C. Tumelo, Eng. M. Chama, Eng. M. Phiri, Eng. B. Siakanomba</p>	<ul style="list-style-type: none"> <li>• Introduction of Schedule of Project</li> <li>• Discussion of 3<sup>rd</sup> Field Training Program on Bridge Routine Maintenance Pilot Project</li> <li>• Discussion of Workshop of Routine maintenance project</li> <li>• Discussion of venue/agenda of 4<sup>th</sup> JCC meeting</li> <li>• Schedule of bridge inspection by JICA Expert</li> <li>• Other Issues</li> </ul>

#### 4.4 Japan Training

(1) Name of the Training

Bridge Maintenance and Repair Training Program for the Project on Bridge Maintenance Capacity Building in Zambia

(2) Period

1<sup>st</sup> Batch: 28 Sep.–07 Oct. 2015

2<sup>nd</sup> Batch: 15-26 May 2016

3<sup>rd</sup> Batch: 9-20 May 2017

(3) Trainees

1<sup>st</sup> Batch (5 trainees)

Eng. Mubuyaeta KAPINDA - Senior Manager Bridges

Eng. Gerald PHIRI - Principal Engineer Emergencies

Eng. Wanzi ZULU - Senior Engineer Muchinga Province

Eng. Bernard ZULU - Senior Engineer Western Province

Eng. Tyson MWALE - Senior Engineer North Western Province

2<sup>nd</sup> Batch (5 trainees)

Eng. Chapwe TUMELO- Pricipal Engineer, Bridge Maintenance

Eng. Habeene HABEENZU- Principal Engineer Structures, Planning and Design

Eng. Alfred MUNYIMBA- Senior Engineer, Maintenance

Eng. George CHITONENA- Senior Engineer, Maintenance

Eng. Alice Chama CHIPASULA- Planning Engineer, Planning and Design

3<sup>rd</sup> Batch (5 trainees)

Eng. William MULUSA- Director, Maintenance - HQ

Eng. Stephen SONDASHI- Senior Manager, HQ

Eng. Bornwell SIAKANOMBA- Engineer, HQ

Eng. Main CHAMA - Senior Engineer, Lusaka Region

Eng. Baldwin BANDA - Senior Engineer, Kasama Region

(4) Purpose of Training

The purpose of Bridge Maintenance and Management Technology training was to learn the bridge repair technology mainly on bridge inspection and techniques. Since there was no bridge maintenance technology in Zambia, the training program aimed to deepen the trainees' knowledge through the tour of the actual bridge repair work sites in Japan.

(5) Training Results

The trainees were able to understand the comprehensive bridge maintenance technology. Specifically, the trainees learned bridge inspection method, analysis of inspection data including the types and causes of damage, maintenance management planning, and selection of bridge repair method.

(6) Utilization of Results

The technology learned in the training will be adopted in the repair pilot projects in the future. To improve the maintenance management skills in Zambia, the technology learned in the training, will be transferred not only to RDA but also to the private contractors and

consultants.

#### 4.5 Training in the Third Countries

##### (1) Training Countries

Republic of the Philippines (Department of Public Works and Highways)  
Republic of South Africa (South African National Roads Agency)

##### (2) Periods

Philippines (August 16 to 25, 2016)  
South Africa (July 18 to 22, 2016)

##### (3) Trainees

Philippines: 2 persons  
Eng. Elias Mwape  
Eng. Mubuyaeta Kapinda

South Africa: 3 persons  
Eng. Lazarous Nyawali  
Eng. Muyunda MAKETO  
Eng. Bornwell Siakanomba

##### (4) Purpose of the Training

Because RDA has no knowledge on bridge technology, the training was implemented in the developing countries including the neighboring countries to learn the bridge repair technology.

##### (5) Training Results

The repair technology in South Africa will be very useful for RDA to implement the bridge repair projects regarding the project proceeding method, the selection of repair method and the quality control, because both Zambia and South Africa are in the same Southern African region.

In the Philippines, the trainees visited the repair work sites which the trainees haven't experienced in Zambia and learned many repair technologies. In Zambia, there were many challenges regarding the implementation of the bridge repair works, such as the procurement of repair materials, the implementation methods of repair works and the technical specifications. However, through this training, the trainees recognized that the said repair works could be implemented in Zambia, and recognized that early implementation of the repair projects is necessary in proceeding with a proper bridge maintenance.

##### (6) Utilization of Results

In the future implementation of bridge repair projects of RDA, the results of the training can be utilized in the selection of repair method, material selection and preparation for project contract.



## 5. Publicity Activity

### 5.1 RDA Website

The project was first publicized in RDA website on August 2015 on the project background, outline, organizational structure of RDA counterparts and JICA Expert Team, call courtesies to concerned offices, conducted baseline surveys, procurement of OJT tools, bidding of Non Destructive Test equipment and the very 1st Joint Coordinating Committee Meeting.

The project was secondly updated on November of 2015 with its succeeding activities. It includes a two week counterparts training in Japan for the 1<sup>st</sup> Batch, condition inspection of about fifty three (53) bridges along main trunk roads T1, T2, T3 and T4 in comparison with the 2011 BMS data. JICA also handed over to RDA the Non-Destructive Test equipment including three (3) Laptops and marked as their assets.

The project was thirdly updated on June of 2016 with its succeeding activities. It includes condition inspection training and others.

### 5.2 JICA Website

(1) ODA visualization site

(2) JICA project News

The news was published seven times.

- April 24, 2015: 1st Joint Coordination Committee (JCC)
- July 10, 2015: Bridge inspection activities
- August 31, 2015: 1st Bridge Routine Maintenance Seminar
- January 5, 2016: OJT of Bridge Routine Maintenance
- June 5, 2016: Japan Training for Bridge Maintenance
- August 15, 2016: OJT of Bridge Condition Inspection at Bridge Site
- October 25, 2016: Implementation of Third Country Training
- May 10, 2017: Field Training of Bridge Routine Maintenance
- June 15, 2017: 3<sup>rd</sup> Batch Japan Training for bridge Maintenance
- August 2017: 4<sup>th</sup> JCC

### III Results of Joint Review

#### 1 Results of Review based on DAC Evaluation Criteria

##### 1.1 Outline of Terminal Evaluation

###### (1) Objectives

This Project is a technical cooperation project between Japan and Zambia with the cooperation period from February 2015 to February 2017. However, as it was confirmed that the implementation of “Activity 1-3 conduct on-the-job training for routine maintenance on bridges and to assist the implementation of a pilot project for routine maintenance on bridges” was delayed by 6 (six) months, only that activity has been extended by 6 months, until August 2017.

The main objectives of the terminal evaluation are to verify the achievement of Output 1 as well as that of Project Purpose for the extended project period, to evaluate project performance by 5 (five) criteria evaluation, and to make recommendations on the future direction of the Project

###### (2) Evaluation Methodology

The status of the project progress was reviewed based on the Project Design Matrix, which is a summary table describing the outline of the Project. Terminal Evaluation examined the following points referring to the PDM version 2, signed in the Third JCC (Joint Coordination Committee) on February 1, 2017, with special attention to the extended activity, 1-3 of Output 1.

###### a. Verification of project performance

The degree of achievements by the project, such as Inputs, Activities, Outputs, and Project Purpose, was assessed with reference to Objectively Verifiable Indicators stated in the PDM. To carry out this, various methods were used including document review, questionnaire survey, interviews, and discussions with counterpart personnel, Japanese experts and relevant stakeholders.

###### b. Examination of Project Implementation Process

The process of the project implementation was examined from the viewpoints of project management.

###### c. Evaluation by Five Evaluation Criteria

The following five evaluation criteria are applied in evaluating the Project. The Criteria has been introduced by OECD-DAC (Organization for Economic and Co-operative Development-Development Assistance Committee) in 1991 as evaluation criteria for development assistance and applied for criteria of value judgement in JICA's project evaluation.

###### d. Recommendations and Lessons Learnt

In Terminal Evaluation, recommendations are made and lessons learnt are drawn based on the results of the evaluation.

Table III-1 Five Evaluation Criteria

Relevance:	Degree of compatibility between the development assistance and priority of policy of the target group, the recipient, and the donor.
Effectiveness:	A measure of the extent to which an aid activity attains its objectives.
Efficiency:	Efficiency measures the outputs -- qualitative and quantitative – in relation to the inputs. It is an economic term which is used to assess the extent to which aid uses the least costly resources possible in order to achieve the desired results. This generally requires comparing alternative approaches to achieving the same outputs, to see whether the most efficient process has been adopted.
Impact:	The positive and negative changes produced by a development intervention, directly or indirectly, intended or unintended. This involves the main impacts and effects resulting from the activity on the local social, economic, environmental and other development indicators.
Sustainability:	Sustainability is concerned with measuring whether the benefits of an activity are likely to continue after donor funding has been withdrawn. Projects need to be environmentally as well as financially sustainable.

Sources: New JICA Guidelines for Project Evaluation First Edition, June 2010.

The relationship between the five evaluation criteria and PDM is described in the following figure.

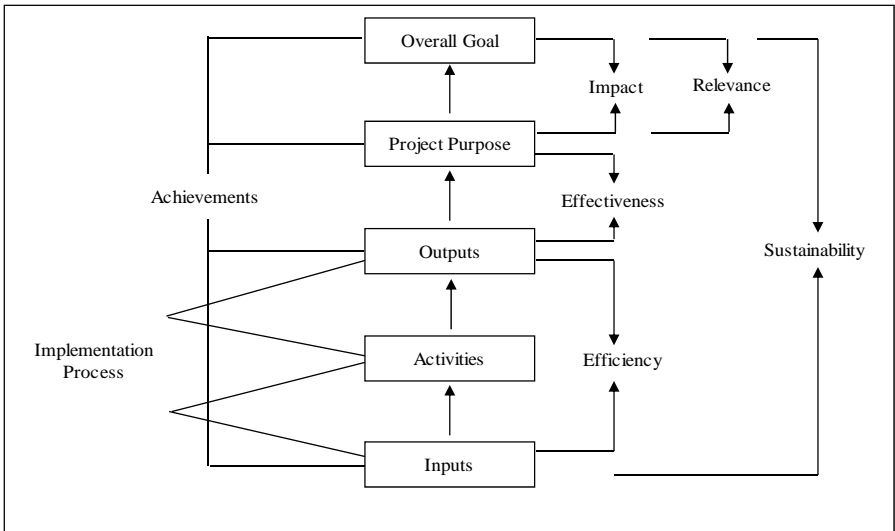


Figure III-1 Relationship between the Five Evaluation Criteria and PDM

Sources: “Practical Methods for Project Evaluation”, March 2004

## 1.2 Evaluation by Five Criteria<sup>1</sup>

### (1) Relevance

The relevance of the Project is assessed as “High” for the following points.

#### a. Relevance to the Zambia’s policies

The Government of Zambia has regarded road and bridge development as a core for promoting poverty reduction and economic development in the country and has implemented road and bridge development by dividing Road Sector Investment Program, “ROADSIP,” into two phases in 1998. The government has come out “Link Zambia 8000 Project” in 2012 and has tackled the improvement of access from cities in all provinces to rural areas by construction and repair of roads and bridges with 8,000km nation-wide by 2018. This Project contributes to strengthening of capacity on bridge routine maintenance of the bridge unit in RDA and, therefore, is consistent with the above-mentioned policies of Zambia.

#### b. Relevance to Japan’s ODA policy toward Zambia

The Government of Japan has ranked “development and improvement of fundamental infrastructure which supports economic activities” as one of priority areas in “Japan’s ODA policy toward Zambia”, modified in June 2014, and will support the development of main roads and strengthening of the maintenance management capacity in the area. Thus, the Project is consistent with Japan’s ODA policy. Also, as the Government of Japan is assisting the construction of long-span bridges such as Chirundu Bridge by grant aid, the Project is to supplement the cooperation.

#### c. Needs of the target group

While many bridges are becoming too old for work in future, bridge maintenance management has not implemented in Zambia so far. The Project corresponds to the needs of RDA for establishing a system for bridge maintenance management in Zambia.

### (2) Effectiveness

The effectiveness of the Project is assessed as “Relatively High” for the following points.

#### a. Achievement of the Project Purpose (Prospect)

In the Project, Guidelines for Bridge Routine Maintenance, Guidebook on Bridge Inspection and Guidebook on Bridge Repair were developed and the technical transfer using those Guidelines/Guidebooks were implemented through seminars, OJTs, and training in Japan as well as training in the third counties. Through these activities, JICA experts have recognized the improvement of the participants’ capacities. Furthermore, RDA has made an outsourcing contract for pilot project on bridge routine maintenance and now has been tackling technology transfer in the pilot project. Considering these progress, it can be said that the Project Purpose will be achieved by the end of extended Project duration.

#### b. Contribution of Outputs to the achievement of the Project Purpose

The capacity of bridge routine maintenance which is regarded as one of RDA’s institutional capacities was improved by achieving Output 1. Similarly, the capacity of bridge inspection was improved by achieving Output 2, the capacity of bridge repair was improved by achieving Output 3, and the capacity of outsourcing contract management was improved by achieving Output 4. In particular, since all of results of the Project have been applied in implementing outsourcing of pilot project on bridge routine maintenance, it can be said that each Output contributed to the strengthening of the institutional capacity of RDA, namely the Project Purpose.

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<sup>1</sup>Judged on a scale from “High”, “Relatively High”, “Moderate”, “Relatively Low” to “Low.”

- c. Analysis of factors
  - Promoting Factor
    - Active participation of engineers of a regional office of RDA and private contractors/consultants into Project activities
    - A weekly meeting for pilot project to supervise its time schedule and to share information
  - Inhibiting factor
    - Delay of contract process for pilot project by RDA led to the extension of the Project duration by six months
- d. Important assumption

There is no policy change by the Government of Zambia on importance of transportation sector, particularly, in the field of bridge maintenance management.

### (3) Efficiency

The efficiency of the Project is assessed as “Moderate” for the following points.

#### a. Achievement of Outputs

AS for Output 1, Guidelines for Bridge Routine Maintenance was developed, seminar, OJTs and Field Trainings were held for deepening related people’s understanding on bridge routine maintenance and, as the result, their understanding on bridge routine maintenance was deepened. Regarding Output 2, similarly, Guidebook on Bridge Inspection was developed and through OJTs, the participants’ understanding was improved. In output 3, Guidebook on Bridge Repair was prepared and related people’s capacity was improved through training in Japan and that in the third countries. As for Output 4, the capacity of RDA engineers on outsourcing management was improved by making actual contract on outsourcing. Therefore, each Output is expected to be achieved by the Project completion.

#### b. Appropriateness of Inputs and Activities

In the Project, sufficient Inputs and activities have been planned and provided to achieve Outputs. The followings are effective points for achieving the Outputs.

- As for the dispatch of experts, the number, expertise and assignment period were appropriate. Activities of the experts were managed by PO and there was no delay in activities by experts.
- Training courses in Japan were conducted two times and 10 RDA engineers participated in the courses. Through the participation, they learned the importance of bridge routine maintenance, basic bridge inspection and bridge repair methods. All of Participants kept high motivation, kept good attitude for participation and actively jointed the discussion.
- Training courses in the third countries were conducted in South Africa in July 2015 and in the Philippines in August in 2015. The participants could observe bridge repair projects and learned actual repair methods. In the Philippines, the participants jointed an on-going pilot project on bridge repair implemented by JICA’s technical cooperation project which was very timely and effective.

On the other hand, the followings were confirmed as points to be considered as inhibiting factors.

- Since all of RDA C/Ps have other assignment of RDA, they are limited to participate in the Project activities.
- In case of business trip, payment of traveling expenses was delayed sometimes in RDA and some engineers could not attend the activities such as OJTs.
- In pilot project on bridge inspection or bridge routine maintenance, the Project planned



to use a BIV owned by RDA. However, there were cases when the Project could not use the BIV due to lack of fuel or insufficient maintenance of BIV.

- An office provided to JICA project team is narrow and communication networks could not be used sometimes.
- Frequent personnel changes in RDA
- Due to delay of advance payment to a contractor in outsourcing contract by RDA, the contractor sometimes is short of cash on hand and necessary materials cannot be prepared as scheduled.

#### (4) Impact

The impact of the Project is assessed as “Relatively High” for the following points.

##### a. Achievement of Overall Goal (Prospect)

Through the activities implemented in the Project, engineers of RDA as well as those of contractors and consultants who participated in the activities could strengthen sufficiently their understanding on bridge maintenance such as the necessity of bridge routine maintenance and the concept of maintenance management cycle. As for actual technology and methods for bridge routine maintenance management, they are continuously learning them through on-going pilot project on bridge routine maintenance which was outsourced by RDA. Therefore, it is expected that the Overall Goal of the Project, “bridge maintenance activities are regularly implemented by RDA”, can be achieved within 3-5 years after the Project termination, if RDA will secure necessary budget for bridge routine maintenance.

##### b. Inhibiting factor for achieving overall goal

- Since bridge routine maintenance needs continuous works, a budget may become an inhibiting factor for overall goal if it is difficult to secure the necessary budget steadily every year.
- RDA does not have enough experiences of bridge routine maintenance in Zambia so far and needs additional opportunities of OJTs for bridge routine maintenance by themselves after the Project completion.

##### c. Ripple effect

- The roll out plan of bridge routine maintenance to other regions in 2018-2019 is now in the planning process.
- The Project team has heard comments from private contractors and consultants in OJTs and in seminars that the concept of bridge routine maintenance management should be promoted in Zambia, because they are very much interested in its prospects of business potential in Zambia in future
- Total of 60 contractors participated in a bit on a pilot project for bridge routine maintenance.
- Besides the acquisition of repair technology in a field training, RDA engineers shared know-how on nationwide expansion of routine maintenance on bridges in future with R/O engineers and private contractors.

#### (5) Sustainability

The sustainability of the Project is assessed as “Relatively High” for the following points.

##### a. Policy and Institutional Aspects

RDA was established based on Public Road Act No. 20, 2002. Since then, the Government of Zambia put high priority in the field of road management including bridge. Recently, the Government also put high priority in agriculture which links to the promotion of roads and bridges development. Therefore, it is expected that RDA will keep the Government’s policy support to their activities continuously.

b. Financial/Organizational Aspects

RDA is just making a start in the implementation of bridge maintenance through the Project and, therefore, RDA needs to tackle some issues by themselves such as the improvement of institutional capacity, human development and securing budget. For these purposes, the roll out plan of bridge routine maintenance to other regions in 2018-2019 is now in the planning process, and RDA is expected to put the plan into practice properly.

c. Technical Aspects

As for equipment provided from Japan side in the Project, RDA is capable for maintaining them appropriately.

Regarding the Guidelines/Guidebook developed in the Project, RDA can mostly maintain them by themselves and may maintain some of them in cooperation with outside consultants as follows. Guidelines for Bridge Routine Maintenance can be maintained and revised by RDA, if bridge routine maintenance projects will be conducted by RDA nation-wide in future. Guidebook on Bridge Inspection can be also maintained and revised by RDA in cooperation with contractors through outsourcing of bridge inspection projects. Guidebook on Bridge Repair should be maintained and revised by implementing pilot project on bridge repair, since RDA does not have working experiences on bridge repair and RDA needs to accumulate working experiences of bridge repair.

## 2 Key Factors affecting Implementation and Outcomes

The following factors should be considered as key factors affecting implementation and outcomes.

- Procedural delay of outsourcing pilot project on bridge routine maintenance in RDA
- Delay of payment of travel expenses to RDA engineers
- Partial absence of RDA C/Ps and engineers in meetings/OJTs due to their other assignment in RDA
- Frequent personnel change in RDA; Project Director (three times), Project Manager (three times) and some RDA engineers

## 3 Evaluation on the results of the Project Risk Management

The results of the Project risk management were summarized by highlighting the progress of the activities, monitoring system and communication in the Project.

### (1) Delay of the implementation of pilot project on bridge routine maintenance

Due to the delay of the process of outsourcing contract at RDA side, OJTs for pilot project on bridge routine maintenance have started with the delay of six (6) months. In order to implement technical transfer on bridge routine maintenance steadily, the Project duration has been extended by six months, until August 2017.

### (2) Monitoring

For monitoring the Project, JICA's Monitoring Sheets have been applied. The Sheets were drafted by the Project Team and discussed in the meetings of JCC and in coordination meetings whose details are summarized in "4. Administration" of the report. The Sheets were drafted and submitted to RDA 7 times since the Project's start. The Sheets submitted so far are listed in ANNEX5 of the report. JCC meetings have been held three times and the coordination meetings have been held 23 times in total and the countermeasure for the above-mentioned delay of the implementation of the pilot projects was discussed based on the Sheets.

Furthermore, an Index Matrix which is to be utilized as a supplemental reference for the Monitoring Sheets was developed on an experimental basis for monitoring purpose. The Matrix was submitted the third JCC meeting held on February 1, 2017. The Matrix is a

summary table for collecting data on the level of the achievement of Project and consists of objectively verifiable indicators in the PDM. The Matrix is expected to be utilized in monitoring the progress of the achievement of the outputs.

### (3) Communication

According to JICA experts, since RDA C/Ps have their regular works in RDA including many business trips and they are absent sometimes in meetings with JICA, there is not always enough communication with each other.

## 4 Lessons Learnt

In the Project, the implementation of pilot project on bridge routine maintenance was delayed due to the procedural delay in RDA for outsourcing. Because of this, in order to accommodate all activities planned in the Project, the Project duration had to be extended by six months. Regarding the delay, JICA experts tried to prevent the delay by preparing necessary documents and participating in RDA's meetings.

In general, when equipment to be provided from JICA is carried in a recipient country or when the Project activities are outsourced, the procedure of implementing agency becomes an obstacle sometimes and makes the delay in implementing activities. It is important that JICA side should try to confirm the procedural delay as early as possible through periodical meetings with the C/P and coordinate countermeasures with the C/P.

## IV For the Achievement of Overall Goals after the Project Completion

### 1 Prospects to achieve Overall Goal

#### (1) Status of achieving overall goal (Prospect)

Through the activities implemented in the Project, engineers of RDA as well as those of contractors and consultants who participated in the activities could strengthen sufficiently their understanding on bridge maintenance such as the necessity of bridge routine maintenance and the concept of maintenance management cycle. As for actual technology and methods for bridge routine maintenance management, they are continuously learning them through on-going pilot project on bridge routine maintenance which was outsourced by RDA. Therefore, it is expected that the Overall Goal of the Project, “bridge maintenance activities are regularly implemented by RDA”, can be achieved within 3-5 years after the Project termination, if RDA will secure necessary budget for bridge routine maintenance

#### (2) Inhibiting factor for achieving overall goal

- Since bridge routine maintenance needs continuous works, a budget may become an inhibiting factor for overall goal if it is difficult to secure the necessary budget steadily every year.
- RDA does not have enough experiences of bridge routine maintenance in Zambia so far and needs additional opportunities of OJTs for bridge routine maintenance by themselves after the Project completion.

### 2 Plan of Operation and Implementation Structure of the Zambia side to achieve Overall Goal

#### (1) Roll-out plan for pilot projects on bridge routine maintenance to other regions in 2018-2019

In the Project, pilot projects on bridge routine maintenance are on-going, targeting Lusaka Province where Lusaka, the capital of Zambia, is located among ten (10) provinces in the country. The activities have been being implemented by a contractor based on an outsourcing contract with RDA. Weekly meetings have been held once a week under the supervision of the Project Team for monitoring the progress of the Project in particular, as one of measures for project management. RDA is now planning the roll-out plan for bridge routine maintenance to other regions in 2018-2019. By implementing the plan, the Overall Goal of the Project, “Bridge maintenance activities are regularly implemented by RDA” is expected to be achieved.

#### (2) Implementation structure

The plan is assumed to be implemented based on outsourcing contract as same as the present, for the time being. In this case, as some contractors will participate in the projects by province, it is expected that the projects will be implemented smoothly by utilizing guidelines on bridge routine maintenance and technical specifications for outsourcing which have been developed by the Project.

In relation to this, RDA should check “3 Recommendations for the Zambia side” carefully for putting the plan into practice.

### 3 Recommendations for the Zambia side

This Project is regarded as the start of bridge maintenance management in Zambia. In order to continue appropriate bridge maintenance from now on, the following measures should be taken by Zambia side;

- (1) To strengthen an organization for Bridge Maintenance Management and to increase the number of bridge engineers.

In order to circulate the bridge maintenance management cycle smoothly, headquarters should be Strengthened by the organization that is responsible for the bridge maintenance management, the regional office should be increased the number of bridge engineers who are in charge of maintenance of bridges for implementation of proper maintenance.

- (2) To secure the necessary budget and implementation

Continuation of steady routine maintenance work can prolong the life of the bridge, so it is important to secure the necessary budget and to ensure the payments which is related to outsourcing contracts.

- (3) To develop human resources of RDA Engineers

Abundant experience and knowledge are required especially for bridge maintenance management. Therefore, it takes time to learn skills. In order to identify the types of damages, causes, evaluation, analysis, and selection of a proper repair method for damaged bridge, RDA should carry out periodic training on bridge maintenance for improvement of the capacity of RDA engineers by themselves.

- (4) To guide to improvement of capacity of local contractors and consultants

Bridge maintenance work such as bridge inspection, routine maintenance work, and repair work are carried out through contractors and consultants by outsourcing contract in RDA.

However, contractors and consultants who have had sufficient experience are very few yet. In order to implement the proper bridge maintenance, RDA should guide local contractors and consultants to improve capacity of bridge maintenance.

#### 4 Monitoring Plan from the end of the Project to Ex-post Evaluation

Since the roll-out plan on bridge routine maintenance to other regions in 2018-2019, which is now in the planning stage by RDA, it is expected to be a continuous activities after the Project completion, monitoring on the implementation process of the plan should be conducted.

With regards to monitoring, as JICA's Monitoring Sheets used in the Project have been submitted seven (7) times to RDA so far and the Project Team explained the contents, RDA are already thought to be familiar with the Sheets. Therefore, JICA side and Zambia side should agree to use of the Sheet for monitoring in which RDA will submit the Sheets every six months to JICA Zambia Office after the Project completion.