Republic of Zambia
Road Development Agency
(RDA)

Republic of Zambia
The Bridge Maintenance Capacity Building Project in Zambia, Phase II

BRIDGE INSPECTION GUIDEBOOK

(Guidelines and Guidebooks for Bridge Maintenance/ Management, Vol.2)

February 2025

Japan International Cooperation Agency
（JICA）

Dia Nippon Engineering Consultants Co., Ltd.
Japan Overseas Consultants Co., Ltd.
Central Nippon Expressway Company Limited

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FOREWORD

The Road Development Agency (RDA) is responsible for the entire classified road network of 67,671 kilometres, including bridges and culverts. However, owing to limited resources, the Agency identified a rationalised network of 40,454 kilometres deemed as the Core Road Network (CRN). The CRN is defined as "the minimum network which when improved will spur socio-economic development and contribute to poverty reduction."

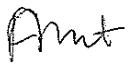
The CRN has over 460 bridges, most of which were constructed over 40 years ago, and have reached a critical stage, in need of repair. In an effort to implement bridge inspection, repair and maintenance, Guidebooks and Guidelines were produced under the Japan International Cooperation Agency (JICA), Technical Cooperation Project (TCP) on Bridge Maintenance Capacity Building in Zambia. These are the Bridge Repair Guidebooks, Bridge Routine Maintenance Guidelines and Bridge Inspection Guidebooks.

These Guidebooks and Guidelines will assist the officers in carrying out bridge inspections and maintenance activities and also offer repair Methods, which will in turn allow for the continued long-term use of the existing bridges.

Our profound gratitude goes to JICA for the technical and financial assistance and the RDA personnel that worked tirelessly to formulate and publish the Guidebooks and Guidelines.

I implore all those charged with the responsibility to inspect, repair and maintain bridges to utilise the Guidebooks and Guidelines as they undertake their work.

April, 2024



Eng. Grace Mutembo
Director and Chief Executive Officer
ROAD DEVELOPMENT AGENCY

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Recognition is given to the staff of RDA, and a heartfelt thanks to the Technical Working Group and Counterpart Working Group members designated for the Project, who had rendered utmost support for the completion of this undertaking.

The following persons had been instrumental for the development of this guidebook:

Phase I

Mr. Elias Mwape	-	Project Manager, Acting Director & CEO, RDA
Mr. William K. Mulusa	-	Project Manager, Director-Maintenance, RDA
Mr. Dickson Ndhlovu	-	Project Manager, Acting Director Planning & Design, RDA
Mr. Mubuyaeta Kapinda	-	Project Coordinator, Senior Manager - Bridge Maintenance, RDA
Mr. Lazarous Nyawali	-	Project Coordinator, Senior Manager - Construction, RDA
Mr. Stephen Sondashi	-	Project Coordinator, Senior Manager - Bridges, RDA
Mr. Habeene Habeenzu	-	Assistant Project Coordinator, Principal Engineer – Structures, RDA
Mr. Muyunda Maketo	-	Principal Engineer - Bridges, RDA
Mr. Chapwe Tumelo	-	Principal Engineer - Bridges, RDA
Mr. Gerald Phiri	-	Principal Engineer - Emergencies, RDA
Mrs. Mwape Phiri	-	Hydrologist Planning & Design, RDA
Mr. Bornwell Siakanomba	-	Engineer – Bridge Management System, RDA
Mr. Hideo Nagao	-	Team Leader; Bridge Expert, JICA
Mr. Masaki Kangawa	-	Bridge Inspection Expert, JICA

Phase II

Ms. Grace Mutembo	-	Project Director, Acting Director and CEO, RDA
Mr. Elias Mwape	-	Former Project Director, Director & CEO, RDA
Mr. George Manyele	-	Former Project Director, Director & CEO, RDA
Mr. Jairos Mhango	-	Project Manager, Acting Director - Road Maintenance, RDA
Mr. William K. Mulusa	-	Former Project Manager, Director - Road Maintenance, RDA
Mr. Dickson Ndhlovu	-	Former Project Manager, Director - Road Maintenance, RDA
Mr. Mubuyaeta Kapinda	-	Project Coordinator, Senior Manager - Bridges & Emergencies, RDA
Mr. Lazarous Nyawali	-	Project Coordinator, Senior Manager - Bridges, RDA
Mr. Stephen Sondashi	-	Former Project Coordinator, Senior Manager - Bridges, RDA
Mr. Felix Mubanga	-	Senior Engineer – Lusaka Region, RDA
Mr. Sundie Silwimba	-	Senior Engineer – Southern Region, RDA
Mr. Tindi Mwema	-	Former Senior Engineer – Southern Region, RDA
Mr. Bornwell Siakanomba	-	Engineer – Bridge Management System, RDA
Ms. Kaulu Mushota	-	Engineer – Bridge Management System, RDA
Mr. Hideo Nagao	-	Team Leader, Bridge Maintenance Management Expert, JICA

Mr. Seiya Hikino	-	Deputy Team Leader, Bridge Repair - 1 Expert, JICA
Mr. Kokichi Terai	-	Special Bridge Maintenance Expert, JICA
Mr. Hiroki Aoi	-	Special Bridge Inspection Expert, JICA

ABBREVIATIONS

BMS	:	Bridge Management System
BS	:	British Standard
GPS	:	Global Positioning System
JICA	:	Japan International Cooperation Agency
LCC	:	Life-cycle Cost
LCD	:	Liquid Crystal Display
MPa	:	Mega-Pascal
NDT	:	Non-Destructive Test
PC	:	Prestressed Concrete
RC	:	Reinforced Concrete
RDA	:	the Road Development Agency
UV	:	Ultraviolet
OSBP	:	One Stop Border Post
ASR	:	Alkali Silica Reaction
RO	:	Regional Office
BIV	:	Bridge Inspection Vehicle
AWP	:	Aerial Work Platform
BI	:	Bridge Inspectors

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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND

According to BMS in 2011, Zambia has 480 bridges on public roads comprising Trunk, Main, District, Primary, Secondary and Tertiary Feeder, Urban and Park Roads. Since most of these bridges were constructed by England on the 1960s, it has been aging.

Although the need for upgrade of the transportation infrastructure is increasing due to the growth of population and increased traffic, bridge maintenance has not yet been performed due to lack of manpower, equipment and technical capabilities of RDA. In recent years, the number of collapse of aging bridges and of unstable bridges placed in service has been increasing. Only then that the Bridge Maintenance effort had begun and a Maintenance Section had just been set up in RDA in 2006 and 2013. But the future challenge is how to proceed with the maintenance systematically while lacking technical capacity. In this situation, The JICA's Technical Cooperation Projects for the "Bridge Maintenance Capacity Building Project in Zambia, Phase I" (February 2015–August 2017) was implemented. Under the above-mentioned Phase-I, BRIDGE INSPECTION GUIDEBOOK is developed. But it contains only general bridges. So it is required that adding special bridge inspection on existing one, because there are many several bridges in Zambia. (What are special bridges is described in CHAPTER 9)

1-2 BRIDGE INSPECTION TYPES

Types of inspection and their frequency, main purpose, and inspector are as shown in Table 1-1. Inspection can be classified into two groups; scheduled inspection and non-scheduled inspection. Scheduled inspection can be further divided into two types: routine inspection and periodic inspection, and non-scheduled inspection can be divided into three types: detail, emergency and inventory inspection.

Routine inspection is the most frequent inspection, which can be performed by a staff or engineers without having detailed knowledge or experience. It is assumed to be implemented with road patrol, aiming at finding defects which can affect the road or other significant defects of bridges. For example, a significant deformation of pavement or losing of parts of expansion joint that can lead to serious traffic accident as well as give adverse effect on the bridge itself, which shall be found and repaired at the earliest possible moment.

Periodic inspection is to regularly assess the bridge's overall soundness. Inspection results shall be precise enough for statistics or future prediction. Thus, it shall be implemented by engineers that are well-educated and trained for bridge inspection.

Routine Inspection is included in Routine Maintenance work. Detailed activities are derived from "Bridge Routine Maintenance Guidelines 2016" prepared by JICA.

Non-scheduled inspection can be classified into: *detailed inspection* for collecting detailed date after condition and routine inspection, *emergency inspection* after disaster or accident and

inventory inspection for collecting initial data of newly-constructed bridges, whose results are inputted into BMS for building maintenance management cycle. All these shall be handled by well-educated and trained engineers since it requires enough knowledge and experience with bridges.

Table 1-1 Bridge Inspection Type

Type	Name	Purpose	Frequency
Scheduled Bridge Inspections			
1	Periodic	- To obtain condition data on major maintenance needs of the bridges for operation of the BMS - To assess and rate condition of the structure - By visual inspection	3 ~ 5 years
Non-Scheduled Bridge Inspections			
2	Detailed	- To investigate major maintenance needs of defective bridges identified by a condition inspection or other inspection. - To evaluate the needs for improvement works - To decide on appropriate countermeasure - To determine safe load capacity of the bridge - To monitor progress of any damage - To test and evaluate strength and seismic vulnerability by non-destructive equipment	As required
3	Emergency	- To regularly check structural soundness. - Visual inspection using simple measuring equipment	As required
4	Inventory	- To obtain/update bridge inventory data for BMS	After the construction or rehabilitation

1-3 SCOPE OF GUIDE BOOK

This guide book should be used as a guide of bridge inspection and the main focus of this book is bridge periodic inspection.

Inspector who engaged in bridge inspections has to understand their roles and follow the contents of this guide book to do unified inspections. Other staff and superintendents who check the results of inspections also have to understand the contents of this book to properly handle their part.

Consistent and standardized bridge inspection procedures are required to ensure that consistent inspection report are delivered from all bridge inspection. And since special bridges have unique design and type of structure, it should be managed separately from standard bridges. The contents of this manual depict a consistent and proper bridge inspection procedures to ensure that inspection reports for all types of bridge inspections are properly prepared.

1-4 PERIODIC INSPECTION

Bridge maintenance is classified into two types, Preventive Maintenance or Corrective maintenance. Preventive Maintenance minimizes the LCC by implementing the countermeasures at the initial stage before the damage gets worse.

In case of Corrective Maintenance, if the bridge condition become serious due to damage, then an immediate replacement of the bridge will be necessary. Preventive maintenance is more preferable than corrective maintenance because of the LCC, small-scale repairs will cost less than large-scale repairs. In order to carry out preventive maintenance, early detection of damage is important. Therefore, a periodic inspection is necessary.

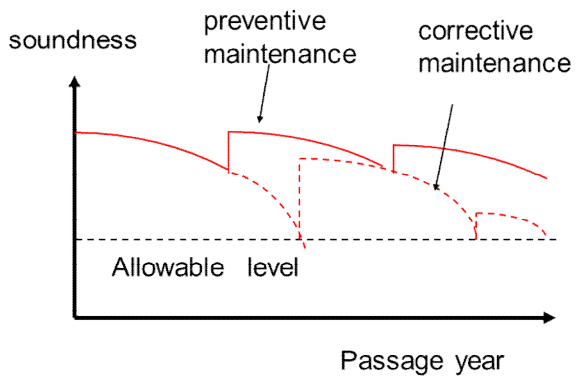


Figure 1-1 Comparison of Maintenance Method

1-5 PURPOSE OF INSPECTION

The purpose of Periodic Inspection is to get information for necessary countermeasure by grasping the condition and diagnosis of the members of the bridge for proper maintenance such as safety traffic and prevention of damage against third parties.

1-6 PREPARATION

The first step in planning inspections is to develop an inspection program. This program should list all bridges to be inspected in the region and the period in which this is to be completed. From there, the staff and equipment can be determined and the program is reviewed to suit available resources. Throughout the inspection program, progress should be monitored so that budget and time constraints are met.

When developing an inspection program, careful consideration has to be given to external factors affecting the inspection.

These include:

- Traffic restriction
- Access difficulties, e.g. waterways, terrain, building, built-up areas and combined bridges
- Safety of staff undertaking the inspection,
- Specialized equipment or personnel such as divers that may need to be called upon,

If the officer who will undertake the inspection is not familiar with the site and possible external factors, then a familiarization visit will be beneficial.

CHAPTER 2 GENERAL REQUIREMENT FOR BRIDGE INSPECTION

2-1 INSPECTION TEAM

A condition inspection team shall consist of six persons.

Table 2-1 Inspection Team

Inspection team member		Periodic Inspection	
Periodic Inspection	Team Leader	1	Bridge Engineer
	Supporting Engineer	1	Bridge Engineer
	Supporting Staff	2	
	Safety Management Person	1	
	Traffic Control Person	As needed	

RDA is implementing the Periodic Inspection by outsourcing contract.

2-2 SAFETY

For the protection and safety of workman, public and environment, safe work practices are essential on every work site.

The following safety aspects apply to bridge inspection work and have to be considered prior to commencement of any inspection:

- Road Safety
- Work Safety
- Public Safety

Health and safety have a high priority at all times during field operations. All statutory rules and regulations and recommended safety practices given in this guide book are for general guidance in planning for safety at all the worksites. Commonsense should be used in anticipating the particular safety requirement for each and every project to be undertaken.

2-2-1 Road Safety

Working on or near roads is extremely hazardous.

The following rules have to be explained to, and observed by, all personnel working on or near the roadways:

1. Before commencing inspection at the site ensure that:
   - All personnel are wearing high visibility vests;
   - Every worker knows direction of traffic running on all the lanes;

- Every worker knows where to take refuge if a vehicle approaches;
- Unprotected or unsafe areas and roads are identified to all personnel.

2. Do not walk on or near the road unless absolutely necessary
3. Always walk in the direction so that you are facing the oncoming vehicles.

   (The vehicles should not come from behind you)
4. Whenever crossing roads (whether single-lane or multilane) make sure that all the lanes are clear before crossing.
5. When operating any machine on or near road:
   - Before commencing work make yourself aware of potential hazards such as adjacent roads, overhead power lines, other workers, etc. ALWAYS ANTICIPATE DANGER.
   - NEVER stop without looking backwards. Under the noise of your machine you may not hear the sound of approaching vehicles.
   - NEVER climb out of a machine without looking in both directions.
   - NEVER climb out of a machine onto a road or non-protected area.

2-2-2 Work Safety

Work safety has to be planned ahead. Before commencing work, the engineer undertaking the inspection shall attend to the following:

1. Be familiar with the full requirement of the inspection work false work and access equipment.
2. Ensure that all tools, plant and equipment are available and in good working order.
3. Arrange any required safety harnesses, clothing, footwear, gloves, earmuff, eye protection glasses, masks, helmets, welding shields, and any other items necessary for personal safety of the workers.
4. Plan and arrange road closures and suitable traffic management procedures.
5. Identify and locate all the utilities existing at site, such as water, sewerage, electricity, signals, communications, gas, etc. If any utility is affected by the inspection process take measures in advance to protect them or get them relocated as necessary through appropriate authorities. If any risk is foreseen, inform the authorities to stand by for emergencies.
6. Ensure that first aid equipment is available at site and that at least one of the personal at site holds a valid qualification for giving first aid.
7. All inspections are carried out in well-ventilated and well-lit areas. If necessary make prior arrangements for exhaust fans and artificial lighting.

8. Do not allow personnel under the influence of alcohol (or any medication which impairs alertness or causes drowsiness) to work at site or to operate any mechanical equipment.
9. Persons who are not qualified for carrying out a particular task or operating particular equipment don't have to be allowed to do that task or operate the equipment.
10. Generally, all the work should be carried out as per industry's normal standards of practice and/or in compliance with relevant standards.

2-2-3 Public Safety

There are obligations to take all necessary precautions and adequate measures for safety of public in and around the working area. The following steps should be taken to safeguard the public against any injury:

1. Attend immediately to any damage and deterioration that may cause loss of strength and stability of a structure and thereby may result in injury, loss of life or damage to public property.
2. Take steps to support damaged structures against instability and collapse, as well as protect the adjacent properties, plant and utilities from possible damage.
3. Until damaged structures are made safe, close off access and prohibit their use by the public by setting up suitable fences and barriers. With the assistance of the Regional Office, and the police if necessary, arrange to divert the pedestrian and hazard lights as necessary to caution the public of damage.
4. At the completion of the inspection, clean up all dirt and debris, remove all plant, equipment and materials and restore the facility to public.

2-3 EQUIPMENT

Except for Detail Inspection, every inspection is conducted as visual inspection with some tools. Inspectors should take necessary inspection tools when they go out to do inspection of bridges.

Table 2-2 Standard of Inspection Tool and Protective Gear

Stock in the car	Carrying	Equipment	Specification
✓		Tape Measure	50m
✓		Ladder	
✓		Shovel	
✓		Steel Brush	
✓		Rope	
✓		Plumb	
✓		Handy Level	
	✓	Handy GPS	
✓		Transceiver	In accordance with license condition
✓		Scraper	
✓		Caliper	
	✓	Pocket Tape	3-5m
	✓	Hammer	
	✓	Binoculars	
	✓	Digital Camera	GPS Function preferable
	✓	Crack Gauge	
	✓	Magnifying Glass	
	✓	Handy Torch	
	✓	Clip Board	
	✓	Chalk	
	✓	Area Map	
	✓	As-built Drawings	
	✓	Hard Cap(Helmet)	
	✓	Working Gloves	
	✓	Safety Vest	
	✓	Safety Belt	
	✓	Goggles	
✓		White Board	

2-4 RECORD

2-4-1 Inspection Forms

Standard inspection forms are available for each type of inspection.

The inspection forms for each inspection will be pre-printed.

The initial data shown for each bridge shall be checked for correctness during bridge inspections and corrections made or missing information added as necessary.

2-4-2 Sketches Record

Sketches of damage can be made on forms. The sketch should show the necessary plan and elevation views of the attribute to which they pertain. All damages should be located on the sketches by dimensioning their location in reference to the beginning or end of each attribute. For each damage the accredited bridge inspector should indicate dimensions showing its length, width, and depth (if applicable).

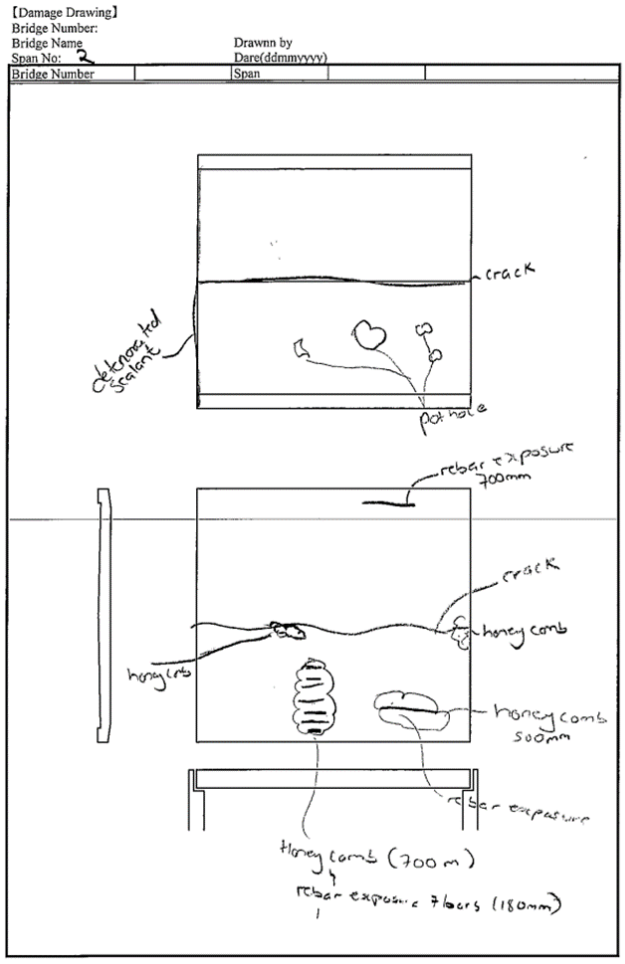


Figure 2-1 Sketch of Damage

2-4-3 Photographic Record

The photograph information required is as follow:

1. Photographic Record
2. Front View from traffic origin: One general photograph from top of deck showing aliment, width, kerbs and barriers.
3. Side View (Each span) from upstream: One photograph from side of bridge showing piers, abutments and waterway or roadway.
4. Under the bridge (Each Span) from upstream: One photograph from under of bridge showing piers, abutments and waterway or roadway.
5. Representative photographs of main superstructure components(i.e. girders), from underneath or side of the structure, used in:
    - The original structure
    - Any modifications (i.e. widening, lengthening, etc.)

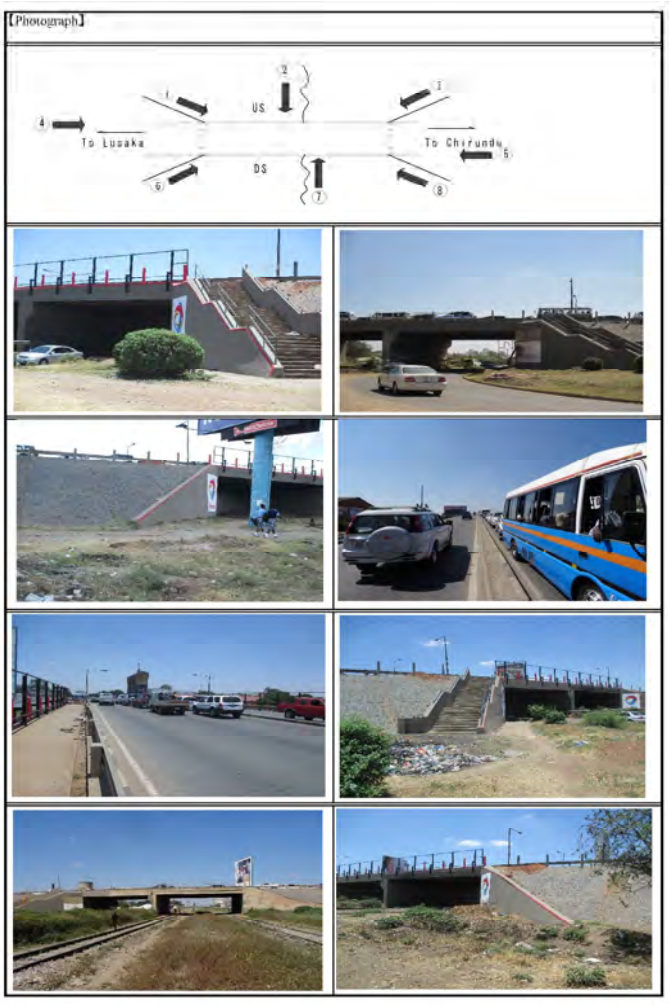


Figure 2-2 Photograph Record (1)

The bridge Engineer should photograph any major defects and append photographic prints to the report.

1. The prints should be annotated in accordance with the bridge component designations previously described.
2. Bridge Engineer has to take the photo of entire condition and defects condition on the bridges exactly.

   During the inspection, Engineer has to use the Blackboard or Whiteboard as well as measuring tape for getting the detailed information.
3. The whiteboard has to be included in the photograph.
4. The bridge inspector should take photographs to obtain as much information as possible.
5. Photograph of Defect has to be taken for the worst condition rating

【Photograph】
Bridge Number:
Bridge Name
Taken by
Dare(ddmmyyyy)

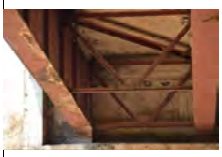
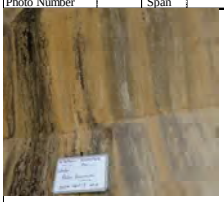
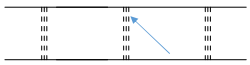
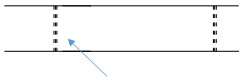
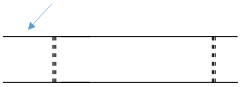
Photo Number		Span		Conponent Name		Type of Damage	
							Corrosion under the lower flange
Photo Number		Span		Conponent Name		Type of Damage	
							Rebar exposure on the pier
Photo Number		Span		Conponent Name		Type of Damage	
							Spalling on the abutment, Deck
Photo Number		Span		Conponent Name		Type of Damage	
							Crack on the abutment

Figure 2-3 Photograph Record (2)

2-4-4 Report

Work plan for bridge inspection which include safety plan is prepared before inspection is carried out at the site.

The deliverables of periodic inspection reports for regional office are follows:

- A filly completed bridge condition form,
- Supporting information for proposed major maintenance,
- Inspection photographs(proof of visit), and
- Photographs of attributes with identified defects of Condition Rating 2 or 3.

CHAPTER 3 BRIDGE INVENTORY

3-1 TYPE OF BRIDGE

3-1-1 Concrete Bridge

Concrete is made up of stone aggregates and sand bounded together by hardened cement paste. It is strong in compression but weak when in tension. To give concrete more strength steel reinforcing bar or wires are normally fixed inside the concrete.

Table 3-1 Classification by Structural Style

Simple Girder	A girder is supported on two points.
Continuous Girder	A girder is supported on three points or more.
Cantilever Bridge	Continuous girder with hinged support in the middle of span

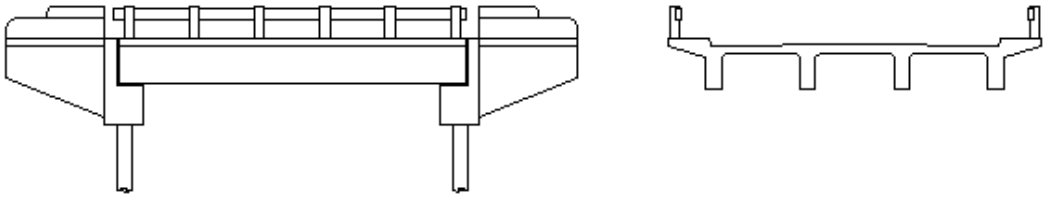


Figure 3-1 Girder

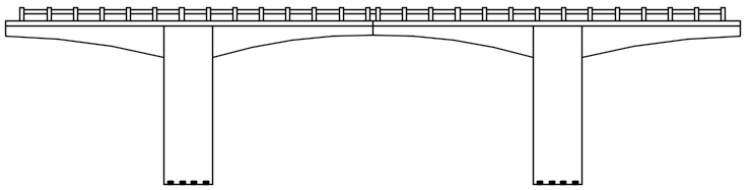
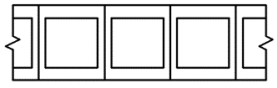
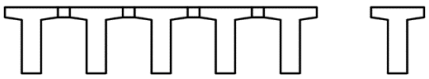
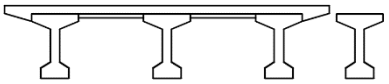
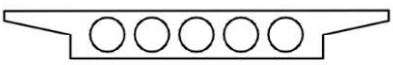
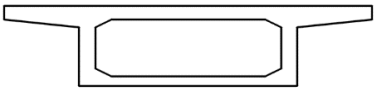


Figure 3-2 Cantilever Girder

Table 3-2 Type of concrete bridge

Cross-section Shape	Cross Section Shape	Overview
Slab bridge		Spreading for two direction. Two sides in opposite directions are fixed, other sides are free.
T*beam bridge		Two girder or more which are T-shape.
Composite girder bridge		Placing in-suit concrete on fabricated slab on the girders for composite structure
Hollow slab bridge		A cavity cut into a slab bridge to decrease weight.
Box girder bridge		Composed of upper flange and lower flange, two web or more.

3-1-2 Steel Bridge

Steel has greater strength in both tension and compression than concrete. Steel used in bridge is most commonly in the form of rolled beam, welded or riveted plate girders and truss.



Figure 3-3 Steel Bridge

(1) I Shaped Steel Girder

Horizontal elements of the “I” are known as flanges, while the vertical element is termed the “web”. The web resists shear forces, while the flange resists most of bending force.

(2) Steel Box Girder

Steel box girders are used for long spans, where the self-weight of the bridge needs to be minimized, and for situations where their excellent high torsional stiffness is of particular benefit.

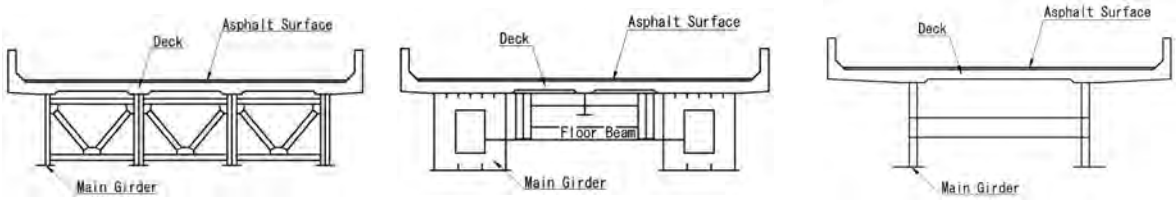


Figure 3-4 Type of Steel Bridge

3-1-3 Timber Bridge

Timber was extensively used for bridge on District Roads, Feeder Road in Zambia. Girders may be either round, hewn or sawn.

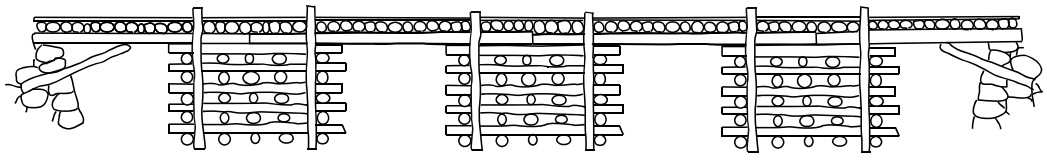


Figure 3-5 Timber Bridge

3-1-4 Bailey Bridge

There are some bailey bridges in Zambia. The baily bridges are military truss firstly developed in England during World War Ⅱ. For the light weight and small members, each members can be carry along by the track. Generally they are used temporary bridges. As for the merits, election of girder have no need of heavy equipment.



Figure 3-6 Bailey Bridge

3-1-5 Masonry

Masonry consists of bricks or stones with sand and cement mortar in joints between them. It is strong in compression and weak in tension, like mass concrete. Masonry is used for constructing masonry arches, abutment, piers and retaining walls.



Figure 3-7 Masonry Bridge

3-2 BRIDGE COMPONENT

3-2-1 Standard Bridge

A Bridge is basically divided into two components namely superstructure(s) which extend to cover entire bridge length to support the road surface and substructure(s) which support the superstructure(s). Other important components of a bridge are bearing support(s) which connects superstructure(s) and substructure(s), and expansion joints which allow movement of superstructure(s) at the end of superstructure(s). Substructures are divided into two type of structures, abutments and piers.

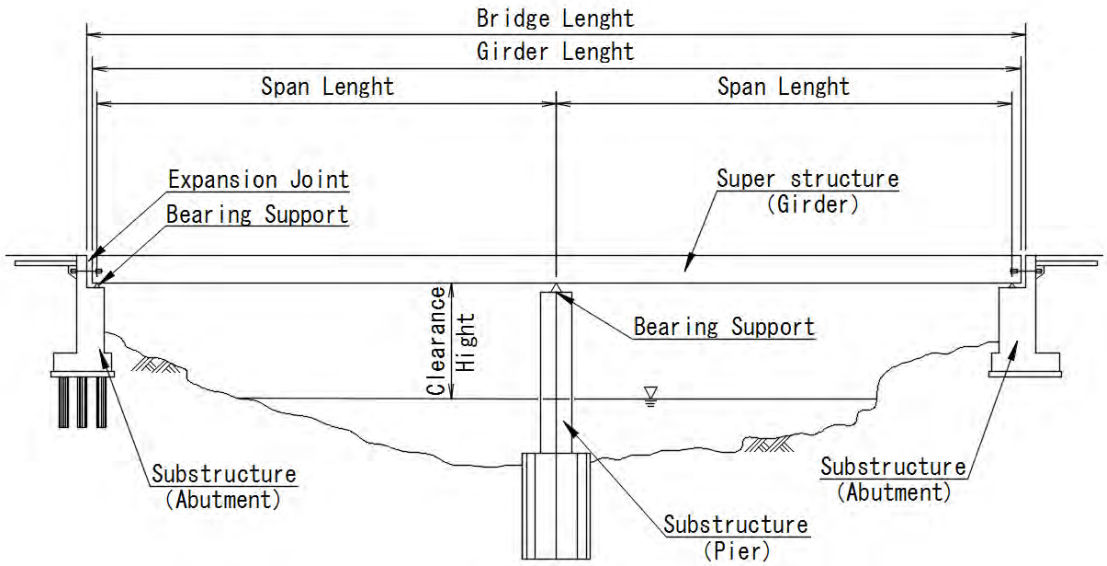


Figure 3-13 Bridge Component (1)

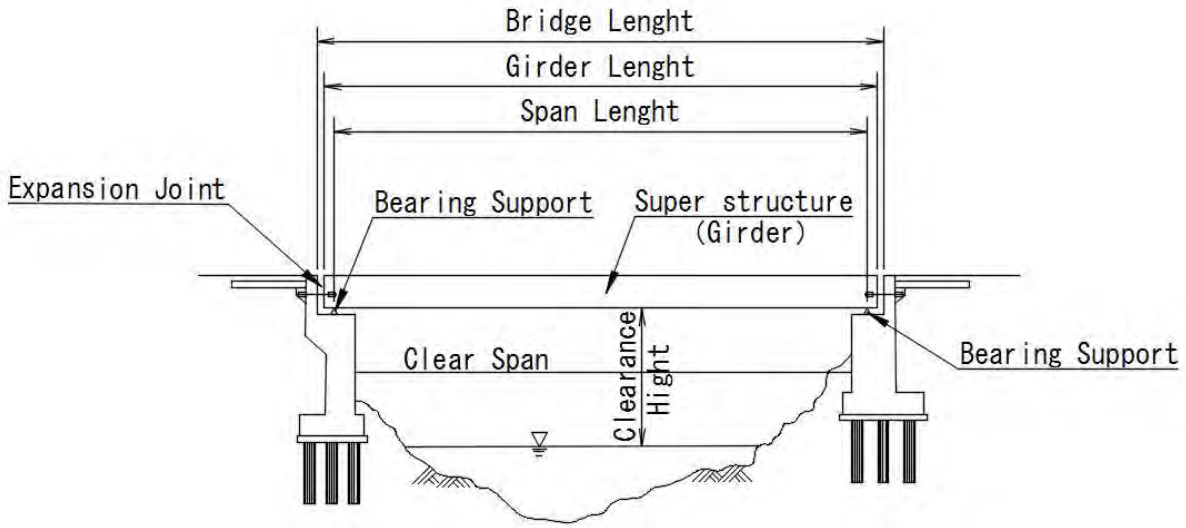


Figure 3-14 Bridge Component (2)

Bridge consists of various kinds of components with different durable years. Component (A) with short durable years, which usually affect traffic safety and component (B) with long durable years, which affect stability strength and durability of the bridge structures themselves, shall be separately judged. Routine inspection mainly targets component A and Periodic inspection targets both component A and B.

Table 3-3 Component

Component (A) with short durable years, some of which usually affect traffic safety. :Secondary members	Component (B) with long durable years, which affect stability, strength and durability of the bridge structures :Main members
Pavement	deck(main structure)
Expansion joint	main structure(main structure)
Railing/parapet	major member excluding deck (main structure)Girder
Lighting/traffic sign	Minor member excluding deck
Noise barrier	Substructure
Curb	Waterway
Drainage	Foundation
Inspection way	Bearing
Approach	Bearing seat
Slope Protection	Wing wall

CHAPTER 4 INVENTORY INSPECTION

4-1 DATA COLLECTION

Inventory inspection is a non-scheduled inspection and the inspection is conducted to collect basic general and structural information on every bridge and the information would not change for its life unless major modification of the structure is conducted after completion. It is effective to collect information from design drawings and as built drawings when completed. If these drawings are not available due to a variety of variety of reasons, inspectors shall collect without drawings. Foundations and abutment are usually covered with soil and other materials and cannot be seen.

Prior to an inspection, inspectors shall collect the following of the targeted bridge such as bridge appropriate inspection based on the basic information of the targeted bridge such as bridge structure or others, record required information on inspection forms, and prepare for the inspection. Location and category of damage discovered on the past inspection results shall be inspected to confirm if the damage has progressed.

Table 4-1 Data Collection

Materials	Contents
Design drawings, As-built drawings	Confirmation bridge length, span length, Structure
Existing registration data	Year of construction, Obstruction (things passing under the bridge)

4-2 PROCEDURE OF INSPECTION

Collect data on bridge name, location, completion years, designer, contractor, structural type, surface dimension, and such as requested with the FORM from drawings. In the field inspectors shall measure the important necessary dimensions.

It is recommended that inspector consult with engineers in charge of design and construction to confirm their inspection results.

4-3 RECORD AND REPORT

Inspection results shall be recorded on “Inspection form” (Form2).

Inspectors shall submit their inspection FORM after checking the result to assigned bridge engineer in charge of inventory inspection.

4-4 REVIEW OF REPORT

When Bridge Engineers receive the inventory inspection reports, they shall review the report and make necessary additional information and corrections if necessary.

4-5 INPUT TO BMS

The inventory inspection results shall be input in BMS.

(1) Procedure

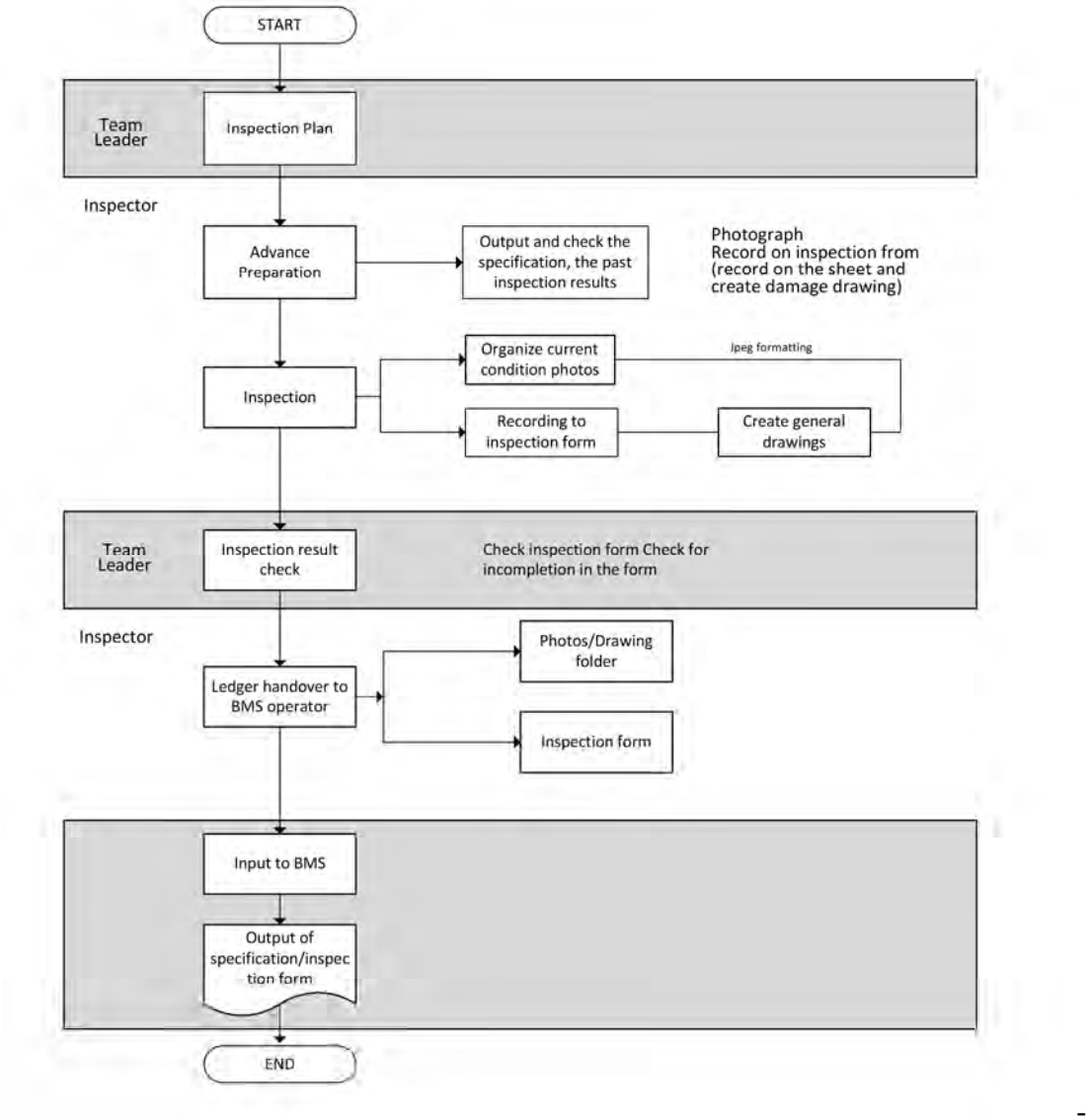


Figure 4-1 Work Flow

(2) BMS Output

Inspection form for superstructures, substructures, and representatives specification of the bridge are output under BMS. Moreover, photos of current conditions and drawings are output as an inspection form if registered.

CHAPTER 5 PERIODIC INSPECTION

5-1 PURPOSE

The purpose of this level of inspection is to monitor and rate the condition of a bridge structure as a basis for identifying current maintenance needs, and forecasting future bridge intervention requirements and estimating future funding requirement.

5-2 SCOPE OF THE INSPECTION

The scope of the periodic inspection will include:

- Reviewing the existing inventory of the bridge structure for accuracy.
- Visually inspecting the bridge components to assess their condition using a condition rating system.
- Reporting the condition of each bridge component
- Providing a general condition rating for the structure as a whole
- Identifying bridges that require Detailed Inspection because of the presence of attributes with a Condition rating of Poor and Bad.
- A photographic record of the bridge.

The bridge inspection is to be visual inspection only and to cover all parts of the bridge above ground and water level.

If it's possible, all surfaces of the attributes shall be in good natural or artificial light during the inspection, sufficient to observe fine cracks and other defects in the surfaces.

All bearings at the abutments and piers shall be inspected, and bearing at one pier shall be inspected by visual.

Components that need not be inspected for bridge periodic inspections are:

(i) Inside box girders(This is desirable where access is readily available)

(ii) In areas behind abutments that are inaccessible

(iii) Piles and foundations below ground or water

These components may be inspected as part of a Detailed Inspection if defects are located reporting further investigations.

Where Detailed Inspection Report is available for a bridge, the conclusion of this report may be used to assist in the periodic inspection though the bridge engineer shall check that those conclusions remain appropriate.

The periodic inspection would not apply to all types of bridges. In particular, complex bridge (e.g. cable stayed bridge) should have a specific maintenance management plan properly implemented by experienced staff, to maintain the bridge. Any management plan would include separate inspection requirements and forms.

The following section is used to indicate if a bridge is a standard bridge to which this guidebook applies or a special bridge with separate inspection requirement;

5-3 INSPECTION METHOD

(1) Process

The process for undertaking condition survey is illustrated in Figure5-1.

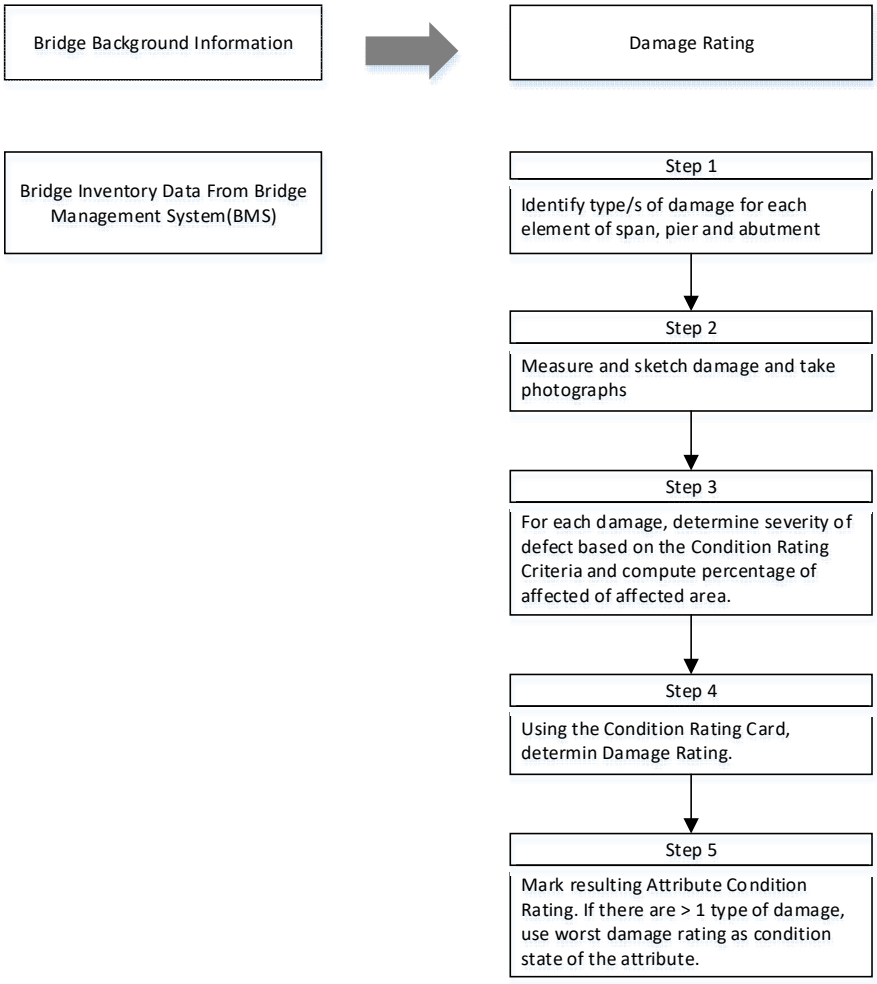


Figure 5-1 Process of Inspection

(2) Periodic inspection Form

All information collected during a periodic inspection is recorded or referenced on a periodic inspection form (PIF). A sample CIF is included in Appendix A.

(3) Condition on Date of Inspection

The bridge engineer will estimate the condition state of each bridge component shown in the CIF based on a detailed visual inspection each component. The affected area, length or number of components will then be roughly estimated which will be the basis in assessing the severity of defects using the Condition Rating Card (Figure 5-3) and eventually deciding the condition.

Bridges are composed of span, pier and abutment elements as shown in Figure 5-2. Each element has a standard set of defined component that cover all the features of the element in general terms.

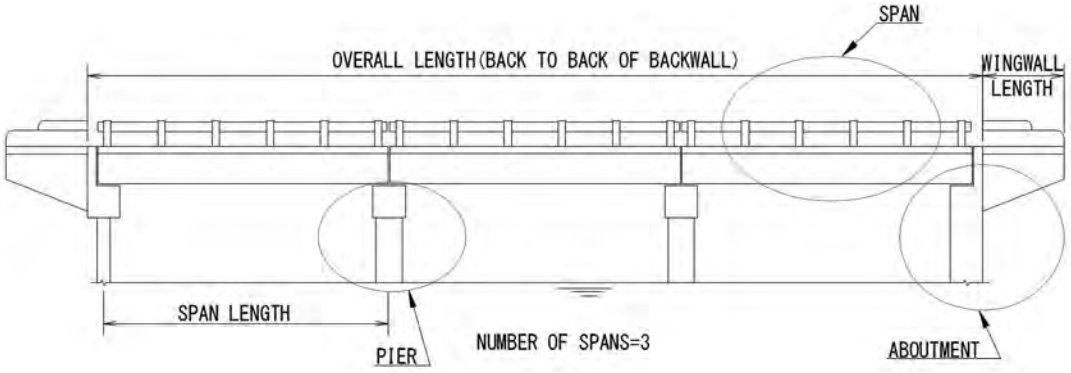


Figure 5-2 Bridge Elements

The defined components of a bridge are listed in Table 5-1.

Table 5-1 Bridge Attributes

Element	Component	Description
Span	Deck	The deck is the surface on which vehicle traffic and/or pedestrian move
	Main members	The structure supporting the span between the supports. The main members are the trusses in truss bridges and the girders in a girder bridge.
	Secondary members(including other members)	The secondary members are any structural members transferring the loads to the deck to the main members. In a girder bridge where the deck is supported directly on the girders, there are no structural members. In a truss bridge, the secondary members are the transverse transoms and longitudinal stringers transferring the load on the deck to the trusses.
	Left railing	The barriers to the left side preventing vehicles and/or pedestrians falling off the bridge
	Right railing	The barriers to the right side preventing vehicles and/or pedestrians falling off the bridge
Pier	Main structure	This is the visible structure of the pier that supports the superstructure
	Foundation	The foundation is the structure that transfers the load of the bridge to the underlying ground. In most cases the foundation may not be visible and can only be assessed based on its performance. The foundation is assumed to be in a good condition if there are no signs that the foundation is moving or other distress.
	Expansion joint	The expansion joint is the connection in the deck between the spans over the pier
	Bearing/Restraints	The bearing and restraints support the superstructure on the pier and limit movement of the superstructure on the pier.
	Scour protection	The surrounds of the base of the pier including any work to prevent scour around the pier during flooding or other events.
	Waterway	The waterway under the bridge defines the condition of the stream or channel banks and/or bed
Abutment	Main structure	This is visible structure of the abutment that supports the superstructure and approach road
	Foundation	The foundation is the structure that transfers the load of the bridge and the approach road to the underlying ground. In most cases the foundation may not be visible and can only be assessed based on its performance. The foundation is assumed to be in a good condition if there are no signs that the foundation is moving or other distress.
	Bearings/Restraints	The bearing and restraints support the superstructure on the abutment and limit movement of the superstructure on the abut
	Expansion Joint	The expansion joint is the connection in the deck between the abutment and adjacent span that allow for movement between the superstructure and the abutment.
	Left wing wall	Any additional wall on the left side of the bridge abutment to support the approach road adjacent to the abutment. Some bridge may not have any wing wall.
	Right wing wall	Any additional wall on the right side of the bridge abutment to support the approach road adjacent to the abutment. Some bridge may not have any wing wall.
	Scour/Bank Protection	The surrounds of the base of the abutment including any works to prevent scour or loss of material from around the abutment during flooding or other or events.
	Bridge approach	The approach road structure adjacent to the bridge that is affected by the bridge abutment.
	Waterway	The waterway under the bridge defines the condition of the stream or channel banks and/or bed

Each span, pier and abutment of a bridge will have the defined components listed in Table 5-1. Therefore, a single span bridge (no pier) will have 21 defined components, a two span bridge will have 31 defined components, and so on.

The bridge inspector shall inspector 100% of the surface of each component and the assessed condition state shall be based on the surfaces that were inspected. Where it is estimated that only 50% or less of the component has been inspected, the assessment shall also be recorded as Partial on the CIF, stating the reason why it cannot be fully observed. Where a component has not been closely inspected at all, the assessment shall be recorded as None on the PIF. Where a component has only a partial or no assessment, the bridge inspector shall still nominate the condition state of the element.

As the periodic inspection is a visual inspection, the inspection only applies to those components that can be visually inspected. Therefore, an N or a P would apply if a component could have been inspected in more detail if additional equipment (e.g. bridge inspection vehicle, ladder, boat) were available. An N or P would indicate that a revisit should be made to the bridge to complete the inspection of incompletely inspected components.

Condition record photographs shall be taken at the site of all components with condition state of 2 or 3 to show the appearance of the observed defect. Photographs shall be taken within three (3) meters of the surface of the component showing the defect if possible, or equivalent using a telephoto lens.

The bridge inspector shall inspect and assess the condition of each component using the standard condition state criteria and record the result of the assessment in the PIF.

(4) Condition Rating of Bridge Attributes

The component condition state rating criteria included in Appendix A.

The condition states have been developed to describe the following conditions listed in Table 5-2.

Table 5-2 Bridge Components Condition

Condition Rating	Description	Action
0	Component is in good condition with little or no deterioration	No action required
1	Component show deterioration of a minor nature to the primary supporting material and is showing first signs of being affected	Major maintenance is required within 10 years
2	Component shows advancing deterioration and loss of protection the supporting material, minor loss of section.	Major maintenance is required within 2 years
3	Component shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress.	Immediate major maintenance is required.

The condition state of each bridge component will be used by the BMS to calculate the overall need of the bridge for intervention.

(5) Non Applicable Component

There are many instances when the PIF is not completed completely or correctly due to uncertainties concerning the occurrence of some bridge components.

The bridge inspector may feel that a component cannot be completed because he cannot recognize the component in the bridge. The bridge inspector doesn’t have to omit the data for any component we cannot recognize. The bridge inspector has to adopt one of the options described below.

Mark the component as not applicable. In the case, the components are not included in the subsequent BMS analysis.

Assume the component is in good condition. In this case, the component is included in the BMS analysis.

(6) Overall Rating

Assessed overall rating can be calculated by using Condition Rating Cards (CRC) as follows.

According to CRC, overall rating depends on the area of damages except for cracks.

For example, the RC deck slab of a concrete girder bridge has 1.20mm wide cracks spaced at an average of 150mm in two directions covering an area of about 10 square meters at Span 1. Span 1 has a dimension of 7 meters width and 10 meters span length. Also, Span 1 has 40cm wide water leakage.

In Table 5-3, the PIF for damage rating of span element, the type of material for the deck component is concrete and the defects identified are cracking and water leakage. In Appendix A, the severity of cracking is 3-Bad since 1.20mm with an average spacing of 150mm in two directions falls under the criteria of more than 1mm cracking in two directions spaced at less than 200mm. The severity of water leakage is 2-Poor since 40cm is under the criteria of more than 20cm wide.

For cracking of concrete of primary components such as deck slab, the severity of damage can be the damage rating, which in this case is 3 regardless of the size of affected area. In the CIF, the damage rating for cracking will then be Bad.

For water leakage where the total calculated affected area is 26%, the Condition rating Card is used to determine the damage rating. The damage rating is 2-Poor since the area affected is within 20～30% of primary component.

When all the ratings of the observed types of defects for the deck in Span 1 are compared, the worst rating will be the condition state of the deck component. The component condition state of the deck will then be “3” or Bad since cracking has the worst rating.

Table 5-3 Sample Component Form (Overall Rating)

Bridge Element: Span1 Type of Material: Concrete

Bridge Component: Deck Type of Damage: Cracking and Water Leakage

Type of Material	Type of Damage		Severity of Defect	Affected		Damage Rating	Overall Rating
				Unit	%		
DECK							
Concrete Slab	×	Cracking	3	-	-	Bad	3
		Spalling/Scalling/Disintegration					
		Rebar exposure/corrosion					
		Honeycomb					
	×	Water leakage	2	Area	26	Poor	

The bridge is a concrete girder bridge with a RC deck slab supported directly on the main members consisting of beams. In this case, there are no secondary members component for Span 1 therefore the box for “Not Applicable” will be marked.

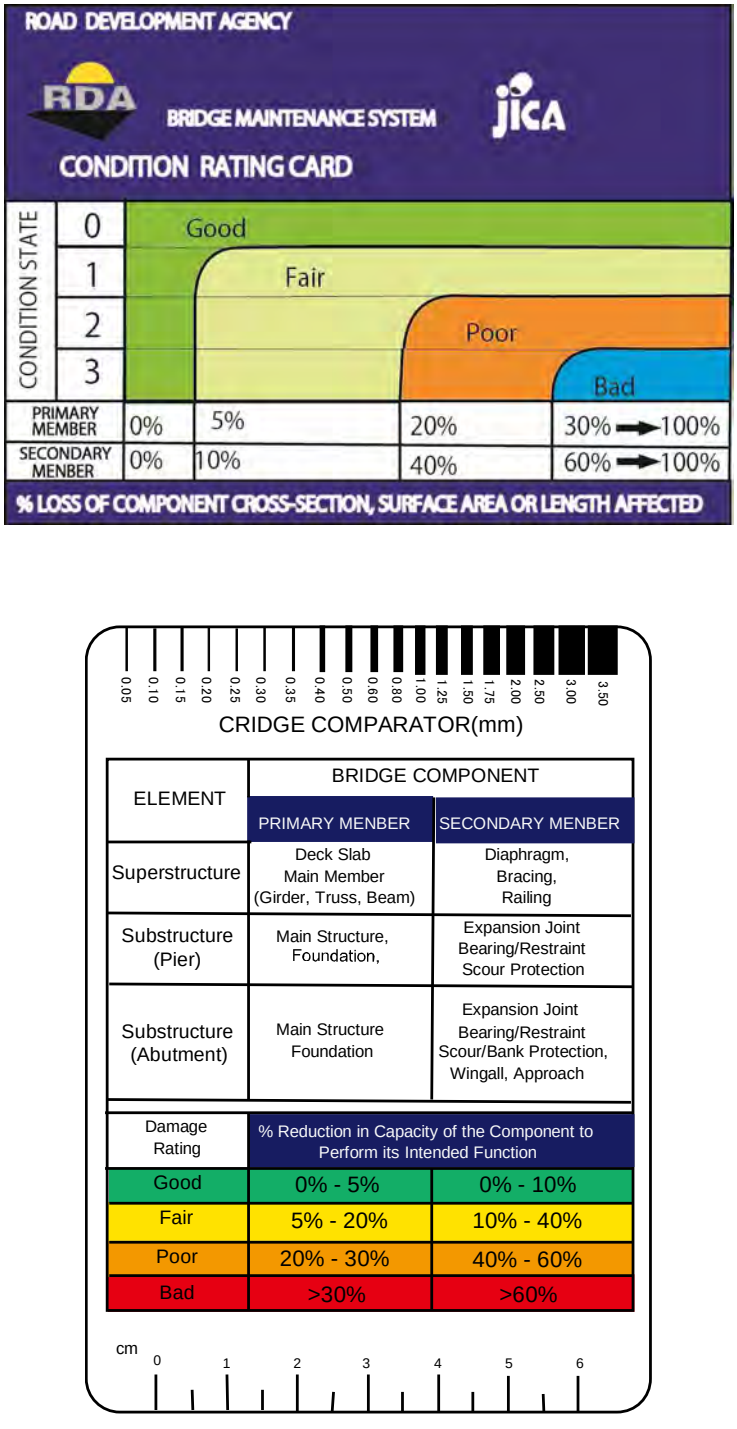


Figure 5-3 Condition Rating Card

(7) Bridge Condition Assessment

The bridge inspector is required to assess the overall condition of the bridge based on the condition of the bridge components. The summary sheet of the CIF will be completed for the overall condition of the bridge. Data needed for this section are described below:

- ***Overall Condition of the Bridge*** refers to the rating given by the bridge inspector to a certain bridge. The bridge can be evaluated as good, fair, poor or bad. Note that the bridge inspector has to rely on his/her engineering knowledge and judgment for the evaluation of the bridge's condition.

In general, structures described as ***Good*** condition shall be free of defects affecting structural performance, integrity and durability; these described in ***Fair*** condition may have defects which affect the durability, and those described as ***Poor*** condition may have defects which affect the performance and structural integrity of the structure beyond repair.

The bridge inspector shall determine the overall condition of the bridge based on the results of the condition rating of the bridge primary components and secondary component that affects structural performance such as bearings/restraints. In general, the worst condition state of any primary component and secondary component that affects structural performance will be the overall condition state of the bridge. Guidelines for assistance are included in Table 5-4.

Table 5-4 Guidelines in Assessment of Bridge Condition

Bridge Condition	Assessment Indicators
	Primary Components and Secondary Components that Affects Structural Performance(Component Condition State)
Good	0
Fair	1
Poor	2
Bad	3

Bridge Condition	Recommended Countermeasure	Remarks
Good	Routine Maintenance	-
Fair	Major Maintenance (Repair, Protective Works, Strengthening)	Total of Bridge Component
Poor	Major Maintenance or Upgrading	Total of Bridge Component
Bad	Major Maintenance, Upgrading or Replacement	Total of Bridge Component

- ***Recommended Action to the Bridge*** refers to the level of rehabilitation works needed for the bridge. The recommended measures will be generally based on the overall bridge condition as shown above.

- ***Bridge Inspector's comment on recommendation***. The bridge inspectors shall indicate his comments on the recommended activity for the bridge.

- ***Major reasons for recommendation***. The bridge inspectors shall indicate the reason(s) for the recommended activity to the bridge. Up to three (3) reasons can be selected.

- ***Estimated Remaining Bridge Life*** refers to the remaining length of time for which the bridge will remain serviceable. The bridge inspection shall estimate the remaining bridge life based on his/her engineering knowledge and judgment.

(8) Report of Bridge Inspection

A bridge condition report is prepared following the periodic inspection.

The bridge condition report shall include the following items.

- A fully completed bridge periodic inspection form(PIF),
- Supporting information for proposed major maintenance,
- Cost estimates for routine maintenance and major maintenance,
- Inspection photographs(proof of visit), and
- Photographs of components with identified defects of Condition State 2 or 3.

A sample completed bridge periodic inspection form (PIF) is included in Appendix F for reference.

The bridge condition reports shall be prepared in the offices in which the bridge inspectors are based for all bridges in each region. The reports shall be checked and reviewed in the Regional Office for completion and accuracy prior to finalization.

The data contained in the Bridge Periodic Reports shall be loaded into the BMS.

5-4 THE POINT OF INSPECTION

After verifying that it is the right bridge, inspector can start inspection in accordance with the suggested focus points as follows:

(1) Observe the Entire Bridge from the Approach Road




Figure 5-4 Approach Road

(2) Observe the Entire Bridge from the Sides

- Observe if there is a problem trough the girder, railing, fellow guard.
- Detecting settlement, incline, move in substructure.




Figure 5-5 Inspection Side View

(3) Observe the defects (Inspect the Kerb)

Look at the kerb. Observe if there are defects. In photo below, rebars are already exposed.



Figure 5-6 Inspection the Curb

(4) Inspect the Pavement

Observe if there are potholes or dent, alligator cracks, large crack in the direction of the bridge axis and in a bridge axis orthogonal direction.

Detecting potholes or alligator cracks, its sign for damage of the deck slab.





Figure 5-7 Inspect of the Pavement

(5) Inspect the Expansion Joint

Observe if there is difference in elevation or abnormal space, whether it's broken.

Damage of the expansion joint cause traffic accident.

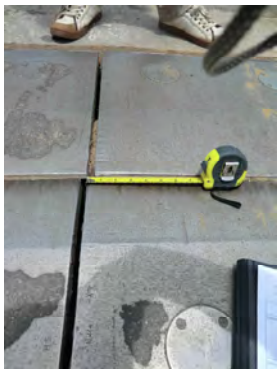



Figure 5-8 Inspect Expansion Joint

(6) Inspect the Drainage

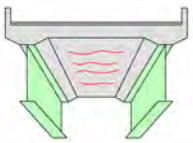
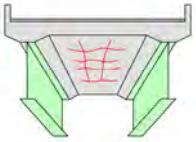
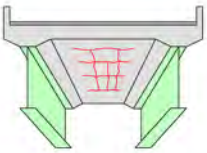
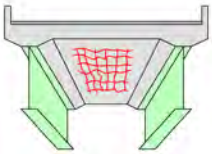
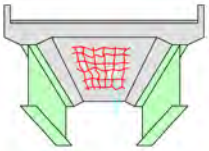
Look at inside the drainage. If there is much debris, clean it as soon as possible



Figure 5-9 Inspect Drainage

(7) Inspect Entire Deck Slab

Observe if there is delamination or scaling, rebar exposure. Attention shall be paid to crack pattern, leakage of water, free lime and rust fluid. Crack progress as follow;

Progress of Damage	
Dry Shrinkage Crack mainly occurs in only direction.	
Crack due to wheel load occur in horizontal and vertical directions. Lattice-shaped cracks increase.	
Bending crack on under surface penetrate to upper surface by iteration for wheel load.	
Crack surface lose shear resistance for ablation and leveling by wearing out.	
Falling out due to punching shear strength declined.	

(8) Inspect all Concrete Girders

1) Inspect all Girders



Figure 5-10 Inspect All Concrete Girders

2) Inspect Concrete Girder at Center of Span



Figure 5-11 Inspect Concrete Girder (Center of Span)

Look for the transverse direction's cracks at bottom of concrete girder. These are flexural cracks.

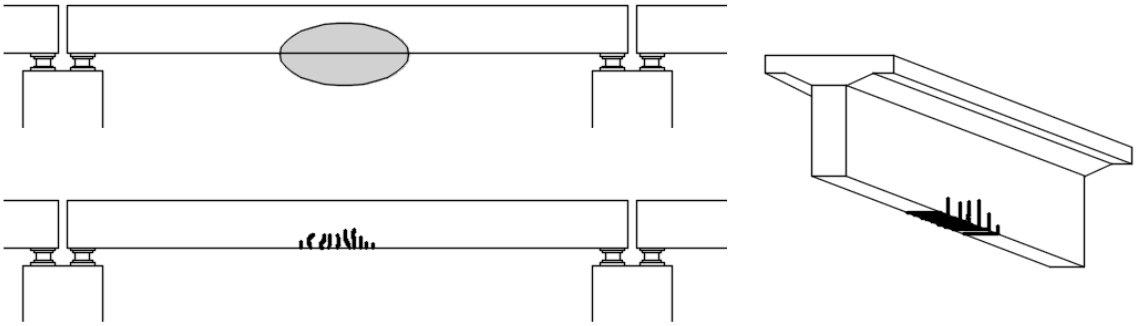


Figure 5-12 Flexural Cracks of Concrete Girder

3) Inspect Concrete Girder at 1/4 Point of Span



Figure 5-13 Inspect Concrete Girder at 1/4 Point of Span

Look for the inclined crack line on the web near 1/4 point of span. These are shear cracks.

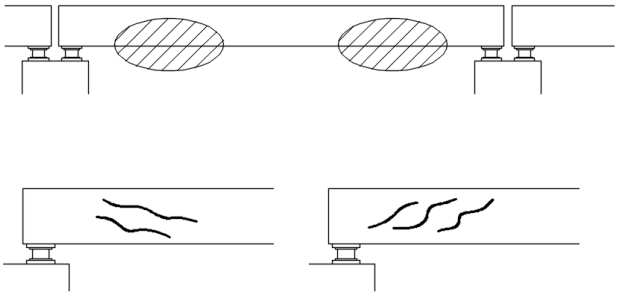


Figure 5-14 Shear cracks in Concrete Girder at 1/4 Point of Span

4) Inspect Concrete Girder at Supporting Point



Figure 5-15 Inspect Concrete Girder at Supporting

Look for shear cracks near the bearing up to edge

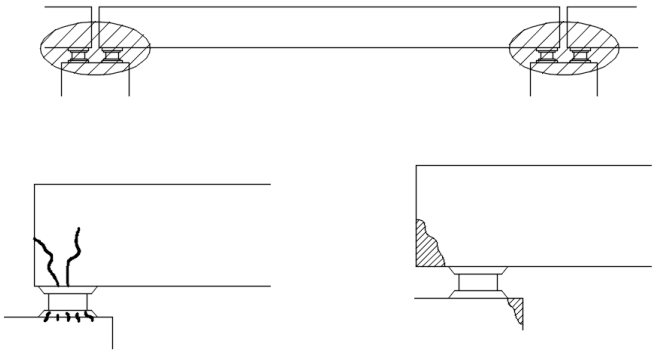


Figure 5-16 Shear Cracks in Supporting

(9) Abutments and Piers





Figure 5-17 Inspect Abutments and Piers

(10) Foundations

Observe if there are incline or move or settlement, if scouring at the riverbed.

If foundation is under the water, inspection should carry out the dry season.



Figure 5-18 Inspect Foundation

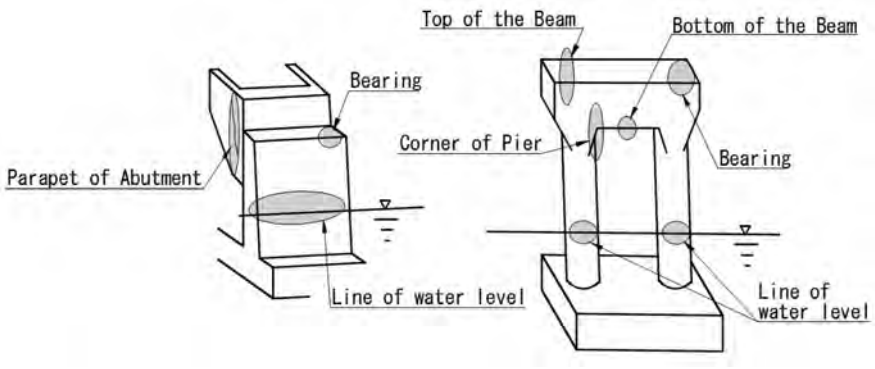


Figure 5-19 Defects at the Focus Points of Pier and Abutments and Foundations

(11) Inspect Steel Structure

1) Entire Structure



Figure 5-20 Inspect Entire Steel Structure

2) Center of Span



Figure 5-21 Inspect Center of Span

3) End of Girder



Figure 5-22 Inspect Ends of Girders

4) Supporting Point



Figure 5-23 Inspect Supporting Points of Structure Steel

5) Splice Plate



Figure 5-24 Inspect Splice Plates of Steel Structure

6) Cross Beams and Gusset Plates



Figure 5-25 Inspect Cross Beam

(12) Bearings

1) Rubber Bearing



Figure 5-26 Inspect Rubber Bearing

2) Bearing Mortar



Figure 5-27 Inspect Bearing Mortar

3) Anchor Bolts of Bearings



Figure 5-28 Inspect Anchor Bolts of Bearings

CHAPTER 6 DETAILED INSPECTION

6-1 PURPOSE

Detailed Inspection is intended to obtain detailed data regarding deterioration and performance of the structure when visual inspection is insufficient for estimating the deteriorating mechanism and assessing/judging the state of deterioration and performance degradation, or when the performance due to damage or deterioration are not evident.

Detailed Inspection is required to be undertaken as a follow-up to bridge condition inspection when the overall condition of the bridge with Poor or Bad rating is recorded based on the result of the rating of any primary component/attribute and/or secondary component/attribute that affects structural performance such as bearing/restraints.

The purposes of Detailed Inspection are as follows:

1) To confirm the results of bridge condition inspection;
2) To undertake additional investigations necessary for defect evaluation including physical testing and/or structural analysis, and documentation of the observed defects with sufficient information for future design of required major maintenance works;
3) To determine the cause/mechanisms of damage;
4) To assess the current bridge structural condition, and,
5) To assess the rate of deterioration and residual life expectancy.
6) To evaluate the need for repair and rehabilitation.

6-2 INSPECTION METHOD

(1) Process

The general process for a bridge detailed inspection is shown in Figure 6-1.

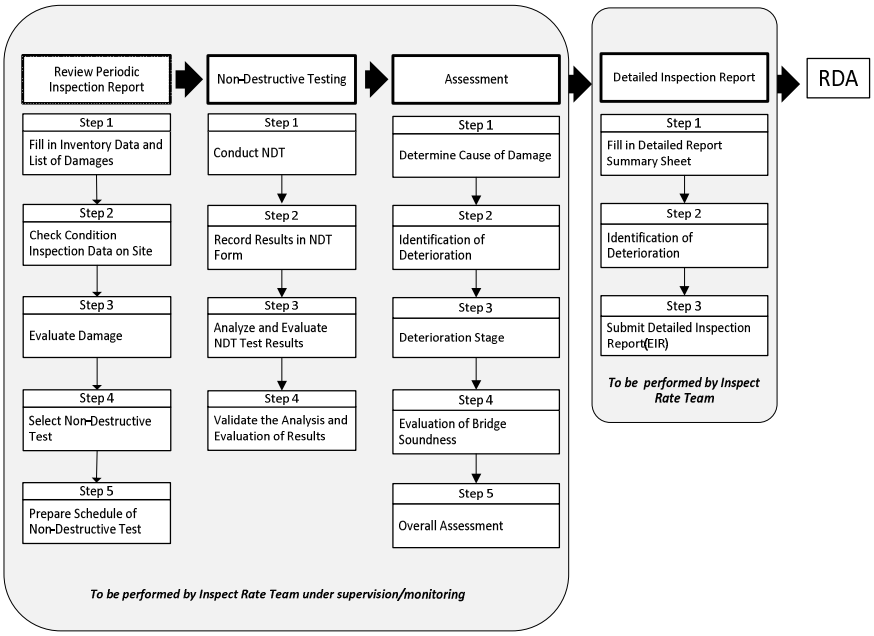


Figure 6-1 Process of Inspection

This is a generic inspection model as the scope and extent of the detailed inspection will vary depending on the nature, extent, magnitude and severity of the observed defects. This type of inspection would be undertaken by the Detailed Inspect Rate team who would develop the appropriate scope necessary to address the identified defects and any particular bridge requirements.

(2) Scope

The Detailed Inspection is a detailed investigation and evaluation of damage and/or material properties of specified elements. The damage may be due to environmental impact (climate, saline, soil, etc.), wear (insufficient maintenance), design and construction errors and overloading or similar conditions.

The scope of the Detailed Inspection will include:

1) Review of any previous inspection reports;
2) Determination and provision of equipment and resources required for the inspection including preparation of safety plan;
3) Inspection of all relevant bridge attributes including measurements, testing and analysis as necessary to supplement the visual inspection; and

4) Identification of the probable causes and projected rate of deterioration and effects of continued deterioration on the performance, durability and residual life of the structure.

If Special NDTs are conducted, scope will include:

5) Determination of components and structural behavior;

(3) Procedure

1) Selection of Inspection Team Members

In order to evaluate and assess bridge soundness, The Engineer who is familiar of NDT should be conducted by the Bridge Detailed Inspection.

2) Preparation before Inspection

- Inspectorate Team collects the Condition Inspection Report all available documents (plans, drawing and report) of the bridge be inspected.
- Inspectorate Team requests Regional Office to clear bridge and surrounding areas that may hamper the Detailed Inspection activity.
- Inspectorate Team checks equipment (including all Non-Destructive Apparatus) and/or vehicles required for Detailed Inspection.
- Inspectorate Team checks that all necessary materials and safety are prepared.
- Inspectorate Team makes sure that safety measures are in-place prior to inspection.

3) Review of Damage Rating of Periodic Inspection Results

In the review of damage rating of condition inspection results, Inspection Team shall visually observe the bridge defects on site.

4) Select the types of NDT Methods

If the cause of defects is clearly visible or if the degree of progress of deterioration is obvious, if may not be necessary to conduct NDT (For example: Serious Water Leakage on Deck Slab, Structural Cracks with more than 3.0mm width)

5) The reliability of NDT

- Concrete strength, rebar status, painting conditions, etc.

  On existing structures can be checked by NDT.

- NDT result may not always be perfect. There is a possibility that the accuracy of the NDT outcome could differ depending on the degree of compliance of the prescribed preparatory works and technical operation of the NDT apparatus.
- The result therefore of NDT has to be sufficiently evaluated by the Engineer from the objective and technical point of view.
- NDT operator has to undergo proper training.

6-3 NON-DESTRUCTIVE TESTING

There are several types of NDTs (Shown Followed Table).

Table 6-1 Types of NDT

For Concrete Attributes		
※	N01	Rebound Hammer Test
	N02	Carbonation Depth Measurement Test
	N03	Ultrasonic Pulse Velocity Test
	N04	Half-Cell Electrical Potential Test
	N05	Rebar Detection Test
		Half-Cell Electrical Potential Test
		N05-01 Magnetic Type
※		N05-02 Radar Type
For Steel Attributes		
	N06	Paint Thickness Test
※	N07	Metal Thickness Test

※ N01, N05-02 and N07 provided by JICA, are described in following pages.

(1) Rebound Hammer Test

1) Fundamental Principles

The test method is based on the principle that the rebound of elastic mass (the hammer piston or impact plunger) depends on hardness of the material it strikes, and the assumptions that (a) the hardness is proportional to the materials strength and (b) the material is homogenous.

Rebound hammer test can only assess the compressive strength of the near surface layer of concrete in the zone of influence of hammer impact. It is useful in finding weak areas in concrete in a structure.

2) Procedures

Explained below are general procedures when using rebound hammer.

a) Gather Reference Information on Structure

Before testing, determine the following information on the structure to be tested:

- Design compressive strength
- Age of concrete(reckoned from data of construction)
- Concrete mix proportions

b) Set-up of Apparatus

After taking out the test hammer from the carrying case, press the plunger head until it is released. Check surface of plunger, and remove any dust or oil with cotton cloth to avoid scratching the surface.

Calibration of the rebound hammer is necessary for its proper operation. A steel anvil is used for verification.

c) Preparation of Test Surface

If necessary, grout or plaster that covers the concrete surface should be ground smooth with abrasive verification.

Avoid testing near joint and areas exhibiting honeycomb, scaling and high porosity. In cases where carbonation is present or suspected, the surface layer maybe removed using power grinder to obtain rebound numbers representative of the interior concrete.

Try to avoid tests directly on top bars. Where possible, use a cover meter to locate bars close to the surface before taking a test or setting out a grid for a number of tests.

Where tests are required on concrete member less than 100mm thick, members should be rigidly supported.

The number of test points shall be determined in the field. Minimum spacing between test points shall be 150mm.

d) Testing

① Draw Grid on Concrete Surface to be Tested

See test point example pattern below

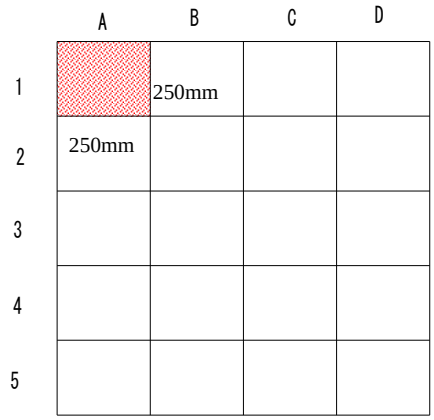


Figure 6-2 Example of Testing Grid

② Take Measurement

At Cell A1:

ⅰ) Rest the plunger head at right angles to the concrete surface.

ⅱ) Press the hammer until it strikes the surface(Note: Do not press push-button under any circumstances when taking reading)

ⅲ) The hammer rebounds moving a reference pointer with it

ⅳ) By pushing the button, the pointer is held at its maximum position.

ⅴ) Repeat procedures for next measurements until a total of 20 readings (Cells A1 to D5) are taken.

ⅵ) The hammer can be used to test surfaces

The hammer can be used to test surfaces at any inclination but only readings at any inclination but only readings at the same inclination (horizontal, up, down, etc.) shall be compared. Test inclination shall be recorded on the test sheet.



Figure 6-3 Manual Type Concrete Test Hammer

③ Test Point

Conduct tests at three (3) test points at each bridge element/attribute (Deck, Girder, Pier and Abutment).

If rebound hammer test is conducted in conjunction with compressive strength test, the test result may be used as reference.

3) Operation and Analysis of Measurements

① Operation

The operation of manual type concrete test hummer is explained in Section (2) Procedure

② Rebound Value and Cube Compressive Strength

The “R” values of rebound have been defined in such a way that they can be converted by means of diagrams, in terms of resistance to compression for tests carried out on a cube or cylinder. In the diagrams below, 5 different curves have been reproduced for cube compressive strength, which take into account the angle of inclination of the hammer. The curves take into account the effect of gravity acting upon the impact shock. Thus the test can be carried out on floors, walls, ceilings and any other inclined surface.

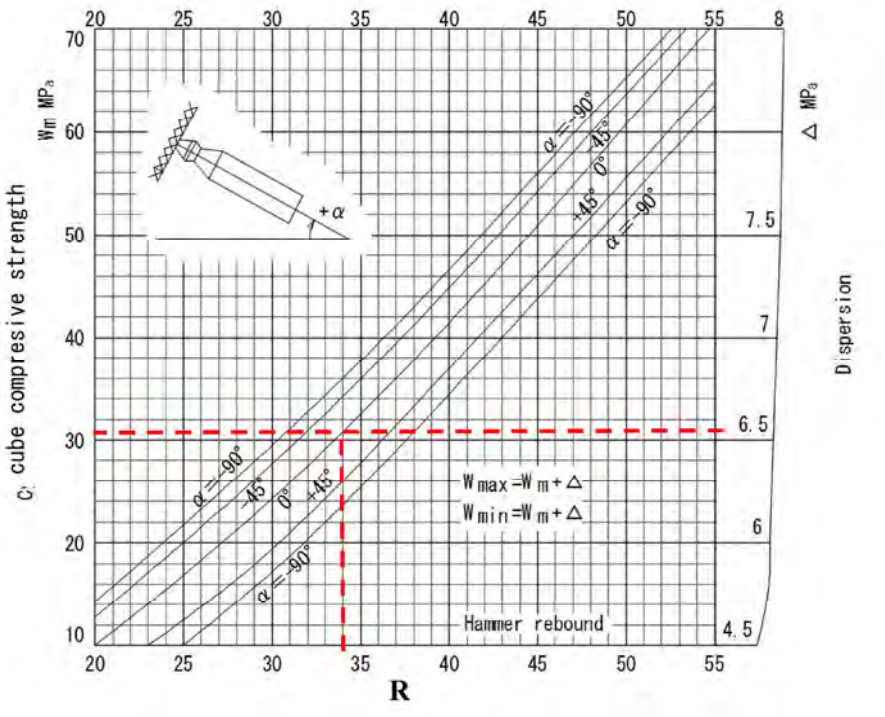


Figure 6-4 Rebound Value and Cube Compressive Strength Chart

③ Cube Compressive Strength

In the example above, R=34 is the mean or average of 20 readings taken from the test of vertical wall (angle of inclination $\alpha = 0^\circ$). Projecting a vertical line at R=34 until it intersects the graph of $\alpha = 0^\circ$ inclination, the resulting mean compressive strength, $fc_{mean}(W_m)$ and Δ (mean error) and obtained.

R=34

$fc_{mean}(W_m)$=31 Mpa(N/mm2)

Δ =6.55Mpa(N/mm2)

fc_{max}=31+6.55=37.55

fc_{min}=31-6.55=24.45

④ Cylinder Compressive Strength

Cylinder strength is 15% lower that of relative cube strength. Above values are converted to cylinder strength as follows:

fc'_{mean} (Wm) = 31×0.85 = 26.35

fc_{max} = 37.55 × 0.85 = 31.92

fc'_{min} = 24.45 × 0.85 = 20.78

⑤ Influence of Age of Concrete on Compressive Strength

The strength of concrete decreases as it ages. The time factor applied in calculating the compressive strength of the structure at the time of inspection that can be applied is as follows:

Table 6-2 Time Factor for Calculation on Compressive Strength

Age (Days)	Time Facror (α)
10	1.55
20	1.15
28	1.00
50	0.87
100	0.78
150	0.74
200	0.72
300	0.70
500	0.67
1,000	0.65
3,000	0.63
10,000	0.57
20,000	0.41

Example: If age of concrete is 20,000 days (54.8years);

Fc_{mean} or Wm (20,000 days)=26.35×0.41=10.80N/mm2

4) Evaluation and Recommendation

- Rebound hammer test is useful in finding weak areas in concrete structures.
- Test results depend on angle of inclination of hammer to the horizontal, because of the influence of gravity on the amount of energy imparted to the impact.
- The test only gives indication of surface strength of concrete.

Based on the BS Code, the concrete design strength used in Zambia bridges are 15, 20, 25, 30, 40, and 50N/mm2.

The degree of damage of concrete member based on rebound hammer test results can be determined by the use of the following empirical formula developed in Japan.

Table 6-3 The Degree of Damage of Concrete member

Rebound Hammer Test/ Compressive Strength Test Degree of Damage	Fc=Design Compressive Strength F=Actual Compressive Strength from Test(in N/mm2)
Ⅰ	$F \geqq Fc$
Ⅱ	$0.8Fc \leqq F < Fc$
Ⅲ	$F < 0.8Fc$

Example:

RC Girder

Rebound Hammer Test Result (Cube Strength), $fc_{mean}(W_m) = 41N/mm^2$

Cylinder compressive strength $fc'_{mean}(Wm)=41\times0.85 = 34.85\ N/mm^2$

If bridge was constructed in 2000, age in days is about 5,475 and

$F_{(5475\ days)}=34.85N/mm^2\times0.63=21.95N/mm^2$

As concrete design strength, 20 or $25N/mm^2$ is normally used.

Comparing the values, If $Fc=20N/mm^2$, then $F_{(5,475\ days)}>Fc$ and the concrete is considered under Degree of Damage-I

The test is the first step in the investigation. If the results are unreliable or less than the design compressive strength, detailed investigations including microcore test should be carried out. If the results show abnormal data between three (3) test points, lowest data is indicative of suspected defects in the concrete.

(2) Rebar Detective Test

1) Fundamental Principle

Electromagnetic waves are transmitted from the antenna toward the concrete as shown in diagram below. The electromagnetic waves are reflected by an interface with the reflective objects (e.g., reinforcing steel bars or cavities) whose electrical property is different from that of concrete. The waves are reflected back into the surface of concrete and received by the receiving antenna placed near the concrete surface. The distance to the reflecting objects can be calculated from the time the waves need to reach the receiving antenna. The horizontal locations of the objects can be detected by moving the main unit on the surface of concrete.

Since this radar is designed to probe objects with high resolution that are near from the surface of concrete, it transmits pulse waves having a width of about one nanosecond(one-billionth of a second) or less.

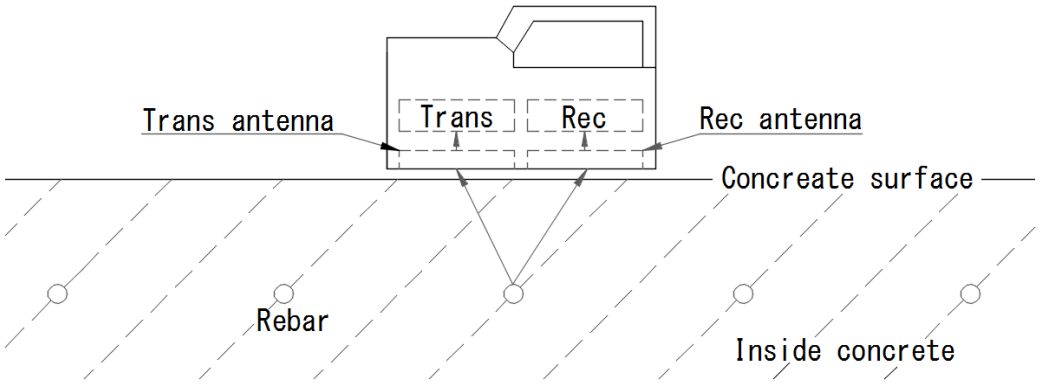


Figure 6-5 Diagram of Reflected Wave Form

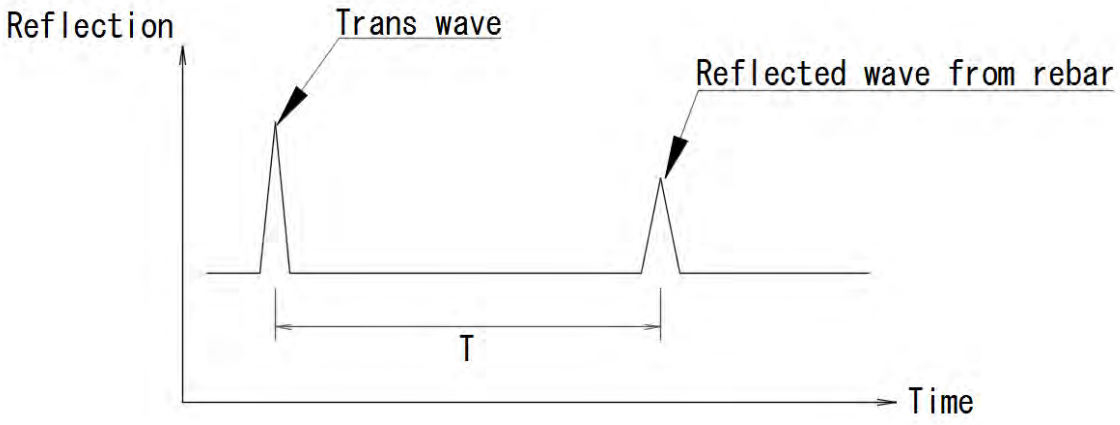


Figure 6-6 Diagram of Reflected Wave Form

① Description of Apparatus



Figure 6-7
Radar Type Rebar Detector

② Applicable measuring condition

- Scan test depth (covering depth) within 0.5 ～30cm (case where relative permittivity of concrete is 6.2 and the diameter of the rebar is at least 6mm)
- Objects to be probed that are at a depth of less than 75mm have an interval spacing of at least 75mm and where the depth of the objects is more than the depth.
- Quality of concrete: Uniform
- Direction of reinforcement steel: Orthogonal to the Handy Search's traveling direction

③ Inapplicable measuring condition

- Scanning of reinforcing steel bars or the like in concrete whose surface contains objects such as metal that reflect radio waves
- Presence of reinforcing steel bars that are parallel to the Handy Search's traveling direction
- Concrete that has a narrow (pitch) arrangement for the interval of rebar in the horizontal direction

Horizontal discrimination Resolution

≧ 75mm for the scanned object located at depth <75mm

≧ Depth of the scanned object for the object located at depth ≧75mm

(Depth less than 75 mm with spacing between rebar less than 75 mm
Depth greater than 75 mm with spacing between rebar less than depth)



Figure 6-8 Inapplicable Measuring Conditions

2) Procedures

① Preparation for scanning

a) Using chalk(or similar tool) make markings on the concrete surface to indicate where to start testing(stating line) and where to scan(scan test line)

b) Make sure the start line and the scan test line are orthogonal (Perpendicular to each other). (As necessary, in other to perform a retest, use an endpoint of the wall as a reference standard for the start line and scan test line).

c) A scan test applicable set up example is shown in Figure 6-9

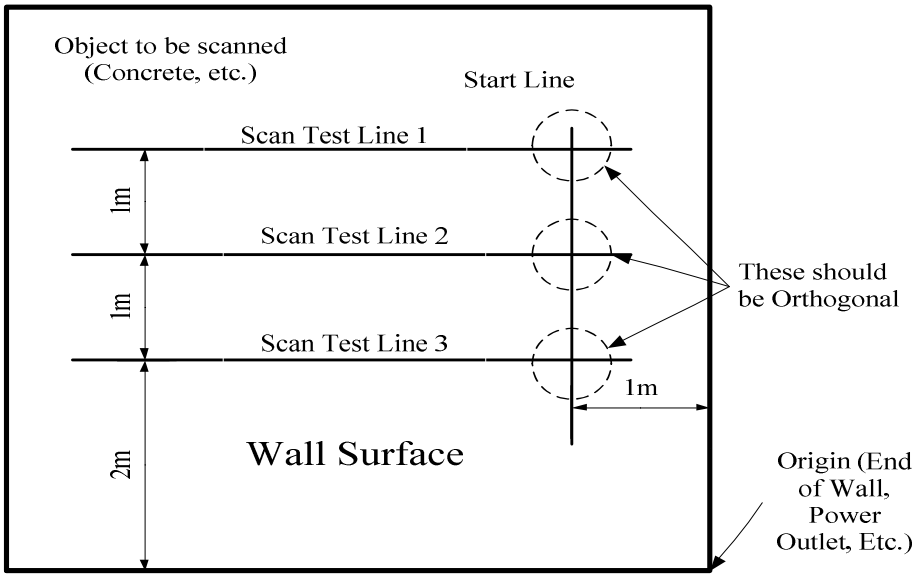


Figure 6-9 Example of Scan Test Set-up

② Scanning

a) Power-on Procedure

- The LCD lights up roughly 5 seconds after the power is turn on by turning on the power switch, and the initialization screen is displayed.
- After the initialization screen completes, the scan rest screen is displayed.
- After confirming that the scan test screen is displayed on the LCD, start the scan test.

b) Scan Test

- Place the unit over the intersection of start line and the scan test line.
- After about one second after pressing START, a short single buzzer sound is generated, the fixed cursor is displayed at a position of about 10cm of the movement distance scale on the screen, and then scan test preparation is complete.
- Move the unit on top of the scan test line at a speed of less than 40 cm/s by rotating the wheels.
- Press START again to finish. A double buzzer sound is generated and the scan test is stopped.

➢ However, if the scan distance reaches 15 m, the buzzer sounds twice and the scan test automatically finishes.

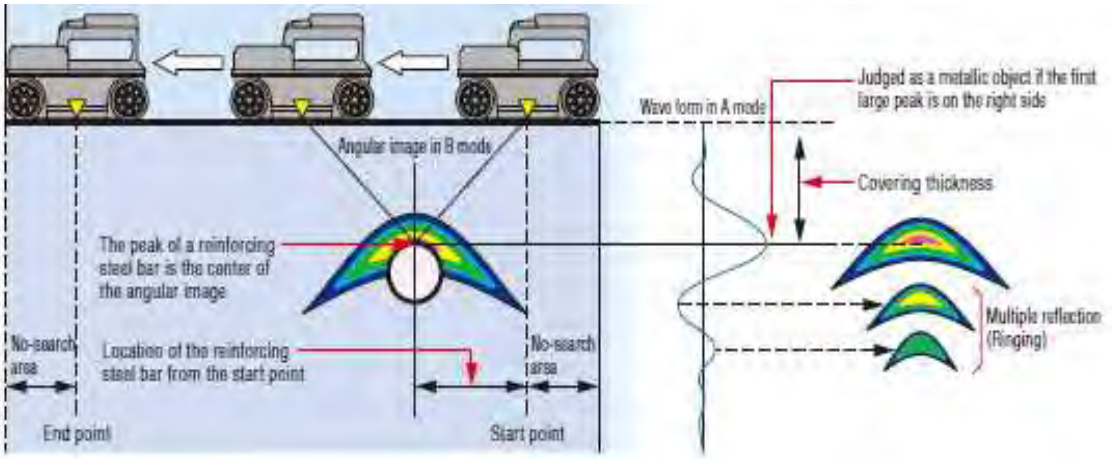


Figure 6-10 Scanning Diagram

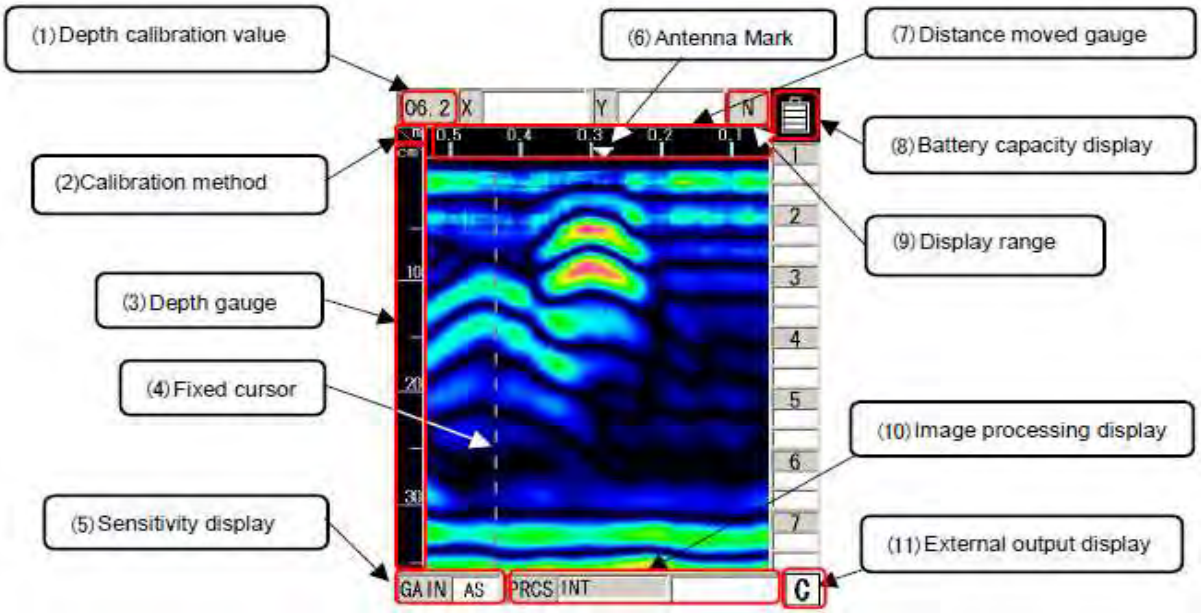


Figure 6-11 Example of a Test Scan

c) Analysis (Interpretation of Data)

- The reflected waves shown in the scan test example in figure above are reflections of rebar. (↓ position)
- The position of the object to be probed (e.g., reinforcing steel bar) in the traveling direction is determined as the peak of the reflected wave.
- An approximate depth (covering depth) of the object to be probed (e.g., reinforcing steel bar) is determined as the center of the reflected wave.

- Perform depth calibration to reduce the error in the depth (covering depth) of the object being probed (such as rebar). The position of the object to be probed (such as rebar) is shown by the peak on the right side of the A mode waveform.
- Match the cursor to the peak position to determine the depth.
- Refer to Figure 6-12 for example of data analysis

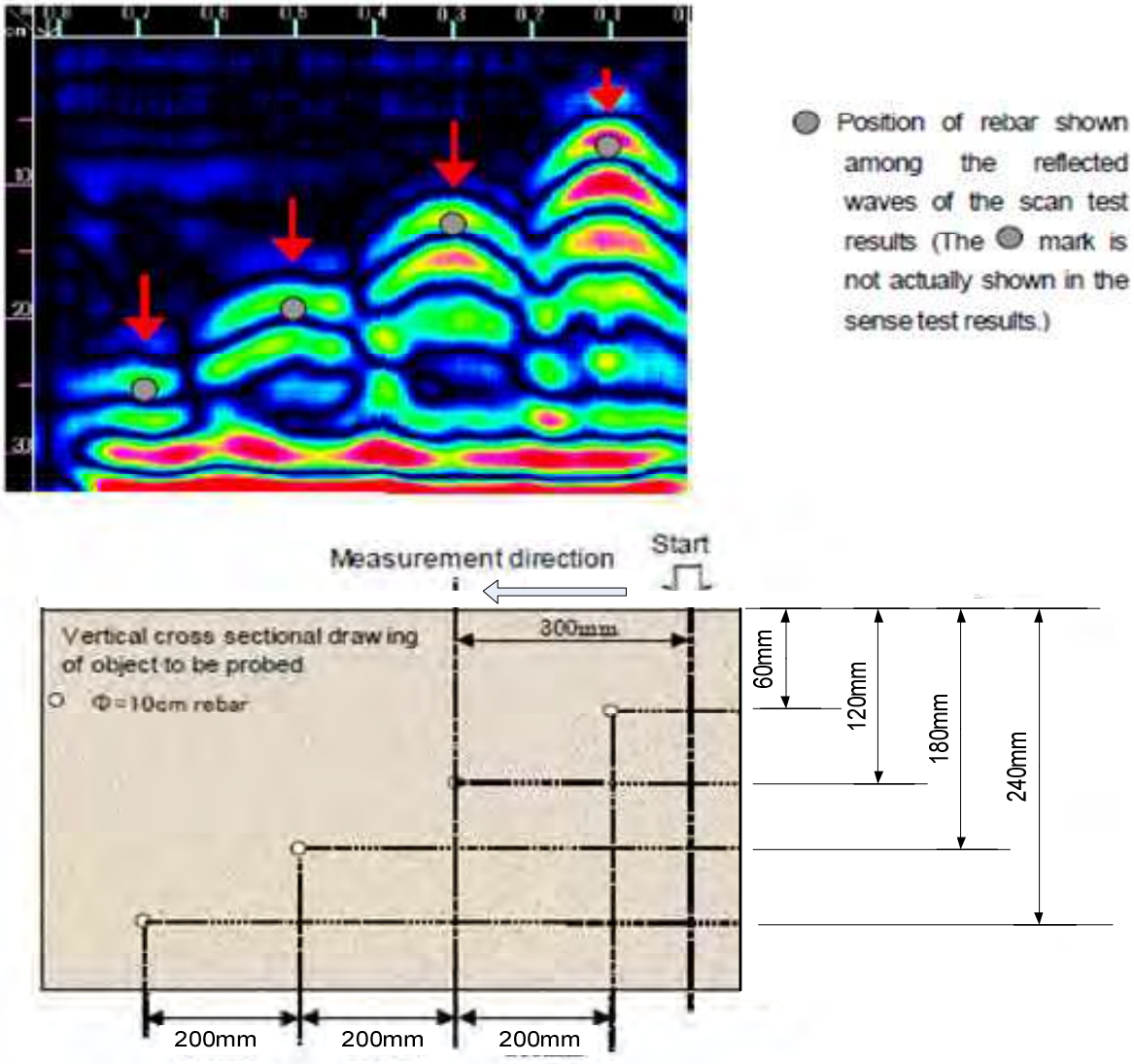


Figure 6-12 Example Data Analysis

d) Evaluation and Recommendations

The test is useful in the:

- Verification of reinforcement: locate rebar when plans are missing, for acceptance inspections, before structural repair or change of loads on a structure.

- Verification of concrete cover over reinforcement: obtain concrete cover information over large areas for acceptance inspections, before renovation or for quality control.
- Avoidance of hitting rebars: avoid cutting through critical reinforcement or costly rebar hits.
- Determination of bar depth and determination of average concrete cover over large areas.
- Investigation of concrete members of which records are not available or need to be checked.

(3) Metal Thickness Test

1) Fundamental Principles

① General

This ultrasonic nondestructive testing is used in characterizing material thickness, integrity, or other physical properties by means of high-frequency sound waves. It has become a widely used technique for quality control. In thickness gauging, ultrasonic techniques permit quick and reliable measurement of thickness without requiring access to both side of part. Accuracies as high as ±1 micron or ±0.0001 inch are achievable in some applications.

Precision ultrasonic thickness gauges usually operate at frequencies between 500 KHz and 100 MHZ, using piezoelectric transducers to generate busts of sound waves excited by electrical pulses. Typically, lower frequencies will be used to optimize penetration when measuring thick, highly attenuating, or highly scattering materials, while higher frequencies will be recommended to optimize resolution in thinner, non-attenuating, non-scattering materials.

A pulse-echo ultrasonic thickness gauge determines the thickness of a part or structure by accurately measuring the time required for a short ultrasonic pulse generated by a transducer to travel through the thickness of the material, reflect from the back or inside surface, and be returned to the transducer. In most applications this time interval is only a few microseconds or less. The measured two-way transit time is divided by two to account for the down-and-back travel path, and then multiplied by the velocity of sound in the test material. The results are expressed in the well-known relationship.

2) Application

Thickness of the most materials can be measured ultrasonically, including metals, plastic, ceramics, composites, epoxies and glass. In the field, it is used to determine remaining plate thickness of corroded steel bridge structures. In the fabrication shop, it is used to test uniformity of thickness of steel plates used in various structures.

3) Procedures

① Operating Instructions

Refer to Operation Manual for adjustments, calibration and proper usage.

② Investigation

Before testing, the following items should be investigated:

a) Design steel thickness

b) Repair work records

c) The latest thickness test results

③ Measurement

a) Press the probe against an object to be measured and the measured value is indicated on the LCD.

b) Record measured steel plate thickness and its location on the plan.

c) Repeat measurement at other locations as necessary

d) Measure thickness of both corroded and un-corroded steel for comparison. Be sure to remove rust on corroded surface by sanding before measuring.

④ Test Guideline

The transducer should be placed on the surface of the test item. The ultrasonic waves will then be reflected by the opposite surface. The thickness is shown digitally. For uneven or corroded surfaces, it may be necessary to grind the surface at the test positions to make proper contact. Possible rust on the opposite surface does not disturb the reflections. If steel plates are laminated, the measured thickness will only be the depth of the first layer.

Before starting the measurements, a contact liquid is applied to the locations. Further, the equipment has to be calibrated. For common steel alloys, the calibration is performed by means of test blocks. For unknown alloys (or if you are not sure), the calibration is performed by adjusting sound velocity setting o the equipment shows the same thickness as can be measured by a slide caliper at a free edge.

⑤ Test Points

a) Measure thickness of good condition metal for reference.

b) Measure thickness of deteriorated metal and analyze deterioration area.

4) Evaluation and Recommendations

- Steel structures should be inspected regularly. To avoid damage, surfaces should be applied with appropriate paints.
- If the existing plate thickness is found to be less than the designed thickness due to corrosion, repair method should be planned.
- The method is generally applicable and is particularly efficient for measuring possible corrosion of structural elements with access only possible from one side. The gauge uses dual transducers to measure the thickness of corroded, pitted, scaled, granular materials from one side only.
- Thicknesses of between 0.15mm and 25mm can usually be determined within ±0.001mm.



CHAPTER 7 EMERGENCY INSPECTION

7-1 PURPOSE

Emergency inspection is only undertaken in response to calamities. These inspections are required to confirm that bridges that bridges remain safe for use by traffic following a calamity or to determine the necessary work that is required to either ensure the safety of a bridge or to enable the function of the bridge to be restored.

7-2 PROCESS

There is no general process for emergency inspections as these inspections are urgent inspections undertaken in difficult conditions.

7-3 PROCEDURE

No standard procedure is required for this type of inspection.

7-4 DELIVERABLES

The deliverable will be an emergency inspection report. This will be the form appropriate for the required emergency action.

CHAPTER 8 TYPES AND CAUSES OF DAMAGES

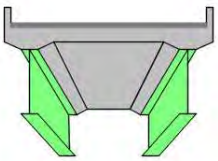
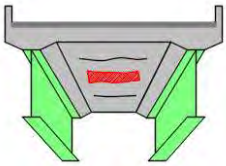
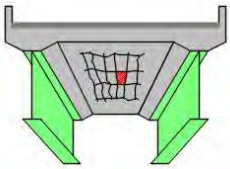
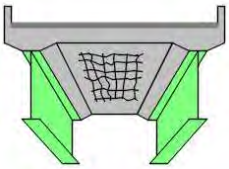
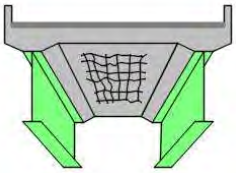
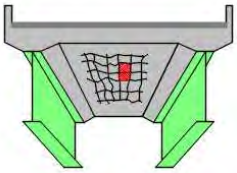
8-1 CONCRETE BRIDGE

8-1-1 Cracking

(1) Concrete Deck Slab

Cracks of deck slab are usually caused by drying/shrinkage and vehicular traffic load. The stages of development of cracks on deck slab are as follows:

Table 8-1 Cracking Deck Slab

	
① Good Condition	
	
② Transverse Crack	
	
③ Orthogonal Crack	
	
④ Alligator Crack	
	
⑤ Increasing Crack/ Water Penetration	
	
⑥ Spalling/Disintegration/Rebar Exposure/Rebar Crrosion	

(2) Concrete Girder

A crack is a linear fracture in concrete that extends partly or completely through the member. Cracks in concrete occur as a result of tensile stresses introduced in the concrete.

The severity of cracking is defined as follows:

Condition state 0 - Good **Hairline or no-crack**

Condition state 1 - Fair w ≤ 0.3mm, 1 direction

Condition state 2 – Poor w > 0.3mm to ≤ 1.0 mm, 2 directions

Condition state 3 - Bad w > 1.0 mm, 2 directions

Typical cracking patterns observed in RC structures and the typical cause of each type of cracking is illustrated in the following figures.

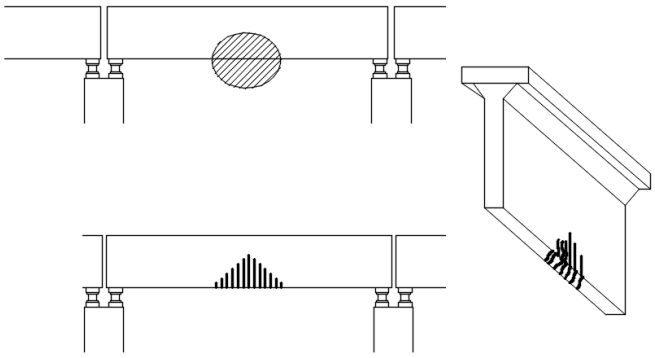


Figure 8-1 Flexural Cracking at Center Span of Span

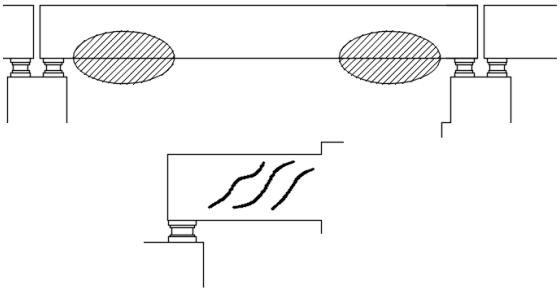


Figure 8-2 Shear Cracking at 1/4 of Span



Figure 8-3 Shear Crack in a Concrete Girder



Figure 8-4 Shear Crack near the Bearing

(3) Pier/Abutment

The pattern of the cracking to the compression faces of concrete abutments will give a clue as to its cause. Shrinkage cracks are usually vertical or near vertical and propagate from base (where the concrete is restrained) up towards the top of the stem where they tail off.

Horizontal cracking could indicate reverse bending due possibly to compaction of the soil by traffic on the approach to the abutment.

Vertical cracking near the top of abutments could indicate that there is insufficient reinforcement to contain the local bursting stresses at bearing positions.



Figure 8-5 Horizontal Crack in Pier Abutment



Figure 8-6 Vertical Cracks in Abutment Wall

Differential settlements can produce serious distress. These cracks are caused by settlement of the ground.



Figure 8-7 Vertical Cracking by Differential Settlement

(4) Wing Wall

Severe crack caused by earth pressure. Maximum crack width is 2mm.



Figure 8-8 Crack in Wing Wall

8-1-2 Spalling/scalling/disintegration

A spall is a fragment, which has been detached from a larger concrete mass. Spalling is a continuation of the corrosion process whereby the actions of external loads or pressure exerted by the corrosion of reinforcement results in breaking off the delaminated concrete. The spalled area left behind is characterized by sharp edges. Spalling may also be caused by overloading of the concrete in compression. This results in the breaking off of the concrete cover to the depth of the outer layer of reinforcement. Spalling may also occur in areas of localized high compressive load concentrations, such as at structure supports, or at anchorage zones in PC.



Figure 8-9 Spalling on Abutment

8-1-3 Delamination

Delamination is defined as a discontinuity in the surface concrete which is substantially separated but not completely detached from concrete below or above it. Visibly, it may appear as a solid surface but can be identified as a hollow sound by tapping. Delamination begins with corrosion of reinforcement and subsequent cracking of the concrete.



Figure 8-10 Delamination in Deck Slab

8-1-4 Rebar Exposure/corrosion

Corrosion is the deterioration of reinforcement by electrolysis. The alkali content in concrete protects the reinforcement from corrosion but when moisture, air/or chloride ions are dissolved in water and penetrate through the concrete to reinforcement this protection breaks down and corrosion starts. In the initial stages, corrosion may appear as rust stain on the concrete surface. In the advanced stages, the surface concrete above the reinforcement cracks, delaminates and spalls off exposing heavily rusted reinforcement.



Figure 8-11 Rebar Exposure in the Girder

8-1-5 Honeycomb

Honeycombing is caused by the improper or incomplete vibration of the concrete that results in voids being left in the poured concrete where the cement mortar failed to completely fill the spaces between the coarse aggregate particles.



Figure 8-12 Honeycomb in Deck Slab

8-1-6 Water Leakage

As a result of continuous progress of cracking, cracks penetrate slab thickness, then water leakage starts. The phenomenon is due to water passing through the concrete and dissolving constituent material such as calcium hydroxide at clacking location. The result is very unsightly causing staining, efflorescence, encrustation or at its very worst stalactites. It causes loss of alkalinity of the concrete which could lead to corrosion of the embedded reinforcement or prestressing cables.



Figure 8-13 Water Leakage from Some Holes for the Anchor Bolt

8-2 STEEL BRIDGE

8-2-1 Corrosion

Corrosion is the deterioration of steel by chemical or electro-chemical reaction resulting from exposure to air, moisture, industrial fumes and other chemicals and contaminants in the environment in which it is placed. The terms rust and corrosion are used inter-changeably in this sense. Corrosion, or rusting, will only occur if the steel is not protected or if the protective coating wears or breaks off.

Rust on carbon steel is initially fine grained, but as rusting progresses it becomes flaky and delaminates exposing a pitted surface. The process thus continues with progressive loss of section. Corrosion is very severe near sea shore due to wind-borne sea water spray.



Figure 8-14 Corrosion of Steel Member

8-2-2 Cracking (Fatigue)

Fatigue cracks may occur in the gusset plate and lateral member connection due to repeated vibrations.

A fatigue crack at bottom flange progresses to the web plate of the cross beam. It is caused by traffic load.



Figure 8-15 Cracking of Steel Member

8-2-3 Deformation/buckling

Permanent deformation of steel members can take the form of bending, buckling, twisting or elongation, or any combination of these. Permanent deformations may be caused by overloading, vehicular impact or damaged intermediate lateral supports or bracing.

Permanent bending deformation may occur in the direction of the applied loads and are usually associated with flexural members; however, vehicular impact may produce permanent deformations in bending in any other member.

Permanent buckling deformations normally occur in the direction perpendicular to the applied load and are usually associated with compression members. Buckling may also produce local permanent deformations of webs and flanges of beams, plate girder and box girders.



Figure 8-16 Deformation of Steel Member

8-2-4 Loose connection

Loose connections can occur in bolted or riveted connections; and, may be caused by corrosion of the connector plates or fasteners, excessive vibration, overstressing, cracking, or the failure of individual fasteners.

Loose connections may sometimes not be detected by visual inspection. Cracking or excessive corrosion of the connector plates or fasteners, or permanent deformation of the connection or members framing into it, may be indications of a loose connection.

A loose connection is susceptible to fatigue damage.



Figure 8-17 Loose Connection of Steel Member

8-2-5 Paint peel off

Condition of the protective system is the most common form of deterioration in structural steelwork. Both paint systems and galvanizing eventually deteriorate and areas of breakdown should not only record, but immediate action should be taken to prevent problem spreading.



Figure 8-18 Paint Peel Off of Steel Member

The picture below shows that the aluminum paint is almost entirely peeled off from the steel surface. Some percentage (%) of steel surface is damaged. Repainting should be done as soon as possible.

8-3 TIMBER BRIDGE

8-3-1 Decay/splitting/cracking

The main forms of biological defects are caused by fungi, termites and marine organisms. These defects are indicated by decay and deterioration thus, they reduce the structural strength of timber structures.

Fungal attack is characterized by discoloration or staining when mild but wood becoming soft and spongy when decay is more advanced. Decay can be found at locations where water could penetrate the members or where high moisture levels are encountered.



Figure 8-19 Decay of Timber Deck Slab

8-3-2 Disconnection

The timber deck is structurally very weak after decay, splitting and cracking. Disconnection in timber deck will occur due to traffic load.



Figure 8-20 Disconnection of Timber Deck

8-4 MASONRY BRIDGE

8-4-1 Fretting/abrasion

Constant daily variations of temperature and the seasonal variations of ambient temperature, rain and wind can seriously weaken the structure by gradual erosion of the masonry. Arches constructed of 'soft' rock such as sandstone and jointed with lime mortar, can suffer to such a degree that often an outside layer of rock has eroded leaving the hard lime mortar joints still in place. Fretting or abrasion occurs at the side of arch wall.



Figure 8-21 Fretting/Abrasion of an Arch Bridge

8-4-2 Material loss/disintegration

The masonry arch material is detached due to compressive stress.



Figure 8-22 Material loss of an Arch Bridge

8-5 BAILEY BRIDGE

The paint of the lower chord is severely peeled off. Total repainting should be done as soon as possible so that the bridge' service life can be extended to another decade.



Figure 8-23 Corrosion of a Bailey Bridge

8-6 BEARING

8-6-1 Rubber Type

Bearing pads are a type of free bearing device, made of rubber-like (elastomer) material, molded into rectangular pads or strips. When placed beneath a beam, they permit the beam to undertake longitudinal movements and rotations.

(1) Bulging

Neoprene bearings are subject to tearing, bulging and cracking, particularly in hot climates which affect the properties of the elastomers and, in extreme situations, this can cause complete failure of the bearing. Bulging occur due to aging and contamination.



Figure 8-24 Bulging Bearing

(2) Abnormal displacement

Abnormal displacement may indicate overloading or unevenness of loading.

Sometimes creep or drying shrinkage provokes to tear the rubber pad.



Figure 8-25 Abnormal Displacement of Bearing

(3) Bed (support) damage

Bed Damage may occur subsidence of bearing and frequently accompanied by other damage of the main part such as crack, subsidence, and anchor-bolt. Once crack occur at the support, leakage cause to rust. (See 8.6.2 (5)).

8-6-2 Steel Type

Metal bearings are fixed in the vertical plane, but in the horizontal plane they may be fixed (no translational movement), guided (unidirectional movement) or free (universal movement).

(1) Corrosion

The Bearing tends to corrode because it is installed in bad condition, humid by water leakage from expansion joint or deposit sand.

Photograph shows heavy rust of steel bearing.



Figure 8-26 Corrosion of Steel Bearing

(2) Loose Connection

Loose connection is caused by many years of vibration of girder or pier. Where the bearings have to resist uplift force, each anchor bolt should be stuck with a heavy hammer to determine if it has been sheared off.

(3) Abnormal Displacement

Incorrect installation procedures lead to failure of bearing. Photograph sows the girder end is not resting on the bearing anymore.



Figure 8-27 Abnormal Displacement at a Support

(4) Paint Deterioration

This red color paint is primer only. Original paint had already peeled off.

(5) Bed (Support) Damage



Figure 8-28 Paint Deterioration of Bearing



Figure 8-29 Bed Damage

8-7 FOUNDATION

Bridge foundations situated in river beds can be susceptible to erosion of the river bed during periods of flooding or simply by attrition over a long period of time under normal flow conditions.

8-7-1 Tilt/settlement

Causes of movement are mining subsidence; 'soft' spots in the subsoil; seasonal changes in the water table and more drastically, earthquakes. Such movements cause cracking and spalling of the concrete, and usual movements of bearings and expansion joints. Inspection in such cases requires the use of accurate survey in equipment to establish the change in geometry of the structure, followed by a close examination of any structural damage and material degradation.



Figure 8-30 Tilt of Pier

If settlement is a problem, boreholes can be made to examine the current nature of the subsoil and to compare it with that assumed in the design. Appropriate remedial works can then be put in hand.

Pile has settled due to impact force. Abutment settled due to earth pressure.



Figure 8-31 Tilt of Pier Due to Collision



Figure 8-32 Settlement of Abutment

8-7-2 Scouring

Scour is the single most common form of bridge failure. The failure was due to scour around the central pier which subsided and initiated progressive collapse of the complete bridge. Pile foundation is severely scoured.



Figure 8-33 Scouring at Abutment

8-8 SLOPE PROTECTION

8-8-1 Concrete Masonry, Grouted Rip Rap

(1) Cracking

This defect is caused by the factors affecting the stability of a masonry structure which include:

- Differential settlement across an abutment which may cause longitudinal cracks along the masonry.
- Movement or settlement of the foundations of an abutment which may cause transverse cracks across the masonry structure and settlement in the roadway.
- Outward movement of the spandrel walls due to lateral pressure which may cause longitudinal cracking near the edge of the arch.
- Settlement at the sides of an abutment which may cause diagonal cracks from the side extending to the center at the crown of the arch.
- Movement of wing walls which may cause cracking and loss of the road surfacing materials.

(2) Bank erosion

The soil materials are completely washed out by flood.



Figure 8-34 Bank Erosion

(3) Slope erosion

Slope protection is completely eroded by flood.



Figure 8-35 Cracking in Slope Protection

(4) Material loss/disintegration

The soil materials are washed out from back of parapet.



Figure 8-36 Slope Protection Erosion

8-9 BRIDGE APPROACH

8-9-1 Depression

Depression occurred due to sinking of approach road.



Figure 8-37 Approach Depression

8-10 EXPANSION JOINT

Expansion joints are probably the most vulnerable parts of a bridge, exposed as they are to direct impact loads from traffic; effects of the environment such as severe temperature changes, UV light from the sun. In generally, the average service life of such joints is about 10 years.

8-10-1 Steel Type

(1) Water Leakage

This can occur for a number of reasons, the most common of which are:

- faulty or poor central reserve, kerb or footway details,
- over stretching of the insert
- seepage of water under the cast-in rails,
- seepage of water through or under the joint where it was bonded to the deck suggesting either that secondary waterproof membrane had failed, or that it did not exist in the first place.

Leakage tends to be localized, and this is borne out by the many unsightly streaks and stains down abutments and piers.



Figure 8-38 Water leakage from Expansion Joint

(2) Abnormal space/noise

If the joints have been incorrectly set at the construction stage, then they may over stretch in cold weather (causing cracking and/or tearing, and constituting a hazard to traffic) or jam tight in hot weather (causing crushing of the surfacing and deck).



Figure 8-39 Abnormal Space

(3) Difference in elevation

Difference in elevation at expansion joint due to bearing problems.



Figure 8-40 Difference in Elevation

(4) Displacement

Displacement due to direct impact loads from traffic. It cause to accident.



Figure 8-41 Displacement of Cover Plates

(5) Cracking

Cracking or breaking of other defective details, such defects may not only cause structural damage but may loosen-up and create a hazard to traffic.

Cracking and spalling at kerb.



Figure 8-42 Cracking at Kerb

8-10-2 Rubber Type

(1) Water Leakage

Deteriorated rubber sealant cause leakage just like a steel type. (See 7.10.1 (1).)



Figure 8-43 Water leakage Due to Deteriorated Rubber Sealant

(2) Abnormal space/noise

The rubber surface type is often fixed by anchor bolts and nuts (lateral type) due to its structural characteristics. These bolts and nuts can be loosened after the long period of service and the noise and vibration problems sometimes happen inevitably.

(3) Difference in elevation

As the amount of expansion becomes longer, rubber is apt to swell in summer when the girder is extended.



Figure 8-44 Difference in Elevation

(4) Rupture

The demerit of the rubber surface type is the wear and the rubber cuts. Generally speaking, the rubber surface type is less durable than the metal surface type. Rubber joint is severely deteriorated and has ruptured in some places.



Figure 8-45 Rupture

8-11 ASPHALT SEALANT

(1) Water Leakage

Asphalt sealant is intact to prevent water leakage, and is used to short span.

And seals are intended to keep out sand, dirt, and stones.



Figure 8-46 Missing Sealant (Cause of Water Leakage)

(2) Abnormal space/noise

Concrete gap is too wide. Edge of concrete is broken due traffic load,



Figure 8-47 Abnormal Space

(3) Difference in elevation

The expansion joint is designed for horizontal movement, but it moved in vertical direction which is abnormal.



Figure 8-48 Difference in Elevation

(4) Deteriorated sealant

This is where the joint material separates from the adjacent surfacing, and is closely associated with cracking. In severe cases where there is substantial cracking it is possible for the joint to separate from the substrate posing a danger to users.



Figure 8-49 Deteriorated Sealant

8-12 RAILING

8-12-1 Impact/Accident damage

Sometimes accidental damage of the railing occurs.

Make a note if a part of the bridge next to the railing is also damaged. For steel railings, look at holding down bolts at post bases, joints in rails, and joints between rails and posts



Figure 8-50 Accidental Damage of Railing

8-13 ASPHALT WEARING SURFACE

8-13-1 Potholes

Potholes occur for several reasons, shortage of asphalt material, excessive heating, deficient mixture, penetration of water, deficient compaction, impact for traffic load.



Figure 8-51 Potholes of Asphalt Surface

8-13-2 Shoving

Indent of part of the asphalt surface due to heavy load.

8-13-3 Rutting

Rough surface for bridge axis occur due to traffic load, temperature, wear. It cause surface ponding and debase abrasion resistance.

8-13-4 Cracking

Crack occurs for several reasons such as temperature stress, defective construction work.



Figure 8-52 Cracking of Asphalt Surface

8-13-5 Raveling

Aggregate leave asphalt surface and become wasting surface for the separation of mortar.



Figure 8-53 Ravelling of Asphalt Surface

CHAPTER 9 SPECIAL BRIDGE INSPECTION

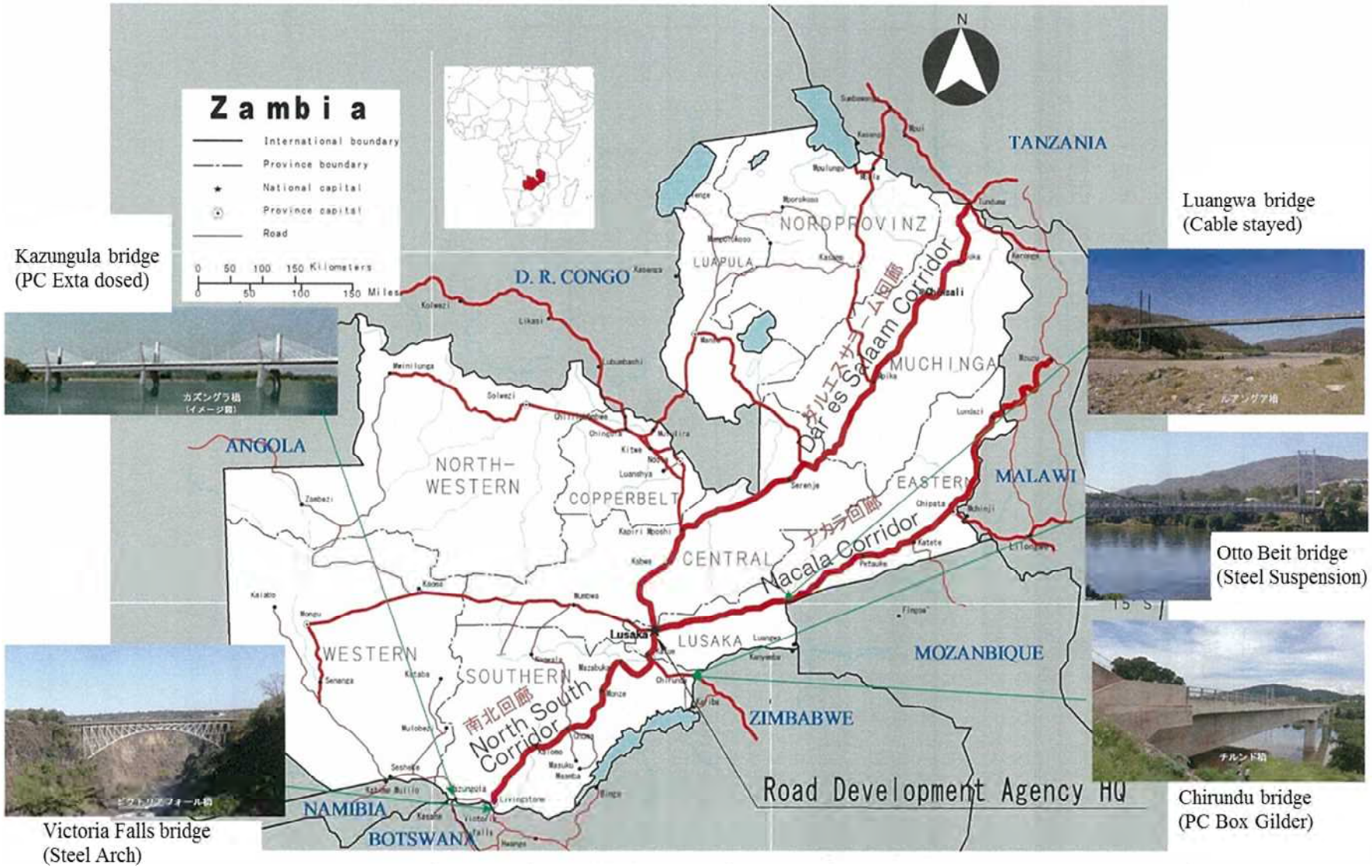
9-1 General

At first, what is called a Special Bridge is defined as being very big and complicated structure, and differ from standard bridges in that its behavior of force. In case of PC Box Girder Bridge, when one of the span of the bridge exceed 60m, the bridge is classified as a special Bridge. Whereas in the case of Steel Arch Bridge, Extradosed Bridge, Cable stayed Bridge and Suspension Bridge, every bridge falls under the category of Special Bridge. Special bridges in Zambia are shown table below. Map of Zambia and locations of these special bridges are shown next page.

Type of bridge	Requirement
Prestressed Concrete Box Girder Bridge	Longest span>60m
Steel Arch Bridge	Every bridge
Prestressed Concrete Extradosed Bridge	Every bridge
Cable Stayed Bridge	Every bridge
Suspension Bridge	Every bridge

Name	Architectural Style	Total Length	Features that includes Year of Opening, Location etc.	Picture of the bridge
Victoria Falls bridge	Steel Arch Bridge	250m	・Opened in 1905 ・Multi-purpose bridge (Road and Rail) ・Carries between Zambia and Zimbabwe	
Luangwa bridge	Cable-Stayed Bridge	302m	・Opened in 1968 ・Originally 2 Lanes but temporarily available one-sided lane due to road damages ・Limited capacity of less than 50tons ・Steel Box-Girder is drooping	
Chirundu bridge	PC box-girder Bridge	400m	・Opened in 2002 with the financial aid of Japan ・2 Lanes for large vehicles ・Replaced Rubber Support in 2015with the financial aid of Japan ・Carries between Zambia and Zimbabwe	
Otto Beit bridge	Steel Suspension Bridge	382m	・Opened in 1939 ・Designed by Englishman, Otto Beit ・2 Lanes for standard-sized passenger car ・Seriously damaged cables ・Carries traffic between Zambia and Zimbabwe	

Kazungula bridge	PC Extra-dosed Bridge	923m	・Scheduled to be completed in 2021 ・Multi-purpose bridge (Road and Rail) ・Scheduled to carry between Zambia and Botswana	


Zambia
International boundary
Province boundary
National capital
Province capital
Road
0 50 100 150 Kilometers
0 50 100 150 Miles
N
TANZANIA
D. R. CONGO
ANGOLA
NAMIBIA
BOTSWANA
ZIMBABWE
MOZANBIQUE
MALAWI
NORDPROVINZ
LUAPULA
MUCHINGA
EASTERN
NORTH-WESTERN
COPPERBELT
CENTRAL
LUSAKA
SOUTHERN
WESTERN
Lusaka
Dar es Salaam Corridor
ダルエスサラーム回廊
Nacala Corridor
ナカラ回廊
North South Corridor
南北回廊
Road Development Agency HQ
Kazungula bridge
(PC Exta dosed)
Luangwa bridge
(Cable stayed)
Otto Beit bridge
(Steel Suspension)
Victoria Falls bridge
(Steel Arch)
Chirundu bridge
(PC Box Gilder)

CHAPTER 9-1 PC Box-Girder Bridge

9-1-1 Bridge Inventory

9-1-1-1 Type of Special Bridge

PC BOX Bridge

Pre-stressing method is used in the concrete structure to counteract tensile stress by introduction of compressive force/stress. In the case of pre-stressed concrete, pre-stressing cables are used to provide compressive stress that balances the tensile stress in concrete members to overcome natural weakness in tension of concrete. PC bridge type is appropriate for long spans due to this attribute. Tension in cable and compression in concrete are the most important forces to keep a structure in a stable condition.



Figure 1-1-1 PC BOX Bridge

9-1-1-2 Bridge Component

PC bridges are appropriate for long spans. Tension in cable and compression in concrete are the most important forces to keep a structure at a stable condition.

PC bridges classify method into two types, inner cable or outer cable. Inner cable method is common and Chirundu Bridge is only inner cable.

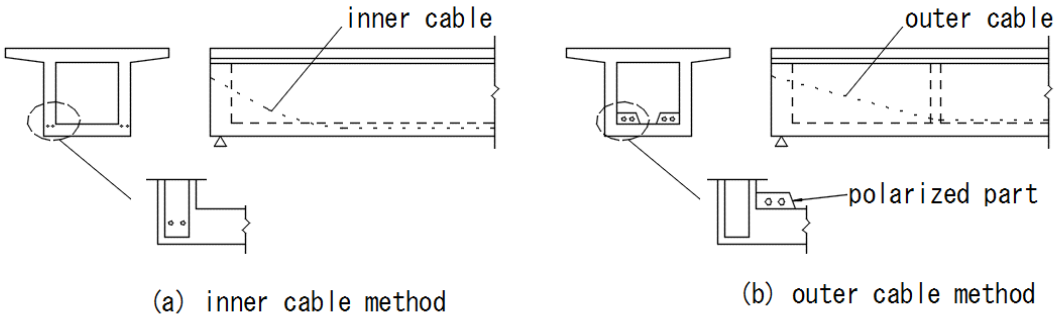


Figure 1-1-2 Bridge Component (PC Box)

9-1-1-3 Bridge Geometry Definition

The bridge is assessed in the direction of increasing chainage. Refer to Figure 1-1-3

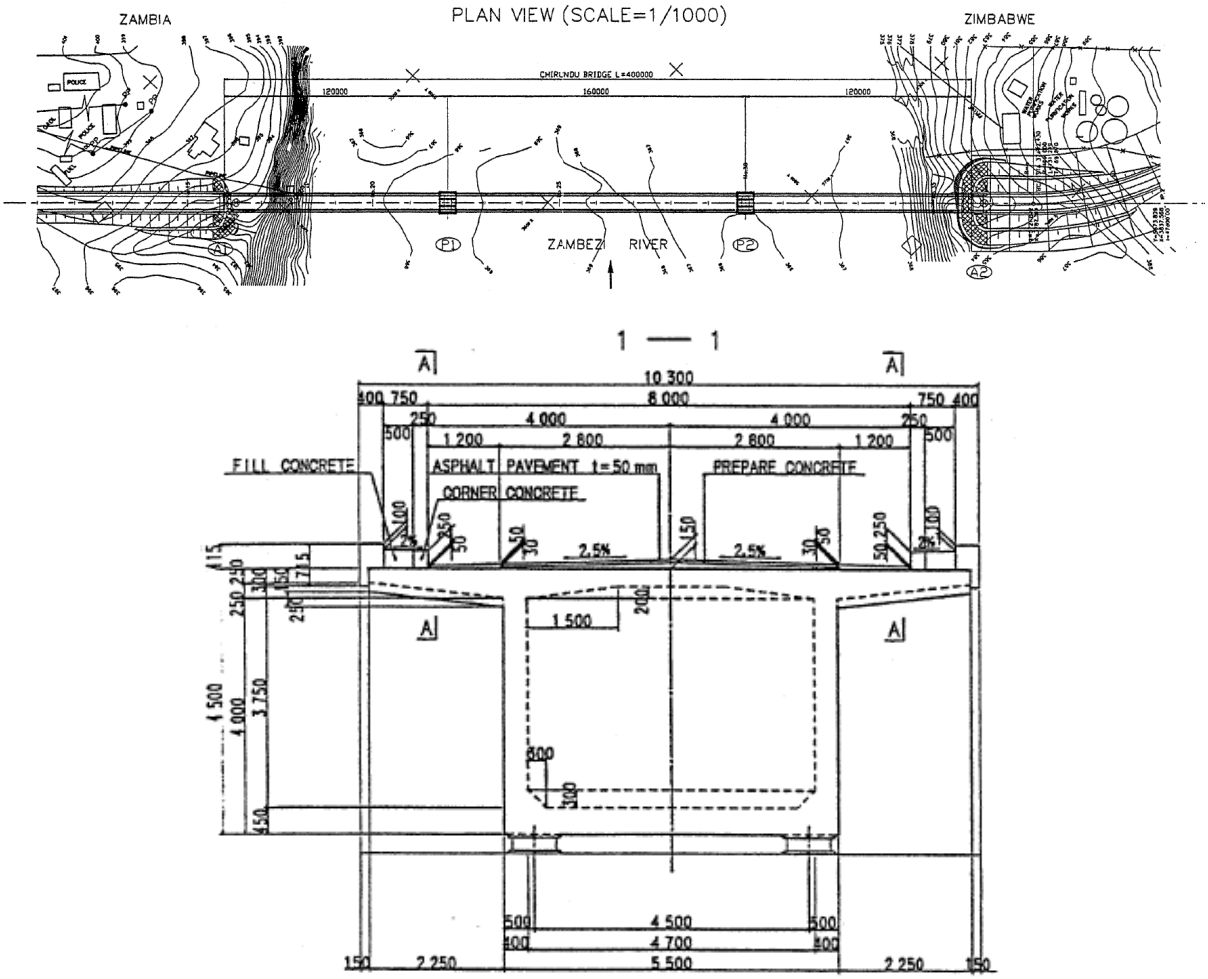


Figure 1-1-3 Bridge Geometry Definition

The following standard abbreviations are adopted to describe the bridge:

ZMBS	-	Zambian Side
ZIMS	-	Zimbabwean Side
S	-	Span
P	-	Pier
A	-	Abutment
G	-	Girder (Left side girder, right side girder, bottom girder)

Example, a three (3) span bridge with 4 girder in each span:

・Abutment 1 (A1) is at Zambian side end of the bridge and Abutment 2 (A2) is at Zimbabwean side end.

・Spans 1 (S1), 2 (S2) and 3 (S3) numbered from Zambian side end of the bridge.

・Pier 1 (P1) and 2 (P2) numbered from Zambian side end of the bridge.
・Chirundu Bridge is a box girder bridge and its girders are classified left side girder, right side girder and bottom girder. Accordingly Left side girder (LG), Right side girder (RG) and Bottom girder (BG). Left and right side is determined by looking at the Zimbabwe side from the Zambian side.
・The girder on the extreme left in span 2 is designated as Span 2 – (S2LG)

Concrete is a mixture of cement, water and aggregates. It is resistant to compression and weak in tension. Concrete is classified as plain concrete, reinforced concrete and pre stressed concrete.

・Plain Concrete (only concrete): concrete is very weak against tensile force.
・Reinforced Concrete (concrete with rebar): Reinforced concrete has reinforcement bars to improve the tensile strength of concrete.
・Pre-stressed Concrete : Reinforced by introduction of pre-stress. And suppress cracking.

RC means "Reinforced Concrete" and it contains "steel bars / rebar (reinforcement bar)". Combination of concrete and steel bars works very well, as concrete is strong in compression and steel is strong in tension.

Steel bars compensates for the concrete that is vulnerable to tensile forces, and the concrete compensates for the steel bars that are vulnerable to compressive forces. Alkaline concrete covers the easily oxidized steel bars. Besides, these two materials show similar elongation and shrinkage behaviors under heat. In other words, they can be said to reinforce each other's weaknesses.

On the other side, PC stands for "Pre-stressed Concrete". In general, the weakness of concrete, which is vulnerable to tension, can be strengthened by the compressive force exerted by PC steel.



Constituents of Concrete

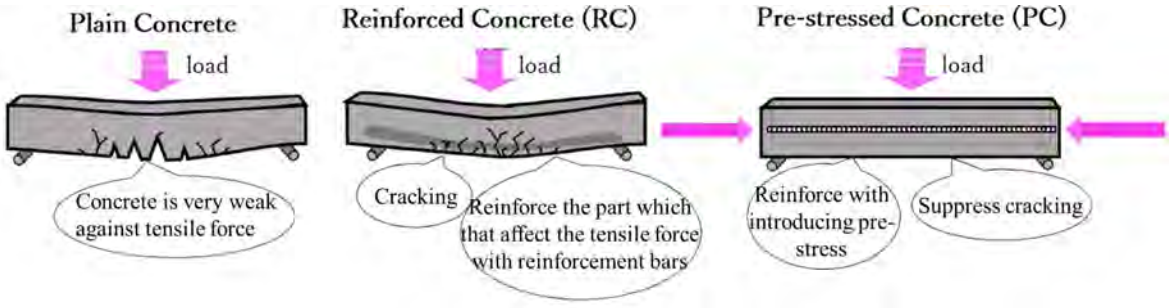


Figure 1-1-4 PC structure

Pre-stressing method is used in the concrete structure to counteract a tensile stress by introducing compressive. In the case of pre-stressed concrete, pre-stressing cable is used to provide compressive stress that balances the tensile stress in concrete members to overcome the natural weakness in tension of concrete. Tension in the cables and compression in concrete are the most important forces to keep a structure at a stable condition.

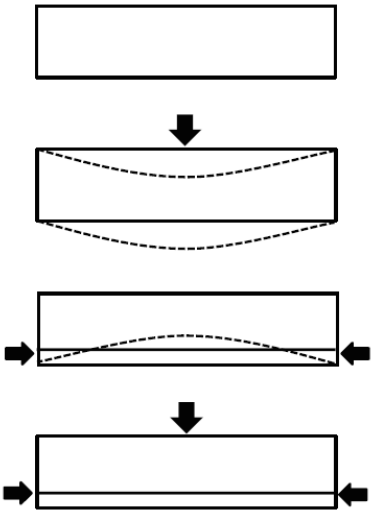


Figure 1-1-5 Function of Pre-stressed Concrete

Shown in Figure 1-1-6, 1-1-7 and 1-1-8 are the General Views of Chirundu Bridge.

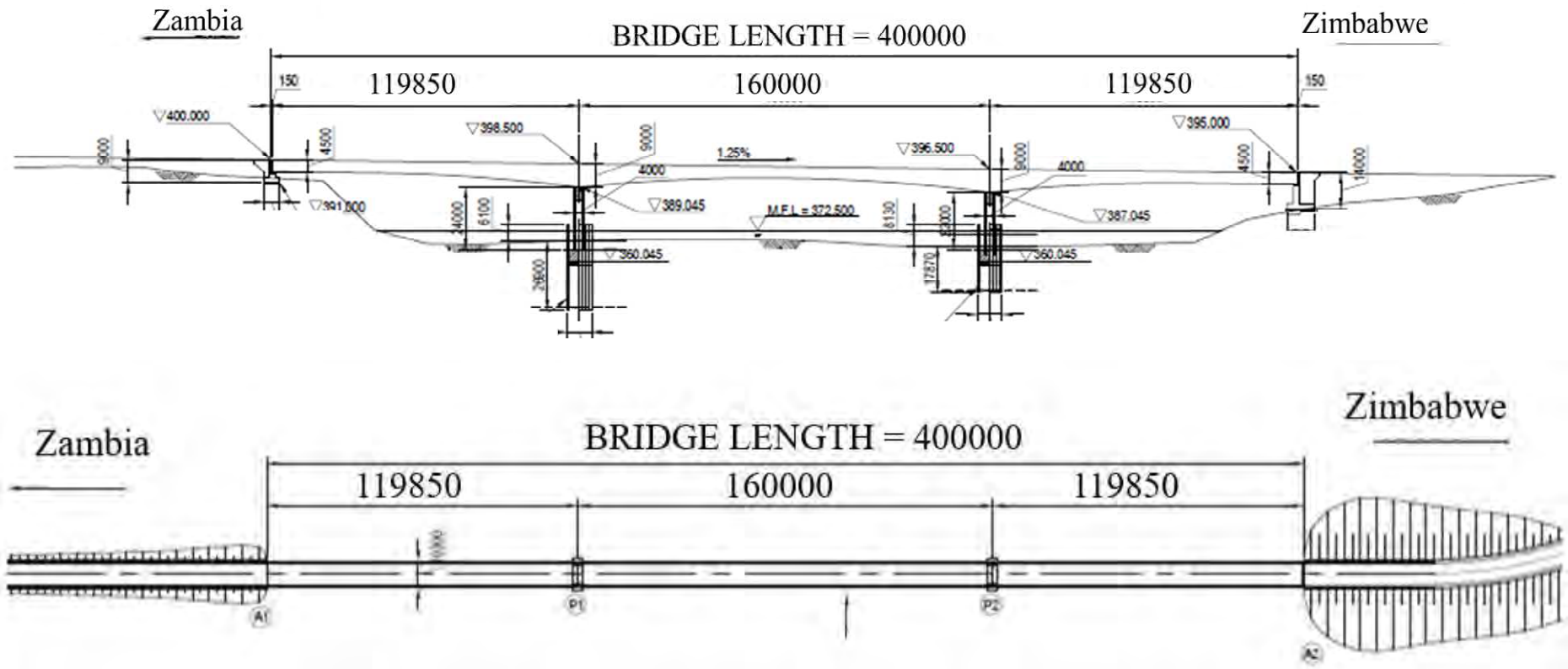


Figure 1-1-6 General View of Chirundu Bridge (1 of 3)

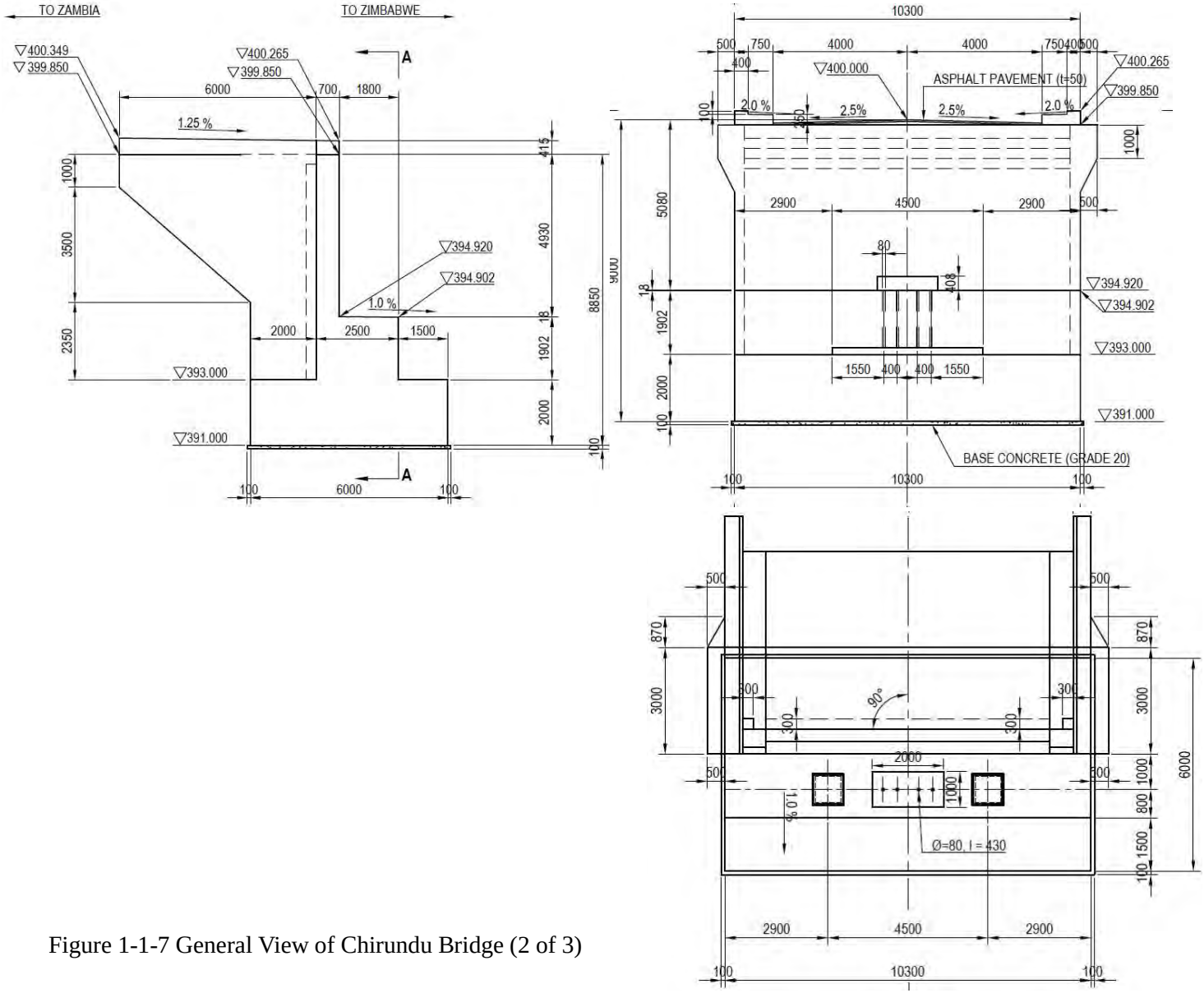


Figure 1-1-7 General View of Chirundu Bridge (2 of 3)

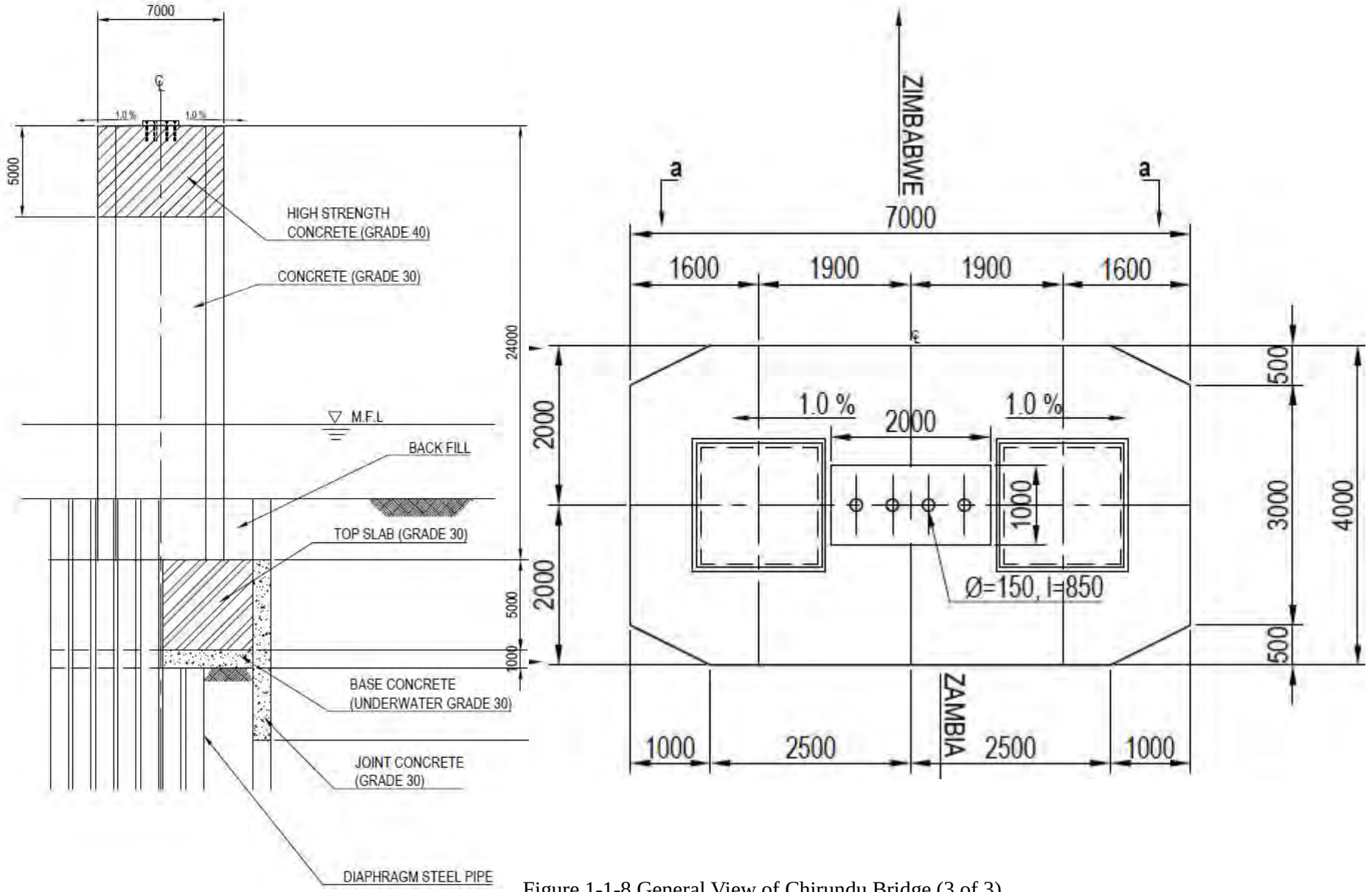


Figure 1-1-8 General View of Chirundu Bridge (3 of 3)

9-1-2 Inventory Inspection

Inventory Inspection for standard bridges is described in CHAPTER 4, and this chapter describes the Inventory Inspection for special bridges.

9-1-2-1 Purpose and process

The purpose of the Inventory Inspection for special bridge is to obtain its inventory data primary for inclusion in the BMS database. Bridge inventory data is a standard series of information that describes the geometry, construction and current function of a bridge.

The Inventory Inspection for the Special Bridge is similar to the inventory inspection of standard bridges.

9-1-2-2 Procedure

All information collected during the bridge inventory inspection is recorded using the Inventory Inspection Form (IIF). The IIF of Chirundu bridge is included in Appendix A-1-1.

The IIF is composed of two parts for the Special Bridge Inventory:

Part I Standard inventory sheet is the same sheet with ordinary bridges in BMS.

・Inventory Inspection Form.

・The special requirements for inspection

・The general bridge data, clearances, geometry, traffic direction, type of bridge, year of construction, public utilities carried by the bridge and detail, if there is lighting provided on the bridge, the type of terrain where the bridge is located, comments if the bridge is unusual, type of construction, substructure type, deck material, wearing surface, drainage, design load and the available drawings.

・The bridge Modification Sheet describes the types and materials of any modifications to the bridge.

・The span/s of the bridge

・The pier/s of the bridge.

・The bridge abutments.

Part II Additional geometrical data sheet for Special Bridge

・Measurement of bridge structure (superstructure and substructure)

As built Drawing are very important for special bridges. There is no standard drawing special bridge. Each bridge has its own unique structure. “As Built Drawing” should be collected and the electronic copies should be installed in the Special Bridge Inventory Database, as one of Inventory Inspection data. In case that there is no available bridge data, measurement survey on site for collecting basic bridge data and general drawing for inventory should be done. All documents

pertaining to the past repair works and useful information are also important for future reference, especially when the bridge is due for retrofitting.

9-1-2-3 Description

The Chirundu Bridge is located between Zambia and Zimbabwe across the Zambezi River, and it is along the one of the biggest economic corridors, which passes through South Africa, Mozambique, Zimbabwe and Zambia. The bridge, which is 40 meters long and 10.3 meters wide, was funded and constructed by the Japanese government in 2002. It is a three-span, continuous, pre-stressed box girder bridge and has two lanes.

The Chirundu Bridge is a highly significant transport infrastructure for socio-economic development of both countries. Over 300 trucks pass through this bridge everyday transporting materials vital to economic growth of the two countries. It is also imperative to note that the Chirundu border post is a model One-Stop Border Post facility that has made international passage between Zambia and Zimbabwe efficient. Therefore, the Chirundu Bridge has also facilitated the effectiveness and efficient operations of the OSBP which accounts for about 20% of taxes collected by Zambia Revenue Authority; and this is ideally channeled back to improve national infrastructure and social services like health and education. With the support and cooperation of the Government of Zambia and the Government of Zimbabwe, rehabilitation works were successfully conducted in July 2015.



Figure 1-2-1 Photo of Chirundu Bridge

9-1-2-4 Inspection Form

The bridge Inventory Inspection Form (IIF) and attached drawings are prepared specifically for Chirundu Bridge as shown in Appendix A-1-1.

9-1-2-5 Location and Inventory Data Collection

The bridge inspector shall inspect the bridge and complete the Location and Inventory sections of the IIF. This can generally be completed by checking the appropriate box and by inserting the required names and numbers.

Several parts of the IIF can be completed even without having to go to the bridge site. Note, however, that all data shall be verified on site.

Data needed for Location and Geographic Information are described in Table 1-2-1.

Table 1-2-1 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

The bridge inspector shall take note of any paticular requirements to gain access or to inspect all parts of the bridge for use in the planning of future bridge condition inspections. Check the appropriate boxes in Special Inspection Requirements, for items such as ladders, inspection vehicles, boats, etc.

A bridge is made up of various inventory elements;

- General,
- Modifications,
- Spans,

・Piers,
・Abutments.

9-1-2-6 Deliverables

The deliverables of Inventory Inspection Report are as follows.

・The Bridge Inventory Reports
  - A fully completed Bridge Inventory Inspection Form (IIF)
  - Geometrical data sheet for Special Bridge
・As Built Drawings
・Data of repair history
・Inventory photographs

The Bridge Inventory Inspection Reports shall be prepared by the bridge inspectors. The reports shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization. When the Bridge Inspection Report is completed, accurate and accepted, all the data shall be stored in the BMS.

9-1-3 Periodic Inspection

Periodic Inspection for standard bridge is described in CHAPTER 5, and this chapter describes the Periodic Inspections for special bridges.

9-1-3-1 Purpose

The purpose of the Periodic Inspection is to record defects and rate the condition of special / long span bridge as a basis for identifying its current maintenance needs, forecasting its future intervention measures and estimating its future funding requirements. Also, the result of Periodic Inspection should be used to monitor the deterioration of defects.

9-1-3-2 Scope of Inspection

The scope of the periodic inspection for special bridge is almost the same as standard bridge, and in addition below.

- Reviewing the existing inventory data of the bridge structure for accuracy
- Visually inspecting the bridge attributes and record their defects to assess their condition using a standard condition rating system.
- Sketch drawings to monitor the progress and deterioration of defects
- Reporting the condition of each bridge attributes
- Providing a general condition rating for the structure as a whole.
- Identifying bridges that require an Detailed inspection (those with an overall condition state poor or bad)
- A photographic record of defects

In Periodic Inspection, the inspector should record all details of defects for assessment of bridge condition using a standard condition rating system and also for the monitoring of progress and deterioration of defects. Therefore, each attribute of the bridge shall be inspected at a distance at least three meters from the surface of the attributes or its equivalent, using binocular as much as possible.

All surfaces of the attributes shall be exposed in good natural or artificial light during the inspection, sufficient to observe fine cracks and other defects on the surfaces. Bearings at the abutments and piers shall be inspected at eye level. The inside of box girder shall also be inspected closely. The bridge inspection is done visually to cover all parts of the bridge above the ground and water level.

Sketch drawings in Periodic Inspection is very important for the analysis of bridge condition and for the monitoring of deterioration of defects. Inspector should sketch carefully the details of defects. Sketch drawing of defects should include the range, length, area and severity of defects as

much as possible. When inspectors cannot possibly measure the defects, they can roughly estimate measurement through their engineering judgement. If a previous Detailed Inspection Report is available, the findings on the report will be used in the next Periodic Inspection to verify whether these findings remain valid.

9-1-3-3 Process

The step-by step procedure for conducting the Periodic Inspection is illustrated in the following flowchart.

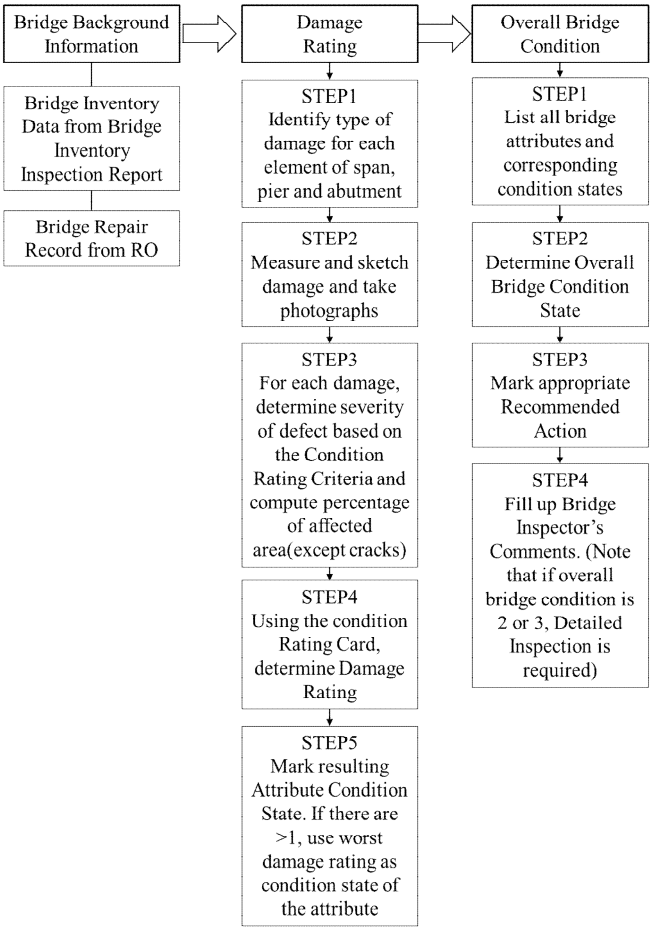


Figure 1-3-1 Flowchart of Bridge Periodic Inspection

9-1-3-4 Inspection route and the points of inspection

【Periodic Inspection Form (PIF)】

As a reference, Periodic Inspection Forms (PIF) and sketch Drawings of Chirundu bridge are shown in Appendix A-1-2.

The bridge Periodic Inspection Routes of Chirundu Bridge are shown in Figure 1-3-2, 1-3-3 and 1-3-4, and the Check Points of the Periodic Inspection are shown in Figure 1-3-5 and 1-3-6.

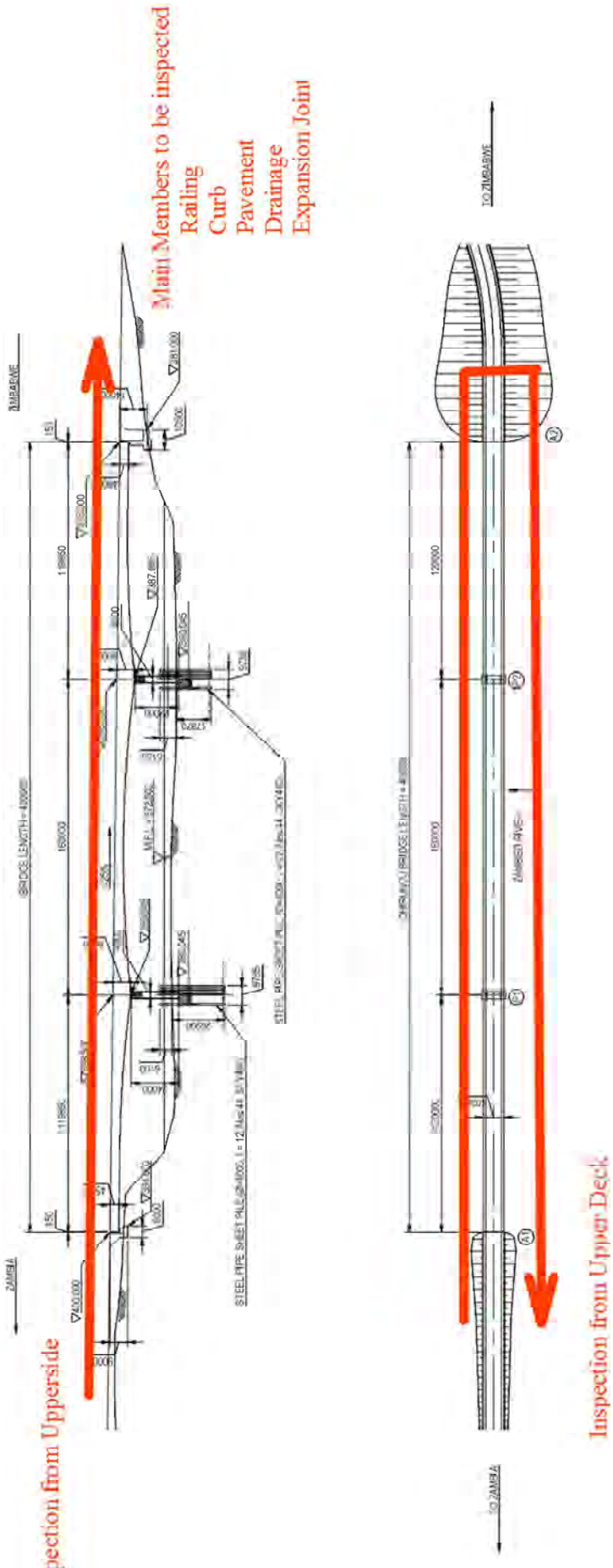


Figure 1-3-2 Periodic inspection route (1of 3)

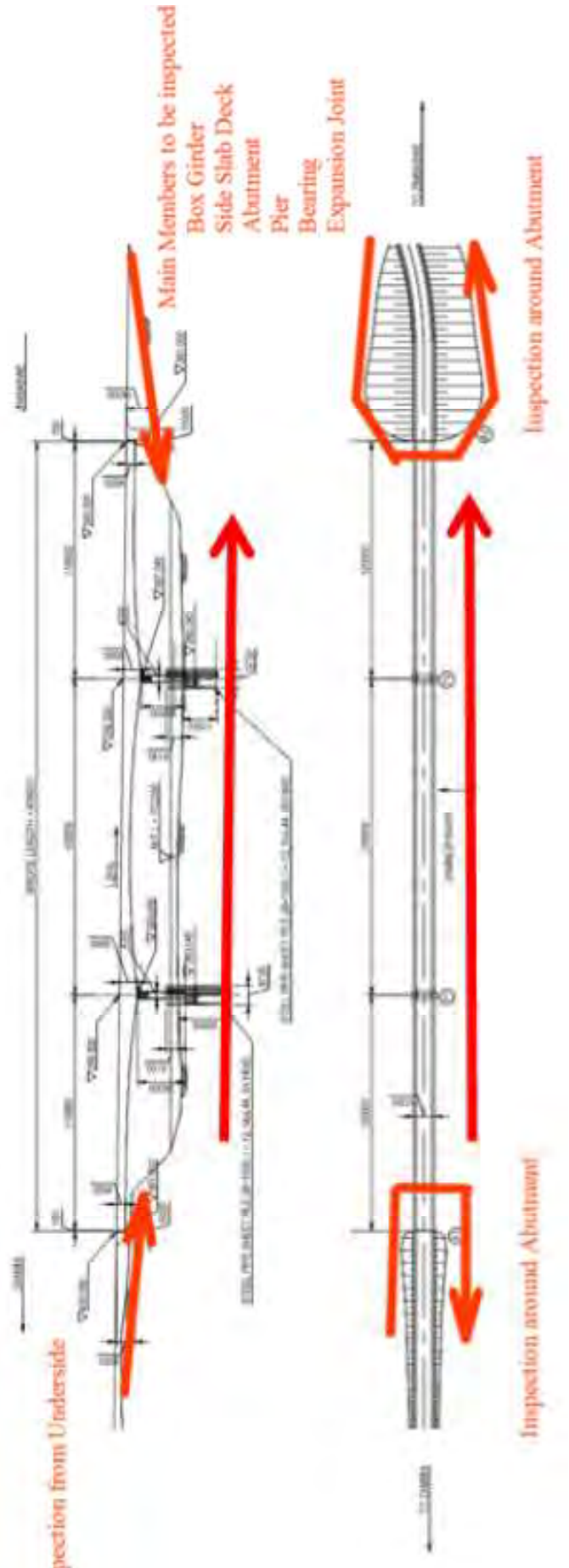


Figure 1-3-3 Periodic inspection route (2of 3)

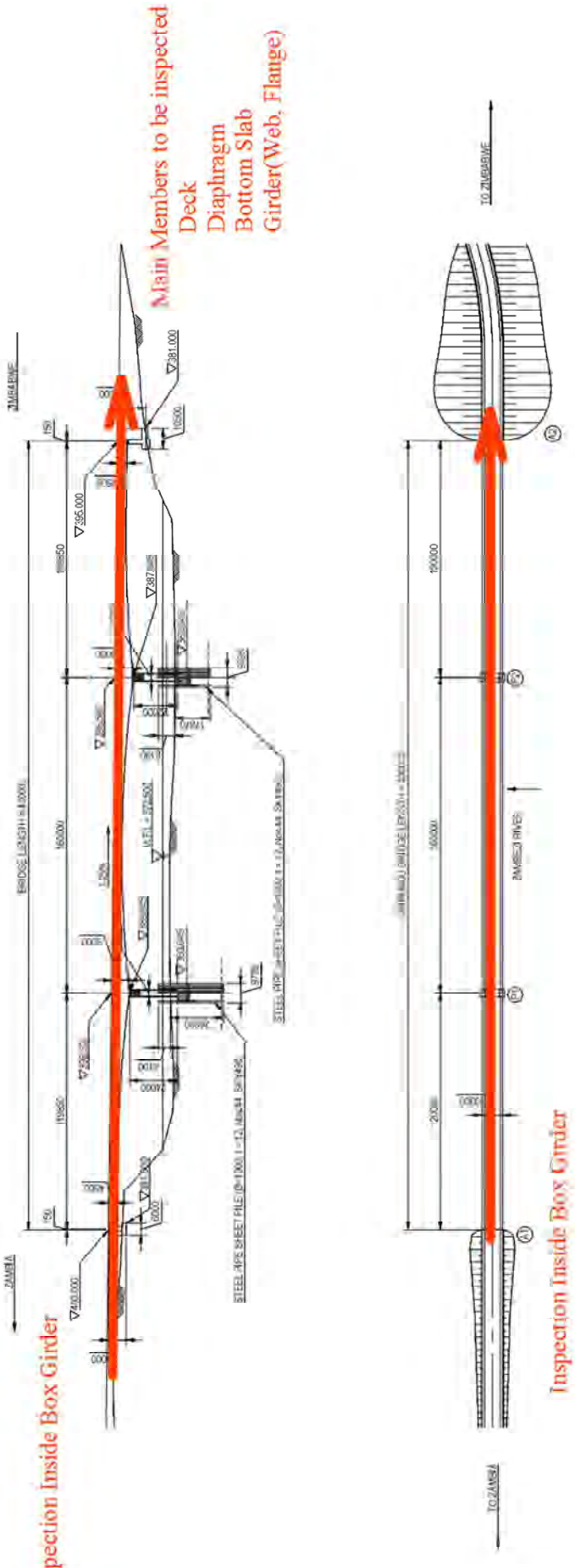
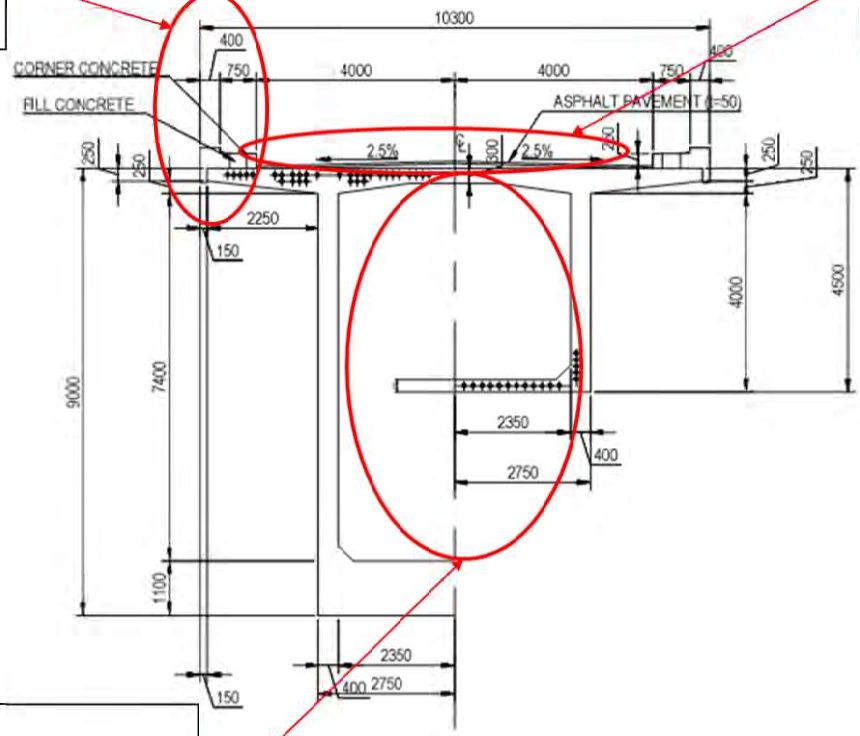


Figure 1-3-4 Periodic inspection route (3of 3)

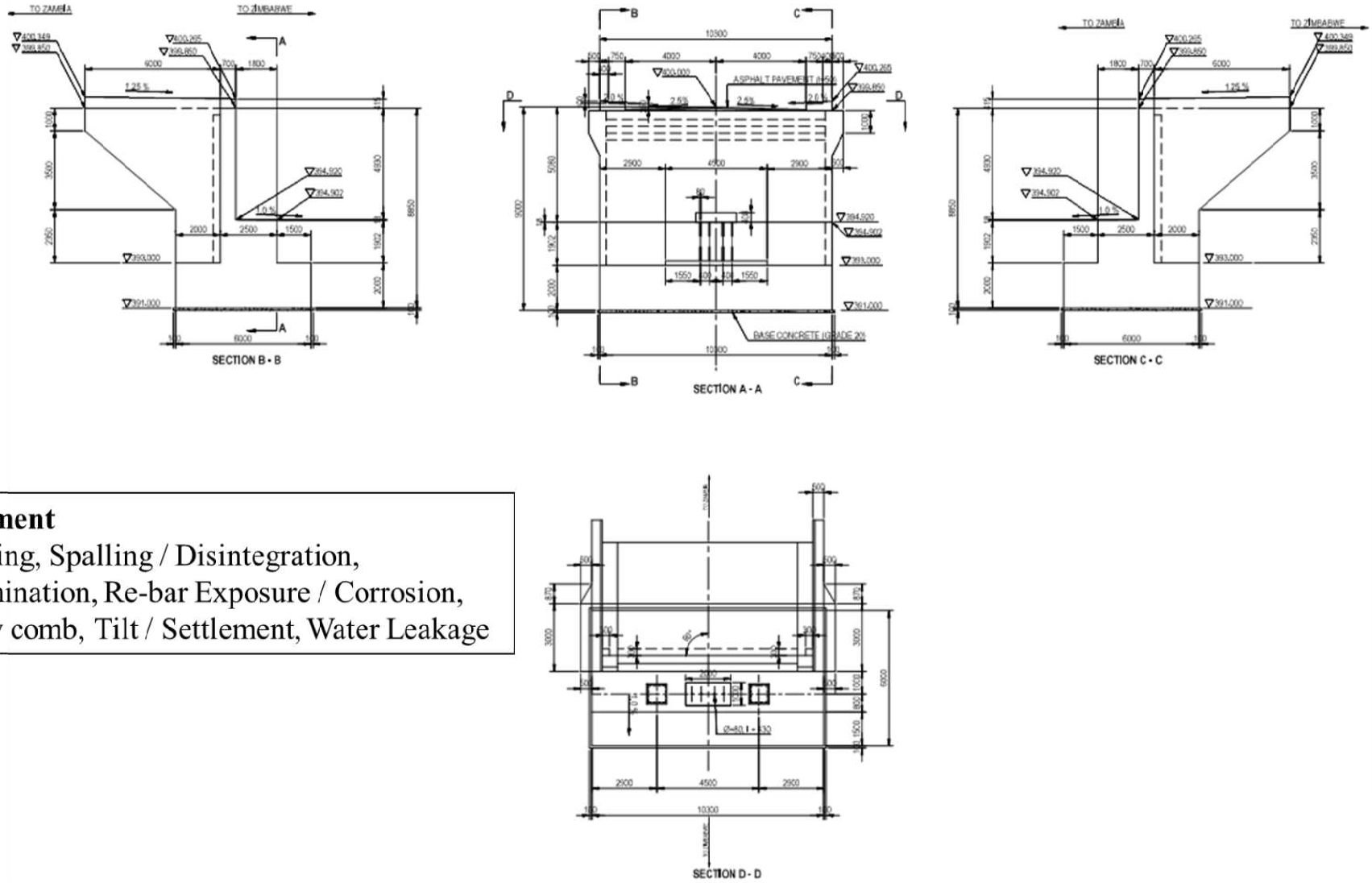
Railing
Impact/Accident Damage,
Missing rails, Rebar Exposure

Asphalt Wearing Surface
Potholes, Waving
Rutting, Cracking, Raveling



Inside / Outside of Box Girder / Buried Anchorage Area
Cracking, Spalling / Disintegration
Delamination, Re-bar Exposure / Corrosion,
Honeycomb, Water Leakage

Figure 1-3-5 Check point of the periodic inspection (1of 2)



Abutment

Cracking, Spalling / Disintegration, Delamination, Re-bar Exposure / Corrosion, Honey comb, Tilt / Settlement, Water Leakage

Figure 1-3-6 Check point of the periodic inspection (2of 2)

【Location and Inventory Data】

The bridge inspector shall inspect the bridge and review the Location data included in the PIF. Data required are described in Table 1-3-1.

Table 1-3-1 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

【Repair Record】

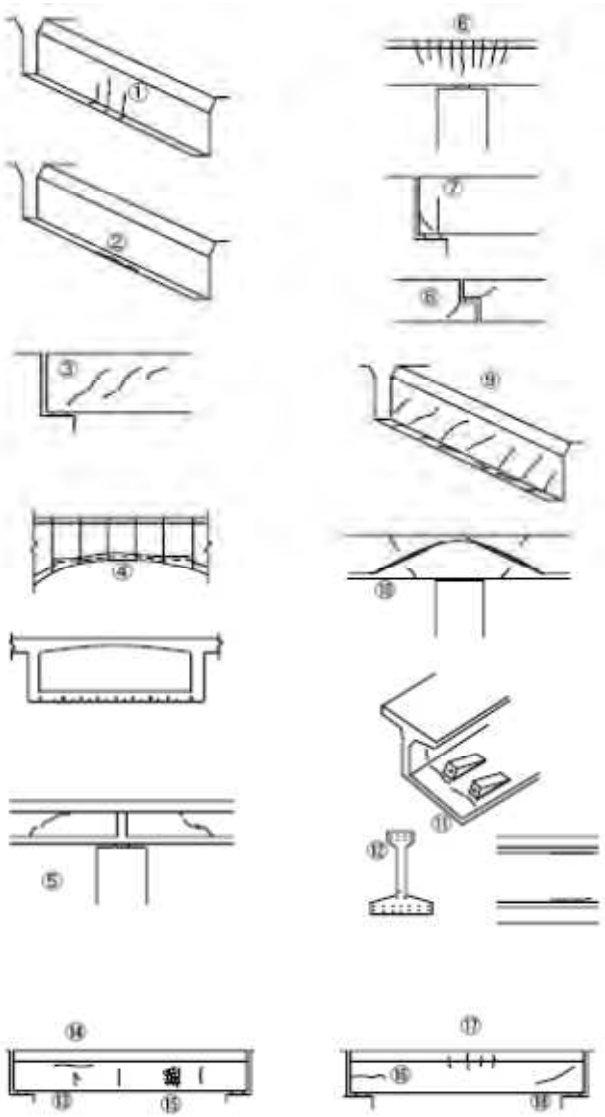
The bridge inspector is required to report the routine and major maintenance activities undertaken to a bridge after the conduct of the last periodic inspection that will include the type, scope and status of maintenance activities. The bridge inspector shall also record observations whether the works undertaken are effective and sufficient.

【Periodic Data Collection】

Special bridges like PC Box Girder Bridge have unique attributes and materials which are not defined in the BMS Manual for standard bridge. Bridge Inspection Team should understand the characteristic and function beforehand by reviewing the As Built Drawings and other related documents.

As a reference, some special attributes of Chirundu Bridge are listed in Table 1-3-2. All other applicable descriptions in the BMS Manual for standard bridge are adopted in this Manual. General pattern of defects in bridges are shown in Figure 1-3-7, 1-3-8, 1-3-9 and 1-3-10.

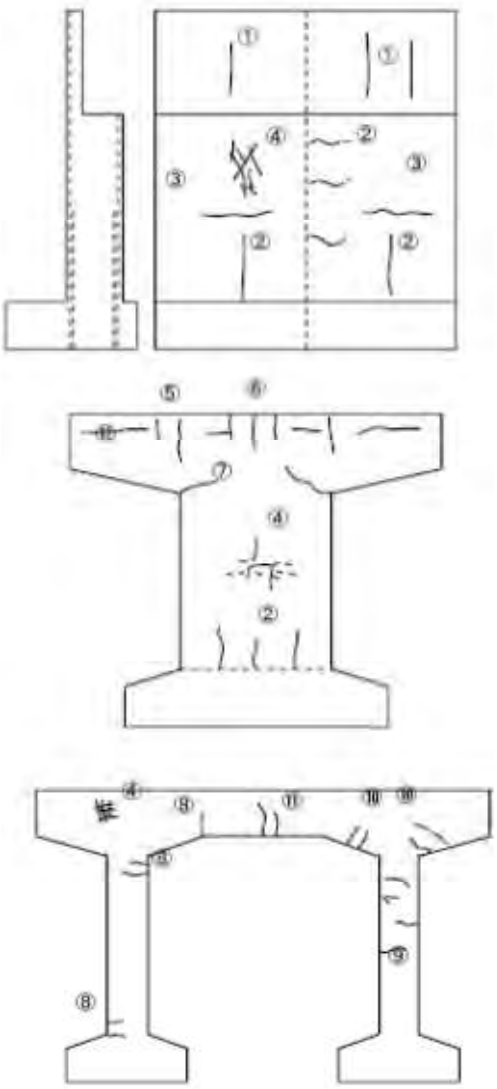
General Patterns of Crack Defects on Pre-stressed Concrete Bridge



Number	Location	Pattern
1	Span center	Vertical bending crack on bottom and side girder
2	Span center	Longitudinal crack on bottom of girder
3	Supporting point	Diagonal shear crack on around supporting point
4	Span center	Crack on lower flange along to Sheath or PC cable
5	Changing point of bending moment	Crack on web along to Sheath or PC cable
6	Supporting point	Crack on upper flange on continuous girder
7	Supporting point	Vertical or diagonal bearing crack on supporting point
8	Supporting point	Crack on the corner point of cantilever hinge
9	-	Diagonal crack on the whole of girder
10	Changing point of bending moment	Right angled crack against PC steel
11	Connecting point of PC Steel	Crack around connecting point of PC cable
12	High density point of PC steel	Crack around PC cable
13	-	Crack on web by regular interval
14	-	Vertical crack on the point between girder and web
15	-	Crack like mesh
16	Supporting point	Horizontal crack on supporting point
17	Span center	Horizontal crack on span center
18	Along to Sheath	Crack along to Sheath or PC cable

Figure 1-3-7 General Patterns of Defects (1of 4)

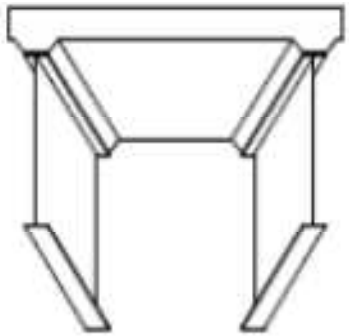
General Patterns of Crack Defects on Abutment and Pier



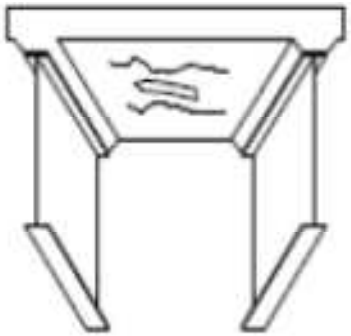
Number	Pattern
1	Crack with regular interval
2	Crack on the concrete casting joint
3	Crack around the changing point of density of reinforcement bar
4	Crack like mesh
5	Crack on topside of overhang beam (coping)
6	Vertical crack on pier center
7	Crack on bottom side of overhang beam (coping)
8	Crack on upper and bottom part of column
9	Crack on column
10	Crack on haunch
11	Bending crack on the span center or beam
12	Horizontal crack on beam

Figure 1-3-8 General Patterns of Defects (2of 4)

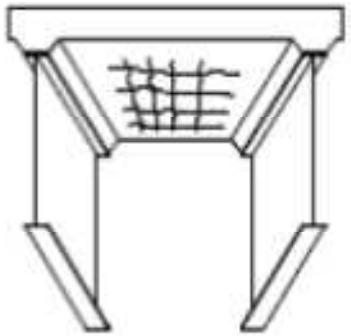
General Patterns of Crack Defects on Concrete Deck



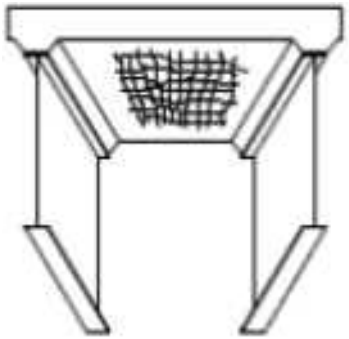
Stage 0
Sound condition



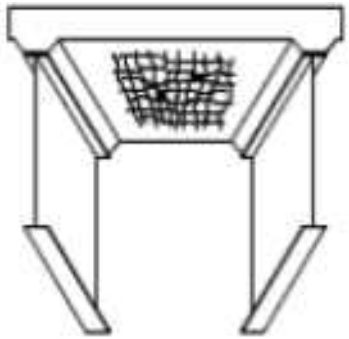
Stage 1
Development of cracks in one direction



Stage 2
Development of cracks in two direction



Stage 3
Cracks develop like a mesh



Stage 4
Water penetrates cracks, spalling

Figure 1-3-9 General Patterns of Defects (3of 4)

General Patterns of Crack Defects on Rubber Bearing

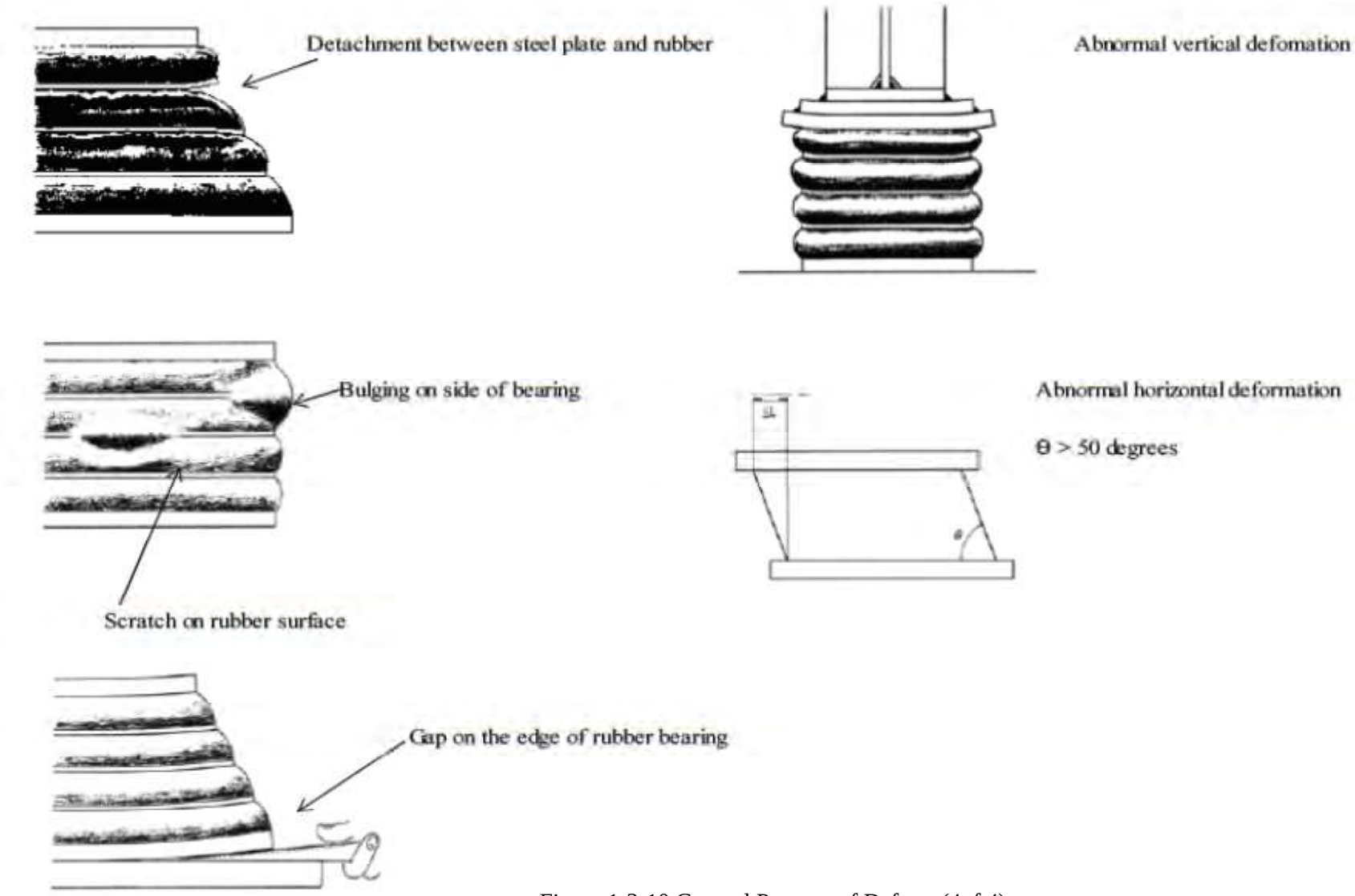


Figure 1-3-10 General Patterns of Defects (4of 4)

Table 1-3-2 Special Attributes

Element	Attribute	Description
Cable	Anchorage inside Concrete Girder	Anchorage is to keep the tension force of PC cable for support of bridge. They are quite important parts for the PC Bridge. They are located inside of concrete girders. The inside girders could not be inspected from outside. Concrete around Anchorages should be carefully inspected. Corrosion and damage of Anchorage is contributory to bridge collapse.
	PC Cable inside Concrete Girder	The cable is the most important attribute for PC Bridge. They put external pre-stressing into the girder for supporting load. They are located inside of concrete girder. Cable inside girders could not be inspcted from outside. Concrete member along PC cable should be carefully inspected. Corrosion and damage of cable is contributory to bridge collapse.

Arrangements of PC Cables in Chirundu Bridge are shown in Appendix D-1-1.

【Condition Rating of Bridge Attributes】

The material defect descriptions and the condition rating criteria in BMS will be utilized by the Bridge Inspectors (BI) to assess the defects identified in bridge elements. On the other hand, the Periodic Inspection for PC cable, anchorage and the asphalt wearing will be undertaken using this Manual.

The condition rating of the bridge attributes will be conducted following Inspection guidebook. Additional material defects are specifically described in Appendix D-1-2. while the corresponding conditon rating criteria concerining the same is included in Appendix A-1-2 (Asphalt wearing).

The affected area, length or number will be roughly estimated and using the Periodic Rating Card, the attribute damage rating can be obtained. The condition state of the attribute is the worst damage rating. The descriptions cannot possibly cover every situation, and the BIs must rely on their engineering knowleage and judgment to evaluate which condition should apply to the bridge elements inspected.

The BIs shall also compare the defects observed in the attriute with the previous sketch drawings and photograph records to check the progress.

The condition states have been developed to describe the following conditions listed in Table 1-3-3.

For each defined attribute in the bridge, the Periodic Inspection Forms includes a separate section covering that attribute and which is to be completed by the BI. Each section shall be completed to include:

・The condition state of the attribute (see Table 1-3-3)

・The type of repair required for each attribute

・The estimated cost to undertake the required repair (major maintenance)

All repairs to attributes are classified as major maintenance.

The standard descriptions of major maintenance that may be undertaken for each attribute are;

・Repair damage

・Protective measures

・Strengthen

・Replace

・Other

Only one type of maintenance can be listed for each attribute. When two or more types of maintenance are required to an attribute, all work shall be listed under the type of maintenance with the highest estimated cost.

The BI shall describe in detail the recommended repair works each identified defect in any attribute, providing sketch drawings if necessary.

Table 1-3-3 Bridge Attributes condition state

Condition State	Description	Action
0 good	Attribute is in good condition with little or no deterioration	Keep inspection
1 fair	Attribute shows deterioration of minor nature to the primary supporting material and is showing first signs of being affected	Keep monitoring
2 poor	Attribute shows advancing deterioration and loss of protection to the supporting material, minor loss of section	Major maintenance is required wihtin 2 years
3 bad	Attribute shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress	Immediate major maintenance is required

The condition state of each bridge attribute will be used by the BMS to calculate the overall need of the bridge for intervention.

【Not Applicable Attributes】

There are many instances when the Periodic Inspection Forms (PIF) is not completely filled out by the Bridge Inspector due to uncertainties in identifying or locating some attributes of the special brige.

The Bridge Inspector may feel that an attribute cannot be completed because there is no attribute in the bridge, he / she cannot recognize or find the attributes in the bridge. In this case, the bridge inspector should mark the attributes as not applicable.

9-1-3-5 Deliverables

The deliverables of Periodic Inspection Report are as follows:

◯Periodic Inspection Report

Bridge Periodic Inspection Form

Summary of Periodic Inspection Results

Repair Record

Inspection Results sheet (condition)

Inspection Results sheet (damage rating)

◯Sketch Drawing sheet

◯Photo record sheet (Pictorial Report)

The Bridge Periodic Inspection Reports shall be prepared in the respective Regional Office where the bridge inspectors are based. The reports shall be checked and reviewed in the Headquarter Office for completeness and accuracy prior to finalization.

When the Bridge Periodic Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory Database.

9-1-4 Detailed Inspection

Detailed Inspection for standard bridge is described in CHAPTER 6, and this chapter describes the Detailed Inspection for special bridges.

9-1-4-1 Purpose

Detailed Inspection is undertaken as a follow-up to periodic inspection when the condition state of 2 or 3 are recorded in any primary component / attribute or in any secondary component that has detrimental effect on the structural performance of the bridge. The purposes of a detailed inspection for special bridge are as follows.

1) To confirm the results of the periodic inspection.
2) To undertake additional investigations in order to evaluate thoroughly noted defects which may include physical testing and / or structural analysis. And also to prepare a documentary record of the observed defects for future design of required major maintenance works.
3) To assess the current bridge structural condition, behavior and capacity.
4) To assess the rate of deterioration and residual life expectancy of the bridge.

9-1-4-2 Recommendation

In the periodic inspection for standard materials, attributes and so on, “BRIDGE INSPECTION GUIDEBOOK 2017 developed by JICA” should be referred to. However. There is no standard method in the Detailed inspection for special components, attributes and so on, like cable, rope, anchorage.

For example, in case of concrete crack along PC cable inside girders. Also when water leakage is observed, there is a possibility that the inside cable is already corroded or when there is the possibility that the tension of PC cable is loose, and should be thoroughly inspected. In this instance, the inspection of Sheath and PC cable inside concrete girder is difficult for the Regional office to carry out.

It is recommended that the Regional office engage the services of detailed inspection / investigation firms specializing on PC Box girder bridge. For example, NDTs (Non-destructive testing) should be conducted in order to grasp whether the defect exist or not. NDTs for concrete attributes are Rebound Hammer Test, Carbonation Depth Measurement Test, Ultrasonic Pulse Velocity test, Half-Cell Electrical Potential Test and Rebar Detection Test mentioned in Chapter 6-3.

9-1-5 Geometrical Inspection

9-1-5-1 Purpose

The purpose of the Geometrical Inspection for Special Bridge is to obtain data primarily basic information of special / long span bridge. Bridge would be moved or deformed by impermissible loading from heavy vehicles or deformed due to a disaster. Deformation, movement, change of alignment of members should be measured regularly. It is useful information for analysis of bridge deformation.

9-1-5-2 Procedure

Geometric dimensions of special / long span bridge should be measured every three years using measuring survey equipment, like a Total Station.

When severe disasters occurred, like earthquake, typhoon and ship or car collision, Geometrical Inspection should be undertaken in order to confirm the degree of deformation.

Geometrical Inspection methods are shown in Figure 1-5-1, 1-5-2 and 1-5-3. As a reference, Geometrical Inspection form (GIF) of Chirundu Bridge are shown in Appendix A-1-3.

The Geometrical inspection is composed of a three-part measurement survey.

Part I leveling of super structure and substructure

・Elevation of longitudinal alignment of deck surface

・Elevation of piers and abutments

Part II horizontal slope of bridge surface

Part III Movement of bearing and expansion joint

In case there is an official bench mark that is close to the bridge, it should be used for the leveling of the bridge. Likewise, additional bench mark should be established around the bridge during the inspection. The interval between bench mark is around twenty meters.

The result of Geometrical Inspection should be stored in the Special Bridge Inventory Database. After Geometrical Inspection, Bridge Inspector and Bridge Engineer should analyze and compare the previous year's result. If excessive movement was observed, further investigation such as Detailed Inspection should be conducted in order to determine the appropriate corrective measure to be undertaken.

9-1-5-3 Deliverables

The deliverables of Geometrical Inspection Report are as follows;

○The Geometrical Inspection Reports – A fully completed geometrical inspection form(IIF)

○Updated Geometrical Inspection (part 3times data)

○Inventory photographs

The Bridge Geometrical Inspection Report shall be prepared by the bridge inspector. The report shall be checked and reviewed in the Regional Office for completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory.

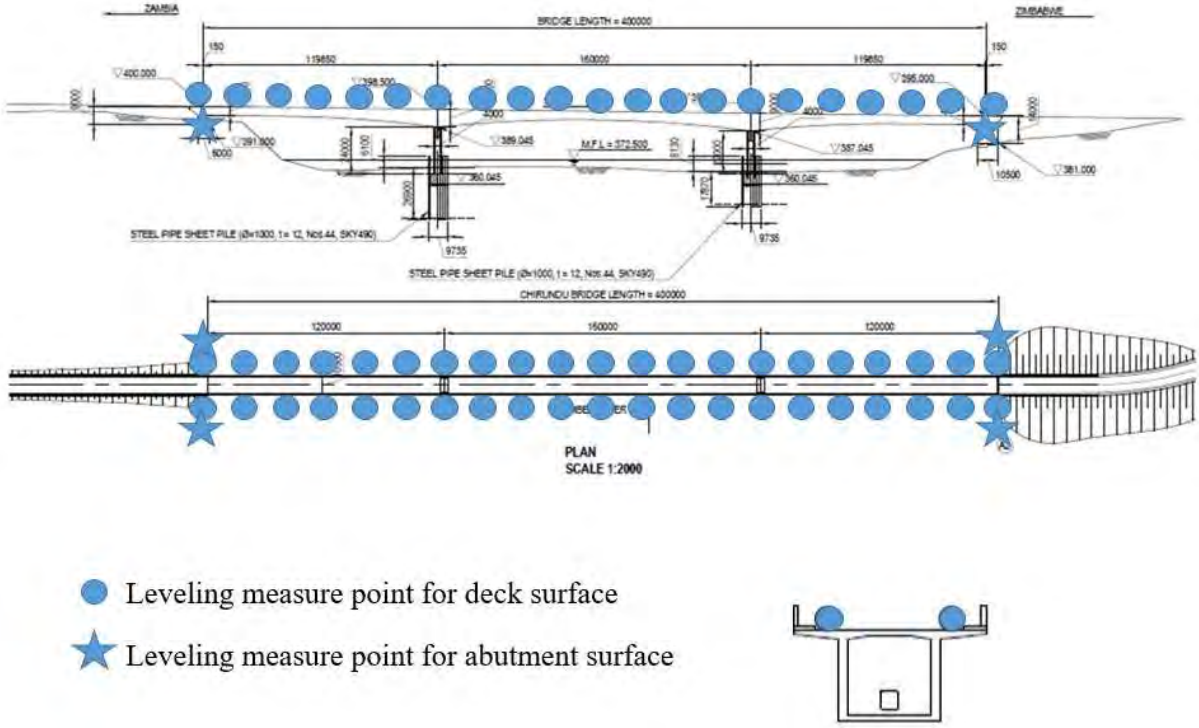
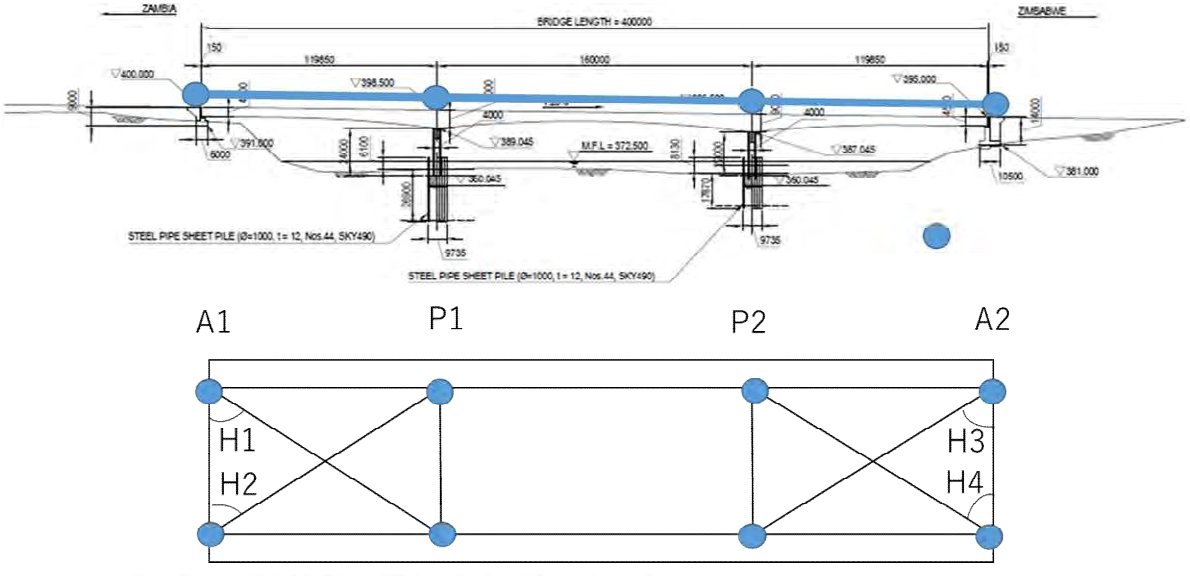


Figure 1-5-1 Geometrical Inspection:
Leveling of Abutments and longitudinal alignment of deck surface



Measure: Angle(Horizontal): H1', H2', H3', H4'

Slope: H1'
H2'
H3'
H4'

Figure 1-5-2 Geometrical Inspection:
Slope of PC Box Girder

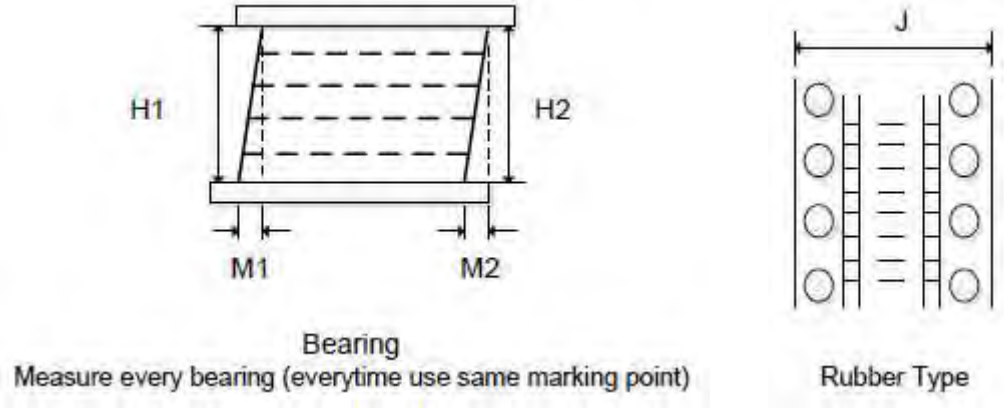


Figure 1-5-3 Geometrical Inspection:
Movement of Bearings and Expansion Joints

9-1-6 Emergency Inspection

Emergency Inspection will be undertaken in response to calamities or occurrence of severe damages that may tend to cause substantial damage to any part of the structure. This inspection is required to confirm that the bridge remain safe to commuters following a calamity or any man-made disasters and to determine the necessary work that is required to ensure the safety of the bridge and to restore the function of the bridge.

9-1-6-1 Purpose

Emergency Inspection will be undertaken in response to calamities or occurrence of severe damages that may tend to cause substantial damage to any part of the structure. This inspection is required to confirm that the bridge remain safe to commuters following a calamity or any man-made disasters and to determine the necessary work that is required to ensure the safety of the bridge and to restore the function of the bridge.

9-1-6-2 Process

There is no general process for emergency inspections as these inspections are ad-hoc inspections undertaken in difficult conditions.

9-1-6-3 Procedure

No standard procedure is required for this type of inspection.

9-1-6-4 Deliverables

The deliverable will be an Emergency Inspection Report. This will be the form appropriate for the required emergency action.

9-1-7 Types and causes of damages

Types and causes of damages for standard bridge by the bridge types are described in CHAPTER 8. And this chapter shows types and causes of damages focused on PC Box girder bridge, and shows where to inspect.

9-1-7-1 damages of Pre stressed Concrete Bridge

The outline of pattern of damage found in pre stressed concrete bridge showed Table 1-7-1.

Figure 1-7-1 outline of pattern of damage

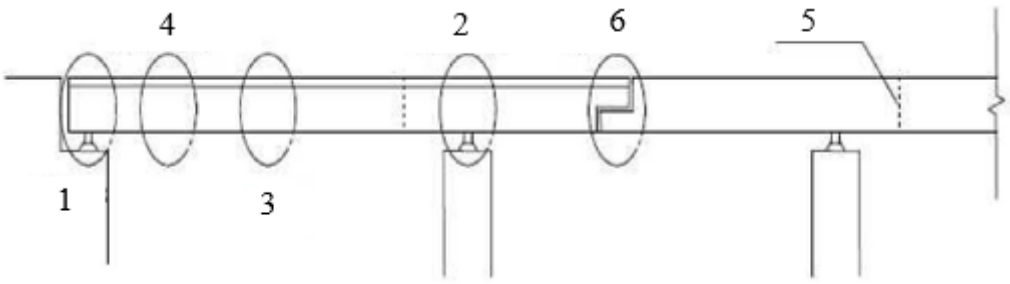
Damage Pattern	Outline
Abnormal deflection	A state in which main girder or slab sags or rises due to internal stress due to drying shrinkage or excessive/insufficient stresses in steel members. If abnormal deflection is discovered, emergency measures are required.
Abnormal sound	A state in which clapping sound is generated by cars due to void or damage in joints or creaking sound is generated due to defect or friction in joints. Since the sound is generated by deformation, it is necessary to check the source of the abnormal sound.
Abnormal vibration	A state in which abnormal vibration can be seen or felt. For instance, abnormal vibration can be felt due to movement disorder of movable bearings.
Abnormal rail joint gap	A state in which the rail joint gap of girders is unusually narrow so that girders, girder and bridge abutment, bearing stoppers, and joints are in contact with each other.
Settlement	A state in unequal settlement of bearings, etc.
Rotating or Shifting Elements	A state in bridge abutment or substructure rotates or moves.
cavities、honeycomb	Cavities or honeycomb can be seen in concrete due to the construction condition of concrete placement. Insufficient grout filling may result in cavities in the sheath.
cracks	A destructive phenomenon of concrete structures (one strucurete in concrete placement) due to tensile or compressive stress by cause(s) in material, construction, usage/environment, or structure/external stress.
Efflorescence	A phenomenon in which lime content of concrete flows out from construction joint and/or cracking area since rainwater infiltrates into concrete structure.
rust leachate	A phenomenon in which rust spills out to the concrete surface by corrosion of internal steel bars.

floating, scaling / spalling	A phenomenon in which the surface of a concrete building material floats, scales, or spalls due to expansion caused by corrosion of internal steel, internal stress in the concrete, or poor joint treatment.
reinforcement exposing, corrosion	A state in which reinforcement bars of concrete structure are exposed to atmosphere or rusted due to oxidation.
discoloration	A phenomenon in which the performance of a concrete member becomes discolored on the concrete surface due to deterioration caused primarily by chemical reactions.
Pop-out damage	Conical delamination of concrete surface due to expansion of concrete aggregates.
Concrete Scaling	Flaky delamination of cement paste or mortar in concrete surface.
corrosion of PC steel	A phenomenon of rusting due to oxidation of PC steel in concrete or in the air
rupture of PC steel	A phenomenon in which PC steel is ruptured due to corrosion
water soaking	The state in which concrete is saturated by water permeating through the concrete.
Water leakage	A state in which water leaks from the backfills or cracks at concrete joints and openings as well as drainages or joints.

The place where damages of pre stressed concrete occur is showed in Figure 1-7-2.

Figure 1-7-2 locations of damage of pre stressed concrete bridge

Damage occurring point	the points to be focused
① Edge supporting area	This point is susceptible to deformation due to water leakage from the expansion and contraction system, bearing reaction forces, and horizontal forces caused by earthquakes, temperature changes, etc.
② Intermediate supporting area	Prone to cracking in the area where the stress state is complex because the negative bending moment and the shear force is maximum and intensive bearing counterforce is generated.
③ central section of girder	Bending moment at the span center is at its maximum and bending cracks are likely to occur.
④ One quarter from the edge supporting areas	Susceptible to cracking due to shearing forces and disorder of bearings in the members with less reinforcing bars.
⑤ construction joints	Prone to cracking, delamination, or water leakage due to drying shrinkage or poor construction.
⑥ cutout section	Susceptible to cracking due to stress concentration in the area where the cross-section of main girder changes suddenly such as Gerber hinge or girder cutout section. The corrosion of steel member is caused by water leakage from expansion joints.
⑦ segment joints	Cracking along the segment joints sometimes occur due to the decrease in the amount of pre-stress. Cracking, scaling (floating), and water leakage are likely to occur due to drying shrinkage and poor construction.
⑧ fixed parts	Susceptible to cracks due to the concentration of tensile stress in areas where PC steel is anchored by projections on the web or flange. In addition, the anchorage area is covered with post-cast concrete, which allows rainwater to penetrate through the construction joints and easily corrode the anchorage apparatus.
⑨ PC steel anchorage	Corrosion of steel is likely to occur due to water penetration caused by insufficient grout filling.
⑩ water drainage	Susceptible to corrosion of steel members due to the loss or dropout of drainage system.



Cracks pattern and its causes show (A) initial defect (B) the damage of deteriorations (C) crack by external force. And damage pattern of water stain and water leakage show (D) water stain of pre stressed concrete bridge (E) Leakage from pre stressed concrete bridge itself.

(A) initial defect

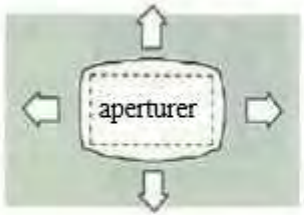
The cross girder in a box girder is a massive concrete, initial crack is easy to occur by thermal stress at construction and shrinkage. Crack is apt to occur in aperture for constraint.

Figure 1-7-3 crack pattern of pre stressed concrete bridge

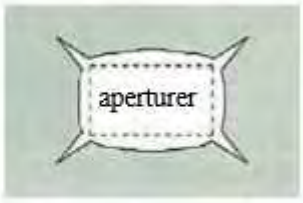
crack occurring point	crack pattern	presumed major causes
Intermediate supporting area	Cracks in the cross girder of the central support	Thermal stress or drying shrinkage



cracks in the cross girder



deformity of the aperture



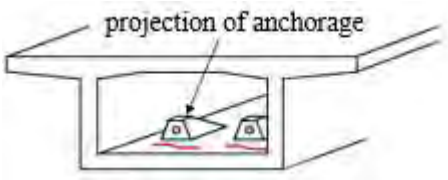
cracks in the aperture due to peripheral constraints

We have to pay attention to below,

- anchorage at main girder (girder end, upper deck)
- anchorage at deck or cross girder
- anchorage of web shear PC steel
- anchorage of external cable
- deviation

Figure 1-7-4 crack pattern of pre stressed concrete bridge

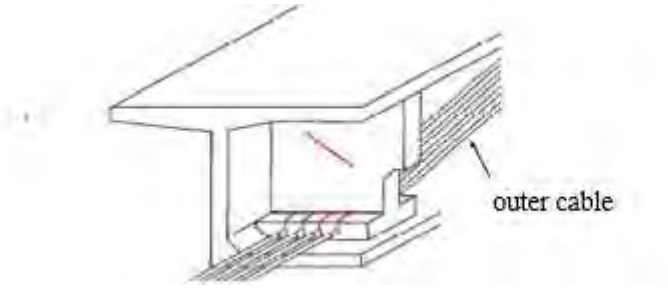
crack occurring point	crack pattern	presumed major causes
fixed parts of PC steel	cracks occurring in the fixed parts or the deviation parts	Insufficient amount of reinforcing steel for local stress around the fixing parts or lack of cross sectional area, applying excessive tension force



cracks occurring around the projection of anchorage



cracks occurring around several anchorage projections

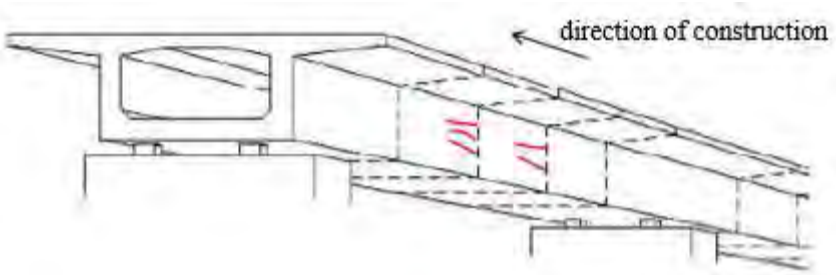


cracks near the deviation of the outer cable

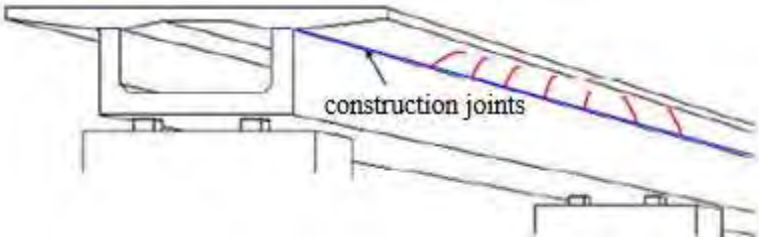
Cracks by thermol stress and shrinkage occur easily at concrete joint of new concrete.

Figure 1-7-5 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
construction joints	cracks at girder joints and floor-slab joints	difference in shrinkage between existing and newly post-casted concrete (heat of hydration, drying shrinkage), poor joint processing



cracks in vertical joints



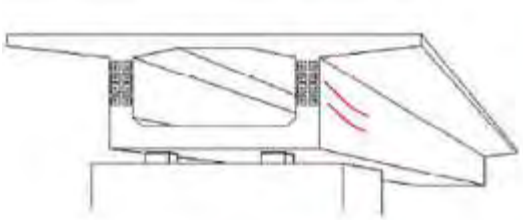
crcks in horizontal joints

(B) The damage by deterioration

We pay attention to along to PC cable. Cracks along to PC cable are caused to insufficient grout filling.

Figure 1-7-6 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
edge supporting area	cracks along with the PC steel	cracks due to water penetration into the sheath from the fixed parts and expansion by alkali-silica reaction





Horizontal cracks along with PC steel

We have to pay attention to crask, delamination or eflorescence at post casting part or side of groud cover. Rain floods to concrete joint of post casting part and anchorage of PC cable corrodes.

Figure 1-7-7 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
fixed parts of PC steel	Cracks on the post-casted area	cracks due to drying shrinkage of post-casting concrete

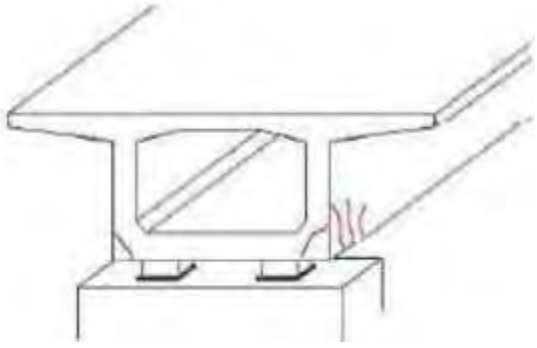


cracks in the post-filling concrete

(C) Crack by external force

Figure 1-7-8 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
edge supporting area	vertical cracks on the underside and sides of the girder above the bearing	excessive local stress on the support, loss of bearing function, earthquake
	diagonal cracks in the web near the bearing	excessive shear force, insufficient shear reinforcing steel, and decreased amount of pre-stress



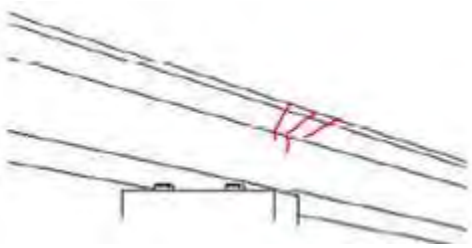
cracks near the end of girder

In intermediate support, negative mement and shear force is maxmum, and condition of stress is complex, so crack should occur. Especially, we have to pay attention to top of overhang deck at continuous girder bridge and joint girder.

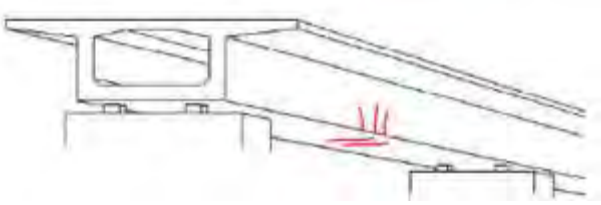
In span center, bending moment is maximum. When bending crack occurs, pre stress may decline. Especially, we have to pay attention to lower deck located PC cable. Vertical crack by corroded stirrup is similar to one by bending moment. In this case, there is corroded stirrup directly below crack so have to inspect directly.

Figure 1-7-9 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
intermediate supporting area	vertical cracks occurring on the upper side of the main girder at the intermediate support of the continuous girder	insufficient reinforcing steel for negative bending moment at the top flange of the intermediate support, decreased amount of pre-stress
central section of girder	cracks occurring in the vertical direction on the underside and sides of the girder in the direction perpendicular to the main girder	excessive bending moment, decreased amount of pre-stress



cracks on the intermediate support

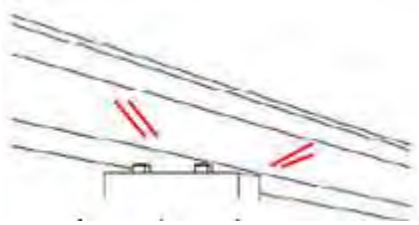


cracks on the central section

In one forth span, shear force is big. We pay attention to diagonal drack in thin web girder bridge.

Figure 1-7-10 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
one quarter from the edge supporting area	cracks occurring in the vertical direction on the underside and sides of the girder in the direction perpendicular to the main girder	insufficient amount of reinforcing bar or pre-stress

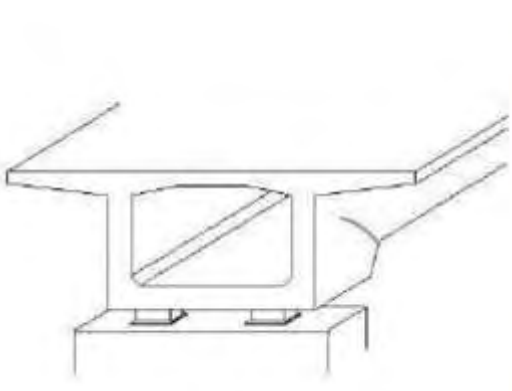


shear cracks near the support

In cross section change part (gerber hinge, supporting point), crack occurs by stress concentration.

Figure 1-7-11 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
cross-sectional changing part	cracks in cross-sectional changing parts	stress concentration due to abrupt cross-sectional change



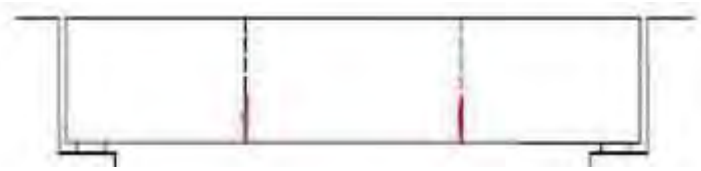
cracks in abrupt cross-sectional changing parts



cracks in Gerber hinge

Figure 1-7-12 crack pattern of pre stressed concrete bridge

crack occurring point	crack pattern	presumed major causes
segment joints	cracks in segment joints	decrease amount of pre-stress



cracks in segment joints

(D) Water stain of pre stressed concrete bridge

Water stain is the state that concrete is full of water, and it occurs mainly the side of the concrete and bottom of the girder. The cause of water stain is water from deck surface, insufficient grout filling in the sheath, flood at hand hall. The color of concrete surface looks wet color.

Figure 1-7-13 water stain pattern of pre stressed concrete bridge

water stain point	water stain pattern	presumed major causes
underneath the overhanging floor slab	water strains on the underneath of the overhanging floor slab	poor compaction of concrete on the underneath of lateral sheaths, trickle-down water around bundled grout hoses, stagnant water in mortar areas directly under curbs, stagnant water in hand holes, and around drainage basins



water stains shaped like worm crawling, parpendicular to the bridge axis



streaked water stains



stagnant water in the hand hole



water stains around the drainage

water stain point	water stain pattern	presumed major causes
anterior of the web	water stains on the sides of the web and lower floor slab surface	poor grout filling of PC steel (including shear PC steel) and trickle-down water around bundled grout hoses





Figure 1-7-14 water stain pattern of pre stressed concrete bridge

water stain point	water stain pattern	presumed major causes
underneath the upper slab	water stains on the underneath of the upper slab and area around construction joints	rainwater intrusion from bridge surface



Water stains around central parts



water stains around construction joints

water stain point	water stain pattern	presumed major causes
inside the web	water stains occurring vertically on the inner surface of the web and around the lower floor slab haunches	trickle-down water around bundled grout hoses



vertical water stain on the inner surface



water stains around the lower floor slab haunches



water stain along PC steel

Figure 1-7-15 water stain pattern of pre stressed concrete bridge

water stain point	water stain pattern	presumed major causes
post casted area	water stains on the post-casted fixing section and the post-casted formwork separator (P-con)	trickle-down water around bundled grout hoses and poor grout filling



water stain on the postcasted area



water stain on the postcasted P-con

(E) Leakage from pre stressed concrete bridge itself

Leakage from pre stressed concrete occurs from concrete joint, post casting of aperture and crack. And it occurs mainly the side of the concrete and bottom of the girder. The cause of leakage is water from deck surface, deterioration of concrete occurs and rebar or PC cable corrode at surrounding leakage.

When we find leakage from pre stressed concrete bridge itself, we have to confirm the location of crack, concrete joint and aperture, whether upper anchorage of PC cable is or not, whether drainage system is or not. And we have to inspect where water floods.

Figure 1-7-16 example of inspection focusing on water

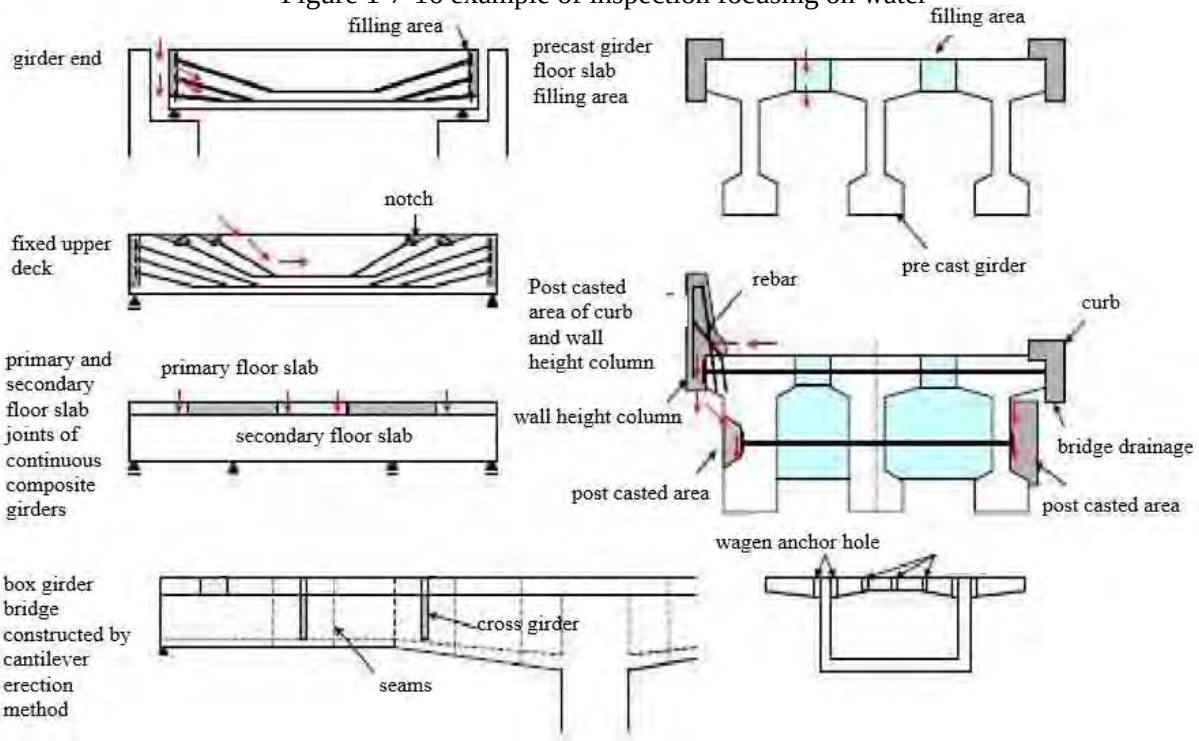


Figure 1-7-17 leakage pattern of pre stressed concrete bridge

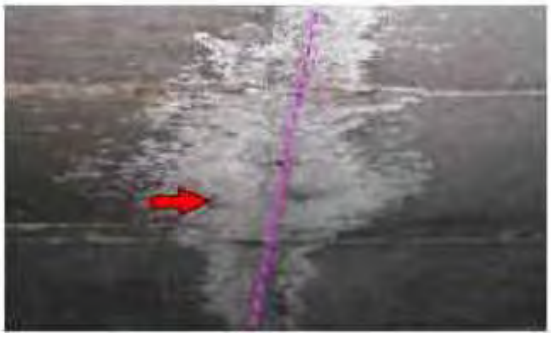
leakage point	leakage pattern	presumed major causes
underneath the upper slab	water leakage in the post-casted area of the upper slab (work aperture, casting aperture, and wagen anchor hole) and construction joints	rainwater intrusion from bridge surface



leakage from work aperture



leakage from casting aperture



leakage from construction joint



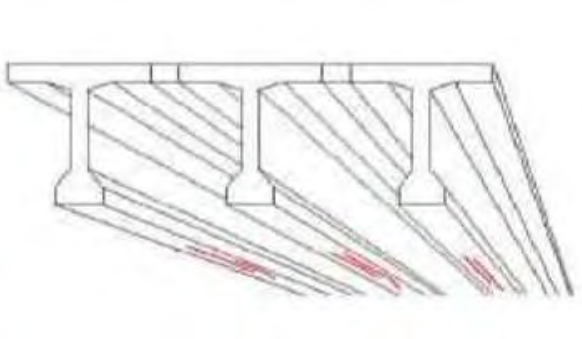
leakage from the upper slab and dripping-down to the lower slab

Figure 1-7-18 water stain pattern of pre stressed concrete bridge

leakage point	leakage pattern	presumed major causes
underneath the main girder	leakage along PC steel in the bottom flange of a precast T-girder bridge	poor grout filling of PC steel



leakage from underneath the main girder



leakage points

leakage point	leakage pattern	presumed major causes
web	from the joints between the upper slab and the web, or cracks along the PC steel	trickle-down water around bundled grout hoses and poor grout filling of PC steel



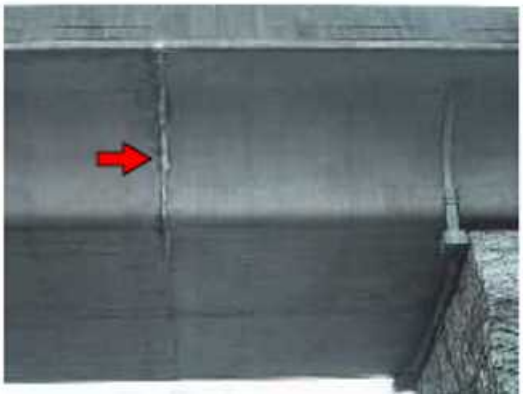
leakage from joints



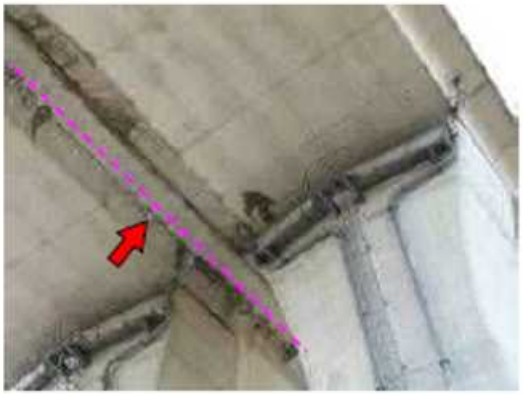
leakage along the PC steel

Figure 1-7-19 water stain pattern of pre stressed concrete bridge

leakage point	leakage pattern	presumed major causes
construction joint	from construction joints and joints of segmental girders, and joints between primary and secondary floor slabs of continuous composite girders	rainwater intrusion from bridge surface



leakage from joints of segmental girders



leakage from construction joints



leakage from joints between primary and secondary floor slabs of continuous composite girders

leakage point	leakage pattern	presumed major causes
anchorage	from post-casted concrete at the projection of anchorage	trickle-down water around bundled grout hoses and poor grout filling of PC steel



water leakage from the projection of lower floor slab



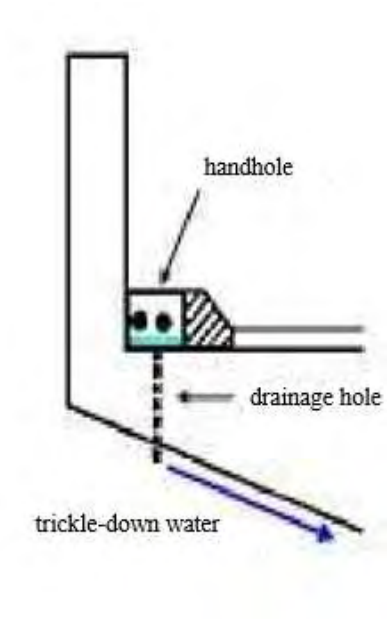
water leakage from the projection of fixed web

Figure 1-7-20 water stain pattern of pre stressed concrete bridge

leakage point	leakage pattern	presumed major causes
other	from drainage hole in hand hole	improper treatment or deterioration of the tip of the drainage hole



Water leakage from outer surface of box girder

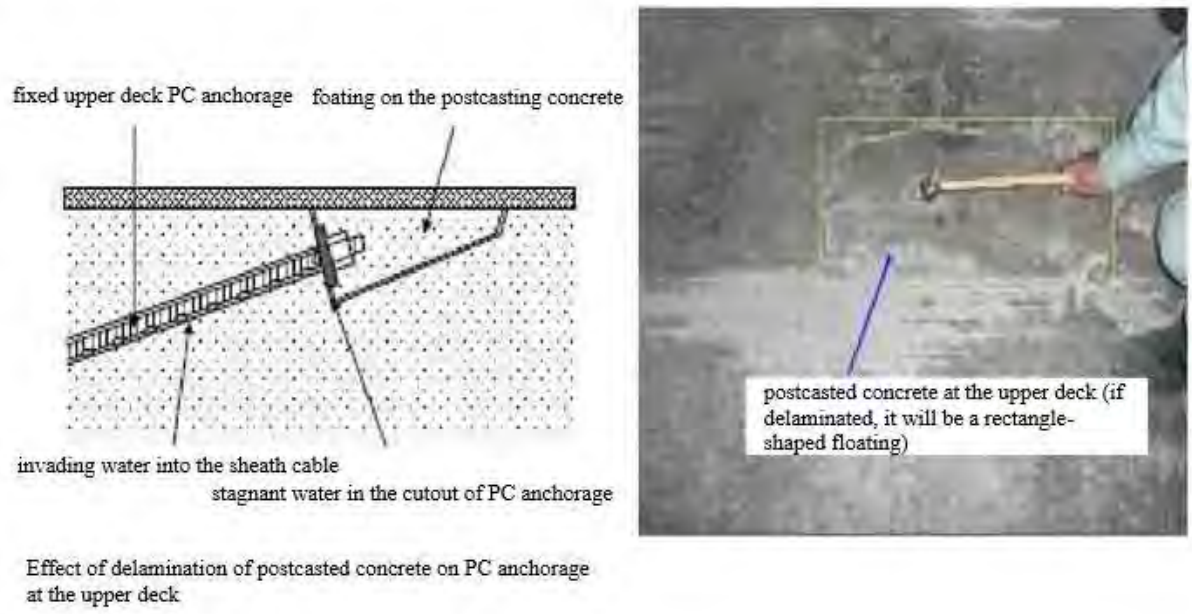


cause of trickle-down water

(F) Road surface and deck upper surface

In case of PC bridge with fixed upper deck anchorage, post casting concrete delaminates and pot hole occurs. Thus, if water floods into cutout of PC anchorage, PC anchorage corrodes or PC cable breaks out by invading water.

Figure 1-7-21 the effect of post casting concrete delamination



Effect of delamination of postcasted concrete on PC anchorage at the upper deck

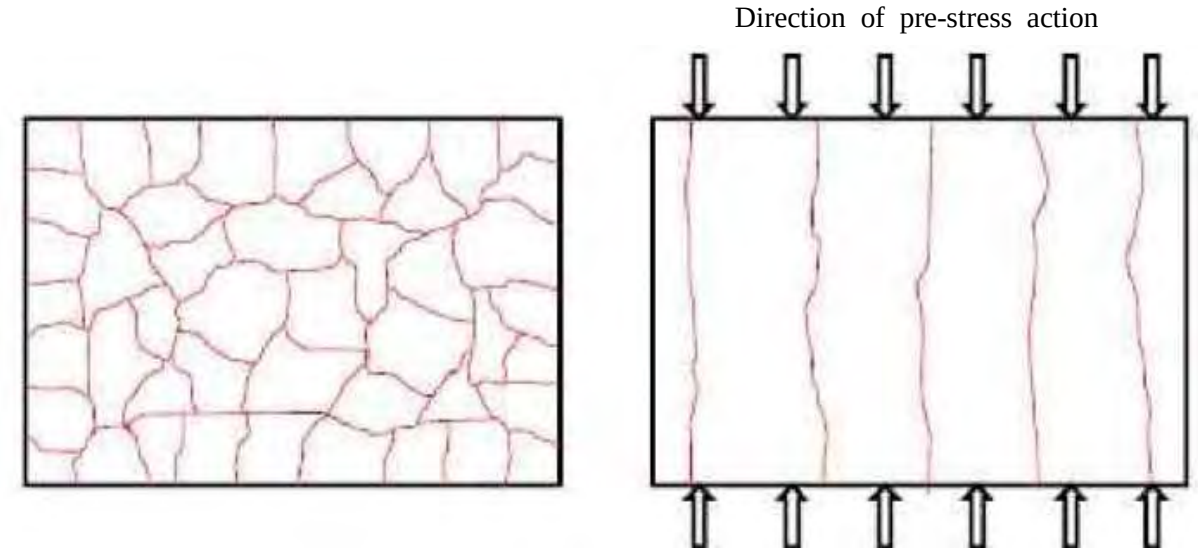
① characteristic of crack in pre stressed concrete bridge

Pre stressed concrete structure is the structure that pre stressed compressive stress resists tensile stress arising by external force, and differs from Reinforced-Concrete structure in decline of load capacity when structural crack occurs. Structural crack is the crack which arising by bending moment and shear forces of dead load or live load. Pre stressed concrete structure is introduced to compressive stress in order to cancel each other tensile stress which arising by bending moment or shear forces above mentioned. Therefore, generally as long as pre stress remains as designed, it never occurs structural crack in pre stressed structure. So, we need to keep in mind the big difference between crack of pre stressed concrete and those of reinforced concrete in evaluating. When structural cracks occurs in pre stressed concrete, deterioration proceeds badly. It is estimated that excess of load capacity is small against at destructive force. Not only we cannot do preventive maintenance but also load capacity already may disappears at the worst case. So, in case of inspection of pre stressed concrete bridge, it is very important that we grasp the sign of cracking as well as condition of cracking.

But it is reinforced structure where except for the direction introduced pre stressed (transverse direction in lower deck slab at Box girder, cross beam and so on) and deck slab filling. It is very important to concern the differences between crack in reinforced concrete and pre stressed concrete.

The crack of concrete arises because tensile stress, which affected orthogonal direction of cracking, surpasses tensile stress of concrete. In other words, if tensile stress occurs in concrete, crack does not occur if the tensile stress is less than tensile strength of concrete. So, cracks of pre stressed

concrete differ from one of reinforced concrete. For example, in case of alkali silica reaction, cracks of RC concrete is alligator crack and on the other hand, cracks of PC concrete is along to the direction of pre stressed introduction.



in RC concrete　　in PC concrete

Difference in crack patterns between RC concrete and pre-stresses concrete
(Example ASR crack pattern)

② leakage from joint and drainage system

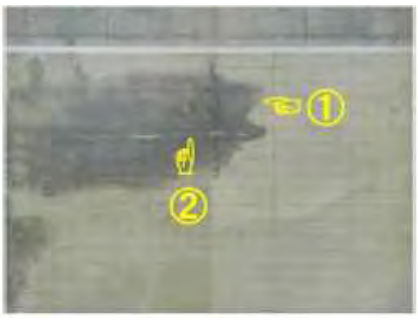
Leakage from joint and drainage system is considered one of factor of accelerating deterioration, because it affects damage of PC anchorage at the girder end and PC cable in the box girder. For that reason, it is better to inspect these appendages at the same time inspecting bridge itself. In order to minimize deterioration of concrete structure, we should repair joint and drainage system.



damage to the girder end



water leakage found in the girder



water soaking on the floor slab

CHAPTER 9-2 Cable-Stayed Bridge

9-2-1 Bridge Inventory

9--2-1-1 Type of Special Bridge

Cable Stayed Bridge is similar to Suspension Bridge that support the load of the deck in different ways. The difference is how the cables are connected to the towers. In suspension bridges, the cables are installed across the towers, transmitting the load from deck to the towers down to the anchorages. In cable-stayed bridges, the cables are attached only to the towers to support the load.



Figure 2-1-1 Cable Stayed Bridge

9-2-1-2 Bridge Component

The components of the bridge are shown below. Generally, it has a bridge deck, pylons and stay cables as superstructure, and piers as substructure. Other important components of the bridge are bearings which connect superstructure and substructure, and expansion joints which allow movement of superstructure at the end of superstructure. Riverfront is the soil or rock surrounding the piers.

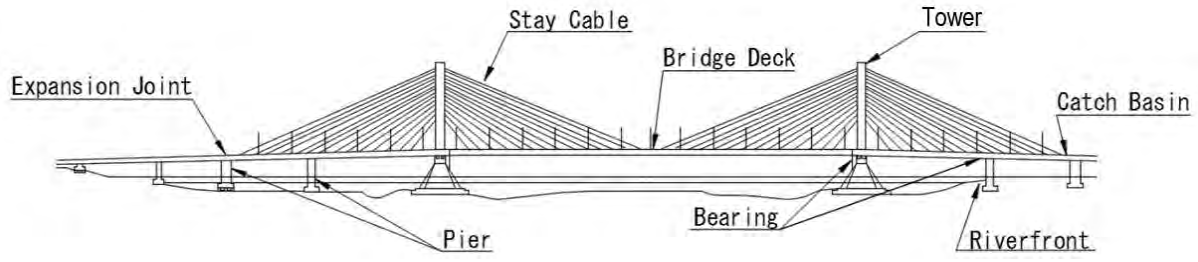


Figure 2-1-2 Bridge Component (Cable Stayed Bridge)

9-2-1-3 Bridge Geometry Definition

The bridge is assessed in the direction of increasing chainage. Refer to Figure 2-1-3.

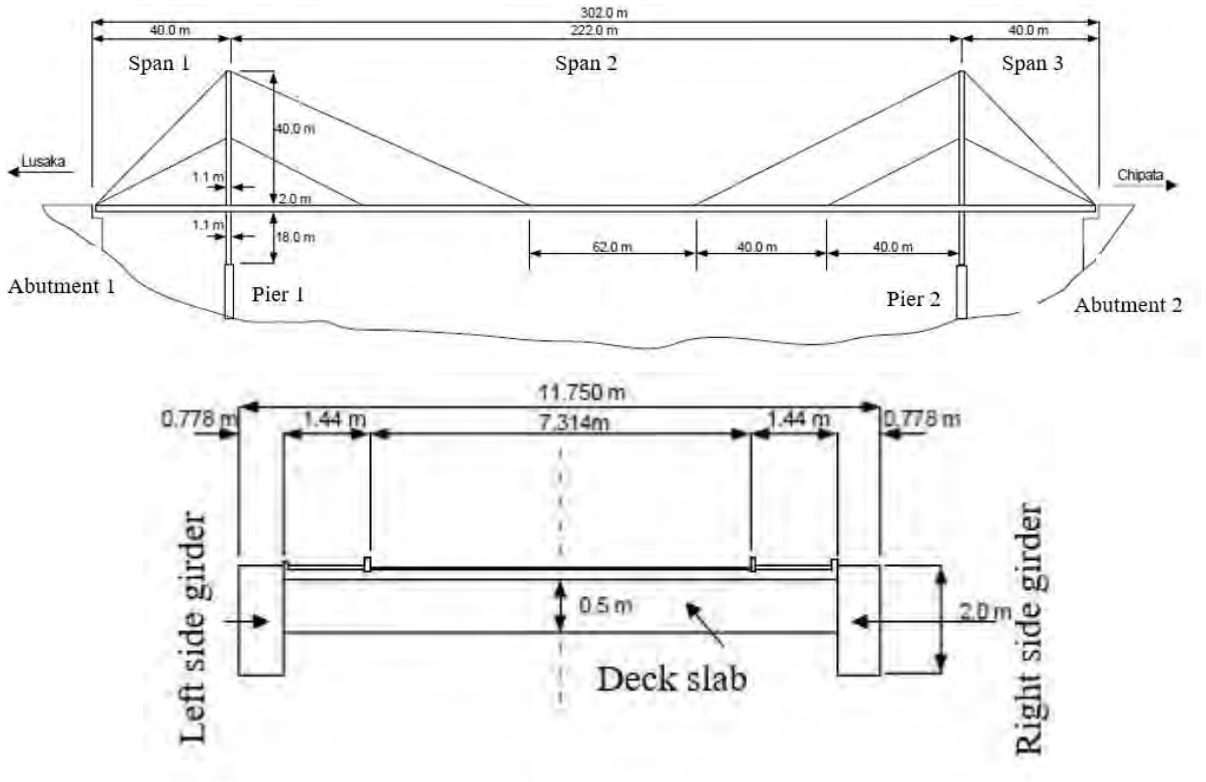


Figure 2-1-3 Bridge Geometry Definition

The following standard abbreviations are adopted to describe a bridge:

WS	-	Western Side (To Lusaka)
ES	-	Eastern Side (To Chipata)
S	-	Span
P	-	Pier
A	-	Abutment
G	-	Girder
C	-	Cable

Example, a three (3) span bridge with girder in each span:

- Abutment 1 (A1) is at Western side end of the bridge and Abutment 2 (A2) is at eastern side end.
- Spans 1 (S1), 2 (S2) and 3 (S3) numbered from the western side end of the bridge.
- Pier 1 (P1) and 2 (P2) numbered from the western side end of the bridge.
- Luangwa Bridge is simple girder bridge and its girder are classified left side

girder and right side girder (Looking in east side). Accordingly, LG and RG.

- The gilder on the extreme left in span 2 is designated as Span 2 – Gilder 1 (S2LG)
- Abutment 1 and 2 may be named Abutment A and B respectively.
- Cable is numbering C1L11, which C means cable, 1 means Pier number, L means Left side and 11 means cable number. Cable numbering is shown in Figure.

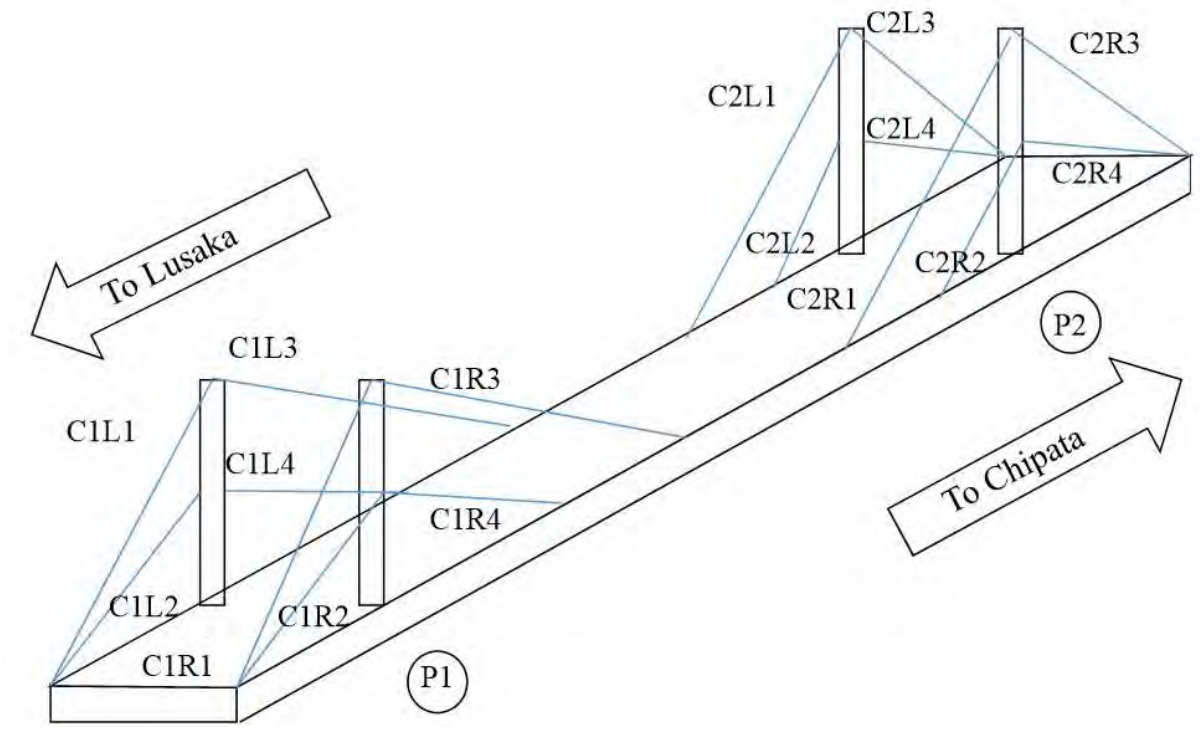


Figure 2-1-4 Cable numbering

9-2-1-4 Cable Stayed Bridge

Cable Stayed Bridge is a bridge which supports girders by stay cables suspended diagonally from the tower to the girder. The typical Cable Stayed Bridge is a continuous girder with one or two towers erected in the middle of the span. Cable Stayed Bridge design is suitable between 150 meter and 800 meter long span. In comparison to suspension bridges, Cable Stayed Bridge required less cable, constructed at a shorter time and cost-effective.

Cable Stayed Bridge is similar to Suspension Bridge that support girders by cables and likewise have high tower. However, these two bridges support the load of the deck in different ways. The difference is how the cables are connected to the towers. In Suspension bridge, the cables are installed across the towers, transmitting the load from deck to the towers down to the anchorages. On the other hand, In Cable Stayed Bridge, the cables are attached only to the towers to support the load.

There are two cable arrangements in Cable Stayed Bridge. Firstly, a fan design,

cables are extended from several points on the girder to a single point at the top of the tower. Secondly, a harp design, cables are attached at different heights along the tower, running parallel to one another. Luangwa Bridge is a harp design cable arrangement.

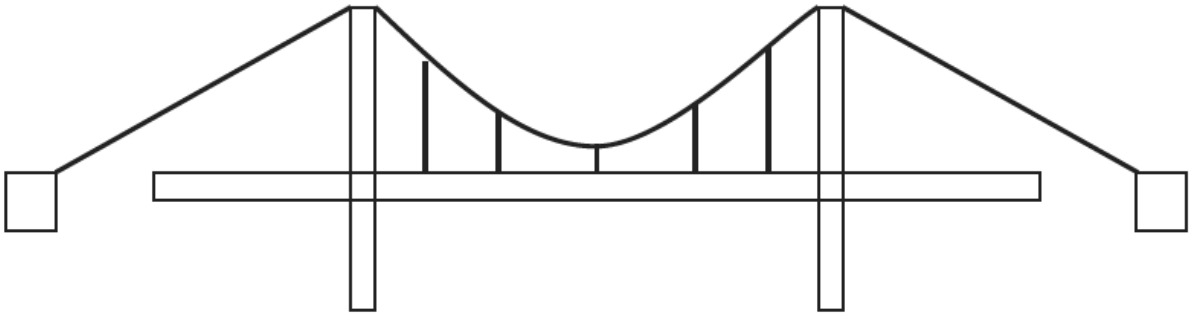


Figure 2-1-5 Suspension Bridge

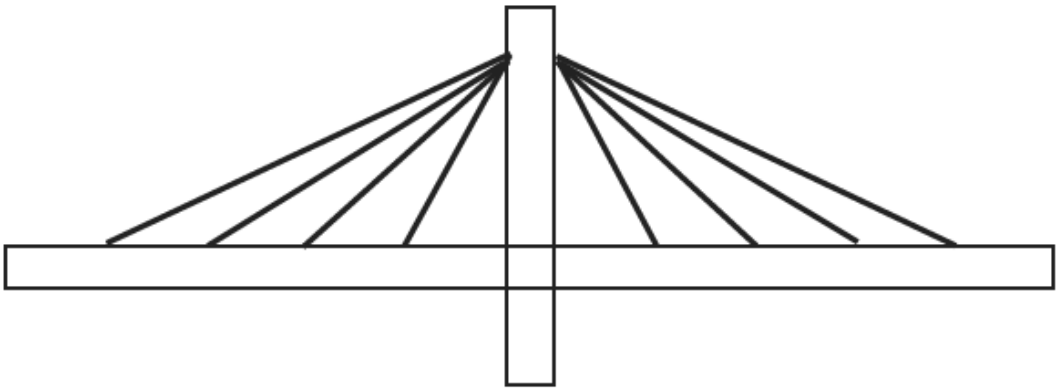


Figure 2-1-6 Cable Stayed Bridge (Fan Design)

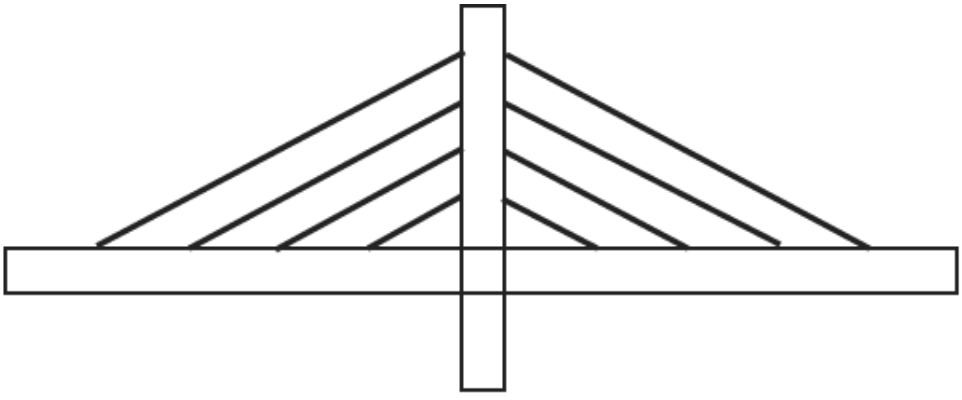


Figure 2-1-7 Cable Stayed Bridge (Harp Design)

For the support of girder, a cantilever approach is often used near the tower, but lengths further from the tower are supported by stay cables. All horizontal forces from Stay Cables are balanced at the tower, and no anchorage needed to resist a horizontal tension from

the main suspension cables.

Due to the diagonally tensioned stayed cables, compressive forces and bending moments are imposed on the girder and the tower. The towers are the load-bearing structures which transmit vertical loads to the ground. The bridge girder should be stronger to resist the resulting axial compression loads, so greater stiffness is necessary. At the same time, it reduces the deformation of the girder, and the bridge could resist wind load.

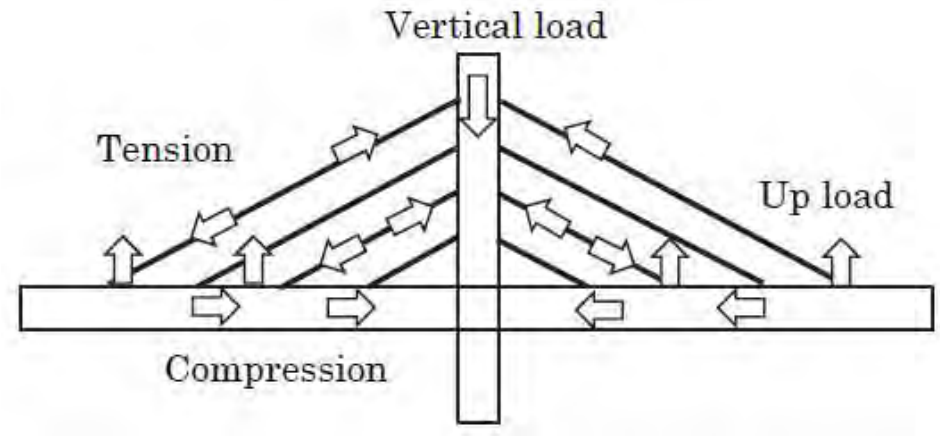


Figure 2-1-8 Load Distribution System in Cable Stayed Bridge

Shown in Figure 2-1-9 is the General Views of Luangwa Bridge.

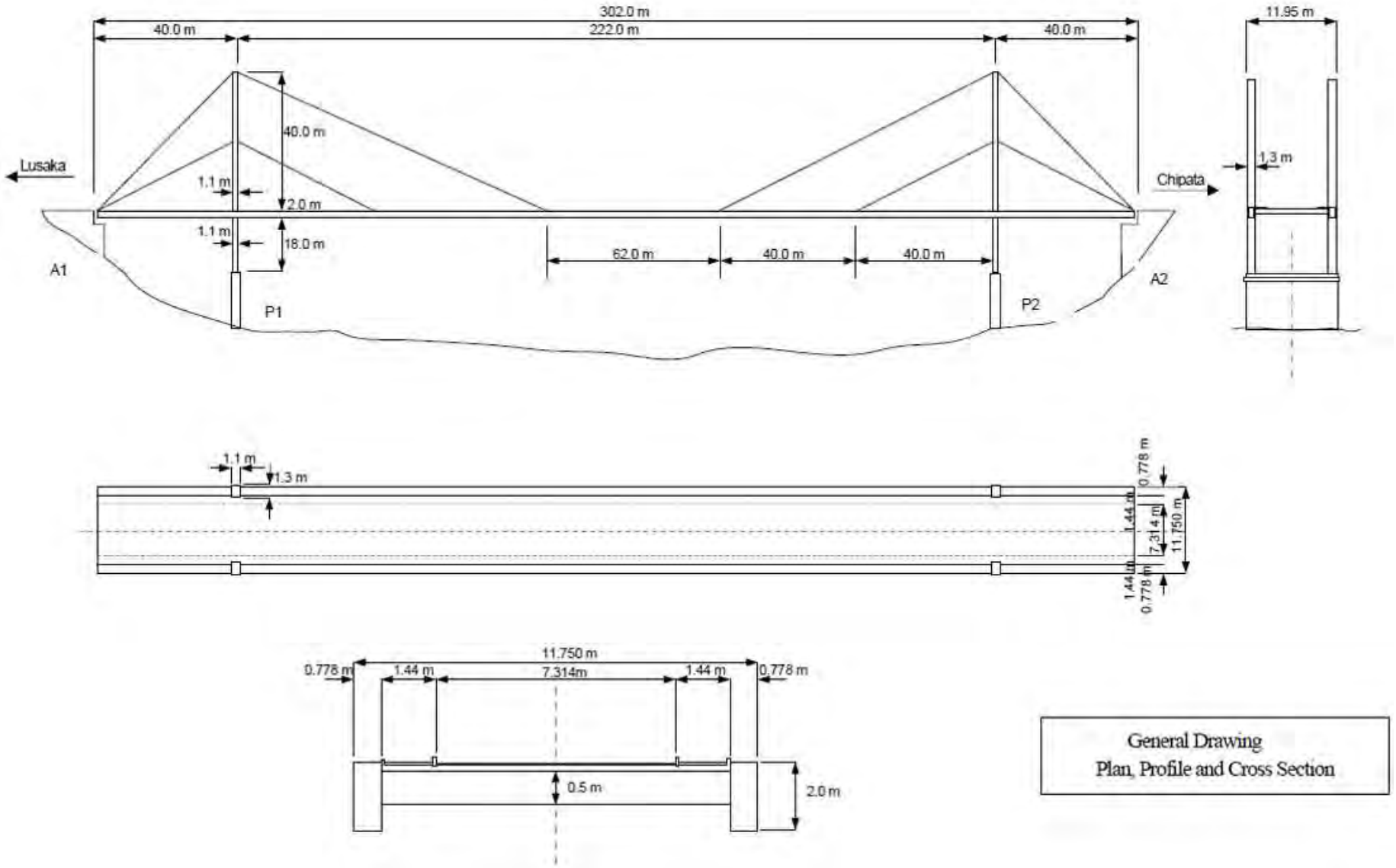


Figure 2-1-9 General View

9-2-2 Inventory Inspection

Inventory Inspection for standard bridges is described in CHAPTER 4. And this chapter is described the Inventory Inspection for special bridges.

9-2-2-1 Purpose and process

The purpose of the Inventory Inspection for Cable Stayed bridge is to obtain its inventory data primary for inclusion in the BMS database. Bridge inventory data is a standard series of information that describe the geometry, construction and current function of a bridge.

The Inventory Inspection for the Special bridge, is similar to the inventory inspection of standard bridges.

9-2-2-2 Procedure

All information collected during the bridge inventory inspection is recorded using the Inventory Inspection Form (IIF). The IIF of Luangwa bridge is included in Appendix A-2-1.

The IIF is composed of two parts for the Special Bridge Inventory:

○Standard inventory sheet is the same sheet with ordinary bridges in BMS.

・Inventory Inspection Form.

・The special requirements for inspection

・The general bridge data, clearances, geometry, traffic direction, type of bridge, year of construction, public utilities carried by the bridge and detail, if there is lighting provided on the bridge, the type of terrain where the bridge is located, comments if the bridge is unusual, type of construction, substructure type, deck material, wearing surface, drainage, design load and the available drawings.

・The bridge Modification Sheet describes the types and materials of any modifications to the bridge.

・The span/s of the bridge.

・The pier/s of the bridge.

・The bridge abutments.

○Additional geometrical data sheet for Special Bridge

・Measurement of bridge structure (superstructure and substructure)

As built Drawing are very important for special bridges. There is no standard drawing in special bridge. Each bridge has its own unique structure. “As Built Drawing” should be collected and electronic copy should be installed in the Special Bridge Inventory Database, as one of Inventory Inspection data. In case that there is no available bridge data, measurement survey on site for collecting basic bridge data and general drawing for inventory should be done. All documents

pertaining to the past repair works and useful information are also important for future reference, especially when the bridge is due for retrofitting.

9-2-2-3 Description

The Luangwa Bridge was constructed with the support of British in 1968. It was repaired and reinforced, but it was aging. The problem is strength and durability against rapid increased traffic and passing heavy vehicle. For these reasons, vehicles that can pass must be less than 55 tons, driving speed is limited under 30km/h and only one car can pass this bridge at one time.

The Luangwa Bridge is the only bridge which connect Lusaka province and eastern province. Its length is 302 meter (40+222+40) and its bridge type is cable stayed bridge. Compared with the cable stayed bridge which is designed generally at the present time, its side span is significantly short. The girder of central span tends to droop down even under dead load. Design drawing of Luangwa Bridge is not exist, and the design is probably based on British Standard 153 (1958). It is not assumed that more than 50 ton heavy trucks pass over the bridge.



Figure 2-2-1 Photo of Luangwa Bridge

9-2-2-4 Inspection Form

The bridge Inventory Inspection Form (IIF) and attached drawings are prepared specifically for Luangwa Bridge as shown in Appendix A-2-1.

9-2-2-5 Location and Inventory Data Collection

The bridge inspector shall inspect the bridge and complete the Location and Inventory sections of the IIF. This can generally be completed by checking the appropriate box and by inserting the required names and numbers.

Several parts of the IIF can be completed even without having to go to the bridge site. Note, however, that all data shall be verified on site.

Data needed for Location and Geographic Information are described in Table 2-2-1.

Table 2-2-1 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

The bridge inspector shall take note of any paticular requirements to gain access or to inspect all parts of the bridge for use in planning future bridge condition inspections. Check the appropriate boxes in Special Inspection Requirements, for items such as ladders, inspection vehicles, boats, etc.

A bridge is made up of various inventory elements;

- General,
- Modifications,
- Spans,
- Piers,
- Abutments.

9-2-2-6 Deliverables

The deliverables of Inventory Inspection Report are as follows.

- The Bridge Inventory Reports
  - A fully completed Bridge Inventory Inspection Form (IIF)

- Geometrical data sheet for Special Bridge

・As Build Drawings

・Data of repair history

・Inventory photographs

The Bridge Inventory Inspection Reports shall be prepared by the bridge inspectors. The reports shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization. When the Bridge Inspection Report is completed, accurate and accepted, all the data shall be stored in BMS.

9-2-3 Periodic Inspection

Periodic Inspection for standard bridge is described in CHAPTER 5. And this chapter is described the Periodic Inspection for special bridges.

9-2-3-1 Purpose

The purpose of the Periodic Inspection is to record defects and rate the condition of special / long span bridge as a basis for identifying its current maintenance needs, forecasting its future intervention measures and estimating its future funding requirements. Also, the result of Periodic Inspection should be used to monitor the deterioration of defects.

9-2-3-2 Scope of the Inspection

The scope of the periodic inspection for special bridge is almost the same as standard bridge, and in addition below.

・Reviewing the existing inventory data of the bridge structure for accuracy

・Visually inspecting the bridge attributes and record their defects to assess their condition using a standard condition rating system.

・Sketch drawings to monitor the progress and deterioration of defects

・Reporting the condition of each bridge attributes

・Providing a general condition rating for the structure as a whole.

・Identifying bridges that require an Detailed inspection (those with an overall condition state poor or bad)

・A photographic record of defects

In Periodic Inspection, the inspector should record all details of defects for assessment of bridge condition using a standard condition rating system and also for the monitoring of progress and deterioration of defects. Therefore, each attribute of the bridge shall be inspected at a distance at least three meters from the surface of the attributes or its equivalent, using binocular as much as possible.

All surfaces of the attributes shall be exposed in good natural or artificial light during the inspection, sufficient to observe fine cracks and other defects on the surfaces. Bearings at the abutments and piers shall be inspected at eye level. The inside of both box girder and tower shall also be inspected closely. The bridge inspection is done visually to cover all parts of the bridge above the ground and water level.

Sketch drawings in Periodic Inspection is very important for the analysis of bridge condition and for the monitoring of deterioration of defects. Inspector should sketch carefully the details of

defects. Sketch drawing of defects should include the range, length, area and severity of defects as much as possible. When inspectors cannot possibly measure the defects, they can roughly estimate measurement through their engineering judgement. If a previous Detailed Inspection Report is available, the findings on the report will be used in the next Periodic Inspection to verify whether these findings remain valid.

9-2-3-3 Process

The step-by step procedure for conducting the Periodic Inspection is illustrated in the following flowchart.

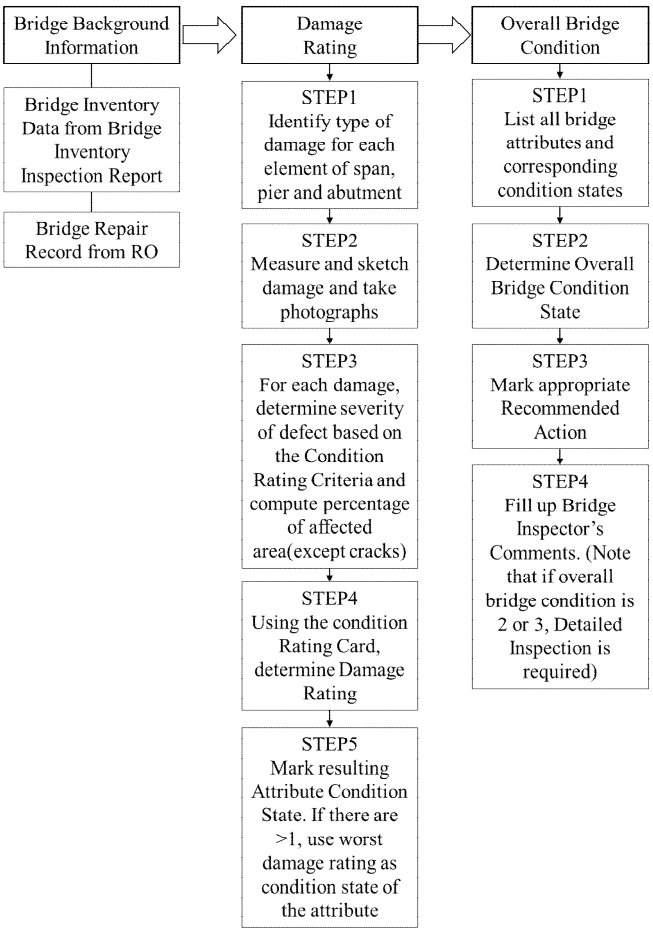


Figure 2-3-1 Flowchart of Bridge Periodic Inspection

9-2-3-4 Inspection route and the points of inspection

【Periodic Inspection Form (PIF)】

As a reference, Periodic Inspection Forms (PIF) and sketch Drawings of Luangwa Bridge are shown in appendix A-2-2.

The bridge Periodic Inspection Routes of Luangwa Bridge are shown in Figure 2-3-2, 2-3-3 and 2-3-4, and the Check Points of the Periodic Inspection are shown in Figure 2-3-5 and 2-3-6. As a breakdown, the PIF is composed of forms shown in Table 2-3-1

Special / long span bridges are complex structures. Before conducting inspection, proper numbering of elements and attributes on the forms should be considered to avoid misinterpretation on its location. During inspection, each attributes shall be numbered / marked for easy identification. Numbering and marking of attributes are shown in Figure 2-3-7.

Inspection of Upper Deck

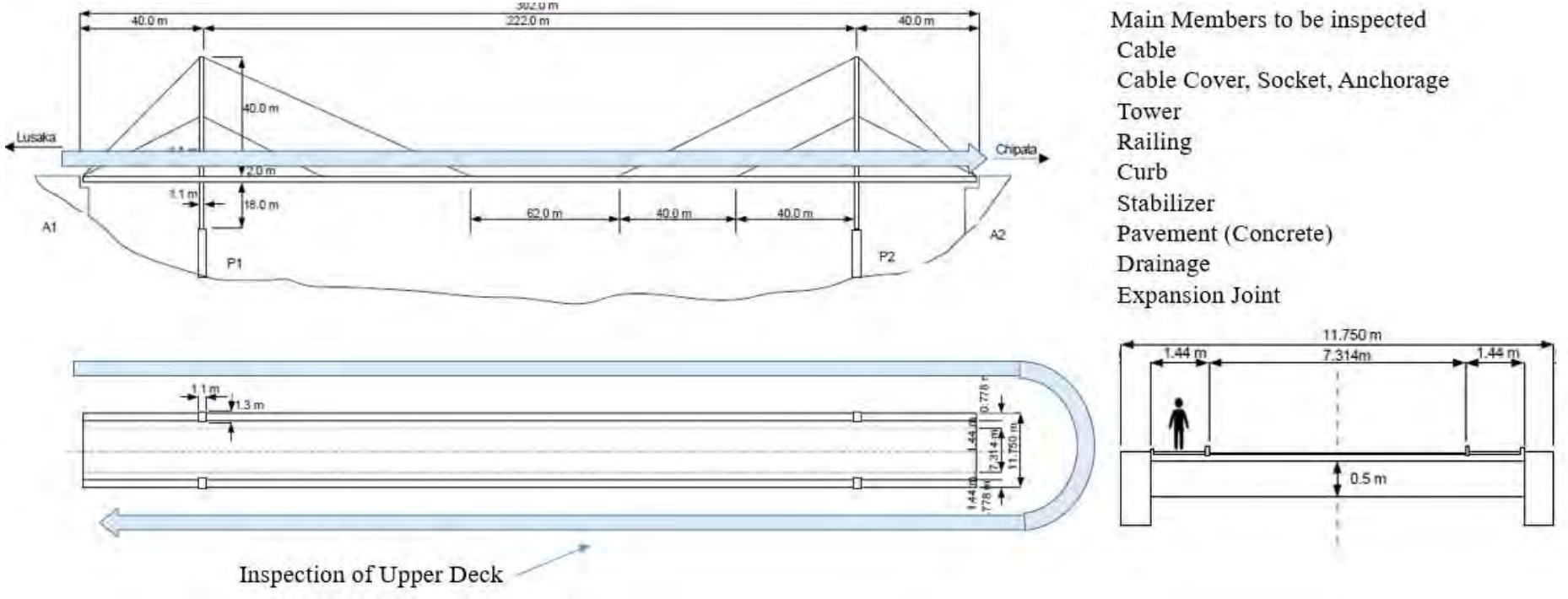


Figure 2-3-2 Periodic Inspection Route of Luangwa Bridge (1 of 3)

Inspection of Underside

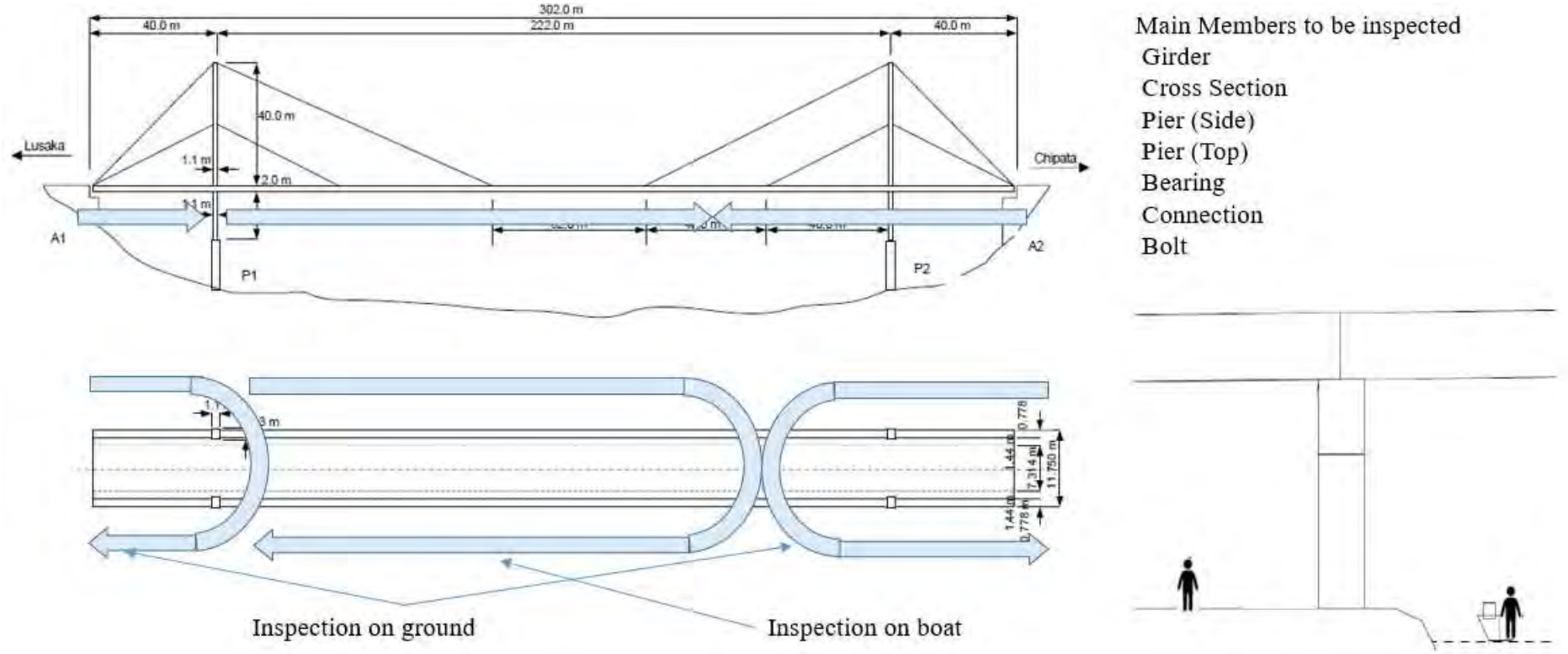


Figure 2-3-3 Periodic Inspection Route of Luangwa Bridge (2 of 3)

Inspection Area of Each Place

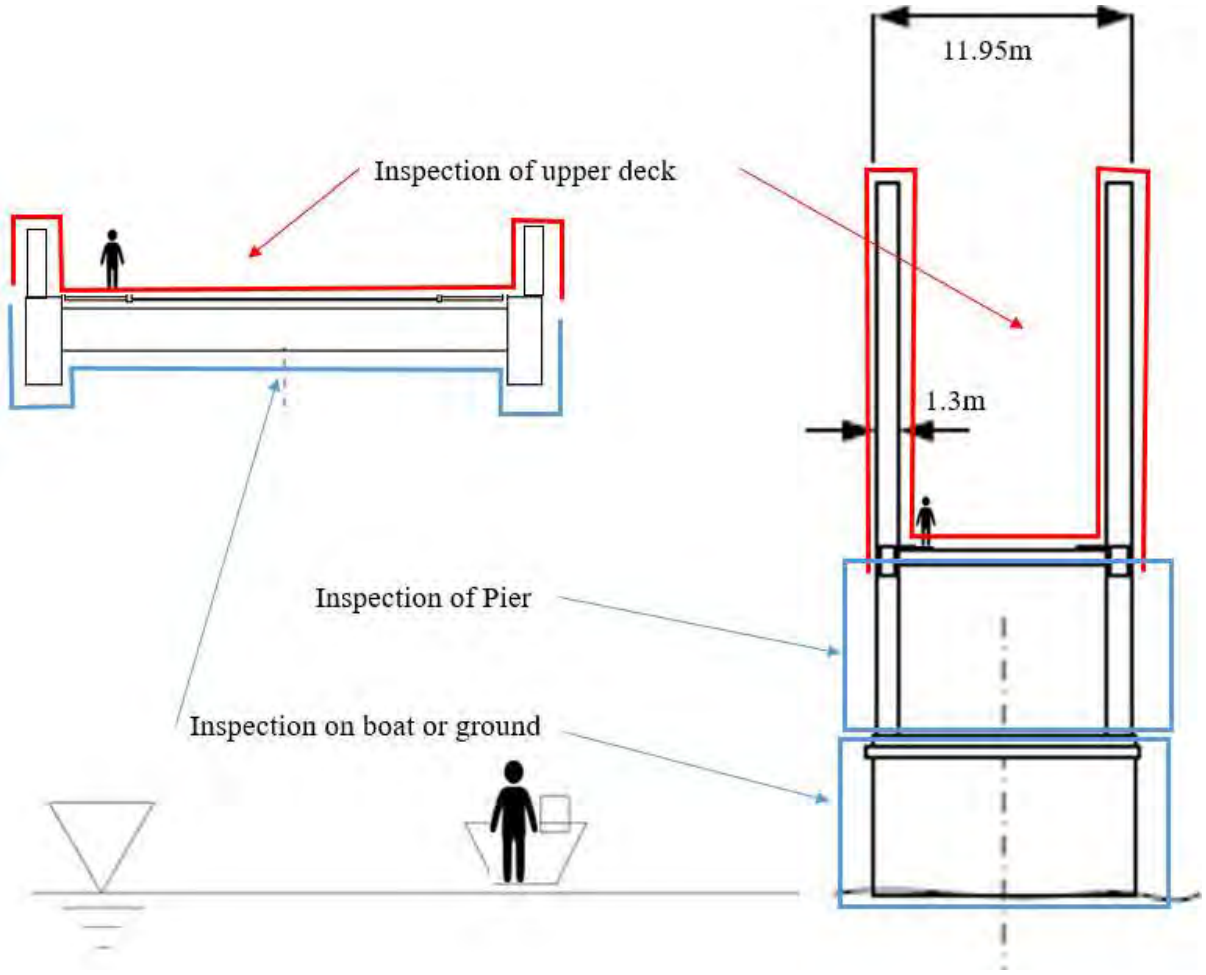


Figure 2-3-4 Periodic Inspection Route of Luangwa Bridge (1 of 3)

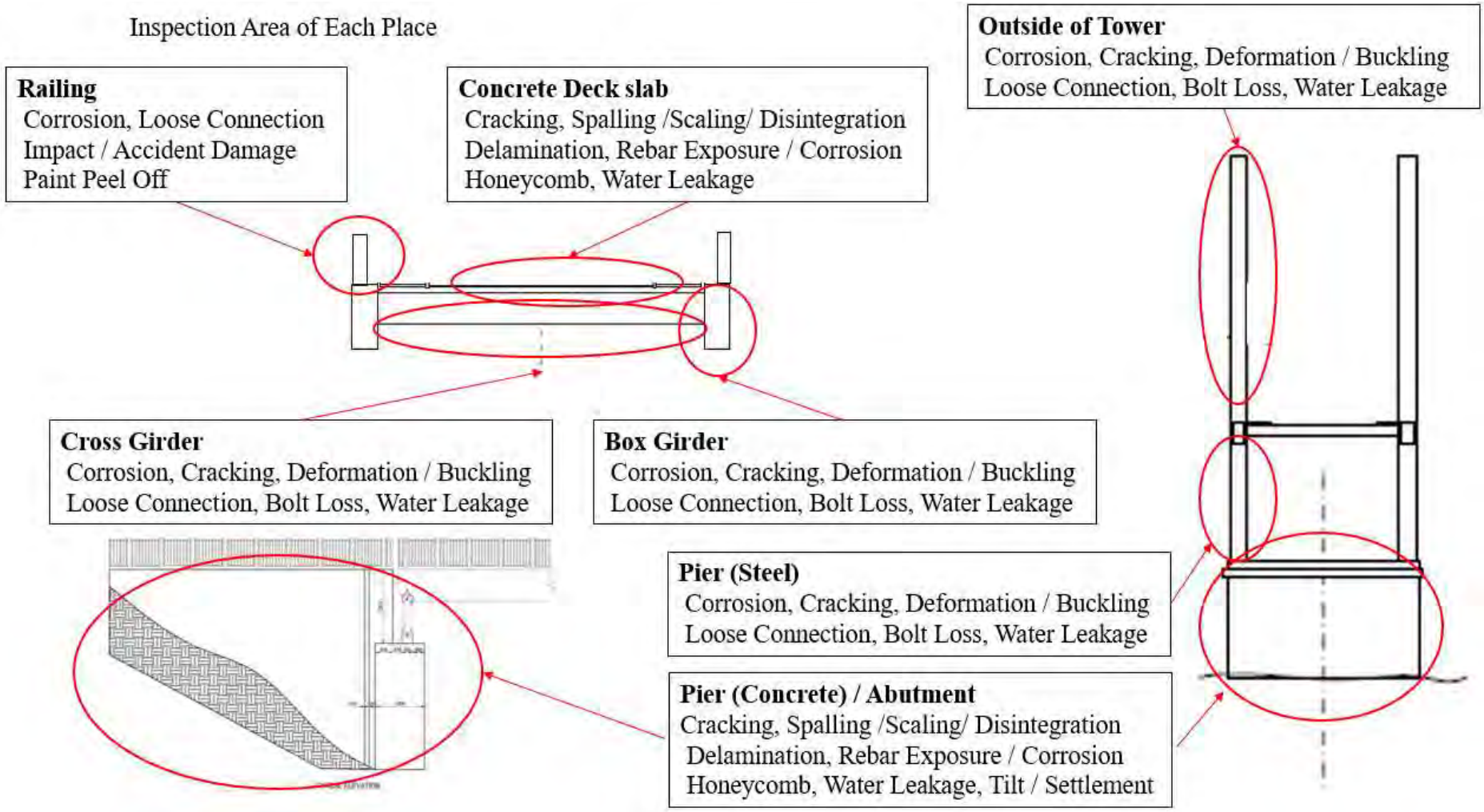


Figure 2-3-5 Check Points of Periodic Inspection – Luangwa Bridge (1 of 2)

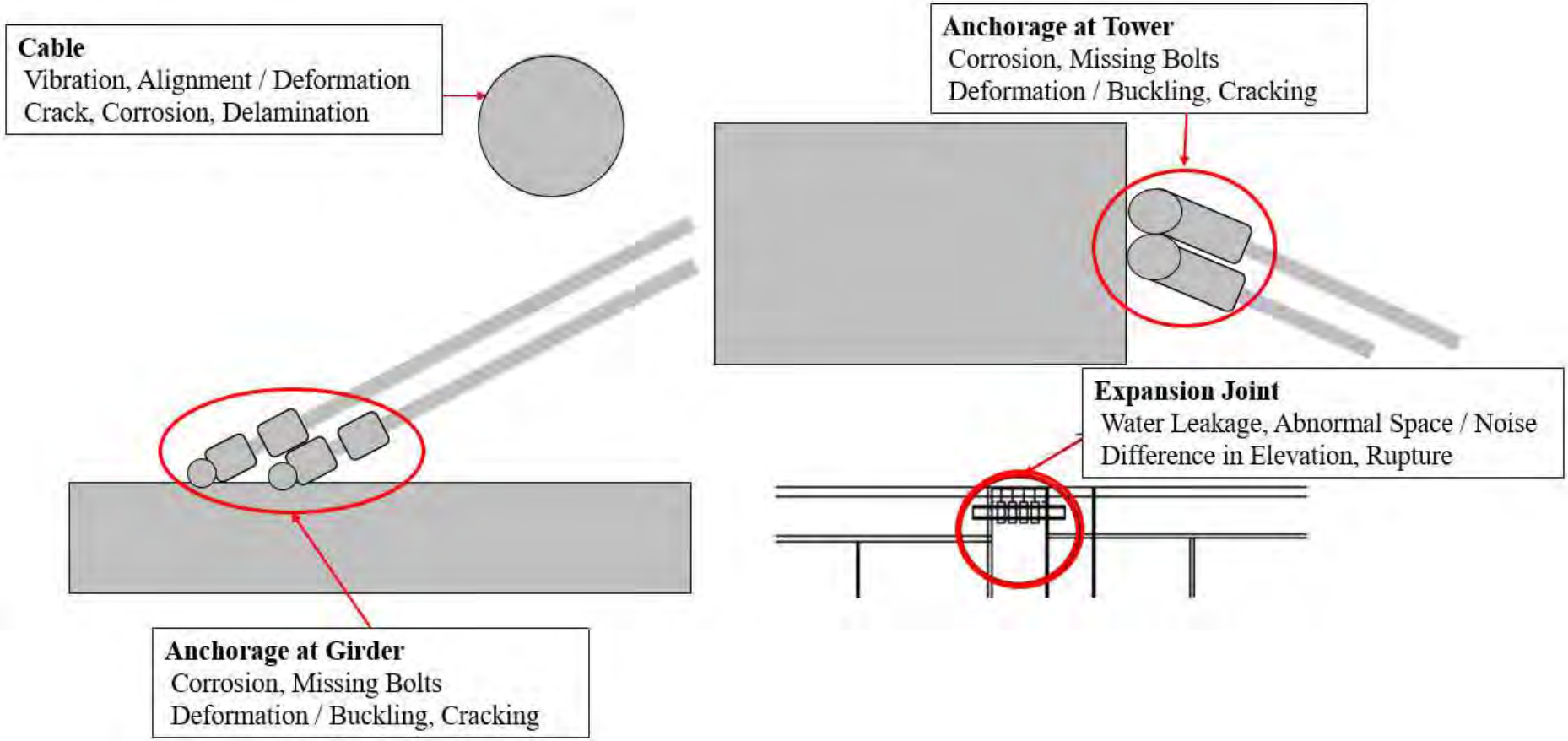
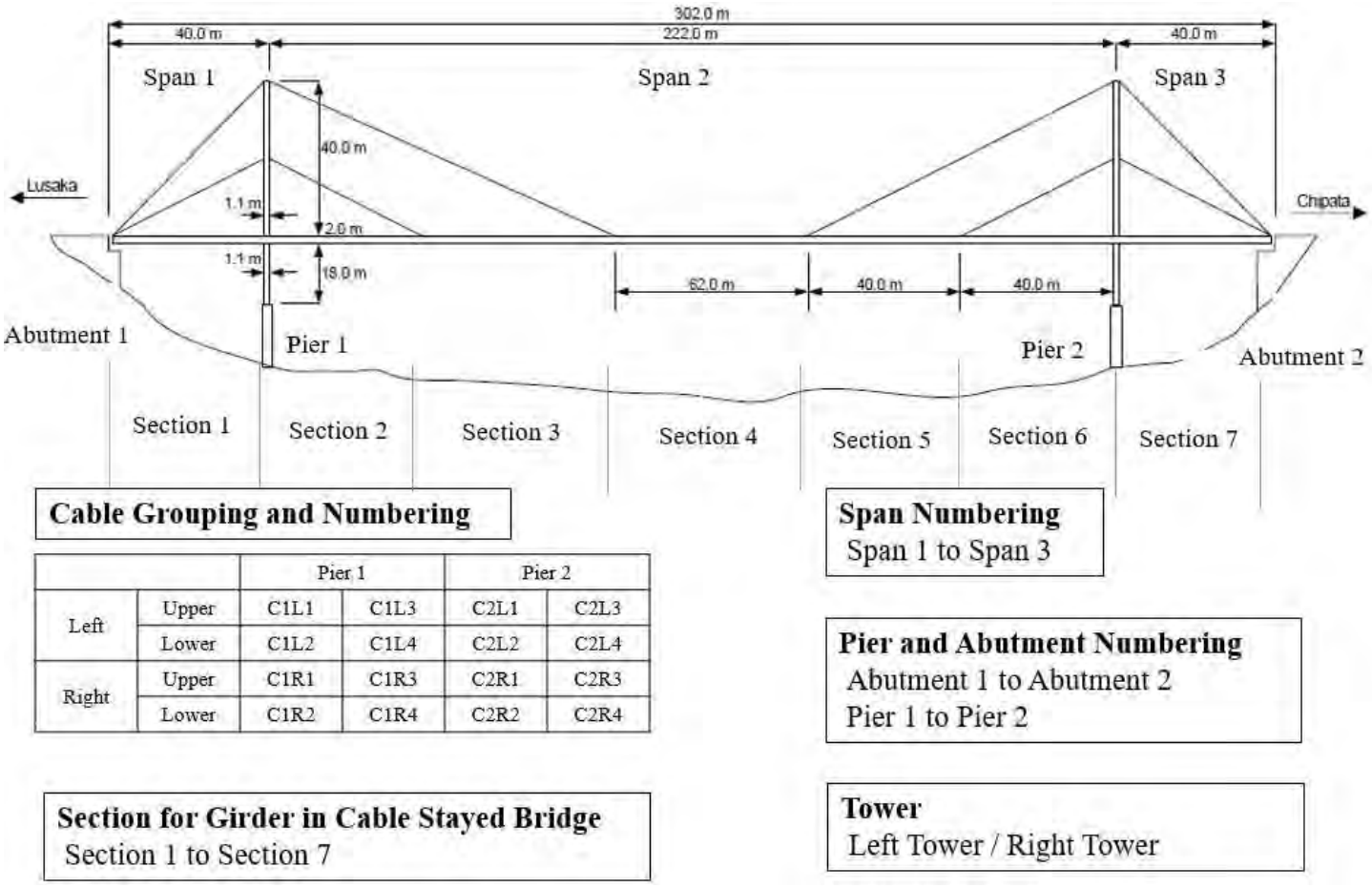


Figure 2-3-6 Check Points of Periodic Inspection – Luangwa Bridge (2 of 2)



		Pier 1		Pier 2	
Left	Upper	C1L1	C1L3	C2L1	C2L3
	Lower	C1L2	C1L4	C2L2	C2L4
Right	Upper	C1R1	C1R3	C2R1	C2R3
	Lower	C1R2	C1R4	C2R2	C2R4

Figure 2-3-7 Numbering of Members – Luangwa Bridge

Table 3-3-1 Composition of Periodic Inspection Form (Luangwa Bridge)

Title of Form	Number of Form
(1) Summary, Repair record	2
(2) Damage Rating (main structure)	6
(3) Damage Rating (cable)	8
(4)Sketch (Deck and Appendage)	7
(5) Sketch (Abutment and Pier)	4
(6) Sketch (Cable)	8
(7) Sketch (Tower)	2
(8) Sketch (Girder)	7
(9) Photo	As needed
Total	44

【Level of Inspection】

The Bridge inspector shall indicate the level of inspection undertaken as shown in Table 2-3-2.

Table 2-3-2 Level of Inspection

Full complete inspection	
Partial inspection only as bridge inspection vehicle not available	
Partial inspection for other reason	

It is practical to use Bridge Inspection Vehicle at least once in every three years, due to the limited number of such vehicle. Bridge Inspector should consider the arrangement of Bridge Inspector Vehicle when they make a maintenance plan for Luangwa Bridge. If a complete inspection is not undertaken, then revisit the bridge and inspect with a Bridge Inspection Vehicle or other required equipment (for example, drone). A countrywide program for the use of the available Bridge Inspection Vehicles should be utilized to ensure optimum result of the inspection.

【Bridge Inspection Vehicle】

Bridge Inspector Vehicle (BIV) is one of the most important equipment used to provide temporary access for inspectors to approach inaccessible area for close inspection, such as high tower, chord, cable and under bridge.

Generally, two types of BIV are used in the inspection of bridges. One type is Bucket Type BIV which is also called Aerial Work Platform (AWP). This type of BIV is widely used for maintenance and construction of bridge and also for power and telecommunications industries. They can lift inspectors up to high level to inspect tower, cable band chord and etc. Figure 2-3-8 shows the picture of the Bucket Type BIV.

Figure 2-3-8 Photo of Aerial Work Platform Type BIV



Another type of BIV is Telescoping Articulated Platform. This type can carry the inspector underneath the bridge to check girders, bottom of slab and etc. Figure 2-3-9 shows the picture of Telescoping Articulated Platform Type BIV.

Figure 2-3-9 Photo of Telescoping Articulated Platform Type BIV



When BIV used, a designated vehicle operator should accompany the inspection and operate the vehicle. Inspectors should be tied to the rigid frame by safety belt during lifting.

【Location and Inventory Data】

The bridge inspector shall inspect the bridge and review the Location data included in the PIF. Data required are described in Table 2-3-3.

Table 2-3-3 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

【Repair Record】

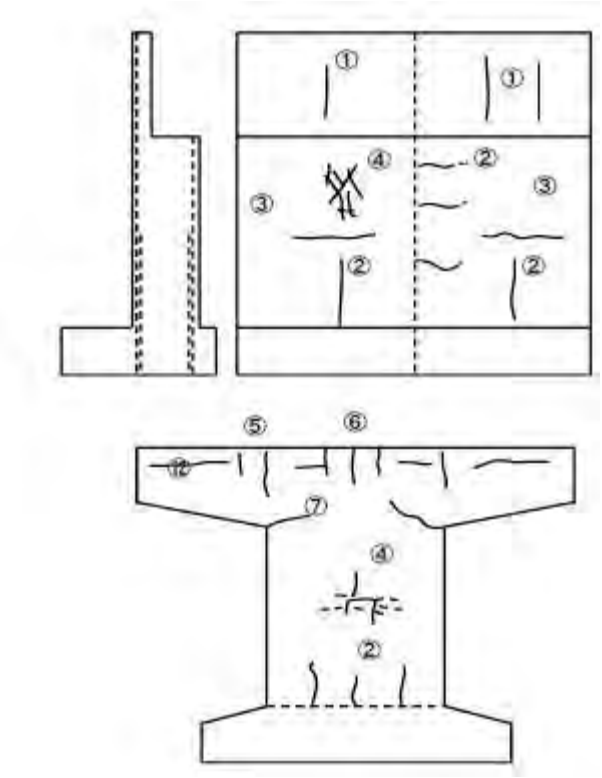
The bridge inspector is required to report the routine and major maintenance activities undertaken to a bridge after the conduct of the last periodic inspection that will include the type, scope and status of maintenance activities. The bridge inspector shall also record observations whether the works undertaken are effective and sufficient.

【Periodic Data Collection】

Special bridges like Cable Stayed Bridge have unique attributes and materials which are not defined in the BMS Manual for standard bridge. Bridge Inspection Team should understand the characteristic and function beforehand by reviewing the As Built Drawings and other related documents.

As a reference, some special attributes of Luangwa Bridge are listed in Table 2-3-4. All other applicable descriptions in the BMS Manual for standard bridge are adopted in this Manual. General pattern of defects in bridges are shown in Figure 2-3-8 and 2-3-9.

General Patterns of Crack Defects on Abutment and Pier



Number	Pattern
1	Crack with regular interval
2	Crack on the concrete casting joint
3	Crack around the changing point of density of reinforcement bar
4	Crack like mesh
5	Crack on topside of overhang beam (coping)
6	Vertical crack on pier center
7	Crack on bottom side of overhang beam (coping)
8	Crack on upper and bottom part of column
9	Crack on column
10	Crack on haunch
11	Bending crack on the span center or beam
12	Horizontal crack on beam

Figure 2-3-8 General Patterns of Defect (1 of 2)

General Patterns of Crack Defects on Steel Bridge

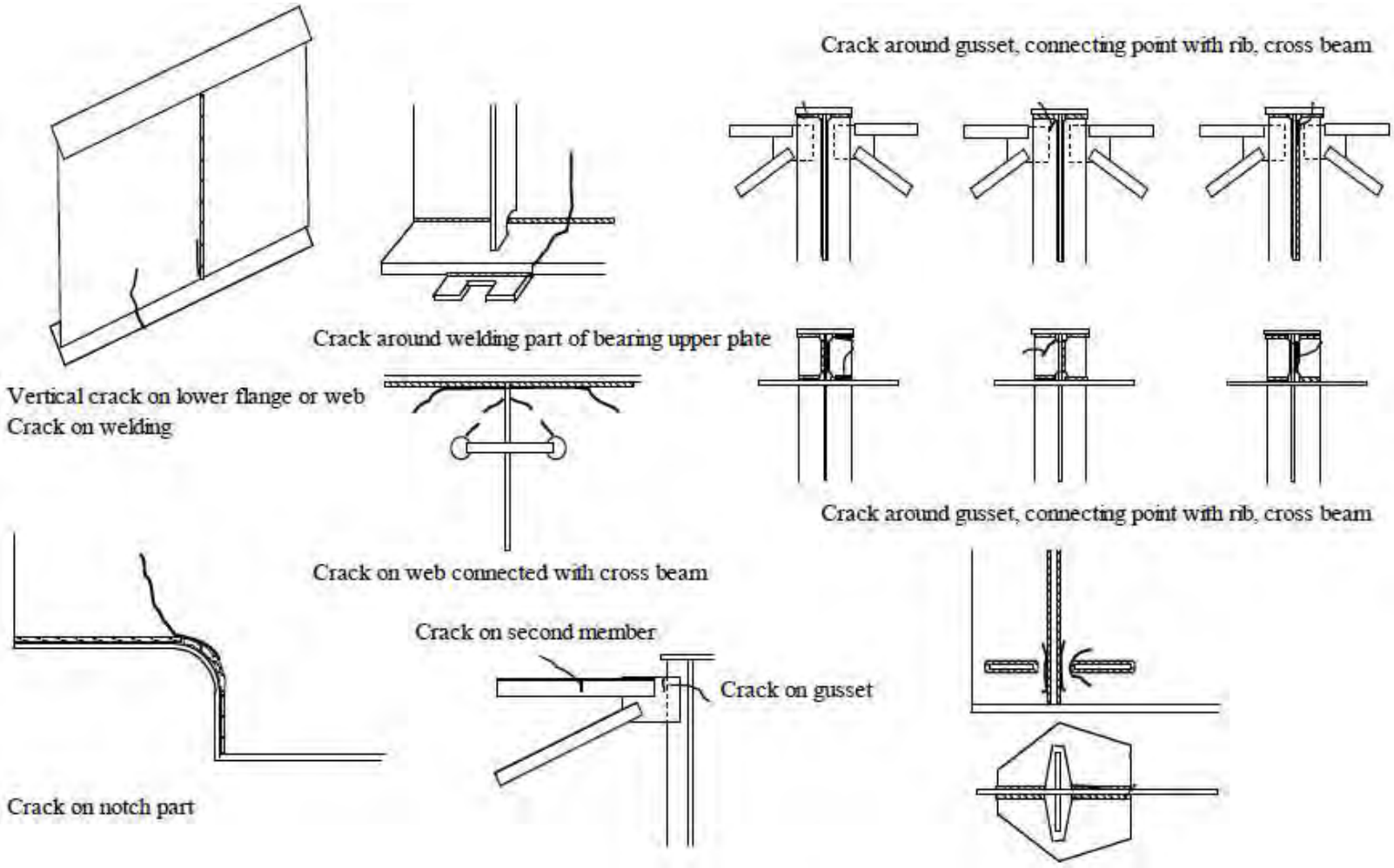


Figure 2-3-9 General Patterns of Defect (2 of 2)

Table 2-3-3 Special Attributes of Luangwa Bridge

Element	Attribute	Description
Anchorage	Main member	Anchorage is to keep the stay cable's tension force for support of bridge. They are quite important parts for the Cable Stayed Bridge. Corrosion and damage of anchorage are contributoriy to bridge collapse.
Cable	Main Member	The cable is the most important attribute for the Cable Stayed Bridge. They suspend girders and put external pre-stressing into the girder. They have coating made of high density polyethylene and cover duct which prevents deterioration of cable. Corrosion and damage of cable are contributory to bridge collapse.

【Condition Rating of Bridge Attributes】

The material defect descriptions and the condition rating criteria in BMS will be utilized by the Bridge Inspectors (BI) to assess the defects identified in bridge elements. On the other hand, the Periodic Inspection for the stay cable and anchorage will be undertaken using this Manual.

The condition rating of the bridge attributes will be conducted following Inspection guidebook. Additional material defects are specifically described in Appendix D-2-1. while the corresponding conditon rating criteria concerining the same is included in Appendix C-2-1 (cable element).

The affected area, length or number will be roughly estimated and using the Periodic Rating Card, the attribute damage rating can be obtained. The condition state of the attribute is the worst damage rating. The descriptions cannot possibly cover every situation, and the BIs must rely on their engineering knowleage and judgment to evaluate which condition should apply to the bridge elements inspected.

The BIs shall also compare the defects observed in the attriute with the previous sketch drawings and photograph records to check the progress.

The condition states have been developed to describe the following conditions listed in Table 2-3-4.

For each defined attribute in the bridge, the Periodic Inspection Forms includes a separate section covering that attribute and which is to be completed by the BI. Each section shall be completed to include:

・The condition state of the attribute (see Table 2-3-4)

・The type of repair required for each attribute

・The estimated cost to undertake the required repair (major maintenance)

All repairs to attributes are classified as major maintenance.

The standard descriptions of major maintenance that may be undertaken for each attribute are;

・Repair damage

・Protective measures

・Strengthen

・Replace

・Other

Only one type of maintenance can be listed for each attribute. When two or more types of maintenance are required to an attribute, all work shall be listed under the type of maintenance with the highest estimated cost.

The BI shall describe in detail the recommended repair works each identified defect in any attribute, providing sketch drawings if necessary.

Table 2-3-4 Bridge Attributes condition state

Condition State	Description	Action
0	Attribute is in good condition with little or no deterioration	Keep inspection
1	Attribute shows deterioration of minor nature to the primary supporting material and is showing first signs of being affected	Keep monitoring
2	Attribute shows advancing deterioration and loss of protection to the supporting material, minor loss of section	Major maintenance is required wihtin 2 years
3	Attribute shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress	Immediate major maintenance is required

The condition state of each bridge attribute will be used by the BMS to calculate the overall need of the bridge for intervention.

【Not Applicable Attributes】

There are many instances when the Periodic Inspection Forms (PIF) is not completely filled out by the Bridge Inspector due to uncertainties in identifying or locating some attributes of the special brige.

The Bridge Inspector may feel that an attribute cannot be completed because there is no attribute in the bridge, he / she cannot recognize or find the attributes in the bridge. In this case, the bridge inspector should mark the attributes as not applicable.

9-2-3-5 Deliverables

The deliverables of Periodic Inspection Report are as follows:

○Periodic Inspection Report

Bridge Periodic Inspection Form

Summary of Periodic Inspection Results

Repair Record

Inspection Results sheet (condition)

Inspection Results sheet (damage rating)

○Sketch Drawing sheet

○Photo record sheet (Pictorial Report)

The Bridge Periodic Inspection Reports shall be prepared in the respective Regional Office where the bridge inspectors are based. The reports shall be checked and reviewed in the Central Office for completeness and accuracy prior to finalization.

When the Bridge Periodic Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory Database.

9-2-4 Detailed Inspection

Detailed Inspection for standard bridge is described in CHAPTER 6. And this chapter is described the Detailed Inspection for special bridges.

9-2-4-1 Purpose

Detailed Inspection is undertaken as a follow-up to periodic inspection when the condition state of 2 or 3 are recorded in any primary component / attribute or in any secondary component that has detrimental effect on the structural performance of the bridge. The purposes of a detailed inspection for Cable stayed bridge are as follows.

1) To confirm the results of the periodic inspection.
2) To undertaken additional investigations in order to evaluate thoroughly noted defects which may include physical testing and / or structural analysis. And also to prepare a documentary record of the observed defects for future design of required major maintenance works.
3) To assess the current bridge structural condition, behavior and capacity.
4) To assess the rate of deterioration and residual life expectancy of the bridge.

9-2-4-2 Recommendation

In the periodic inspection for standard materials, attributes and so on, “BRIDGE INSPECTION GUIDEBOOK 2017 developed by JICA” should be referred to. However. There is no standard method in the Detailed inspection for special materials, attributes and so on, like cable, rope, anchorage.

For example, in case of abnormal vibration of the stay cable, the extent of vibration should be measured using video and other amplitude measuring instruments. Aside from the vibration amplitude, the tensile strength of the Stay Cable should also be determined. Also when water leakage and discoloration of cable element is observed, there is a possibility that the inside of cable is already corroded and should be thoroughly inspected. In both instances, determining the vibration amplitude and tensile strength of the Stay cables is difficult for the Regional Office.

It is recommended that the Regional office engage the services of detailed inspection / investigation firms specializing on Cable stayed bridge. For example, NDTs (Non-destructive testing) should be conducted in order to grasp whether the defect exist or not. NDTs for steel attributes are Paint Thickness Test and Metal Thickness Test mentioned in Chapter 6-3.

9-2-5 Geometrical Inspection

9-2-5-1 Purpose

The purpose of the Geometrical Inspection for Special Bridge is to obtain data primarily of a basic information of special / long span bridge. Bridge would be moved or deformed by impermissible loading from heavy vehicles or deformed due to a disaster. Deformation, movement, change of alignment of members should be measured regularly. It is useful information for analysis of bridge deformation.

9-2-5-2 Procedure

Geometric dimensions of special / long span bridge should be measured every three years using measuring survey equipment, like Total Station.

When severe disasters occurred, like earthquake, typhoon and ship or car collision, Geometrical Inspection should be undertaken in order to confirm the degree of deformation.

Geometrical Inspection methods are shown in Figure 2-5-1, 2-5-2, 2-5-3, and 2-5-4. As a reference, Geometrical Inspection form (GIF) of Luangwa Bridge are shown in Appendix A-2-3.

The Geometrical inspection is composed of a three-part measurement survey.

- ○leveling of super structure and substructure
  - ・Elevation of longitudinal alignment of deck surface
  - ・Elevation of piers and abutments
- ○Slope of tower and top chord
- ○Movement of bearing and expansion joint

In case there is an official bench mark that is close to the bridge, it should be used for the leveling of bridge. Likewise, additional bench mark should be established around the bridge during the inspection.

The result of Geometrical Inspection should be stored in the Special Bridge Inventory Database. After Geometrical Inspection, Bridge Inspector and Bridge Engineer should analyze and compare the previous year's result. If excessive movement was observed, further investigation such as Detailed Inspection should be conducted in order to determine the appropriate corrective measure to be undertaken.

9-2-5-3 Deliverables

The deliverables of Geometrical Inspection Report are as follows;

- ○The Geometrical Inspection Reports – A fully completed geometrical inspection form(IIF)
- ○Updated Geometrical Inspection (part 3times data)
- ○Inventory photographs

The Bridge Geometrical Inspection Report shall be prepared by the bridge inspector. The report shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization.

When the Bridge Geometrical Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory.

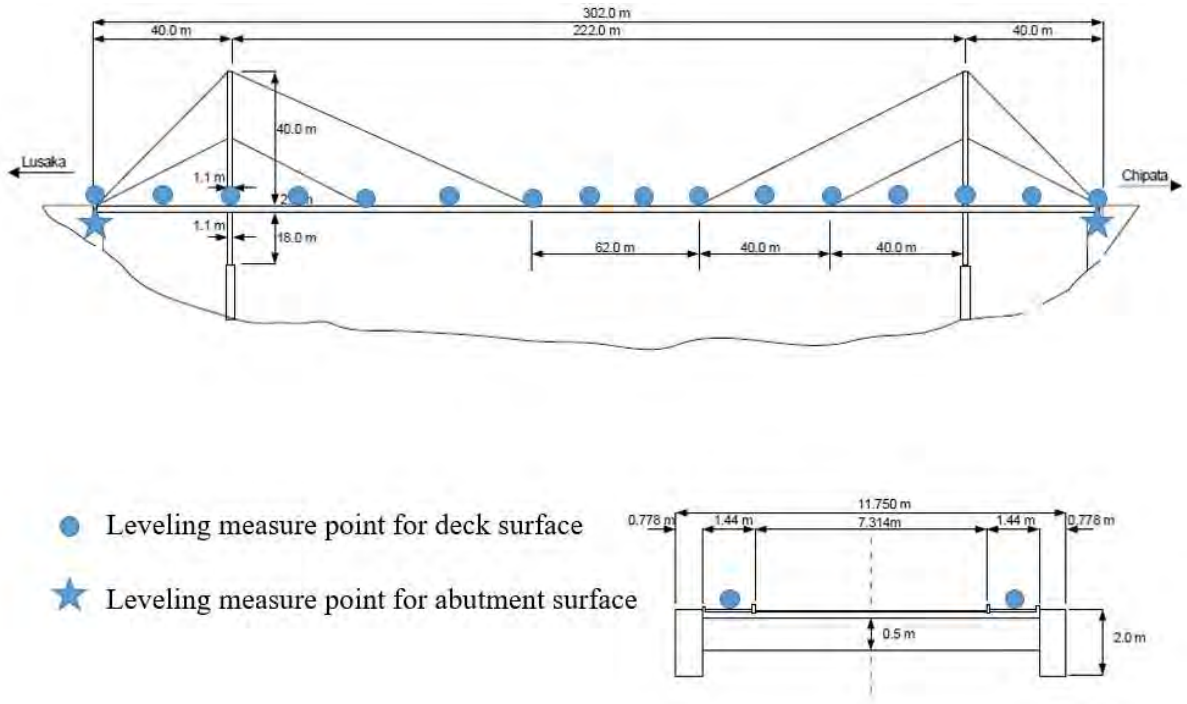


Figure 2-5-1 Geometrical Inspection:
Leveling of Abutments and longitudinal alignment of deck surface

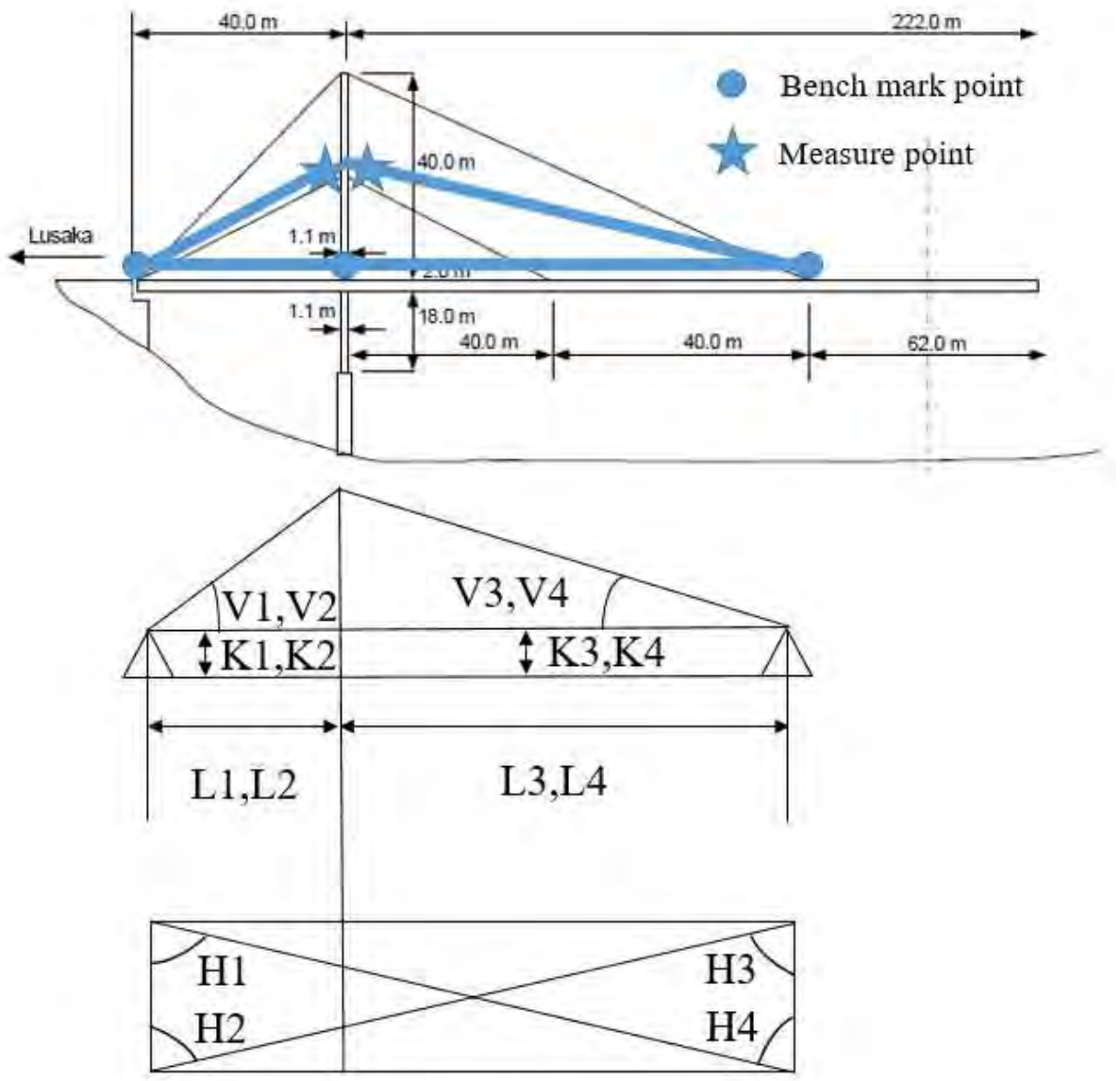


Figure 2-5-2 Geometrical Inspection:
Slope of Vertical Alignment of Arch Chord (1/2)

Measure: Angle (Vertical): V1',V2',V3,V4'
Angle (Horizon):H1',H2',H3',H4'
Length: L1', L2', L3', L4'
Height; K1', K2', K3', K4'

Raise: K1'+L1'*tanV1'
K2'+L2'*tanV2'
K3'+L3'*tanV3'
K4'+L4'*tanV4'

Slope: L1'/tanH1'
Slope: L2'/tanH2'
Slope: L3'/tanH3'
Slope: L4'/tanH4'

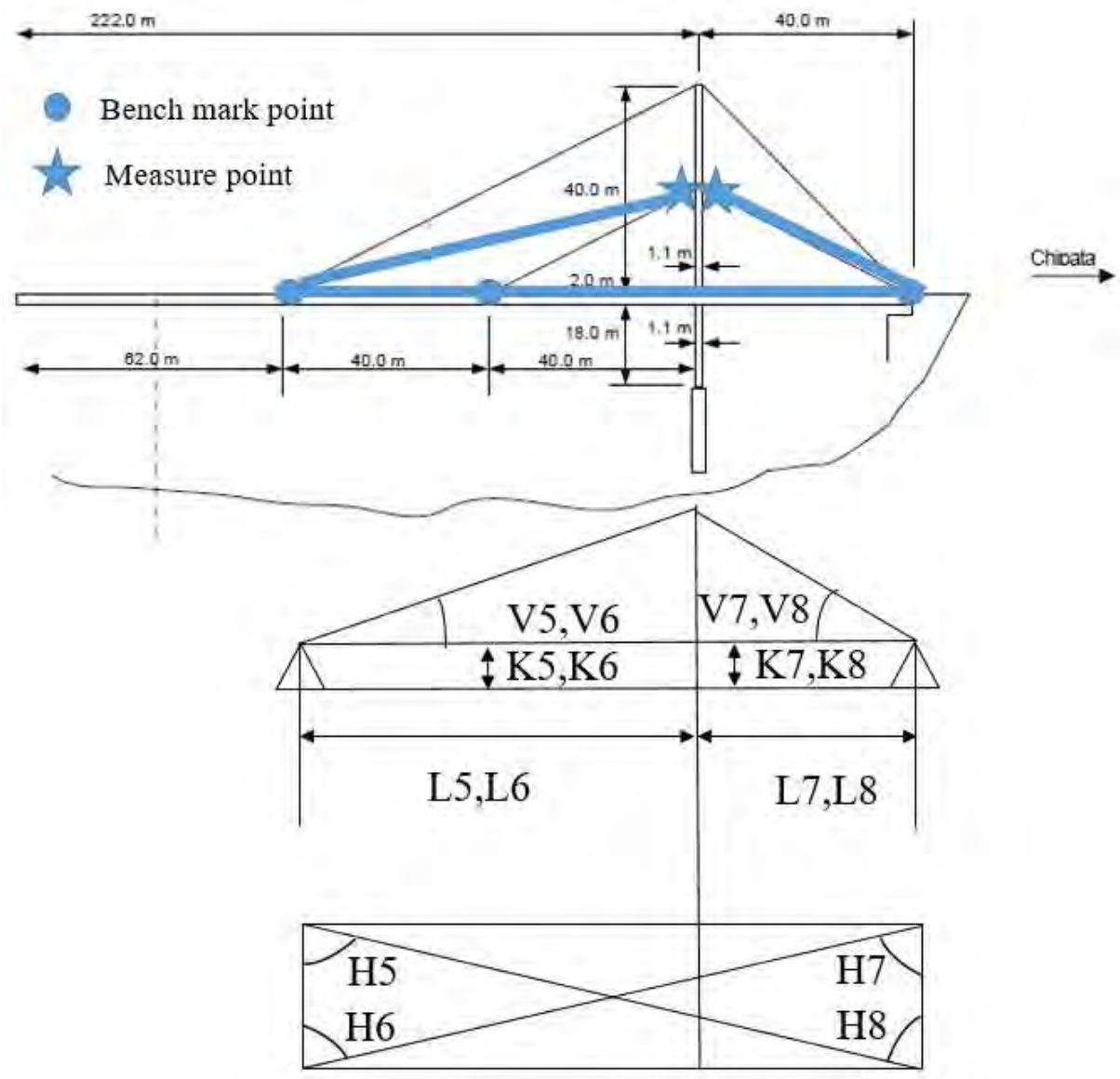
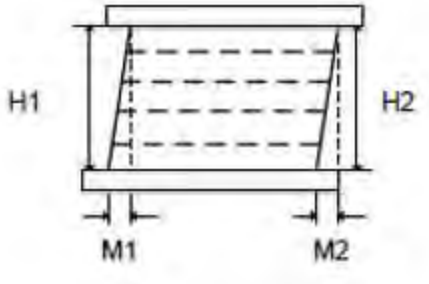


Figure 2-5-3 Geometrical Inspection:
Slope of Vertical Alignment of Arch Chord (2/2)

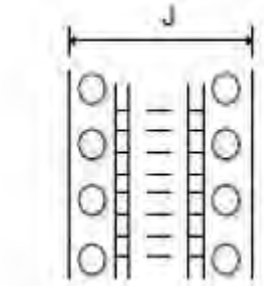
Measure: Angle (Vertical): V5’,V6’,V7,V8’
Angle (Horizon):H5’,H6’,H7’,H8’
Length: L5’, L6’, L7’, L8’
Height; K5’, K6’, K7’, K8’

Raise: K5’+L5’*tanV5’	Slope: L5’/tanH5’
K6’+L6’*tanV6’	Slope: L6’/tanH6’
K7’+L7’*tanV7’	Slope: L7’/tanH7’
K8’+L8’*tanV8’	Slope: L8’/tanH8’



Bearing

Measure every bearing (everytime use same marking point)



Rubber Type

Expansion Joint

Measure 5 selected points in each joint and average (everytime use same marking point)

Figure 2-5-4 Geometrical Inspection:
Movement of Bearings and Expansion Joints

9-2-6 Emergency Inspection

9-2-6-1 Purpose

Emergency Inspection will be undertaken in response to calamities or occurrence of severe damages that may be tend to cause substantial damage to any part of the structure. This inspection is required to confirm that the bridge remain safe to commuters following a calamity or any man-made disasters and to determine the necessary work that is required to ensure the safety of the bridge and to restore the function of the bridge.

9-2-6-2 Process

There is no general process for emergency inspections as these inspections are ad-hoc inspections undertaken in difficult conditions.

9-2-6-3 Procedure

No standard procedure is required for this type of inspection.

9-2-6-4 Deliverables

The deliverable will be an Emergency Inspection Report. This will be the form appropriate for the required emergency action.

9-2-7 Types and causes of damage

Types and causes of damages for standard bridge by the bridge types are described in CHAPTER 8. In addition, this chapter shows types and causes of damages focused on Cable Stayed Bridge (especially Luangwa Bridge), and shows where to inspect.

9-2-7-1 damages of stay-cable system, tower, girder and deck slab

The possible types of deterioration of the stay-cable system in a cable stayed bridge or similar structure are as shown below.

- Stay-cables (Figure 2-7-1): Cable fracture, corrosion, fatigue cracking, corrosion or cracking of the protective tubing, vibration
- Stay-cable anchors (steel, Figure 2-7-2 and Figure 2-7-3): Corrosion of the anchor, deformation or buckling close to the anchor, deterioration or corrosion of paint, water leakage or water accumulation, fatigue cracking



Figure 2-7-1 Stay cable in Luangwa Bridge



Figure 2-7-2 Stay cable anchor in Luangwa Bridge (girder side)



Figure 2-7-3 Stay cable anchor in Luangwa Bridge (tower side)

The possible types of deterioration of the towers in a cable stayed bridge or similar structure are as shown below.

· Tower (steel, Fig 2-7-4): Corrosion at the boundary between the concrete foundation and steel tower, corrosion and deterioration of paint caused by airborne salt, cracking of concrete foundation

· Others: Subsidence or inclination caused by earthquake or ground deformation, deterioration of tower-side stay-cable anchors

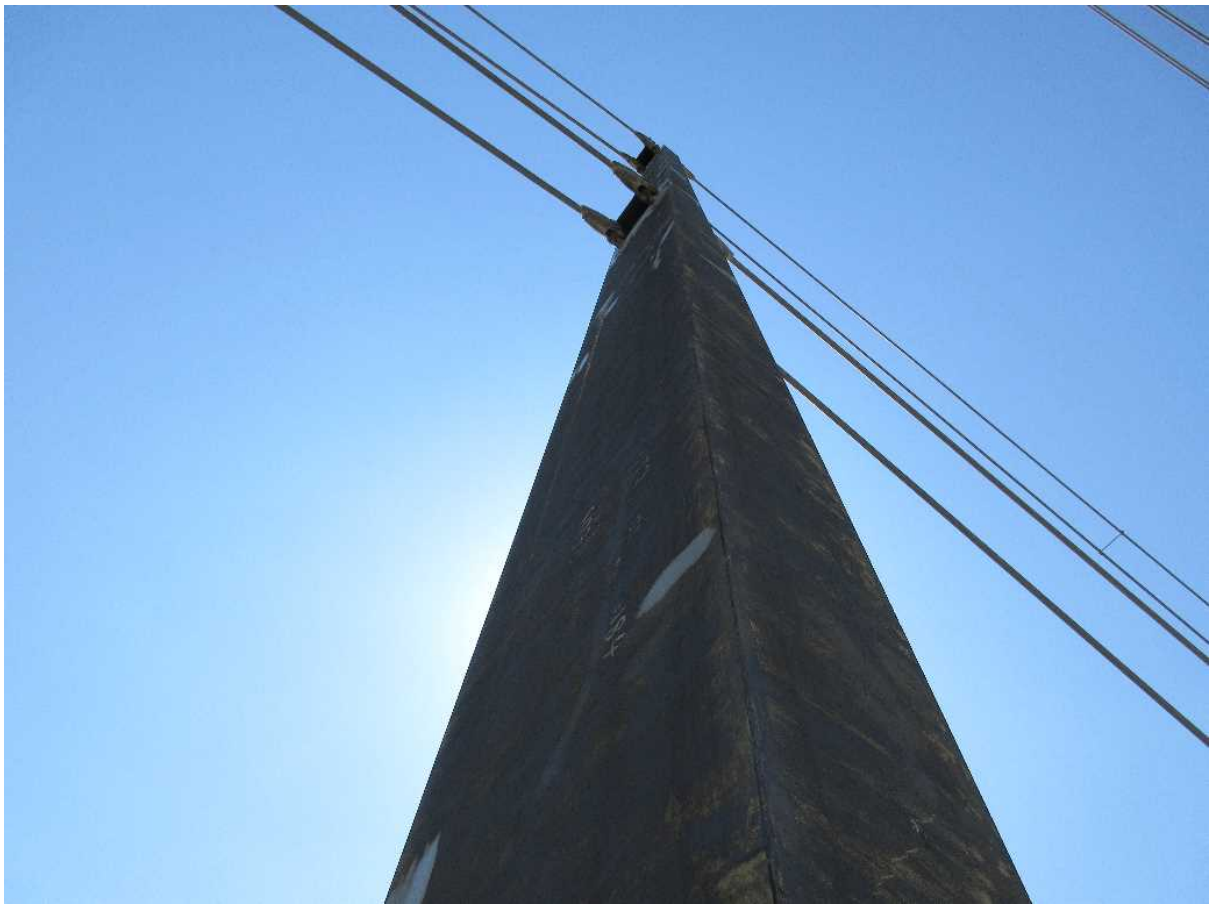


Figure 2-7-4 Tower in Luangwa Bridge

The corrosion of steel occurs in presence of water and oxygen. In the air, oxygen is always supplied from the atmosphere and water is supplied from rainfall or moisture, so corrosion may occur. But various substances such as meteorological conditions – temperature, sunshine, salt or dust contained in the atmosphere – strongly affect the rate and extent of corrosion reaction. In case of Luangwa Bridge, one of the cause of corrosion is the moisture from Luangwa River and stay-cable, anchors, bolts and tower may rust. It should also be noted that corrosion environment differs depending on the structural factors of each part of the bridge.

In Luangwa Bridge, the plate connected cable and tower is welded as shown in Figure 2-7-3 and there is a possibility that deformation or cracking may occur by traffic load. As these damages progress, the cable may break. Therefore, it is very important to inspect the plate carefully, especially pay particular attention to the welded part.

In Stayed Cable Bridge, the tension of cables plays a very important role in the structural system. So it is essential to grasp whether the tension of cables is appropriate or not. The possible

types of deterioration of the two box girders in Luangwa Bridge are as shown below.

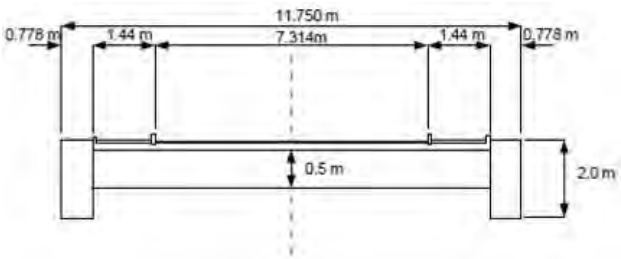
· Two box girders (steel, Fig 2-7-5): Torsion and deformation according to heavy traffic vehicle. In the Luangwa Bridge, reinforcement work is being carried out to additionally construct a cross girder, so any torsion of the box girder have not been shown.



Figure 2-7-5 Two Box girders in Luangwa Bridge

Compared with another Stayed Cable Bridge, girder span is so wide and height of the girder is low in Luangwa Bridge as shown in Figure 2-7-6, therefore, it is structurally unbalanced. So we have to inspect two box girders and cross girders in order to make sure that there are no problems.

Cross section (Luangwa Bridge)



Cross section (Meiko West Bridge)

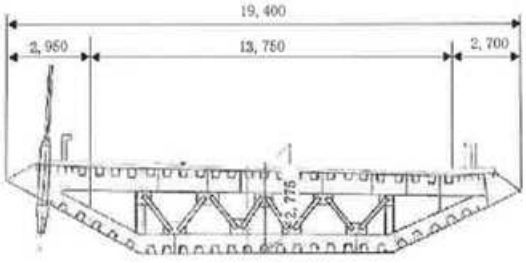


Figure 2-7-6 comparison of cross section

The existing type of deterioration of the deck in Luangwa Bridge is as shown below.

・ Deck slab (Figure 2-7-7): Sagging of the central span of the bridge. Especially, central span of Luangwa Bridge (222 meters) is longer than end span (40 meters). According to the report, the tension of cables was getting to lose when it was constructed. And the tension of cables have not lose after that. It is considered that sagging of central span occurs due to lose tension not due to heavy traffic load.



Figure 2-7-7 sagging of deck slab in Luangwa Bridge

9-2-7-2 Points to focus on during inspection and investigation

The points to focus on during inspection and investigation of a cable stayed bridge or similar structure are as shown in Table 2-7-1.

Table 2-7-1 Points to focus on during inspection and investigation of a cable stayed bridge

Inspection location / structure	Component part	Component element	Example of possible deterioration
Stay-cable system	Stay-cables	Cable (tension)	Change in tensile force
			Additional sectional force resulting from change in tensile force that was not foreseen during design
		Cable (free length part close to anchor)	Cable corrosion caused by water intrusion, cable breakage and loss
			Corrosion of cable close to the anchor
	Stay-cable anchors	Cable (part close to anchor)	Fatigue cracking of cable part close to the anchor caused by water accumulation, wind, or traffic vibration; contact vibration inside casing tube caused by change in tensile force or girder deformation
		Main girder side	Stress concentration on in cable close to the stay-cable anchor, cracking or fatigue cracking caused by localized stress
			Corrosion of part of stay-cable anchor embedded in secondary concrete
			Cracking of fatigue cracking of cable close to the anchor caused by vibration of the stay-cables or main girders
		Tower side	Cracking of steel shell and anchor caused by stay-cable vibration, missing bolts, loose bolts, cracking in welded part
		Anchors	Corrosion of anchors caused by damage to protective tube or other cause of deterioration
	Other		Lightning strike or fire affecting the stay-cable system, damage caused by ship collision or other collision
Towers	Towers (concrete)	Base	Cracking
		Beam support	Cracking
	Towers (steel)	Base	Water accumulation; base corrosion at boundary between tower base and encasing concrete; buckling out-of-plane deformation, or cracking at points where rigidity changed as a result of an earthquake
		Joints	Fatigue cracking, loosening of bolts, corrosion
		General	Deterioration of anti-corrosion function caused by airborne salt or other factor, corrosion

9-2-7-3 Action in response to deterioration of unknown cause

(1) If deterioration that has not been seen before or deterioration of unknown cause was found during inspection of a cable stayed bridge or similar structure, detailed investigation and analysis or testing must be performed in order to identify the cause.

(2) After provisionally identifying the cause by detailed investigation or other means, it is necessary to carry out prediction, performance evaluation, decision of whether or not countermeasures are required, and selection of countermeasures according to the presumed mechanism of deterioration.

(3) If deterioration that has not been seen before or deterioration of unknown cause was found,

the information must be shared within the organization and applied to the maintenance and management plan.

A cable stayed bridge or similar structure includes many important parts, such as the stay-cable system, that are not present in an ordinary bridge. At these parts that are unique to a cable stayed bridge, there is the possibility of finding deterioration that has not been seen before or deterioration of unknown cause.

If such deterioration is found, then detailed inspection should be conducted by special inspection company. Studies must be carried out to identify the cause, evaluate performance, and decide the countermeasure methods. At that time, input from outside experts should be requested as necessary.

9-2-7-4 【Reference】Damage examples of another cable stayed bridge (Multi strand type cable)

As a reference, the case of other cable stayed bridge types will be introduced. In General Cable stayed Bridge which is used multi strand cable, the detailed explanations of damage types are described in below from (A) to (H) as a reference.

(A) Stayed Cables (multi strand): Partial cable fracture caused by corrosion

At cable-stayed Bridge in Japan, as a result of possible stress corrosion cracking, the cable strands sagged and partial cable fracture occurred as shown in Figure 2-7-8.



Figure 2-7-8 Example of partial cable fracture caused by corrosion

(B) Stayed Cables: Cable fracture caused by fatigue

The primary deterioration caused by stay-cable fatigue is cable fracture due to axial fatigue resulting from vehicle loads, and to fatigue (angular change and fatigue strength) caused by vibration.

Vibration of the stay-cables is most often caused by wind, and can be classified into the following primary phenomena.

- Rain vibration: This is vibration occurring in the stay-cables themselves caused when wind-accompanying rainfall acts in a certain direction. It manifests when two water paths are created on the top and bottom of the stay-cables, and the stay-cable cross-section becomes an aerodynamically unstable shape.
- Resonance: This phenomenon causes the stay-cables to resonate as a result of vibration in other parts (such as the main girders) of a cable stayed bridge or extra-dosed bridge.
- Galloping: This is a type of self-excited vibration, and is a form of aerodynamically unstable vibration with a single bending degree of freedom that is perpendicular to the wind direction.
- Vortex induced vibration: This is a phenomenon that occurs when vibration is caused by a vortex acting cyclically on the stay-cables. The vortex acting on the cables occurs as a result of a vortex formed by Karman vortex shedding or by a flow that separated from the cable.
- Wake galloping: In parallel stay-cables, mutual interference between the upstream-side stay-cables and downstream-side stay-cables induces a self-excited hydrodynamic force and causes vibration primarily of the downstream-side cables.
- Buffeting: This is irregular vibration occurring as a result of sudden changes in natural wind.

Examples of vibration in the stay-cables of cable stayed bridges and similar structures, and examples of deterioration caused by vibration, are shown in Figure 2-7-9, Figure 2-7-10 and Figure

2-7-11.



Figure 2-7-9 Example of rain vibration

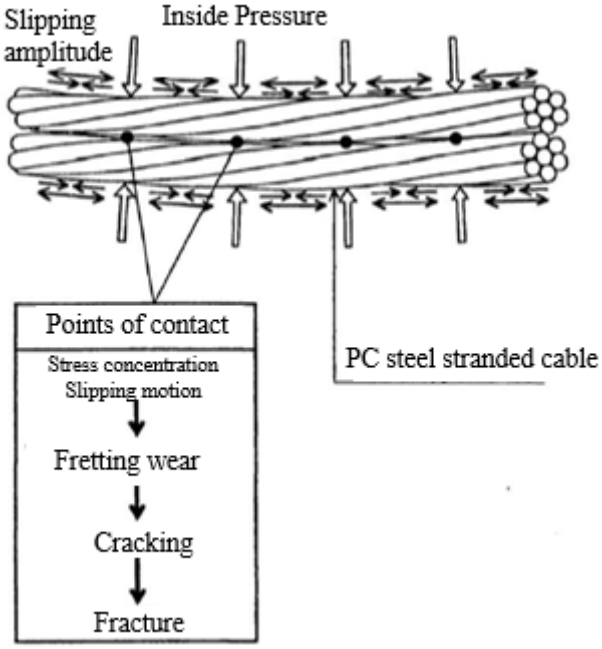


Figure 2-7-10 Concept diagram of fretting fatigue

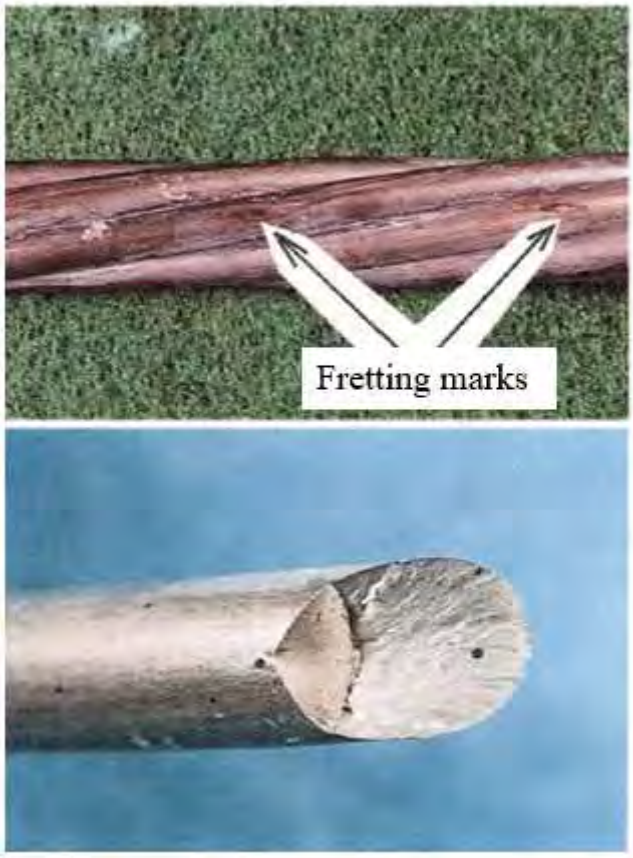


Figure 2-7-11 Fracture conditions at fretting test

Fretting is a wear phenomenon that occurs between two surfaces in contact that are subjected to minute relative movement. When PC steel stranded cables are bound together to create a tendon, in the case of a deviator there are multiple overlapping layers of steel material and inside pressure acts as a result of the change from the outer steel material to the inner steel material. When this occurs, the steel stranded cables are in point contact with one another, and this produces stress concentration at the points of contact due to inside pressure. Under this condition, when changes in axial-direction stress occur in the steel material and result in minute relative slipping in the PC stranded cables or strand tubes, wear and tear occurs at the points of contact. When this progresses, it results in fracture. This series of phenomena is referred to as fretting fatigue.

(C) Stayed Cables: Cable fracture due to fire

At Cable Stayed Bridge in Greece, a fire caused by lightning resulted in fracture of the stay-cables on the top level.

In the same way at the Bridge in Korea, a fire thought to have been caused by lightning resulted in fracture of the top level of stay-cables as shown in Figure 2-7-12. Following the incident, countermeasures were carried out including placing a lightning arrestor cable on top of the stay-cables to reduce the frequency of direct lightning strikes on the stay-cables, and using non-flammable material at points that attract lightning strikes. As shown in Figure 2-7-13, there are also cases of lightning arrestor cables being installed as a lightning countermeasure on cable stayed bridges in Japan as well.



Figure 2-7-12 Conditions of stay-cable fracture



Figure 2-7-13
Example of lightning arrestor cable installation

Although no cases have been reported so far, there are concerns about the effects of vehicle fires caused by accidents or other reason. The results from a cable high-temperature fracture test are shown in Figure 2-7-14. When high temperature conditions occur for a prolonged time around a stay-cable, deterioration of the cable may result in decreased tensile force or, in the worst case, fracture.

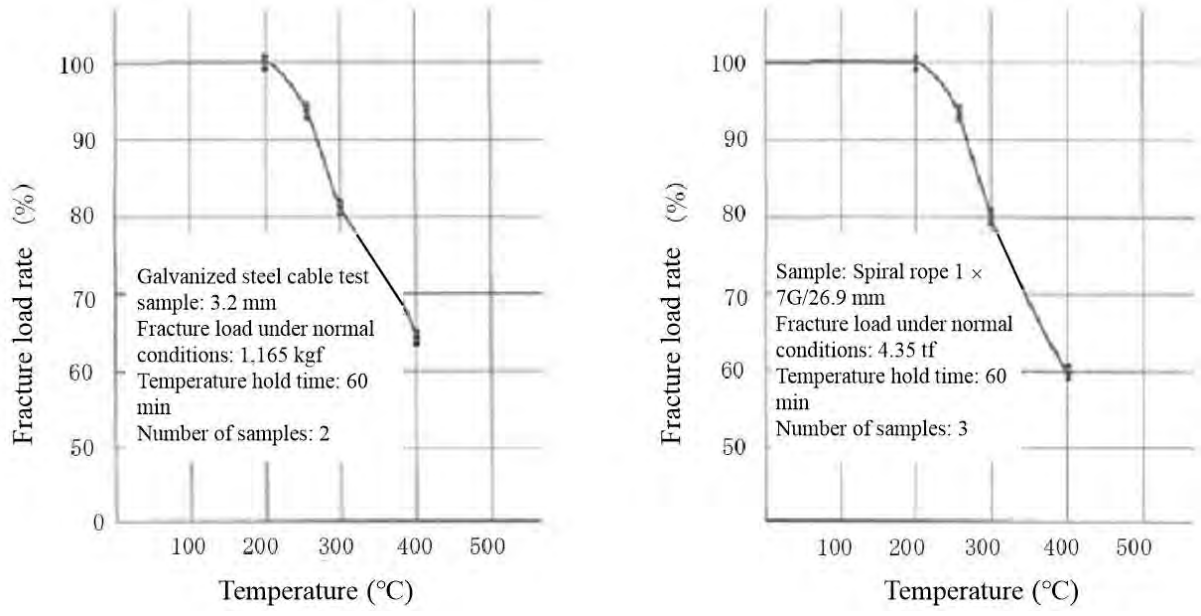


Figure 2-7-14 Results of cable high- temperature fracture test

(D) Stayed Cables: Cable fracture resulting from ship collision

At the cable stayed Bridge in Vietnam, three ships that were set adrift by a typhoon collided with and damaged the bridge, and the stay-cables were replaced. The cable fracture conditions are shown in Figure 2-7-15.



Figure 2-7-15 cable fracture conditions

(E) Stay-cable anchors (steel): Deterioration of stay–cable anchors

The primary deterioration of stay-cable anchors caused by fatigue are loosening of the anchor and fatigue cracking close to the anchor as a result of repeated load or vibration. There are also other types of cable fatigue fracture including bending fatigue fracture at the anchor base caused by reduced function of the cable holding material, fretting fatigue fracture at the saddle, and fatigue fracture caused by stress concentration resulting from cable bending at saddle corners.

(F) Stay-cable anchors (steel): Others

An example of deterioration in the tower-side stay-cable anchor of a cable stayed bridge is shown in Figure 2-7-16



Figure 2-7-16 Example of deterioration in tower side stay cable anchor

(G) Tower: Corrosion

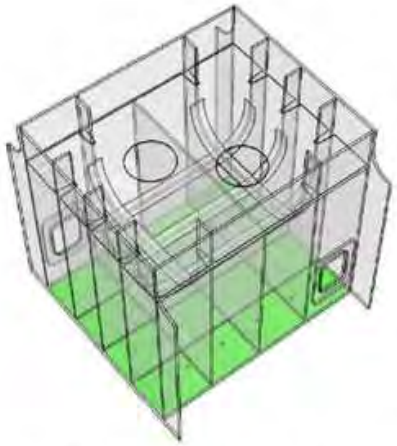
A metal touch structure is used in the towers and other compression members that do not produce tension. The members are joined stacked on top of one other, and high manufacturing accuracy (touch rate) for the contact surface is required in order to ensure verticality. Therefore

caution is required because when corrosion at the metal touch parts occurs, the touch rate of the contact surfaces decreases and unexpected deterioration may occur.

Corrosion of the main tower base is most often caused by water accumulation. Therefore inspections for water accumulation must be conducted, and at the same time checks must be performed to ensure that drain holes are created in suitable locations and are functioning correctly. An example of corrosion in a tower (steel) of a cable stayed bridge is shown in Figure 2-7-17.



Corrosion at joint (metal touch structure)



Corrosion at tower base (water accumulation)

Figure 2-7-17 Example of tower corrosion

(H) Tower: Fatigue cracking

Because the cross section and thickness of the tower base are determined according to the stress produced by an earthquake, the stress range produced by live loads is generally small, and the value is thought to be below the fatigue limit (range within which fatigue cracking is not expected to occur). Therefore it is expected that there is little concern of fatigue cracking occurring. However there is the possibility of deterioration. Sufficient caution must be given to bolt loosening.

9-3-7-5【Reference】 Points to focus on during inspection and investigation in another cable stayed bridge

The trigger for progressing deterioration of stay-cable systems is *water intrusion*. For example, corrosion may be caused by water intrusion into the inside of the stay-cable. Check for this possibility by first checking the surface conditions of the protective tube for cracking or other problems, and checking for leakage or deterioration of the filler. If the conditions could permit intrusion of water into the inside of the stay-cable, then there is the risk of progressing corrosion of cable strands on the inside of the stay-cable. In this case, an inspection of the free-length part of the cable, the cable part close to the stay-cable anchor, and the anchor should be conducted, and a detailed investigation should be carried out including checking for cable cross-section flaws and tensile force measurement. It is also necessary to immediately enact measures to prevent water intrusion.

If deterioration other than the deterioration in the focus points listed in this section is found, it is necessary to take the action in response to deterioration of unknown cause that is listed in Section 9-3-7-3 of this chapter.

The locations where corrosion is likely to occur in the stay-cable system of a cable stayed

bridge or similar structure are shown in Table 2-7-2.

Table 2-7-2 Locations where corrosion is likely to occur in a stay-cable system

Component part	Component element	Location of water intrusion	Remarks
Stay-cables	Cables	Deteriorated locations on waterproofing cover	Covering conditions, deterioration of filler inside tube
		Moisture intrusion from the anchor	
		Deteriorated part of protective tube (cracking of grout injection hole)	Around the deterioration part and between the deteriorated part and anchor Causes of protective tube deterioration ☐Aging deterioration ☐Collision from automobile or ship ☐Weld cracking of injection hole
		Other (covering material joints, etc.)	Around covering material joints Deterioration or damage to heat-shrinkable tubing
Stay-cable anchors	Anchor	Deteriorated locations on waterproofing cover	
		Moisture intrusion from the anchor	
		Deteriorated part of protective tube (cracking of grout injection hole)	Causes of protective tube deterioration ☐Aging deterioration ☐Collision from automobile or ship ☐Weld cracking of injection hole
		Other (covering material joints, etc.)	
	Mantle tube	Deteriorated locations on waterproofing cover	Internal corrosion

CHAPTER 9-3 Suspension Bridge

9-3-1 Bridge Inventory

9-3-1-1 Type of Special Bridge

A Suspension Bridge is a type of bridge which the deck is hung below main suspension cables connected by hanger ropes. Main suspension cables are suspended between towers and have group of parallel wires bundled together to support the stiffening girder/trusses. Main suspension cables have to be anchored at each end of the bridge to hold tension stress. So main suspension cables and anchorages are the most important members to support the whole structure.



Figure 3-1-1 Suspension Bridge

9-3-1-2 Bridge Component

Suspension Bridge is similar to Cable Stayed Bridge that supports girder by cables and likewise has high tower. However, these two bridge support the load of the deck in different ways. The difference is how the cables are connected to the towers. In Suspension Bridge, the cables are installed across the towers, transmitting the load from deck to the towers down to the anchorages. In Cable Stayed Bridges, the cables are attached only to the towers to support the load.

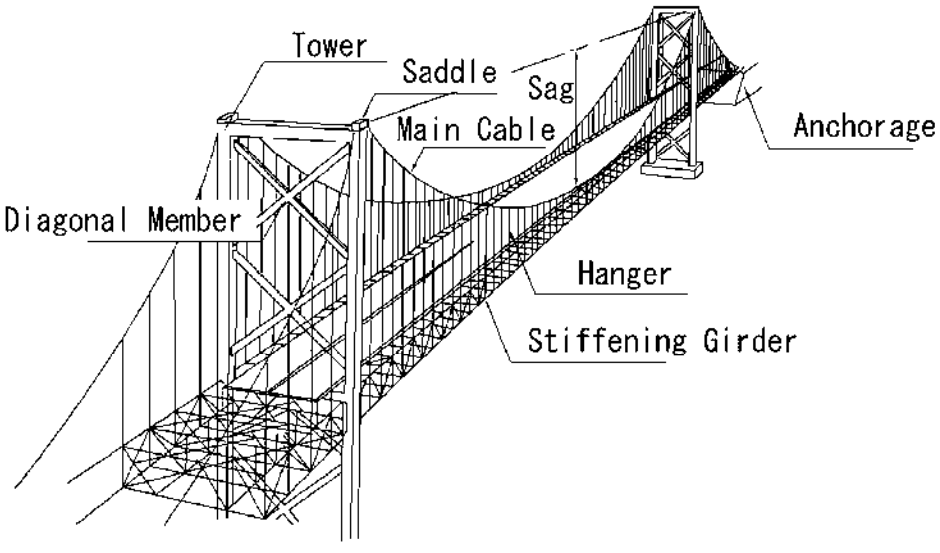


Figure 3-1-2 Bridge Component (Suspension Bridge)

9-3-1-3 Bridge Geometry Definition

The bridge is assessed in the direction of increasing chainage. Refer to Figure 3-1-3.

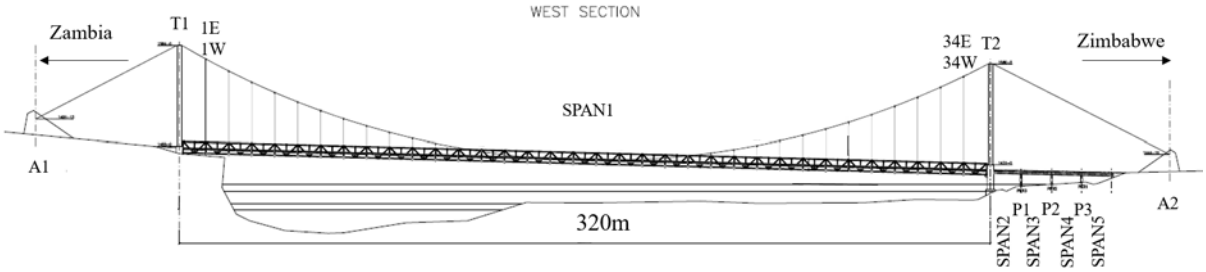


Figure 3-1-3 Bridge Geometry Definition

The following standard abbreviations are adopted to describe a bridge:

ZMBS	-	Zambian Side
ZIMS	-	Zimbabwe Side
S	-	Span
P	-	Pier
A	-	Anchorage
G	-	Girder
C	-	Cable

Example, a three (3) span bridge with girder in each span:

- Anchorage 1 (A1) is at Zambian side end of the bridge and Anchorage 2 (A2) is at Zimbabwean side end.
- Spans 1 (S1), 2 (S2), 3 (S3), 4(S4) and 5(S5) numbered from the Zambian side end of the bridge.
- Pier 1 (P1), 2 (P2) and 3(P3) numbered from the Zambian side end of the bridge.
- Otto beit Bridge's girders are classified left side girder and right side girder (Looking in Zimbabwe side). Accordingly, LG and RG.
- The gilder on the extreme left in span 2 is designated as Span 2 – Gilder 1 (S2LG)
- Vertical cable is numbering 1W, … and 34W in the right side (Looking in Zimbabwe side), and is also numbering 1E,⋯ and 34E in the left side (Looking Zimbabwe side) from the Zambian side shown in Figure 3-1-3.

9-3-1-4 Suspension Bridge

A Suspension Bridge is a type of bridge which the deck is hung below main suspension cables connected by hanger ropes. Main suspension cables are suspended between

towers and have group of parallel wires bundled together to support the stiffening girders / trusses. Any load applied to the bridge is transformed into tension in main suspension cables through hanger ropes and transferred to tower as a vertical load. The tower which supports the main suspension cables transmits the vertical loads to the foundation through piers. Main suspension cables must be anchored at each end of the bridge to hold tension stress. So main suspension cables and anchorages are the most important members to support the whole structure.

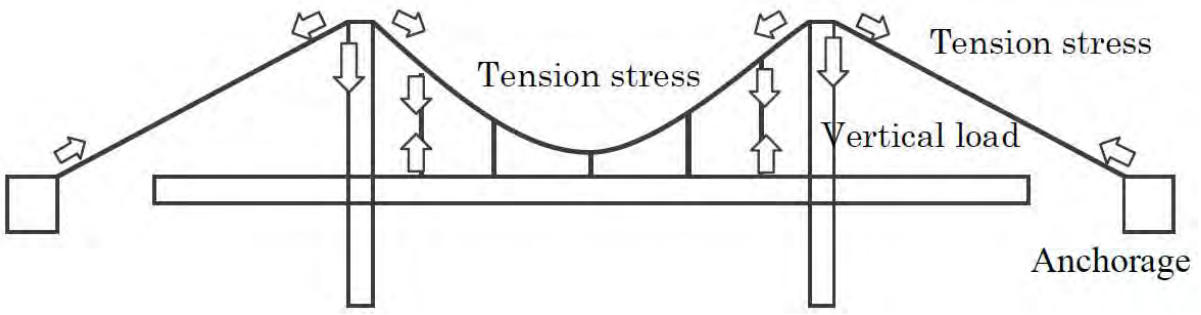


Figure 3-1-4 Load Distribution System for Suspension Bridge

Suspension Bridge is similar to Cable Stayed Bridge that supports girders by cables and likewise has high tower. However, these two bridges support the load of the deck in different ways. The difference is how the cables are connected to the towers. In Suspension Bridge, the cables are installed across the towers, transmitting the load from deck to the towers down to the anchorages. In Cable Stayed Bridges, the cables are attached only to the towers to support the load.

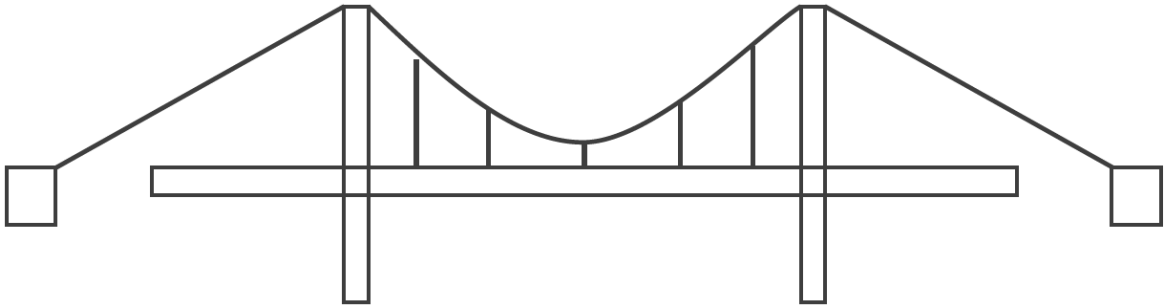


Figure 3-1-5 Suspension Bridge

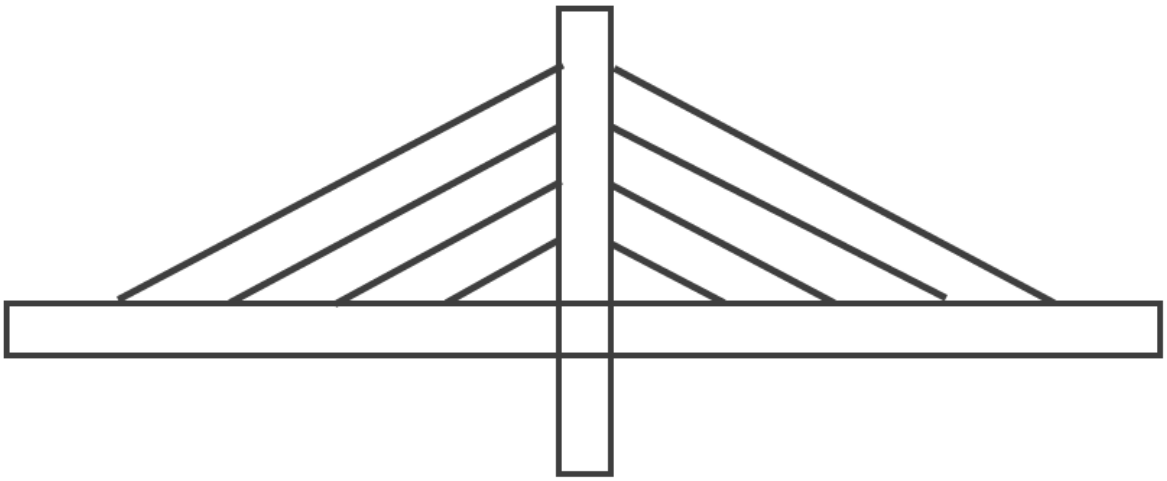


Figure 3-1-6 Cable Stayed Bridge (Harp Design)

Suspension Bridges are classified into single-span, three-span suspension with two towers and multi-span suspension with three or more towers. Otto Beit Bridge is the single-span suspension type shown Figure 3-1-7.



Figure 3-1-7 Types of Otto Beit Bridge (Single - Span)

Towers are classified into rigid, flexible, or rocker types. Otto Beit Bridge has the rigid towers shown Figure 3-1-8.

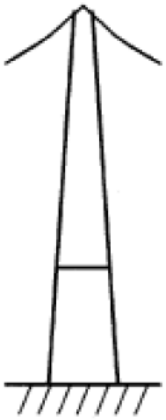


Figure 3-1-8 Types of Tower (Rigid Tower)

The main cable of Otto Beit Bridge is made of several parallel wires and diameter of them is 215mm shown Figure 3-1-9. The cables are covered by wrapping.

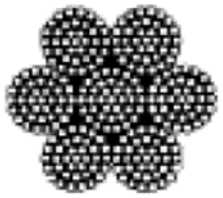
Name	Shape of section	Structure
Parallel Wire		Wires are bundled in parallel. The figure on the left is a standard drawing, and it is unknown what the shape is because the detailed drawing is not exist.

Figure 3-1-9 Types of Cable

Anchorage structure includes foundation, anchor block, cable anchor frames and protective housing. Anchorages of Otto Beit Bridge are classified into gravity anchorage system. Gravity anchor relies on the mass of the anchorage to resist the tension of the main suspension cable. Figure 3-1-10 shows the anchorage in Otto Beit Bridge

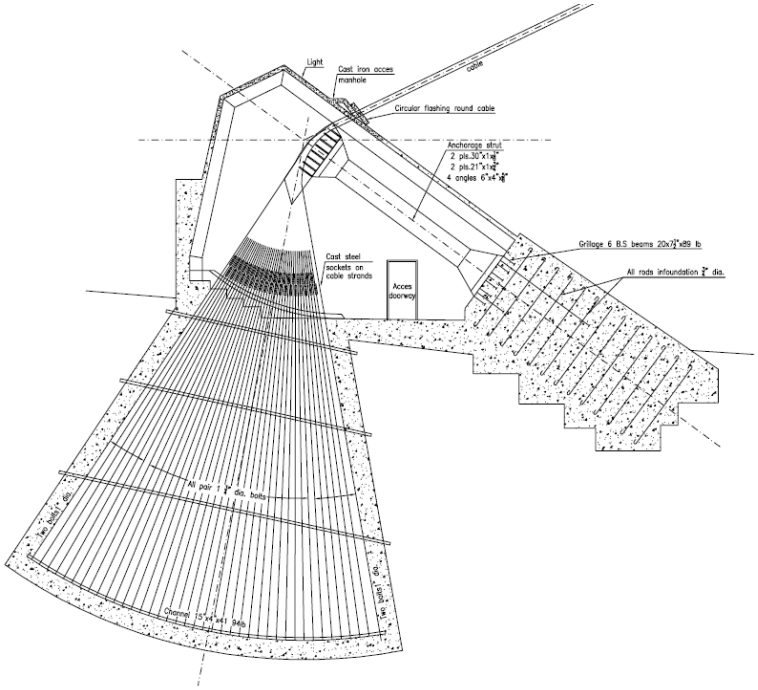


Figure 3-1-10 Anchorage in Otto Beit Bridge

Hanger ropes are fixed to the main suspension cable with suspender clamp and shackle for U bolt shown in Figure 3-1-11. And hanger ropes are spiral strands, and diameter is 69mm (long hangers) and double round steel hangers (short hangers).

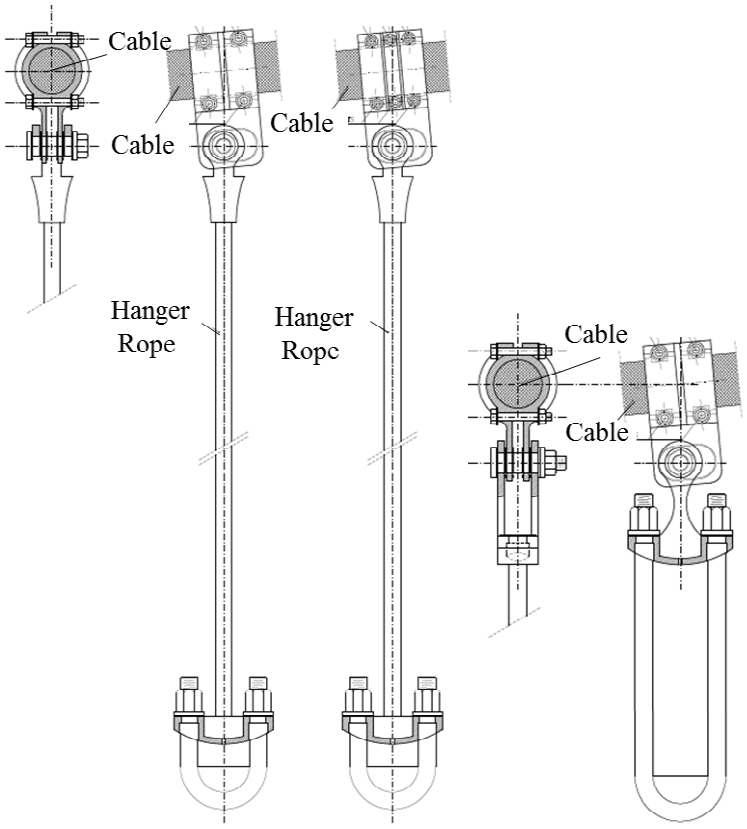


Figure 3-1-11 Connection system

Tower saddle supports the main suspension cable at the tower.

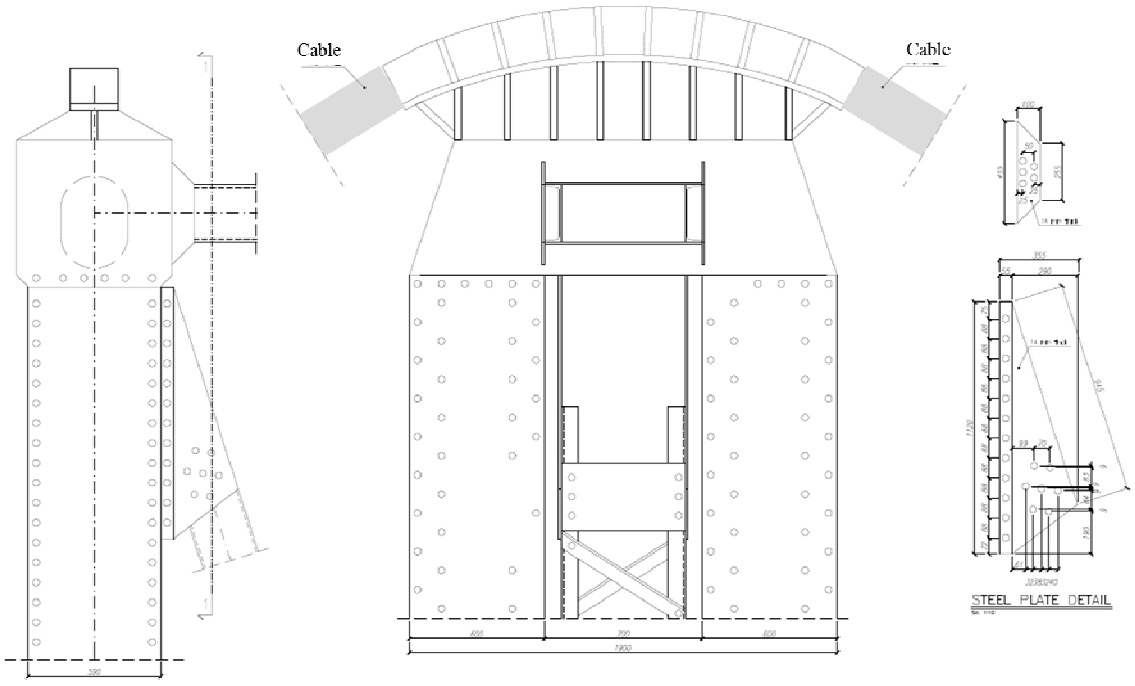


Figure 3-1-12 Type of Saddle

Shown in Figure 3-1-13, 3-1-14, 3-1-15 and 3-1-16 are the General View of Otto Beit Bridge.

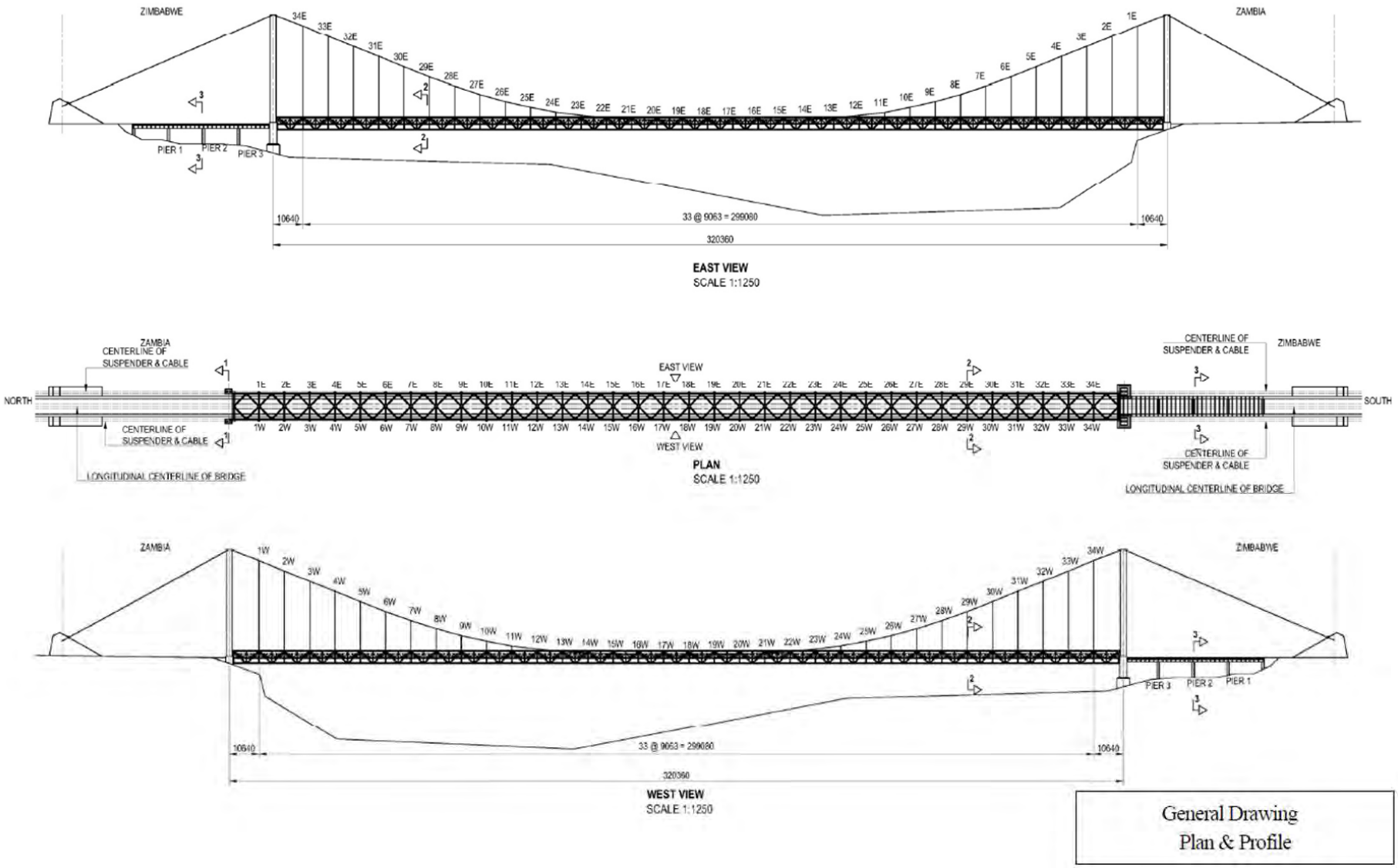


Figure 3-1-13 General View(1of4)

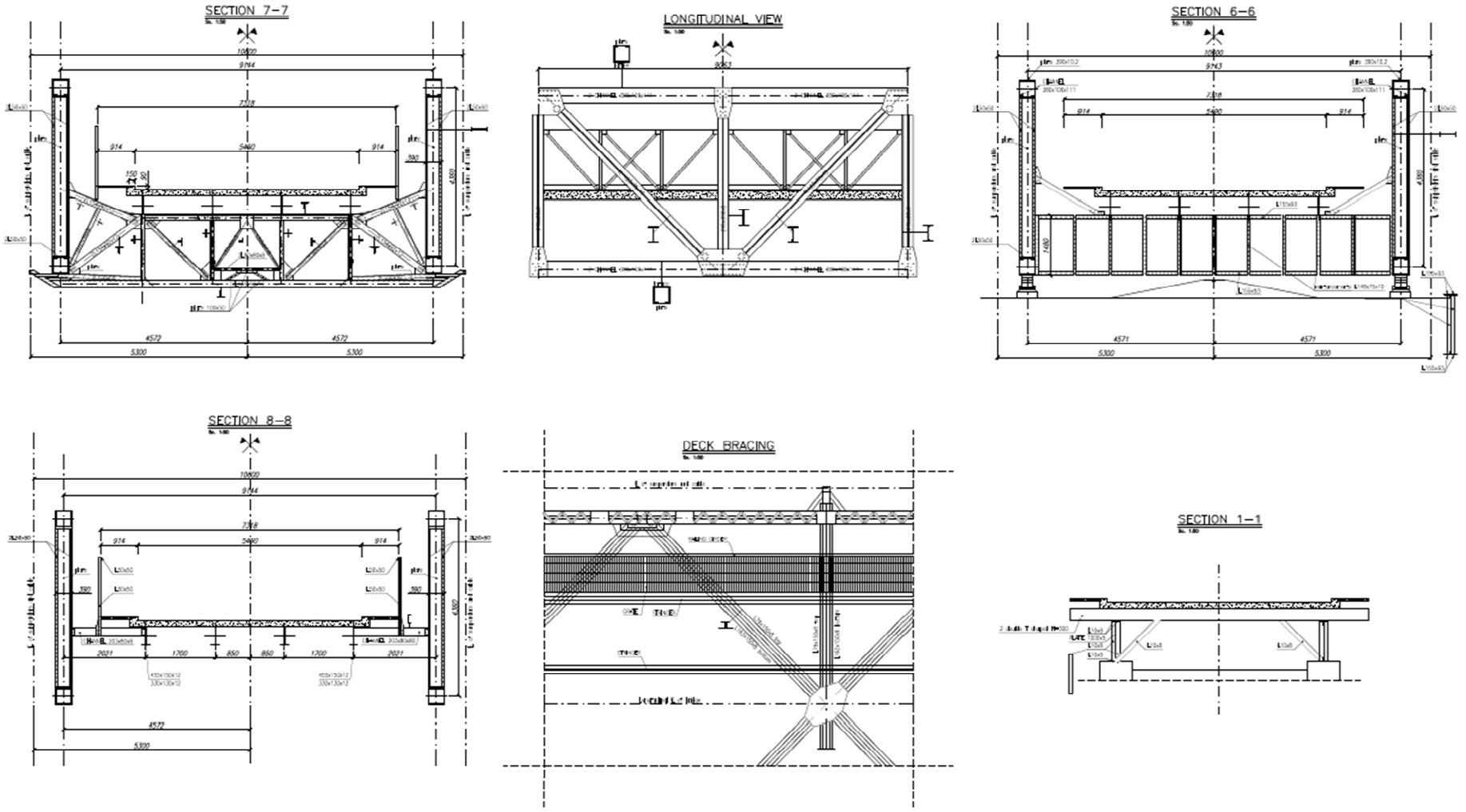


Figure 3-1-14 General View(2of4)

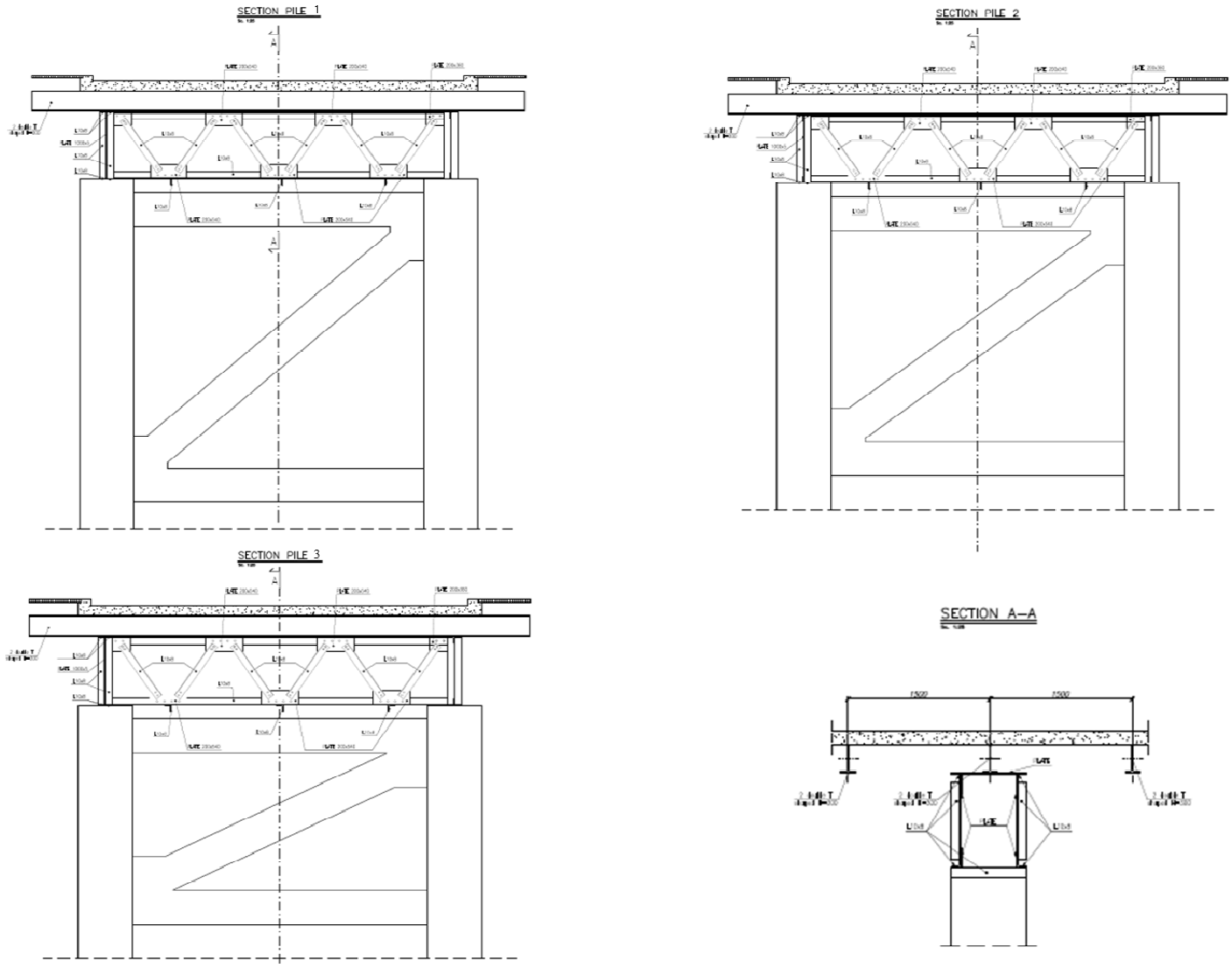


Figure 3-1-15 General View(3of4)

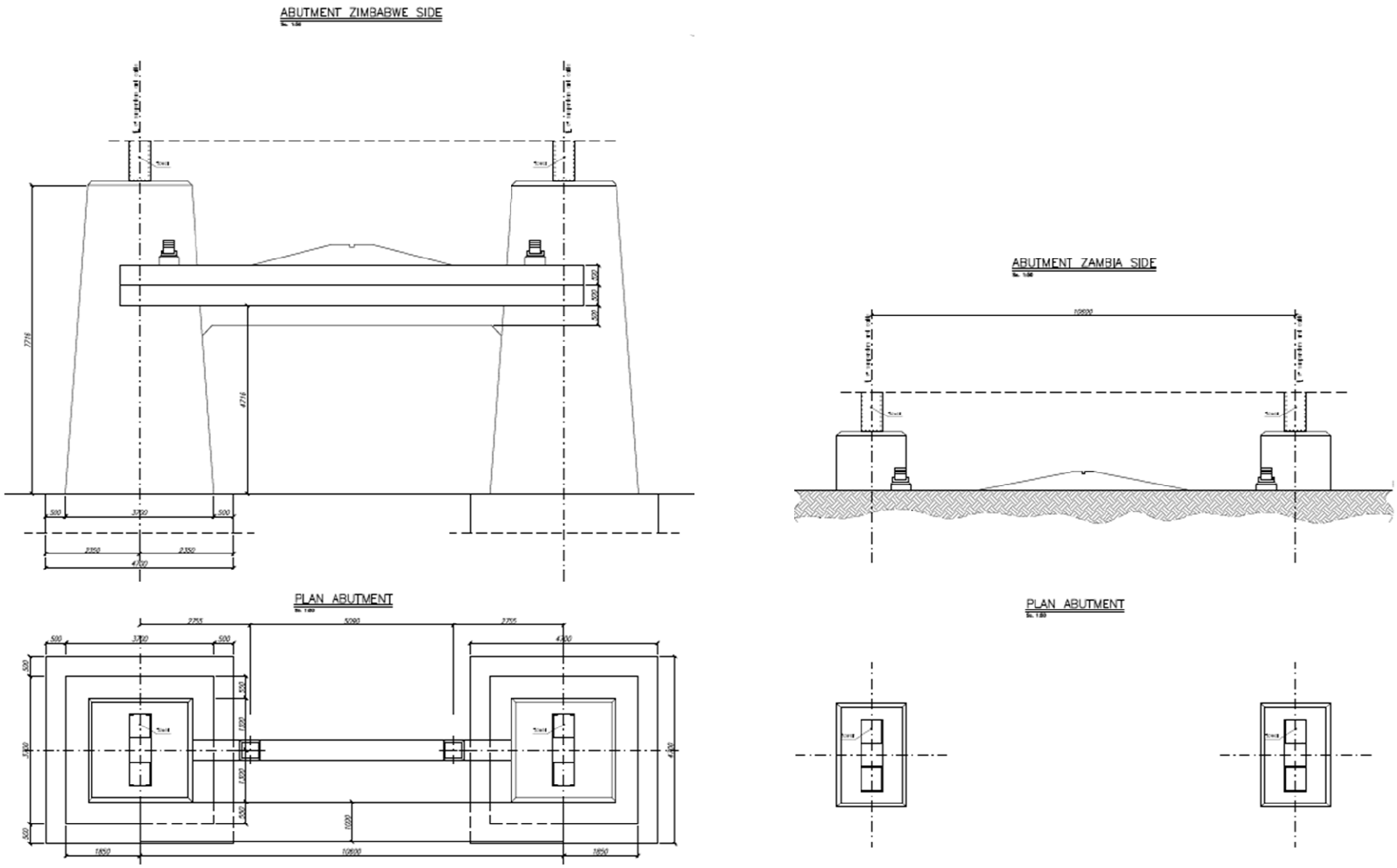


Figure 3-1-16 General View(4of4)

9-3-2 Inventory Inspection

Inventory Inspection for standard bridges is described in CHAPTER 4. And this chapter is described the Inventory Inspection for special bridges.

9-3-2-1 Purpose and process

The purpose of the Inventory Inspection for Suspension Bridge is to obtain its inventory data primary for inclusion in the BMS database. Bridge inventory data is a standard series of information that describe the geometry, construction and current function of a bridge.

The Inventory Inspection for the Special bridge, is similar to the inventory inspection of standard bridges.

9-3-2-2 Procedure

All information collected during the bridge inventory inspection is recorded using the Inventory Inspection Form (IIF). The IIF of Otto Beit Bridge is included in Appendix A-3-1.

The IIF is composed of two parts for the Special Bridge Inventory:

○Standard inventory sheet is the same sheet with ordinary bridges in BMS.

- Inventory Inspection Form.
- The special requirements for inspection
- The general bridge data, clearances, geometry, traffic direction, type of bridge, year of construction, public utilities carried by the bridge and detail, if there is lighting provided on the bridge, the type of terrain where the bridge is located, comments if the bridge is unusual, type of construction, substructure type, deck material, wearing surface, drainage, design load and the available drawings.
- The bridge Modification Sheet describes the types and materials of any modifications to the bridge.
- The span/s of the bridge.
- The pier/s of the bridge.
- The bridge abutments.

○Additional geometrical data sheet for Special Bridge

- Measurement of bridge structure (superstructure and substructure)

As built Drawing are very important for special bridges. There is no standard drawing in special bridge. Each bridge has its own unique structure. “As Built Drawing” should be collected and electronic copy should be installed in the Special Bridge Inventory Database, as one of Inventory Inspection data. In case that there is no available bridge data, measurement survey on site for collecting basic bridge data and general drawings for inventory should be done. All documents pertaining to the past repair works and useful information are also important for future reference, especially when the bridge is due for retrofitting.

9-3-2-3 Description

The Otto Beit Bridge was built in 1938-9 by Dorman Long and financed by the Beit Trust provide connectivity by linking Zambia to Zimbabwe across the Zambezi river. It was suspension bridge in single span and approach bridge is with 4 spans on the Zimbabwe side. The span length of suspension bridge is 320 meters and the span of approach bridge is 4×12.4m=49.6 meters. Height of the tower is approximately 38.3meters and bridge width is 7.318m (5.49meters with 0.914meter sidewalk on both sides).

Non destructive tests were performed in order to assess the structural capacity of the bridge in 2016. The structural diagnosis was carried out on all the structures of the bridge including the cables in the anchoring chamber and hangers. The non destructive test results and its analysis shows that the speed of each truck must be lower than 10 km/h in order to avoid dynamic effects and only one truck at a time is allowed to transit (one way lane).



Figure 3-2-1 Photo of Otto Beit Bridge

9-3-2-4 Inspection Form

The bridge Inventory Inspection Form (IIF) and attached drawings are prepared specifically for Otto Beit Bridge as shown in Appendix A-3-1.

9-3-2-5 Location and Inventory Data Collection

The bridge inspector shall inspect the bridge and complete the Location and Inventory sections of the IIF. This can generally be completed by checking the appropriate box and by inserting the required names and numbers.

Several parts of the IIF can be completed even without having to go to the bridge site. Note, however, that all data shall be verified on site.

Data needed for Location and Geographic Information are described in Table 3-2-1.

Table 3-2-1 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

The bridge inspector shall take note of any paticular requirements to gain access or to inspect all parts of the bridge for use in planning future bridge condition inspections. Check the appropriate boxes in Special Inspection Requirements, for items such as ladders, inspection vehicles, boats, etc.

A bridge is made up of various inventory elements;

- General,
- Modifications,
- Spans,
- Piers,
- Anchorage.

9-3-2-6 Deliverables

The deliverables of Inventory Inspection Report are as follows.

- The Bridge Inventory Reports
  - A fully completed Bridge Inventory Inspection Form (IIF)
  - Geometrical data sheet for Special Bridge
- As Build Drawings
- Data of repair history

・Inventory photographs

The Bridge Inventory Inspection Reports shall be prepared by the bridge inspectors. The reports shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization. When the Bridge Inspection Report is completed, accurate and accepted, all the data shall be stored in BMS.

9-3-3 Periodic Inspection

Periodic Inspection for standard bridge is described in CHAPTER 5. And this chapter is described the Periodic Inspection for special bridges.

9-3-3-1 Purpose

The purpose of the Periodic Inspection is to record defects and rate the condition of special / long span bridge as a basis for identifying its current maintenance needs, forecasting its future intervention measures and estimating its future funding requirements. Also, the result of Periodic Inspection should be used to monitor the deterioration of defects.

9-3-3-2 Scope of the Inspection

The scope of the periodic inspection for special bridge is almost the same as standard bridge, and in addition below.

- Reviewing the existing inventory data of the bridge structure for accuracy
- Visually inspecting the bridge attributes and record their defects to assess their condition using a standard condition rating system.
- Sketch drawings to monitor the progress and deterioration of defects
- Reporting the condition of each bridge attributes
- Providing a general condition rating for the structure as a whole.
- Identifying bridges that require an Detailed inspection (those with an overall condition state poor or bad)
- A photographic record of defects

In Periodic Inspection, the inspector should record all details of defects for assessment of bridge condition using a standard condition rating system and also for the monitoring of progress and deterioration of defects. Therefore, each attribute of the bridge shall be inspected at a distance at least three meters from the surface of the attributes or its equivalent, using binocular as much as possible.

All surfaces of the attributes shall be exposed in good natural or artificial light during the inspection, sufficient to observe fine cracks and other defects on the surfaces. Bearings at the abutments and piers shall be inspected at eye level. The inside of tower shall also be inspected closely. The bridge inspection is done visually to cover all parts of the bridge above the ground and water level.

Sketch drawings in Periodic Inspection is very important for the analysis of bridge condition and for the monitoring of deterioration of defects. Inspector should sketch carefully the details of defects. Sketch drawing of defects should include the range, length, area and severity of defects as much as possible. When inspectors cannot possibly measure the defects, they can roughly estimate measurement through their engineering judgement. If a previous Detailed Inspection Report is available, the findings on the report will be used in the next Periodic Inspection to verify whether these findings remain valid.

9-3-3-3 Process

The step-by step procedure for conducting the Periodic Inspection is illustrated in the following flowchart.

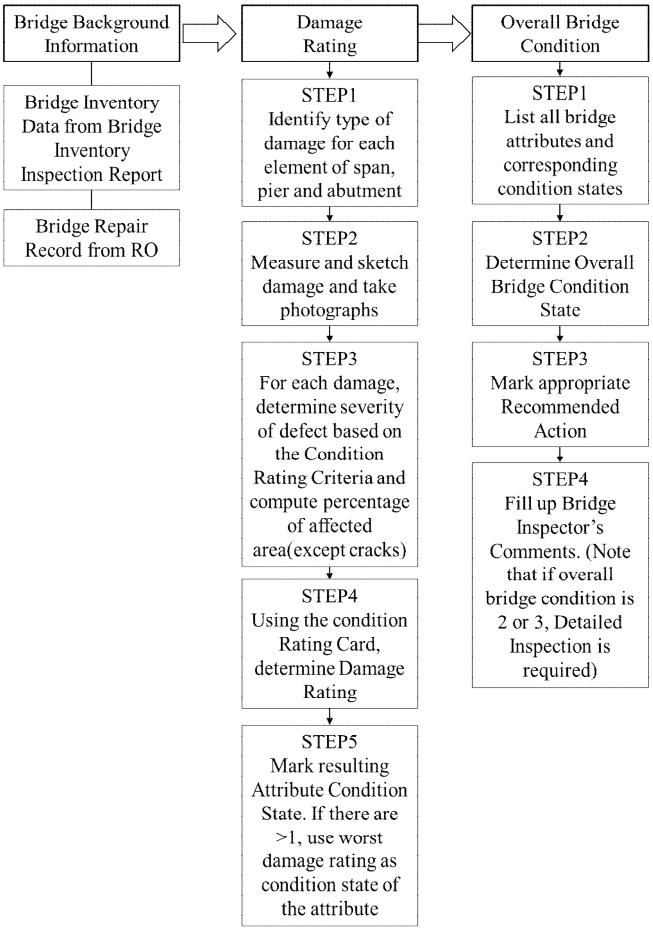


Figure 3-3-1 Flowchart of Bridge Periodic Inspection

9-3-3-4 Inspection route and the points of inspection

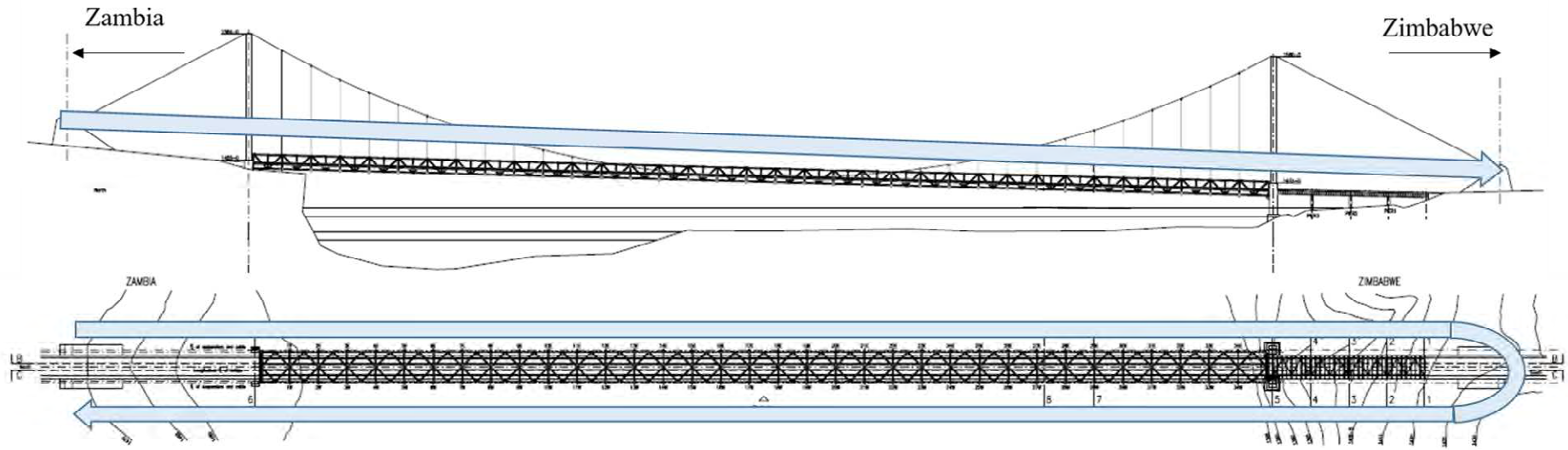
【Periodic Inspection Form (PIF)】

As a reference, Periodic Inspection Forms (PIF) and sketch Drawings of Otto Beit Bridge are shown in appendix A-3-2.

The bridge Periodic Inspection Routes of Otto Beit Bridge are shown in Figure 3-3-2, 3-3-3, 3-3-4 and 3-3-5, and the Check Points of the Periodic Inspection are shown in Figure 3-3-6, 3-3-7, 3-3-8 and 3-3-9. As a breakdown, the PIF is composed of forms shown in Table 3-3-2

Special / long span bridges are complex structures. Before conducting inspection, proper numbering of elements and attributes on the forms should be considered to avoid misinterpretation on its location. During inspection, each attributes shall be numbered / marked for easy identification. Numbering and marking of attributes are shown in Figure 3-3-10, 3-3-11, 3-3-12 and 3-3-13.

Inspection of Upper Deck



Main Members to be inspected

Main Cable
Hanger Rope, Cable band and Suspender
Tower
Railing
Curb
Pavement (Concrete)
Drainage
Expansion Joint

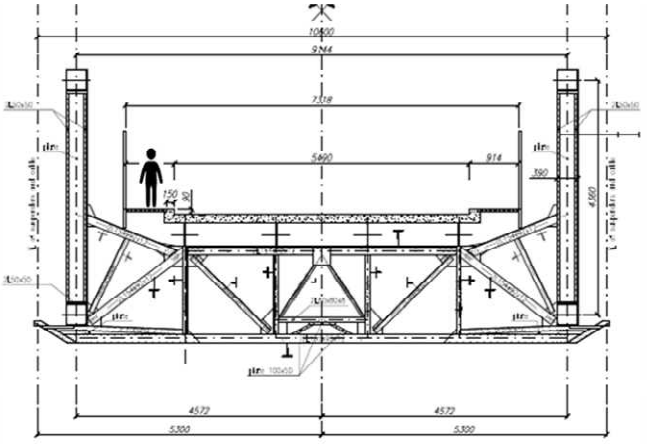


Figure 3-3-2 Periodic Inspection Route of Otto Beit Bridge (1 of 4)

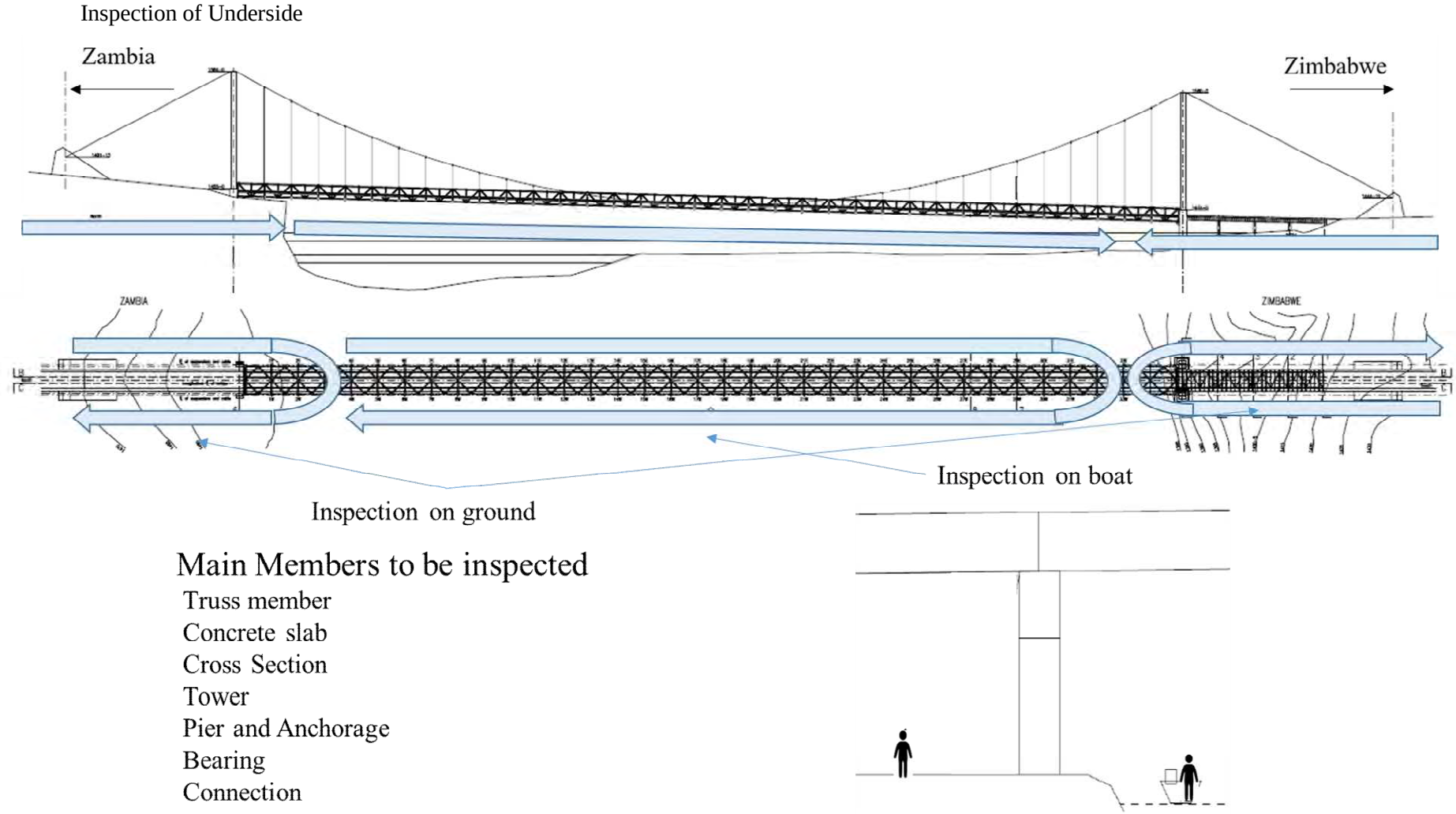
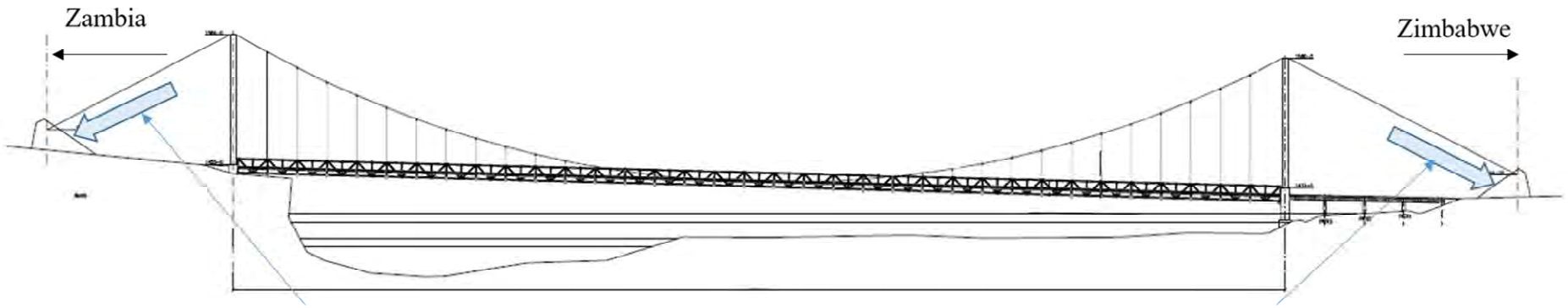


Figure 3-3-3 Periodic Inspection Route of Otto Beit Bridge (2 of 4)

Inspection of Anchorage House



Inspection Inside Anchorage House

Inspection Inside Anchorage House

Main Members to be inspected

Main Cable

Anchor Bolt

Anchorage and Anchor Bolt

Anchor Saddle

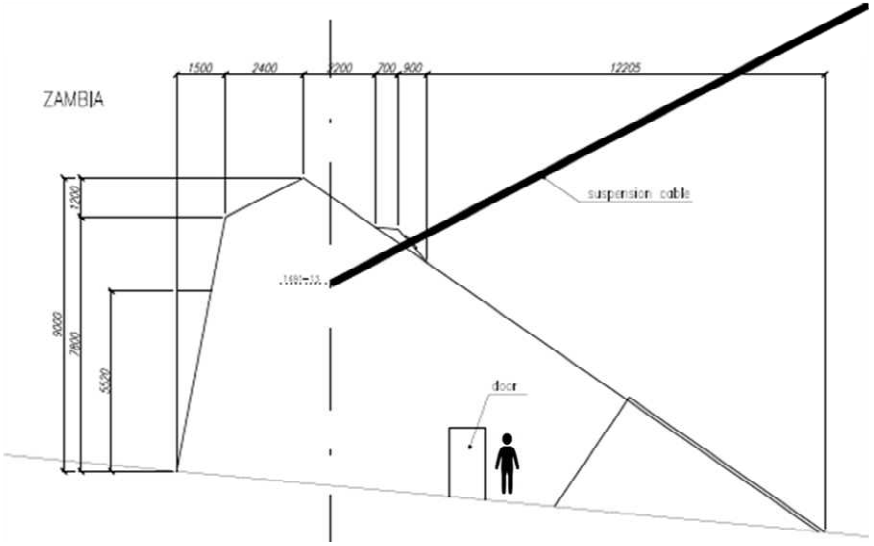


Figure 3-3-4 Periodic Inspection Route of Otto Beit Bridge (3 of 4)

Inspection the Tower

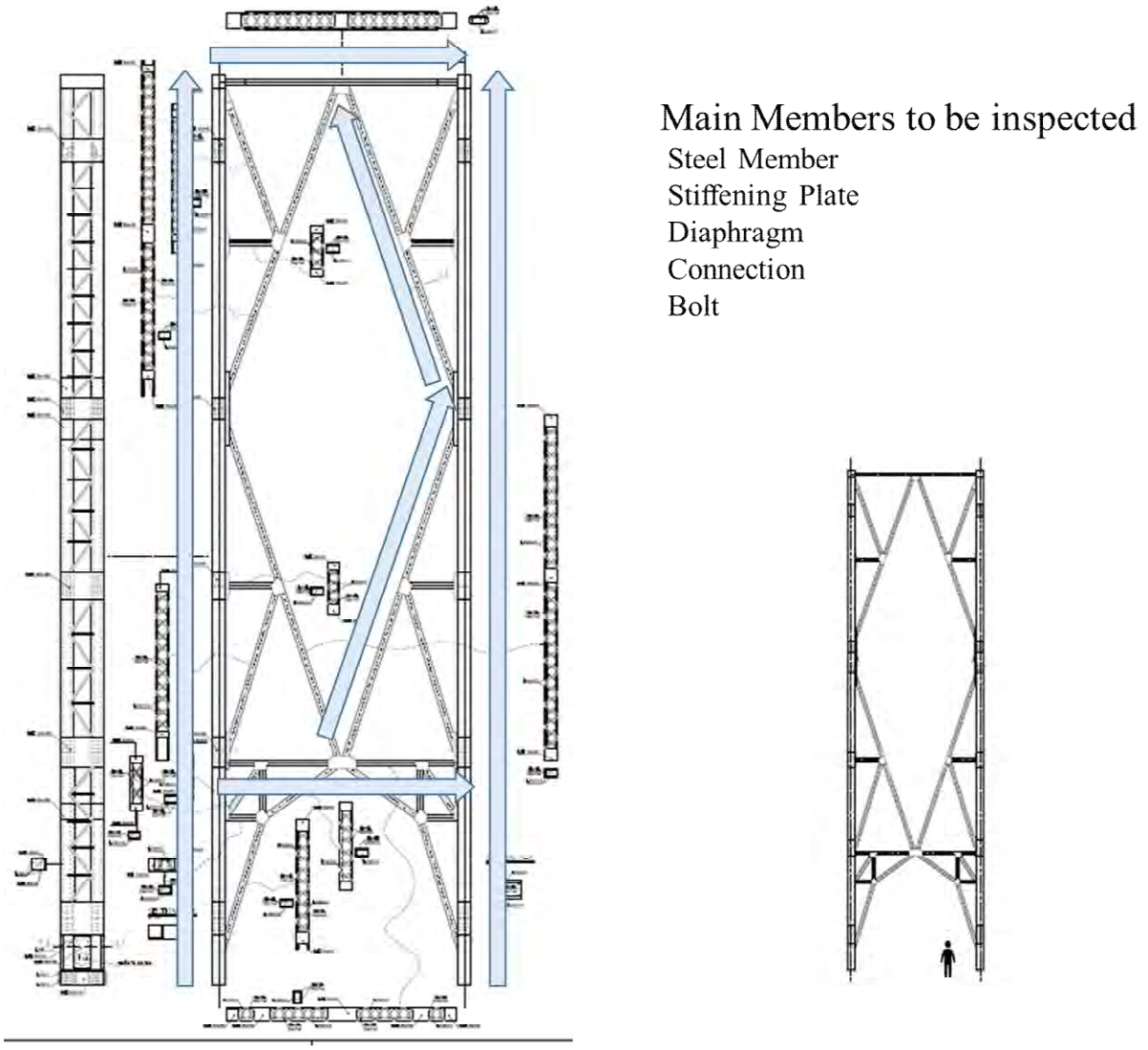


Figure 3-3-5 Periodic Inspection Route of Otto Beit Bridge (4 of 4)

Main Span (Main Structure)

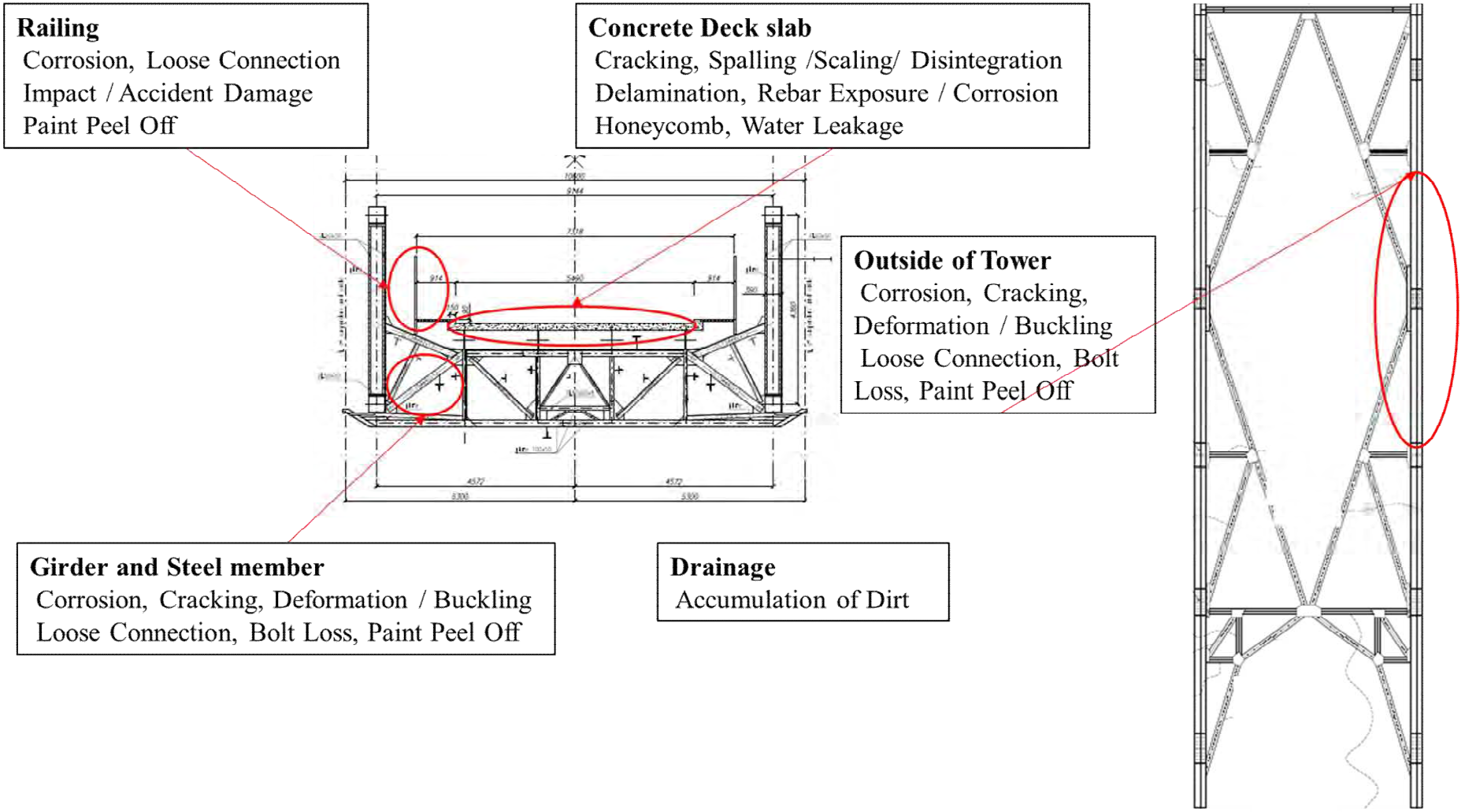


Figure 3-3-6 Check Points of Periodic Inspection – Otto Beit Bridge (1 of 4)

Approach Viaduct and Pier

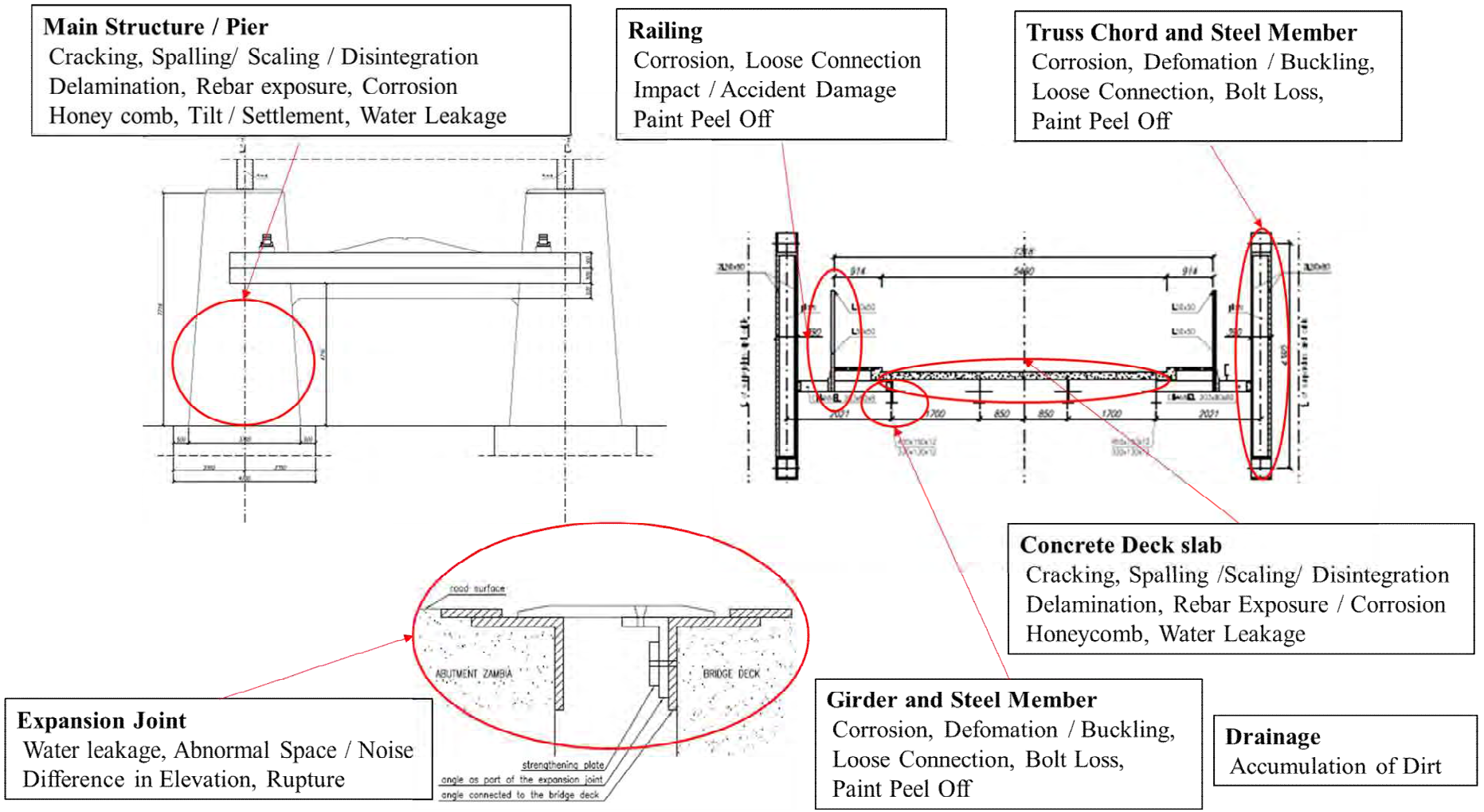
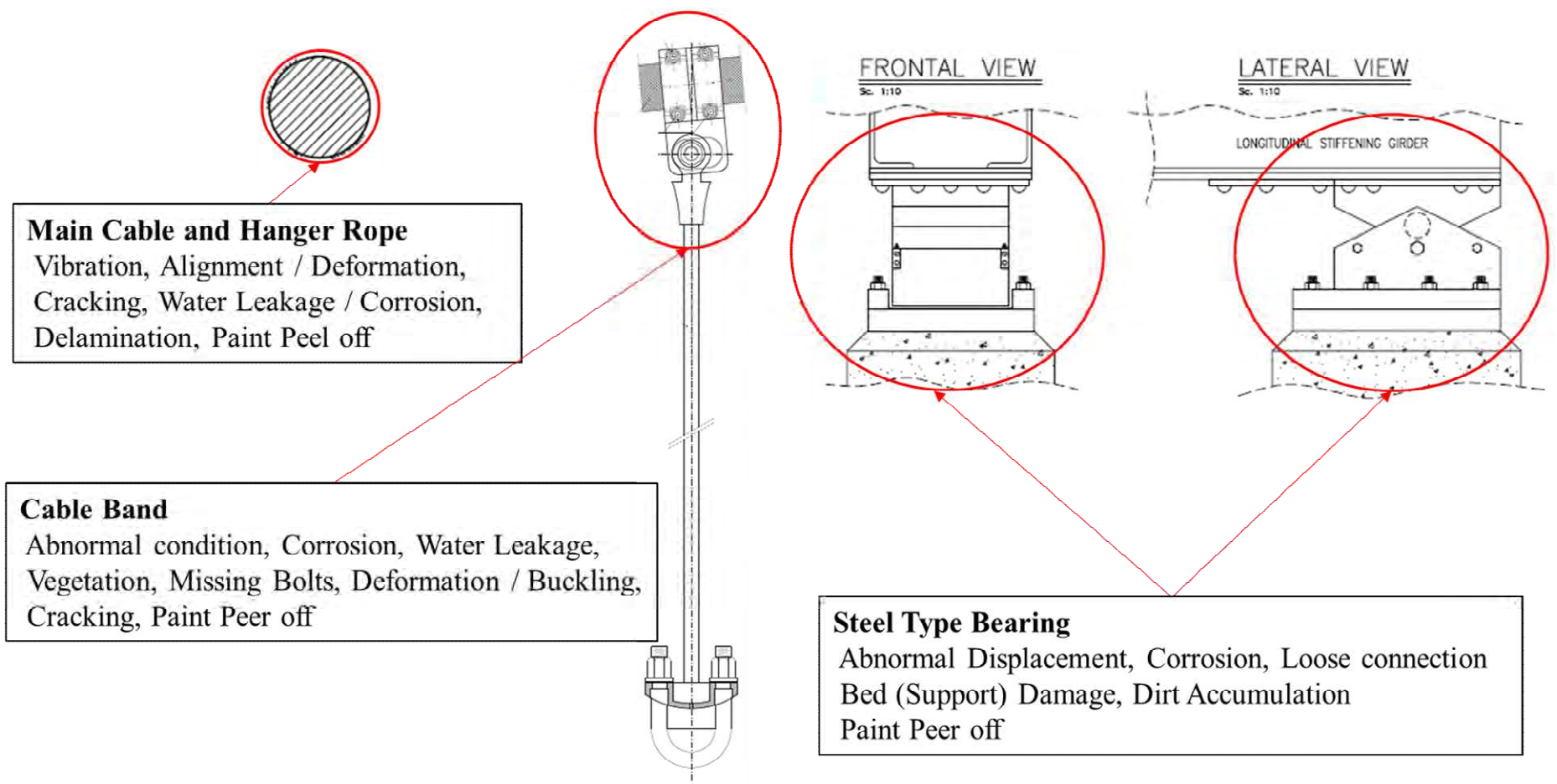


Figure 3-3-7 Check Points of Periodic Inspection – Otto Beit Bridge (2 of 4)

Cable, Cable Band and Bearing

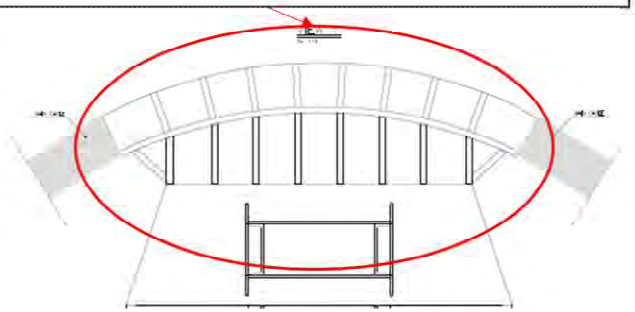


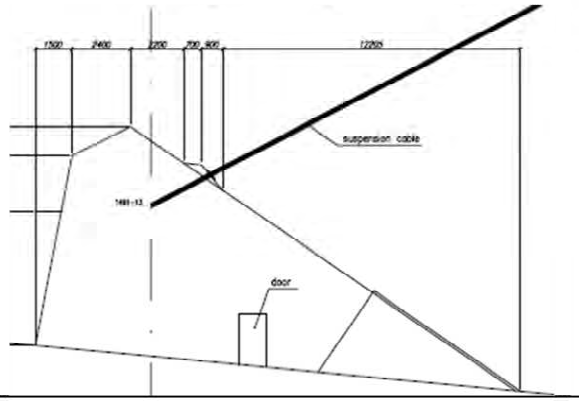
]

Figure 3-3-8 Check Points of Periodic Inspection – Otto Beit Bridge (3 of 4)

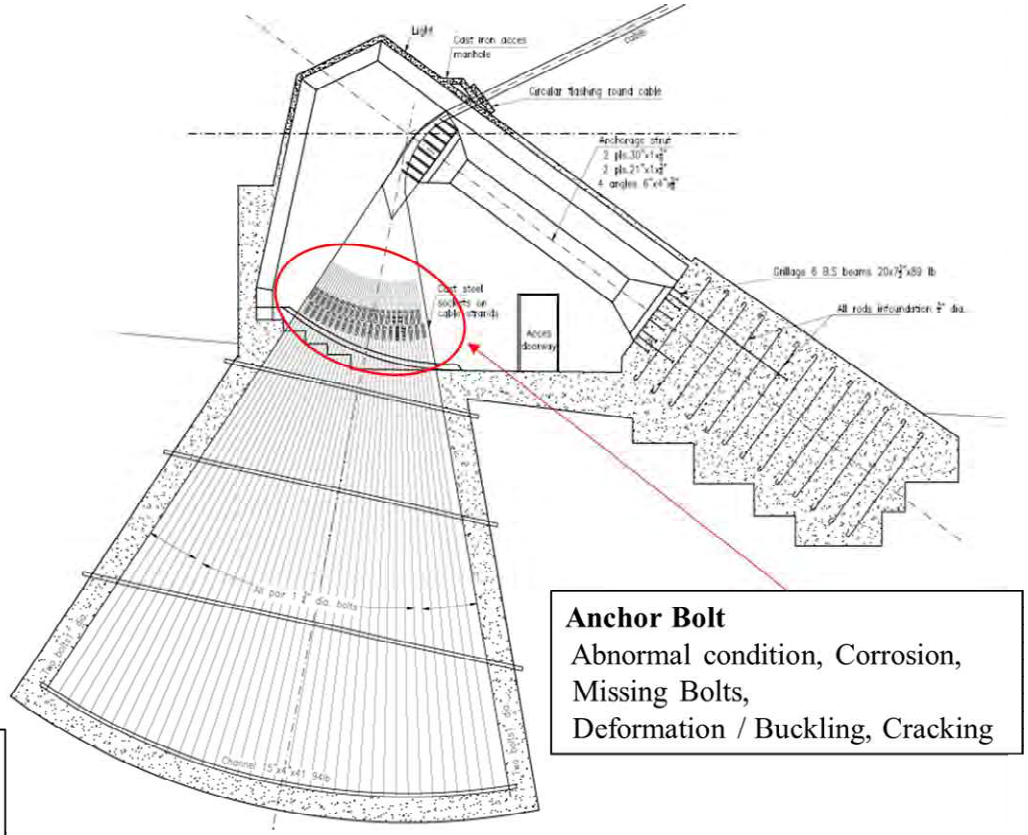
Anchorage, Anchor Bolt and Saddle

Tower Saddle
Abnormal Displacement, Corrosion, Loose connection, Paint Deterioration, Bed (Support) Damage, Dirt Accumulation





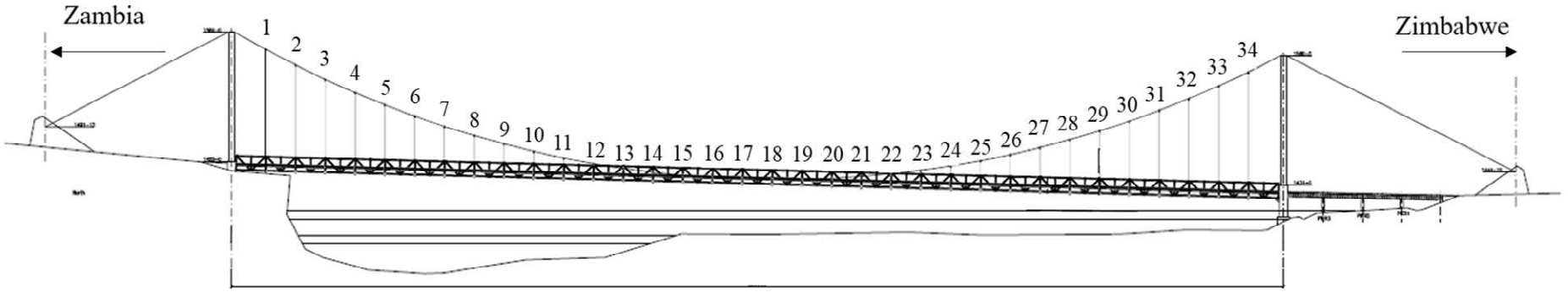
Anchorage
Water and Dirt Accumulation, Abnormal Condition, Water Leakage, Vegetation, Cracking, Spalling / Scaling / Disintegration, Delamination, Rebar Exposure / Corrosion, Honey comb, Buckling



Anchor Bolt
Abnormal condition, Corrosion, Missing Bolts, Deformation / Buckling, Cracking

Figure 3-3-9 Check Points of Periodic Inspection – Otto Beit Bridge (4 of 4)

Suspension Bridge Hanger Ropes

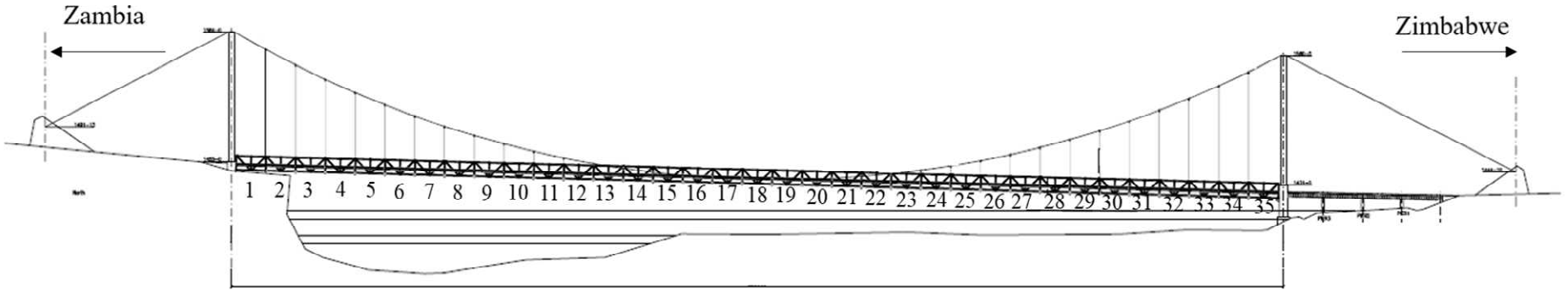


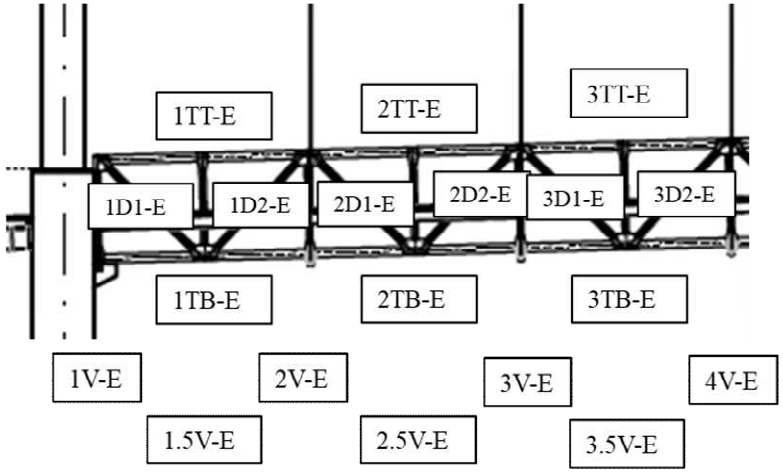
Hanger Rope Left Side	1E	13E	25E	Hanger Rope Right Side	1W	13W	25W
	2E	14E	26E		2W	14W	26W
	3E	15E	27E		3W	15W	27W
	4E	16E	28E		4W	16W	28W
	5E	17E	29E		5W	17W	29W
	6E	18E	30E		6W	18W	30W
	7E	19E	31E		7W	19W	31W
	8E	20E	32E		8W	20W	32W
	9E	21E	33E		9W	21W	33W
	10E	22E	34E		10W	22W	34W
	11E	23E			11W	23W	
	12E	24E			12W	24W	

E: East (left)
W: West (right)

Figure 3-3-10 Numbering of Members – Otto Beit Bridge

Suspension Bridge – Truss at Left Side





1V-E	Vertical Truss Member	1D1-E	Diagonal Truss Member
1.5V-E		1D2-E	
2V-E		2D1-E	
…		2D2-E	
36V-E		3D1-E	
1TT-E	Truss Top Member	3D2-E	
2TT-E		…	
3TT-E		35D1-E	
…		35D2-E	
35TT-E			
1TB-E	Truss Bottom Member		
2TB-E			
3TB-E			
…			
35TB-E			

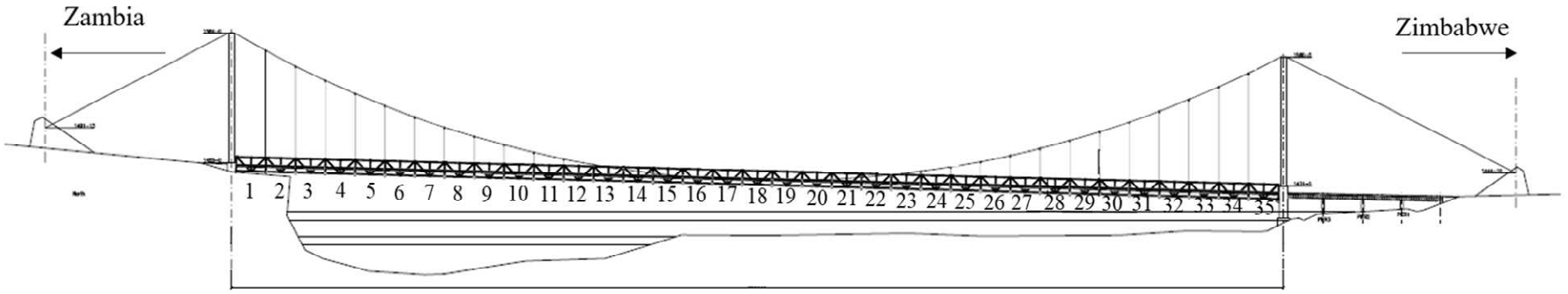
E: East (left)
W: West (right)

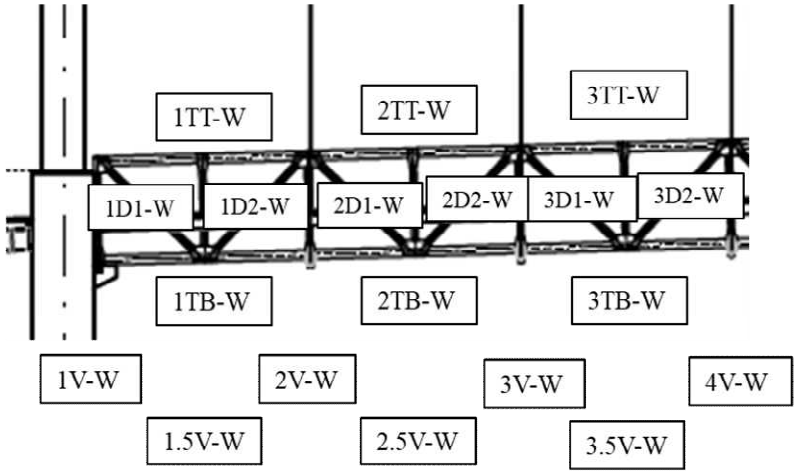
TT: Truss
TB: Truss Bottom

V: Vertical
D: Diagonal

Figure 3-3-11 Numbering of Members – Otto Beit Bridge

Suspension Bridge – Truss at Right Side





1V-W	Vertical Truss Member	1D1-W	Diagonal Truss Member
1.5V-W		1D2-W	
2V-W		2D1-W	
…		2D2-W	
36V-W		3D1-W	
1TT-W	Truss Top Member	3D2-W	
2TT-W		…	
3TT-W		35D1-W	
…		35D2-W	
35TT-W			
1TB-W	Truss Bottom Member		
2TB-W			
3TB-W			
…			
35TB-W			

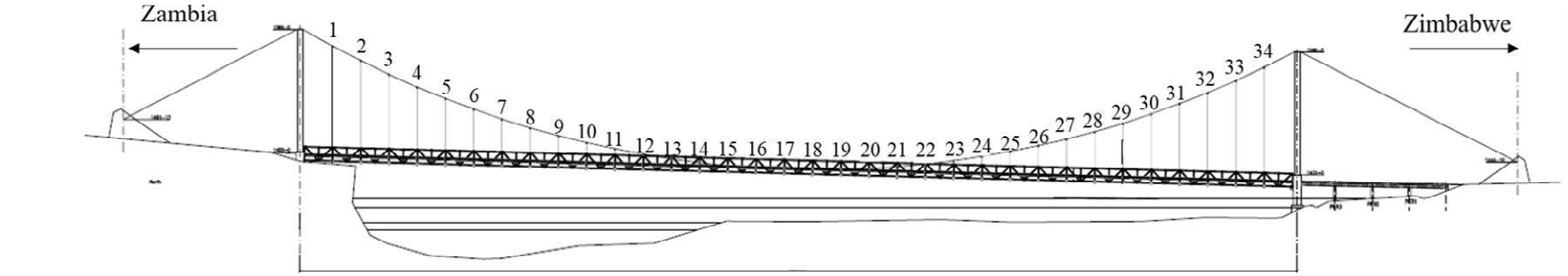
E: East (left)
W: West (right)

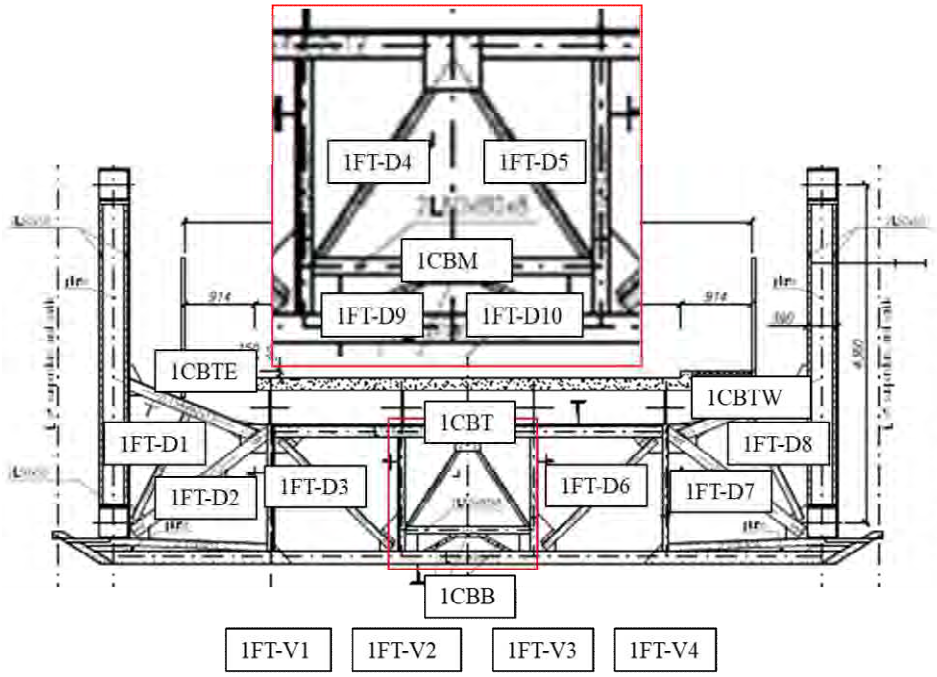
TT: Truss
TB: Truss Bottom

V: Vertical
D: Diagonal

Figure 3-3-12 Numbering of Members – Otto Beit Bridge

Suspension Bridge – Cross Beams and Floor Truss





1CBT	Cross Beam Top	1FT-V1	Vertical Truss Member	1FT-D1	2FT-D1	…	34FT-D1	Diagonal Truss Member
2CBT		1FT-V2		1FT-D2	2FT-D2	…	34FT-D2	
…		1FT-V3		1FT-D3	2FT-D3	…	34FT-D3	
34CBT		1FT-V4		1FT-D4	2FT-D4	…	34FT-D4	
1CBTE	Cross Beam Top Left Side	2FT-V1		1FT-D5	2FT-D5	…	34FT-D5	
2CBTE		2FT-V2		1FT-D6	2FT-D6	…	34FT-D6	
…		2FT-V3		1FT-D7	2FT-D7	…	34FT-D7	
34CBTE		2FT-V4		1FT-D8	2FT-D8	…	34FT-D8	
1CBTW	Cross Beam Top Right Side	…		1FT-D9	2FT-D9	…	34FT-D9	
2CBTW		34FT-V1		1FT-D10	2FT-D10	…	34FT-D10	
…		34FT-V2						
34CBTW		34FT-V3						
1CBM	Cross Beam Middle	34FT-V4						
2CBM								
…								
34CBM								
1CBB	Cross Beam Bottom							
2CBB								
…								
34CBB								

CBT: Cross Beam Top
CBTE: Cross Beam Top East
CBTW: Cross Beam Top West
CBM: Cross Beam Middle
CBB: Cross Beam Bottom
FT: Floor truss
V: Vertical
D: Diagonal

Figure 3-3-13 Numbering of Members – Otto Beit Bridge

Table 3-3-2 Composition of Periodic Inspection Form (Luangwa Bridge)

Title of Form	Number of Form
(1) Summary, Repair record	2
(2) Damage Rating (main structure)	22
(3) Sketch (Deck and Appendage)	11
(4) Sketch (Pier)	5
(5) Sketch (Cable)	18
(6) Sketch (Tower)	2
(7) Sketch (Girder)	As needed
(8) Photo	As needed
Total	60+ α

【Level of Inspection】

The Bridge inspector shall indicate the level of inspection undertaken as shown in Table 3-3-3.

Table 3-3-3 Level of Inspection

Full complete inspection	
Partial inspection only as bridge inspection vehicle not available	
Partial inspection for other reason	

It is practical to use Bridge Inspection Vehicle at least once in every three years, due to the limited number of such vehicle. Bridge Inspector should consider the arrangement of Bridge Inspector Vehicle when they make a maintenance plan for Otto Beit Bridge. If a complete inspection is not undertaken, then revisit the bridge and inspect with a Bridge Inspection Vehicle or other required equipment (for example, drone). A countrywide program for the use of the available Bridge Inspection Vehicles should be utilized to ensure optimum result of the inspection.

【Location and Inventory Data】

The bridge inspector shall inspect the bridge and review the Location data included in the PIF. Data required are described in Table 3-3-4.

Table 3-3-4 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first anchorage) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

【Repair Record】

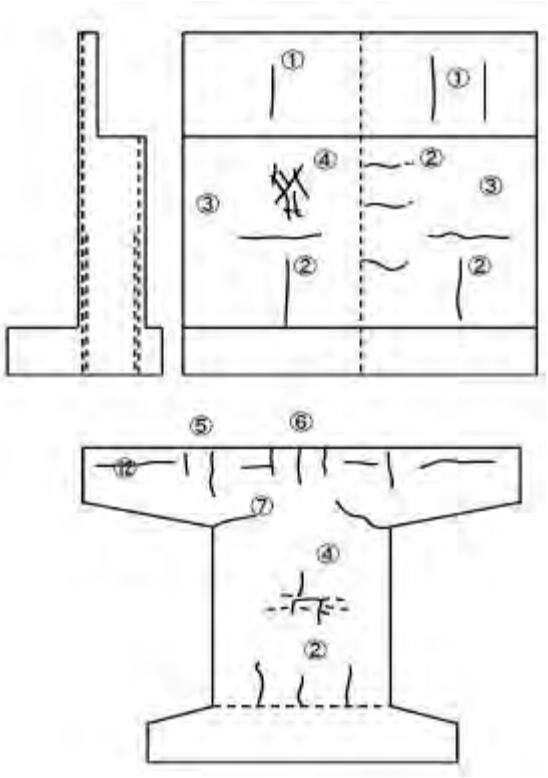
The bridge inspector is required to report the routine and major maintenance activities undertaken to a bridge after the conduct of the last periodic inspection that will include the type, scope and status of maintenance activities. The bridge inspector shall also record observations whether the works undertaken are effective and sufficient.

【Periodic Data Collection】

Special bridges like Suspension Bridge have unique attributes and materials which are not defined in the BMS Manual for standard bridge. Bridge Inspection Team should understand the characteristic and function beforehand by reviewing the As Built Drawings and other related documents.

As a reference, some special attributes of Otto Beit Bridge are listed in Table 3-3-5. All other applicable descriptions in the BMS Manual for standard bridge are adopted in this Manual. General pattern of defects in bridges are shown in Figure 3-3-14 and 3-3-15.

General Patterns of Crack Defects on Abutment and Pier



Number	Pattern
1	Crack with regular interval
2	Crack on the concrete casting joint
3	Crack around the changing point of density of reinforcement bar
4	Crack like mesh
5	Crack on topside of overhang beam (coping)
6	Vertical crack on pier center
7	Crack on bottom side of overhang beam (coping)
8	Crack on upper and bottom part of column
9	Crack on column
10	Crack on haunch
11	Bending crack on the span center or beam
12	Horizontal crack on beam

Figure 3-3-14 General Patterns of Defect (1 of 2)

General Patterns of Crack Defects on Steel Bridge

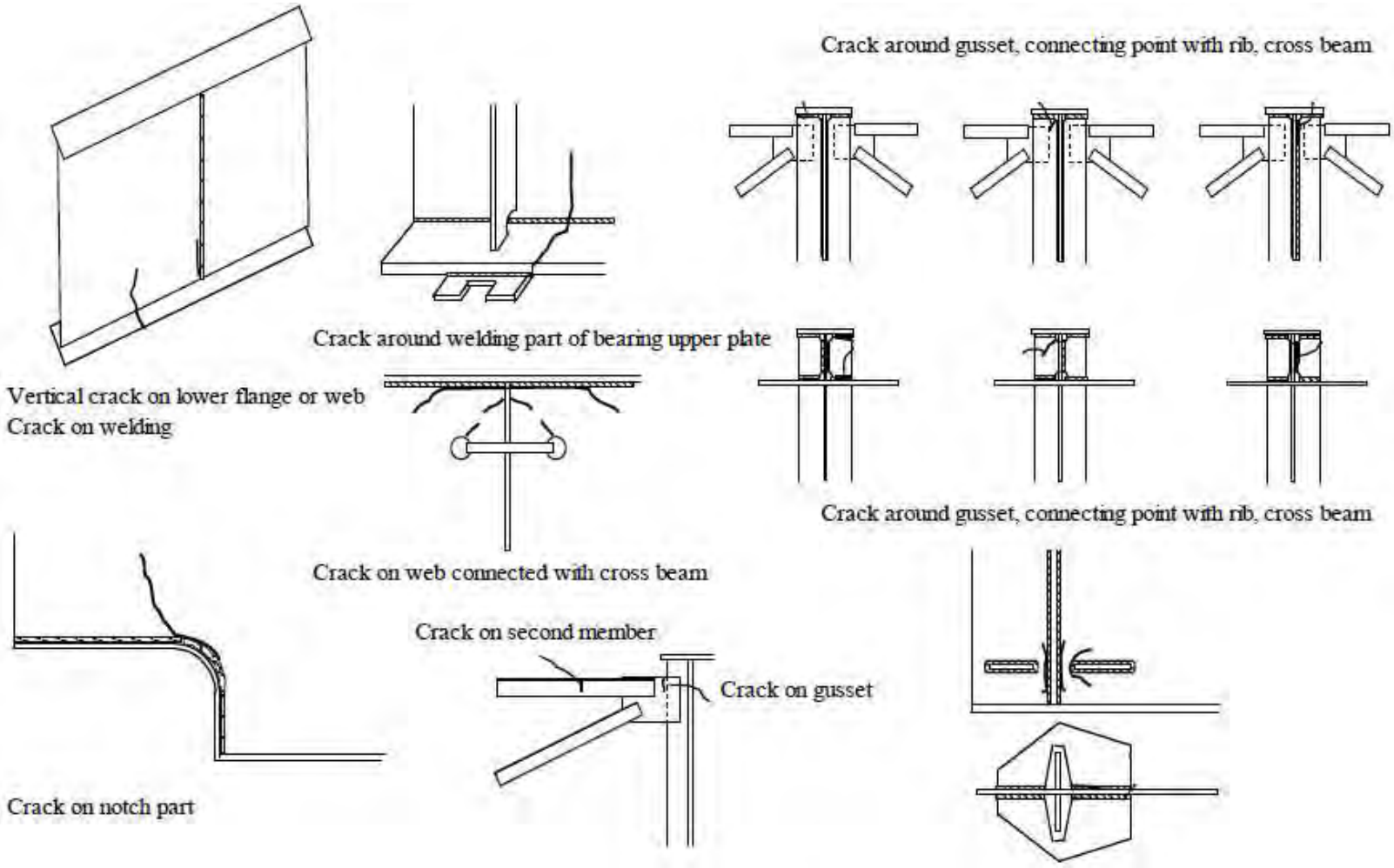


Figure 3-3-15 General Patterns of Defect (2 of 2)

Table 3-3-5 Special Attributes of Otto Beit Bridge

Element	Attribute	Description
Anchorage	Main member	Anchorage is located at each end of bridge to anchor main cable into anchor block to hold tension stress. Anchorage structure includes foundation, anchor block, cable anchor frame and protective house. The connection area of strand in anchorage is weak against corrosion. Corrosion and damage of Anchorage is contributory to bridge collapse.
Hanger Rope	Main Member	Hanger rope is the most important attribute for Suspension Bridge. They connect main cable to suspend girders. They are painted for protection from water penetration to avoid corrosion. Corrosion and damage of rope is contributory to bridge collapse.
Main Cable	Main Member	Main cable is the most important attribute for Suspension Bridge. Main cables are suspended between towers and have paralleled hanger ropes to support the stiffening girders. Main cables must be connected with anchor blocks at each end of the bridge to hold tension stress. Corrosion and damage of cable is contributory to bridge collapse. Zinc plating Wires are protected by wrapping wire and paint from water penetration to avoid corrosion.
Suspender clamp and shackle	Secondary Member	Hanger ropes are fixed to main cable with suspender clamps and shackles. Stay cables fixed the main suspension cables to restrict longitudinal displacement of the girder due to wind, earthquake and temperature change.
Saddle	Secondary Member	Tower saddle is located on the top of tower to support the main cables and transfers tension main cable to tower as vertical load. Splay saddle at anchorage bent main cable toward anchor block.

【Condition Rating of Bridge Attributes】

The material defect descriptions and the condition rating criteria in BMS will be utilized by the Bridge Inspectors (BI) to assess the defects identified in bridge elements. On the other hand, the Periodic Inspection for cable and anchorage will be undertaken using this Manual.

The condition rating of the bridge attributes will be conducted following Inspection guidebook. Additional material defects are specifically described in Appendix D-3-1. while the corresponding conditon rating criteria concerining the same is included in Appendix C-3-1 (cable element).

The affected area, length or number will be roughly estimated and using the Periodic Rating Card, the attribute damage rating can be obtained. The condition state of the attribute is the worst damage rating. The descriptions cannot possibly cober every situation, and the BIs must rely on their engineering knowleage and judgment to evaluate which condition should apply to the bridge elements inspected.

The BIs shall also compare the defects observed in the attriute with the previous sketch drawings and photograph records to check the progress.

The condition states have been developed to describe the following conditions listed in Table 3-3-6.

For each defined attribute in the bridge, the Periodic Inspection Forms includes a separate section covering that attribute and which is to be completed by the BI. Each section shall be completed to include:

・The condition state of the attribute (see Table 3-3-6)

・The type of repair required for each attribute

・The estimated cost to undertake the required repair (major maintenance)

All repairs to attributes are classified as major maintenance.

The standard descriptions of major maintenance that may be undertaken for each attribute are;

・Repair damage

・Protective measures

・Strengthen

・Replace

・Other

Only one type of maintenance can be listed for each attribute. When two or more types of maintenance are required to an attribute, all work shall be listed under the type of maintenance with the highest estimated cost.

The BI shall describe in detail the recommended repair works each identified defect in any attribute, providing sketch drawings if necessary.

Table 3-3-6 Bridge Attributes condition states

Condition State	Description	Action
0	Attribute is in good condition with little or no deterioration	Keep inspection
1	Attribute shows deterioration of minor nature to the primary supporting material and is showing first signs of being affected	Keep monitoring
2	Attribute shows advancing deterioration and loss of protection to the supporting material, minor loss of section	Major maintenance is required wihtin 2 years
3	Attribute shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress	Immediate major maintenance is required

The condition state of each bridge attribute will be used by the BMS to calculate the overall need of the bridge for intervention.

【Not Applicable Attributes】

There are many instances when the Periodic Inspection Forms (PIF) is not completely filled out by the Bridge Inspector due to uncertainties in identifying or locating some attributes of the special brige.

The Bridge Inspector may feel that an attribute cannot be completed because there is no attribute in the bridge, he / she cannot recognize or find the attributes in the bridge. In this case, the bridge inspector should mark the attributes as not applicable.

9-3-3-5 Deliverables

The deliverables of Periodic Inspection Report are as follows:

○Periodic Inspection Report

Bridge Periodic Inspection Form

Summary of Periodic Inspection Results

Repair Record

Inspection Results sheet (condition)

Inspection Results sheet (damage rating)

○Sketch Drawing sheet

○Photo record sheet (Pictorial Report)

The Bridge Periodic Inspection Reports shall be prepared in the respective Regional Office where the bridge inspectors are based. The reports shall be checked and reviewed in the Headquarter Office for completeness and accuracy prior to finalization.

When the Bridge Periodic Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory Database.

9-3-4 Detailed Inspection

Detailed Inspection for standard bridge is described in CHAPTER 6. And this chapter is described the Detailed Inspection for special bridges.

9-3-4-1 Purpose

Detailed Inspection is undertaken as a follow-up to periodic inspection when the condition state of 2 or 3 are recorded in any primary component / attribute or in any secondary component that has detrimental effect on the structural performance of the bridge. The purposes of a detailed inspection for Suspension bridge are as follows.

1) To confirm the results of the periodic inspection.
2) To undertaken additional investigations in order to evaluate thoroughly noted defects which may include physical testing and / or structural analysis. And also to prepare a documentary record of the observed defects for future design of required major maintenance works.
3) To assess the current bridge structural condition, behavior and capacity.
4) To assess the rate of deterioration and residual life expectancy of the bridge.

9-3-4-2 Recommendation

In the periodic inspection for standard materials, attributes and so on, “BRIDGE INSPECTION GUIDEBOOK 2017 developed by JICA” should be referred to. However. There is no standard method in the Detailed inspection for special materials, attributes and so on, like cable, rope, anchorage.

For example, in case of abnormal vibration of cable and rope, the extent of vibration should be measured using video and other amplitude measuring instruments. Aside from the vibration amplitude, the tensile strength of the cable and rope should also be determined. Also when water leakage and discoloration of cable and rope element is observed, there is a possibility that the inside of cable and rope is already corroded and should be thoroughly inspected. In both instances, determining the vibration amplitude and tensile strength of the rope in the Suspension Bridge is difficult for the Regional Office.

It is recommended that the Regional office engage the services of detailed inspection / investigation firms specializing on Suspension bridge. For example, NDTs (Non-destructive testing) should be conducted in order to grasp whether the defect exist or not. NDTs for steel attributes are Paint Thickness Test and Metal Thickness Test mentioned in Chapter 6-3.

9-3-4-3 Example of Special devices used in Inspection cables

(a) Main Flux Method

Main Flux Method provides to inspect a degree of corrosion, wire breakage and tension

dropping with considering their usage and circumstance by innovative system, and evaluate the deterioration through their data accurately, and propose various countermeasure for safety.

Reductions in the section area of a steel rope are evaluated by measuring the magnetic flux of its section exposed to a magnetic field. As shown in Figure 3-4-1. This method is based on the proper relationship between the magnetic flux and the section area of a steel structure placed in a magnetic field.

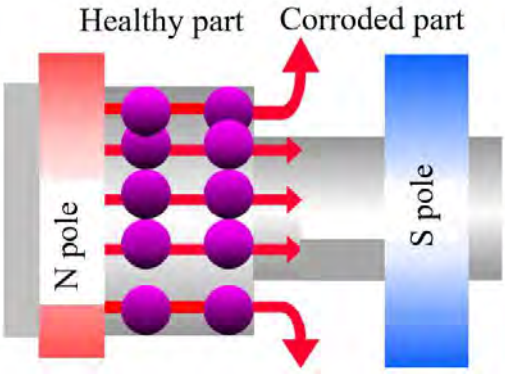


Figure 3-4-1 Mechanism of Main Flux Method

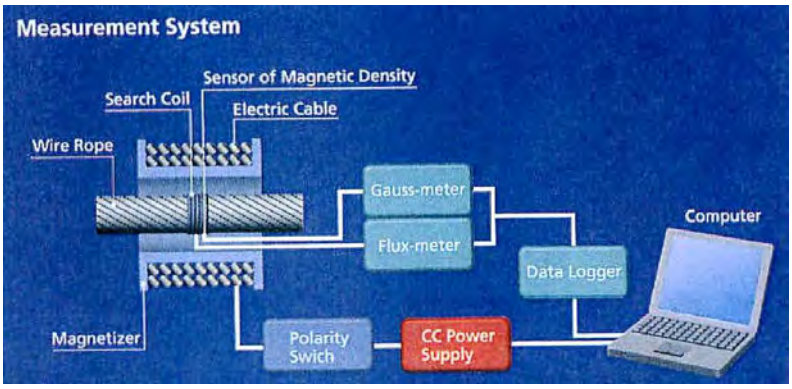


Figure 3-4-2 Measurement System of Main Flux Method



Figure 3-4-3 Inspection Device of Main Flux Method

(b) Internal Main Cable inspection method

Internal main cable method inspection is conducted to evaluate the soundness of the cables by removing an exhaust cover of the main cable. The steel wires are visually observed by driving wedge into the cable as shown Figure 3-4-4. The example of internal main cable inspection is shown in Figure 3-4-5. Surprisingly, some cross sections had rust on the majority of the cables.



Figure 3-4-4 Internal main cable inspection (cable wires were wedged)

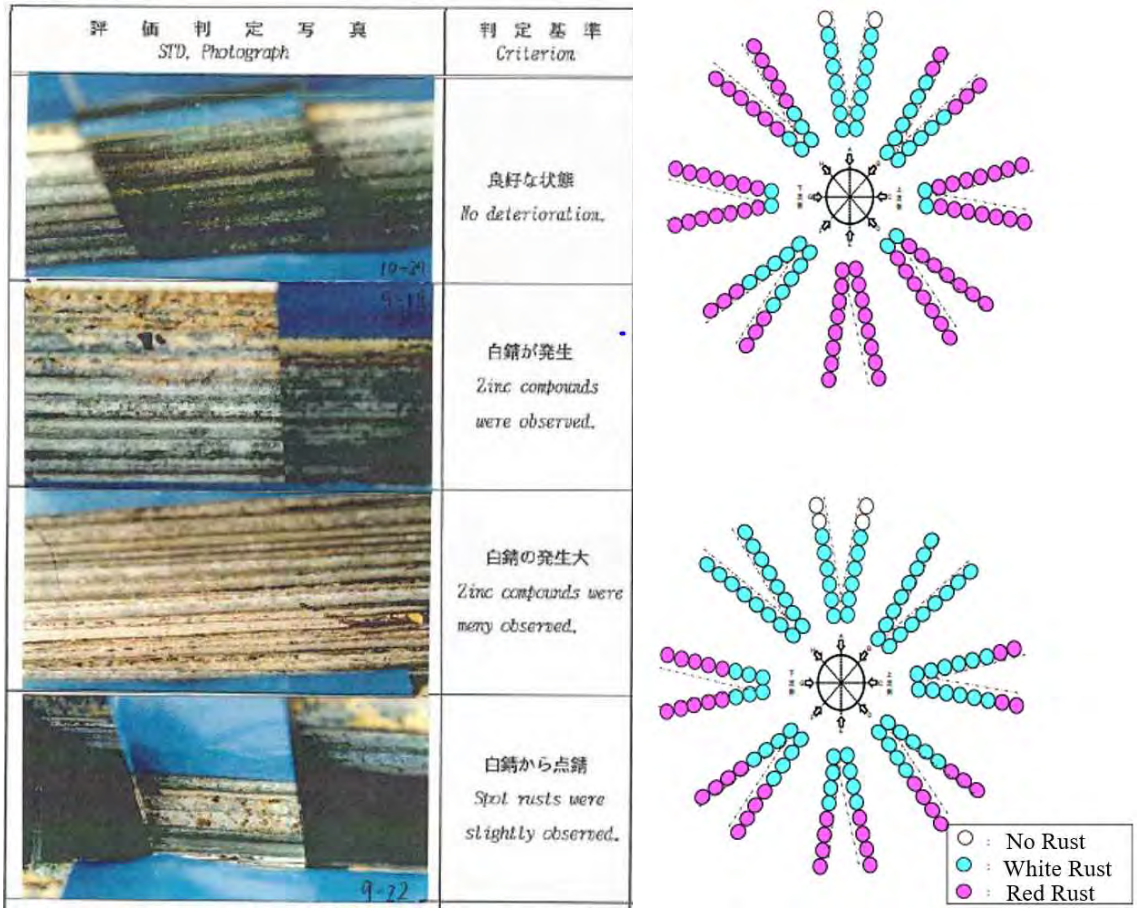


Figure 3-4-5 The sample internal Main Cable Inspection

(c) Self-Driven Stay Cable Inspection system

Self-Driven Stay Cable Inspection system can investigate deformation of the protective tube of the cable and breakage of wires that make up cable. This device can move up and down automatically to inspect and record the appearance with video camera. And this can confirm whether or not the steel wire placed on the outer peripheral part of the steel wire inside the diagonal member is broken as shown in Figure 3-4-7.

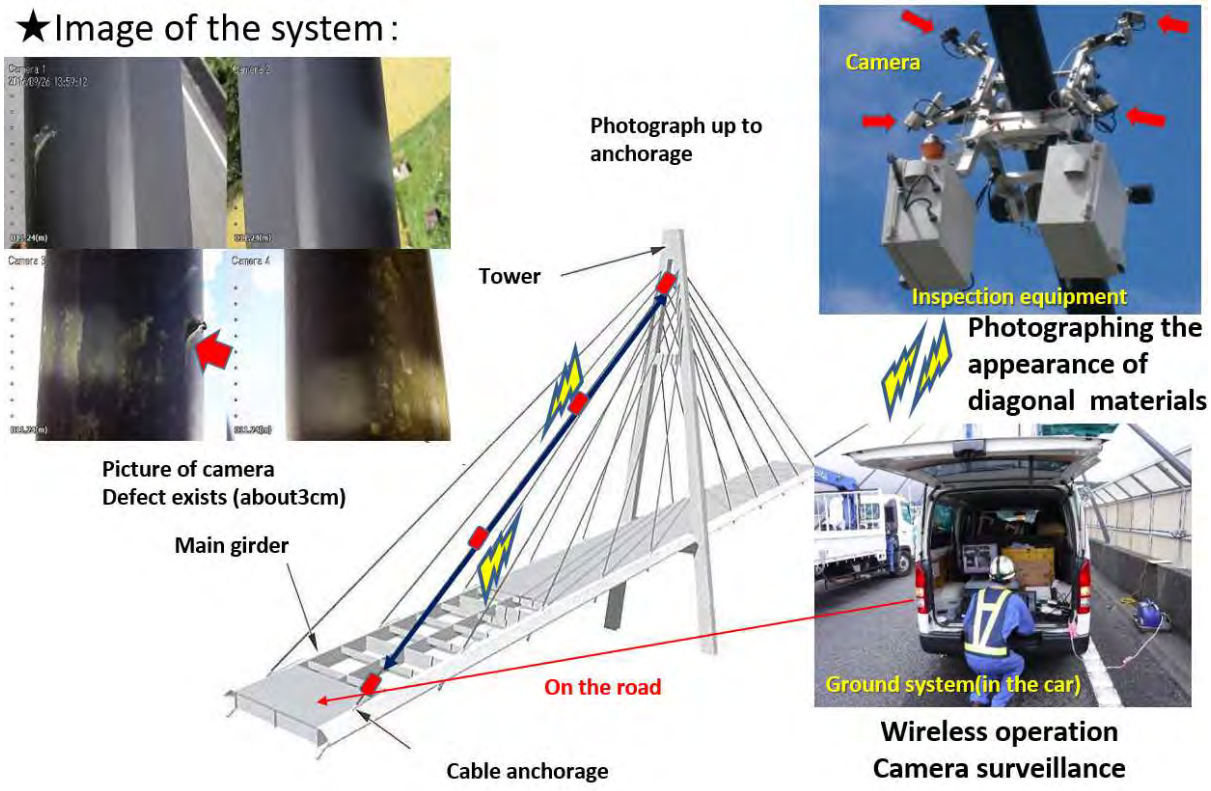


Figure 3-4-6 Image of Self-Driven Stay Cable Inspection System

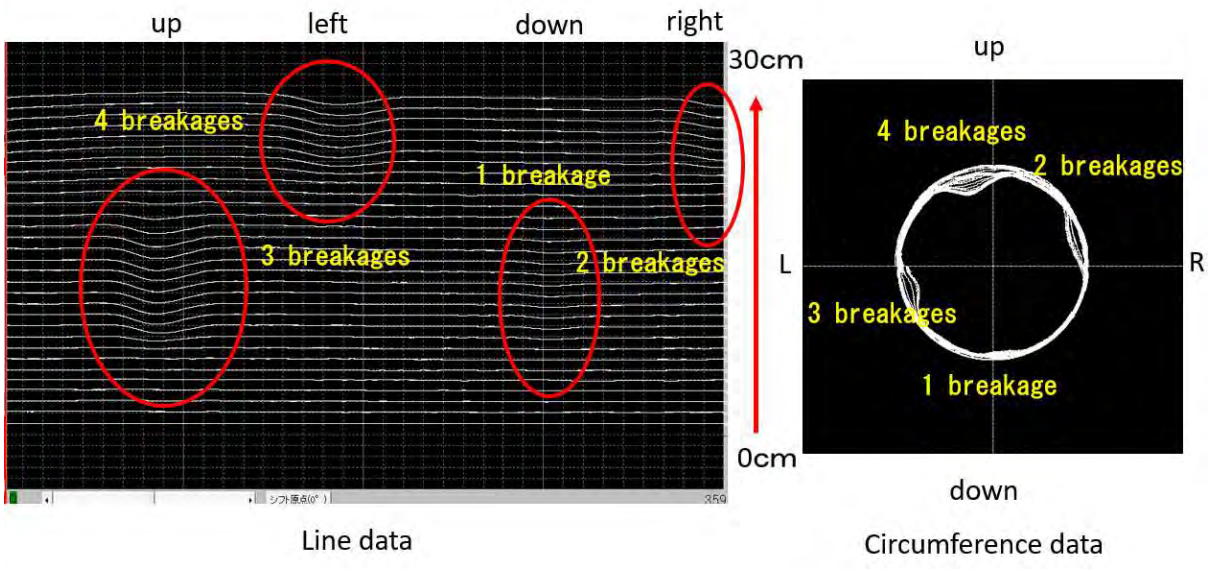


Figure 3-4-7 eddy current flaw detection test

9-3-5 Geometrical Inspection

9-3-5-1 Purpose

The purpose of the Geometrical Inspection for Special Bridge is to obtain data primarily of a basic information of special / long span bridge. Bridge would be moved or deformed by impermissible loading from heavy vehicles or deformed due to a disaster. Deformation, movement, change of alignment of members should be measured regularly. It is useful information for analysis of bridge deformation.

9-3-5-2 Procedure

Geometric dimensions of special / long span bridge should be measured every three years using measuring survey equipment, like Total Station.

When severe disasters occurred, like earthquake, typhoon and ship or car collision, Geometrical Inspection should be undertaken in order to confirm the degree of deformation.

Geometrical Inspection methods are shown in Figure 3-5-1, 3-5-2 and 3-5-3. As a reference, Geometrical Inspection form (GIF) of Otto Beit Bridge are shown in Appendix A-3-3.

The Geometrical inspection is composed of a three-part measurement survey.

○leveling of super structure and substructure

・Elevation of longitudinal alignment of deck surface

・Elevation of towers and piers

○Slope of tower and top chord

○Movement of expansion joint

In case there is an official bench mark that is close to the bridge, it should be used for the leveling of bridge. Likewise, additional bench mark should be established around the bridge during the inspection.

The result of Geometrical Inspection should be stored in the Special Bridge Inventory Database. After Geometrical Inspection, Bridge Inspector and Bridge Engineer should analyze and compare the previous year’s result. If excessive movement was observed, further investigation such as Detailed Inspection should be conducted in order to determine the appropriate corrective measure to be undertaken.

9-3-5-3 Deliverables

The deliverables of Geometrical Inspection Report are as follows;

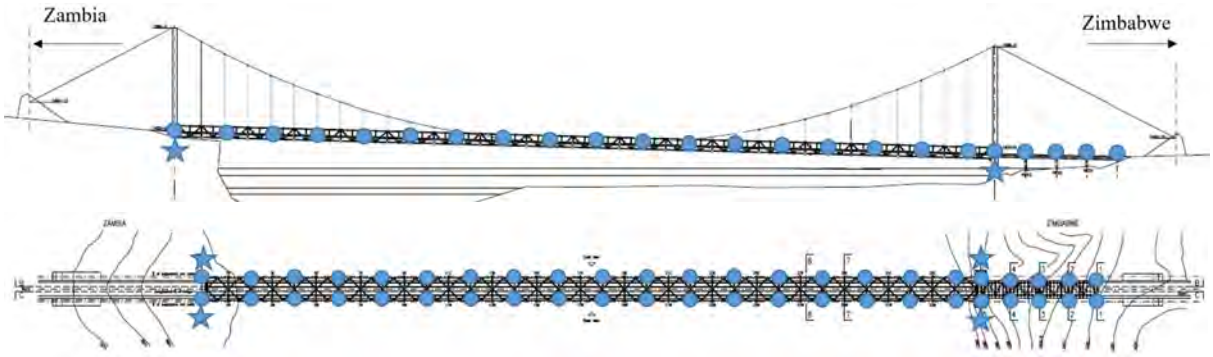
○The Geometrical Inspection Reports – A fully completed geometrical inspection form(GIF)

○Updated Geometrical Inspection (part 3times data)

○Inventory photographs

The Bridge Geometrical Inspection Report shall be prepared by the bridge inspector. The report shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization.

When the Bridge Geometrical Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory.



● : Leveling measure point for deck surface

★ : Leveling measure point for towers and piers

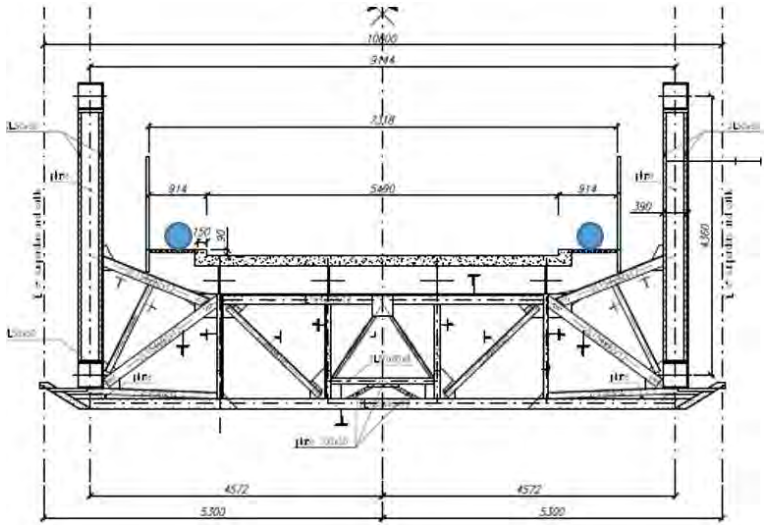


Figure 3-5-1 Geometrical Inspection:
Leveling of Towers and Piers and longitudinal alignment of deck surface

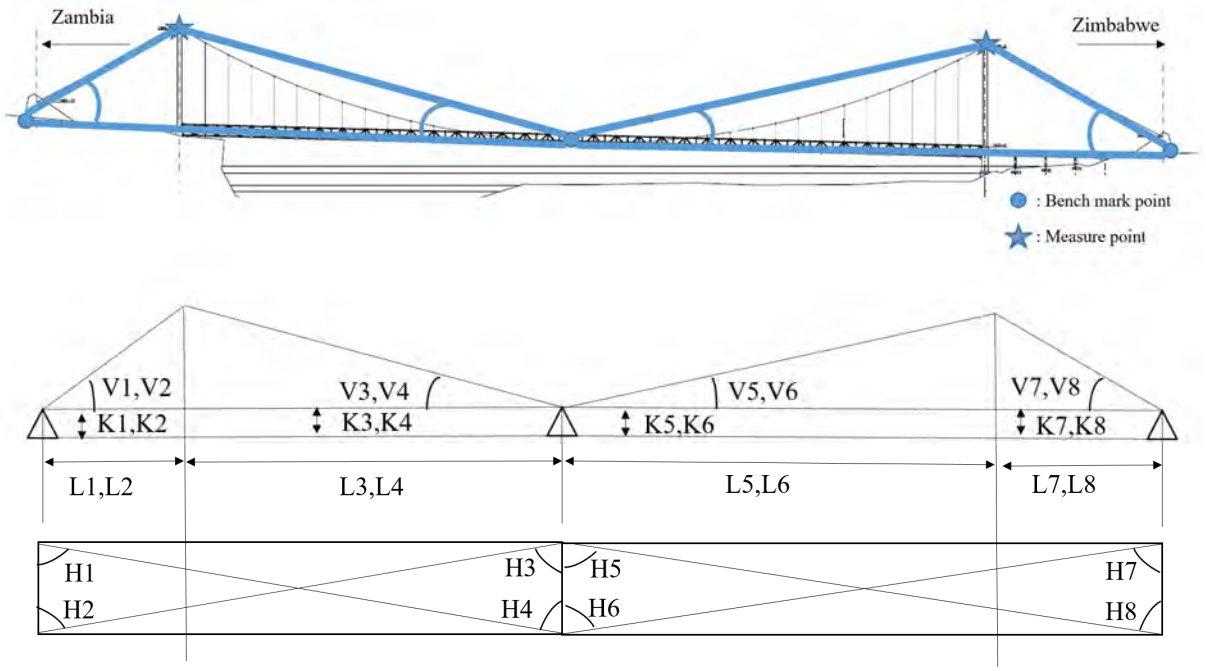
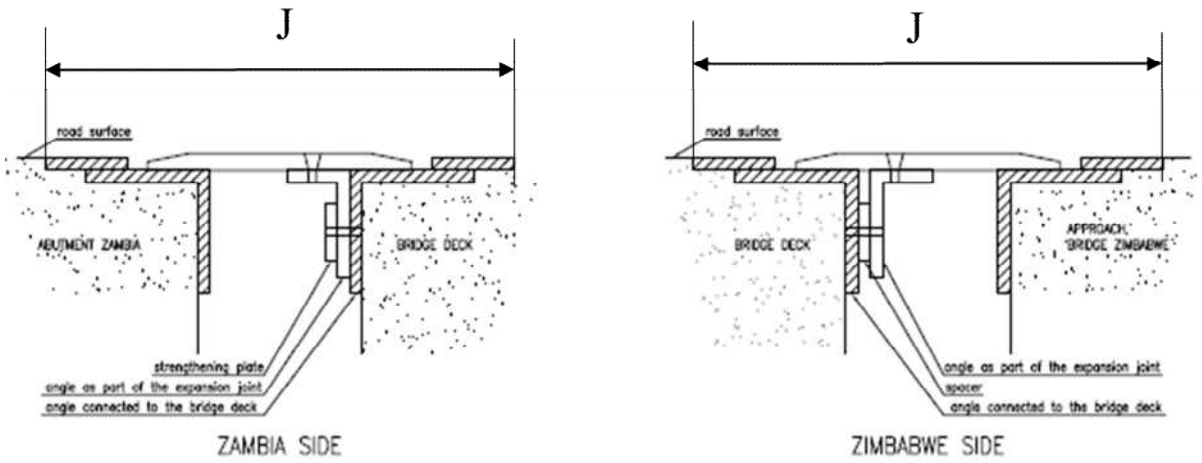


Figure 3-5-2 Geometrical Inspection:
Slope of Vertical Alignment of Tower

Measure: Angle (Vertical): V1',V2',V3',V4', V5',V6',V7',V8'
Angle (Horizon):H1',H2',H3',H4', H5',H6',H7',H8'
Length: L1', L2', L3', L4', L5', L6', L7', L8'
Height; K1', K2', K3', K4', K5', K6', K7', K8'

Raise:	Slope:
K1'+L1'*tanV1'	L1'/tanH1'
K2'+L2'*tanV2'	L2'/tanH2'
K3'+L3'*tanV3'	L3'/tanH3'
K4'+L4'*tanV4'	L4'/tanH4'
K5'+L5'*tanV5'	L5'/tanH5'
K6'+L6'*tanV6'	L6'/tanH6'
K7'+L7'*tanV7'	L7'/tanH7'
K8'+L8'*tanV8'	L8'/tanH8'



Expansion Joint

Measure 5 selected points in each joint and average (everytime use same marking point)

Figure 3-5-3 Geometrical Inspection:
Movement of Expansion Joints

9-3-6 Emergency Inspection

9-3-6-1 Purpose

Emergency Inspection will be undertaken in response to calamities or occurrence of severe damages that may be tend to cause substantial damage to any part of the structure. This inspection is required to confirm that the bridge remain safe to commuters following a calamity or any man-made disasters and to determine the necessary work that is required to ensure the safety of the bridge and to restore the function of the bridge.

9-3-6-2 Process

There is no general process for emergency inspections as these inspections are ad-hoc inspections undertaken in difficult conditions.

9-3-6-3 Procedure

No standard procedure is required for this type of inspection.

9-3-6-4 Deliverables

The deliverable will be an Emergency Inspection Report. This will be the form appropriate for the required emergency action.

CHAPTER 9-4 Steel Truss Bridge

9-4-1 Bridge Inventory

9-4-1-1 Type of Special Bridge

Arch Bridge is a unique from that looks like a half circle or ellipse turned upside down. Arch Bridge is divided into three types: Tied, Deck, Through Arch Bridge.

Arch Bridge is a structure that supports load by compression stress in the arch member. Rigidity of bridge is high to avoid bending moment in the main members. At the same time, Arch Bridge generates large horizontal thrust by the arch reaction on their footing. In a Through Arch Bridge, they have massive foundation and the horizontal thrust of the arch reaction is transferred to large rock, masonry, or concrete foundation.



Figure 4-1-1 Steel Arch Bridge

9-4-1-2 Bridge Component

Arch Bridges are classified into Deck Bridge that bridge deck is higher than major structure, Tied Bridge that bridge deck is lower than major structure, Through Bridge that bridge deck go cross major structure. Tied Bridge and Through Bridge suit the ground which stand horizontal reaction force.

In the Arch Bridge, Dead load (ex deck) and live road reach the bearing through the deck→ longitudinal beam・Cross Beam→ Stiffening Girder→ Vertical Member→ Arch Rib. Upper and lower Lateral Bracing stand for horizontal force such as wind seismic load and have a role to enhance safety which raise stiffness by functioning with Sway Bracing and Strut.

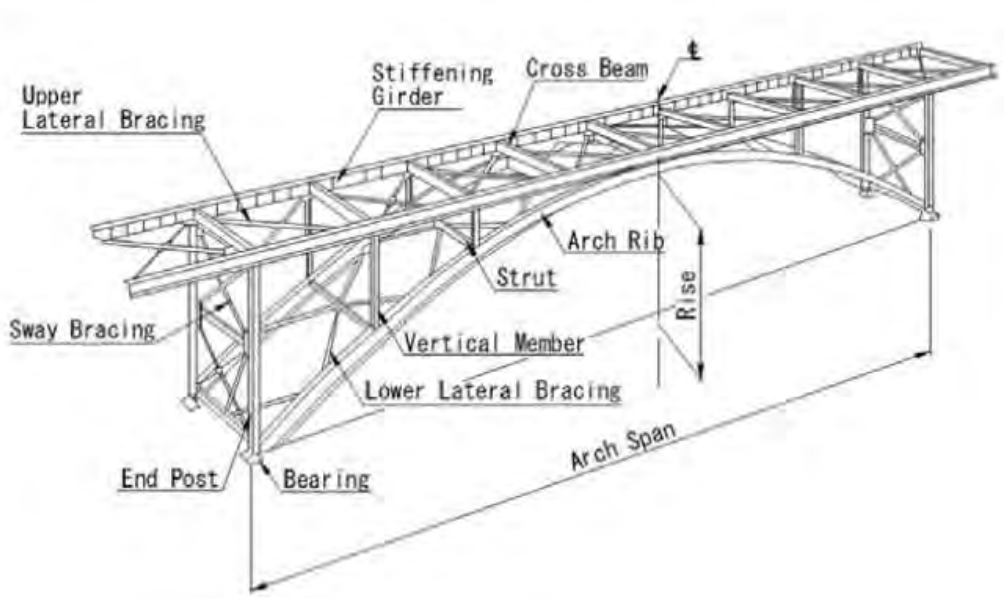


Figure 4-1-2 Bridge Component (Steel Arch Bridge)

9-4-1-3 Bridge Geometry Definition

The bridge is assessed in the direction of increasing chainage. Refer to Figure 4-1-3.

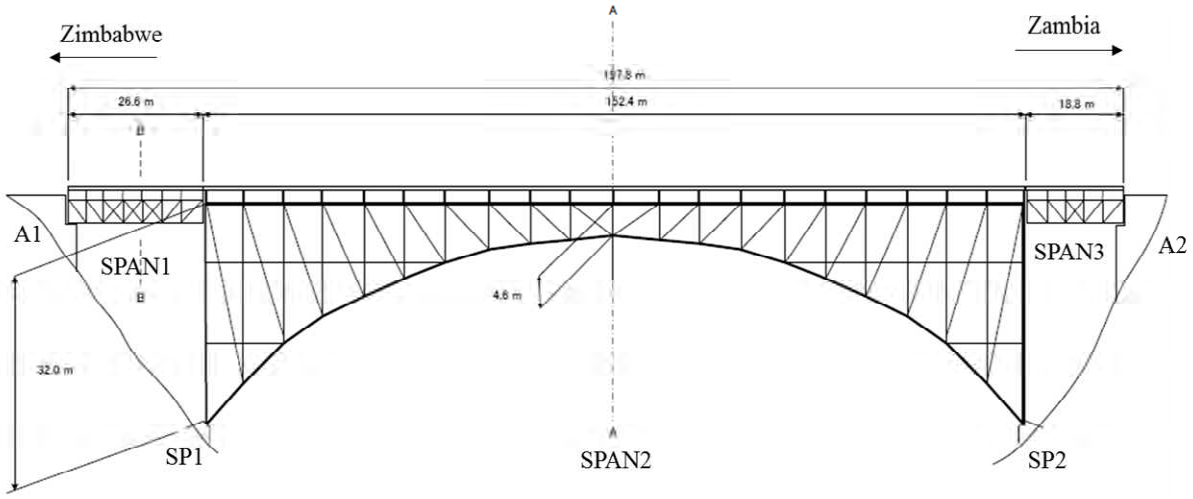


Figure 4-1-3 Bridge Geometry Definition

The following standard abbreviations are adopted to describe a bridge:

ZMBS	-	Zambian Side
ZIMS	-	Zimbabwe Side
SP	-	Springing
A	-	Abutment
G	-	Girder

Example, a three (3) span bridge with girder in each span:

- Abutment 1 (A1) is at Zimbabwean side end of the bridge and Abutment 2 (A2) is at Zambian side end.
- Spans 1 (S1), 2 (S2) and 3 (S3) numbered from the Zimbabwean side end of the bridge.
- Springing 1 (SP1) and Springing 2 (SP2) numbered the Zimbabwean side and the Zambian side respectively.
- Victoria Falls Bridge's girders are classified left side girder and right side girder (Looking in Zambia side). Accordingly, LG and RG.
- The gilder on the extreme left in span 2 is designated as Span 2 – Gilder 1 (S2LG)
- Vertical and horizontal truss members are numbered complexly. The numbering details are described in later 9-4-3 Periodic Inspection.

9-4-1-4 Steel Arch Bridge

Arch Bridge is a unique form that looks like a half circle or ellipse, turned upside down. It was built since Roman times, but Steel Type Arch Bridge have only been constructed in the late 1800's. Arch Bridge are divided into three types: Tied, Deck, and Through Arch Bridge. Victoria Falls Bridge is categorized as Deck Arch Bridge.

Arch Bridge is a structure that supports load by compression stress in the arch members as shown in the Figure 4-1-4. Rigidity of bridge is high to avoid bending moment in the main members. At the same time, Arch Bridge generate large horizontal thrust by the arch reaction on their footing. In a Through Arch Bridge, they have massive foundation and the horizontal thrust of the arch reactions is transferred to large rock, masonry, or concrete foundations. On the other hand, in a Deck Arch Bridge, the load is supported not only arch member but also deck slab. Load Distribution system for Deck Arch Bridge is shown in Figure 4-1-5.

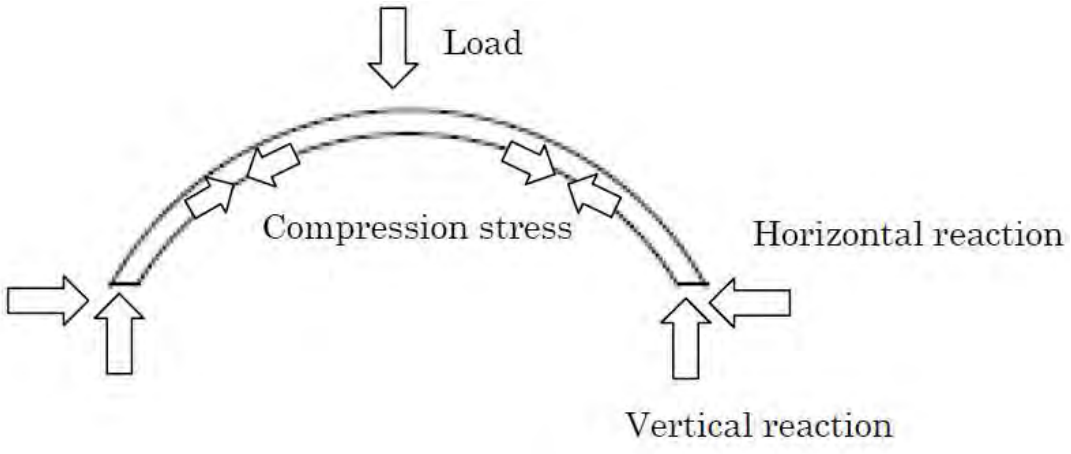


Figure 4-1-4 Load Distribution System for Through Arch Bridge

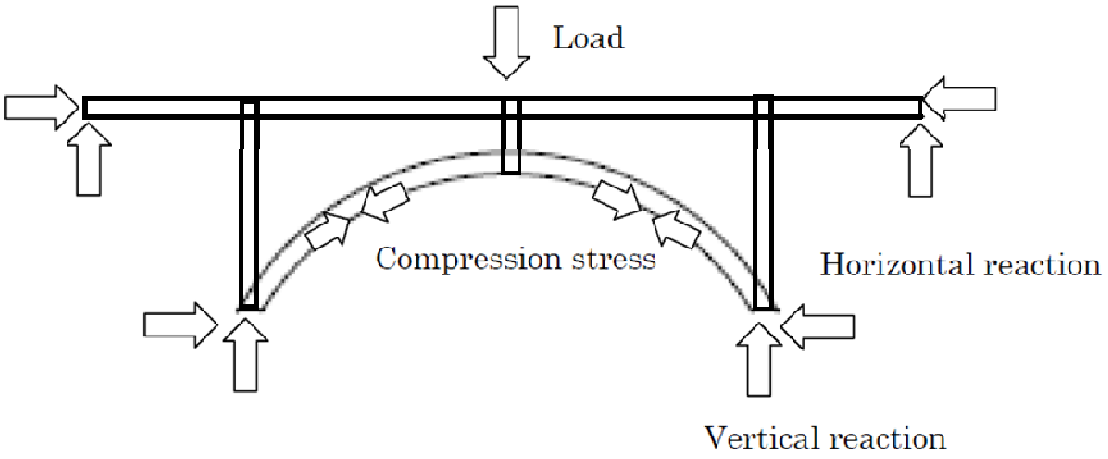


Figure 4-1-5 Load Distribution System for Deck Arch Bridge

A Tied Arch transfers the horizontal reactions through a horizontal tie which connects the ends of the arch together, like the string on an archer's bow. The tie girder is a tension member and is considered fracture critical. If the tie girders fail, the arch will lose its tension and will collapse. Since Tied Arch Bridge redistribute the horizontal loads to the tie girders, the piers for Tied Arch Bridge are smaller than the piers for Through Arch Bridge.

Traffic loads are supported by a deck. The load from the deck is transmitted to the stringers and then the floor beams. The stringer and floor beams resist the load in bending and shear.

The load is transferred to the hangers through tie member, which are in tension. The arch support the hangers and load transfers the compressive load to arch members. Tie girder has tension stress from the arch reaction on their footing.

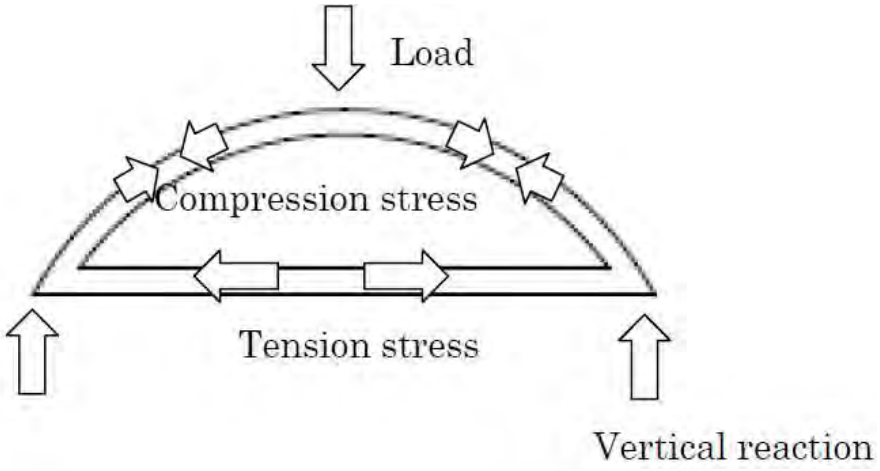


Figure 4-1-6 Load Distribution System for Tied Arch Bridge

Shown in Figure 4-1-7 is the General View of Victoria Falls Bridge.

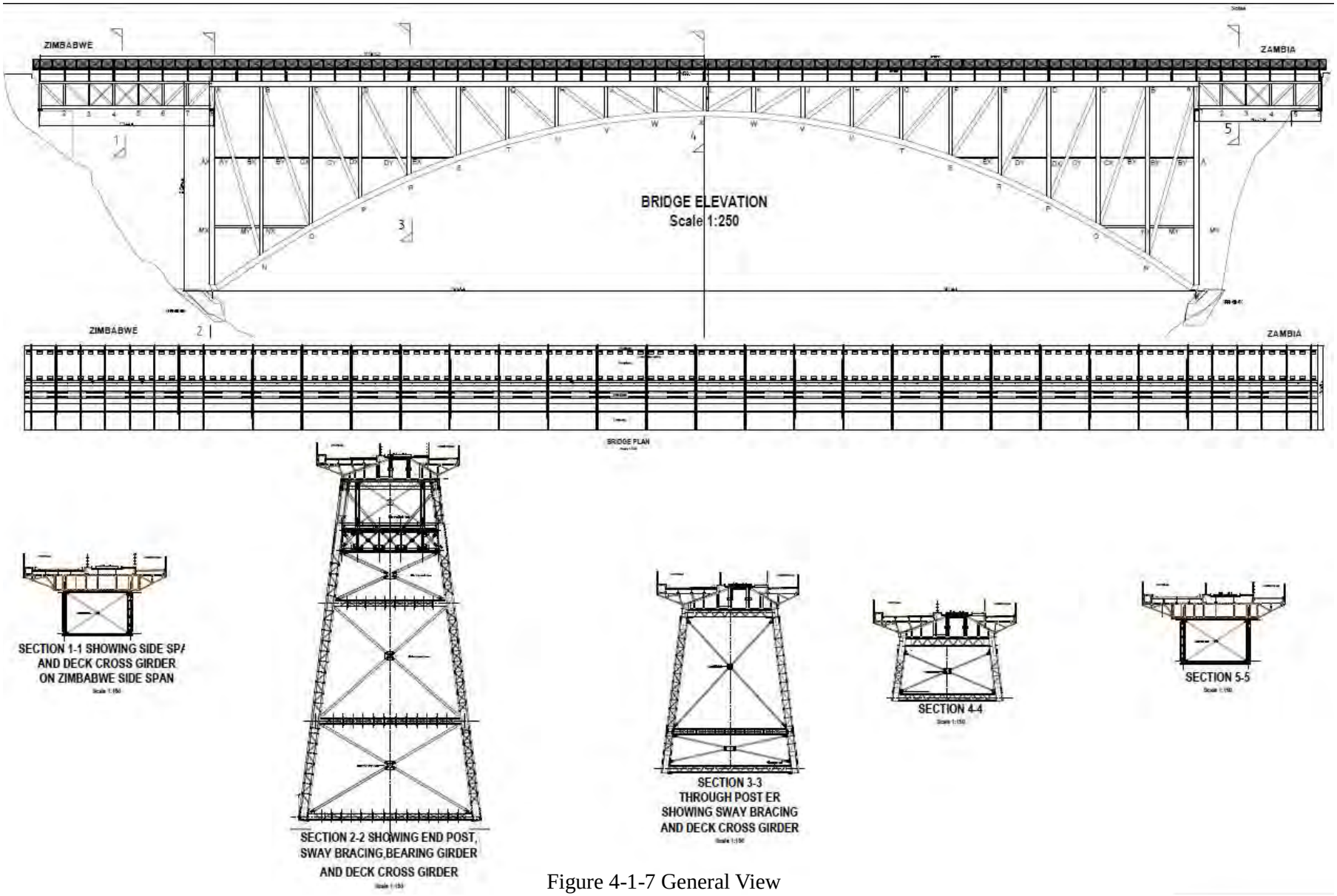


Figure 4-1-7 General View

9-4-2 Inventory Inspection

Inventory Inspection for standard bridges is described in CHAPTER 4. And this chapter is described the Inventory Inspection for special bridges.

9-4-2-1 Purpose and process

The purpose of the Inventory Inspection for Steel Arch Bridge is to obtain its inventory data primary for inclusion in the BMS database. Bridge inventory data is a standard series of information that describe the geometry, construction and current function of a bridge.

The Inventory Inspection for the Special bridge, is similar to the inventory inspection of standard bridges.

9-4-2-2 Procedure

All information collected during the bridge inventory inspection is recorded using the Inventory Inspection Form (IIF). The IIF of Victoria Falls Bridge is included in Appendix A-4-1.

The IIF is composed of two parts for the Special Bridge Inventory:

○Standard inventory sheet is the same sheet with ordinary bridges in BMS.

・Inventory Inspection Form.

・The special requirements for inspection

・The general bridge data, clearances, geometry, traffic direction, type of bridge, year of construction, public utilities carried by the bridge and detail, if there is lighting provided on the bridge, the type of terrain where the bridge is located, comments if the bridge is unusual, type of construction, substructure type, deck material, wearing surface, drainage, design load and the available drawings.

・The bridge Modification Sheet describes the types and materials of any modifications to the bridge.

・The span/s of the bridge.

・The pier/s of the bridge.

・The bridge abutments.

○Additional geometrical data sheet for Special Bridge

・Measurement of bridge structure (superstructure and substructure)

As built Drawing are very important for special bridges. There is no standard drawing in special bridge. Each bridge has its own unique structure. “As Built Drawing” should be collected and electronic copy should be installed in the Special Bridge Inventory Database, as one of Inventory Inspection data. In case that there is no available bridge data, measurement survey on site for

collecting basic bridge data and general drawings for inventory should be done. All documents pertaining to the past repair works and useful information are also important for future reference, especially when the bridge is due for retrofitting.

9-4-2-3 Description

The Victoria Falls Bridge crosses the Zambezi River and it is located just downstream of Victoria Falls, on the border between Zambia and Zimbabwe. The bridge was officially opened on September 1905. The American Society of Civil Engineers, the Engineering Council of Zimbabwe and the Engineering Institution of Zambia list the bridge as a Historic Civil Engineering Landmark. The bridge length is 197.8 meters and central main arch span is 152.4 meters. Railroad track, roadway and sidewalk are provided and bridge width is 13.24 meters (5.87 meters with roadway, 4.50 meters with railroad and 2.86 meters with sidewalk). The longest longitudinal member is 32.0 meters.

The bridge concept was initiated by Cecil Rhodes, part of his ambitious and unfulfilled Cape to Cairo railway scheme, even though he never visited the falls and died before construction of the bridge began. Rhodes is recorded as instructing the engineers to “build the bridge across the Zambezi where the trains will catch the spray of the Falls.” It was designed by George Andrew Hobson of consultants Sir Douglas Fox and Partners, assisted by ralph Freeman, who later the principal designer of the Sydney Harbor Bridge. The bridge was fabricated in England by the Cleveland Bridge & Engineering Company of Darlington, before being shipped to the port city of Beira in Portuguese-ruled Mozambique, and then transported on the newly constructed railway which had reached the Victoria Falls on 1st June 1904. It took 14 months to construct and was completed in 1905 the erection of the bridge structure took only nine weeks and the central girders were inserted on 1st April 1905.

There are several records of repair and reinforcement work. For example, in 1930, new deck and braking struts added in order to allow the passage of “Touring Cars” and additional strengthening members were made in 1963. This bridge is well known as a famous tourist bridge with bungee jumping. And the Victoria Falls, one of the world’s three largest waterfalls, can be usually seen clearly from April to June.



Figure 4-2-1 Photo of Victoria Falls Bridge

9-4-2-4 Inspection Form

The bridge Inventory Inspection Form (IIF) and attached drawings are prepared specifically for Victoria Falls Bridge as shown in Appendix A-4-1.

9-4-2-5 Location and Inventory Data Collection

The bridge inspector shall inspect the bridge and complete the Location and Inventory sections of the IIF. This can generally be completed by checking the appropriate box and by inserting the required names and numbers.

Several parts of the IIF can be completed even without having to go to the bridge site. Note, however, that all data shall be verified on site.

Data needed for Location and Geographic Information are described in Table 4-2-1.

Table 4-2-1 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located

Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

The bridge inspector shall take note of any paticular requirements to gain access or to inspect all parts of the bridge for use in planning future bridge condition inspections. Check the appropriate boxes in Special Inspection Requirements, for items such as ladders, inspection vehicles, boats, etc.

A bridge is made up of various inventory elements;

- General,
- Modifications,
- Spans,
- Piers,
- Abutments.

9-4-2-6 Deliverables

The deliverables of Inventory Inspection Report are as follows.

- The Bridge Inventory Reports
  - A fully completed Bridge Inventory Inspection Form (IIF)
  - Geometrical data sheet for Special Bridge
- As Build Drawings
- Data of repair history
- Inventory photographs

The Bridge Inventory Inspection Reports shall be prepared by the bridge inspectors. The reports shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization. When the Bridge Inventory Inspection Report is completed, accurate and accepted, all the data shall be stored in BMS.

9-4-3 Periodic Inspection

Periodic Inspection for standard bridge is described in CHAPTER 5. And this chapter is described the Periodic Inspection for special bridges.

9-4-3-1 Purpose

The purpose of the Periodic Inspection is to record defects and rate the condition of special / long span bridge as a basis for identifying its current maintenance needs, forecasting its future intervention measures and estimating its future funding requirements. Also, the result of Periodic Inspection should be used to monitor the deterioration of defects.

9-4-3-2 Scope of the Inspection

The scope of the periodic inspection for special bridge is almost the same as standard bridge, and in addition below.

・Reviewing the existing inventory data of the bridge structure for accuracy

・Visually inspecting the bridge attributes and record their defects to assess their condition using a standard condition rating system.

・Sketch drawings to monitor the progress and deterioration of defects

・Reporting the condition of each bridge attributes

・Providing a general condition rating for the structure as a whole.

・Identifying bridges that require an Detailed inspection (those with an overall condition state poor or bad)

・A photographic record of defects

In Periodic Inspection, the inspector should record all details of defects for assessment of bridge condition using a standard condition rating system and also for the monitoring of progress and deterioration of defects. Therefore, each attribute of the bridge shall be inspected at a distance at least three meters from the surface of the attributes or its equivalent, using binocular as much as possible.

All surfaces of the attributes shall be exposed in good natural or artificial light during the inspection, sufficient to observe fine cracks and other defects on the surfaces. Bearings at the abutments and piers shall be inspected at eye level. The truss members and arch chord shall also be inspected closely. The bridge inspection is done visually to cover all parts of the bridge above the ground and water level.

Sketch drawings in Periodic Inspection is very important for the analysis of bridge condition and for the monitoring of deterioration of defects. Inspector should sketch carefully the details of defects. Sketch drawing of defects should include the range, length, area and severity of defects as much as possible. When inspectors cannot possibly measure the defects, they can roughly estimate measurement through their engineering judgement. If a previous Detailed Inspection Report is available, the findings on the report will be used in the next Periodic Inspection to verify whether these findings remain valid.

9-4-3-3 Process

The step-by step procedure for conducting the Periodic Inspection is illustrated in the following flowchart.

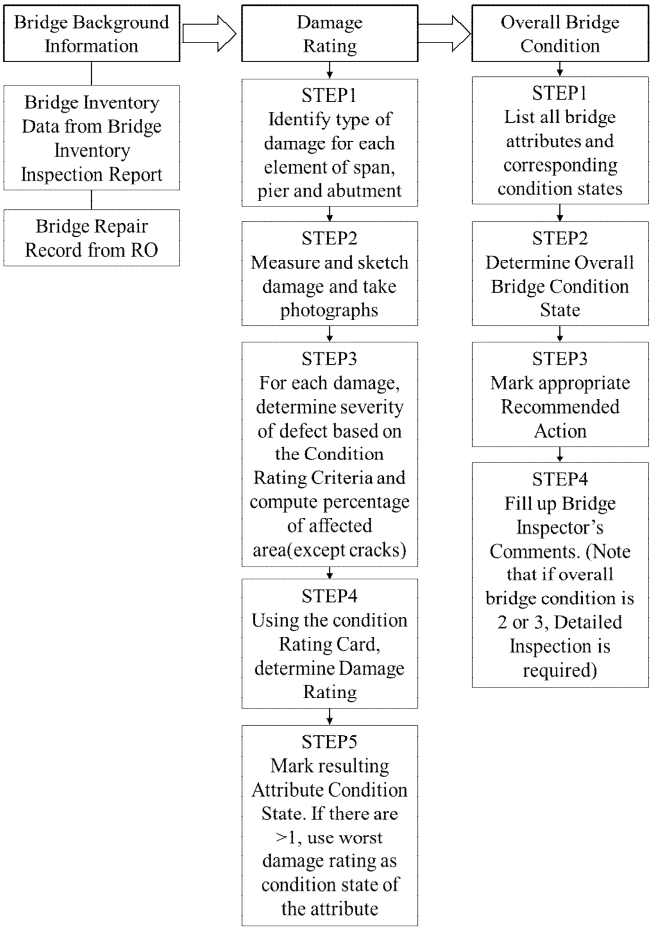


Figure 4-3-1 Flowchart of Bridge Periodic Inspection

9-4-3-4 Inspection route and the points of inspection

【Periodic Inspection Form (PIF)】

As a reference, Periodic Inspection Forms (PIF) and sketch Drawings of Victoria Falls Bridge are shown in appendix A-4-2.

The bridge Periodic Inspection Routes of Victoria Falls Bridge are shown in Figure 4-3-2, 4-3-3 and 4-3-4, and the Check Points of the Periodic Inspection are shown in Figure 4-3-5 and 4-3-6. As a breakdown, the PIF is composed of forms shown in Table 4-3-1

Special / long span bridges are complex structures. Before conducting inspection, proper numbering of elements and attributes on the forms should be considered to avoid misinterpretation on its location. During inspection, each attributes shall be numbered / marked for easy identification. Numbering and marking of attributes are shown in Figure 4-3-7 and 4-3-8.

Inspection of Upper Deck

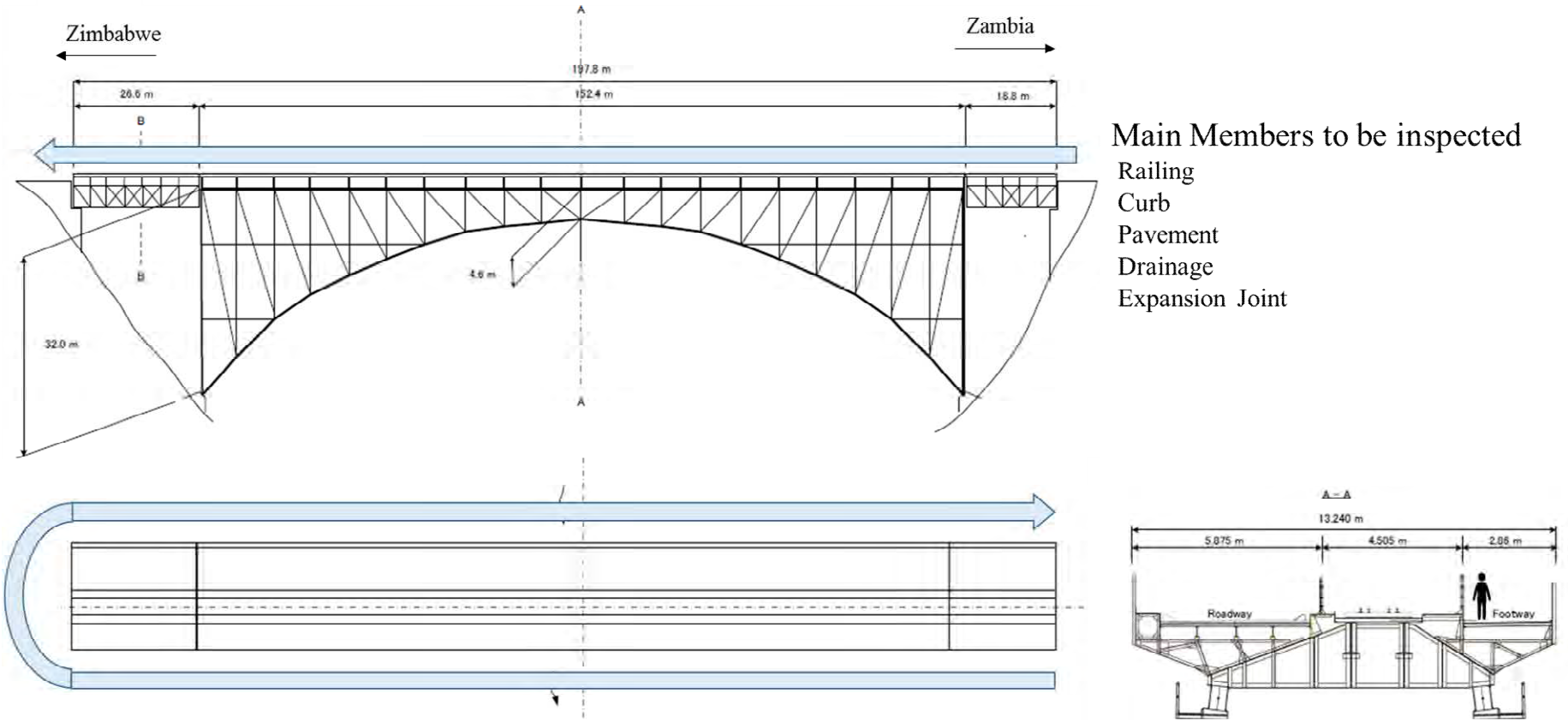


Figure 4-3-2 Periodic Inspection Route of Victoria Falls Bridge (1 of 3)

Inspection of Underside

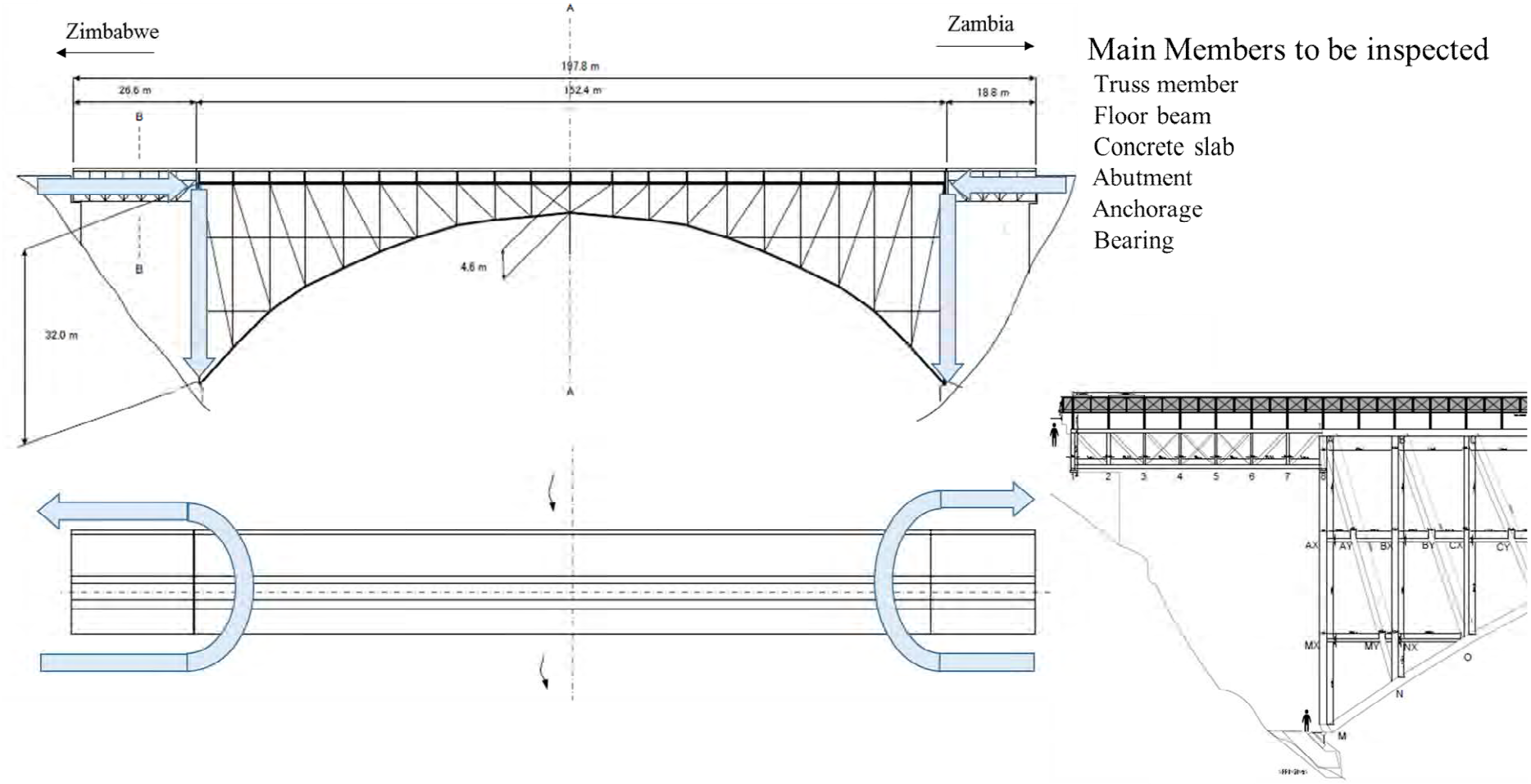


Figure 4-3-3 Periodic Inspection Route of Victoria Falls Bridge (2 of 3)

Inspection of Underside and Arch chord

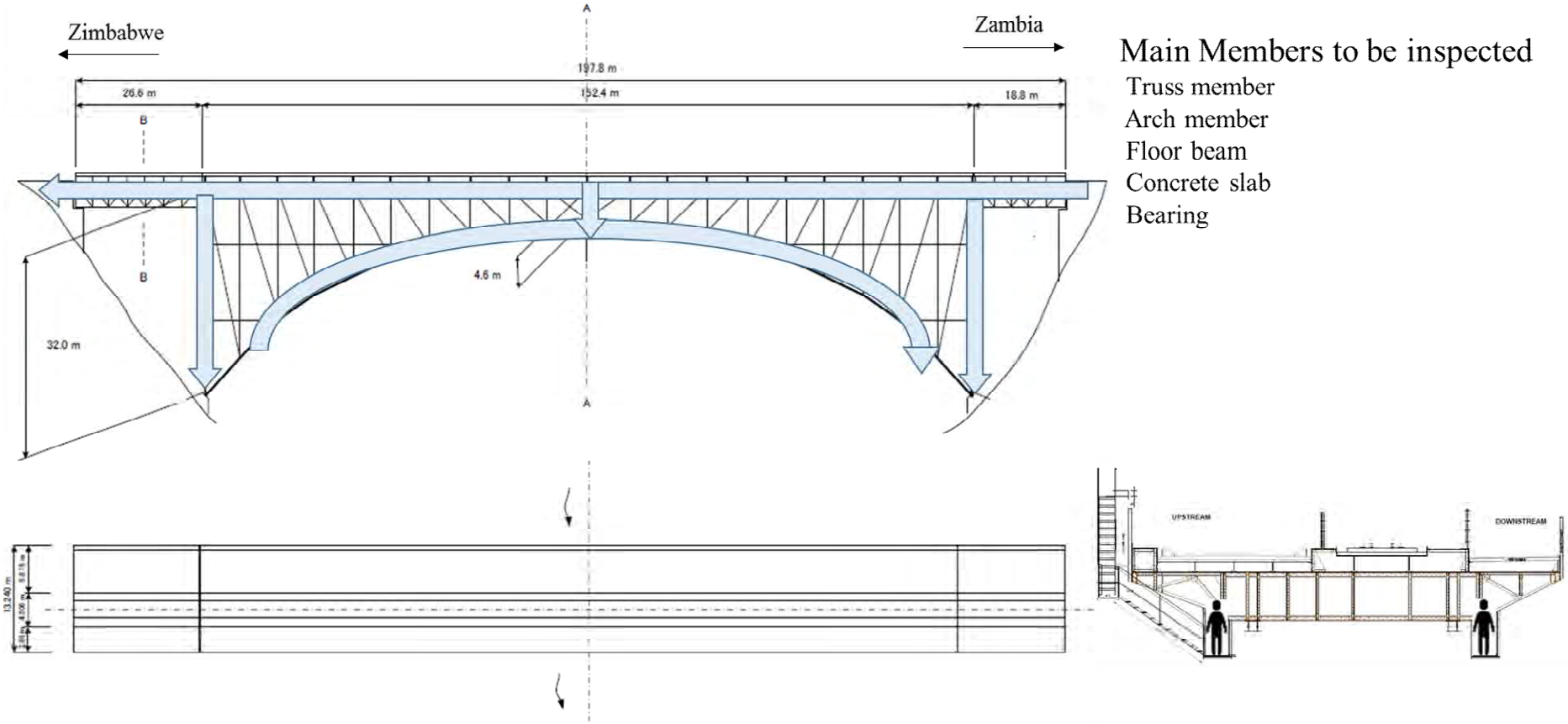


Figure 4-3-4 Periodic Inspection Route of Victoria Falls Bridge (3 of 3)

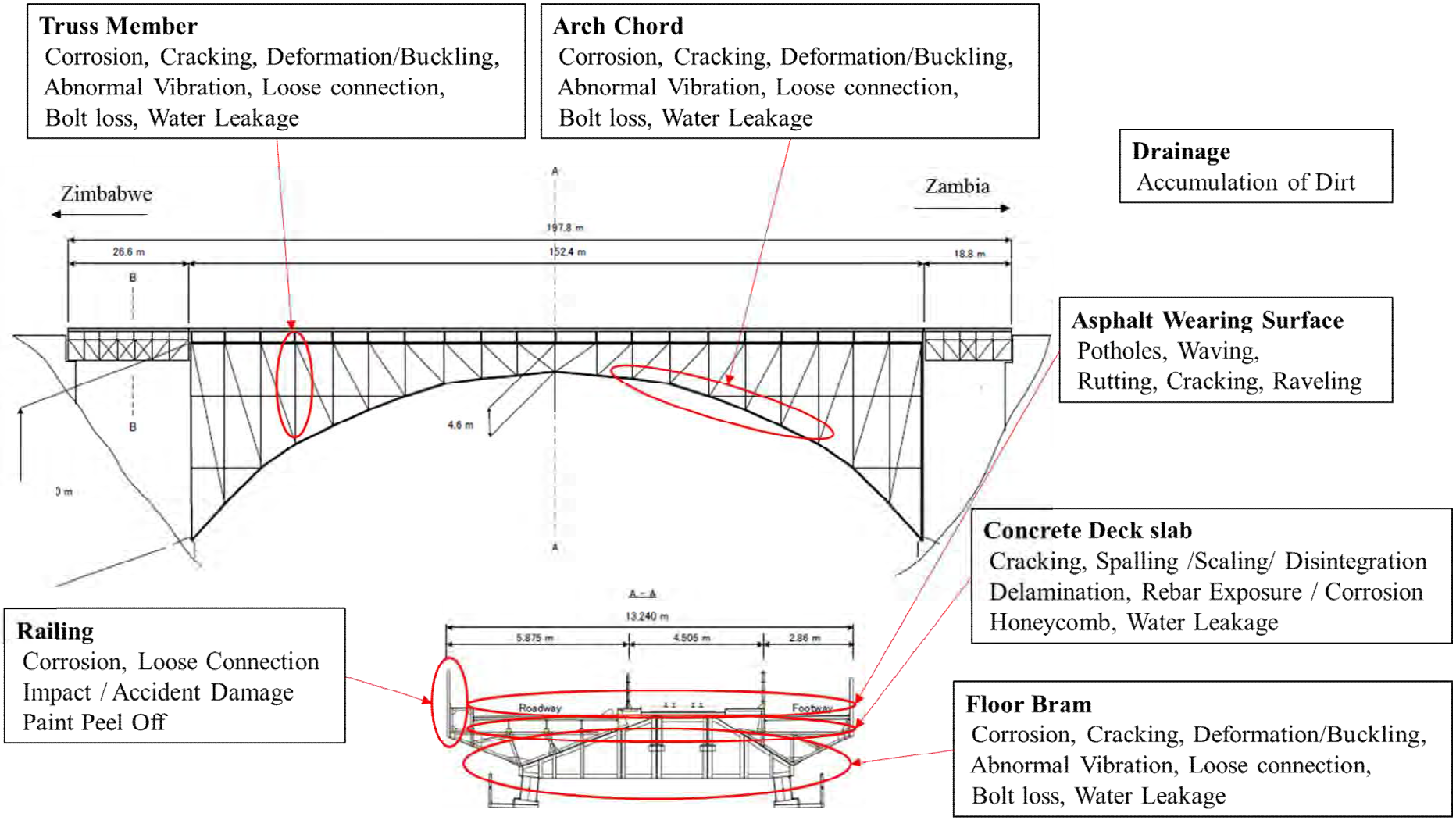


Figure 4-3-5 Check Points of Periodic Inspection – Victoria Falls Bridge (1 of 2)

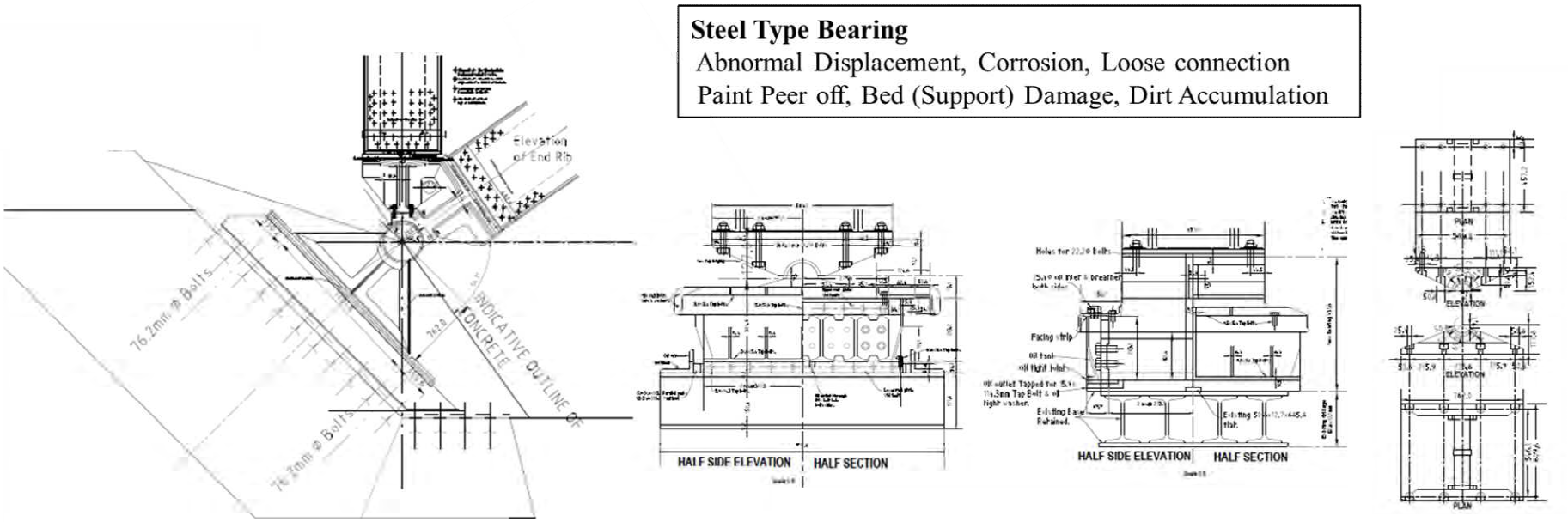


Figure 4-3-6 Check Points of Periodic Inspection – Victoria Falls Bridge (2 of 2)

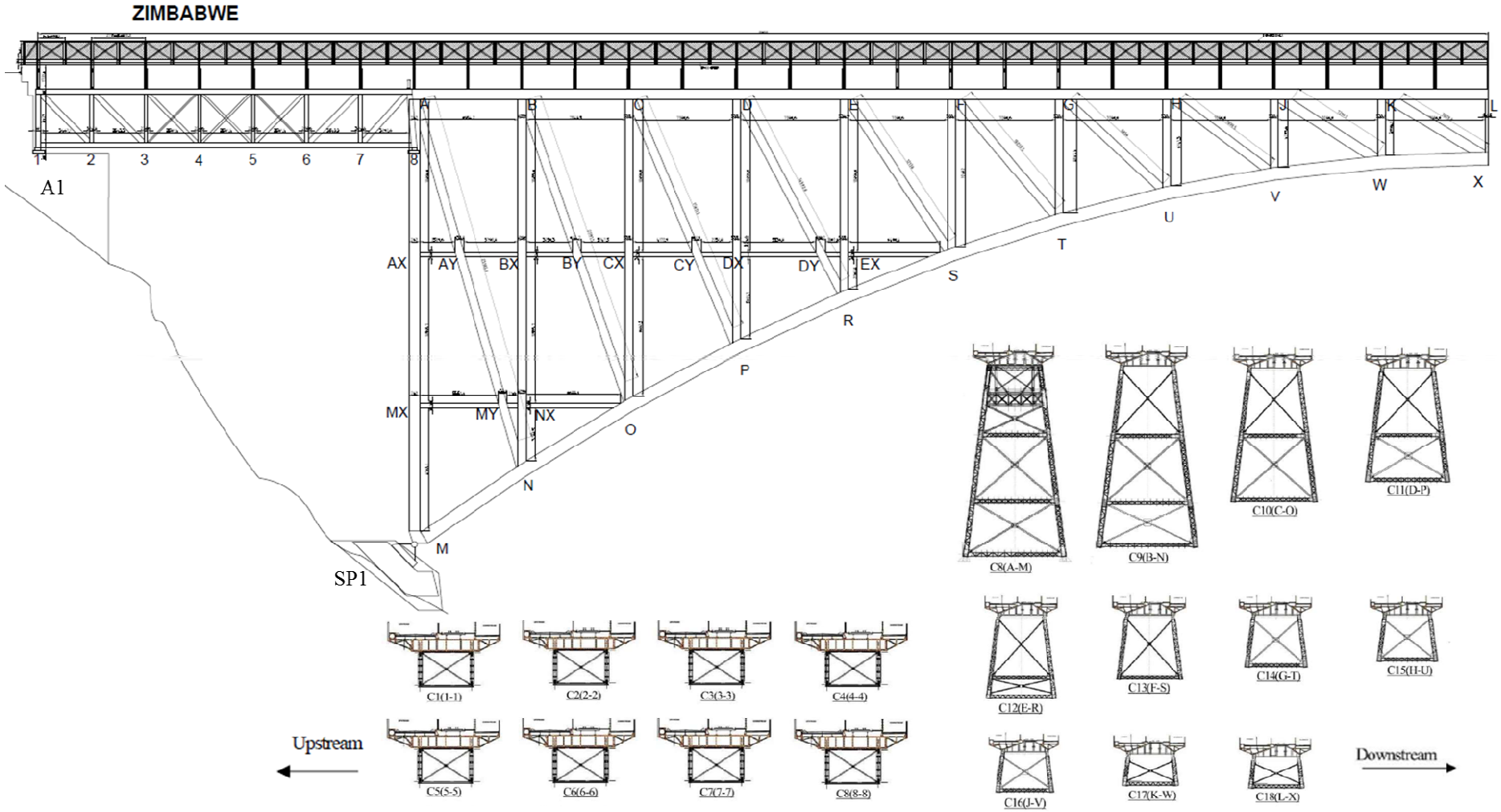


Figure 4-3-7 Numbering of Members – Victoria Falls Bridge (1 of 2)

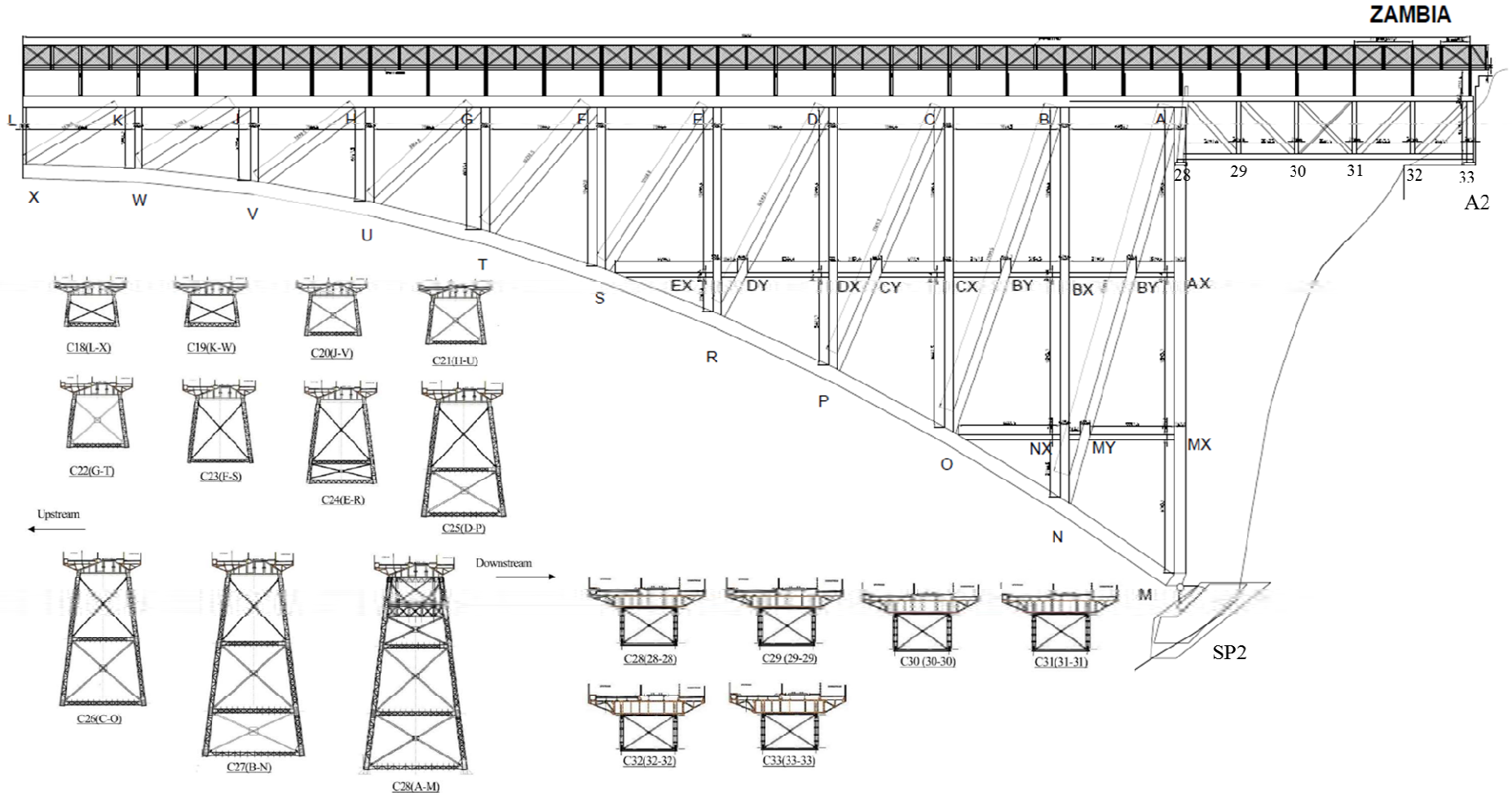


Figure 4-3-8 Numbering of Members – Victoria Falls Bridge (2 of 2)

Table 4-3-1 Composition of Periodic Inspection Form (Victoria Falls Bridge)

Title of Form	Number of Form
(1) Summary, Repair record	2
(2) Damage Rating (main structure)	16
(3)Sketch (Deck and Appendage)	8
(4) Sketch (Abutment and Springing)	2
(5) Sketch (Truss)	8
(6) Photo	As needed
Total	36

【Level of Inspection】

The Bridge inspector shall indicate the level of inspection undertaken as shown in Table 4-3-2.

Table 4-3-2 Level of Inspection

Full complete inspection	
Partial inspection only as bridge inspection vehicle not available	
Partial inspection for other reason	

It is practical to use Bridge Inspection Vehicle at least once in every three years, due to the limited number of such vehicle. Bridge Inspector should consider the arrangement of Bridge Inspector Vehicle when they make a maintenance plan for Victoria Falls Bridge. If a complete inspection is not undertaken, then revisit the bridge and inspect with a Bridge Inspection Vehicle or other required equipment (for example, drone). A countrywide program for the use of the available Bridge Inspection Vehicles should be utilized to ensure optimum result of the inspection.

【Location and Inventory Data】

The bridge inspector shall inspect the bridge and review the Location data included in the PIF. Data required are described in Table 4-3-3.

Table 4-3-3 Bridge Location Data

Data Description	Comment
Bridge ID	Unique identification number assinged by the RDA for each bridge
Bridge Name	The name given to the bridge
Road Name	Then name of the road on which the bridge is located
Road ID	Unique identification number assinged by the RDA for the road on which the bridge is located
Location	The location of the bridge with in the road section
Province	The administrative area in which the bridge (i.e. the first abutment) is located
River Name	The name of the stream crossed by the bridge (where appropriate)

【Repair Record】

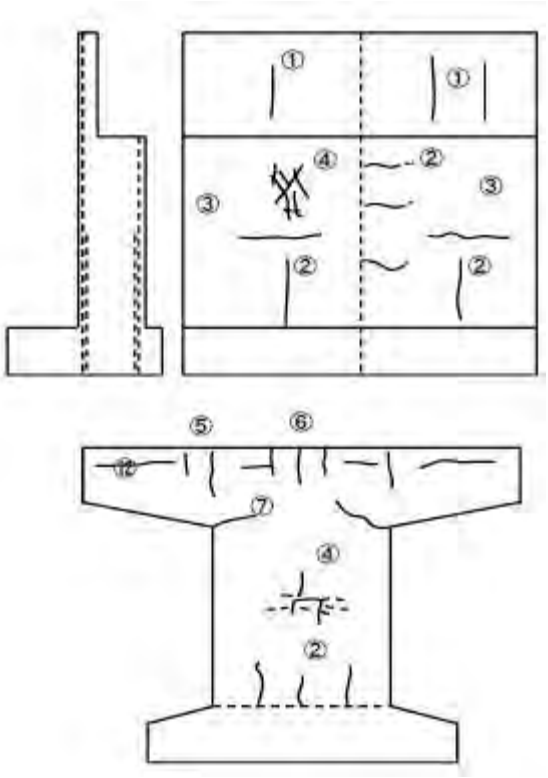
The bridge inspector is required to report the routine and major maintenance activities undertaken to a bridge after the conduct of the last periodic inspection that will include the type, scope and status of maintenance activities. The bridge inspector shall also record observations whether the works undertaken are effective and sufficient.

【Periodic Data Collection】

Special bridges like Steel Arch Bridge have unique attributes and materials which are not defined in the BMS Manual for standard bridge. Bridge Inspection Team should understand the characteristic and function beforehand by reviewing the As Built Drawings and other related documents.

As a reference, some special attributes of Victoria Falls Bridge are listed in Table 4-3-4. All other applicable descriptions in the BMS Manual for standard bridge are adopted in this Manual. General pattern of defects in bridges are shown in Figure 4-3-9 and 4-3-10.

General Patterns of Crack Defects on Abutment and Pier



Number	Pattern
1	Crack with regular interval
2	Crack on the concrete casting joint
3	Crack around the changing point of density of reinforcement bar
4	Crack like mesh
5	Crack on topside of overhang beam (coping)
6	Vertical crack on pier center
7	Crack on bottom side of overhang beam (coping)
8	Crack on upper and bottom part of column
9	Crack on column
10	Crack on haunch
11	Bending crack on the span center or beam
12	Horizontal crack on beam

Figure 4-3-9 General Patterns of Defect (1 of 2)

General Patterns of Crack Defects on Steel Bridge

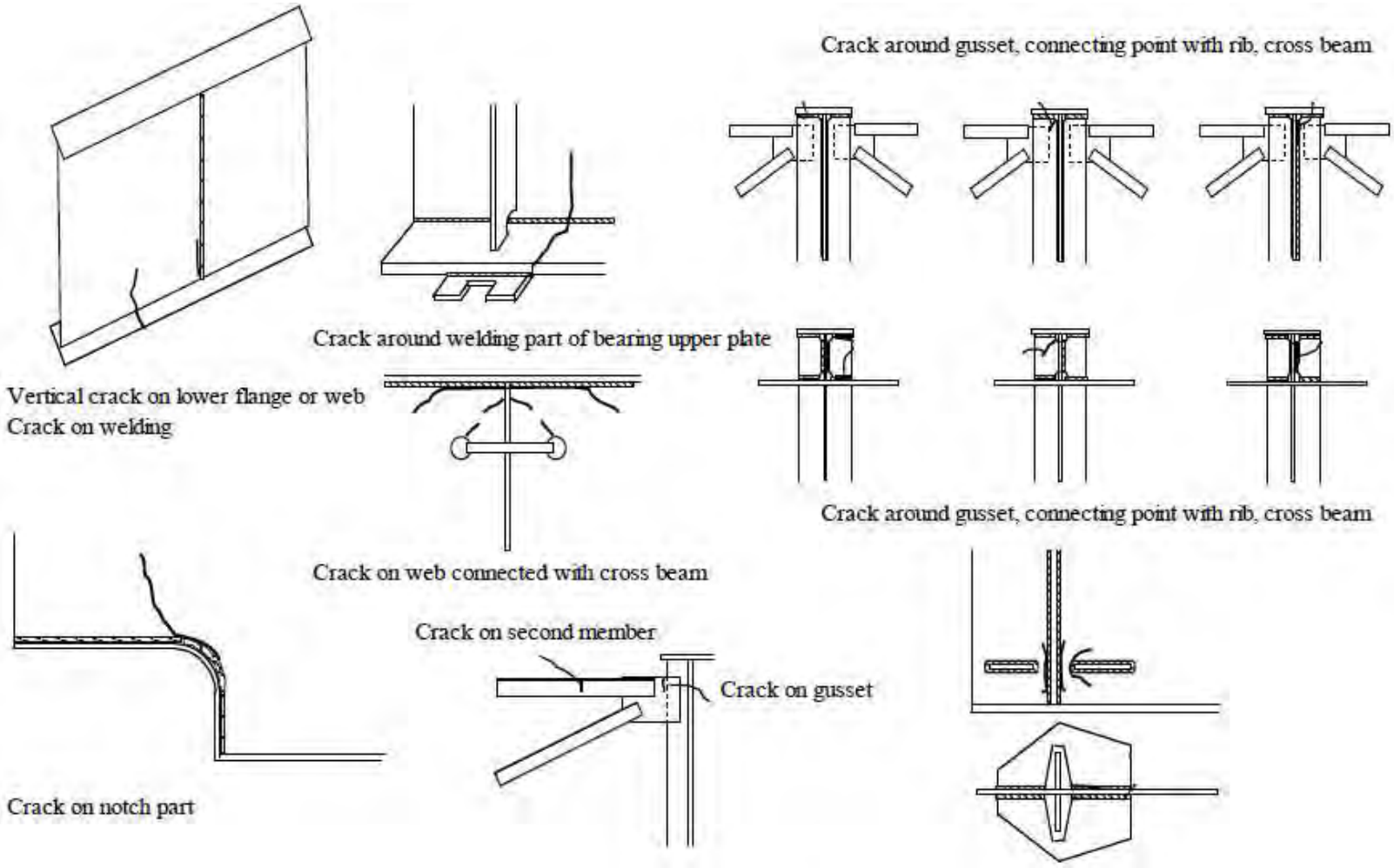


Figure 4-3-10 General Patterns of Defect (2 of 2)

Table 4-3-3 Special Attributes of Victoria Falls Bridge

Element	Attribute	Description
Span	Asphalt Wearing Surface	The asphalt wearing surface is the surface on which vehicle traffic and pedestrian travels. Asphalt wearing surface plays an important role to protect the deck slab.

【Condition Rating of Bridge Attributes】

The material defect descriptions and the condition rating criteria in BMS will be utilized by the Bridge Inspectors (BI) to assess the defects identified in bridge elements. On the other hand, the Periodic Inspection for the asphalt wearing surface will be undertaken using this Manual.

The condition rating of the bridge attributes will be conducted following Inspection guidebook. Additional material defects are specifically described in Appendix D-4-1. while the corresponding conditon rating criteria concerining the same is included in Appendix C-4-1.

The affected area, length or number will be roughly estimated and using the Periodic Rating Card, the attribute damage rating can be obtained. The condition state of the attribute is the worst damage rating. The descriptions cannot possibly cover every situation, and the BIs must rely on their engineering knowleage and judgment to evaluate which condition should apply to the bridge elements inspected.

The BIs shall also compare the defects observed in the attriute with the previous sketch drawings and photograph records to check the progress.

The condition states have been developed to describe the following conditions listed in Table 4-3-4.

For each defined attribute in the bridge, the Periodic Inspection Forms includes a separate section covering that attribute and which is to be completed by the BI. Each section shall be completed to include:

・The condition state of the attribute (see Table 4-3-4)

・The type of repair required for each attribute

・The estimated cost to undertake the required repair (major maintenance)

All repairs to attributes are classified as major maintenance.

The standard descriptions of major maintenance that may be undertaken for each attribute are;

・Repair damage

・Protective measures

・Strengthen

・Replace

・Other

Only one type of maintenance can be listed for each attribute. When two or more types of maintenance are required to an attribute, all work shall be listed under the type of maintenance with the highest estimated cost.

The BI shall describe in detail the recommended repair works each identified defect in any attribute, providing sketch drawings if necessary.

Table 4-3-4 Bridge Attributes condition state

Condition State	Description	Action
0	Attribute is in good condition with little or no deterioration	Keep inspection
1	Attribute shows deterioration of minor nature to the primary supporting material and is showing first signs of being affected	Keep monitoring
2	Attribute shows advancing deterioration and loss of protection to the supporting material, minor loss of section	Major maintenance is required wihtin 2 years
3	Attribute shows advanced deterioration, loss of effective section to the primary supporting material, and is acting differently to design or is showing signs of overstress	Immediate major maintenance is required

The condition state of each bridge attribute will be used by the BMS to calculate the overall need of the bridge for intervention.

【Not Applicable Attributes】

There are many instances when the Periodic Inspection Forms (PIF) is not completely filled out by the Bridge Inspector due to uncertainties in identifying or locating some attributes of the special brige.

The Bridge Inspector may feel that an attribute cannot be completed because there is no attribute in the bridge, he / she cannot recognize or find the attributes in the bridge. In this case, the bridge inspector should mark the attributes as not applicable.

9-4-3-5 Deliverables

The deliverables of Periodic Inspection Report are as follows:

○Periodic Inspection Report

Bridge Periodic Inspection Form

Summary of Periodic Inspection Results

Repair Record

Inspection Results sheet (condition)

Inspection Results sheet (damage rating)

○Sketch Drawing sheet

○Photo record sheet (Pictorial Report)

The Bridge Periodic Inspection Reports shall be prepared in the respective Regional Office where the bridge inspectors are based. The reports shall be checked and reviewed in the Central Office for completeness and accuracy prior to finalization.

When the Bridge Periodic Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory Database.

9-4-4 Detailed Inspection

Detailed Inspection for standard bridge is described in CHAPTER 6. And this chapter is described the Detailed Inspection for special bridges.

9-4-4-1 Purpose

Detailed Inspection is undertaken as a follow-up to periodic inspection when the condition state of 2 or 3 are recorded in any primary component / attribute or in any secondary component that has detrimental effect on the structural performance of the bridge. The purposes of a detailed inspection for Steel Arch Bridge are as follows.

1) To confirm the results of the periodic inspection.
2) To undertaken additional investigations in order to evaluate thoroughly noted defects which may include physical testing and / or structural analysis. And also to prepare a documentary record of the observed defects for future design of required major maintenance works.
3) To assess the current bridge structural condition, behavior and capacity.
4) To assess the rate of deterioration and residual life expectancy of the bridge.

9-4-4-2 Recommendation

In the periodic inspection for standard materials, attributes and so on, “BRIDGE INSPECTION GUIDEBOOK 2017 developed by JICA” should be referred to. However. There is no standard method in the Detailed Inspection for special materials, attributes and so on.

It is recommended that the Regional office engage the services of detailed inspection / investigation firms specializing on Steel Arch Bridge. For example, NDTs (Non-destructive testing) should be conducted in order to grasp whether the defect exist or not. NDTs for steel attributes are Paint Thickness Test and Metal Thickness Test mentioned in Chapter 6-3.

9-4-5 Geometrical Inspection

9-4-5-1 Purpose

The purpose of the Geometrical Inspection for Special Bridge is to obtain data primarily of a basic information of special / long span bridge. Bridge would be moved or deformed by impermissible loading from heavy vehicles or deformed due to a disaster. Deformation, movement, change of alignment of members should be measured regularly. It is useful information for analysis of bridge deformation.

9-4-5-2 Procedure

Geometric dimensions of special / long span bridge should be measured every three years using measuring survey equipment, like Total Station.

When severe disasters occurred, like earthquake, typhoon and ship or car collision, Geometrical Inspection should be undertaken in order to confirm the degree of deformation.

Geometrical Inspection methods are shown in Figure 4-5-1, 4-5-2 and 4-5-3. As a reference, Geometrical Inspection form (GIF) of Victoria Falls Bridge are shown in Appendix A-2-4.

The Geometrical inspection is composed of a three-part measurement survey.

○leveling of super structure and substructure

・Elevation of longitudinal alignment of deck surface

・Elevation of piers and abutments

○Slope of tower and top chord

○Movement of expansion joint (seal)

In case there is an official bench mark that is close to the bridge, it should be used for the leveling of bridge. Likewise, additional bench mark should be established around the bridge during the inspection.

The result of Geometrical Inspection should be stored in the Special Bridge Inventory Database. After Geometrical Inspection, Bridge Inspector and Bridge Engineer should analyze and compare the previous year's result. If excessive movement was observed, further investigation such as Detailed Inspection should be conducted in order to determine the appropriate corrective measure to be undertaken.

9-4-5-3 Deliverables

The deliverables of Geometrical Inspection Report are as follows;

○The Geometrical Inspection Reports – A fully completed geometrical inspection form(GIF)

○Updated Geometrical Inspection (part 3times data)

○Inventory photographs

The Bridge Geometrical Inspection Report shall be prepared by the bridge inspector. The report shall be checked and reviewed in the Regional Office for completeness and accuracy prior to finalization.

When the Bridge Geometrical Inspection Report would be completed, accurate and accepted, all the data shall be stored in Special Bridge Inventory.

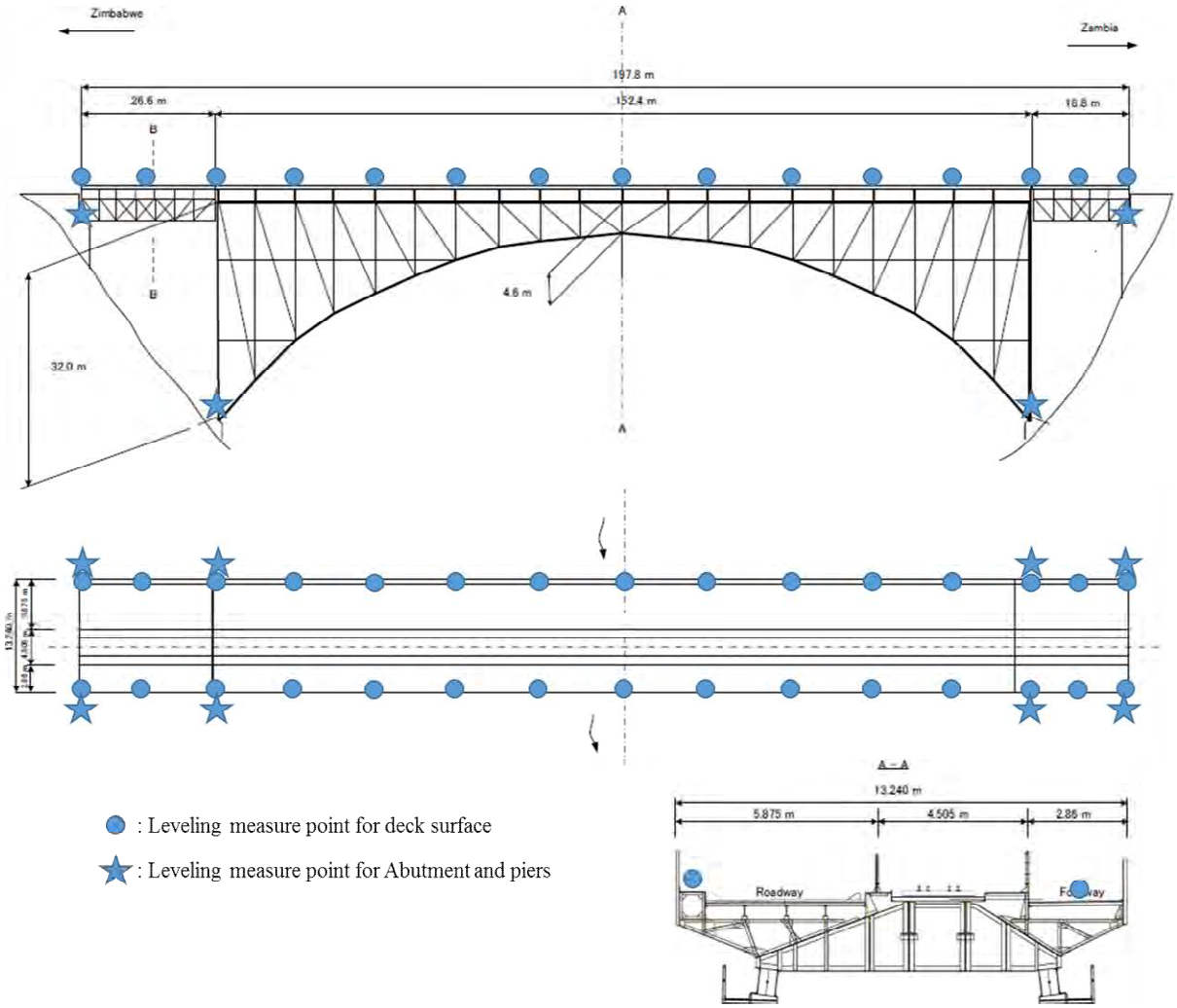


Figure 4-5-1 Geometrical Inspection:
Leveling of Abutments and longitudinal alignment of deck surface

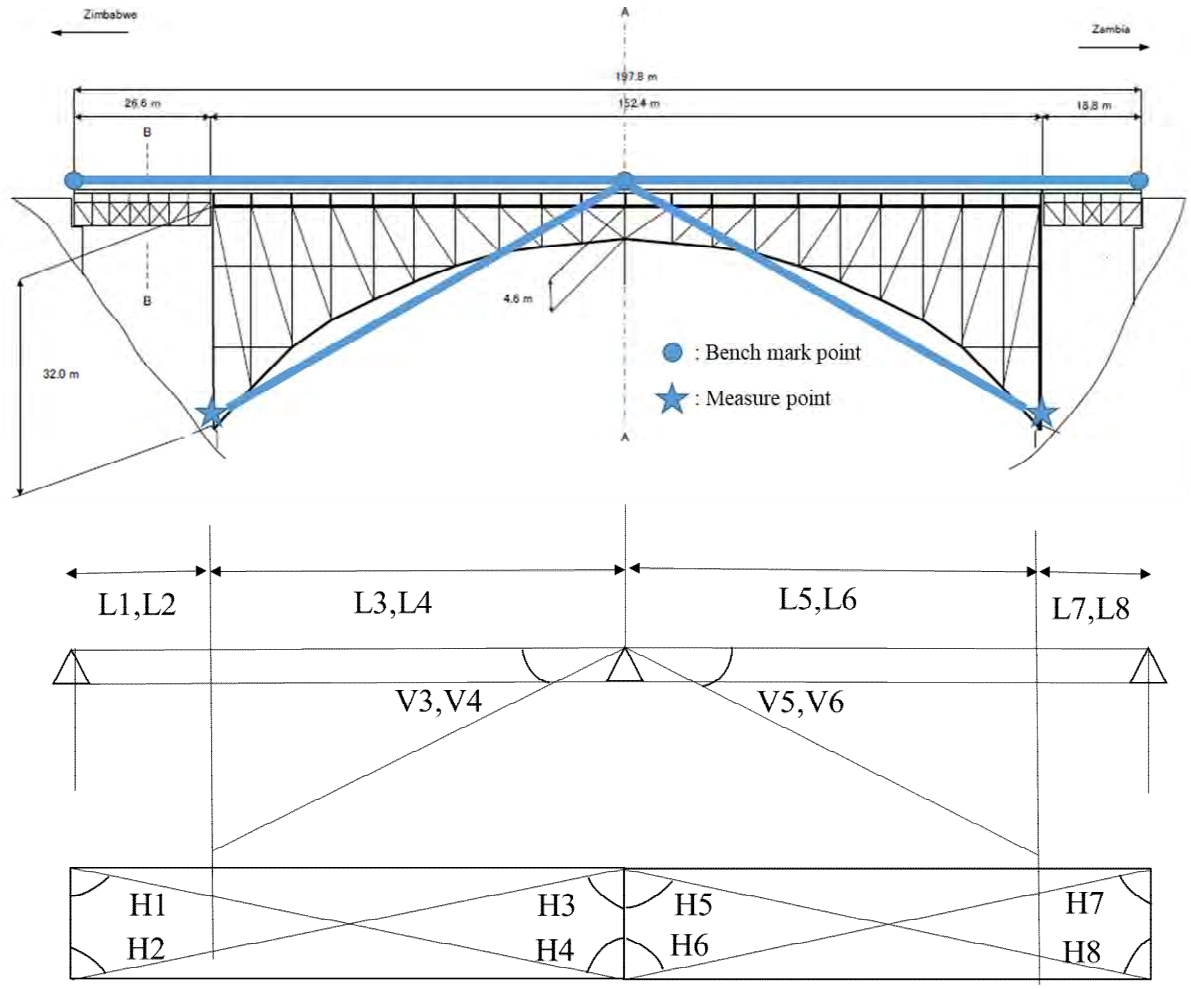
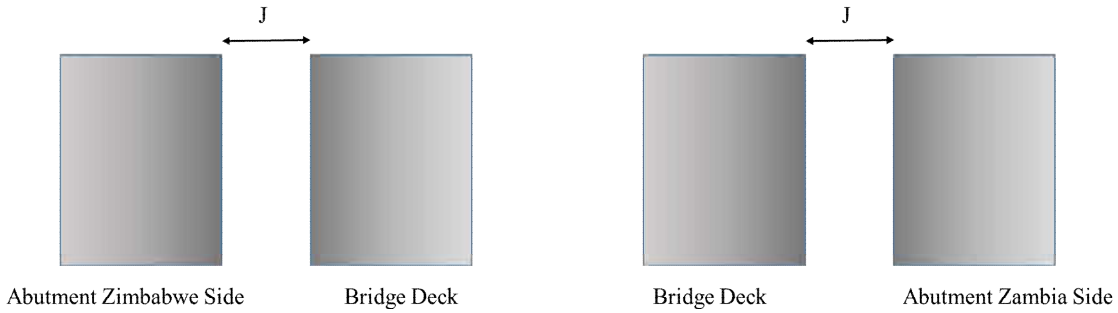


Figure 4-5-2 Geometrical Inspection:
Slope of Vertical Alignment of Arch Chord

Measure: Angle (Vertical): V3',V4', V5',V6'
Angle (Horizon):H1',H2',H3',H4', H5',H6',H7',H8'
Length: L1', L2', L3', L4', L5', L6', L7', L8'

Raise:	L1'*tanV1'	Slope: L1'/tanH1'
	L2'*tanV2'	Slope: L2'/tanH2'
	L3'*tanV3'	Slope: L3'/tanH3'
	L4'*tanV4'	Slope: L4'/tanH4'
	L5'*tanV5'	Slope: L5'/tanH5'
	L6'*tanV6'	Slope: L6'/tanH6'
	L7'*tanV7'	Slope: L7'/tanH7'
	L8'*tanV8'	Slope: L8'/tanH8'



Expansion Joint (seal)

Measure 5 selected points in each joint and average (everytime use same marking point)

Figure 4-5-3 Geometrical Inspection:
Movement of Expansion Joints

9-4-6 Emergency Inspection

9-4-6-1 Purpose

Emergency Inspection will be undertaken in response to calamities or occurrence of severe damages that may be tend to cause substantial damage to any part of the structure. This inspection is required to confirm that the bridge remain safe to commuters following a calamity or any man-made disasters and to determine the necessary work that is required to ensure the safety of the bridge and to restore the function of the bridge.

9-4-6-2 Process

There is no general process for emergency inspections as these inspections are ad-hoc inspections undertaken in difficult conditions.

9-4-6-3 Procedure

No standard procedure is required for this type of inspection.

9-4-6-4 Deliverables

The deliverable will be an Emergency Inspection Report. This will be the form appropriate for the required emergency action.

CHAPTER 9-5 Extra-dosed Bridge

9-5 Recommendations to Operation & Maintenance Manuals of Kazungula Bridge

Operation and Maintenance Manual of Kazungula Bridge was submitted 26th June 2020 The recommendations to Operation & Maintenance Manuals of Kazungula Bridge are considered as follows;

(1) Inspection Route

(2) Inspection Sheets (Inventory, Periodic and Geometrical)

(3) Rating Criteria

Each is described in more detail below.

(1) Inspection Route

In order to conduct inspections efficiently, there should be documentation showing what is to be inspected and the order in which the inspections are to be performed.

From the as-built drawings, it seemed feasible to enter the girder to inspect the cable anchorage inside the box girder. However, it was not clear from where we could access the inside of the girders. It should be mentioned in the manual where to enter the girder in order to inspect the cables and anchorage so that there will be no trouble when inspection is done. Regarding the inspection route, it is recommended to organize in what order the inspections are to be conducted and what areas to focus on during the inspections. Especially, it should be clear that where the inspectors enter from. Although there was no description regarding the pylons, the pylons are particularly important for Extra-dosed Bridge and should be defined as an area to be inspected.

Regarding the inspection of pylons and cables, it should be noted what is used for inspection depending on the height. Areas that can be reached by bridge inspection vehicles are inspected using bridge inspection vehicles, while areas that cannot be reached are inspected using drone. Moreover, anchorages are located in the box girder, so inspectors have to enter the box girder and inspect them. Inspectors must remember to turn on the lights or bridge a flashlight, as the inside of the girders cannot be inspected without lightning.

(2) Inspection Sheets (Inventory, Periodic and Geometrical)

Inspection forms should be available to conduct inventory, periodic and geometrical inspections.

An inspection sheet should be available for use in inspections so that every inspection can be performed. Operation & Maintenance Manuals of Kazungula Bridge have inspection sheets partly, but there should be an inspection sheet dedicated to Kazungula Bridge for each inspection. Therefore, it is recommended to prepare inspection sheets (Inventory, Periodic and Geometrical).

(3) Rating Criteria

Criteria are needed to determine from the inspection results whether repairs are needed or observation is sufficient.

While it is important to conduct inspections and keep inspection records, it is also very important to use those inspection records to create the criteria for determining the required response measures. Concrete, pavement and miscellaneous should be common to general bridges, but special bridge criteria should be established for items unique to Extra-dosed Bridge, such as pylons, cables and anchorages.

CHAPTER 10 BRIDGE INSPECTION USING DRONE

10-1 INTRUDUCTION

Before performing bridge inspections, the method used with the equipment should be selected based on the bridge's structure and location.

In the absence of any specific conditions, the inspection methods are the "groundwork and ladders" and "inspection paths" originally installed on the bridge.

However, in case that inspecting components in locations that cannot be reached by these methods, or in case that facilities for inspection were not originally installed, it is necessary to adopt other inspection methods.

Especially for special bridges, there are many components that cannot be reached by general inspection methods or ordinary inspection equipment, so drone inspections can be very effective in reducing costs and time.

This chapter describes the use of drones for bridge inspections and presents methods and case studies.



Groundwork, Ladder



Inspection Way

Photo 10-1 General (Simple) Inspection Methods

10-2 PURPOSE AND BENEFITS OF DRONE INSPECTION

10-2-1 General Inspection Methods

There are many types of inspection equipment, but in Zambia, there are problems where there is no equipment or where it takes a lot of money, people and time to adopt that inspection method.

Listed below are some commonly used bridges inspection methods. Here we list their types, an overview, and their problems in Zambia.

1. Lift Car

- Summary: Conduct inspections up to a height of approximately 15 meters above the ground.
- Main inspection targets: Bottom of deck slab, Girder, Substructure etc.
- Problems: Traffic control, Not available on the river and the ground-slope is large, There is a limit to the height of the bucket.




Photo 10-2 List Car

2. Bridge Inspection Vehicle (BIV)

- Summary: BIV is placed on the bridge surface, and the arm is extended to inspect under the slab.
- Main inspection targets: Bottom of deck slab, Girder, Substructure etc.
- Problems: Arm cannot reach under high box girders (BIV owned by RDA is smaller than the photo), Space for vehicles is needed on the bridge surface, Expensive and few units owned, etc.




Photo 10-3 BIV

3. Floating Boat

- Summary: Conduct inspection of the girder from the river under the bridge.
- Main inspection targets: Bottom of deck slab, Girder, Sub-str. etc.
- Problems: It is difficult when the river flow is fast. No inspect on high points. And, An anchor is needed to secure the float, which is difficult when the river is deep. Animals such as crocodiles are also dangerous.




Photo 10-4 Floating Boat

4. Special High-altitude Technology

- Summary: A technician using a rope will conduct a survey of difficult-to-inspect areas.
- Main inspection targets: Trusses, high piers, and other locations where it is difficult to install inspection equipment.
- Problems: Only technicians with this skill can inspect it.



Photo 10-5 Special High-altitude Technology

5. Suspended Scaffolding

- Summary: A scaffold is set up under the girder to conduct an inspection under the slab.
- Main inspection targets: Bottom of deck slab, Girder, etc.
- Problems: It will take time and money to install this. Especially for long bridges, the number of inspection days is not balanced by the preparation of time.



Photo 10-6 Suspended Scaffolding

In many cases, inspection of special bridge towers, high piers, and large rivers cannot be approached with ordinary inspection equipment. If facilities for inspection are already installed on the bridge, can be used. However, there is a wide range with no inspection facilities are available. Installing new normal inspection equipment and conducting inspections would require a huge amount of cost, time, and human resources.

The use of drones has attracted attention and is being utilized as an inspection equipment and method to solve these problems.



Cable-stayed bridge (Mozambique)



Tuss bridge (Japan)

Photo 10-7 Example of an inspection facility installed on a special bridge

10-2-2 Bridges and parts where drone inspections are efficient

When general bridge inspection methods are not applicable, the use of drones offers the following advantages

1. Drones can be used to approach areas that are difficult to inspect by workers. In addition, the work is not affected by the conditions of the terrain.
2. There is no need to spend time preparing the equipment, and the personnel and time required for inspection can be greatly reduced. In addition, the cost can be reduced compared to other inspection equipment.

In Japan, conventional bridge inspections are based on direct visual confirmation. However, MLIT (The Ministry of Land, Infrastructure, Transport and Tourism) has approved the use of drones for from 2019 to improve the efficiency of inspection work and the development of drone technology in recent years. Currently, many bridge inspections using drones are being carried out.



Photo 10-8 Status of bridge inspection by drone (Japan)

The figure below shows the selection flow of general bridge inspection methods and the scope of effective inspections by drones.

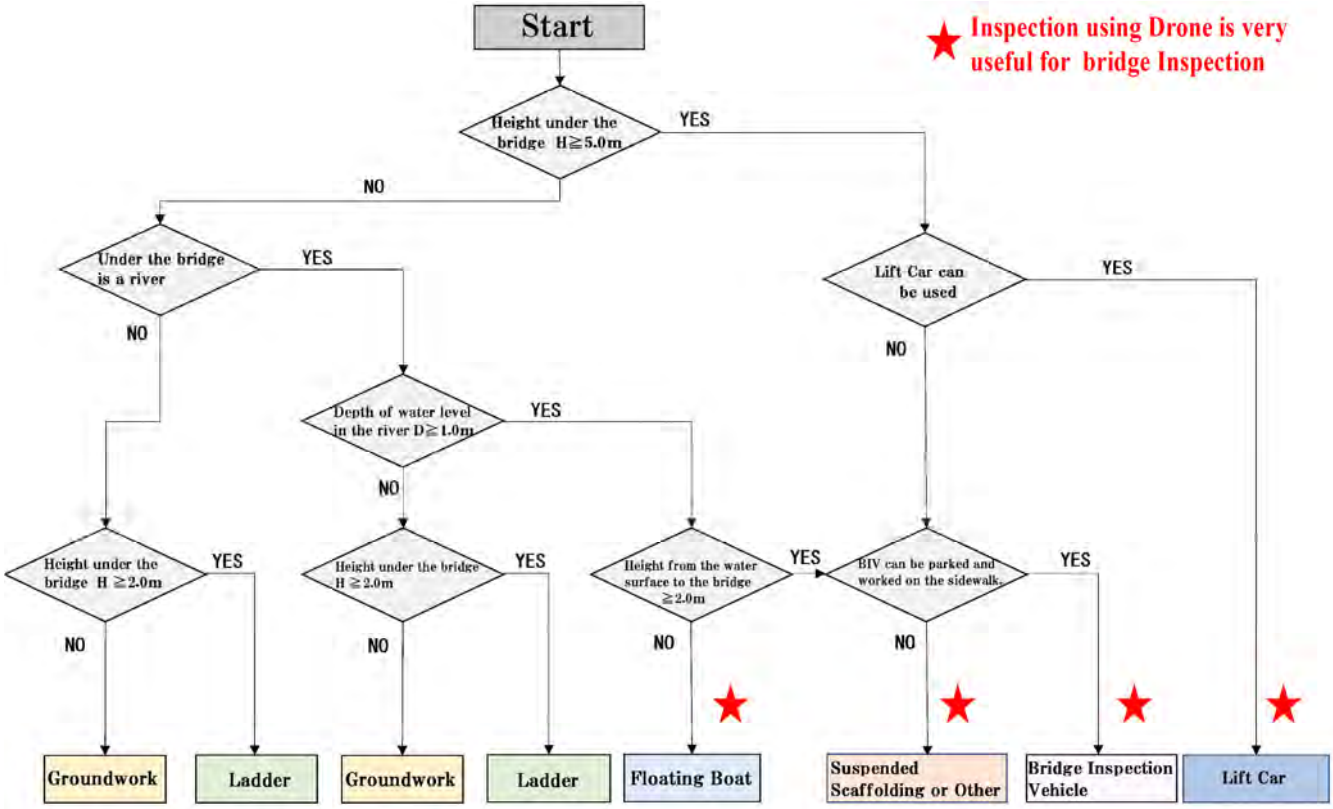


Figure 10-1 General selection flow of inspection methods

10-3 PROCEDURE

10-3-1 Contents of drone inspection results

The results of the bridge inspection by drone will be collected mainly in the form of "images" and "video". Prior to the drone inspection, the location and number of the member to be inspected will be ascertained. Based on the results of the "image" and "video", the engineer will verify the damage to the subject component and prepare a "damage sketch". If further investigation is required or an emergency response is needed, a proximity survey will be conducted. In such cases, a reasonable amount of scaffolding and other equipment is required for the proximity survey, but the use of drones keeps the cost to the minimum necessary.

10-3-2 Flow of analysis of drone inspection results

The following is a flowchart of a drone-based bridge inspection.

- STEP1: Images shooting by drone

  Use drones to acquire video and photos

- STEP2: Checking of all images by bridge engineers

  Check all retrieved Image data

- STEP3: Extraction of Interest-Points

  Detection of Interest Points (damaged or abnormal areas) by engineers

- STEP4: Interest-Point analysis and damage evaluation

  Analysis and evaluation of the type, scope, and level of damage

- STEP5: Report on inspection results



Figure 10-2 Flow of analysis of drone inspection results

10-3-3 Type of Drone

Different types of drones shall be deployed depending on the type of operation to be conducted. Both fixed and rotor types of drones are suitable for area mapping. The former uses (Bridge Inspection) its wings that generate lift from the aircraft's airspeed, while the latter is a propeller-based system having a set of rotor blades attached to the drone.



Fixed Type　　Rotor Type

Photo 10-9 Type of Drones

For taking tight shot photographs and video recordings, only the rotor type shall be used. The required drone maneuverings to obtain the necessary images makes fixed wings unfit to perform the task.

Care should also be made when inspecting steel bridges as the amount of steel material can affect the internal compass of the UAV. In these situations, manual or assisted manual flight mode should be used. Because of the effect on the internal compass of steel in bridges and weak GPS signals under the deck of bridges, inspection of these areas is not recommended.

10-3-4 Permits Required for Using Drone

In order to conduct drone inspections in Zambia, it is necessary to obtain and comply with various regulations for conducting drone inspections. Below are the procedures required for drone inspections at the Chirundu Bridge and Victoria Falls Bridge.

When using a drone to conduct bridge inspections, the necessary procedures must be followed with the agencies involved with the bridges.

[Procedures required for drone inspections of the Chirundu and Victoria Falls bridges (for reference)]

- Zambia Revenue Authority (ZRA) import and export requirements for Inspection Equipment (Drones/Survey Equipment) Note: When importing Drone
- Zambia Civil Aviation Authority flying permit
- Zambia Air Force permit
- Zimbabwe Air Force flying permit

10-3-5 Inspection Preparation

For bridge inspections using drones, prepare the following;

- Drone (main unit)
- Spare drone, propeller and battery
- Operation tablet
- Inspection record format
- Permit for inspection and operation by drone

10-3-6 Points of Interest Survey

Close-up aerial video at of accessible areas of the bridge shall be conducted. The colored arrows in Figures represent the planned flight lines. Given the dimensions of the structure, the Drone must be manned by 2 persons: one to control the Drone and another to monitor the camera view. These measures are to ensure the safety of the Drone and at the same time maintain quality of the video. In addition to this, assuming there's enough power, the Drone shall make its way back in the opposite direction to obtain more viewpoints.

The video photography shall, as much as possible, be taken continuously in consideration of battery safety limitations, these outputs shall be later arranged according to the management sections as previously described. Still photographs shall then be extracted from the acquired video.

Close-up video shall be taken at an approximate distance of 5 meters between the Drone and the structure as conditions would allow. While camera angles shall, as much as possible, accommodate the client requirements, these are still bound by hardware and safety limitations.

Below is an example of a flight route and component inspection at Special Bridge.

[Sample-1] Chirundu Bridge



Bridge Information;

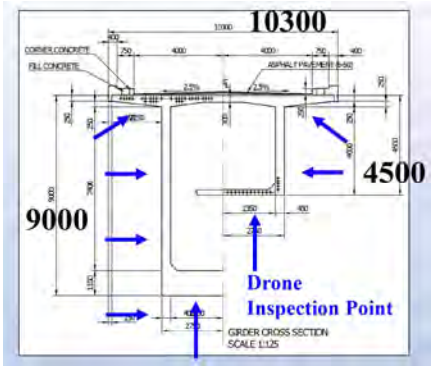
- Opened in 2002 with the financial aid of Japan
- Bridge Length:400.0m, Width:10.3m
- 3span-continuous PC Box Girder

Features

- The height of the girders varies from 4.5 to 9.0 m.
- The height of the piers located on the river are also high, exceeding about more than 10 meters.

Scope of drone inspection

- Use of drone to inspect the following parts. Side and bottom of girder, Overhang of slab, Pier, Bearing etc.



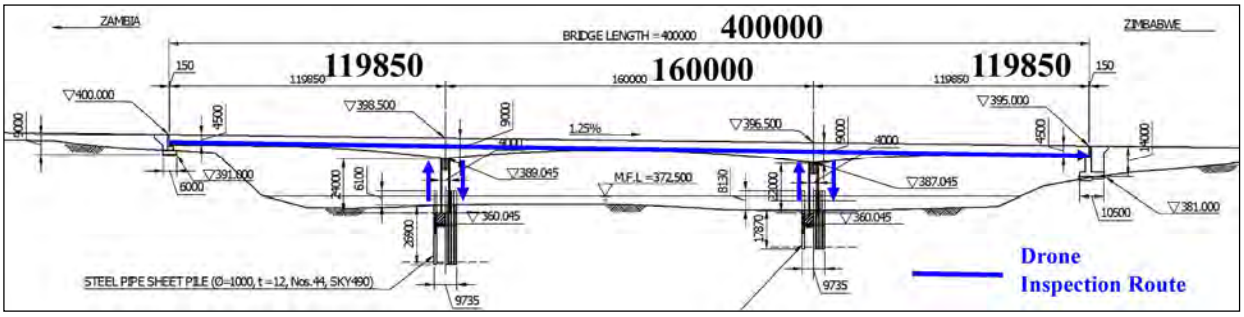


Figure 10-3 Points of Interest Survey and Inspection Route of Drone (Chirundu BRG)[Reference]

[Sample-2] Victoria Falls Bridge



Bridge Information;

- Opened in 1905
- Bridge Length:198.2m
- Steel Arch Bridge
- Multi-purpose (Road and Rail)

Features

- It is an arch bridge, and the height from the pier's bearing to the bridge surface is very high.
- There are many steel members in the bridge, and visual inspection method is very time consuming.

Scope of drone inspection

- Use of drone to inspect the following damages.

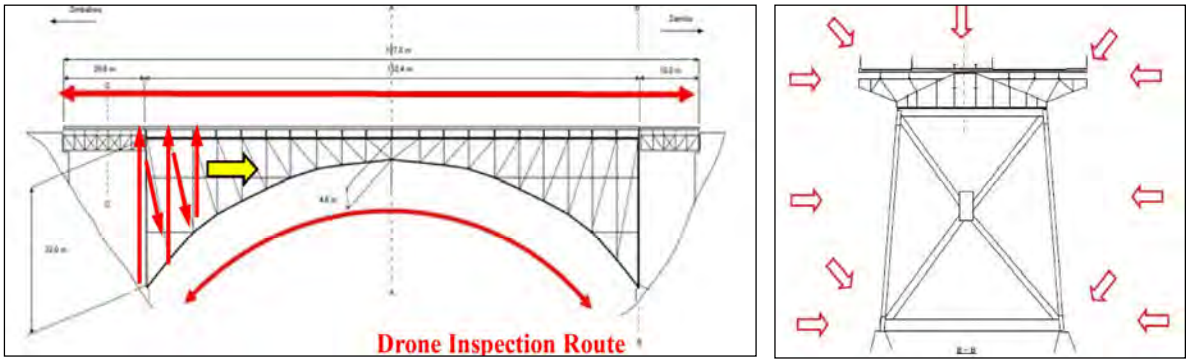


Figure 10-4 Points of Interest Survey and Inspection Route of Drone

(Victoria Falls Bridge) [Reference]

10-3-7 Safety Distance of Drone

When a certain quality in the report of the inspection by the drone is required, the skill of the photographer must be kept at a certain level. The appropriate distance between drone and object is about 5 m when shooting. It is to avoid drone colliding with the bridge when gust of wind is blowing. If the distance is far from the bridge, the accuracy of the picture will be lower. It requires considerable skill to always keep the distance of 5 m under the wind blowing condition.

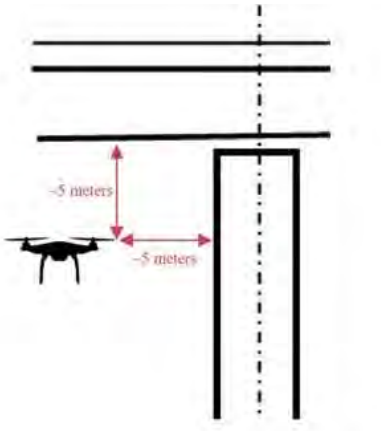


Figure 10-5 Safety Distance of Drone

10-3-8 Sample of Drone Inspection (Reference)

The results of bridge inspections using a drone (conducted on OJT of this project) will be

included as a sample.

[Sample-1] Chirundu Bridge

The videos and photos acquired at Chirundu Bridge were reviewed for damages. Damages mainly consisted of isolated limes and cracks on the concrete surface.

And, in the field check conducted in advance, slight settlement of the bridge surface was observed between P2 and A2 (Zimbabwe Side). The Gap of the abutment (A2) on the Zimbabwe side is larger in the upper part. (Upstream side.) This may indicate that the surface of the bridge is slightly settled between P2 and A2.

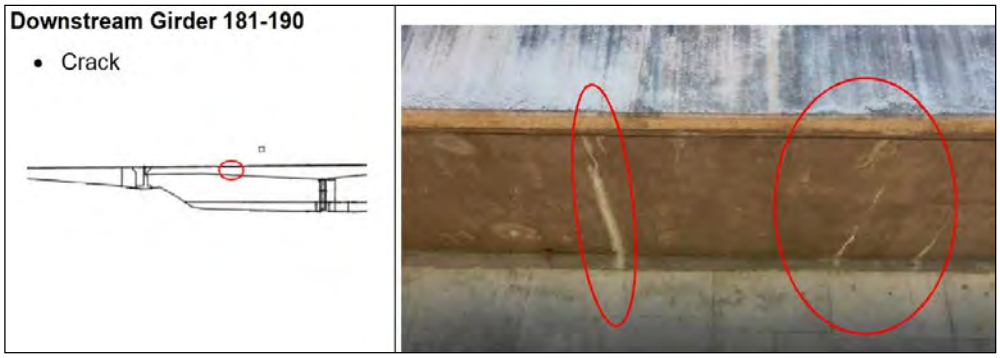


Photo 10-10 Isolated limes at Overhang of Slab

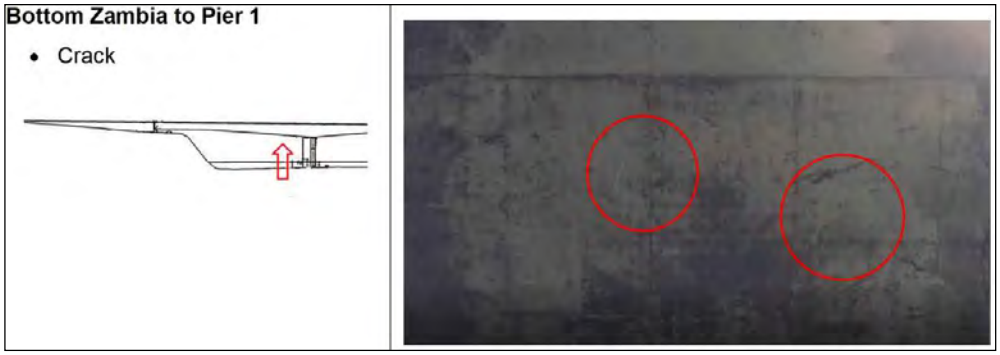


Photo 10-11 Crack at Bottom Deck

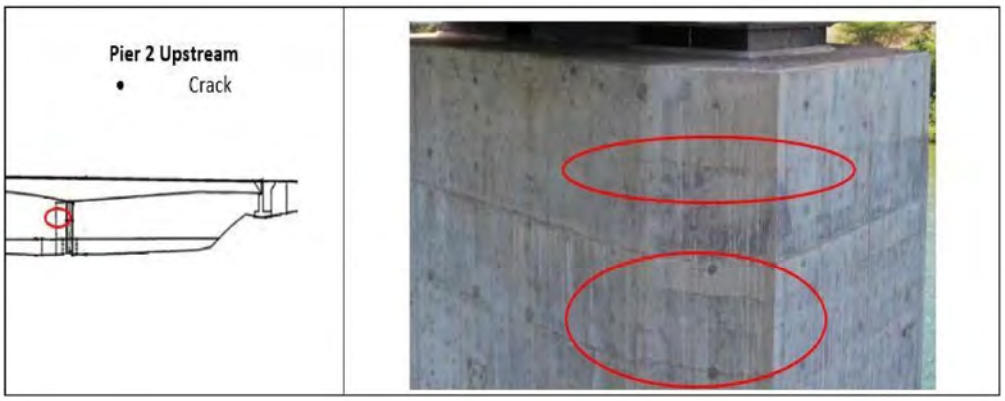


Photo 10-12 Crack at Pier P2 on upstream side

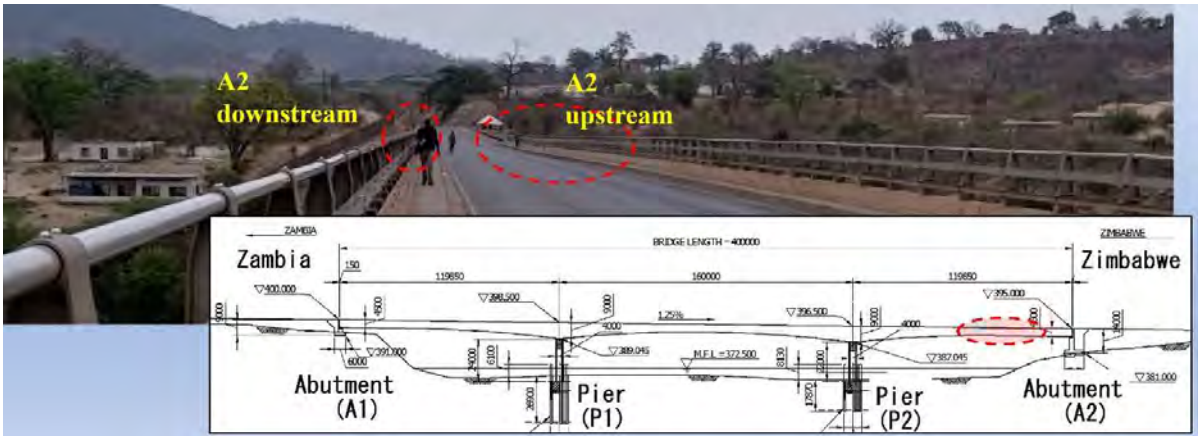


Photo 10-13 Sagging of the bridge surface (Between P2 and A2)



Photo 10-13 Gap of A2 on upstream side

[Sample-2] Victoria Falls Bridge

The videos and photos acquired at Victoria Falls Bridge were reviewed for damages. Damages mainly consisted of:

- corrosion
- Missing bolt
- Buckling of steel member

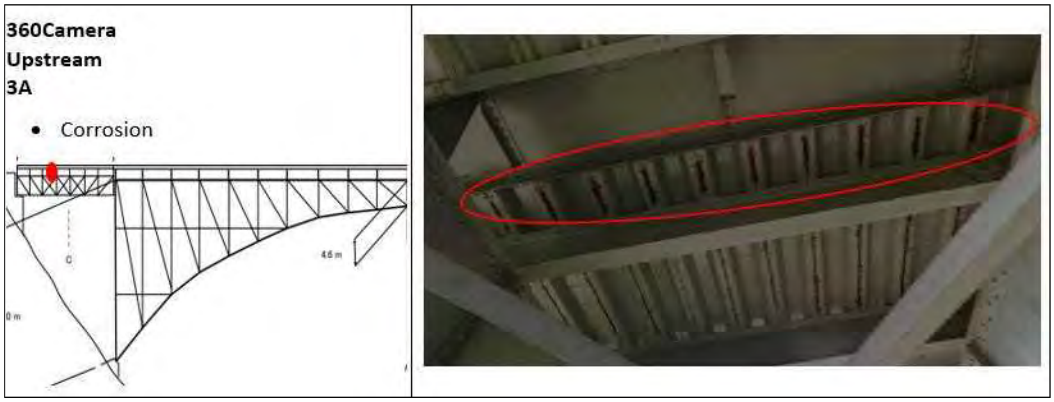


Photo 10-14 corrosion at bottom deck

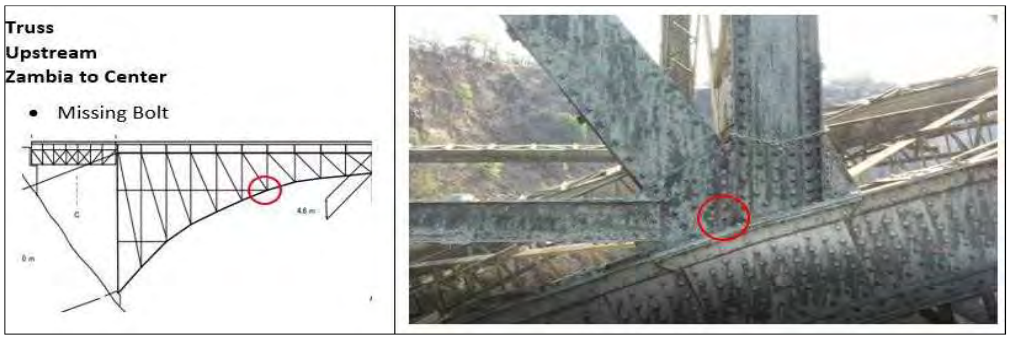


Photo 10-15 Mission Bolt



Photo 10-16 Buckling of Steel Member

10-3-9 Examples of another Drone uses

The following are examples of useful applications of drones, such as bridge inspections. The use of these drone results is not necessarily mandatory, but depending on their use, they can be very informative.

1) 3D Model of Victoria Falls Bridge

Pix4d software was used to create a 3D model in the form of a point cloud of Victoria Falls Bridge from drone imagery. A point cloud is a set of data points in space where each point has 3D coordinates and color. It can be used to visualize the bridge and make measurements. The Victoria Falls Bridge point cloud can be viewed and measured using Cloud Compare, an open-source software for visualizing and measuring point clouds. The software can be downloaded from the following link: https://www.cloudcompare.org/ . The point cloud of Victoria Falls Bridge is shown in Figure10-6 .

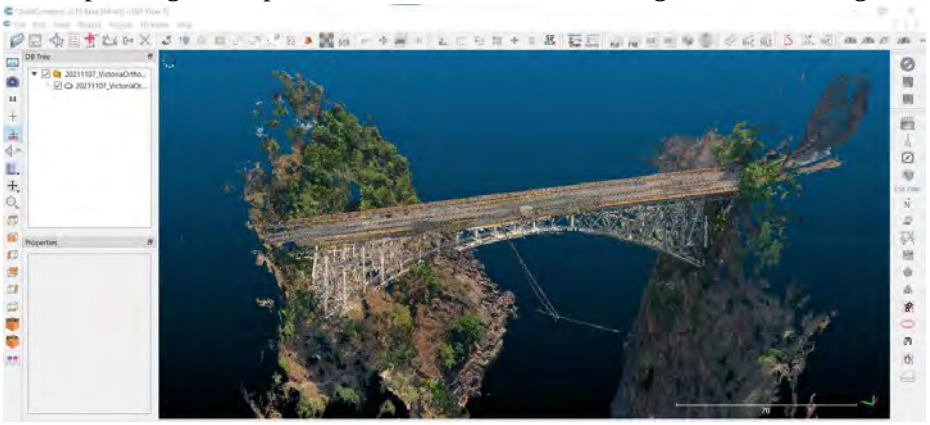


Figure 10-6 Point Cloud of Victoria Falls Bridge viewed using Cloud Compare software

2) Raw 360 image of an interior section of bridge

The interior areas of the bridge under the road deck were inspected using 360 camera since it was difficult to safely fly drones in these enclosed spaces. The free software to view the 360 camera outputs of Victoria Falls Bridge that was used by the drone team is Render stuff. It can be accessed through the following link: https://renderstuff.com/tools/360-panorama-web-viewer/. Photo 10-17 shows how the interior areas of Victoria Falls Bridge were captured by 360 Camera. Photo 10-18 shows a raw 360 image of an interior section of the bridge while Figure 3.7 shows the rendered image which can be panned and zoomed using Render stuff application. The inspection methods of the different sections of the bridge are summarized in Table 10-1.

Table 10-1 Inspection Methods for Interior and Exterior Sections of Victoria Falls Bridge

Sections of Victoria Bridge	Inspection Method
Side Truss Inspection	Drone
Bottom Truss Inspection	Drone
Top Road Deck	Drone
Bottom Road Deck and Interior Trusses (accessed from gangways under the road deck)	360 Camera
Interior Trusses (accessed from gangways along the arch of the bridge)	360 Camera



Photo 10-17 Interior areas of bridge capture using 360 camera mounted on range pole



Photo 10-18 Raw 360 image of an interior section of bridge

APPENDIX-A INSPECTION FORMS

FORM1: INVENTORY INSPECTION FORM
FORM2: PERIODIC INSPECTION FORM

LOCATION

	Bridge ID	
	Bridge Name	
	Road Name	
	Road ID	
	Location	
A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	

DESIGN LOAD

Available?	Yes	
	No	
If yes, insert as:		

BRIDGE DESCRIPTION

Type of Bridge	Simply spported
Superstructure	
Substructure	
Foundation	

DESIGN STANDARD

Available?	Yes	
	No	
If yes, insert as:		

Province	
Rever Name	

BRIDGE GEOMETRY

Bridge length, (m)		
Bridge width, (m)		
Number of lanes		
Number of spans		
Width of carriageway, (m)		
Width of island(s), (m)		
Width of shoulder, (m)	Left	
	Right	
Sidewalk width, (m)	Left	
	Right	

TERRAIN CROSSED

River or waterway (fresh water)	
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	

WING WALL TYPE	**L**	**R**
Solid wall		
Protected slope		
Other		
None		

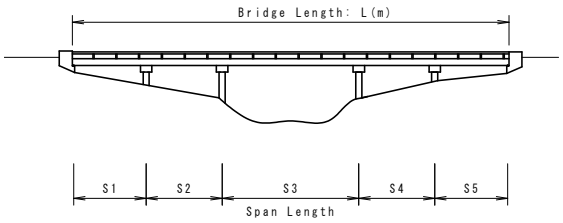
WING WALL MATERIAL	**L**	**R**
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

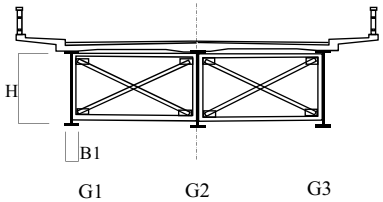
WING WALL FOUNDATION TYPE	**L**	**R**
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS





Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S		
	H		
	B1		
S2	S		
	H		
	B1		
S3	S		
	H		
	B1		
S4	S		
	H		
	B1		
S5	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
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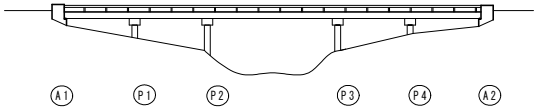
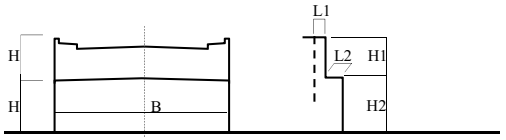
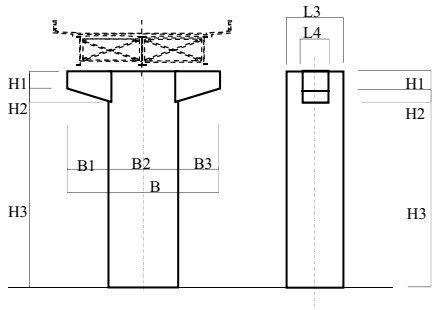
	S		
	H		
	B1		

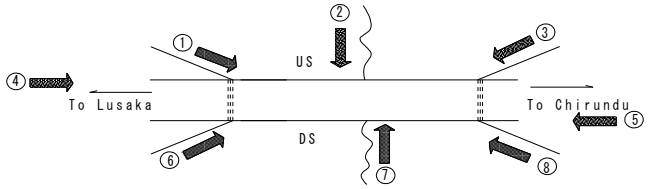






Abutment and Pier Measurement			
Height and Width			
No.	Component	L (m)	Remarks
A1	H1		
	H2		
	B		
	L1		
	L2		
P1	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
P2	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
P3	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
P4	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
A2	H1		
	H2		
	B		
	L1		
	L2		

【Photograph】



PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	
Total Number of Span	
Total Number of Abutment	
Total Number of Pier	

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION

Full conmplete inspection		
Partial inspection only:		
	BIV not available	
	Other reason	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPAN No.	
(one set of forms foe each pier)	

Bridge ID

Bridge NAME

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Timber		Decay/Splitting/Cracking					
		Disconnection					
MAIN MEMBER(GIRDER)							
Concrete Girder		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
Steel Girder/		Corrosion					
		Cracking					
		Deformation/Buckling					
		Abnormal vibration					
		Loose connection					
		Paint peel off					
		Missing element					
Bailey Demount-able		Corrosion					
		Loose connection					
		Deformation/Buckling					
Masonry Arch		Fretting/Abrasion					
		Cracking					
		Material displacement/loss					
		Bulging					
Timber Beam		Decay/Splitting/Cracking					
		Disconnection					
Substructure							
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier		Cracking					
		Spalling/Scaling/Disintegration					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Foundation (Steel Type)		Corrosion					
		Cracking					
		Deformation/Buckling					
		Tilt/Settlement					
		Scouring					
Overall Rating							

PERIODIC INSPECTION FORM

Steel Bridge

Bridge ID:

Bridge NAME:

Span No:

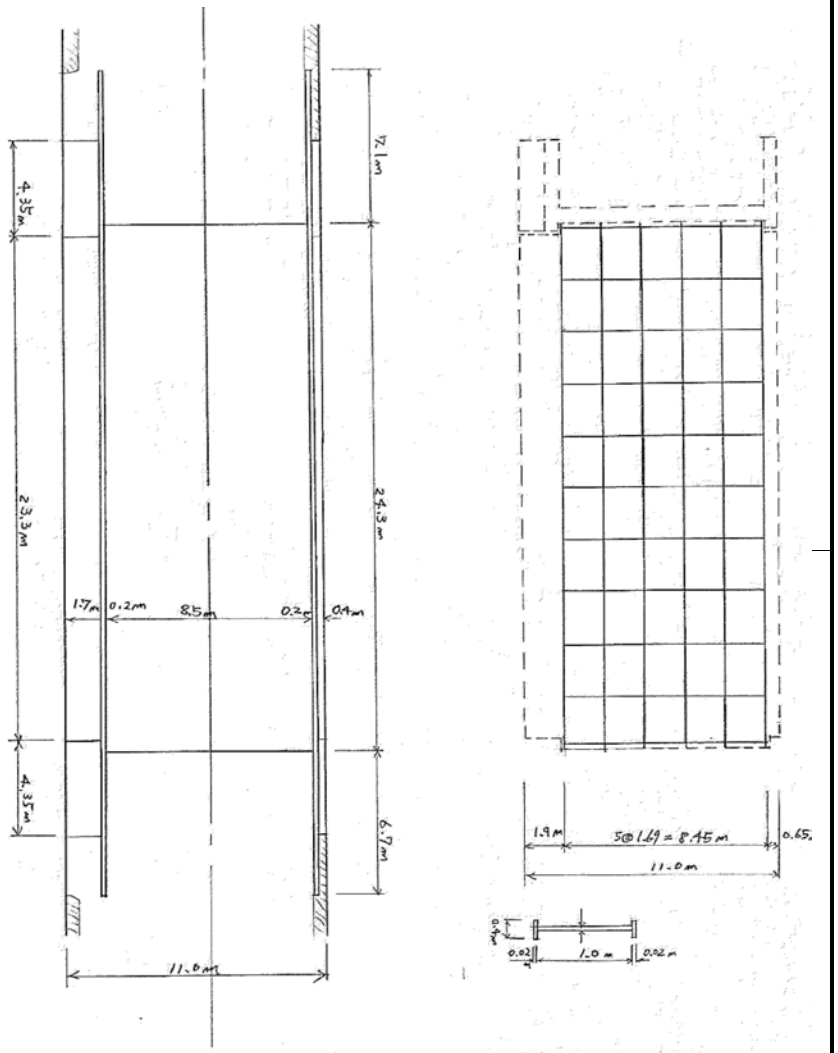
Conponent	Defect Found Type	Rating Good	Fair	Poor	Bad	Comment
Concrete Deck	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Steel Girder	Corrosion					
	Cracking					
	Deformation/Buckling					
	Abnormal vibration					
	Loose connection					
	Paint peel off					
	Missing element					
Abutment	Cracking					
	Spalling/scalling/disintegration					
	Rebar exposure/corrosion					
	Delamination					
	Honeycomb					
	Tilt/Settlement					
Pier	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Waterway	Flood debris accumulation					
	Siltation					
	Vegetation growth					
Bearing(Steel)	Corrosion					
	Loose connection					
	Abnormal Displacement					
	Paint deterioration					
	Bed (support) damage					
Bearing(Rubber)	Bulging					
	Abnormal displacement					
	Bed (support) damage					
Foundation(Concrete)	Cracking					
	Spalling,Scaling,Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
Slope Protection	Damage on containing wire					
	Bank erosion					
	Slope erosion					
Wing Wall	Cracking					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Bridge Approach	Depression					
Expansion Joint(Steel)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Displacement					
	Cracking					
Expansion Joint(Rubber)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Rupture					
Expansion Joint(Asphalt)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Deteriotated sealant					
Railing(Steel)	Corrosion					
	Loose connection					
	Impact/Accident Damage					
	Paint peel off					
Railing(Concrete)	Corrosion					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Asphalt wearing surface	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					

【Damage Drawing】

Bridge ID:		Bridge NAME:	

Span No:

Bridge Number		Span		

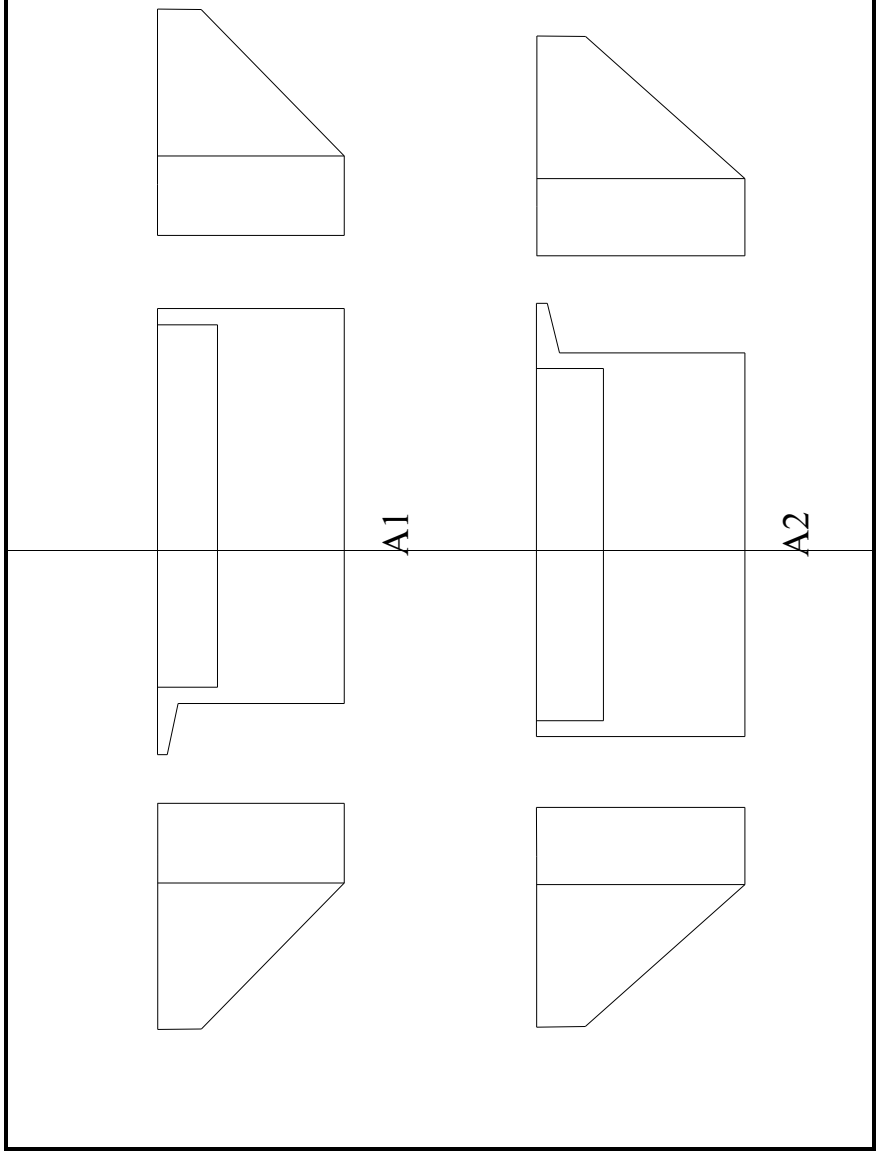


【Damage Drawing】

Bridge ID:		Bridge NAME:	

Span No:

Bridge Number		Span		



【Photograph】

Bridge ID:		Bridge NAME:	

Photo Number		Span		Conponent Name		Type of Damage	
Photograph			Location Map				Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph			Location Map				Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph			Location Map				Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph			Location Map				Comment

APPENDIX-A-1-1

INVENTORY INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	
Road Name	
Road ID	
Location	

A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	

BRIDGE GEOMETRY

Bridge length, (m)		
Bridge width, (m)		
Number of lanes		
Number of spans		
Width of carriageway, (m)		
Width of island(s), (m)		
Width of shoulder, (m)	Left	
	Right	
Sidewalk width, (m)	Left	
	Right	

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	
	Insert year if known	

DESIGN LOAD

Available?	Yes	
	No	
If yes, insert as:		

DESIGN STANDARD

Available?	Yes	
	No	
If yes, insert as:		

Province	
Rever Name	

TERRAIN CROSSED

River or waterway (fresh water)	
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	✔
Bridge inspection vehicle	
Ladder	✔
Binoculars	✔
Safety Belt / Harness	✔
Geologist Hammer	✔
Oxygen meter	✔
Camera	✔
Hard Hat with Headlight	✔
Other(meter tape, safety shoes, gloves, total station)	✔ total station

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	✔
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	✔

END OF WARRANTY PERIOD

Insert year of end of warranty period	–

LIGHTING TO BRIDGE

yes or no	No

INTERVAL OF LIGHTING POLES

Left, (m)	-
Right, (m)	-

AS-BUILT DRAWING

Available?(yes, no or unknown)	yes
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	no
If yes, insert year of widening.	-
Bridge strengthened? (yes or no)	no
If yes, insert year of strengthening	–
Bridge retrofitted? (yes or no)	no
If yes, insert year of seismic retrofitting	–
Bridge lengthened? (yes or no)	no
If yes, insert year of lengthening	–

SUPERSTRUCTURE WIDENING FORM

Widened left side	-
Widened right side	-
Widened both side	-

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing berige	-
Same detail / modified material	-
Different details	-

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	-
Girder	-
Box girder	-
Slab	-
Voided slab	-
Demontable (Bailey type)	-
Truss	-
Trestle	-
Cable stayed	-
Suspension	-
Arch	-
Portal frame	-
Other structure	-

SUPERSTRUCTURE WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF PIER WIDENING

Widening original piers	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

TYPE OF ABUTMENT WIDENING

Widerning original abutments	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

PIER / ABUTMENT WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF STRENGTHENING

Main member reinforcement	-
Deck reinforcement	-
Additional piers	-
Substrucutre reinforcement	-
Other	-

TYPE OF SEISMIC RETROFIT

Sleeves to columns	-
Lateral restraints	-
Longitudinal restraints	-
Beam continuity	-
Deck continuity	-
Other	-

TYPE OF LENGTHENING

Low chainage end, original and widening	-
Low chainage ehd, widened part only	-
High chainage end, original and widening	-
High chainage end, widened part only	-

GENERAL SPAN INFORMATION

Span Number	**1**
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**2**
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**1**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**2**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	1

WING WALL TYPE	L	R
Solid wall		
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH	
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Abutment Number	2

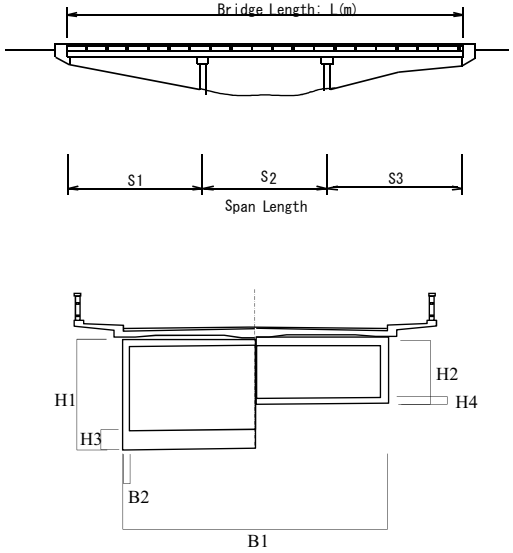
WING WALL TYPE	L	R
Solid wall		
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

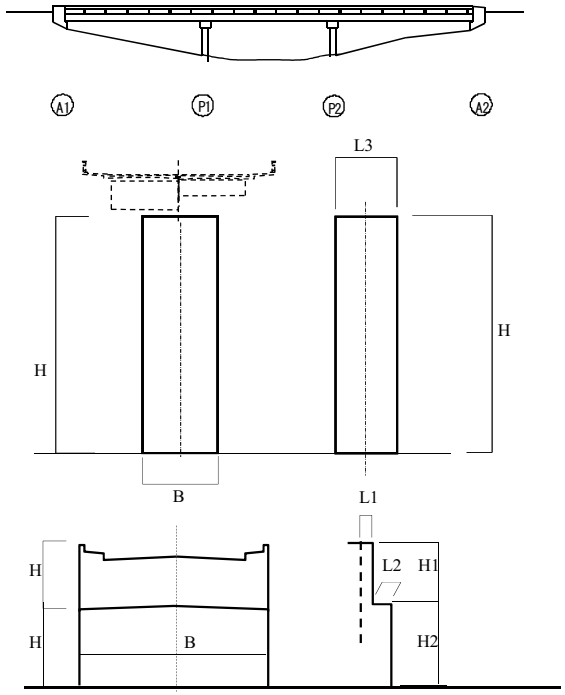
WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH	
Left, (m)	
Right, (m)	

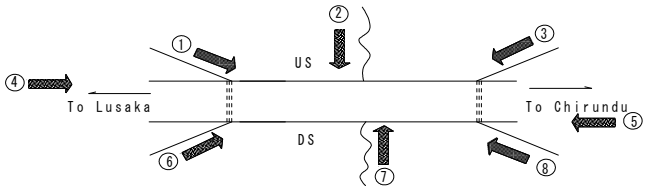
BRIDGE APPROACH COMMENTS



Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S		
	H1		
	H2		
	H3		
	H4		
	B1		
	B2		
S2	S		
	H1		
	H2		
	H3		
	H4		
	B1		
	B2		
S3	S		
	H1		
	H2		
	H3		
	H4		
	B1		
	B2		



Height and Width			
No.	Component	L (m)	Remarks
A1	H1		
	H2		
	B		
	L1		
	L2		
P1	H		
	B1		
	L3		
P2	H		
	B1		
	L3		
A2	H1		
	H2		
	B		
	L1		
	L2		

【Photograph】	
	
①	②
③	④
⑤	⑥
⑦	⑧

APPENDIX-A-1-2

PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION	
Bridge ID	
Bridge Name	Chirundu
Road Name	
Road ID	
Location	
Province	
Rever Name	

BRIDGE DESCRIPTION	
Type of Bridge	
Superstructure	
Substructure	
Foundation	
Total Number of Span	
Total Number of Abutment	
Total Number of Pier	

BRIDGE OVERALL RATING	
Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION	
Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	
BIV not available	
Other reason	

RECOMMENDED ACTION	
Routine maintenance only	
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION	
Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:	Bridge NAME:	Chirundu

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D:Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1	Bridge ID	
(one set of forms for each pier)		Bridge NAME	Chirundu

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
MAIN / SECONDARY MEMBER						
Concrete Girder	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
MAIN STRUCTURE						
Abutment (A1)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Pier (P1)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
WATERWAY						
River Water	Flood debris accumulation					
	Siltation					
	Vegetation growth					
BEARING / RESTRAINT						
Steel	Corrosion					
	Loose Connection					
	Abnormal Displacement					
	Paint Deterioration					
	Bed (support) damage					
FOUDATION						
Concrete Pile	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
RAILING /WINGWALL						
Steel (Left side)	Corrosion					
	Loose Connection					
	Impact / Accidnet Damage					
	Paint Peel Off					
Steel (Right side)	Corrosion					
	Loose Connection					
	Impact / Accidnet Damage					
	Paint Peel Off					
BRIDGE APPROACH						
Embankment	Depression					
	Slope erosion					
Expansion Joint						
Stteel	Water leakage					
	Abnormal Space/Noise					
	Difference in elevation					
	Displacement					
	Cracking					
Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
ANCHORAGE (INSIDE BOX GIRDER)						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
Overall Rating						

SPAN No.	Span 2	Bridge ID	
(one set of forms for each pier)		Bridge NAME	Chirundu

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
MAIN / SECONDARY MEMBER						
Concrete Girder	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
MAIN STRUCTURE						
Abutment (Nothing)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Pier (P2)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
WATERWAY						
River Water	Flood debris accumulation					
	Siltation					
	Vegetation growth					
BEARING / RESTRAINT						
Steel	Corrosion					
	Loose Connection					
	Abnormal Displacement					
	Paint Deterioration					
	Bed (support) damage					
FOUDATION						
Concrete Pile	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
RAILING /WINGWALL						
Steel (Left side)	Corrosion					
	Loose Connection					
	Impact / Accidnet Damage					
	Paint Peel Off					
Steel (Right side)	Corrosion					
	Loose Connection					
	Impact / Accidnet Damage					
	Paint Peel Off					
BRIDGE APPROACH						
Embankment	Depression					
	Slope erosion					
Expansion Joint						
Stteel	Water leakage					
	Abnormal Space/Noise					
	Difference in elevation					
	Displacement					
	Cracking					
Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
ANCHORAGE (INSIDE BOX GIRDER)						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
Overall Rating						

SPAN No.	Span 3

(one set of forms for each pier)

Bridge ID

Bridge NAME Chirundu

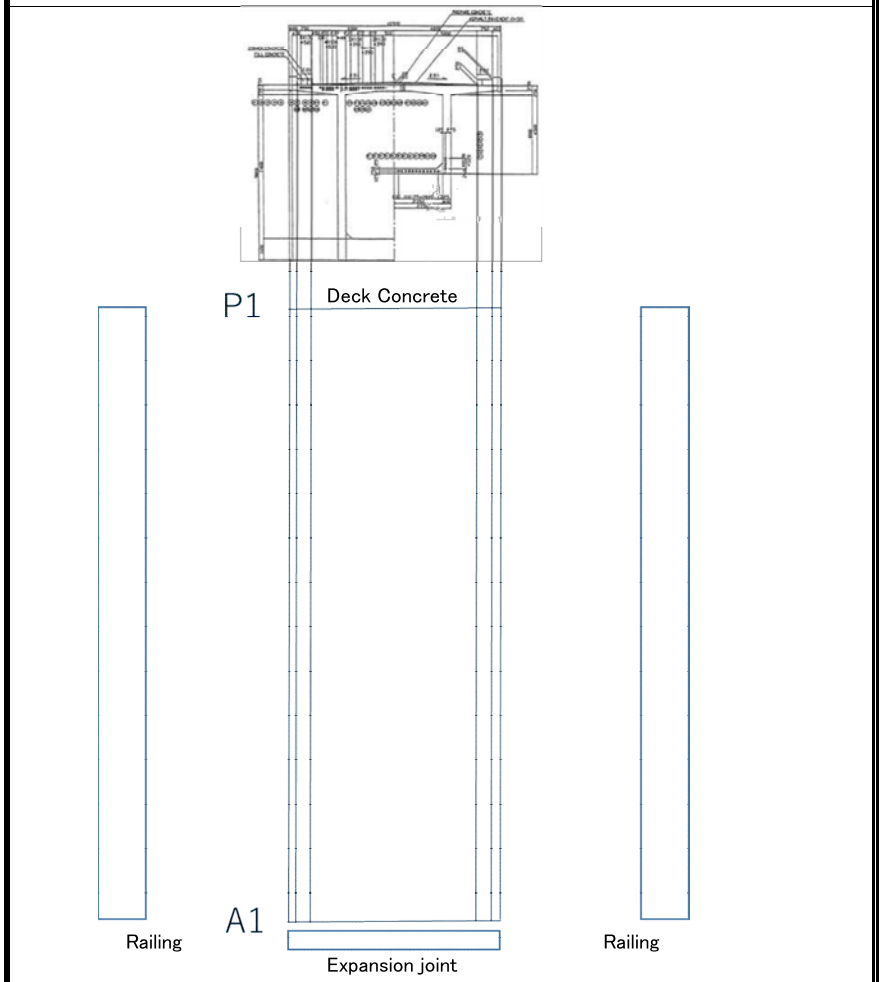
Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN / SECONDARY MEMBER							
Concrete Girder		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
MAIN STRUCTURE							
Abutment (A2)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (Nothing)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
WATERWAY							
River Water		Flood debris accumulation					
		Siltation					
		Vegetation growth					
BEARING / RESTRAINT							
Steel		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
FOUDATION							
Concrete Pile		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
RAILING /WINGWALL							
Steel (Left side)		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Steel (Right side)		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
BRIDGE APPROACH							
Embankment		Depression					
		Slope erosion					
Expansion Joint							
Stteel		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
ANCHORAGE (INSIDE BOX GIRDER)							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
Overall Rating							

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	1	

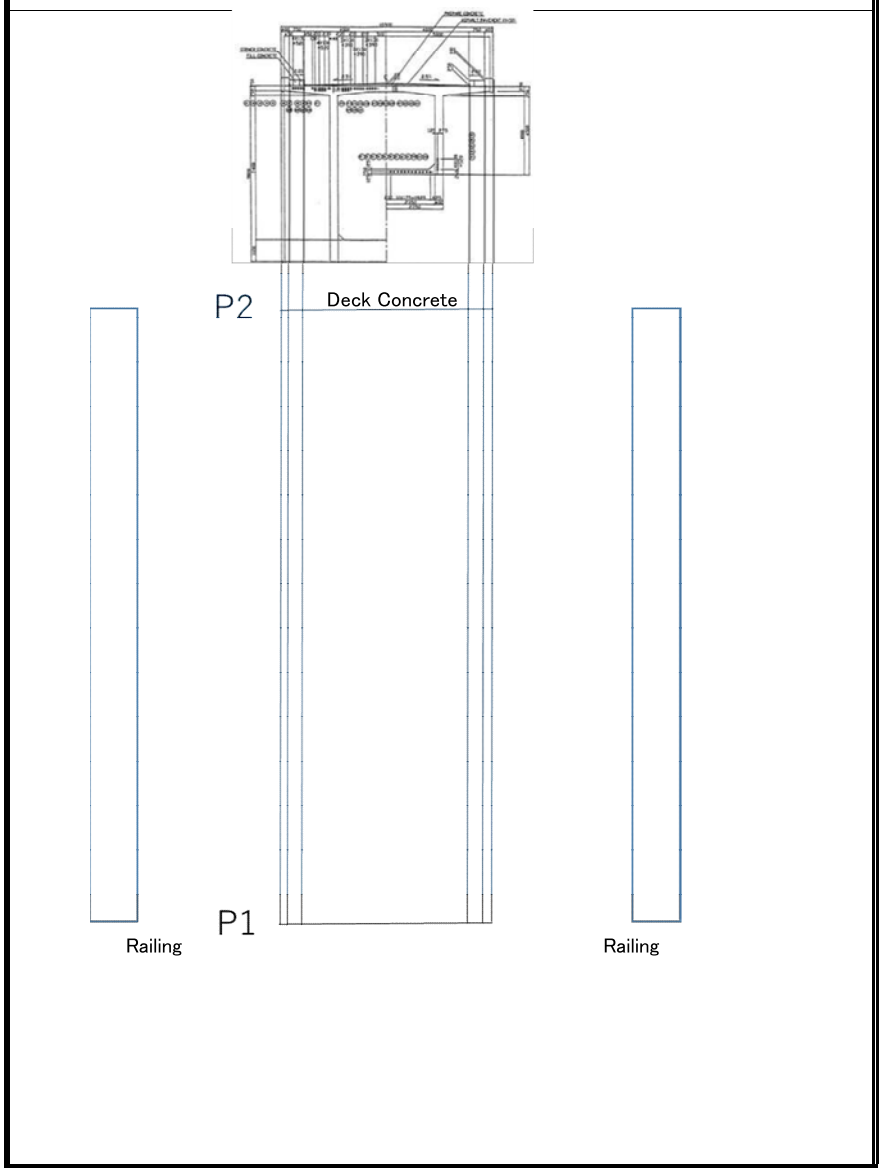


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	2

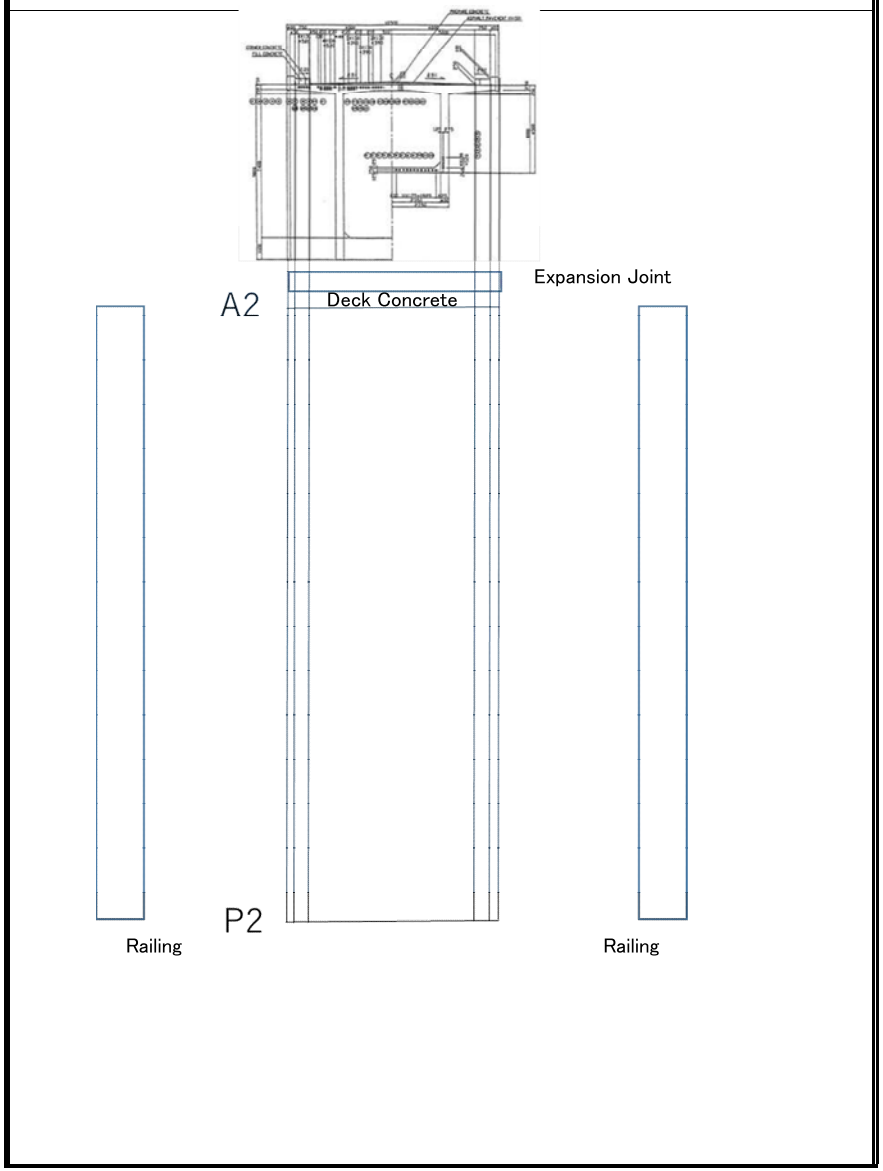


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	3

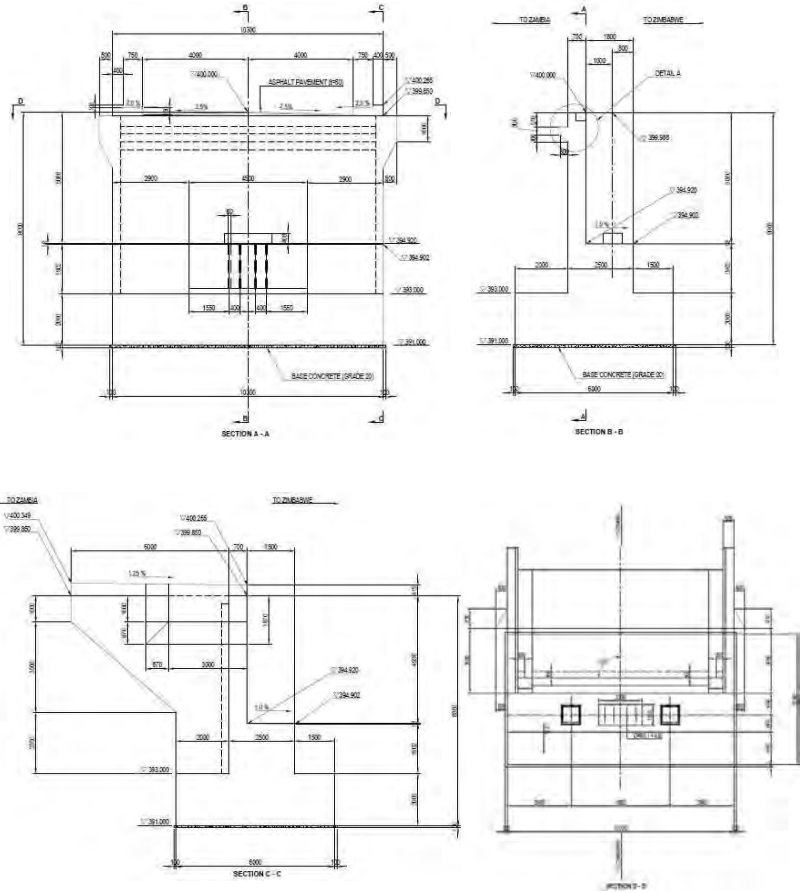


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span		



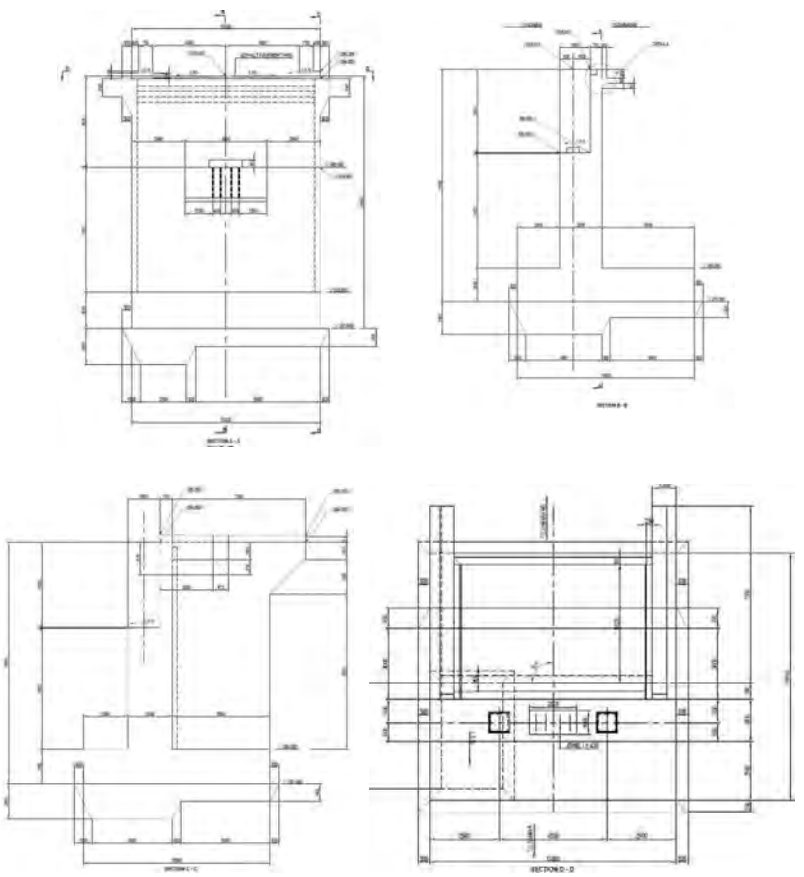
A1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span		



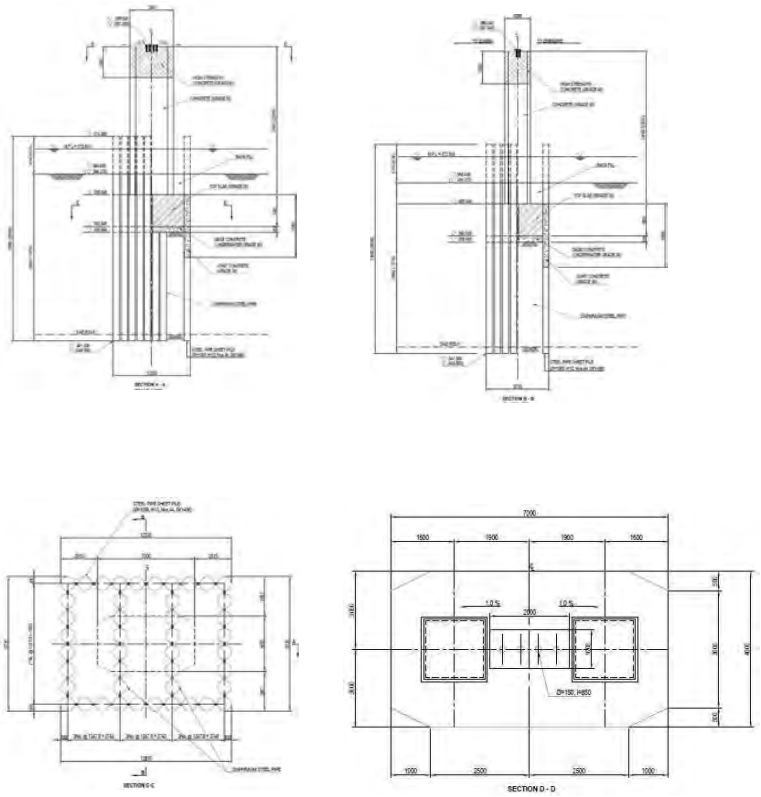
A2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span		



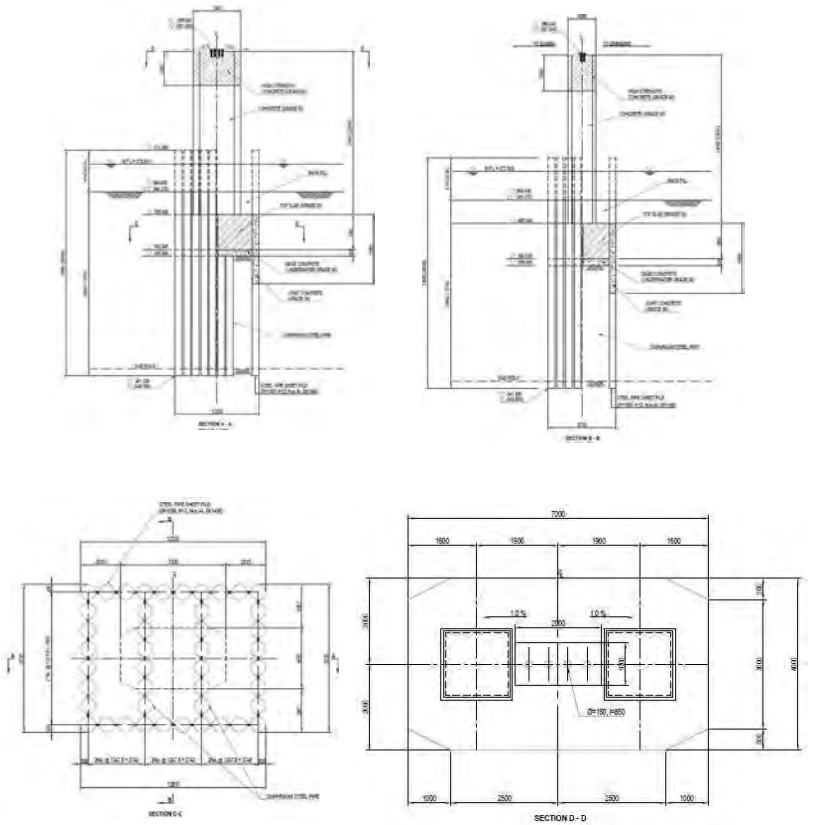
P1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span		



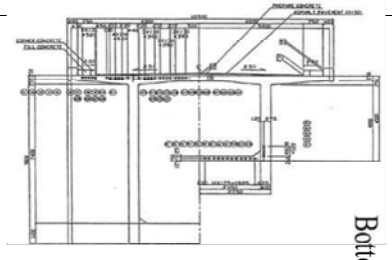
P2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	1



A1

Web (Left side)

Bottom of Box girder and side deck slab

Web (Right side)

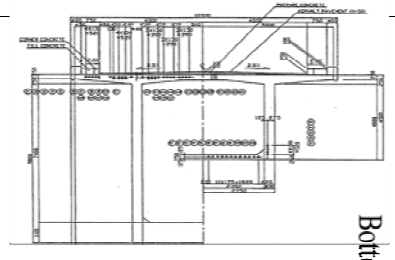
P1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	2



P1

Web (Left side)

Bottom of Box girder and side deck slab

Web (Right side)

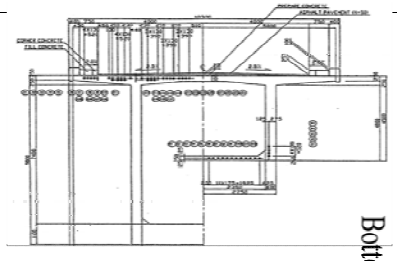
P2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	3

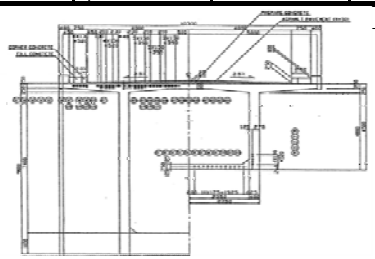


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	1

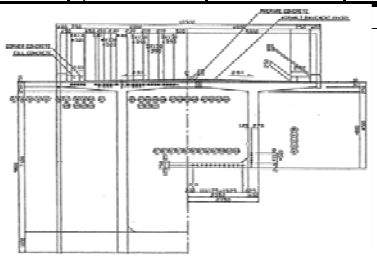


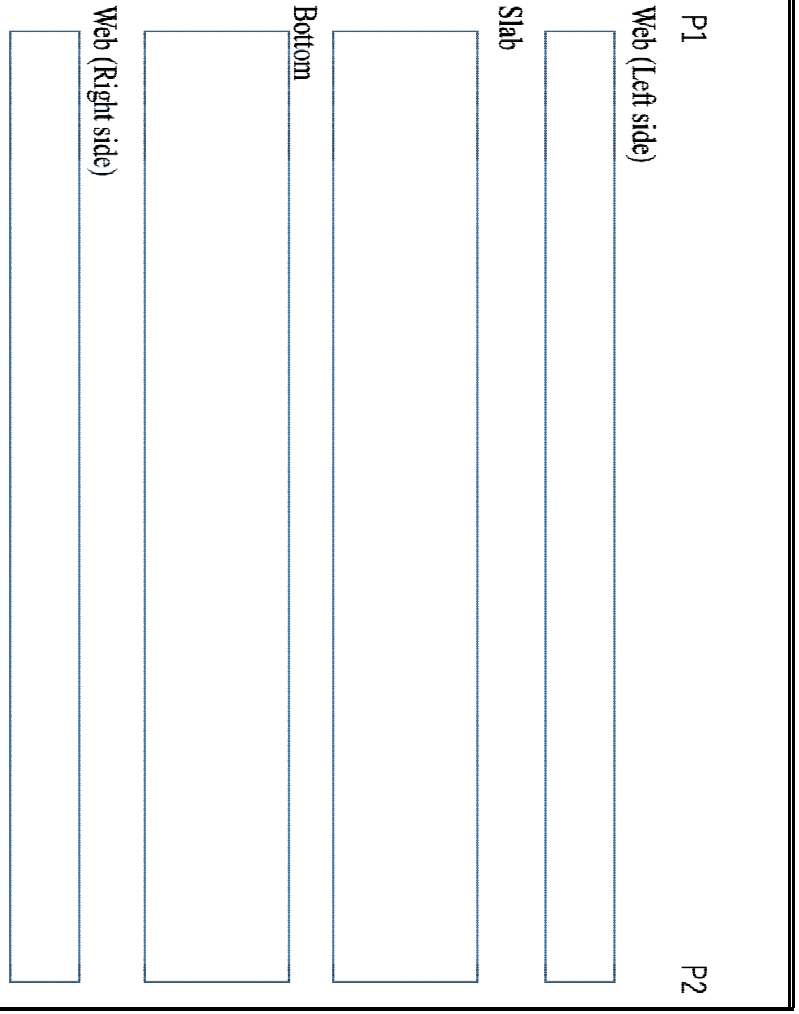
【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	2



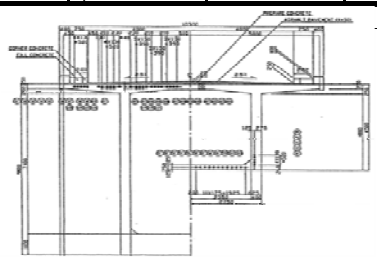


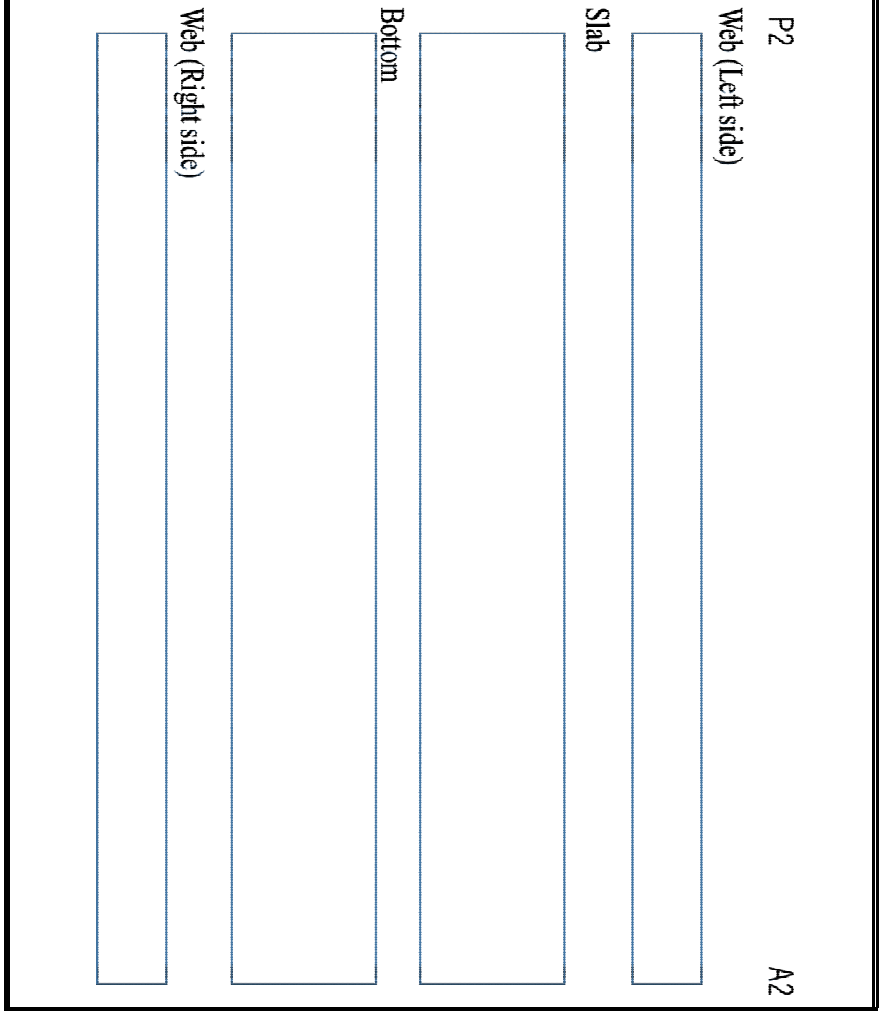
【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	3





【Photograph】

Bridge ID:		Bridge NAME:	Chirundu

Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment

APPENDIX-A-1-3

GEOMETRICAL INSPECTION FORM

GEOMETRICAL INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Chirundu
Road Name	
Road ID	
Location	

Province	Lusaka
Rever Name	Zambezi

BRIDGE INSPECTOR COMMENT

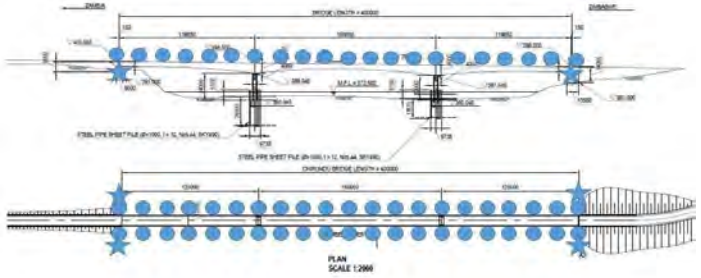
Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

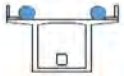
Bridge ID:		Bridge NAME:	Chirundu

Leveling

Element	Place		2021		Difference	Remark
A1		Left				
		Right				
A2		Left				
		Right				
Longitudal Alignment	1	Left				
Longitudal Alignment	2	Left				
Longitudal Alignment	3	Left				
Longitudal Alignment	4	Left				
Longitudal Alignment	5	Left				
Longitudal Alignment	6	Left				
Longitudal Alignment	7	Left				
Longitudal Alignment	8	Left				
Longitudal Alignment	9	Left				
Longitudal Alignment	10	Left				
Longitudal Alignment	11	Left				
Longitudal Alignment	12	Left				
Longitudal Alignment	13	Left				
Longitudal Alignment	14	Left				
Longitudal Alignment	15	Left				
Longitudal Alignment	16	Left				
Longitudal Alignment	17	Left				
Longitudal Alignment	18	Left				
Longitudal Alignment	19	Left				
Longitudal Alignment	20	Left				
Longitudal Alignment	21	Left				
Longitudal Alignment	1	Right				
Longitudal Alignment	2	Right				
Longitudal Alignment	3	Right				
Longitudal Alignment	4	Right				
Longitudal Alignment	5	Right				
Longitudal Alignment	6	Right				
Longitudal Alignment	7	Right				
Longitudal Alignment	8	Right				
Longitudal Alignment	9	Right				
Longitudal Alignment	10	Right				
Longitudal Alignment	11	Right				
Longitudal Alignment	12	Right				
Longitudal Alignment	13	Right				
Longitudal Alignment	14	Right				
Longitudal Alignment	15	Right				
Longitudal Alignment	16	Right				
Longitudal Alignment	17	Right				
Longitudal Alignment	18	Right				
Longitudal Alignment	19	Right				
Longitudal Alignment	20	Right				
Longitudal Alignment	21	Right				



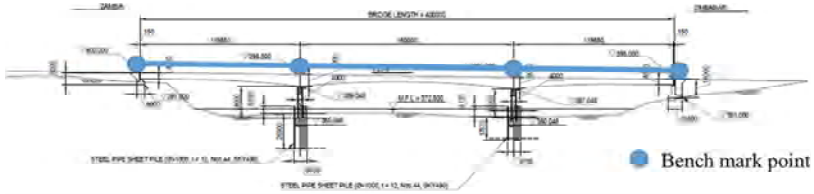
● Leveling measure point for deck surface
★ Leveling measure point for abutment surface



Bridge ID:		Bridge NAME:	Chirundu

Vertical Slope

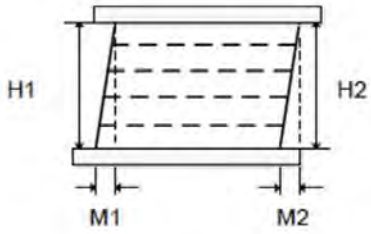
Measure	Place	2021		Difference	Remark
Angle (Holizontal)	H1				
	H2				
	H3				
	H4				



Bridge ID:		Bridge NAME:	Chirundu

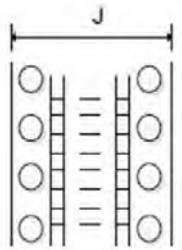
Bearing & Expansion Joint

Measure	Place			2021		Difference	Remark
A1	Bearing Left	H1	A1 side				
		H2	A2 side				
		H3	Left				
		H4	Right				
		Ave					
		M1	A1 side				
		M2	A2 side				
		M3	Left				
		M4	Right				
		Ave					
	Bearing Right	H1	A1 side				
		H2	A2 side				
		H3	Left				
		H4	Right				
		Ave					
		M1	A1 side				
		M2	A2 side				
		M3	Left				
		M4	Right				
		Ave					
	expansion joint		J				
A2	Bearing Left	H1	A1 side				
		H2	A2 side				
		H3	Left				
		H4	Right				
		Ave					
		M1	A1 side				
		M2	A2 side				
		M3	Left				
		M4	Right				
		Ave					
	Bearing Right	H1	A1 side				
		H2	A2 side				
		H3	Left				
		H4	Right				
		Ave					
		M1	A1 side				
		M2	A2 side				
		M3	Left				
		M4	Right				
		Ave					
	expansion joint		J				



Bearing

Measure every bearing (everytime use same marking point)



Rubber Type

APPENDIX-A-2-1

INVENTORY INSPECTION FORM

LOCATION

Bridge ID		
Bridge Name		
Road Name		
Road ID		
Location		
A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	
	Insert year if known	

DESIGN LOAD

Available?	Yes	
	No	
If yes, insert as:		

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	

DESIGN STANDARD

Available?	Yes	
	No	
If yes, insert as:		

Province	Lusaka
Rever Name	Zambezi

BRIDGE GEOMETRY

Bridge length, (m)		
Bridge width, (m)		
Number of lanes		
Number of spans		
Width of carriageway, (m)		
Width of island(s), (m)		
Width of shoulder, (m)	Left	
	Right	
Sidewalk width, (m)	Left	
	Right	

TERRAIN CROSSED

River or waterway (fresh water)	
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	
Bridge inspection vehicle	
Ladder	
Binoculars	
Safety Belt / Harness	
Geologist Hammer	
Oxygen meter	
Camera	
Hard Hat with Headlight	
Other(meter tape, safety shoes, gloves, total station)	

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	

END OF WARRANTY PERIOD

Insert year of end of warranty period	

LIGHTING TO BRIDGE

yes or no	

INTERVAL OF LIGHTING POLES

Left, (m)	
Right, (m)	

AS-BUILT DRAWING

Available?(yes, no or unknown)	
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	
If yes, insert year of widening.	
Bridge strengthened? (yes or no)	
If yes, insert year of strengthening	
Bridge retrofitted? (yes or no)	
If yes, insert year of seismic retrofitting	
Bridge lengthened? (yes or no)	
If yes, insert year of lengthening	

SUPERSTRUCTURE WIDENING FORM

Widened left side	
Widened right side	
Widened both side	

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing bridge	
Same detail / modified material	
Different details	

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	
Girder	
Box girder	
Slab	
Voided slab	
Demontable (Bailey type)	
Truss	
Trestle	
Cable stayed	
Suspension	
Arch	
Portal frame	
Other structure	

SUPERSTRUCTURE WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF PIER WIDENING

Widening original piers	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

TYPE OF ABUTMENT WIDENING

Widerning original abutments	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

PIER / ABUTMENT WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF STRENGTHENING

Main member reinforcement	
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	
Lateral restraints	
Longitudinal restraints	
Beam continuity	
Deck continuity	
Other	

TYPE OF LENGTHENING

Low chainage end, original and widening	
Low chainage ehd, widened part only	
High chainage end, original and widening	
High chainage end, widened part only	

GENERAL SPAN INFORMATION

Span Number	1
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

W Western side

E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	2
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

W Western side

E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

W Western side

E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	1
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**2**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	**1**

WING WALL TYPE	**L**	**R**
Solid wall		
Protected slope		
Other		
None		

WING WALL MATERIAL	**L**	**R**
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	**L**	**R**
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Abutment Number	2

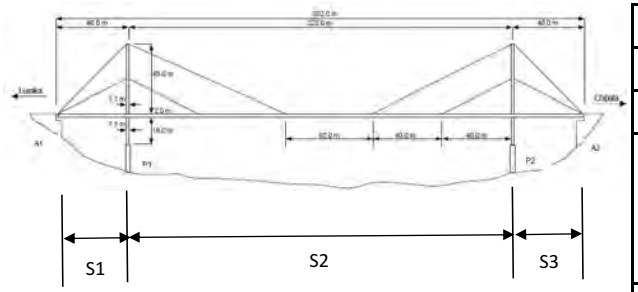
WING WALL TYPE	L	R
Solid wall		
Protected slope		
Other		
None		

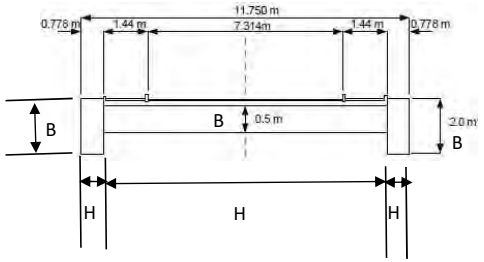
WING WALL MATERIAL	L	R
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

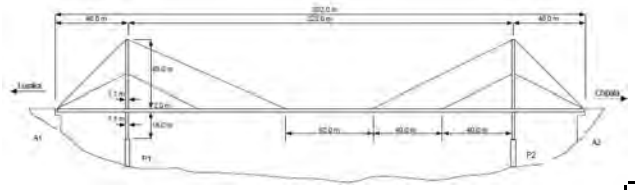
WING WALL LENGTH	
Left, (m)	
Right, (m)	

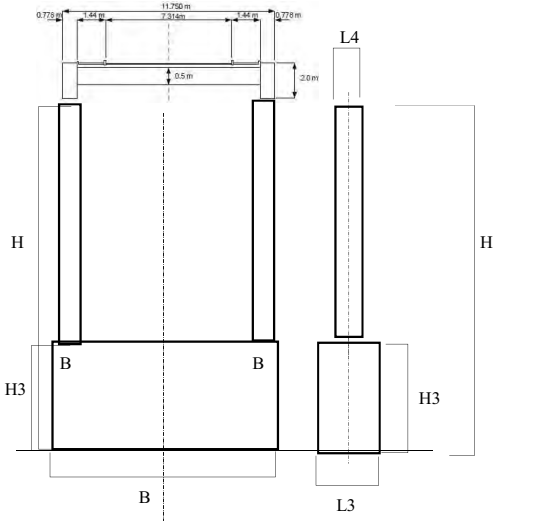
BRIDGE APPROACH COMMENTS

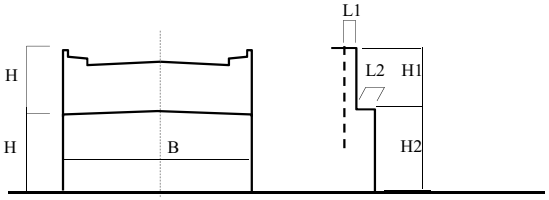




Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S		
	H1		
	H2		
	H3		
	B1		
	B2		
	B3		
S2	S		
	H1		
	H2		
	H3		
	B1		
	B2		
	B3		
S3	S		
	H1		
	H2		
	H3		
	B1		
	B2		
	B3		

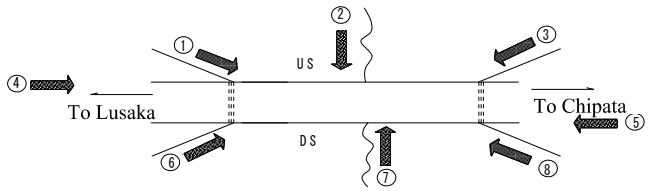






Height and Width			
No.	Component	L (m)	Remarks
A1	H1		
	H2		
	B		
	L1		
	L2		
P1	H		
	H3		
	B1		
	B2		
	B3		
	L3		
	L4		
P2	H		
	H3		
	B1		
	B2		
	B3		
	L3		
	L4		
A2	H1		
	H2		
	B		
	L1		
	L2		

【Photograph】



①	②
③	④
⑤	⑥
⑦	⑧

APPENDIX-A-2-2

PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	
Total Number of Span	
Total Number of Abutment	
Total Number of Pier	

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	
BIV not available	
Access restricted	
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Luangwa

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1	Bridge ID	
(one set of forms for each pier)		Bridge NAME	Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	%	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN MEMBER							
Steel Box Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Box Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (steel)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Substructure							
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							

SPAN No.	Span 2	Bridge ID
(one set of forms for each pier)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN MEMBER							
Steel Box Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Box Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (steel)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Substructure							
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							

SPAN No.	Span 3	Bridge ID
(one set of forms for each pier)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN MEMBER							
Steel Box Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Box Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (steel)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Substructure							
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							

Cable No.	C1L1

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

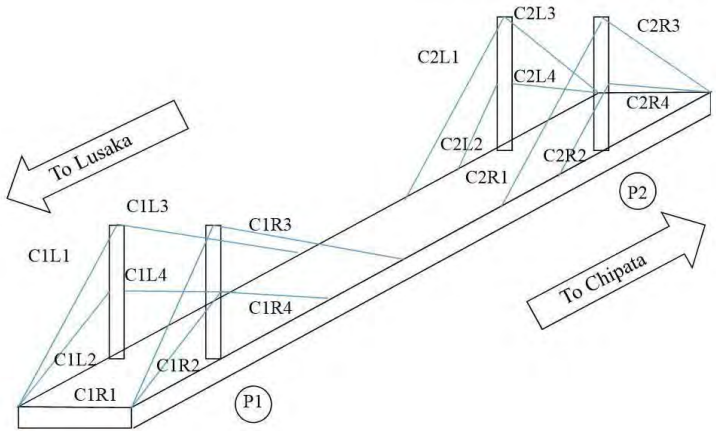
Cable No.	C1L2

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							



Cable No.	C1L3

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

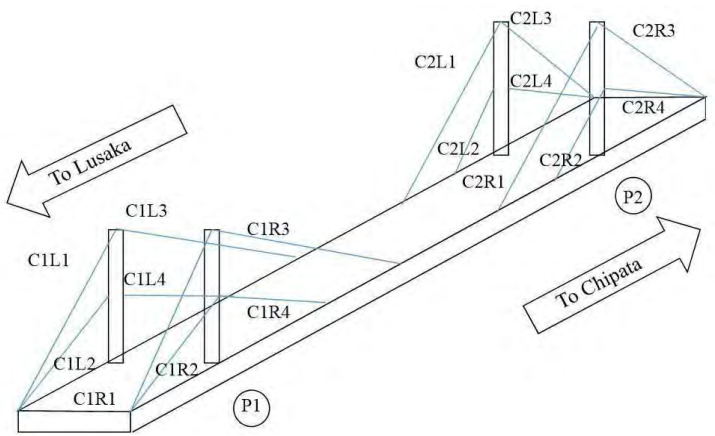
Cable No.	C1L4

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

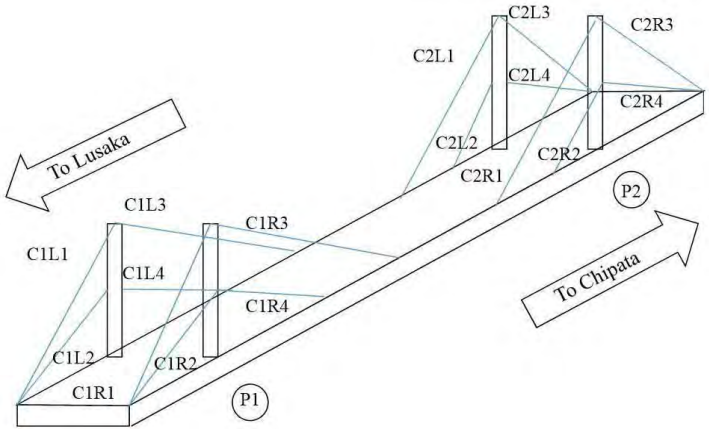


Cable No.	C1R1	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C1R2	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

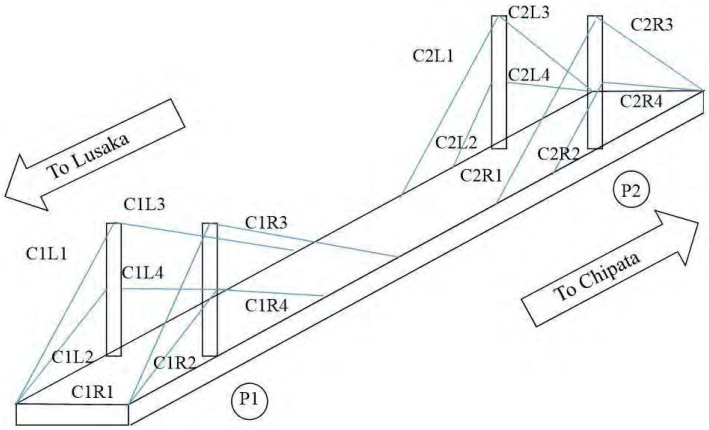


Cable No.	C1R3	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C1R4	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

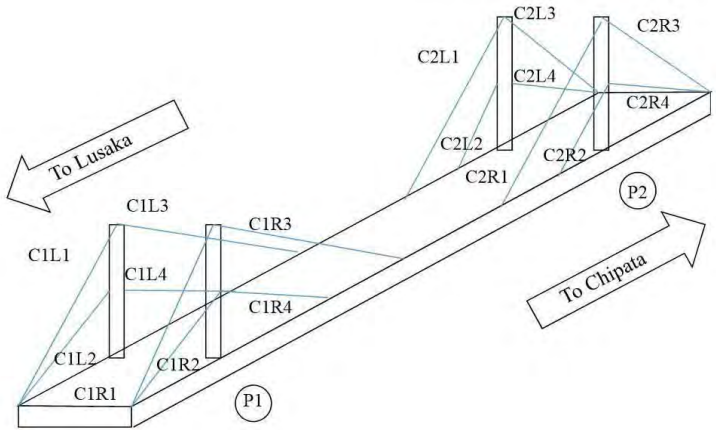


Cable No.	C2L1	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C2L2	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

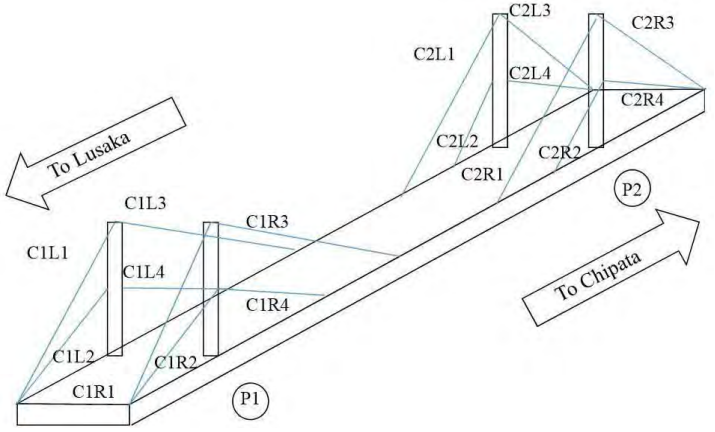


Cable No.	C2L3	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C2L4	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

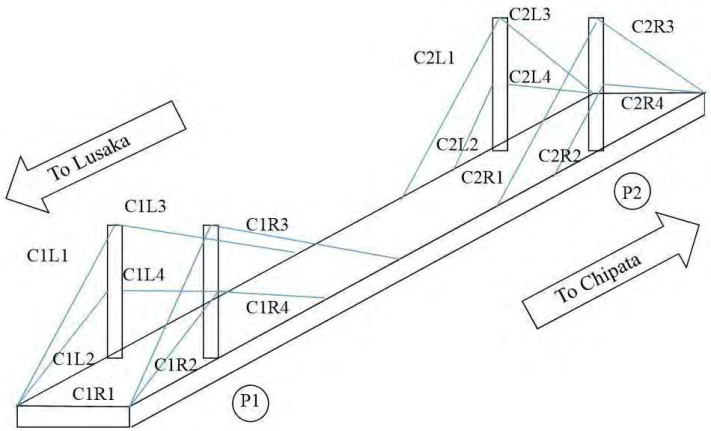


Cable No.	C2R1	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C2R2	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

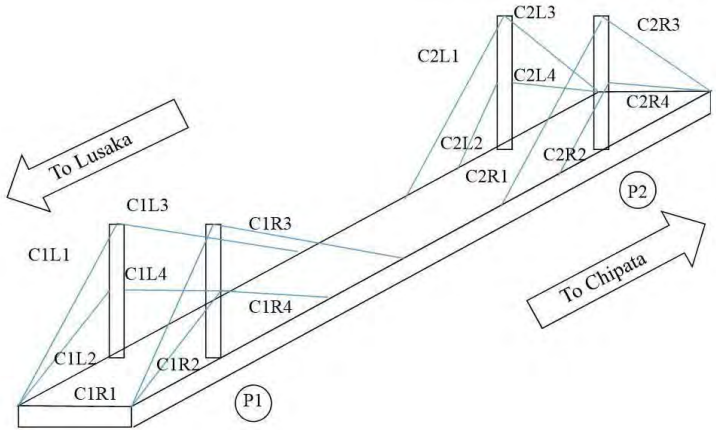


Cable No.	C2R3	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

Cable No.	C2R4	Bridge ID
(one set of forms for each Cable)		Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							

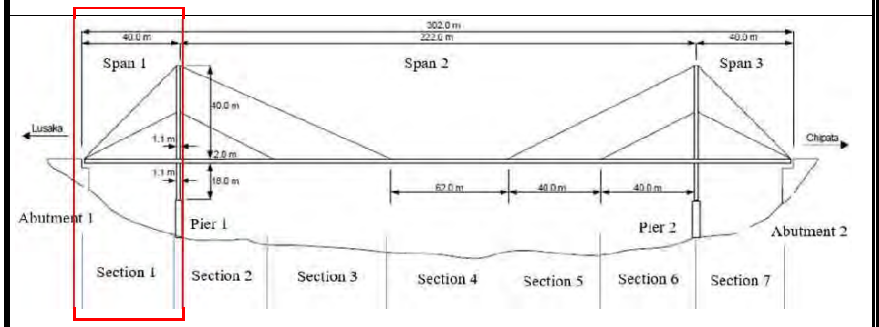


【Damage Drawing】

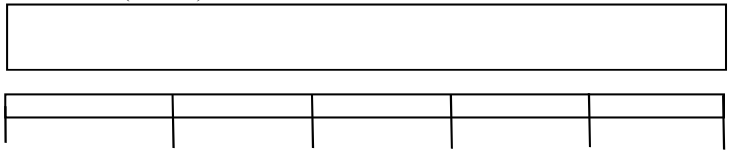
Bridge ID:		Bridge NAME:	Luangwa

Span No:

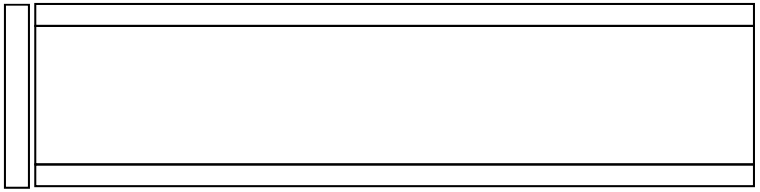
Bridge Number		Span	1	Section	1



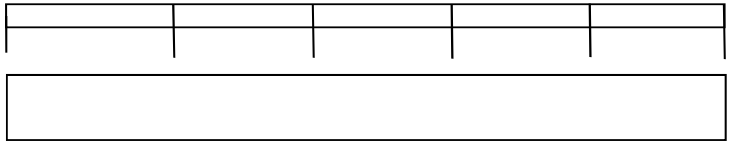
Railing and Guardrail (left side)



Expansion Joint and Deck Concrete



Railing and Guardrail (right side)

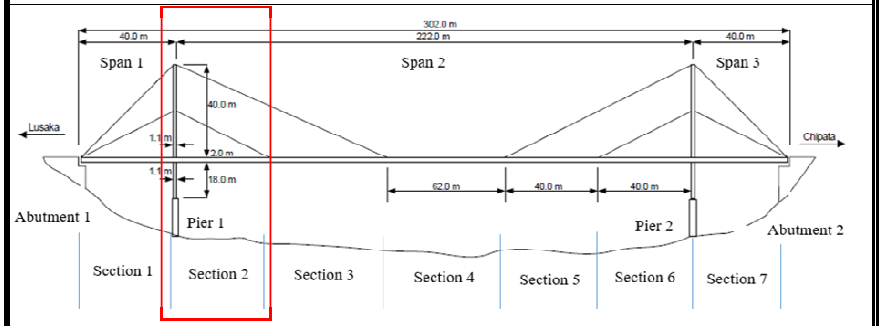


【Damage Drawing】

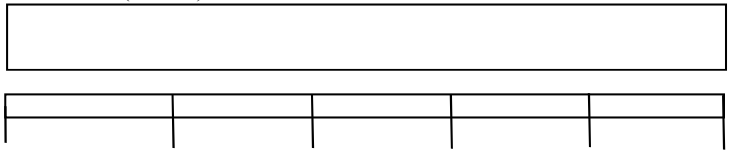
Bridge ID:		Bridge NAME:	Luangwa

Span No:

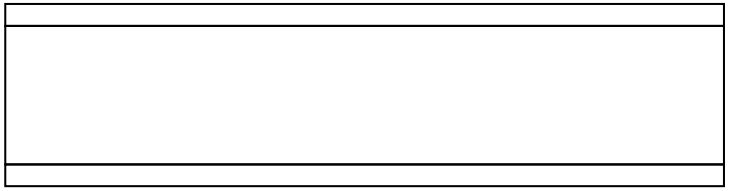
Bridge Number		Span	2	Section	2



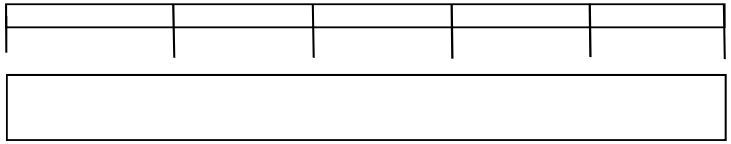
Railing and Guardrail (left side)



Expansion Joint and Deck Concrete



Railing and Guardrail (right side)

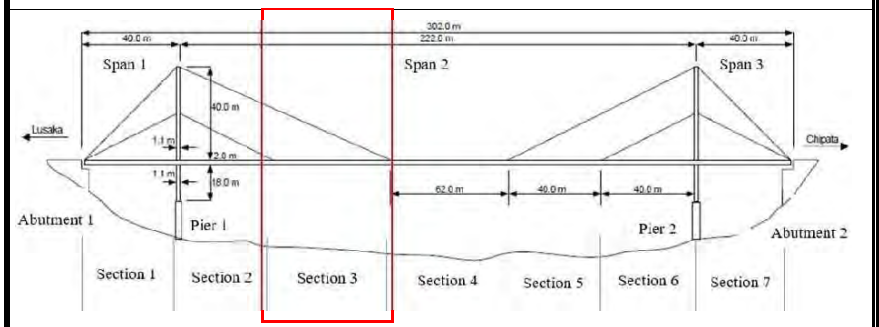


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	3



Railing and Guardrail (left side)

Expansion Joint and Deck Concrete

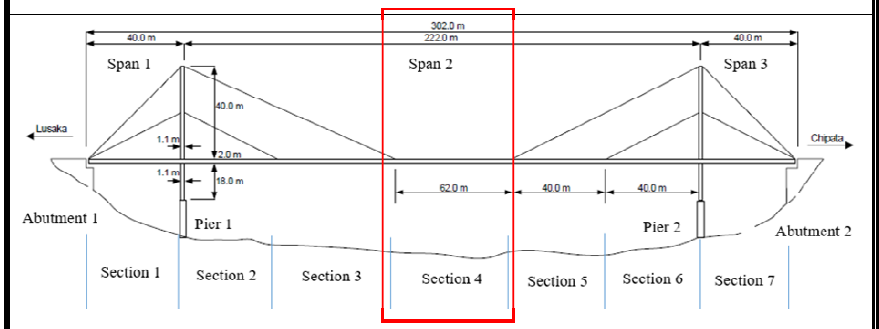
Railing and Guardrail (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	4



Railing and Guardrail (left side)

Expansion Joint and Deck Concrete

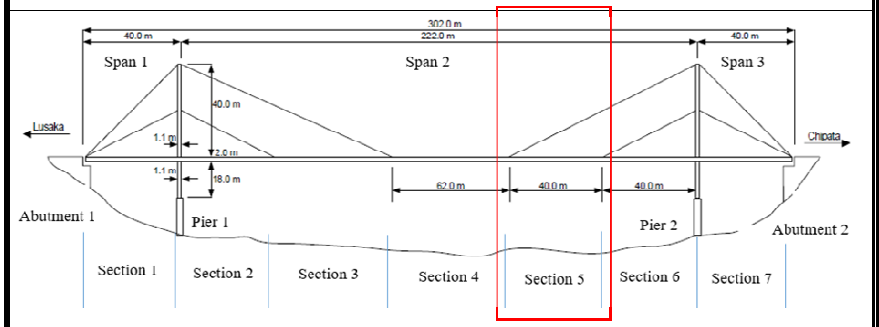
Railing and Guardrail (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	5



Railing and Guardrail (left side)

Expansion Joint and Deck Concrete

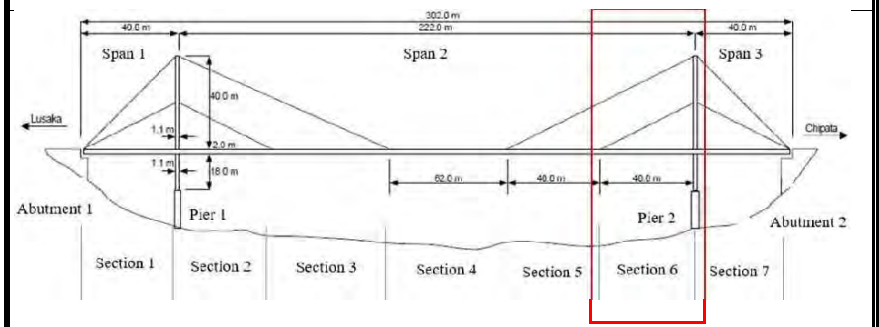
Railing and Guardrail (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	6



Railing and Guardrail (left side)

Expansion Joint and Deck Concrete

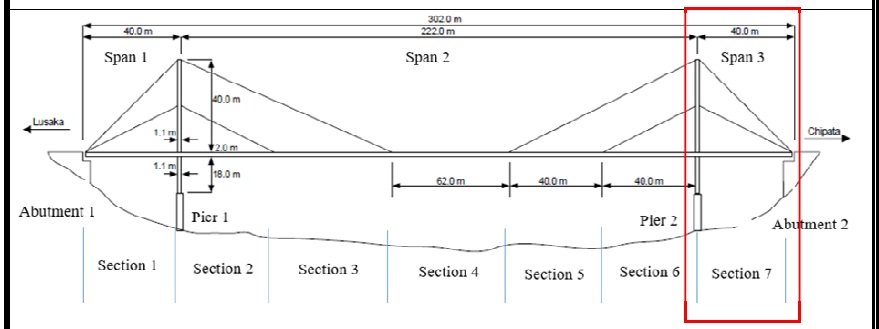
Railing and Guardrail (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	3	Section	7



Railing and Guardrail (left side)

Expansion Joint and Deck Concrete

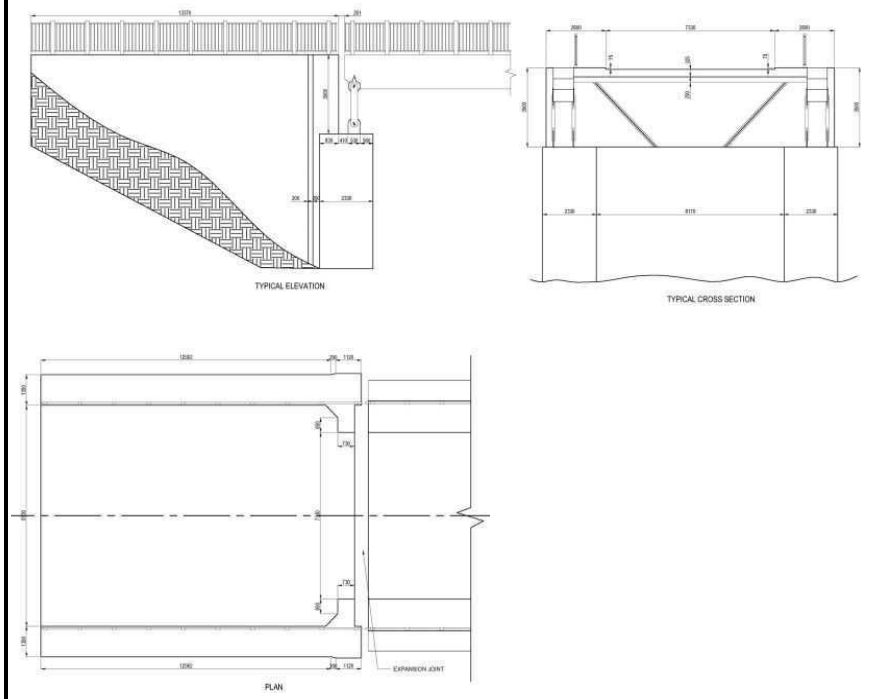
Railing and Guardrail (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span		



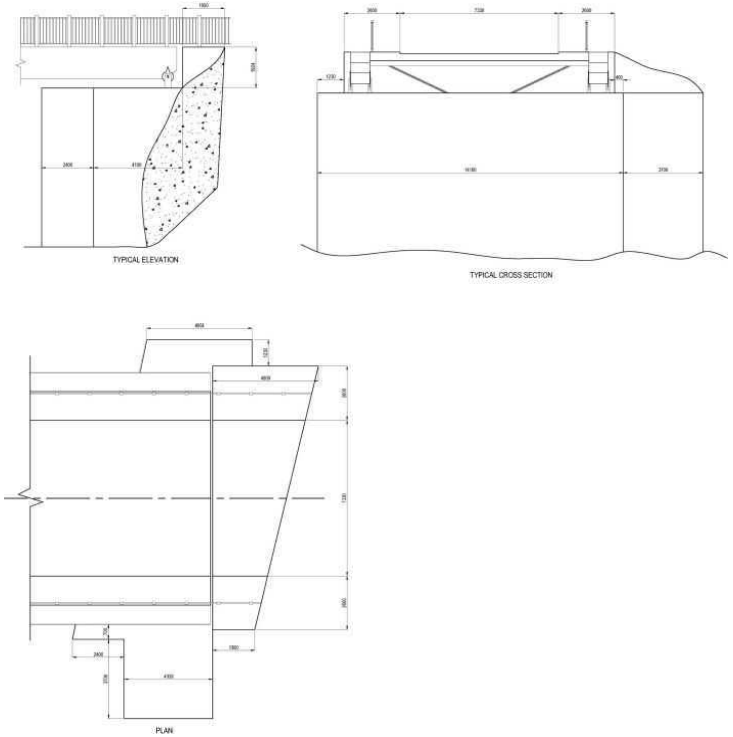
A1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span		



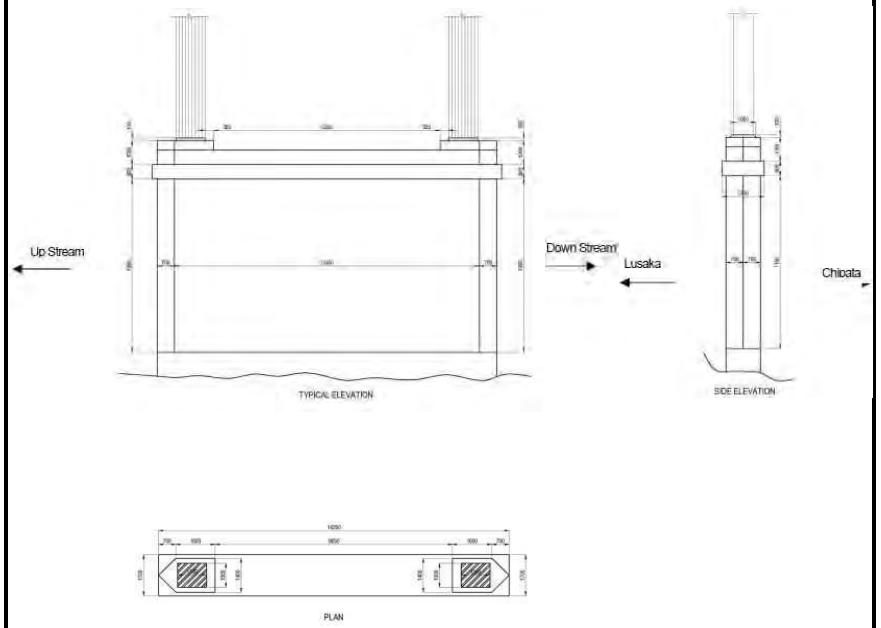
A2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span		



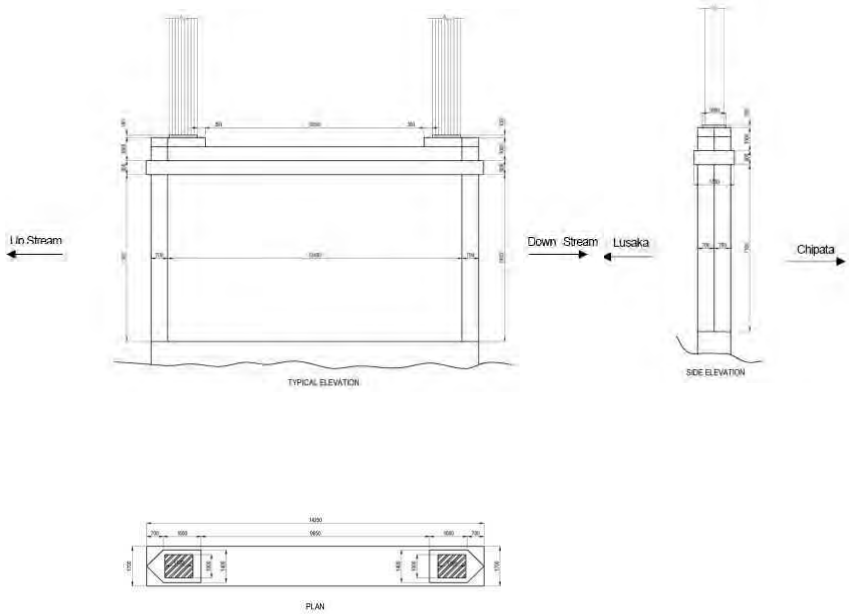
P1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span		



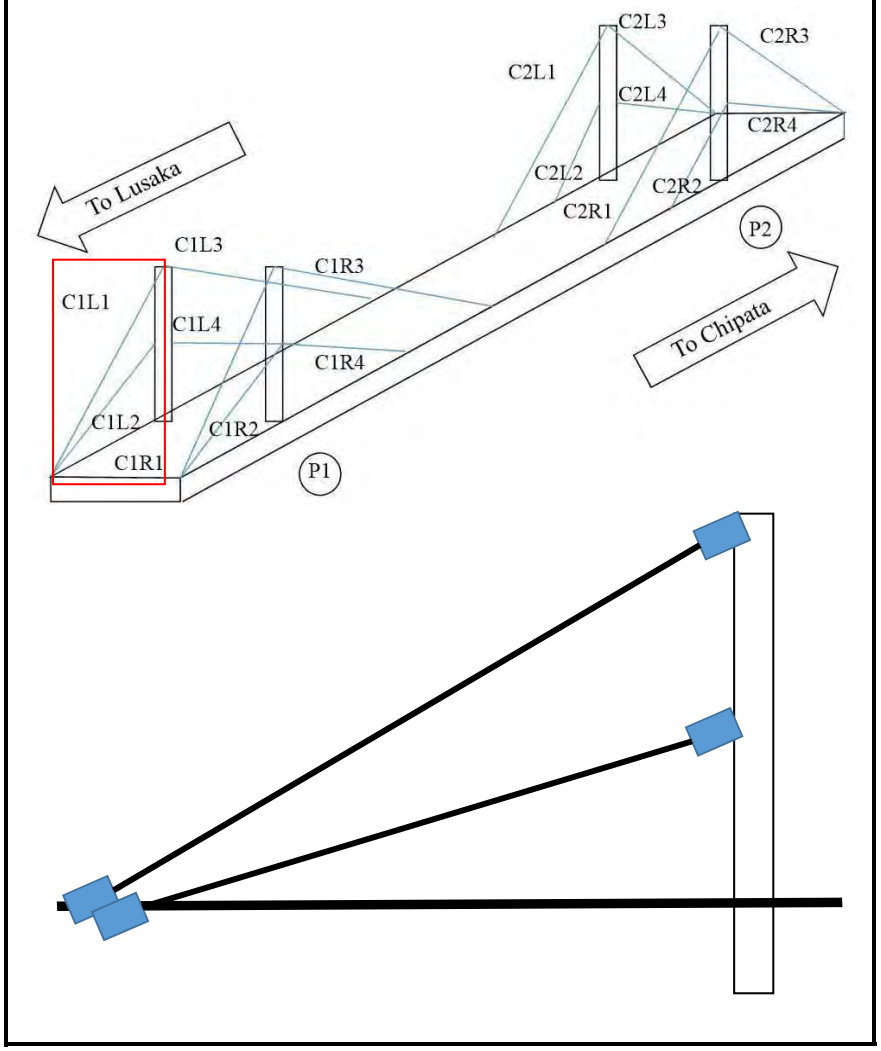
P2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C1L1 C1L2	

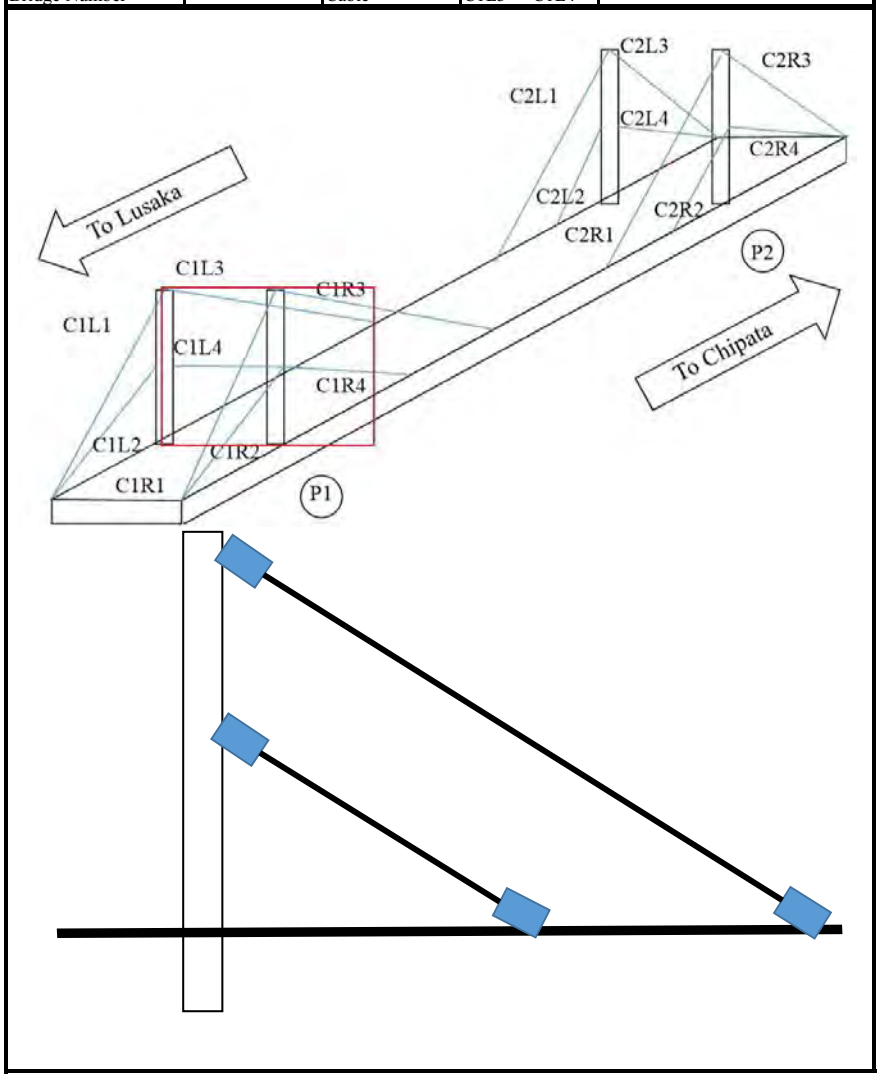


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C1L3 C1L4	

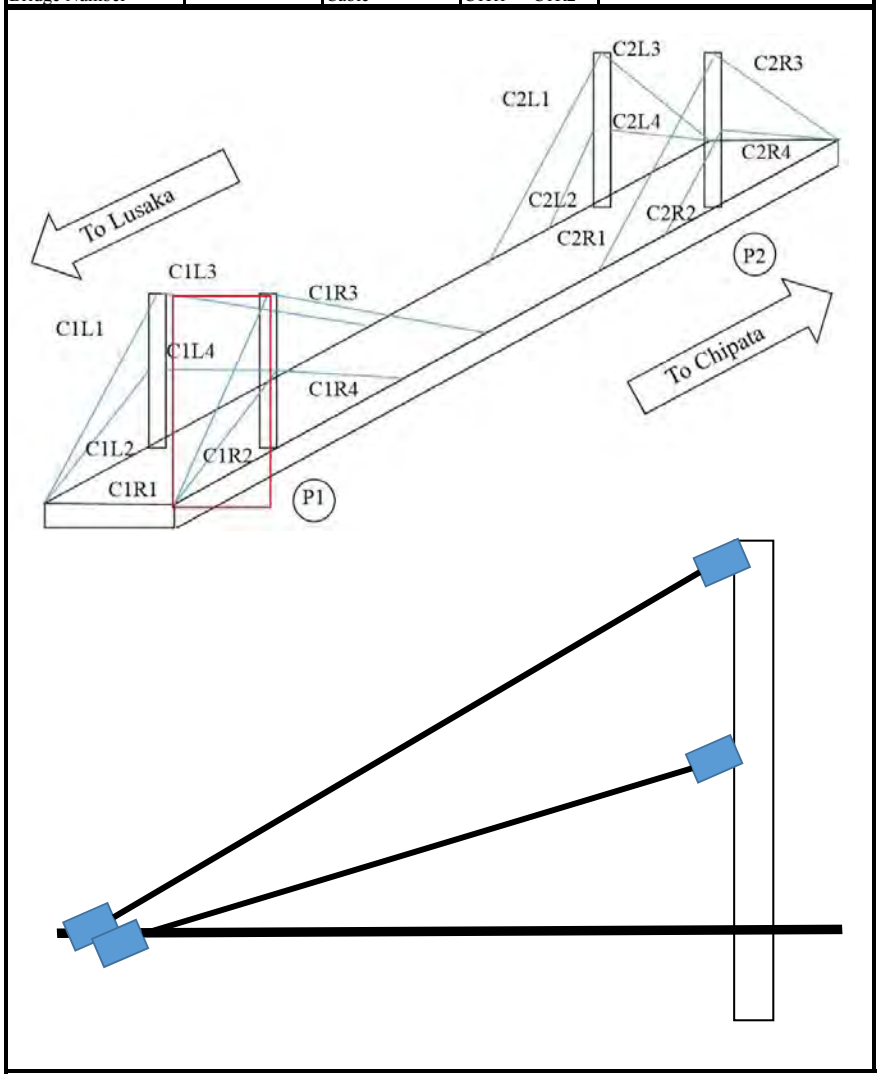


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C1R1 C1R2	

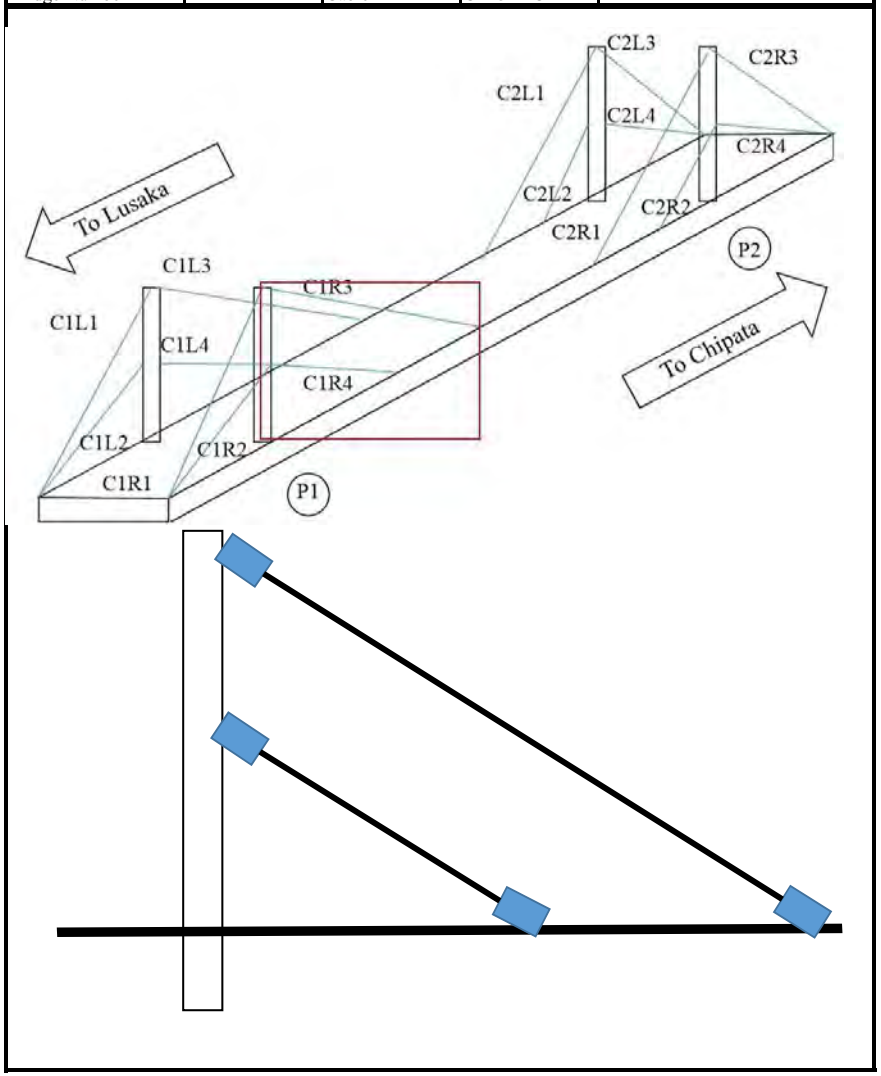


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C1R3 C1R4	

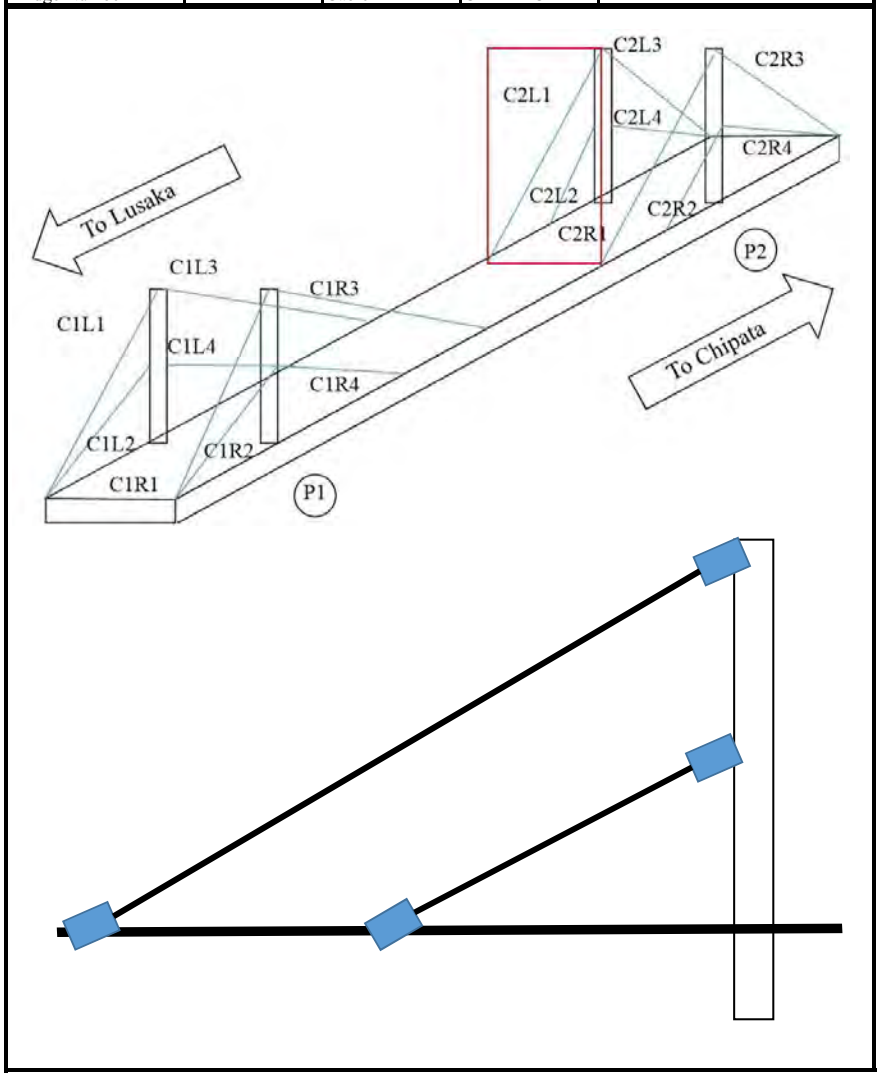


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C2L1 C2L2	

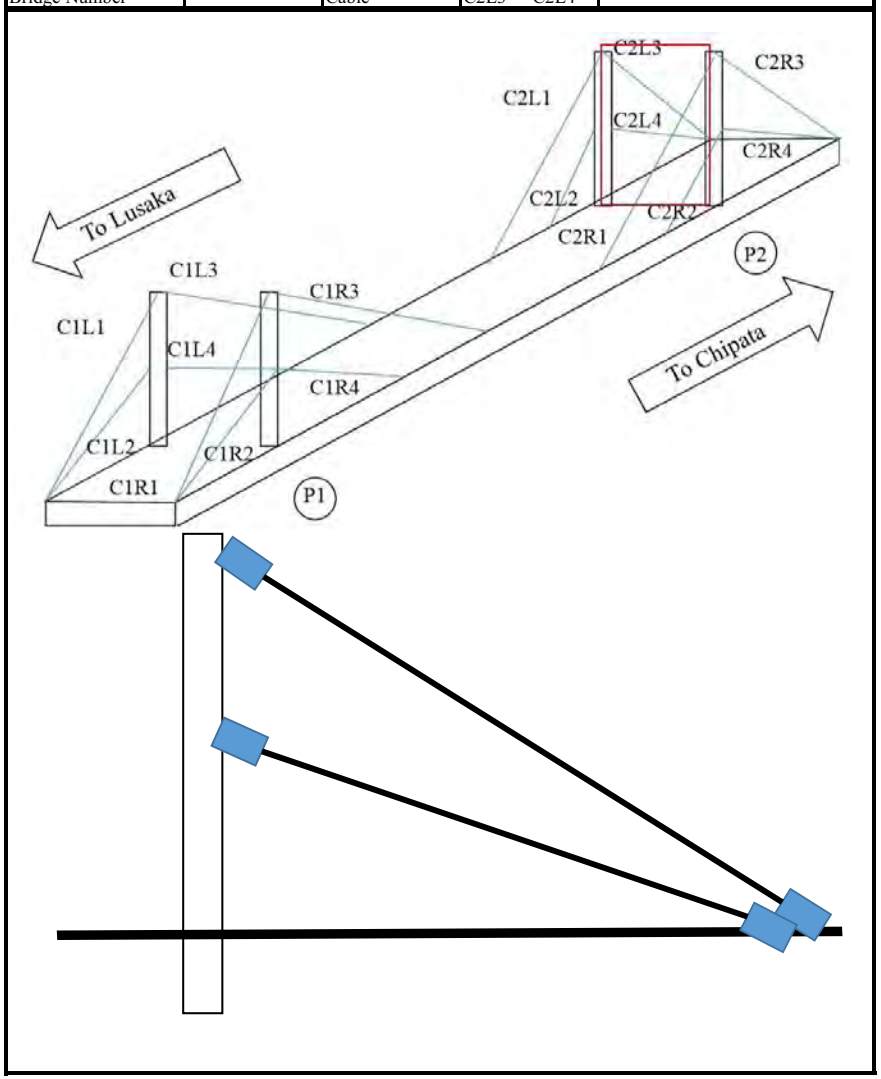


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C2L3 C2L4	

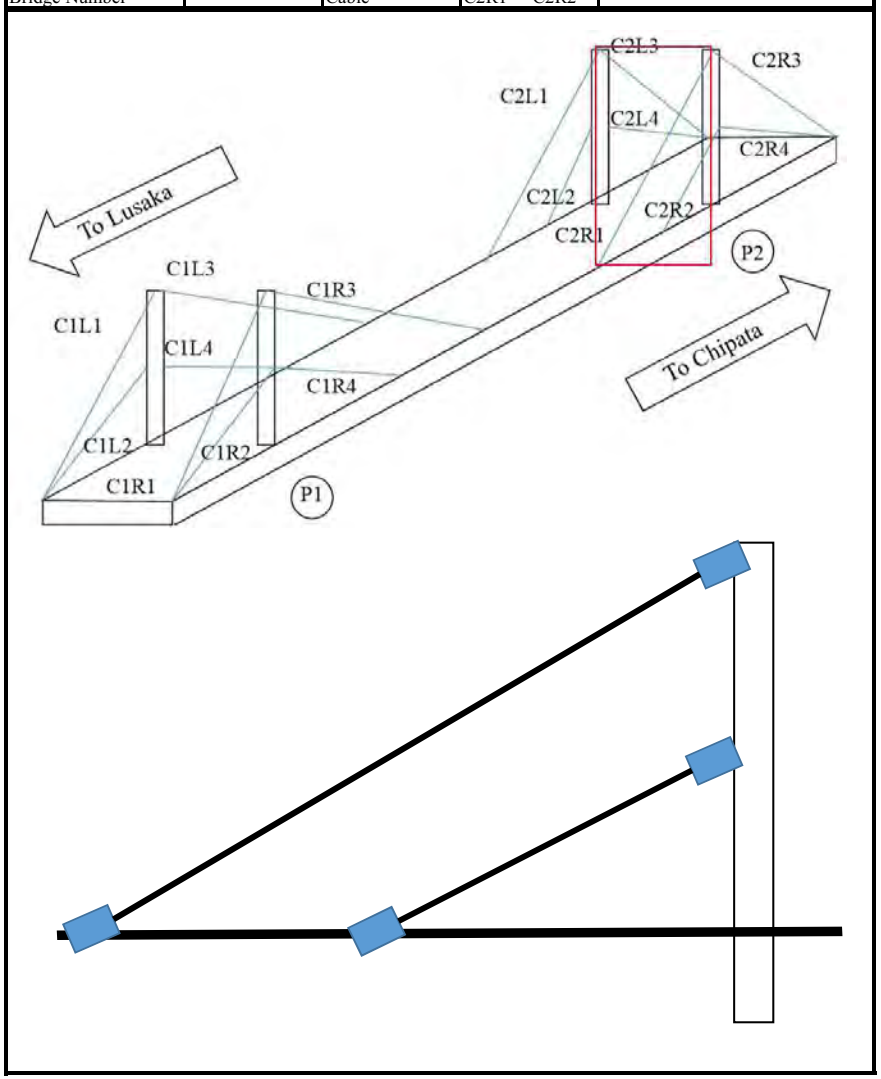


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C2R1 C2R2	

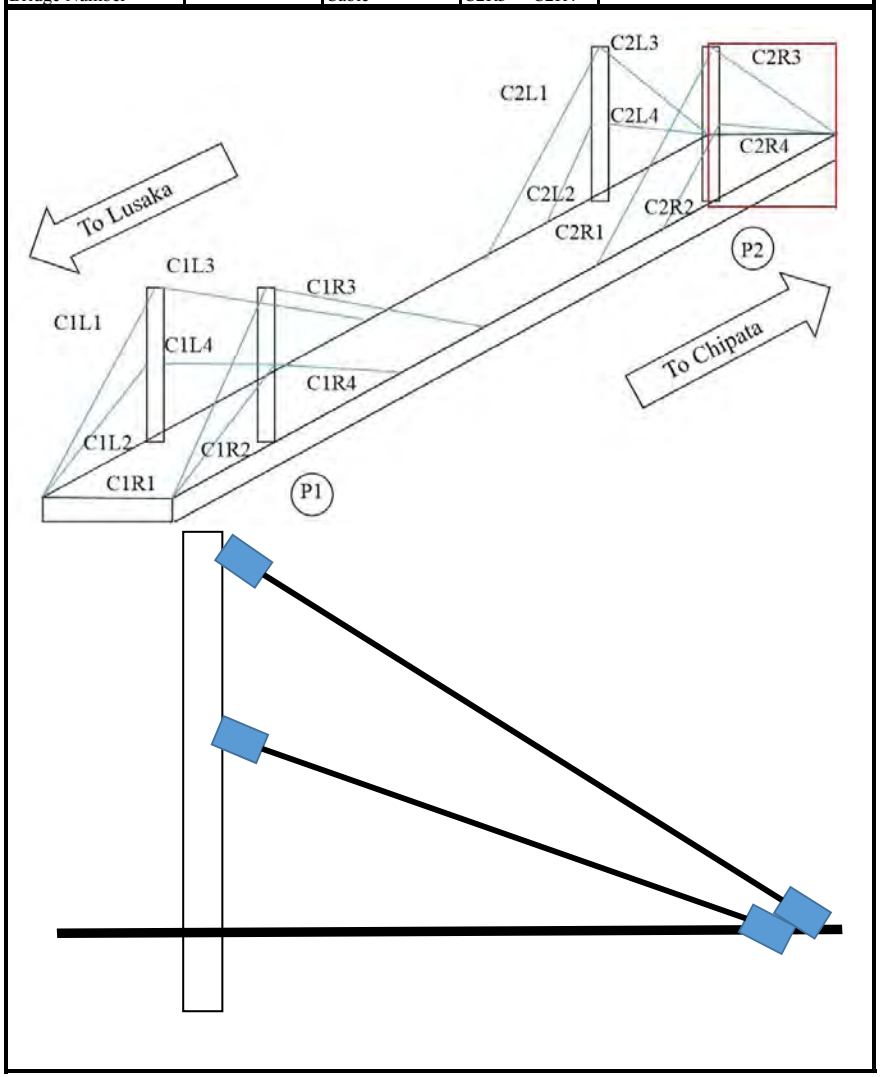


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C2R3 C2R4	

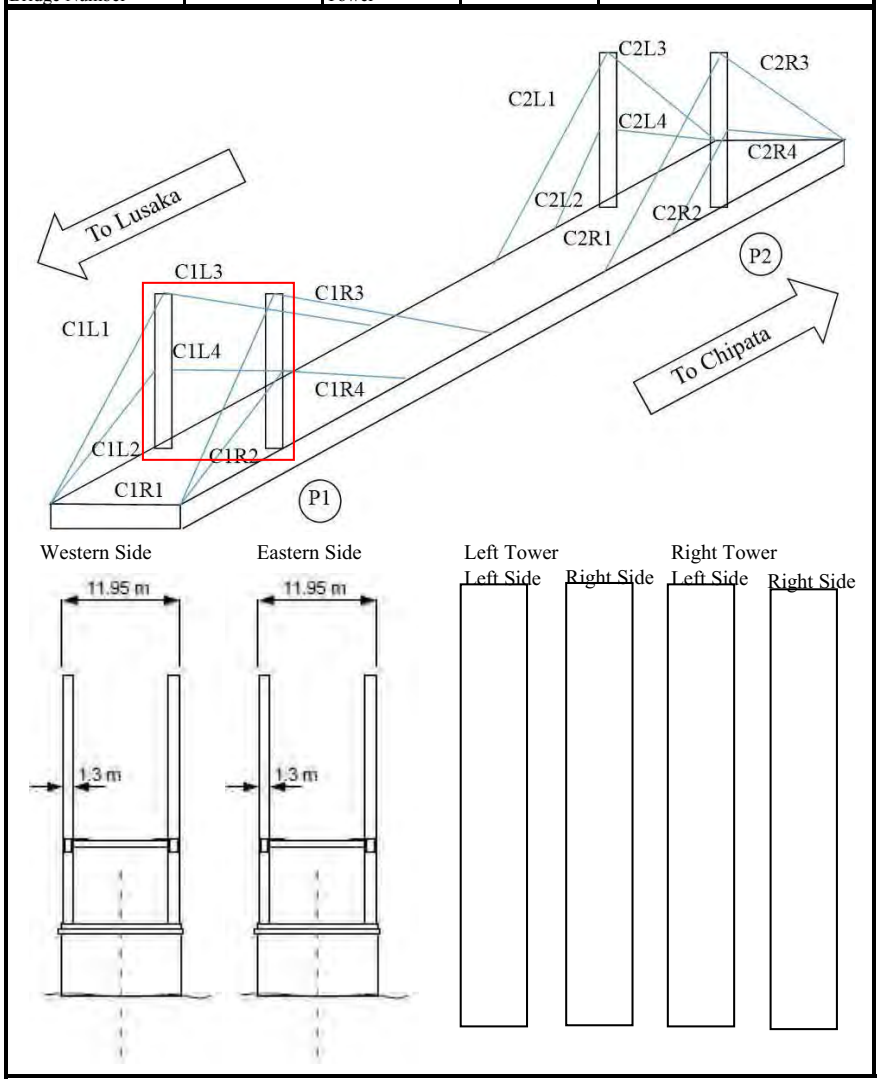


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Tower		

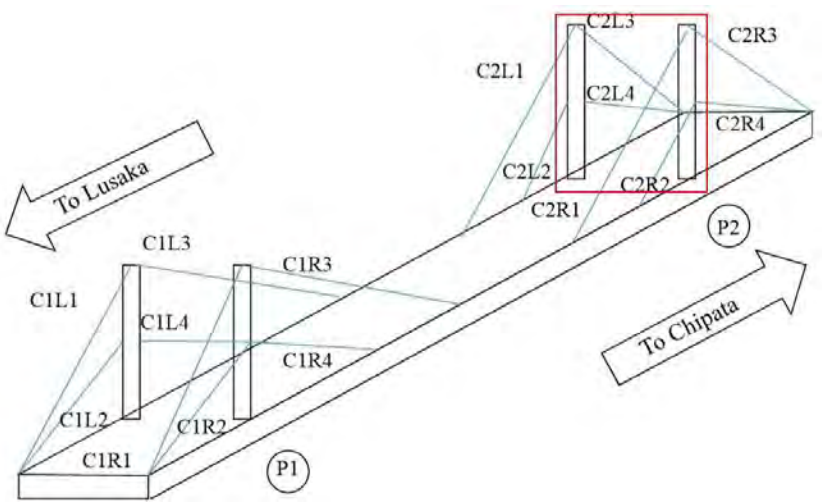


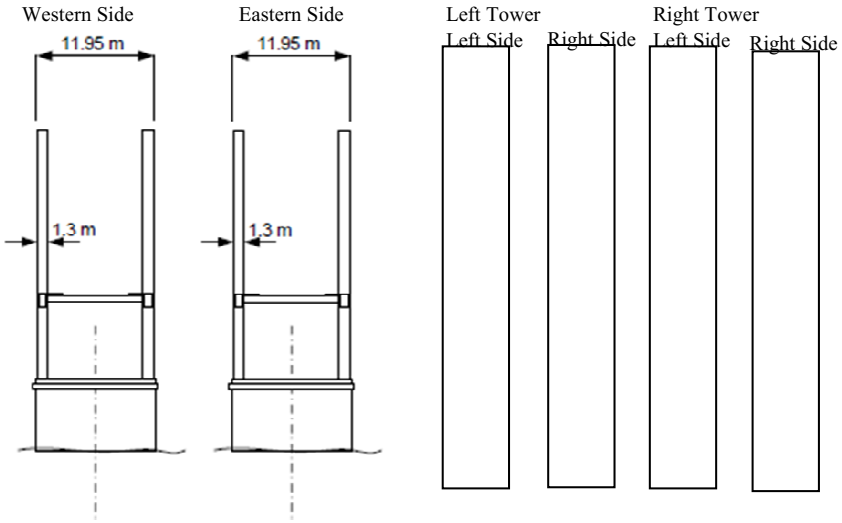
【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Tower		



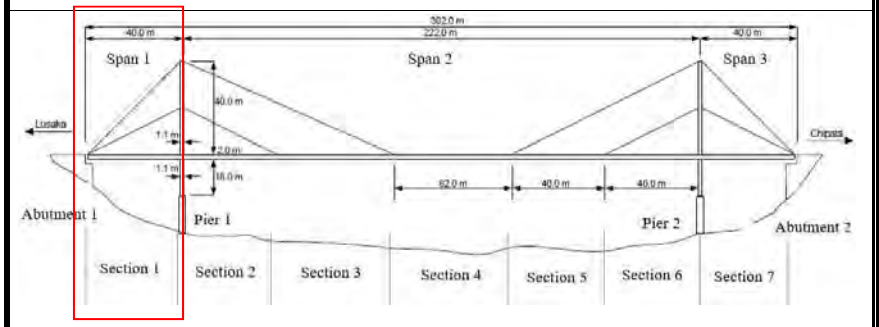


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	1	Section	1



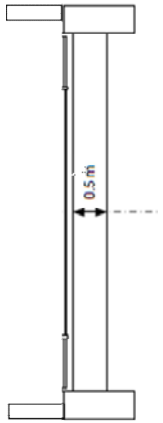
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

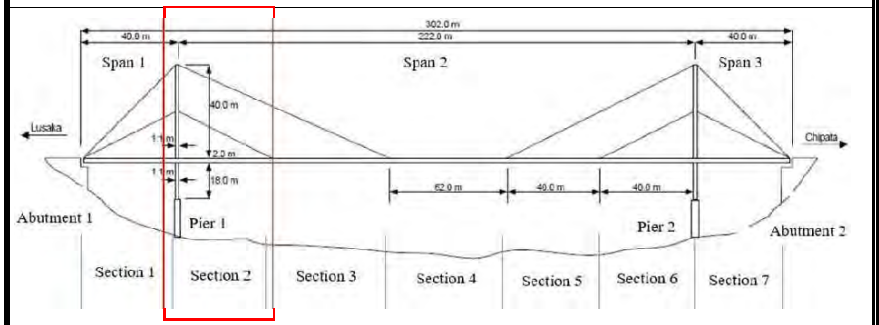
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	2



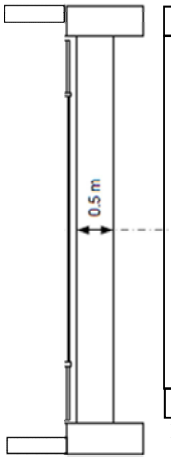
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

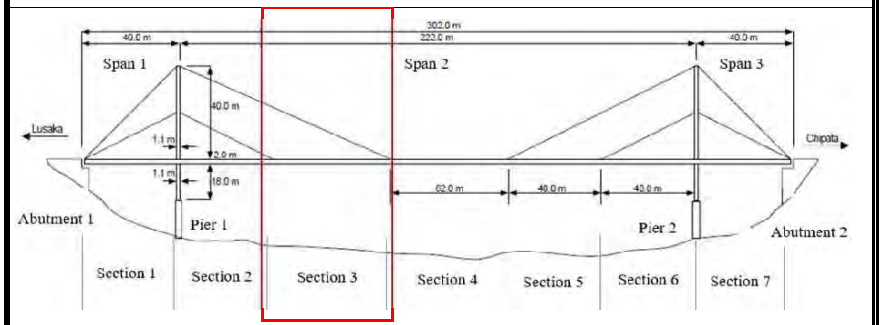
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	3



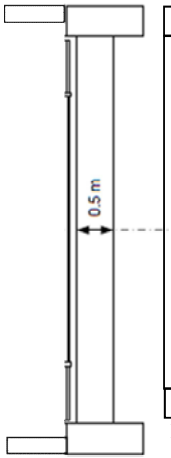
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

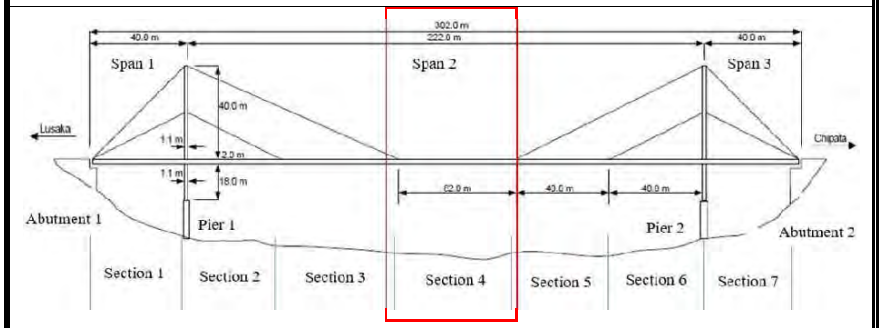
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	4



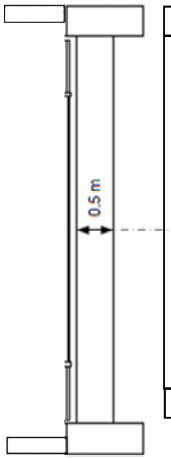
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

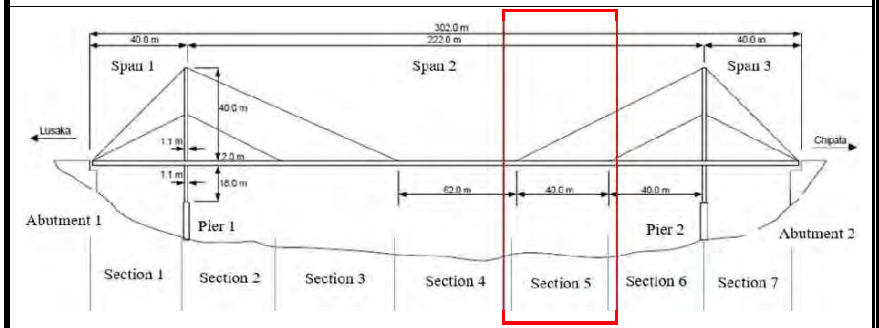
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	5



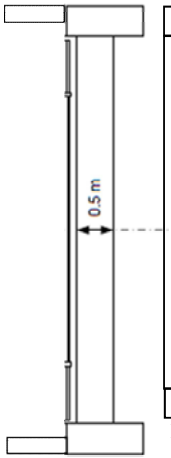
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

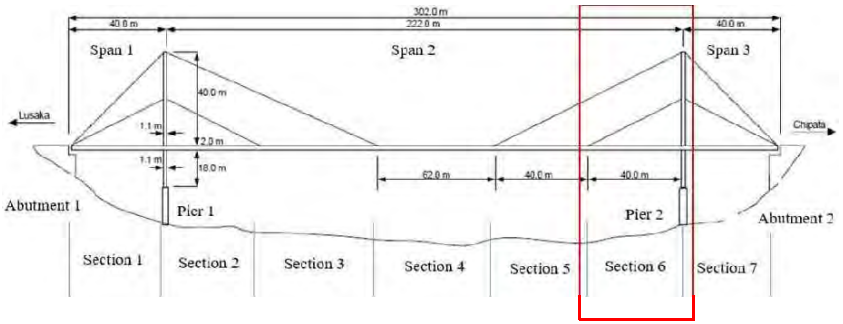
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	2	Section	6



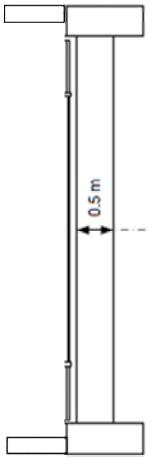
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

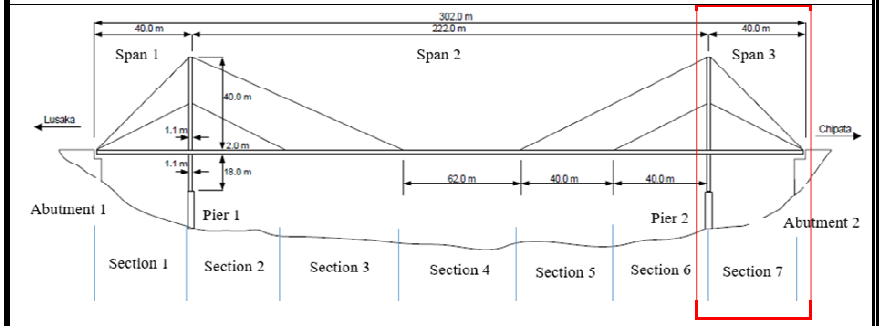
Left Side

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	3	Section	7



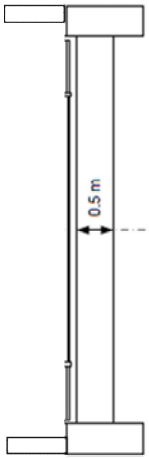
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

Left Girder

Right Side

Left Side

【Photograph】

Bridge ID:		Bridge NAME:	Luangwa

Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment

APPENDIX-A-2-3

GEOMETRICAL INSPECTION FORM

GEOMETRICAL INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE INSPECTOR COMMENT

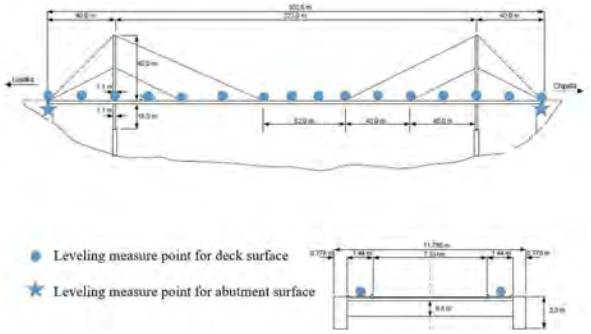
Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

Bridge ID:		Bridge NAME:	

Leveling

Element	Place		1968	2021	Difference	Remark
A1	Left					
	Right					
A2	Left					
	Right					
Longitudal Alignment	1	Left				
Longitudal Alignment	2	Left				
Longitudal Alignment	3	Left				
Longitudal Alignment	4	Left				
Longitudal Alignment	5	Left				
Longitudal Alignment	6	Left				
Longitudal Alignment	7	Left				
Longitudal Alignment	8	Left				
Longitudal Alignment	9	Left				
Longitudal Alignment	10	Left				
Longitudal Alignment	11	Left				
Longitudal Alignment	12	Left				
Longitudal Alignment	13	Left				
Longitudal Alignment	14	Left				
Longitudal Alignment	15	Left				
Longitudal Alignment	16	Left				
Longitudal Alignment	1	Right				
Longitudal Alignment	2	Right				
Longitudal Alignment	3	Right				
Longitudal Alignment	4	Right				
Longitudal Alignment	5	Right				
Longitudal Alignment	6	Right				
Longitudal Alignment	7	Right				
Longitudal Alignment	8	Right				
Longitudal Alignment	9	Right				
Longitudal Alignment	10	Right				
Longitudal Alignment	11	Right				
Longitudal Alignment	12	Right				
Longitudal Alignment	13	Right				
Longitudal Alignment	14	Right				
Longitudal Alignment	15	Right				
Longitudal Alignment	16	Right				



Bridge ID:		Bridge NAME:	

Measure	Place	1968	2021	Difference	Remark
Angle (Vertical)	K1+L1tanV1				
	K2+L2tanV2				
	K3+L3tanV3				
	K4+L4tanV4				
Angle (Vertical)	K5+L5tanV5				
	K6+L6tanV6				
	K7+L7tanV7				
	K8+L8tanV8				
Angle (Holizontal)	L1/tanH1				
	L2/tanH2				
	L3/tanH3				
	L4/tanH4				
Angle (Holizontal)	L5/tanH5				
	L6/tanH6				
	L7/tanH7				
	L8/tanH8				

APPENDIX-A-3-1

INVENTORY INSPECTION FORM

LOCATION

Bridge ID		
Bridge Name	Otto Beit	
Road Name		
Road ID		
Location		
A1 GPS: S		
A1 GPS: E		
A2 GPS: S		
A2 GPS: E		

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	
	Insert year if known	

DESIGN LOAD

Available?	Yes	
	No	
If yes, insert as:		

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	

DESIGN STANDARD

Available?	Yes	
	No	
If yes, insert as:		

Province	Lusaka
Rever Name	Zambezi

BRIDGE GEOMETRY

Bridge length, (m)		
Bridge width, (m)		
Number of lanes		
Number of spans		
Width of carriageway, (m)		
Width of island(s), (m)		
Width of shoulder, (m)	Left	
	Right	
Sidewalk width, (m)	Left	
	Right	

TERRAIN CROSSED

River or waterway (fresh water)	
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	
Bridge inspection vehicle	
Ladder	
Binoculars	
Safety Belt / Harness	
Geologist Hammer	
Oxygen meter	
Camera	
Hard Hat with Headlight	
Other(meter tape, safety shoes, gloves, total station)	

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	

END OF WARRANTY PERIOD

Insert year of end of warranty period	

LIGHTING TO BRIDGE

yes or no	

INTERVAL OF LIGHTING POLES

Left, (m)	
Right, (m)	

AS-BUILT DRAWING

Available?(yes, no or unknown)	
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	
If yes, insert year of widening.	
Bridge strengthened? (yes or no)	
If yes, insert year of strengthening	
Bridge retrofitted? (yes or no)	
If yes, insert year of seismic retrofitting	
Bridge lengthened? (yes or no)	
If yes, insert year of lengthening	

SUPERSTRUCTURE WIDENING FORM

Widened left side	
Widened right side	
Widened both side	

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing bridge	
Same detail / modified material	
Different details	

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	
Girder	
Box girder	
Slab	
Voided slab	
Demontable (Bailey type)	
Truss	
Trestle	
Cable stayed	
Suspension	
Arch	
Portal frame	
Other structure	

SUPERSTRUCTURE WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF PIER WIDENING

Widening original piers	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

TYPE OF ABUTMENT WIDENING

Widerning original abutments	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

PIER / ABUTMENT WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF STRENGTHENING

Main member reinforcement	
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	
Lateral restraints	
Longitudinal restraints	
Beam continuity	
Deck continuity	
Other	

TYPE OF LENGTHENING

Low chainage end, original and widening	
Low chainage ehd, widened part only	
High chainage end, original and widening	
High chainage end, widened part only	

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side

ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side

W Right side

※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	3
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

PIER COMMENTS

GENERAL TOWER DATA

Tower Number	1
Tower height, (m)	

TOWER TYPE

Solid wall	
Truss	
Other	
Not known	

TOWER MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

TOWER FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL TOWER DATA

Tower Number	**2**
Tower height, (m)	

TOWER TYPE

Solid wall	
Truss	
Other	
Not known	

TOWER MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

TOWER FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Anchorage Number	**1**

ANCHORAGE TYPE

Solid wall	
Inside the ground	
Other	
None	

ANCHORAGE MATERIAL

Concrete	
Masonry	
Timber	
Gabions or mattresses	
Other	

ANCHORAGE FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	

ANCHORAGE LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Anchorage Number	**2**

ANCHORAGE TYPE

Solid wall	
Inside the ground	
Other	
None	

ANCHORAGE MATERIAL

Concrete	
Masonry	
Timber	
Gabions or mattresses	
Other	

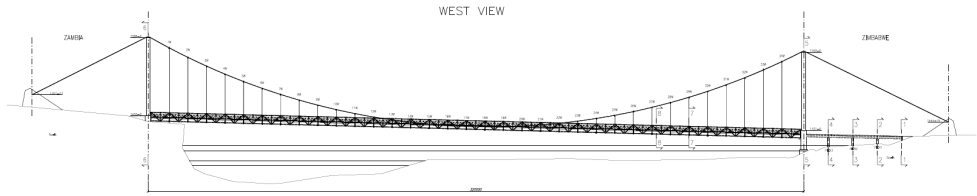
ANCHORAGE FOUNDATION TYPE

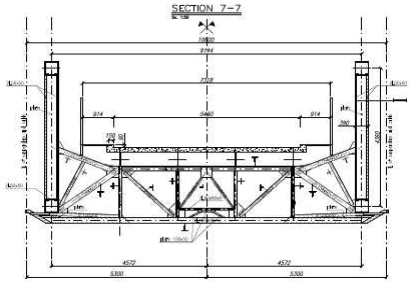
Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	

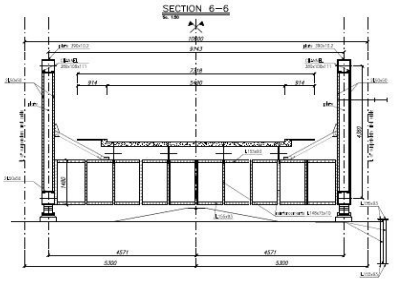
ANCHORAGE LENGTH

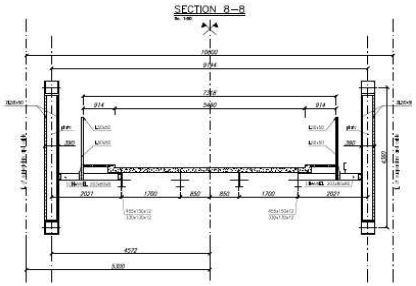
Left, (m)	
Right, (m)	

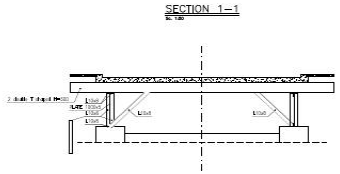
BRIDGE APPROACH COMMENTS

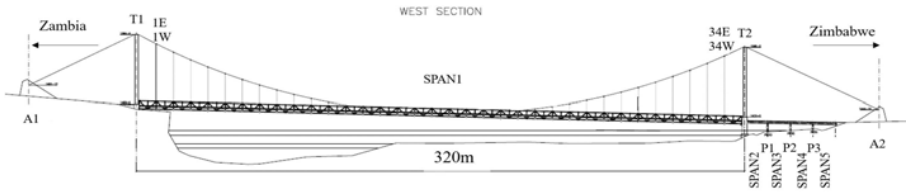


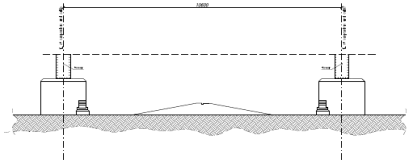


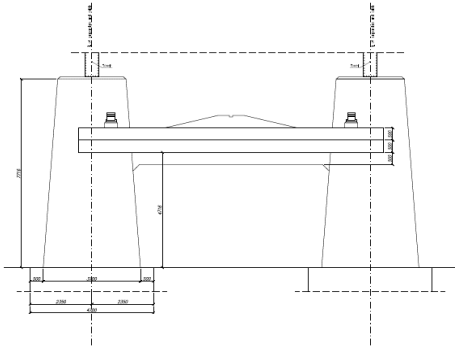








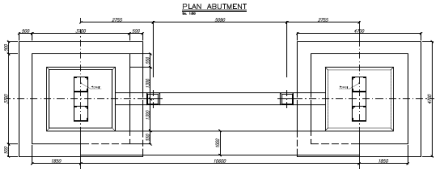


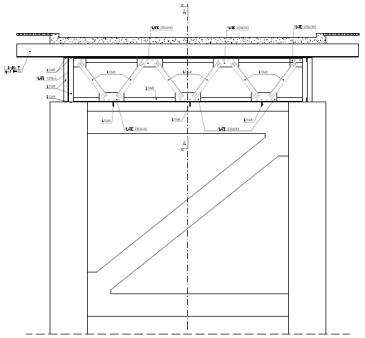


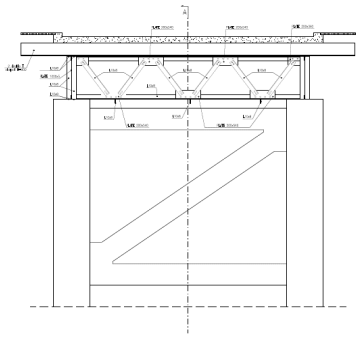
PLAN ABUTMENT

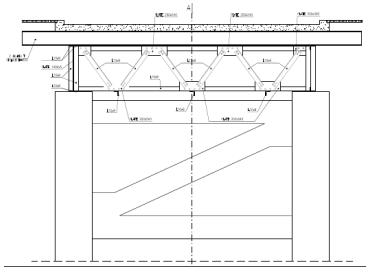


PLAN ABUTMENT

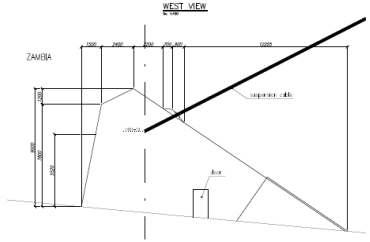


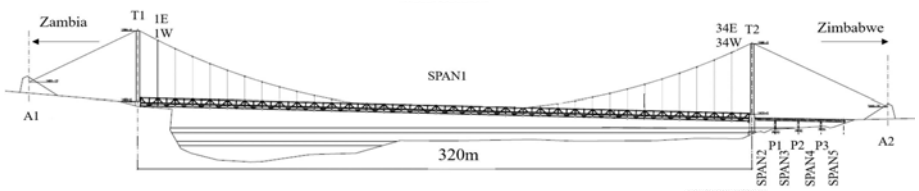


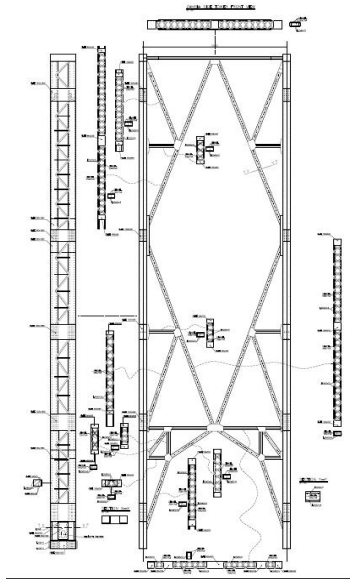


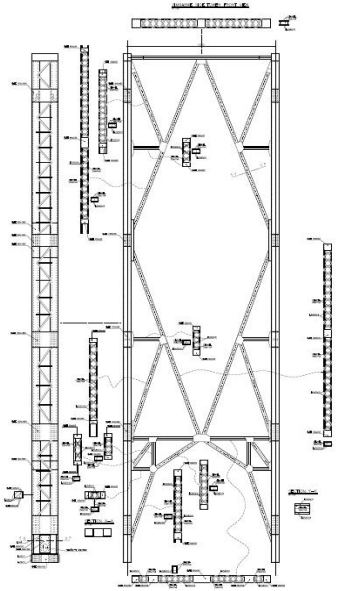


WEST VIEW

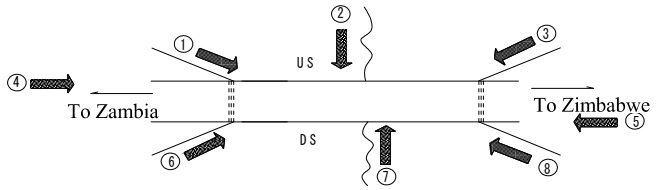








【Photograph】



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③	④
⑤	⑥
⑦	⑧

APPENDIX-A-3-2

PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Otto Beit
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	
Total Number of Span	
Total Number of Abutment	
Total Number of Pier	
Total Number of Anchorage	

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	
BIV not available	
Access restricted	
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Otto Beit

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1, Section 1

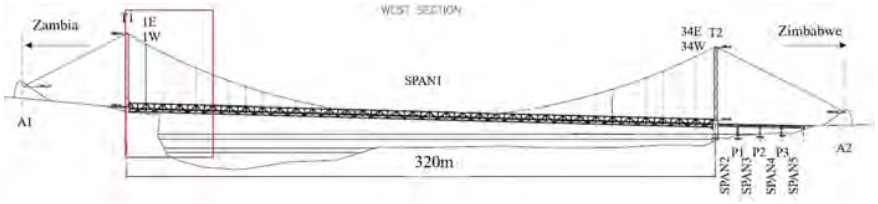
(one set of forms for each pier)

Bridge ID

Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower Zambian side		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block A1		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete) T1		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

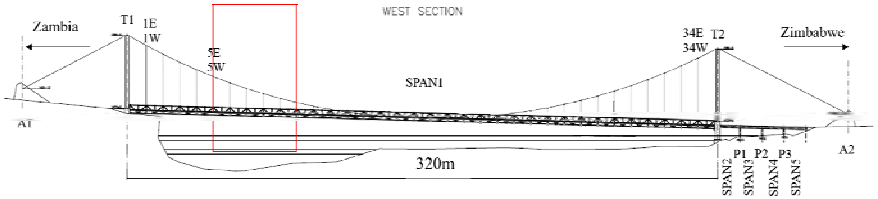
SECONDALY MEMBER							
Anchorage Housing A1	Debris accumulation						
	Vegetation growth						
	Door locking						
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (steel)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Displacement						
	Cracking						
Overall Rating							



SPAN No.	Span 1, Section 2	Bridge ID
(one set of forms for each pier)		Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing	Debris accumulation						
	Vegetation growth						
	Door locking						
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (steel)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Displacement						
	Cracking						
Overall Rating							



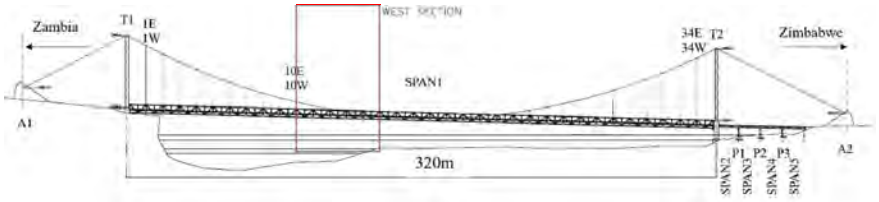
SPAN No.	Span 1, Section 3
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Asphalt	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					
MAIN MEMBER						
Steel Girder (Left)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder (Right)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Tower	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint Peel Off					
Cable Saddle	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint peel off					
Cable and Rope	Vibration					
	Alignment / Deformation					
	Cracking					
	Delamination / Scaling					
	Water Leakage					
Cable Anchorage	Corrosion					
	Deformation					
	Loose Connection					
	Missing Bolts					
Anchorage Block	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water Leakage					
Pier (concrete)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							



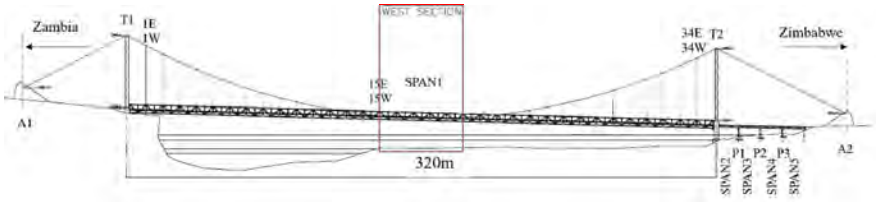
SPAN No.	Span 1, Section 4
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing	Debris accumulation						
	Vegetation growth						
	Door locking						
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (steel)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Displacement						
	Cracking						
Overall Rating							



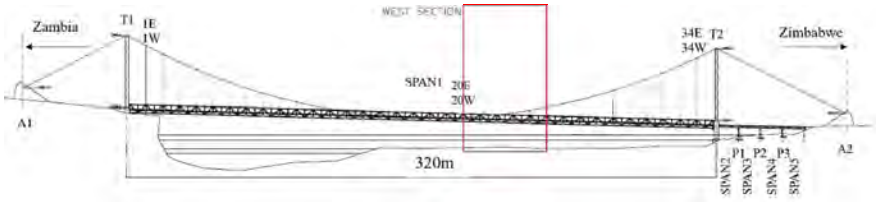
SPAN No.	Span 1, Section 5
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Asphalt	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					
MAIN MEMBER						
Steel Girder (Left)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder (Right)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Tower	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint Peel Off					
Cable Saddle	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint peel off					
Cable and Rope	Vibration					
	Alignment / Deformation					
	Cracking					
	Delamination / Scaling					
	Water Leakage					
Cable Anchorage	Corrosion					
	Deformation					
	Loose Connection					
	Missing Bolts					
Anchorage Block	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water Leakage					
Pier (concrete)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing	Debris accumulation						
	Vegetation growth						
	Door locking						
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (steel)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Displacement						
	Cracking						
Overall Rating							



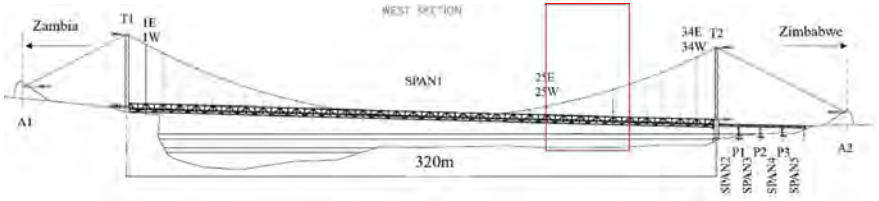
SPAN No. Span 1, Section 6 (one set of forms for each pier)

Bridge ID

Bridge NAME Otto Beit

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Asphalt	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					
MAIN MEMBER						
Steel Girder (Left)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder (Right)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Tower	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint Peel Off					
Cable Saddle	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint peel off					
Cable and Rope	Vibration					
	Alignment / Deformation					
	Cracking					
	Delamination / Scaling					
	Water Leakage					
Cable Anchorage	Corrosion					
	Deformation					
	Loose Connection					
	Missing Bolts					
Anchorage Block	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water Leakage					
Pier (concrete)	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							



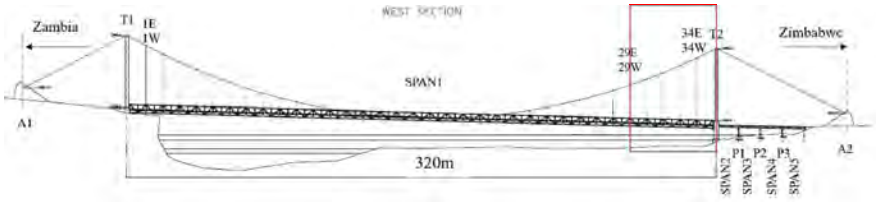
SPAN No.	Span 1, Section 7
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower Zimbabwe side		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block A2		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete) T2		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing A2	Debris accumulation						
	Vegetation growth						
	Door locking						
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (steel)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Displacement						
	Cracking						
Overall Rating							



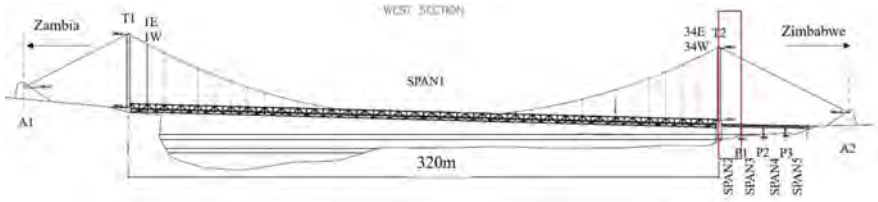
SPAN No.	Span 2
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Concrete	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Asphalt	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					
MAIN MEMBER						
Steel Girder (Left)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder (Right)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Tower	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint Peel Off					
Cable Saddle	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint peel off					
Cable and Rope	Vibration					
	Alignment / Deformation					
	Cracking					
	Delamination / Scaling					
	Water Leakage					
Cable Anchorage	Corrosion					
	Deformation					
	Loose Connection					
	Missing Bolts					
Anchorage Block	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water Leakage					
Pier (concrete) P1	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							



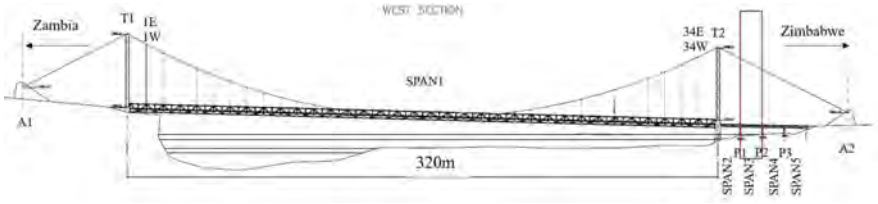
SPAN No.	Span 3
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete) P2		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

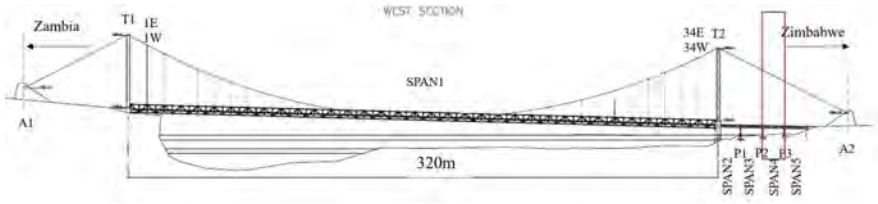
SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							



SPAN No.	Span 4	Bridge ID
(one set of forms for each pier)		Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete) P3		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							



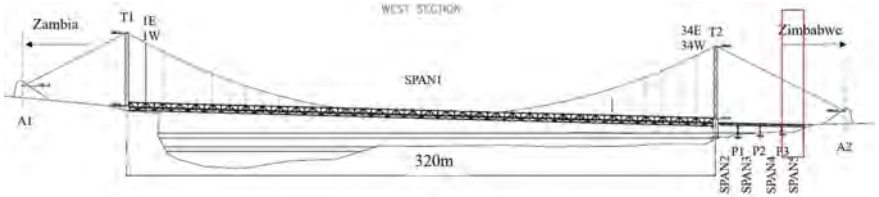
SPAN No.	Span 5
(one set of forms for each pier)	

Bridge ID

Bridge NAME Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Cable Saddle		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					
		Alignment / Deformation					
		Cracking					
		Delamination / Scaling					
		Water Leakage					
Cable Anchorage		Corrosion					
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing		Debris accumulation					
		Vegetation growth					
		Door locking					
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							

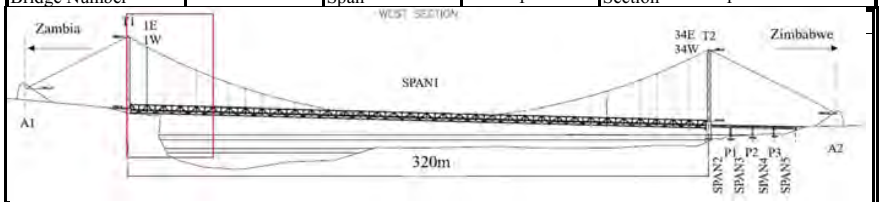


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	1



Railing (left side)

Expansion Joint and Deck Concrete

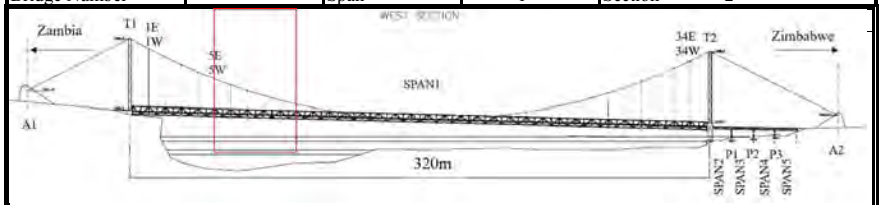
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	2



Railing (left side)

Expansion Joint and Deck Concrete

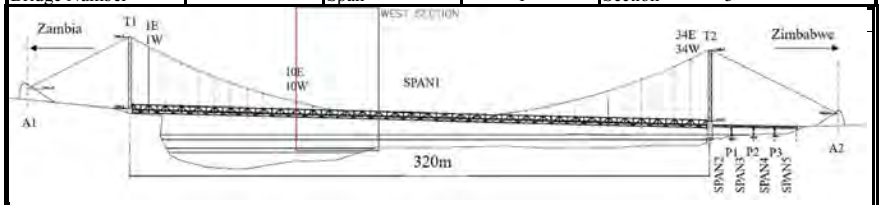
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	3



Railing (left side)

Expansion Joint and Deck Concrete

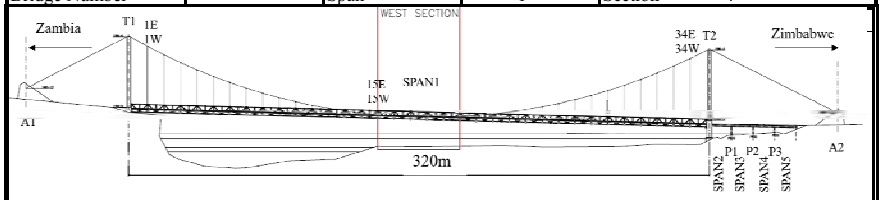
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	4



Railing (left side)

Expansion Joint and Deck Concrete

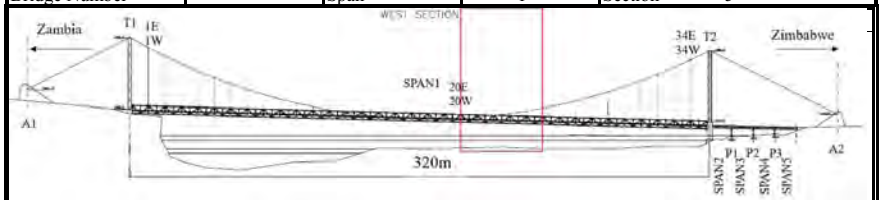
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	5



Railing (left side)

Expansion Joint and Deck Concrete

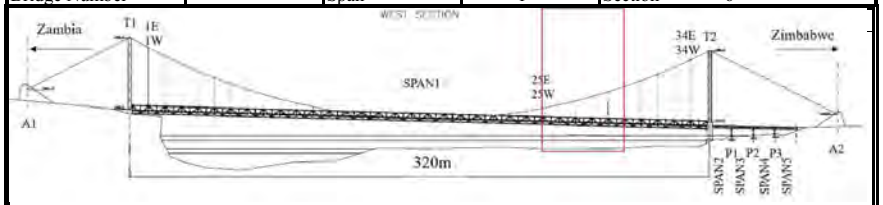
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	6



Railing (left side)

Expansion Joint and Deck Concrete

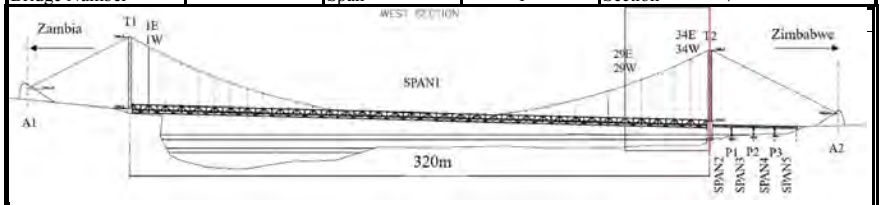
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	1	Section	7



Railing (left side)

Expansion Joint and Deck Concrete

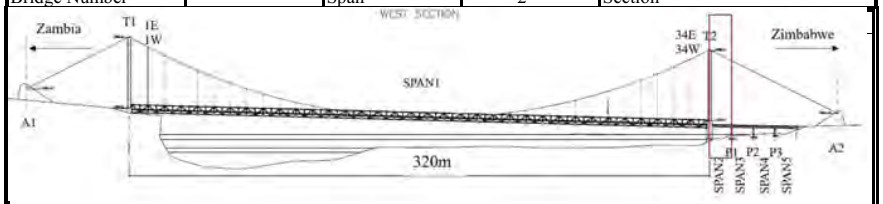
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	2	Section



Railing (left side)

Expansion Joint and Deck Concrete

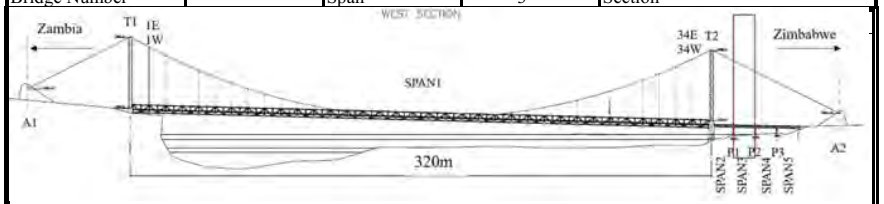
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	3	Section



Railing (left side)

Expansion Joint and Deck Concrete

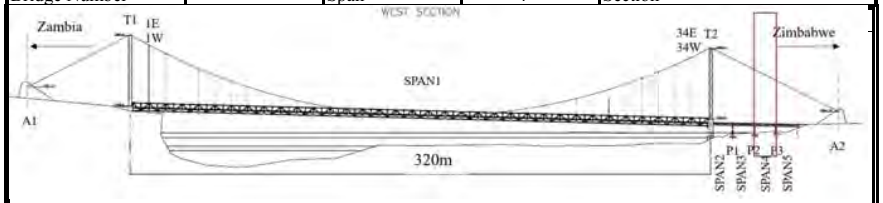
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	4	Section



Railing (left side)

Expansion Joint and Deck Concrete

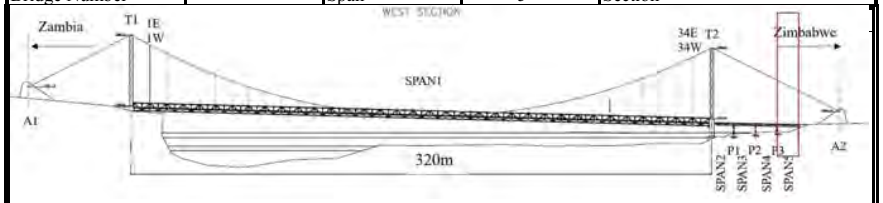
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span	5	Section



Railing (left side)

Expansion Joint and Deck Concrete

Railing (right side)

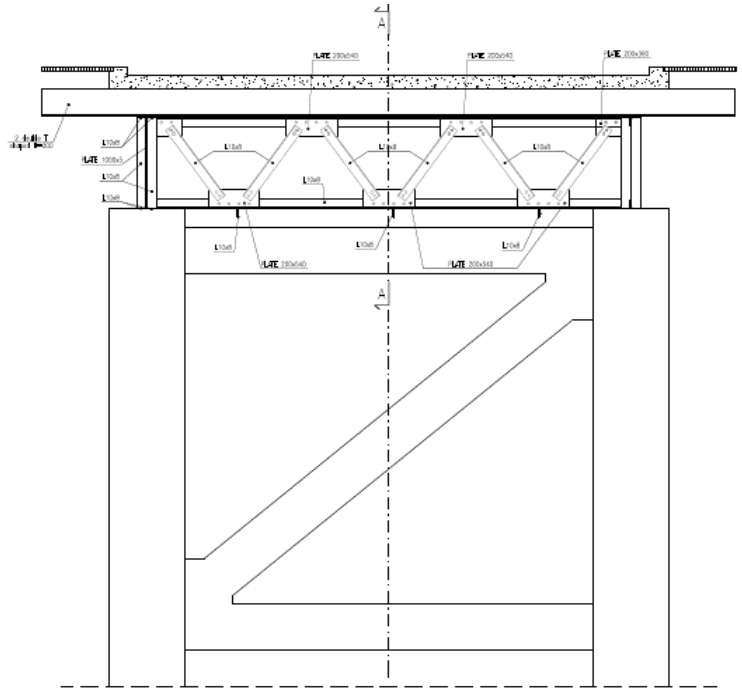
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		

765



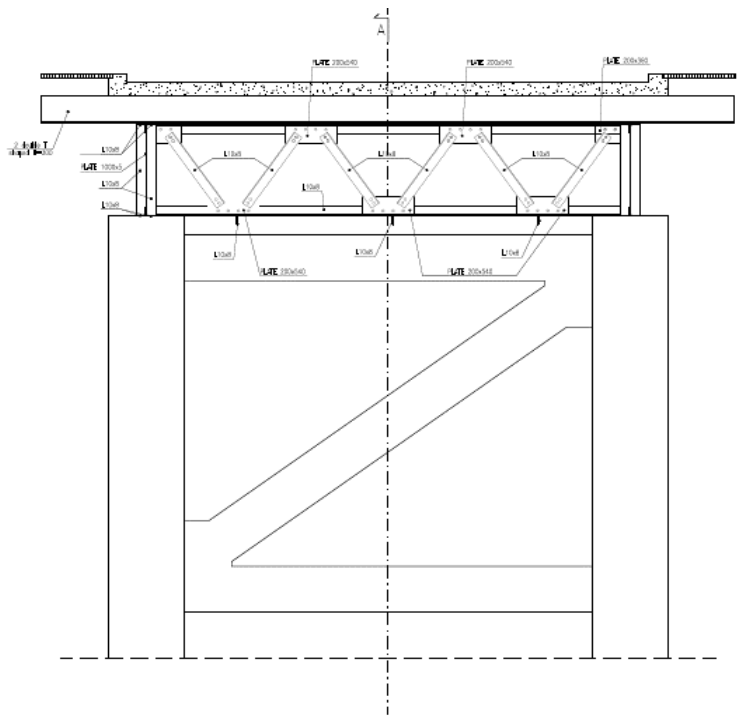
P1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		



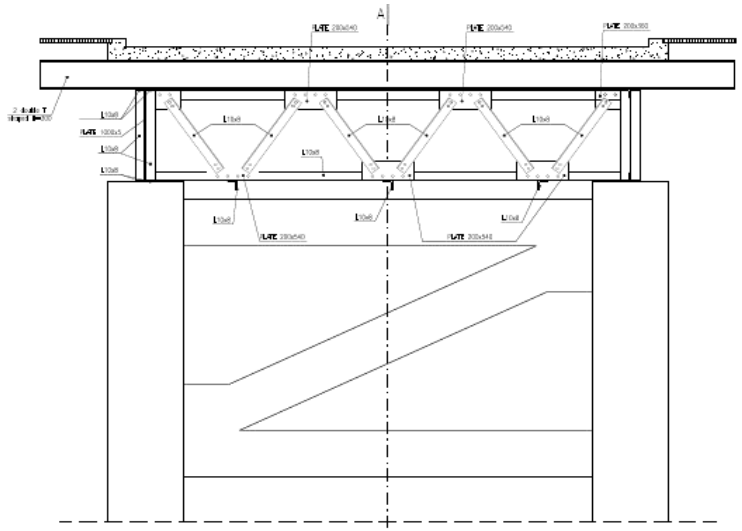
P2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		



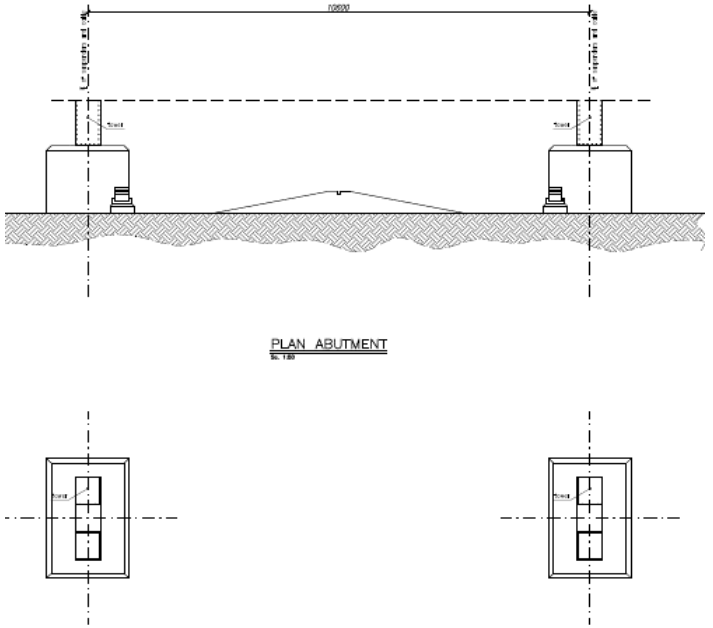
P3

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		



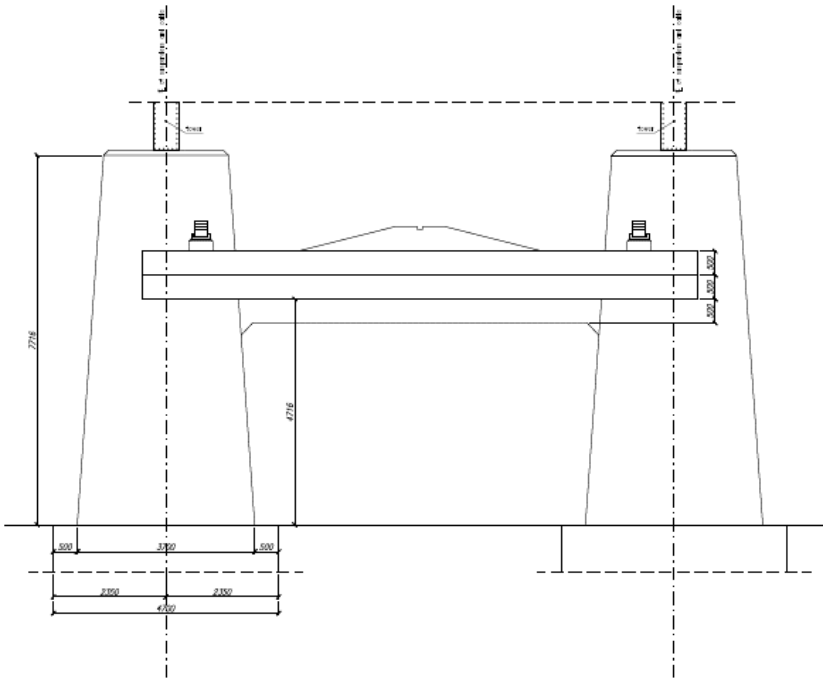
Tower1

【Damage Drawing】

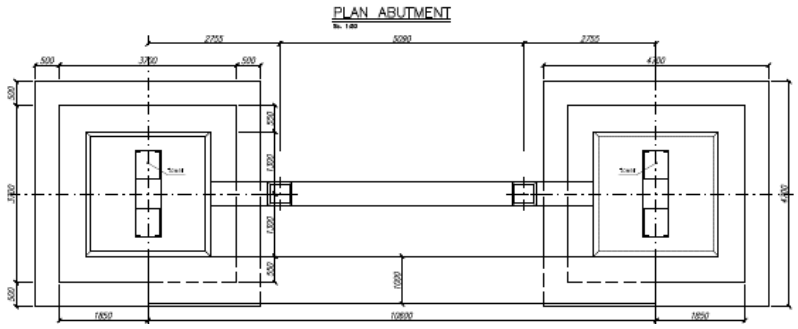
Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		



PLAN ABUTMENT



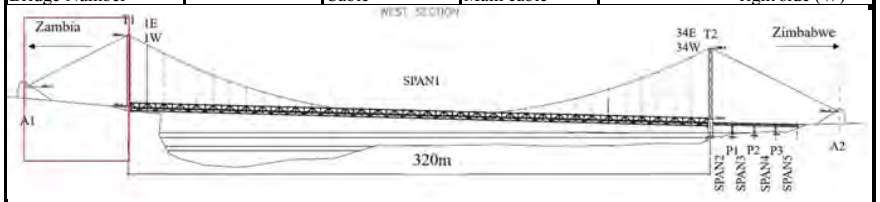
Tower2

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable	right side (W)

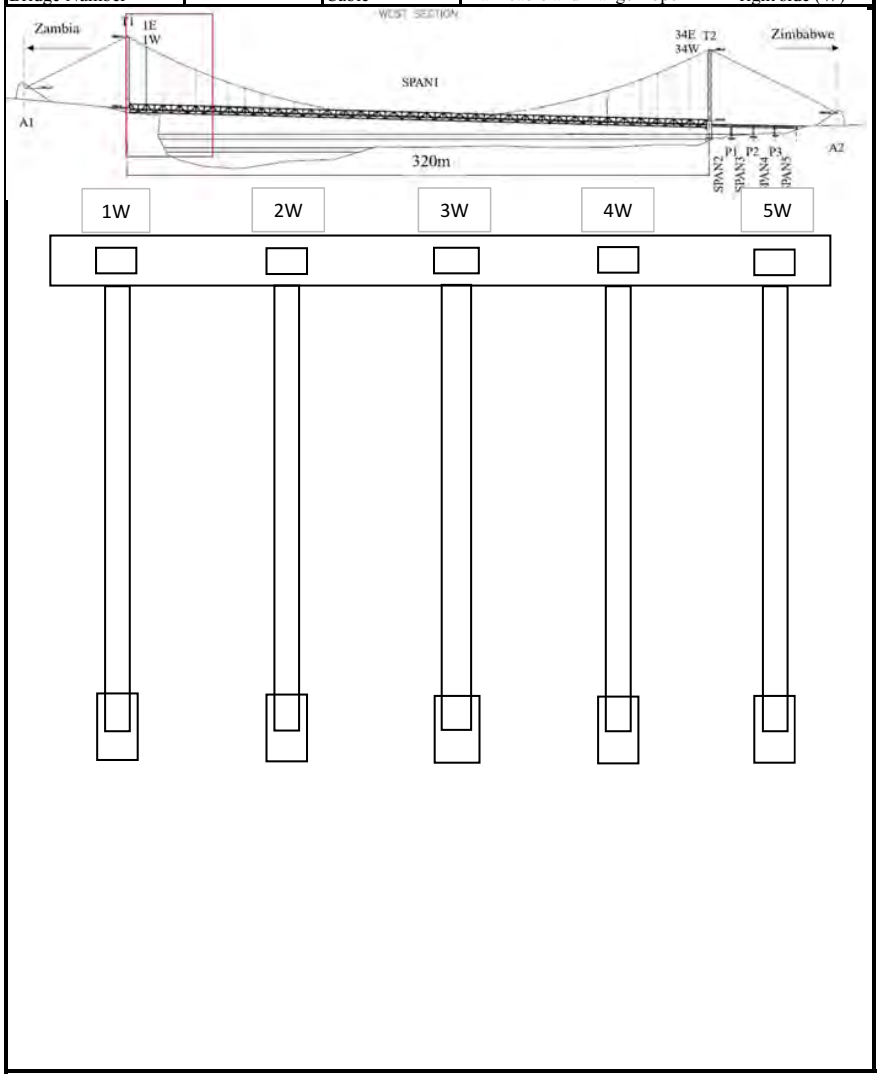


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

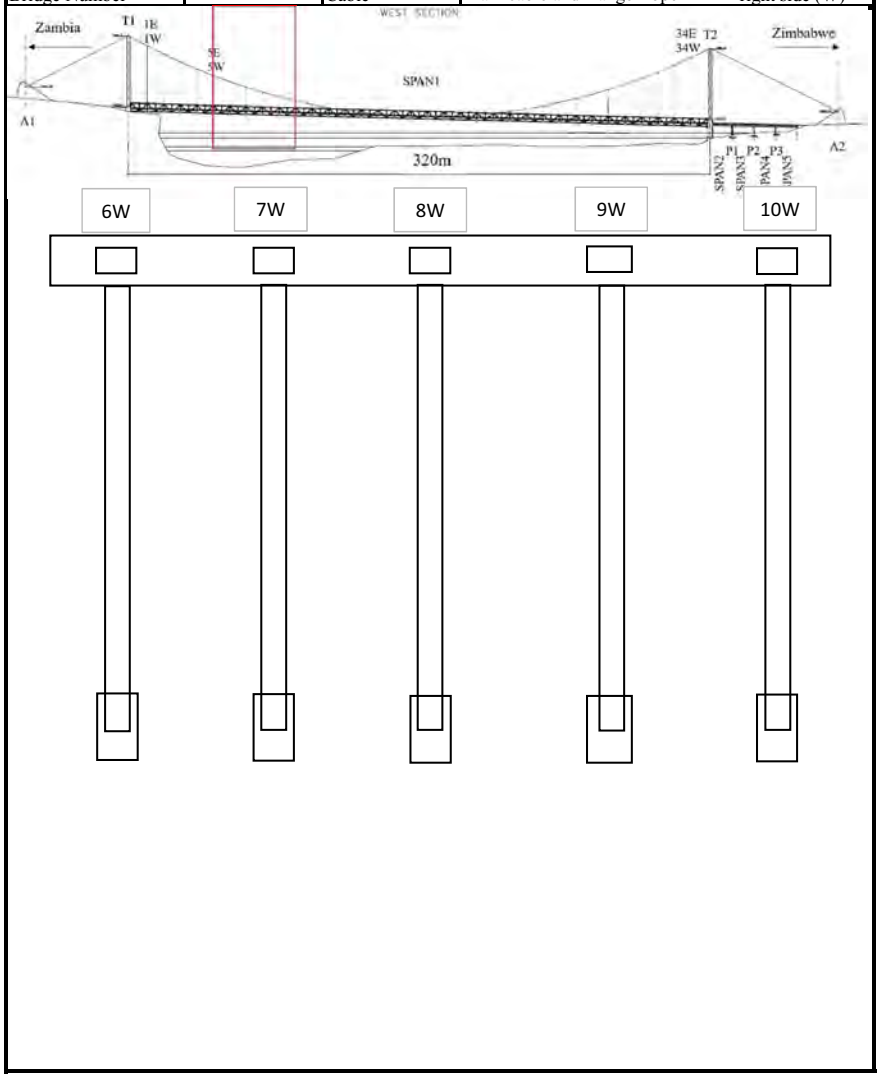


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

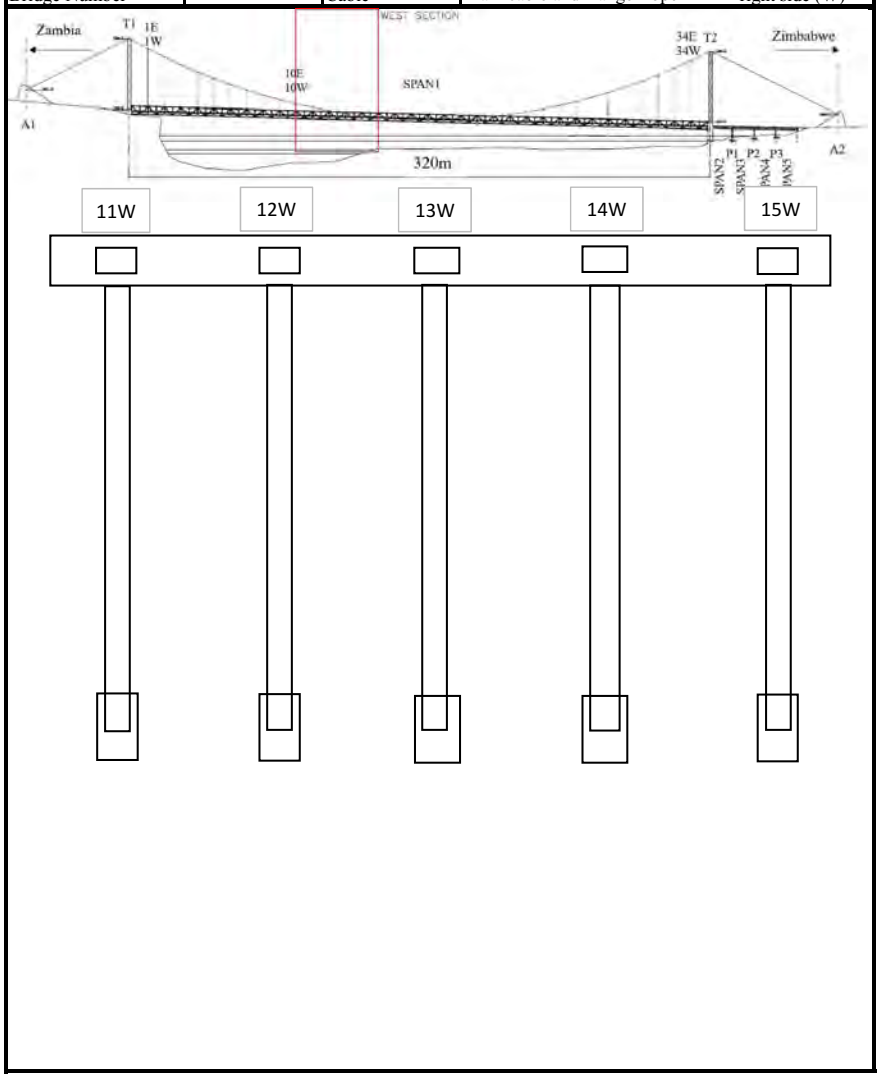


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

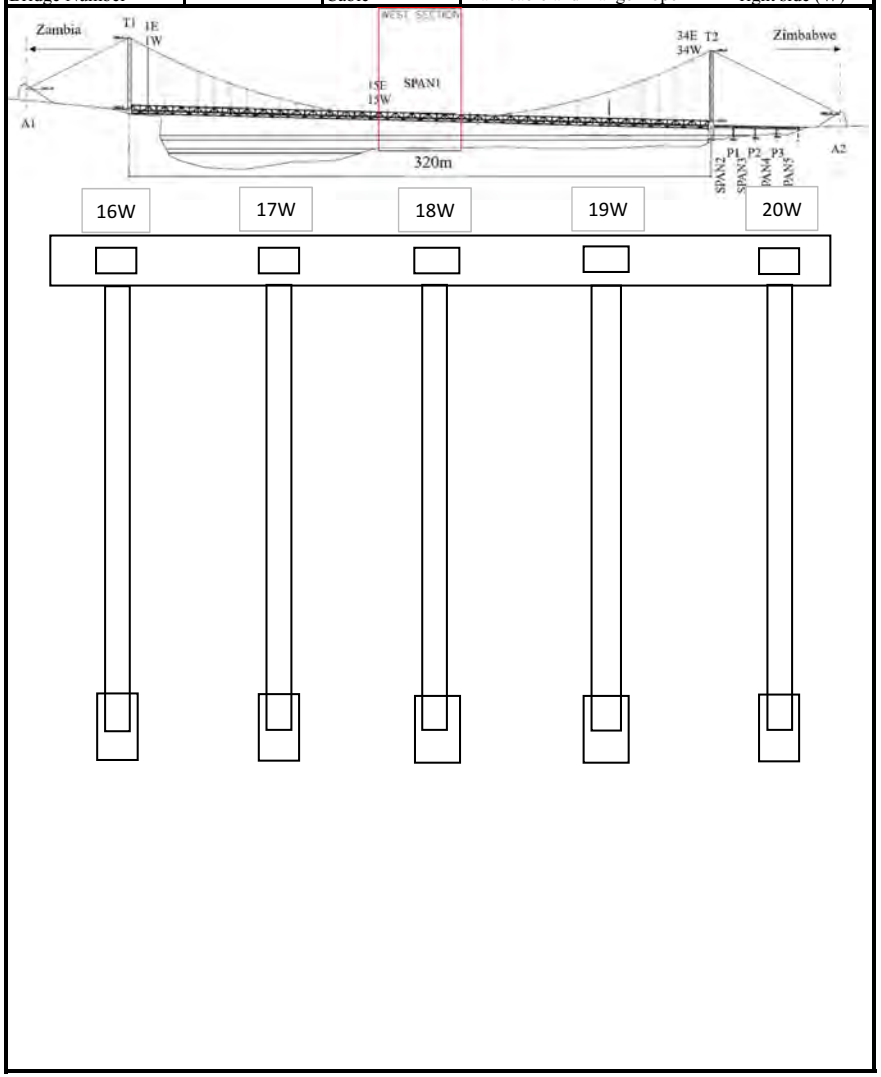


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

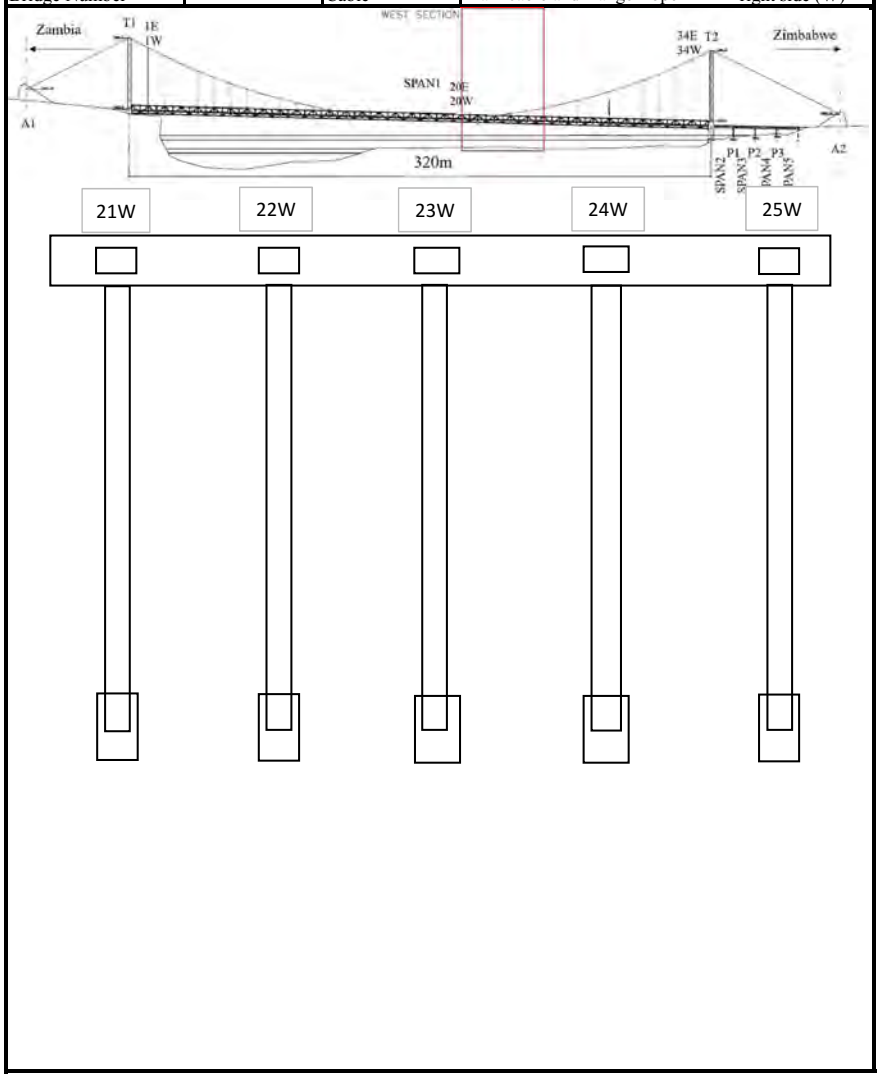


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

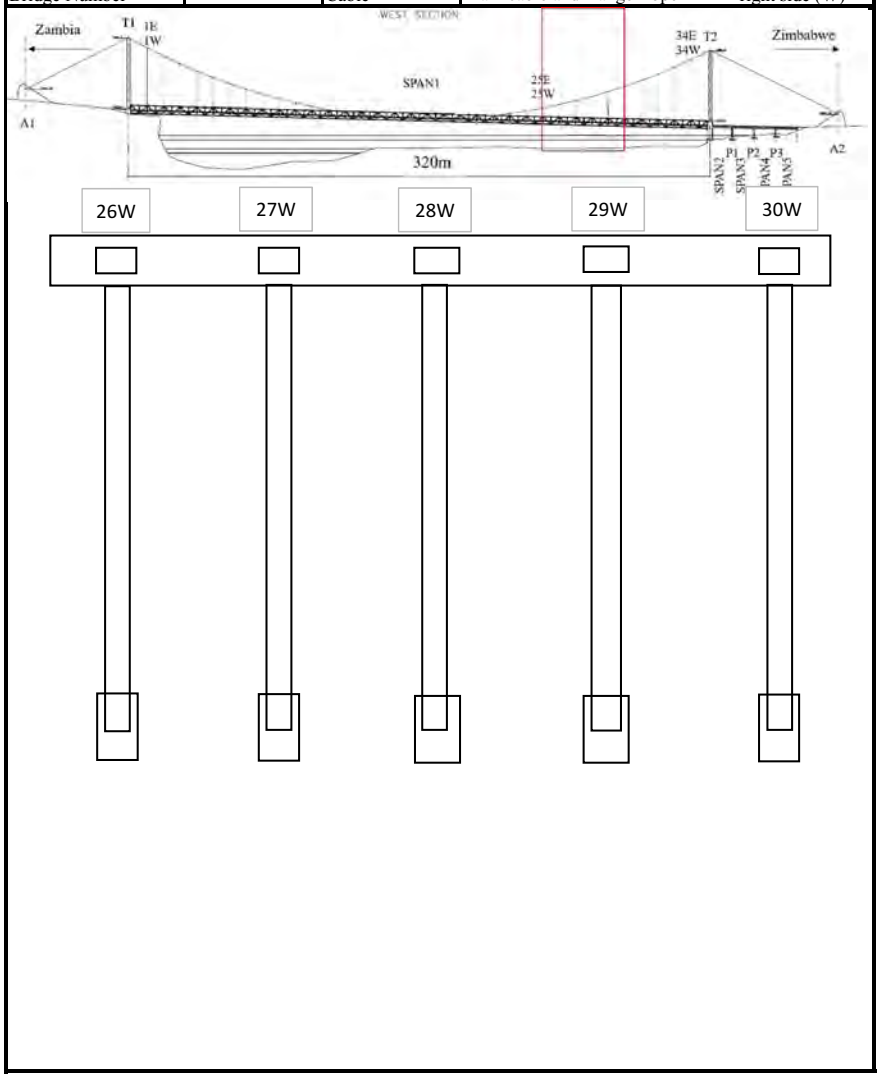


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)

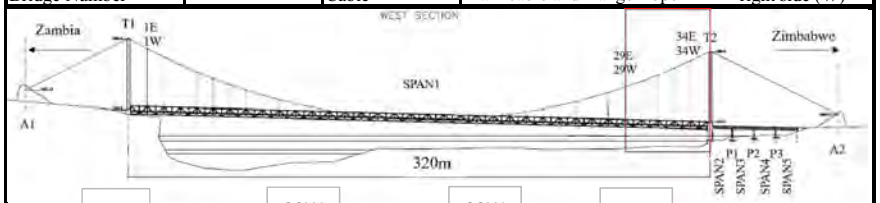


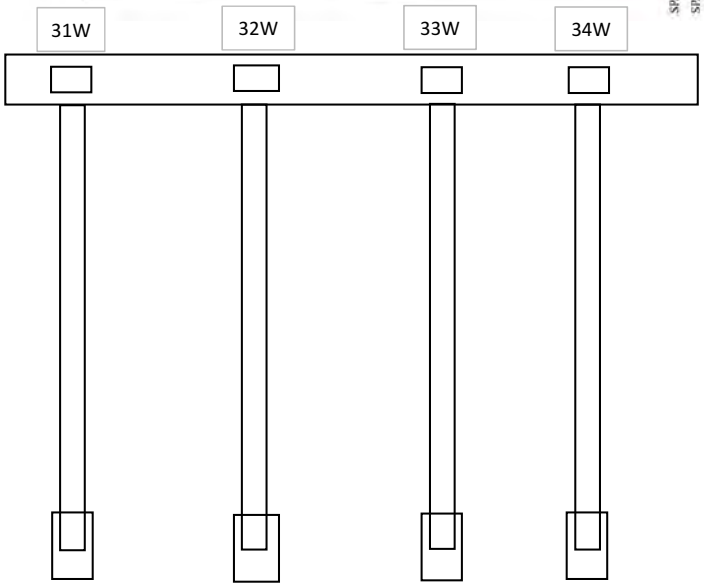
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)



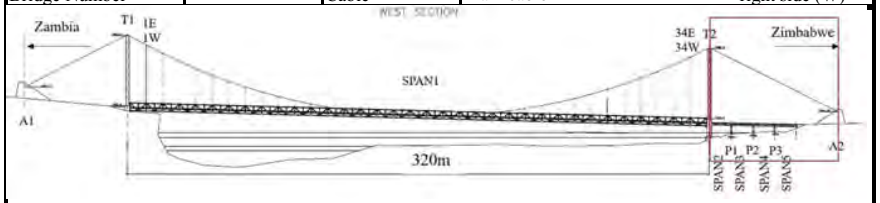


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable	right side (W)

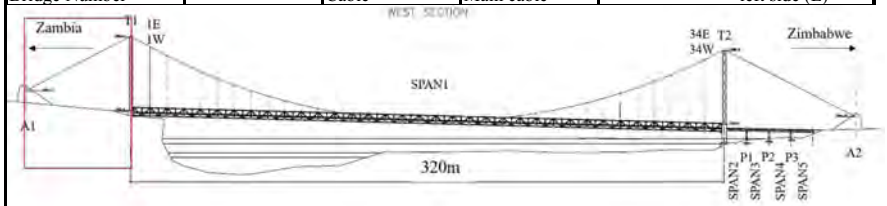


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable	left side (E)

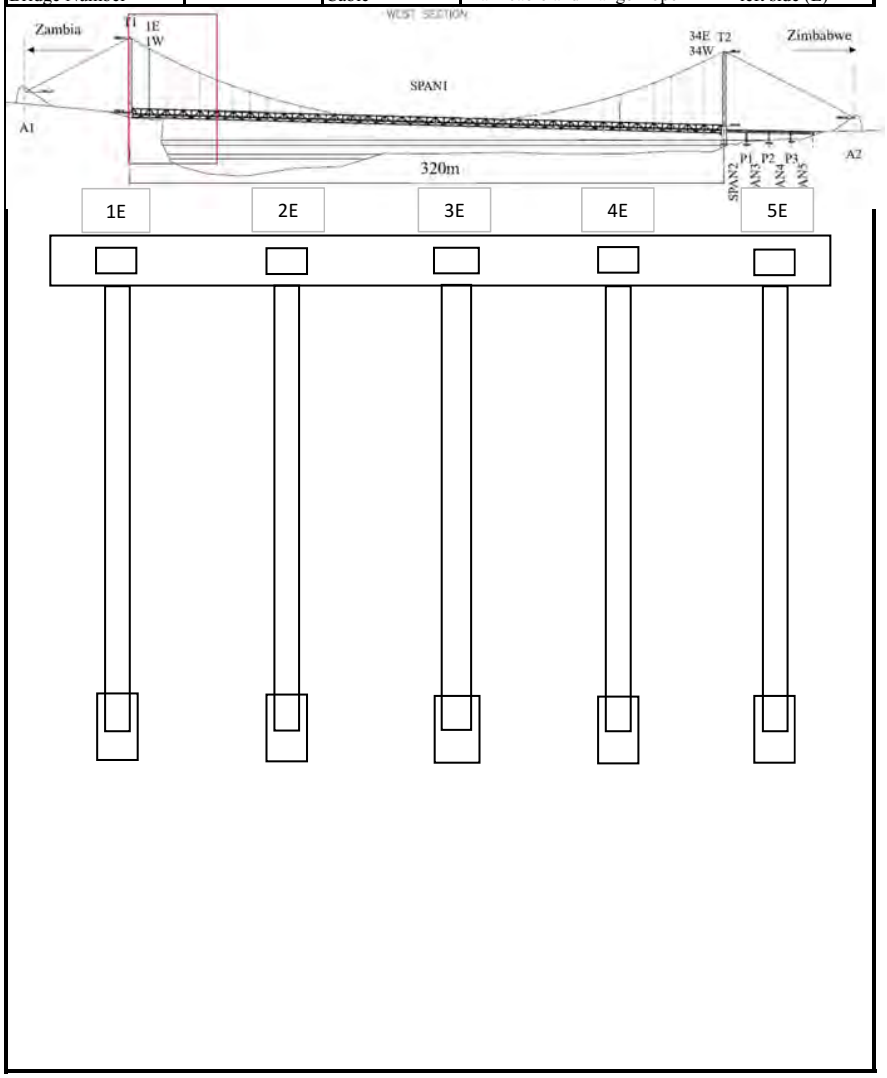


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)

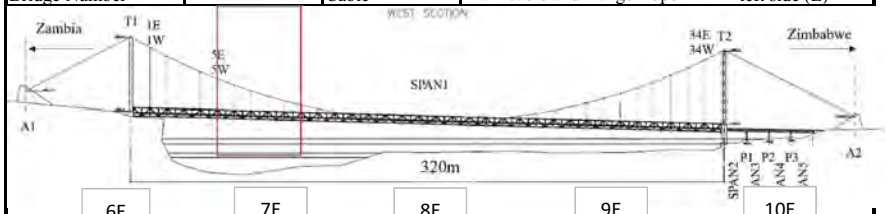


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)



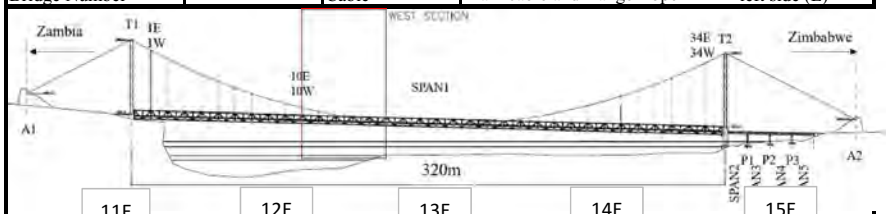
6E 7E 8E 9E 10E

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)



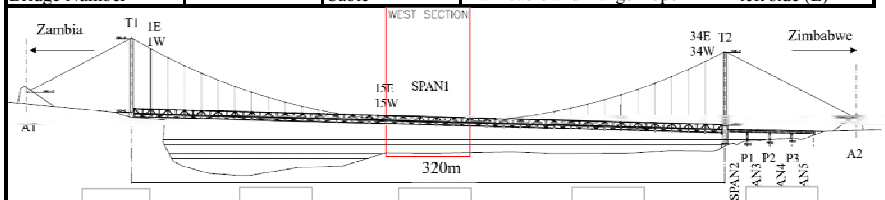
11E 12E 13E 14E 15E

【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)

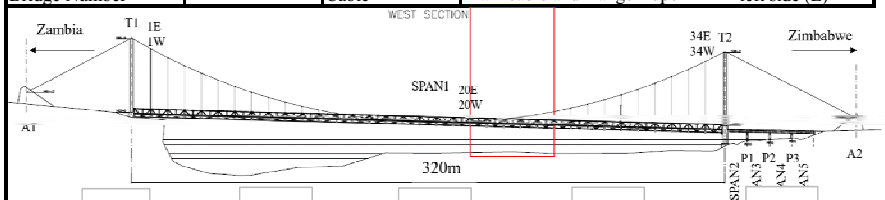


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)

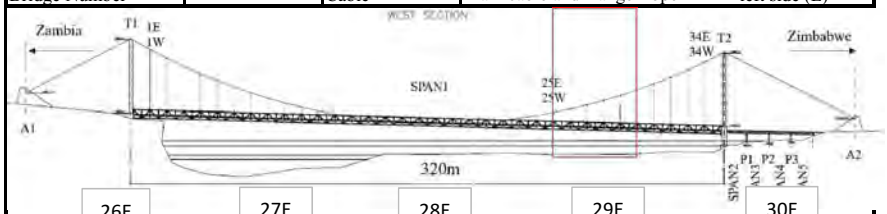


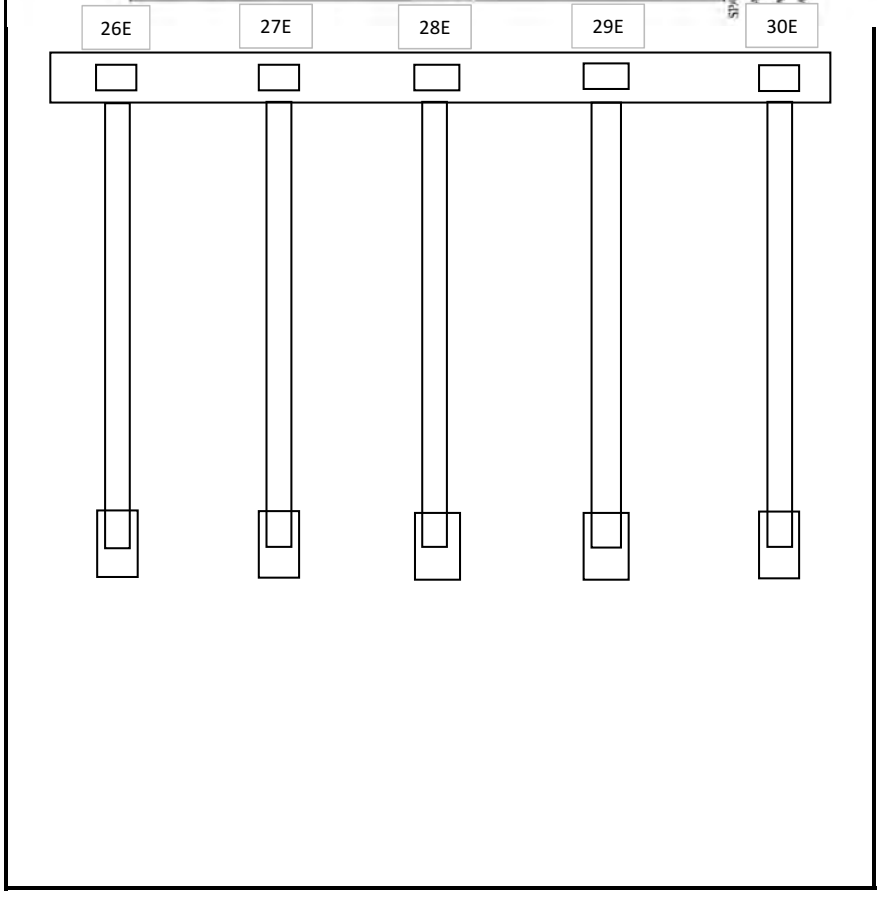
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)



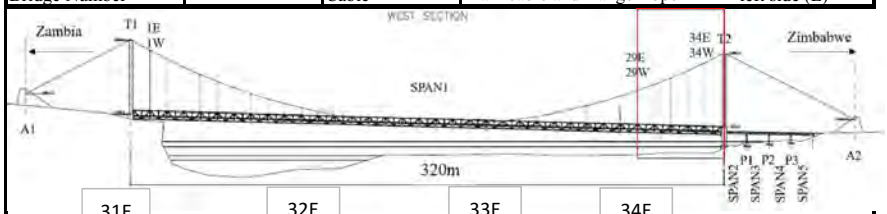


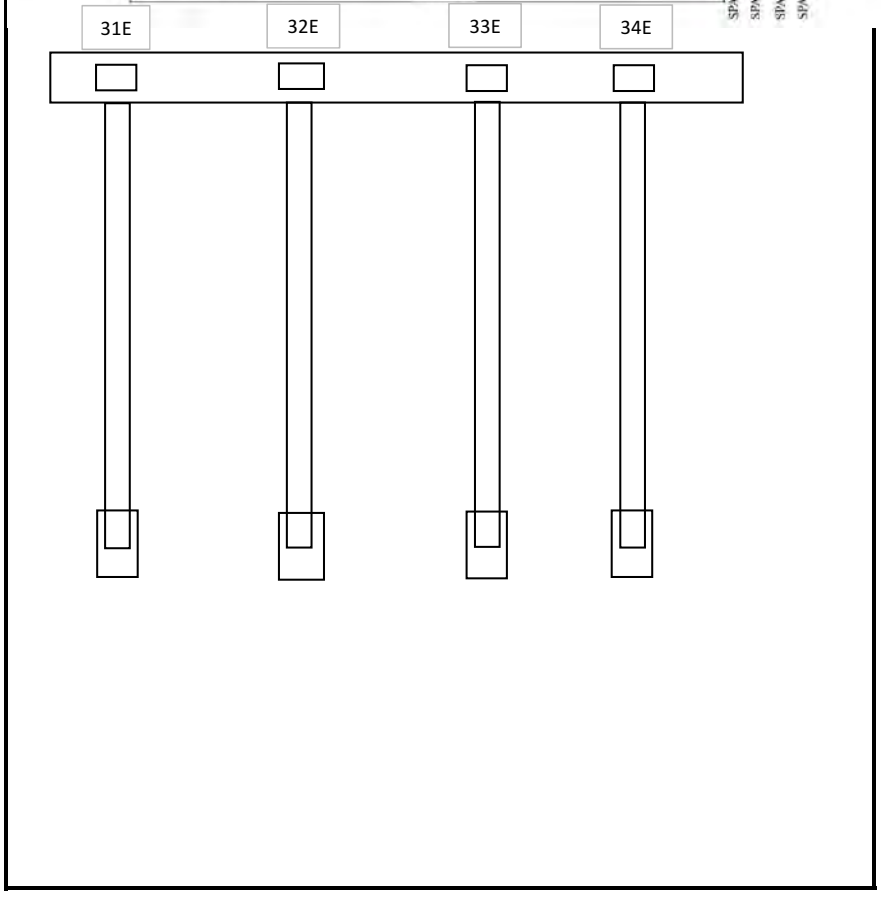
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	left side (E)



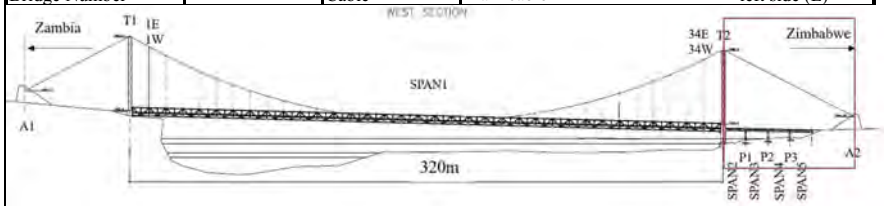


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable	left side (E)

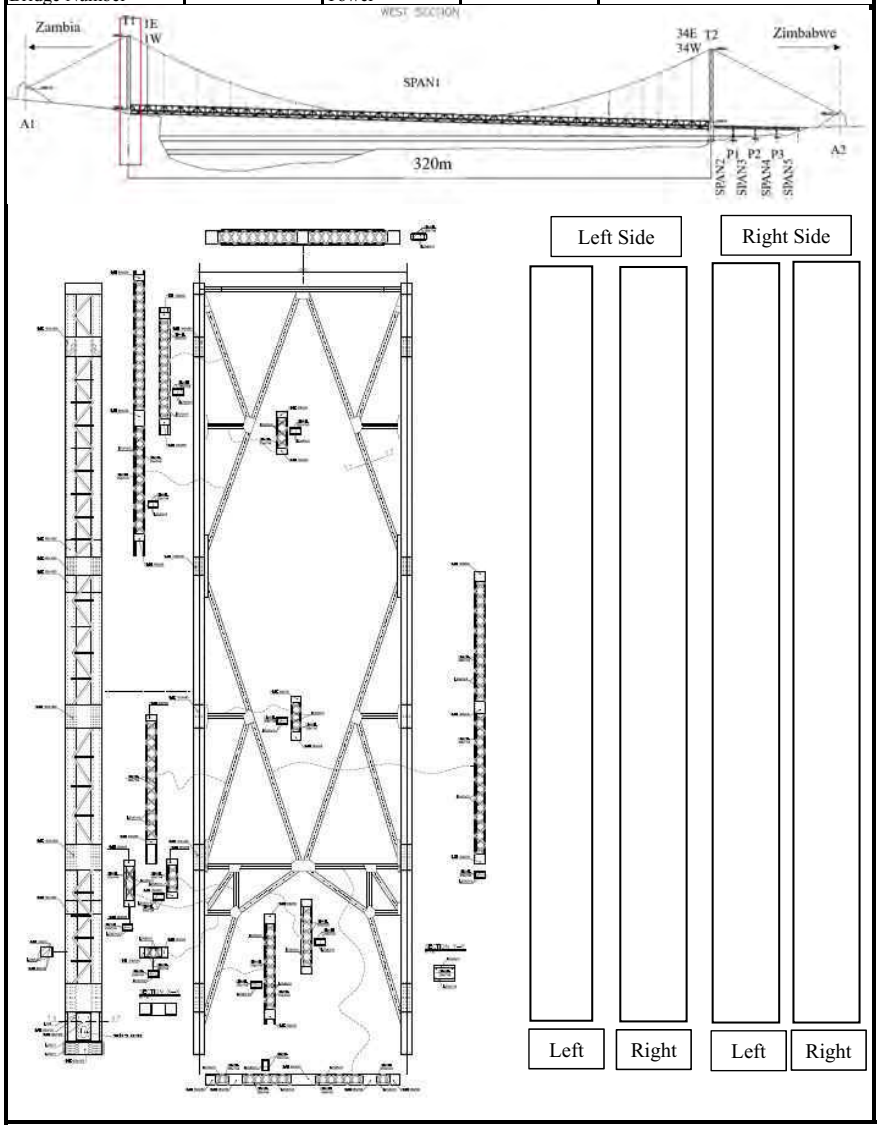


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Tower		

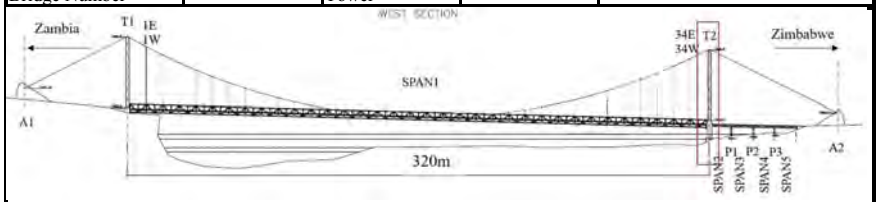


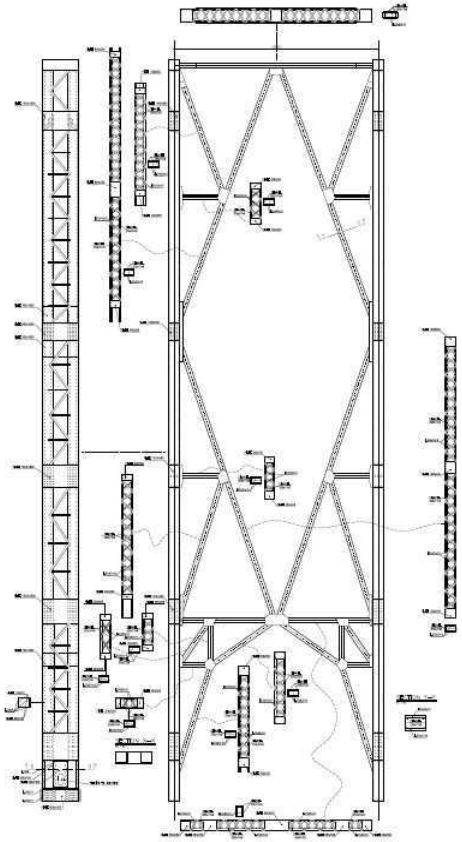
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Tower		





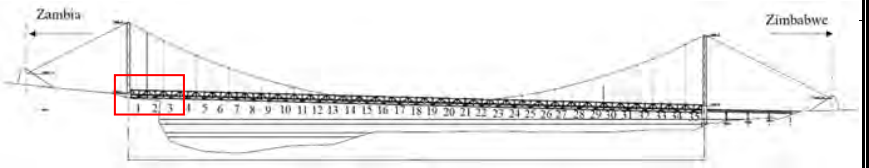
Left Side		Right Side	
Left	Right	Left	Right

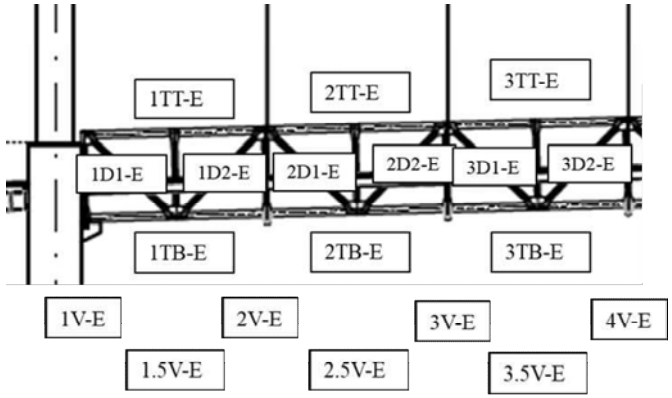
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

member name

○V-△

left	ZMB	right	ZIM

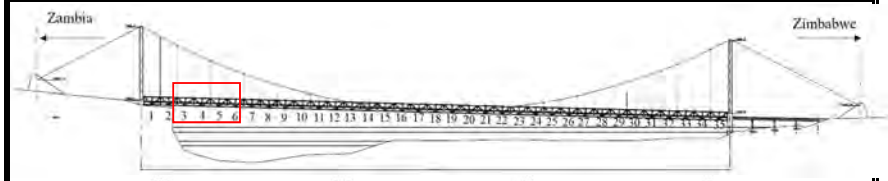
※○: number
△: E or W (east or west)

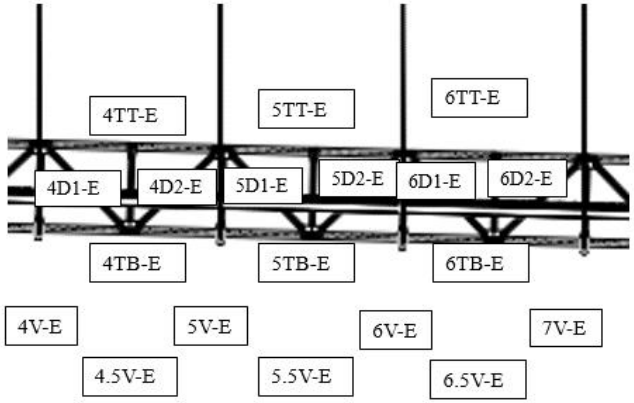
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

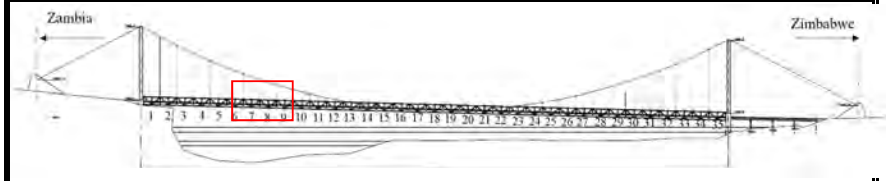
※○: number
△: E or W (east or west)

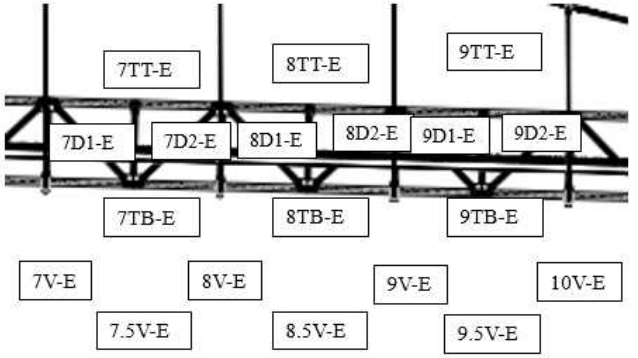
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

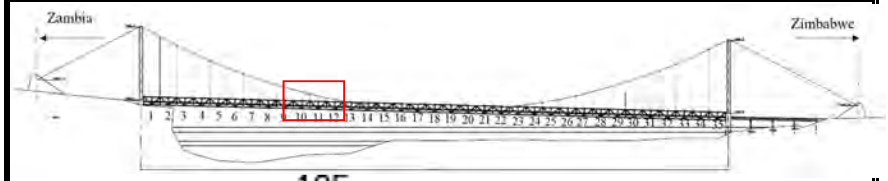
※○: number
△: E or W (east or west)

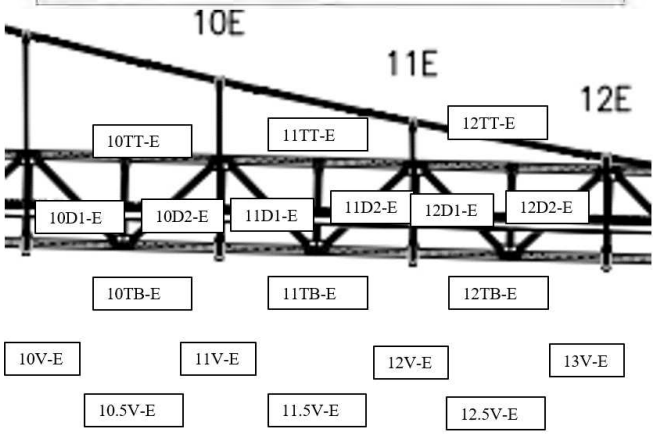
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

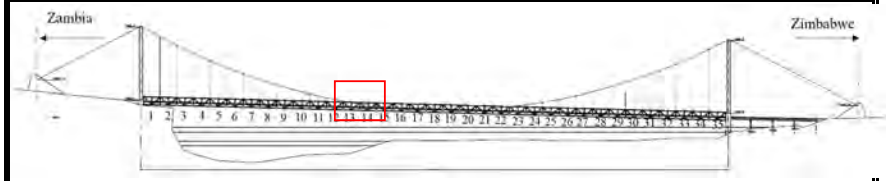
※○: number
△: E or W (east or west)

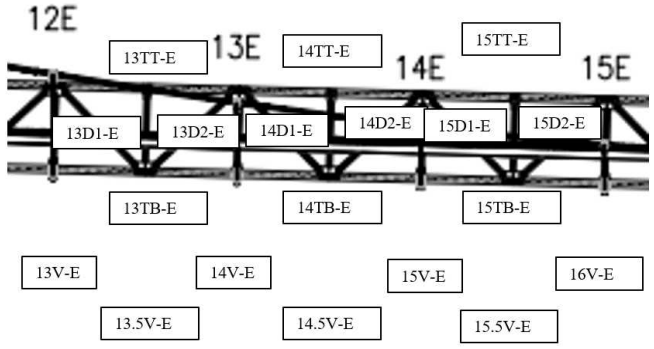
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

※○: number
△: E or W (east or west)

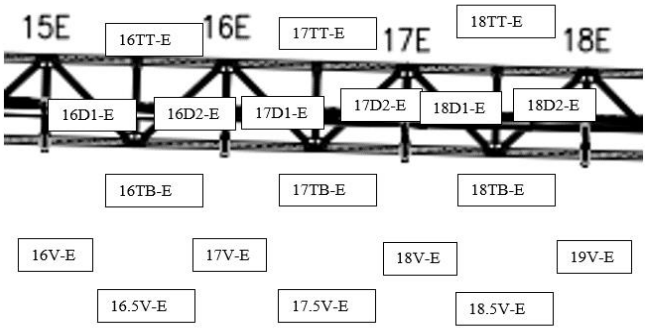
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

※○: number
△: E or W (east or west)

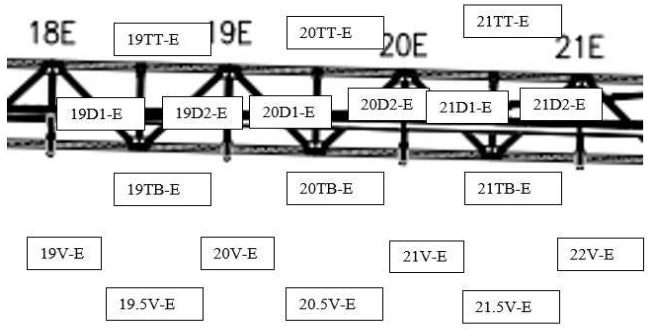
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

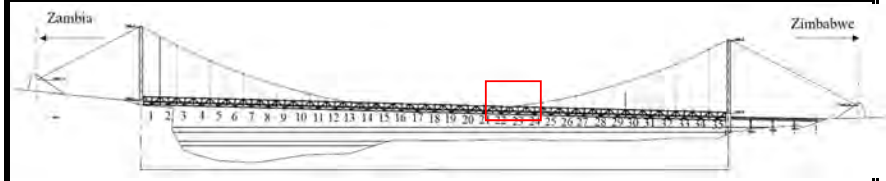
※○: number
△: E or W (east or west)

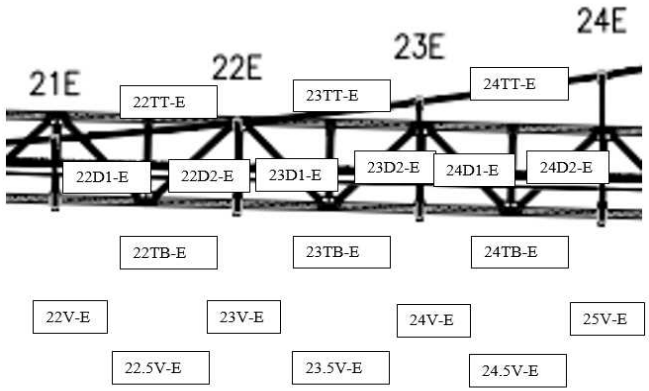
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

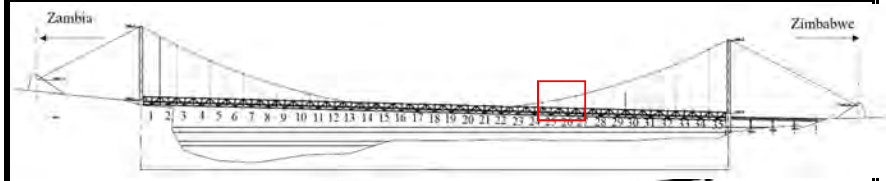
※○: number
△: E or W (east or west)

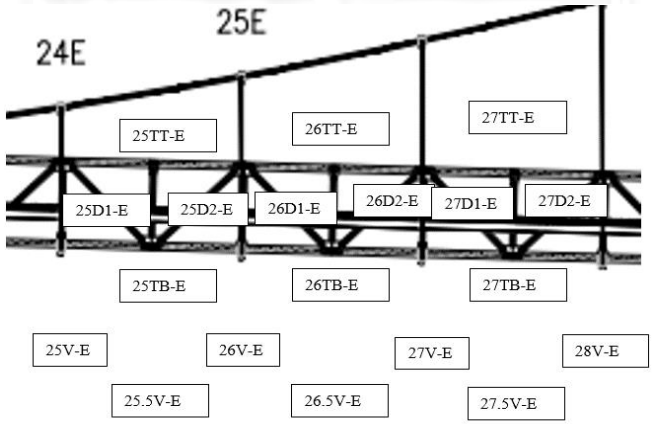
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

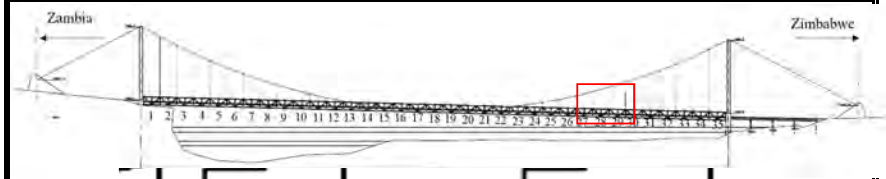
※○: number
△: E or W (east or west)

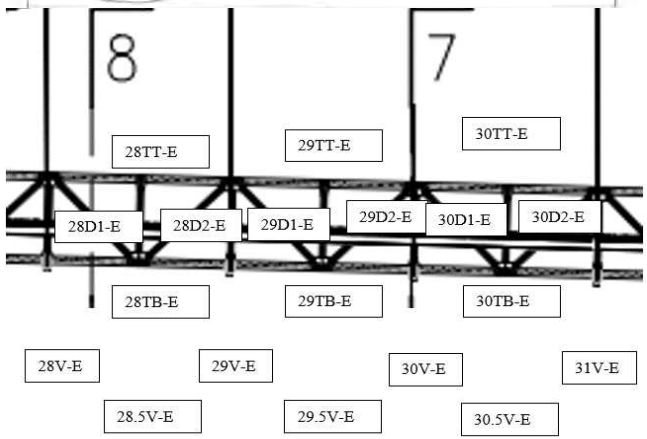
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name [ ]

○TT-△
or
○TB-△
or
○D○-△

Up side [ ]

Bottom side [ ]

Left side [ ]

Right side [ ]

member name [ ]

○V-△

left	ZMB	right	ZIM

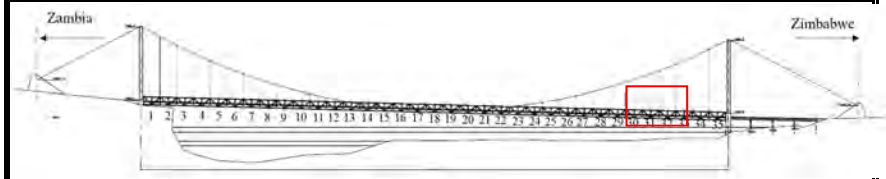
※○: number
△: E or W (east or west)

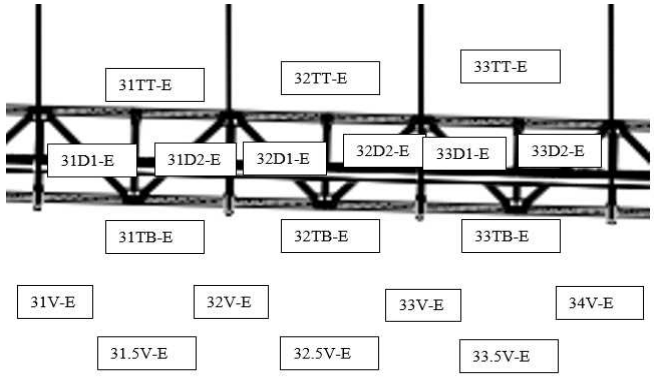
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name [ ]

○TT-△
or
○TB-△
or
○D○-△

Up side [ ]

Bottom side [ ]

Left side [ ]

Right side [ ]

member name [ ]

○V-△

left	ZMB	right	ZIM

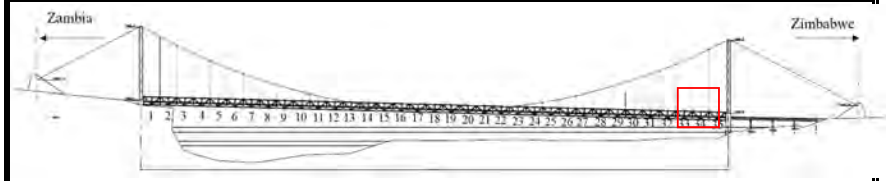
※○: number
△: E or W (east or west)

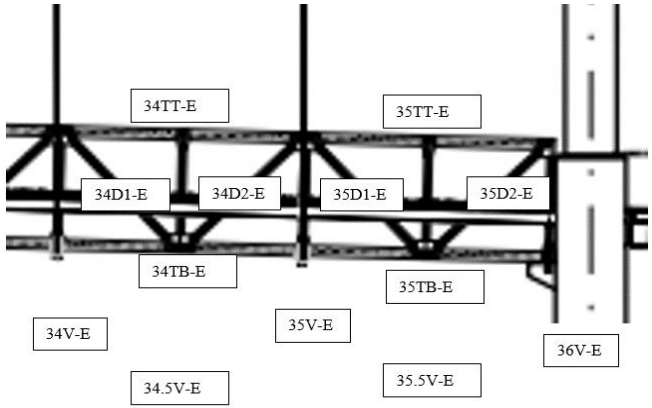
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

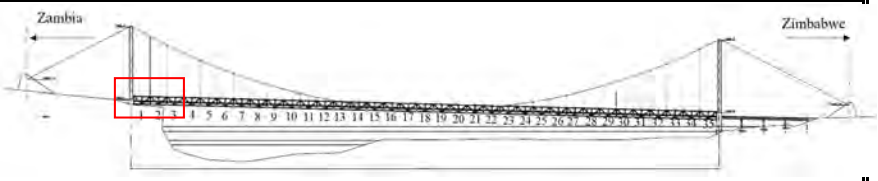
※○: number
△: E or W (east or west)

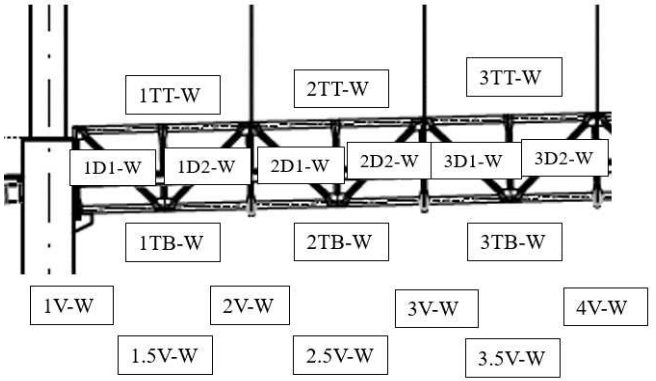
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

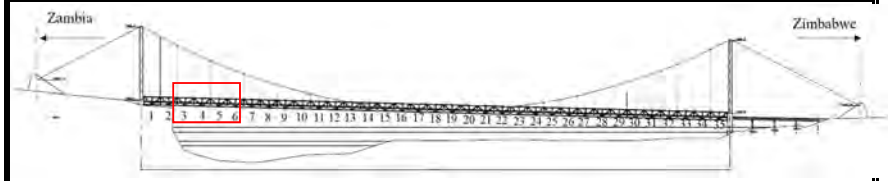
※○: number
△: E or W (east or west)

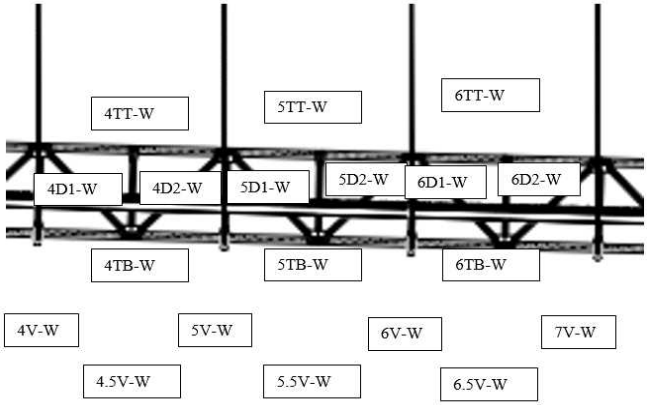
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

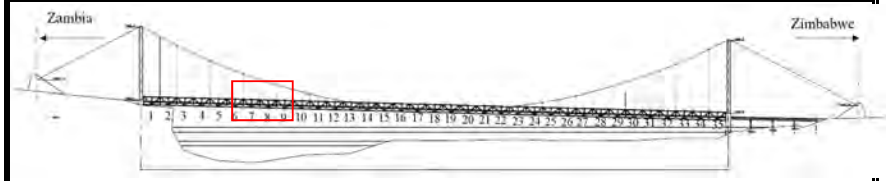
※○: number
△: E or W (east or west)

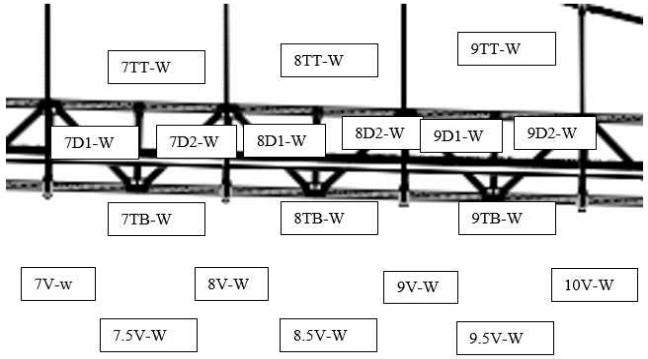
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

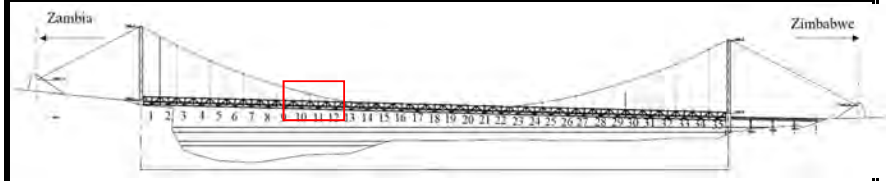
※○: number
△: E or W (east or west)

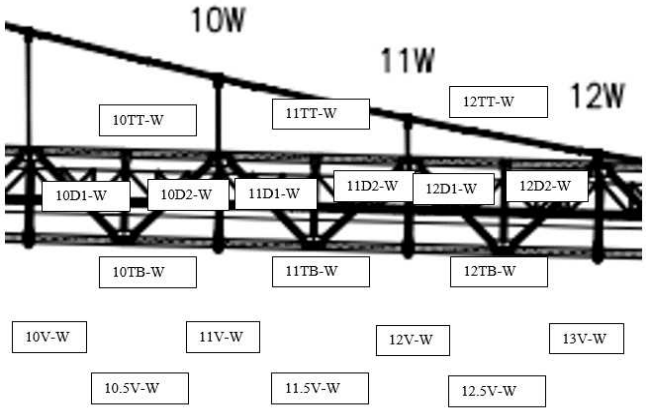
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name				
			left	ZMB	right	ZIM
○TT-△ or ○TB-△ or ○D○-△	Up side	○V-△				
	Bottom side					
	Left side					
	Right side					

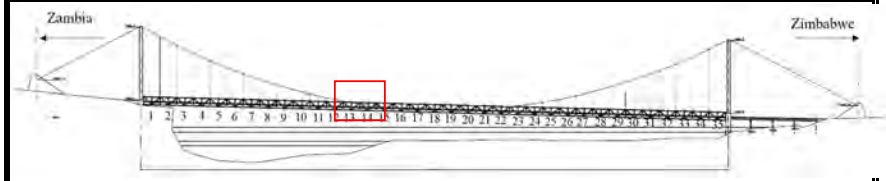
※○：number
△：E or W (east or west)

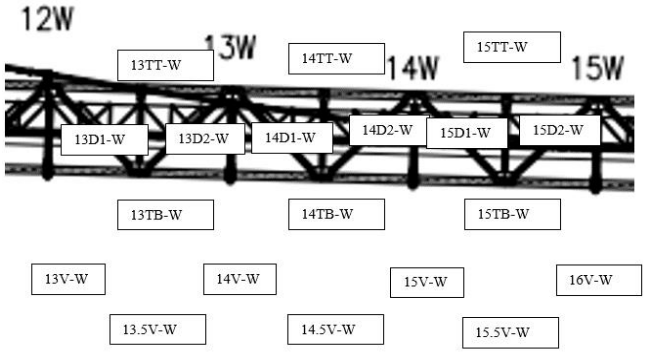
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name				
			left	ZMB	right	ZIM
○TT-△ or ○TB-△ or ○D○-△	Up side	○V-△				
	Bottom side					
	Left side					
	Right side					

※○：number
△：E or W (east or west)

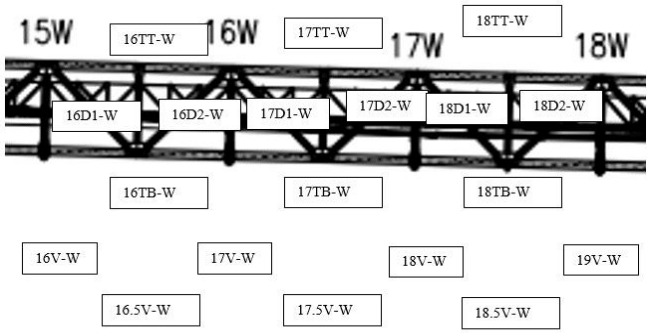
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

※○: number
△: E or W (east or west)

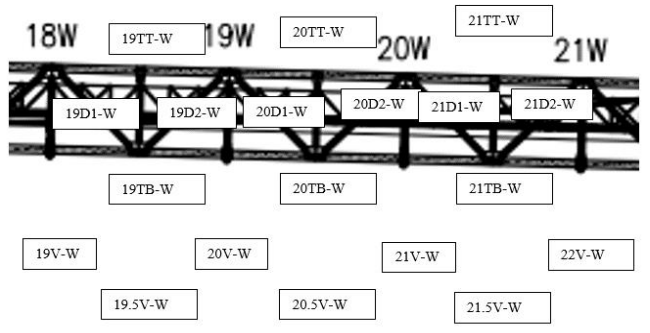
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

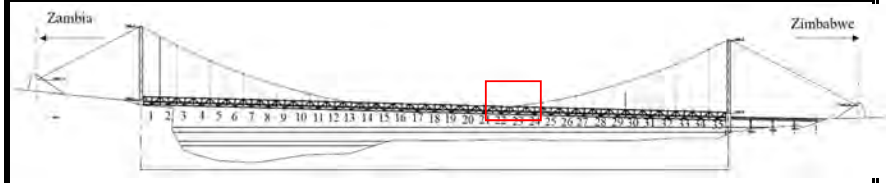
※○: number
△: E or W (east or west)

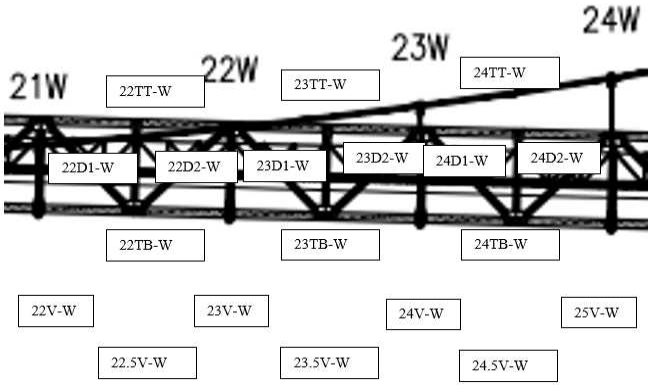
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

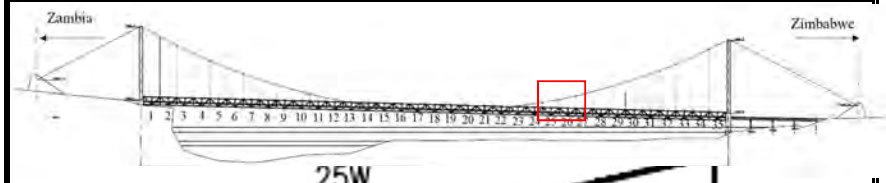
※○: number
△: E or W (east or west)

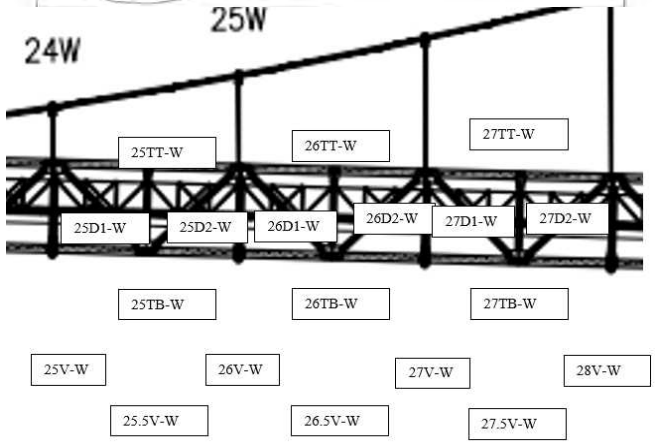
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left ZMB right ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

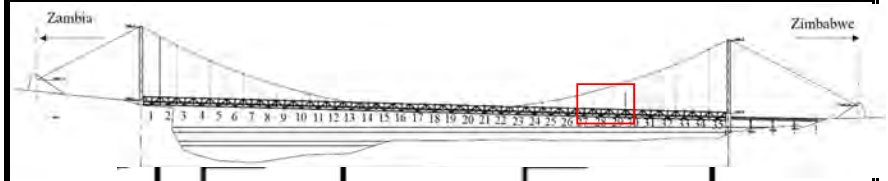
※○: number
△: E or W (east or west)

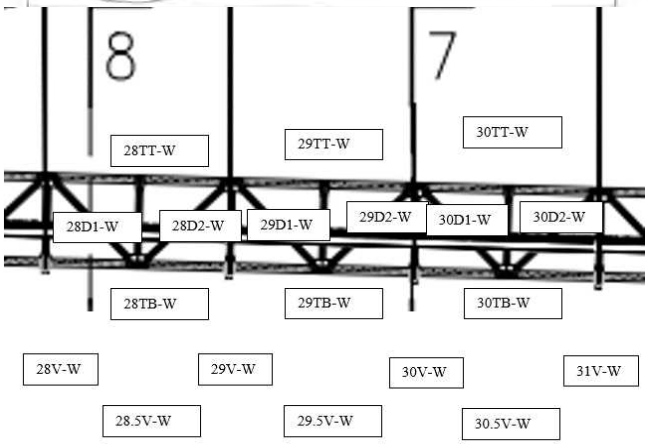
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left	ZMB	right	ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

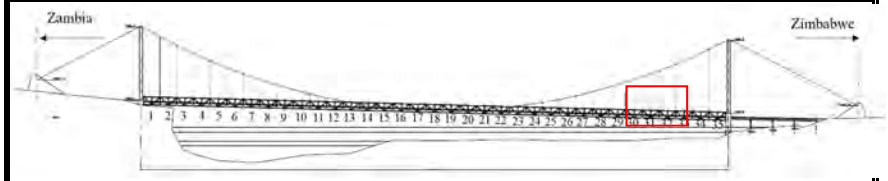
※○: number
△: E or W (east or west)

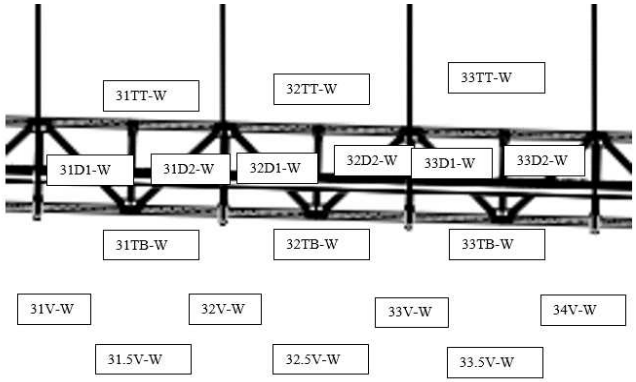
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

left	ZMB	right	ZIM

○TT-△
or
○TB-△
or
○D○-△

Up side

Bottom side

Left side

Right side

○V-△

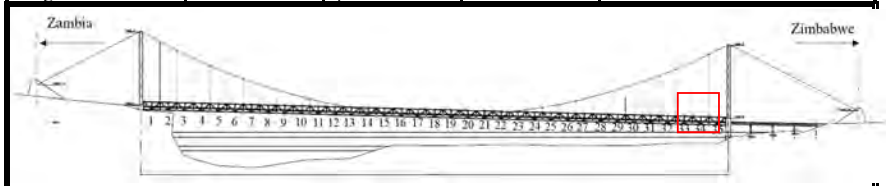
※○: number
△: E or W (east or west)

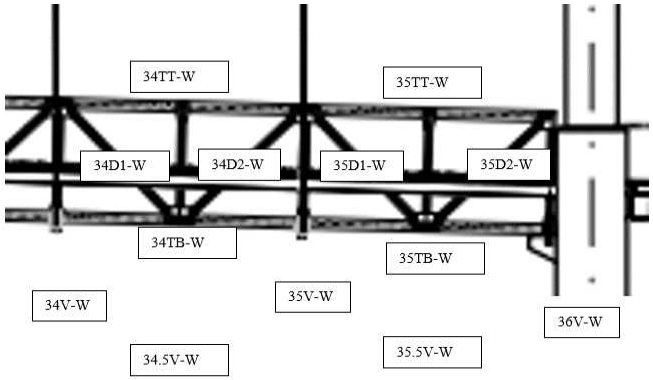
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○TT-△ or ○TB-△ or ○D○-△	Up side	○V-△					
	Bottom side						
	Left side						
	Right side						

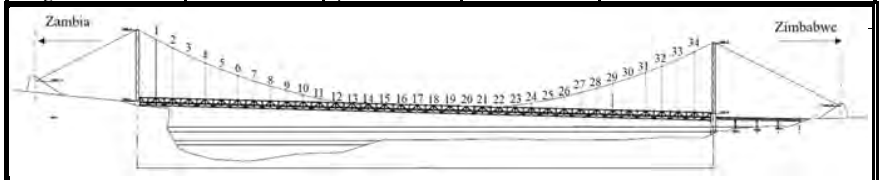
※○：number
△：E or W (east or west)

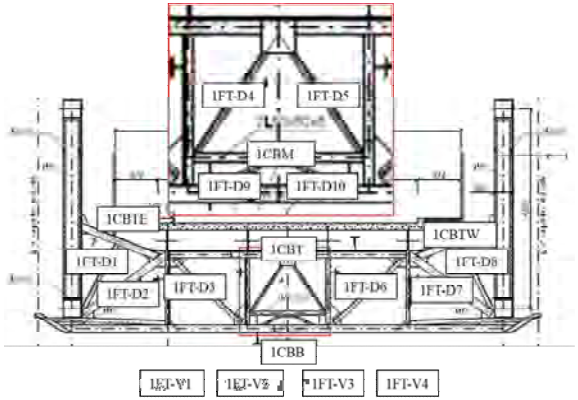
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○					
	Bottom side						
	Zambia						
	Zimbabwe						

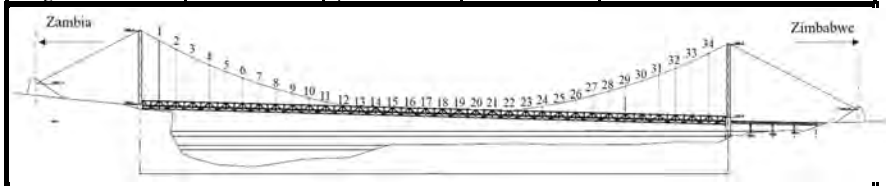
※○：number

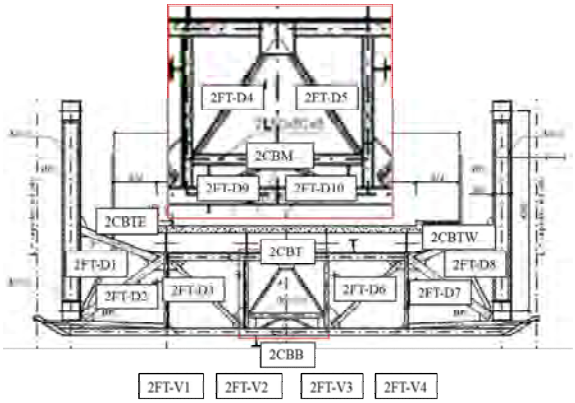
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

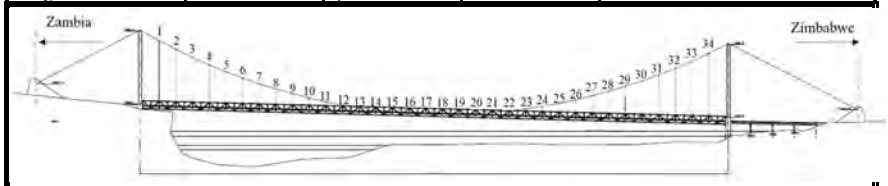
※○：number

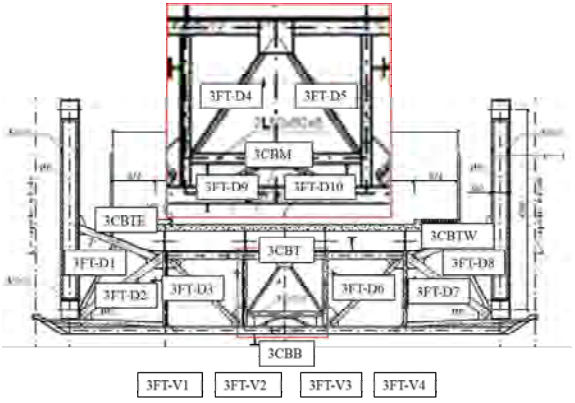
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

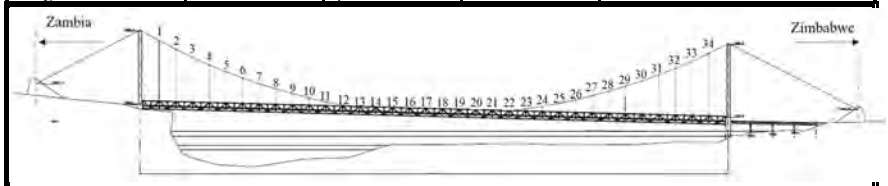
※○：number

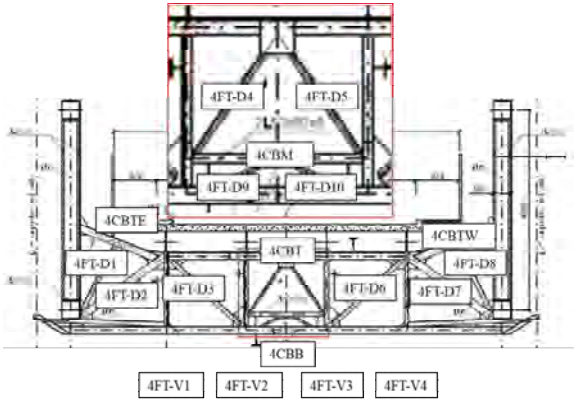
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

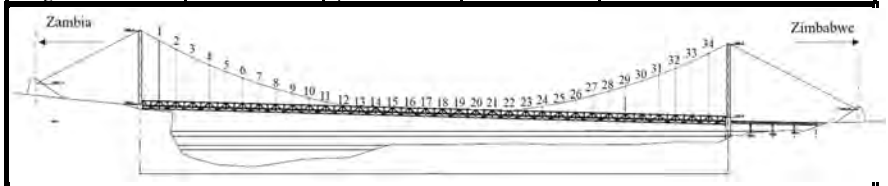
※○：number

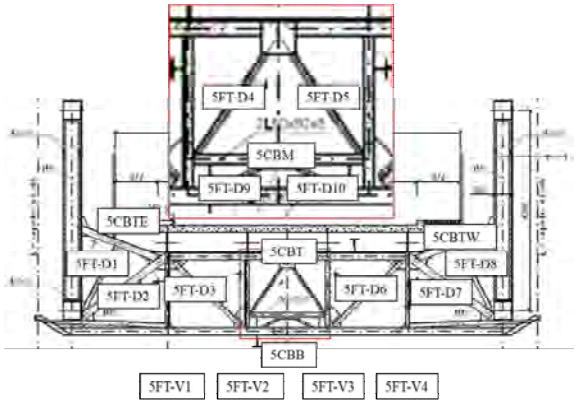
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

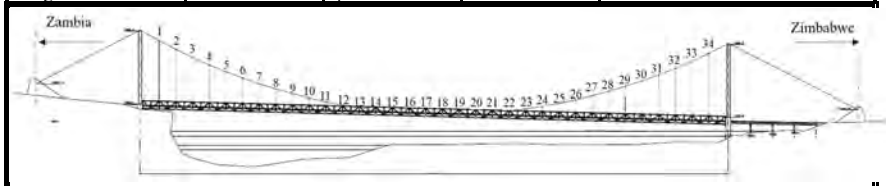
※○：number

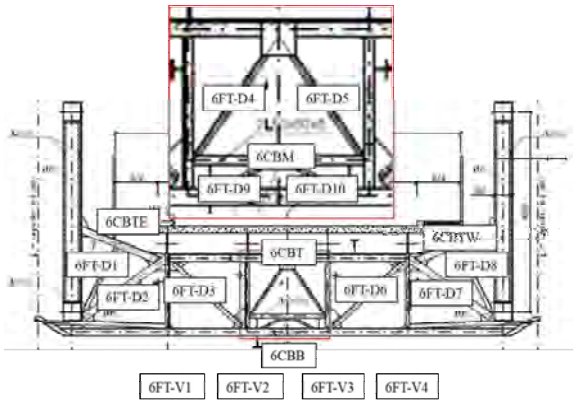
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

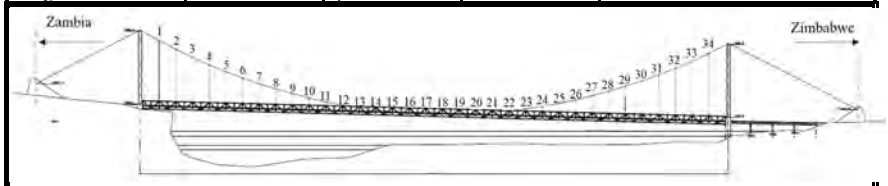
※○：number

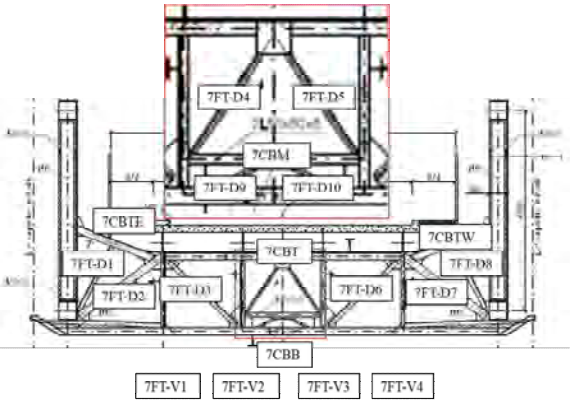
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

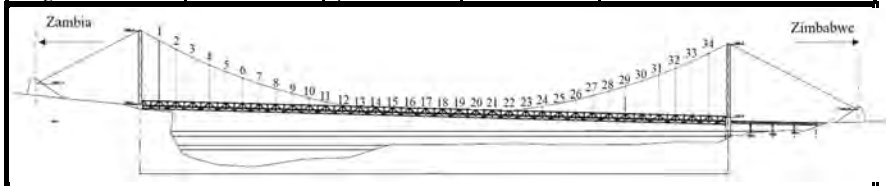
※○：number

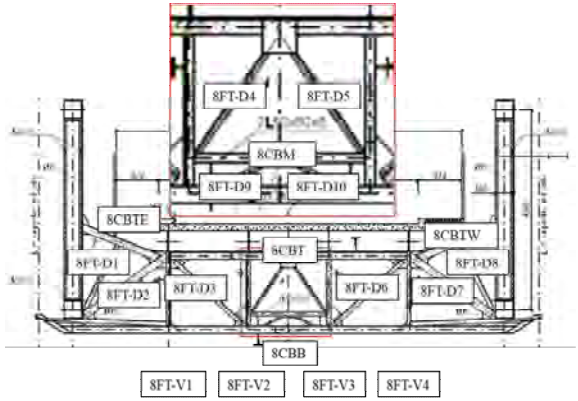
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

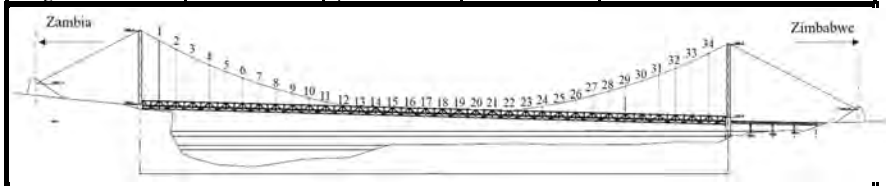
※○：number

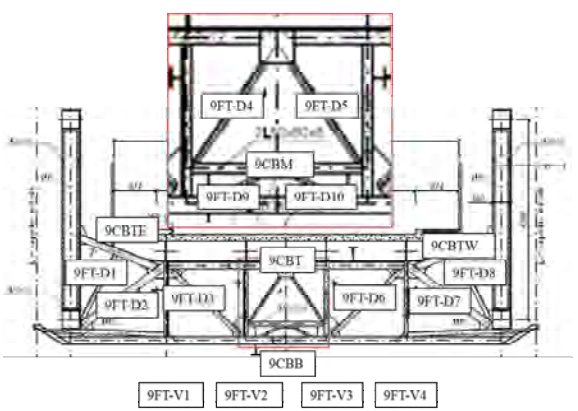
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

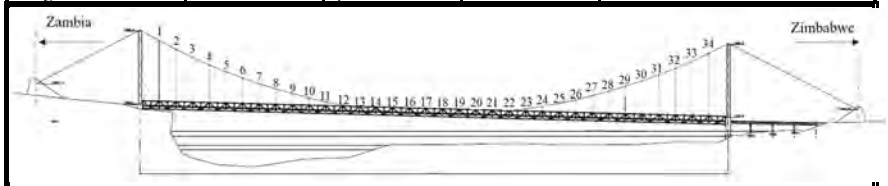
※○：number

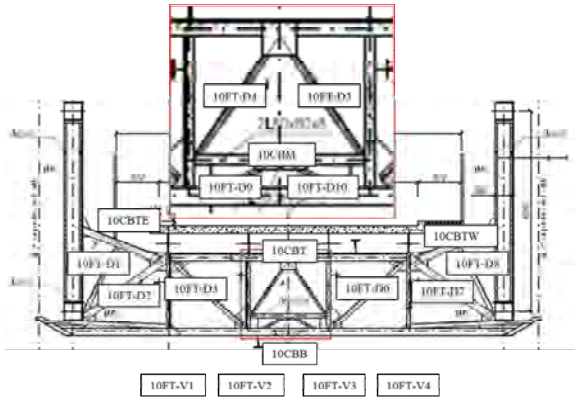
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

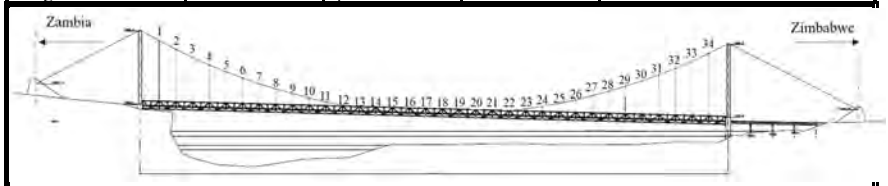
※○：number

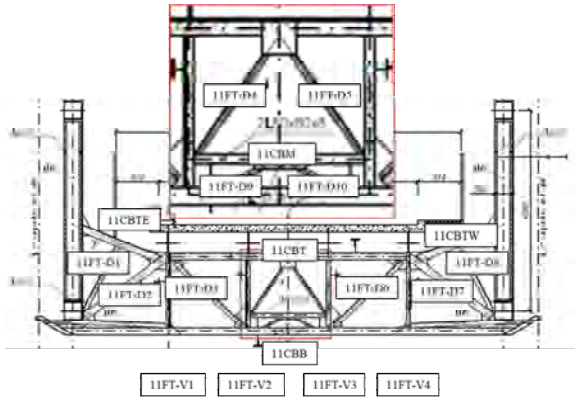
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

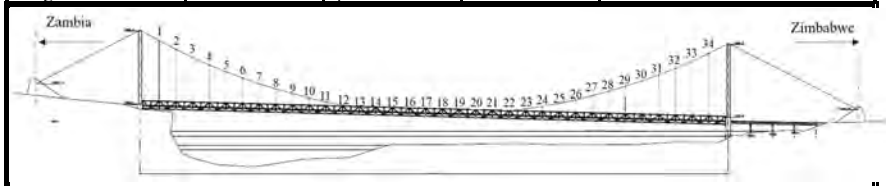
※○：number

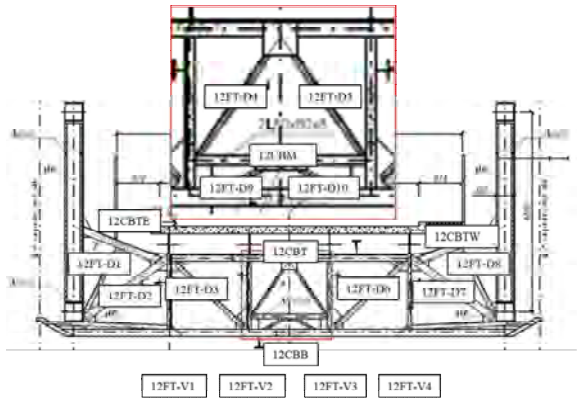
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

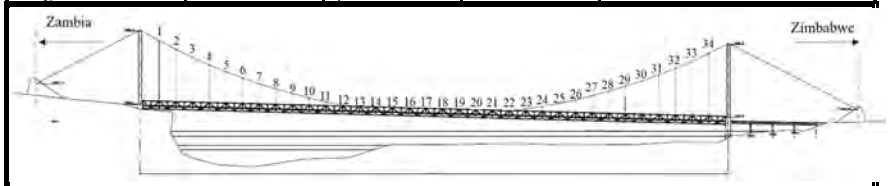
※○：number

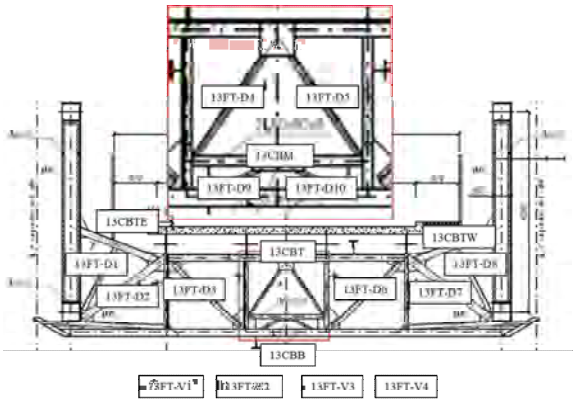
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

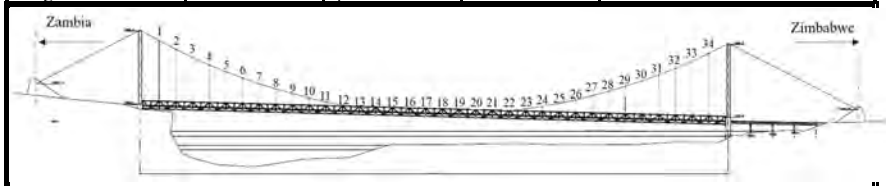
※○：number

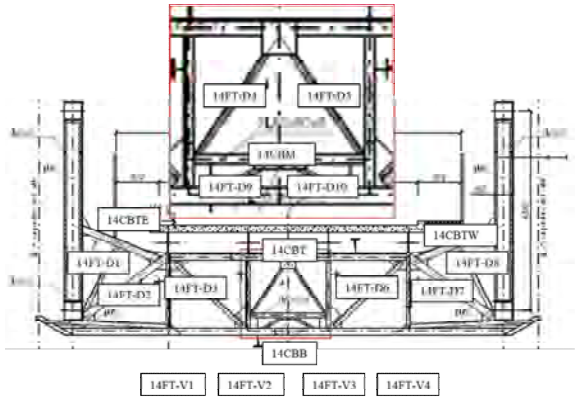
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

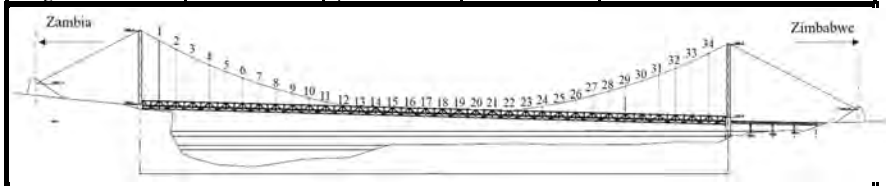
※○：number

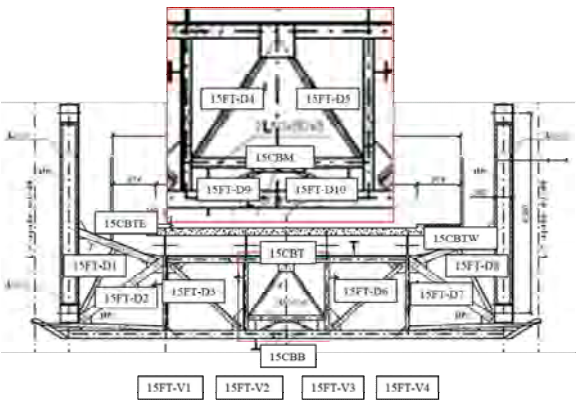
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

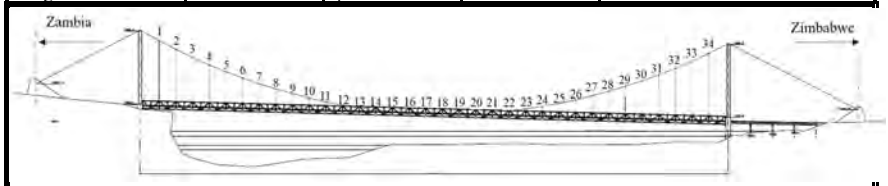
※○：number

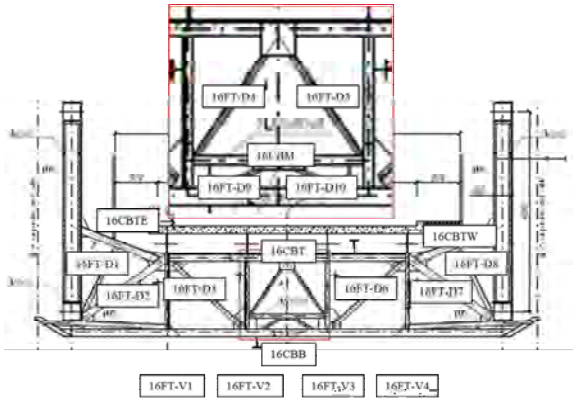
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

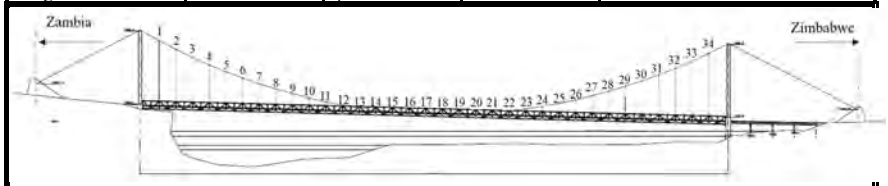
※○：number

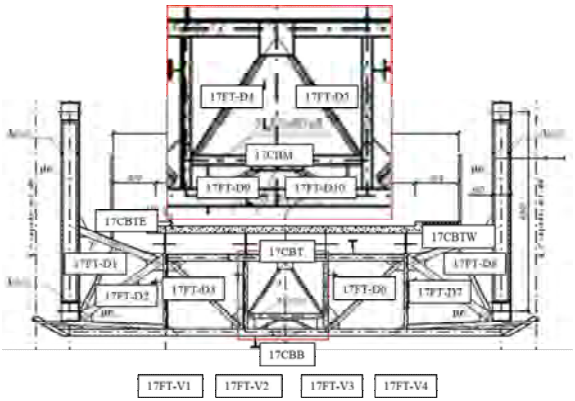
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

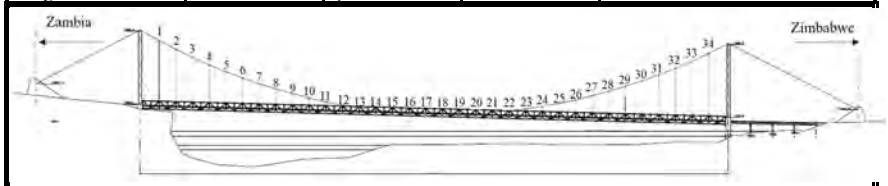
※○：number

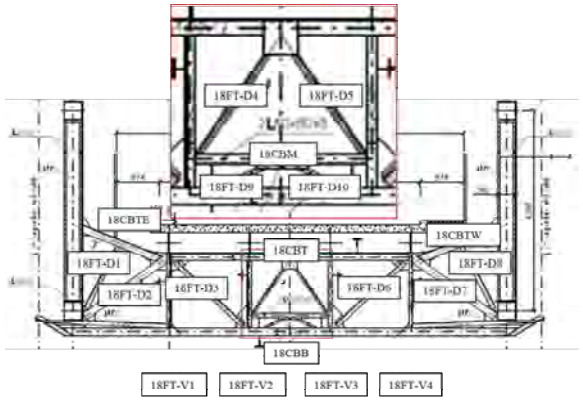
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

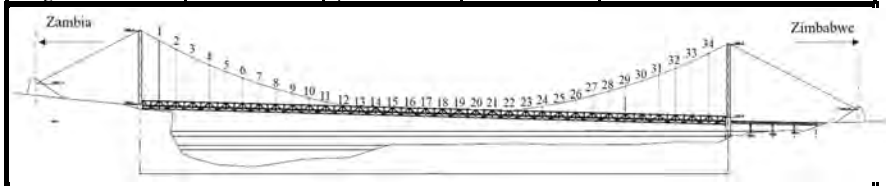
※○：number

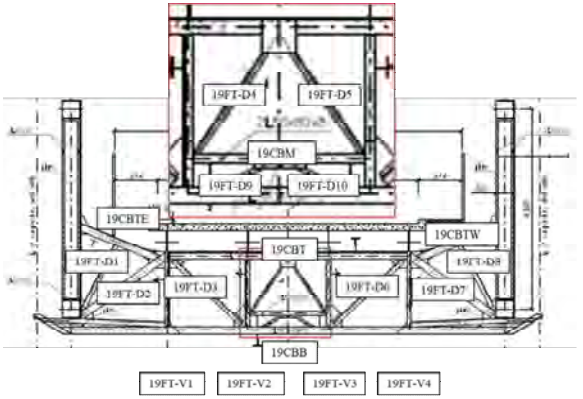
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

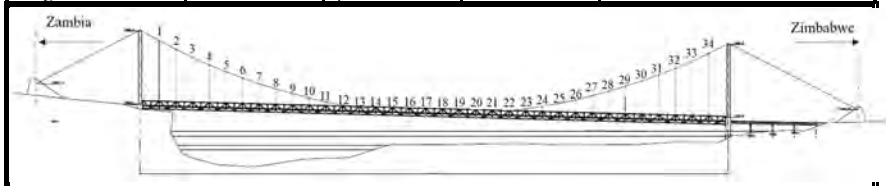
※○：number

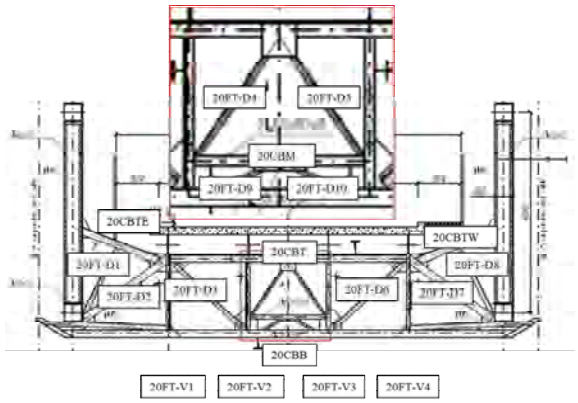
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

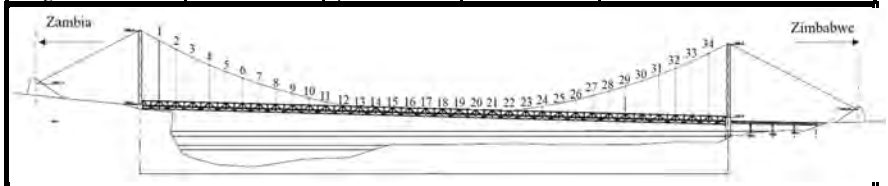
※○：number

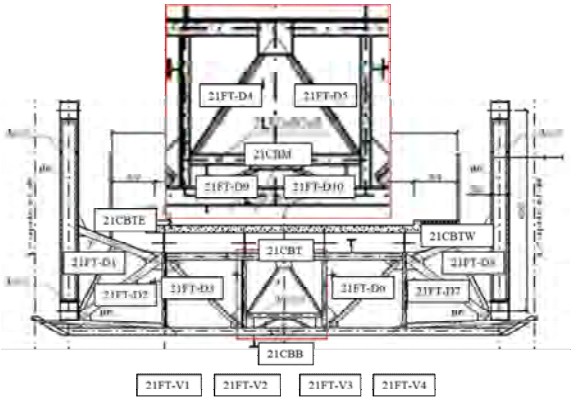
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

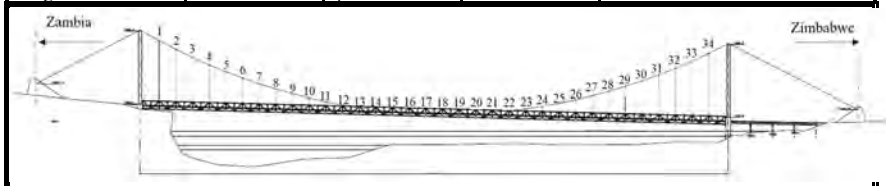
※○：number

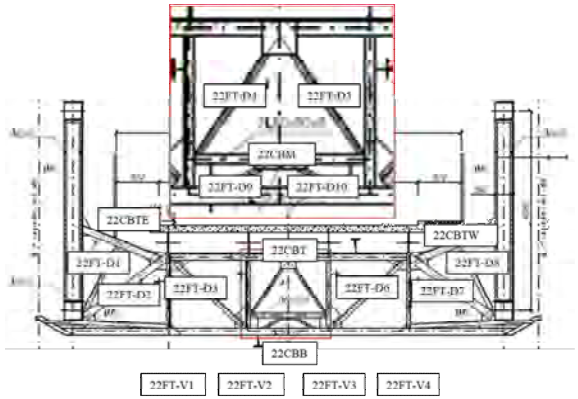
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

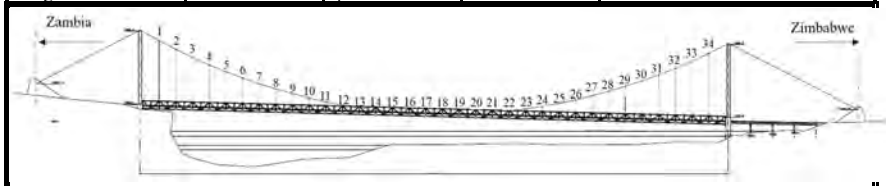
※○：number

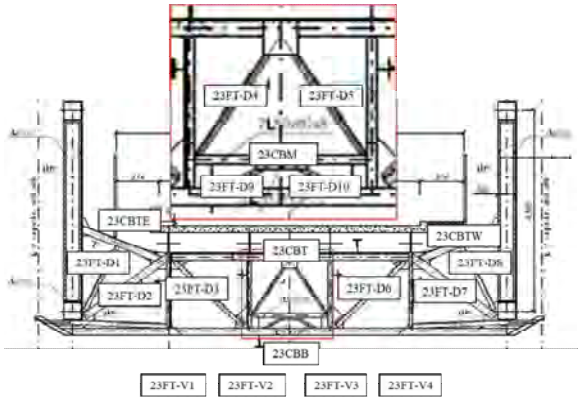
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

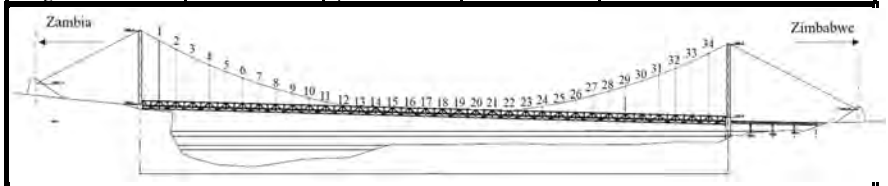
※○：number

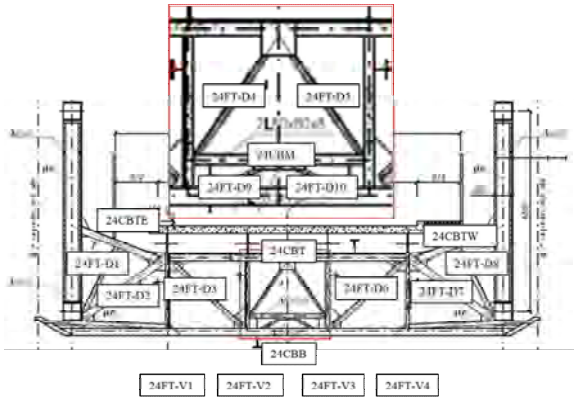
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○					

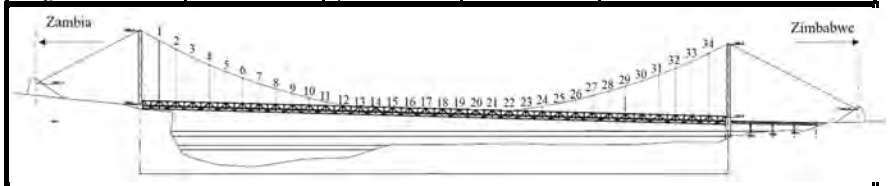
※○：number

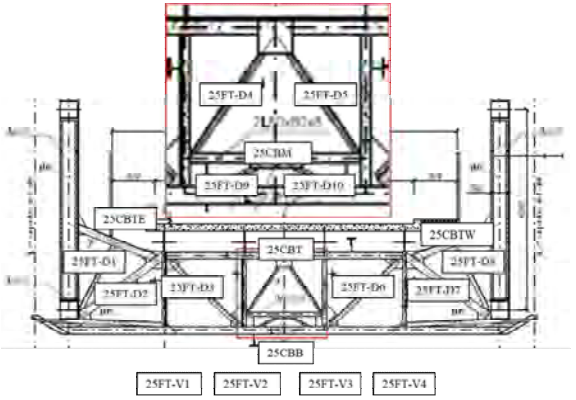
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○					

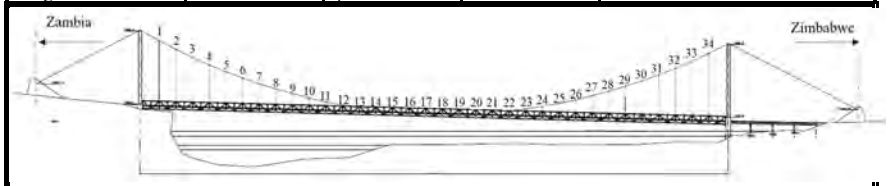
※○：number

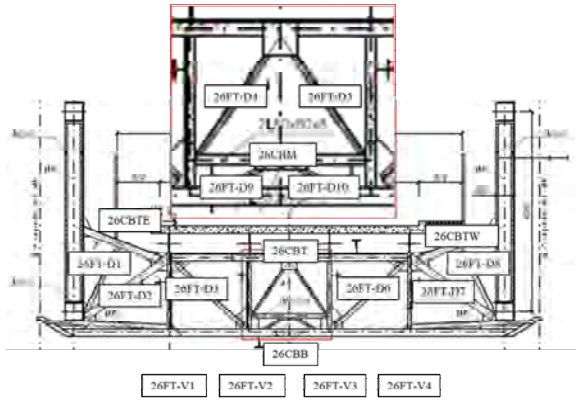
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

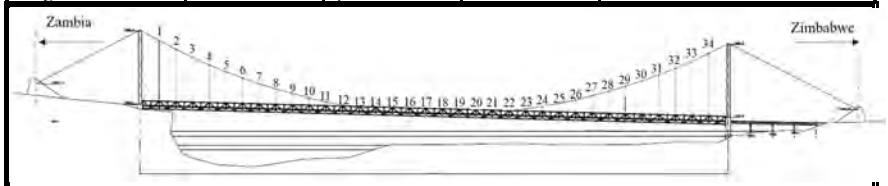
※○：number

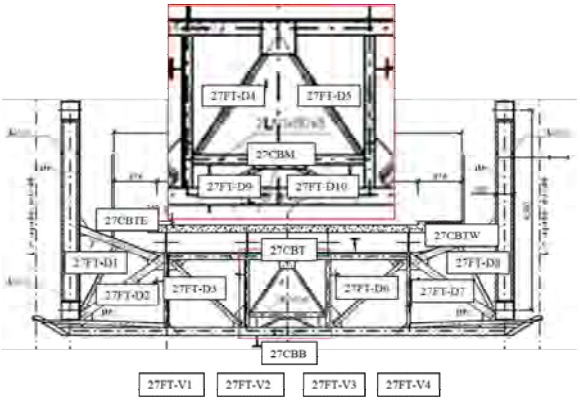
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

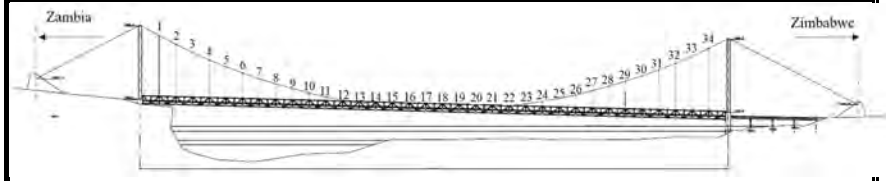
※○：number

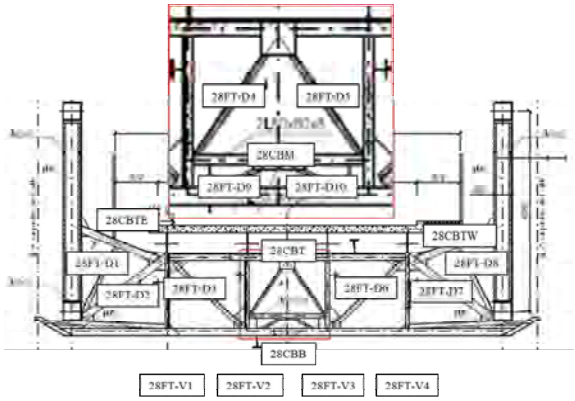
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

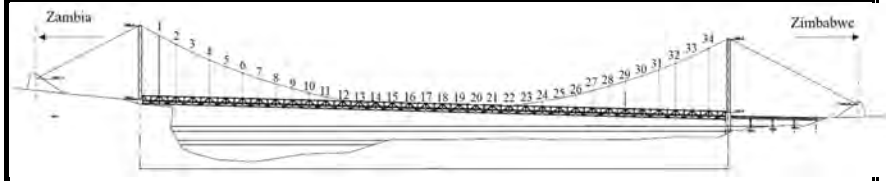
※○：number

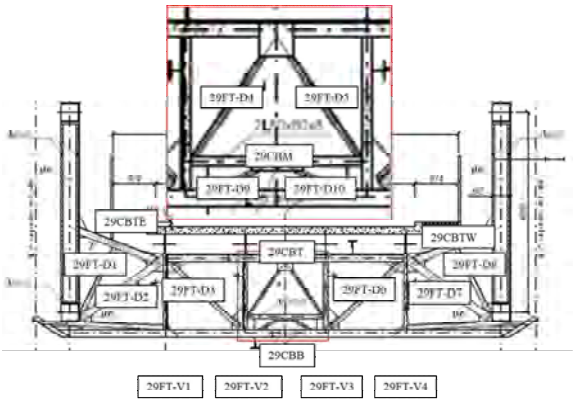
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○				

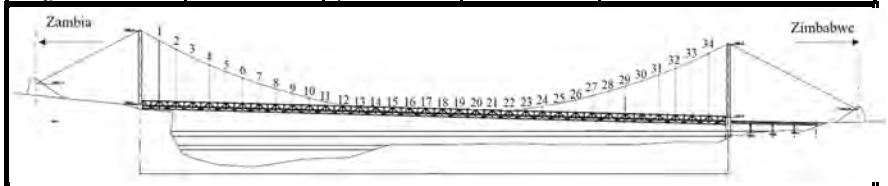
※○：number

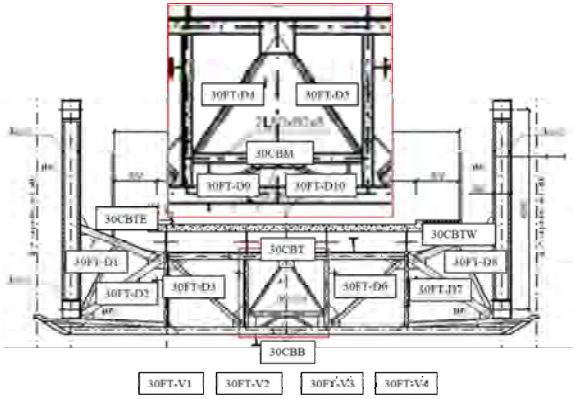
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○					

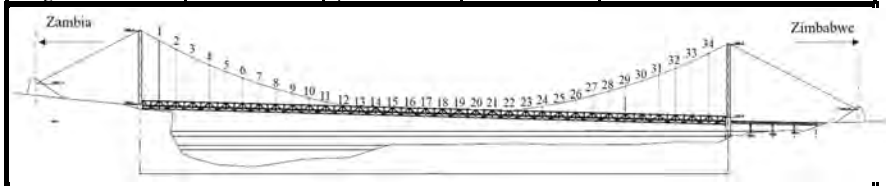
※○：number

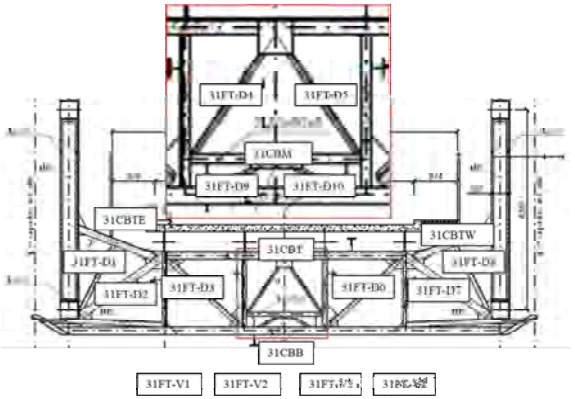
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name		left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side Bottom side Zambia Zimbabwe	○FT-V○					

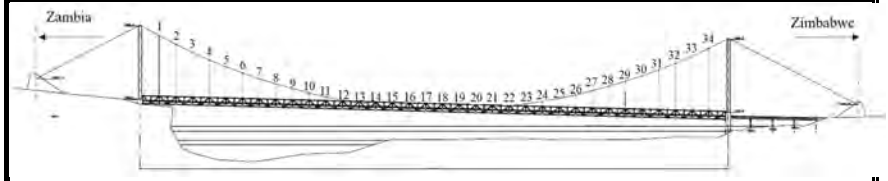
※○：number

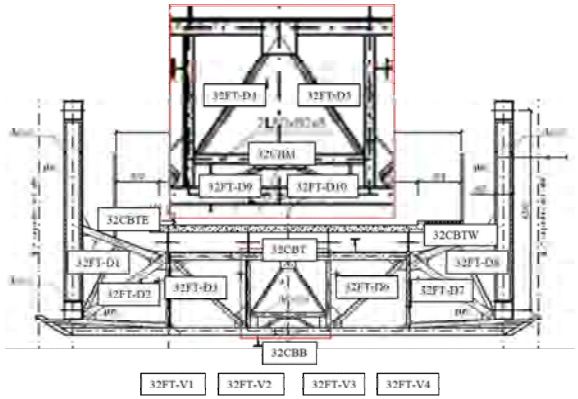
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

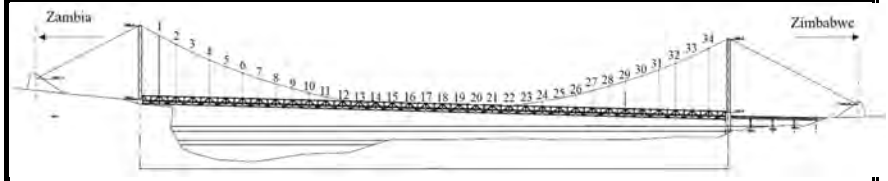
※○：number

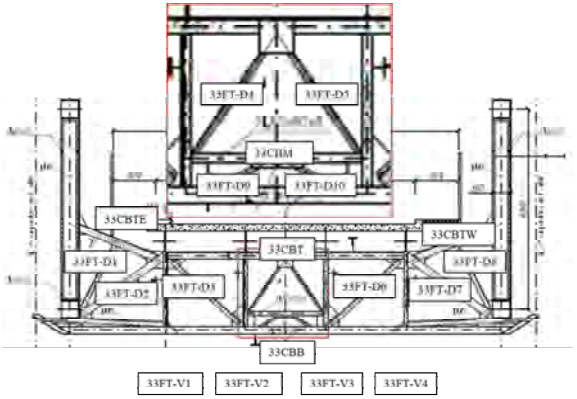
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name		member name	left	ZMB	right	ZIM
○CBT or ○CBTE or ○CBTW or ○CBM or ○CBB or ○FT-D○	Up side	○FT-V○				
	Bottom side					
	Zambia					
	Zimbabwe					

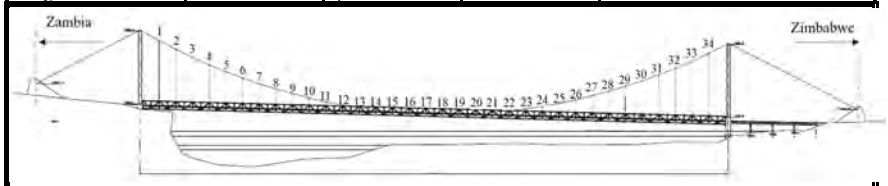
※○：number

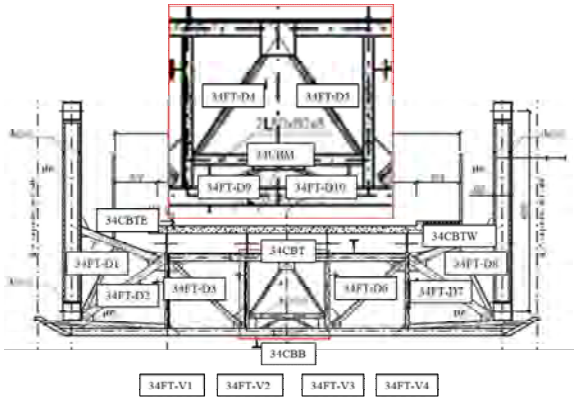
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Span		Section





member name

member name

○CBT
or
○CBTE
or
○CBTW
or
○CBM
or
○CBB
or
○FT-D○

Up side

Bottom side

Zambia

Zimbabwe

○FT-V○

left	ZMB	right	ZIM

※○: number

【Photograph】

Bridge ID:		Bridge NAME:	Otto Biet

Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment

APPENDIX-A-3-3

GEOMETRICAL INSPECTION FORM

GEOMETRICAL INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	
Road Name	
Road ID	
Location	

Province	
Rever Name	

APPENDIX-A-3-3

BRIDGE INSPECTOR COMMENT

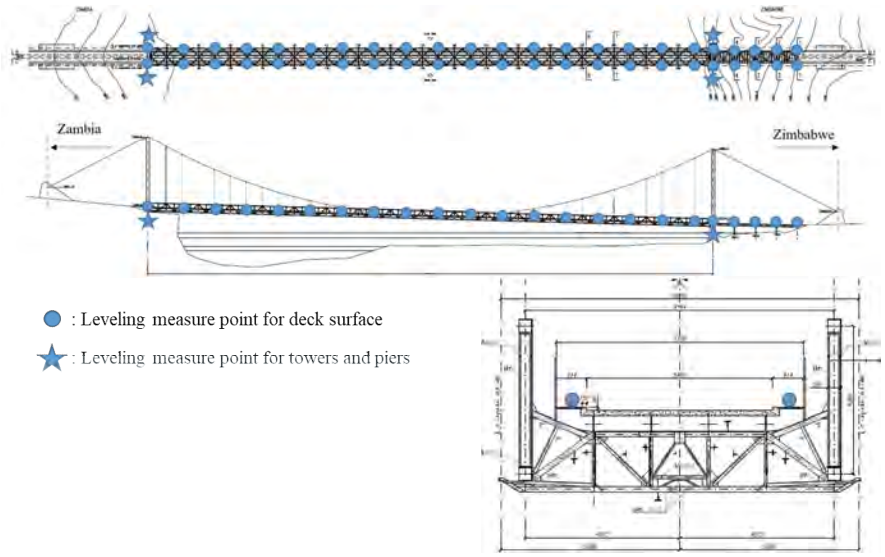
Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

Bridge ID:		Bridge NAME:	

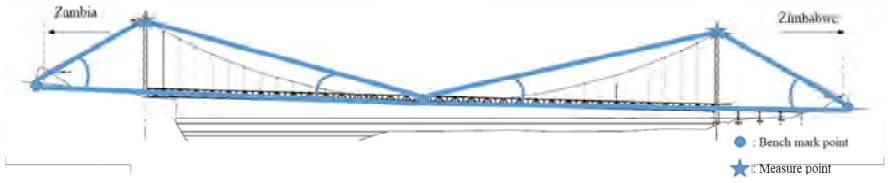
Leveling

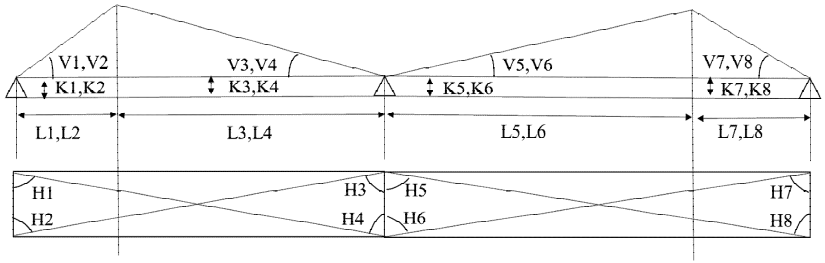
Element	Place		1939	2022	Difference	Remark
Tower 1	Left					
	Right					
Tower 2	Left					
	Right					
Longitudal Alignment	1	Left				
Longitudal Alignment	2	Left				
APPENDIX-A-3-3	3	Left				
Longitudal Alignment	4	Left				
Longitudal Alignment	5	Left				
Longitudal Alignment	6	Left				
Longitudal Alignment	7	Left				
Longitudal Alignment	8	Left				
Longitudal Alignment	9	Left				
Longitudal Alignment	10	Left				
Longitudal Alignment	11	Left				
Longitudal Alignment	12	Left				
Longitudal Alignment	13	Left				
Longitudal Alignment	14	Left				
Longitudal Alignment	15	Left				
Longitudal Alignment	16	Left				
Longitudal Alignment	17	Left				
Longitudal Alignment	18	Left				
Longitudal Alignment	19	Left				
Longitudal Alignment	20	Left				
Longitudal Alignment	21	Left				
Longitudal Alignment	22	Left				
Longitudal Alignment	23	Left				
Longitudal Alignment	1	Right				
Longitudal Alignment	2	Right				
Longitudal Alignment	3	Right				
Longitudal Alignment	4	Right				
Longitudal Alignment	5	Right				
Longitudal Alignment	6	Right				
Longitudal Alignment	7	Right				
Longitudal Alignment	8	Right				
Longitudal Alignment	9	Right				
Longitudal Alignment	10	Right				
Longitudal Alignment	11	Right				
Longitudal Alignment	12	Right				
Longitudal Alignment	13	Right				
Longitudal Alignment	14	Right				
Longitudal Alignment	15	Right				
Longitudal Alignment	16	Right				
Longitudal Alignment	17	Right				
Longitudal Alignment	18	Right				
Longitudal Alignment	19	Right				
Longitudal Alignment	20	Right				
Longitudal Alignment	21	Right				
Longitudal Alignment	22	Right				
Longitudal Alignment	23	Right				



Bridge ID:		Bridge NAME:	

Measure	Place	1939	2021	Difference	Remark
Angle (Vertical)	K1+L1tanV1				
	K2+L2tanV2				
	K3+L3tanV3				
	K4+L4tanV4				
Angle (Vertical)	K5+L5tanV5				
	K6+L6tanV6				
	K7+L7tanV7				
	K8+L8tanV8				
Angle (Holizontal)	L1/tanH1				
	L2/tanH2				
	L3/tanH3				
	L4/tanH4				
Angle (Holizontal)	L5/tanH5				
	L6/tanH6				
	L7/tanH7				
	L8/tanH8				

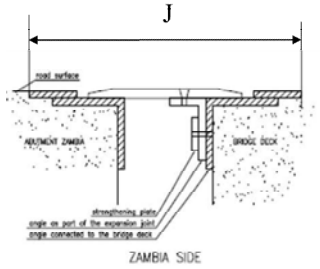




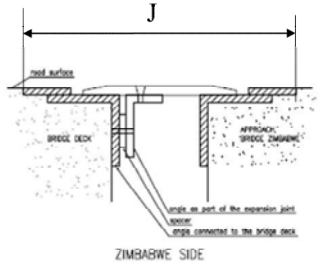
Bridge ID:		Bridge NAME:	

Expansion Joint

Measure	Place		1939	2022	Difference	Remark		
Tower 1	expansion Joint	J						
Tower 2	expansion Joint	J						



ZAMBIA SIDE



ZIMBABWE SIDE

APPENDIX-A-4-1

INVENTORY INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Victoria Falls
Road Name	
Road ID	
Location	

A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	

BRIDGE GEOMETRY

Bridge length, (m)		
Bridge width, (m)		
Number of lanes		
Number of spans		
Width of carriageway, (m)		
Width of island(s), (m)		
Width of shoulder, (m)	Left	
	Right	
Sidewalk width, (m)	Left	
	Right	

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	
	Insert year if known	

DESIGN LOAD

Available?	Yes	
	No	
If yes, insert as:		

DESIGN STANDARD

Available?	Yes	
	No	
If yes, insert as:		

Province	Lusaka
Rever Name	Zambezi

TERRAIN CROSSED

River or waterway (fresh water)	
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

INSPECTOR COMMENTS

Date of Field Inspection
ACCOMPLISHED BY:
SUBMITTED BY:

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	
Bridge inspection vehicle	
Ladder	
Binoculars	
Safety Belt / Harness	
Geologist Hammer	
Oxygen meter	
Camera	
Hard Hat with Headlight	
Other(meter tape, safety shoes, gloves, total station)	

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	

END OF WARRANTY PERIOD

Insert year of end of warranty period	

LIGHTING TO BRIDGE

yes or no	

INTERVAL OF LIGHTING POLES

Left, (m)	
Right, (m)	

AS-BUILT DRAWING

Available?(yes, no or unknown)	
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	
If yes, insert year of widening.	
Bridge strengthened? (yes or no)	
If yes, insert year of strengthening	
Bridge retrofitted? (yes or no)	
If yes, insert year of seismic retfofitting	
Bridge lengthened? (yes or no)	
If yes, insert year of lengthening	

SUPERSTRUCTURE WIDENING FORM

Widened left side	
Widened right side	
Widened both side	

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing bridge	
Same detail / modified material	
Different details	

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	
Girder	
Box girder	
Slab	
Voided slab	
Demontable (Bailey type)	
Truss	
Trestle	
Cable stayed	
Suspension	
Arch	
Portal frame	
Other structure	

SUPERSTRUCTURE WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF PIER WIDENING

Widening original piers	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

TYPE OF ABUTMENT WIDENING

Widerning original abutments	
Bored pile bents	
Driven pile bents	
Coping widening	
Other	

PIER / ABUTMENT WIDENING MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

TYPE OF STRENGTHENING

Main member reinforcement	
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	
Lateral restraints	
Longitudinal restraints	
Beam continuity	
Deck continuity	
Other	

TYPE OF LENGTHENING

Low chainage end, original and widening	
Low chainage ehd, widened part only	
High chainage end, original and widening	
High chainage end, widened part only	

INVENTORY INSPECTION A-4-1

GENERAL SPAN INFORMATION

Span Number	1
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zambia side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	2
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zambia side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported		
Not supported		
Not known		

ZMBS Zambian side

ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails		
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side

W Right side

※Looking in Zambia side

SPAN COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**1**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**2**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	**1**

WING WALL TYPE	**L**	**R**
Solid wall		
Protected slope		
Other		
None		

WING WALL MATERIAL	**L**	**R**
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	**L**	**R**
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Abutment Number	2

WING WALL TYPE	L	R
Solid wall		
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete		
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH	
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Springing Number	1

SPRINGING TYPE	
Solid wall	
Protected slope	
Other	
None	

SPRINGING MATERIAL	
Concrete	
Masonry	
Timber	
Gabions or mattresses	
Other	

SPRINGING FOUNDATION TYPE	
Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	

SPRINGING LENGTH	
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Springing Number	2

SPRINGING TYPE

Solid wall	
Protected slope	
Other	
None	

SPRINGING MATERIAL

Concrete	
Masonry	
Timber	
Gabions or mattresses	
Other	

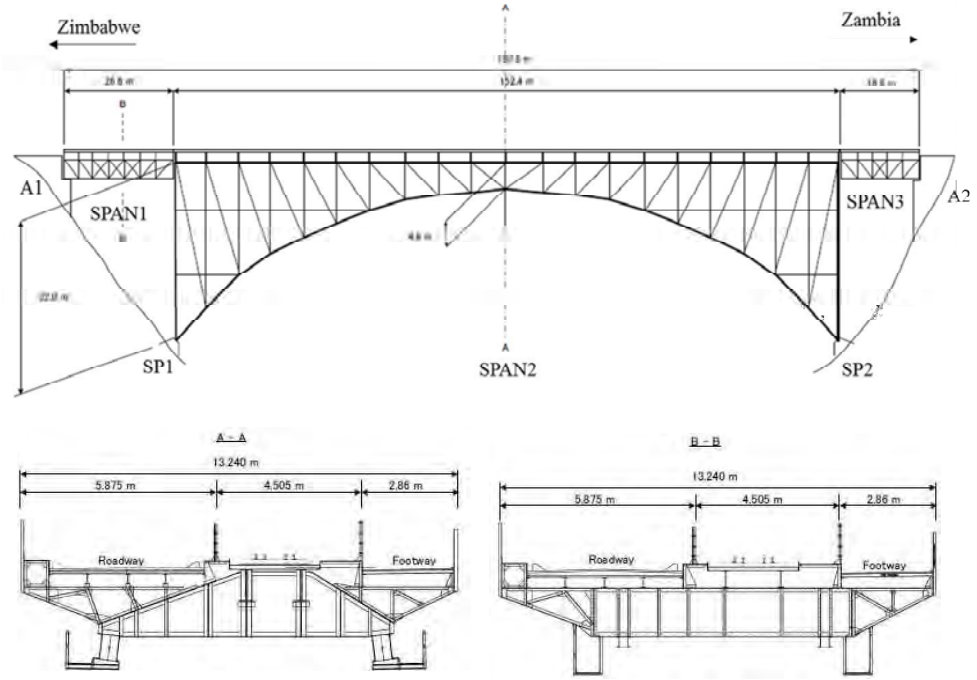
SPRINGING FOUNDATION TYPE

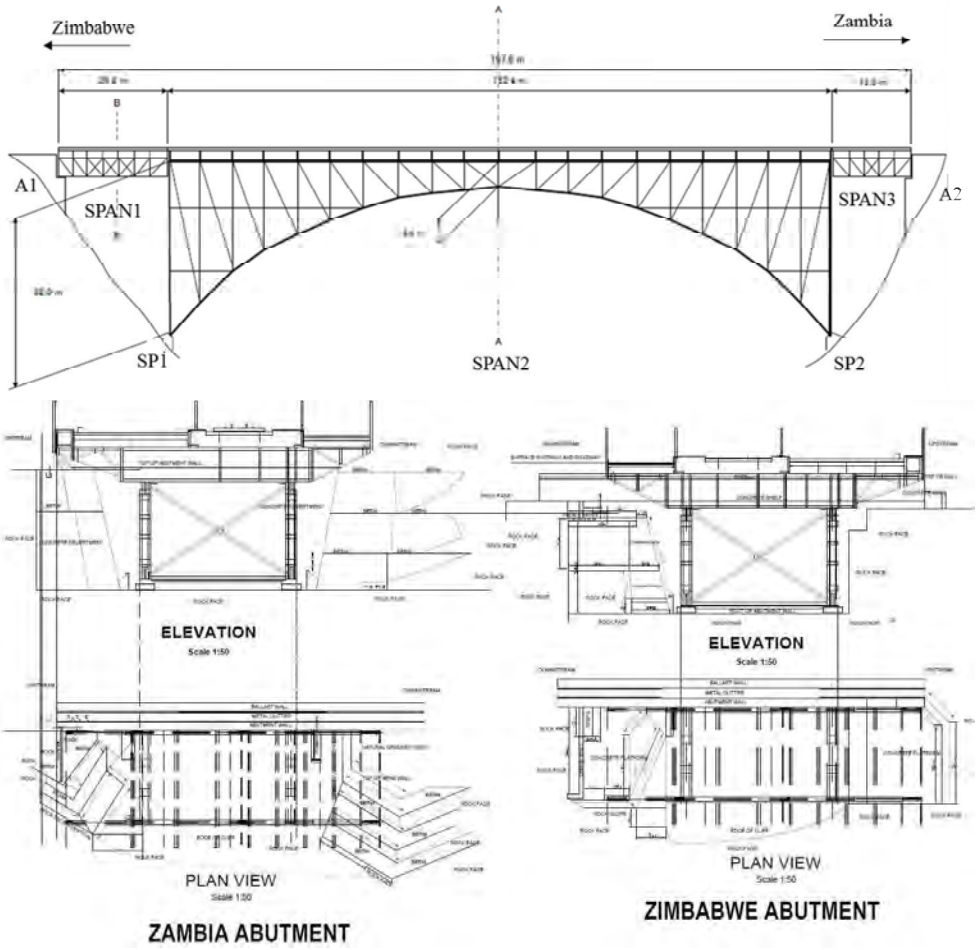
Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	

SPRINGING LENGTH

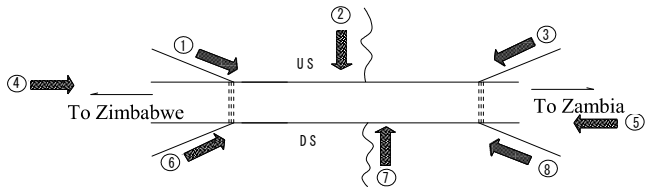
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS





【Photograph】



①	②
③	④
⑤	⑥
⑦	⑧

APPENDIX-A-4-2

PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Victoria Falls
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE DESCRIPTION

Type of Bridge	
Superstructure	
Substructure	
Foundation	
Total Number of Span	
Total Number of Anchorage	
Total Number of Pier	

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	
BIV not available	
Access restricted	
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Victoria Falls

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

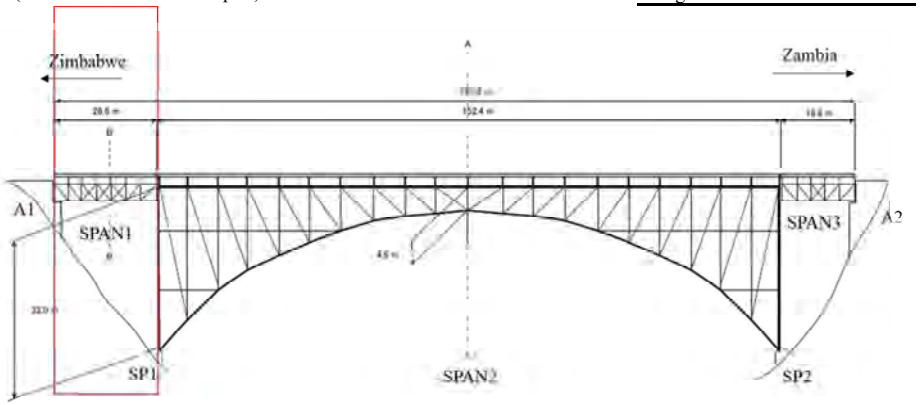
LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment A1		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

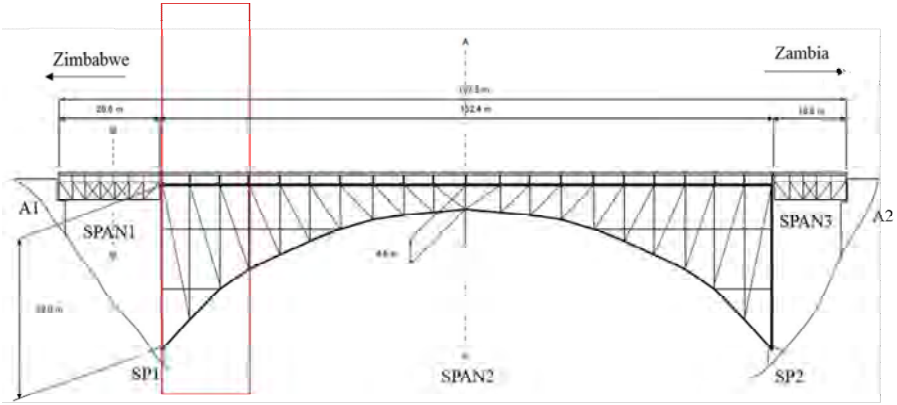
SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Rupture					
Overall Rating							

SPAN No.	Span 2, Section1

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing SP1		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

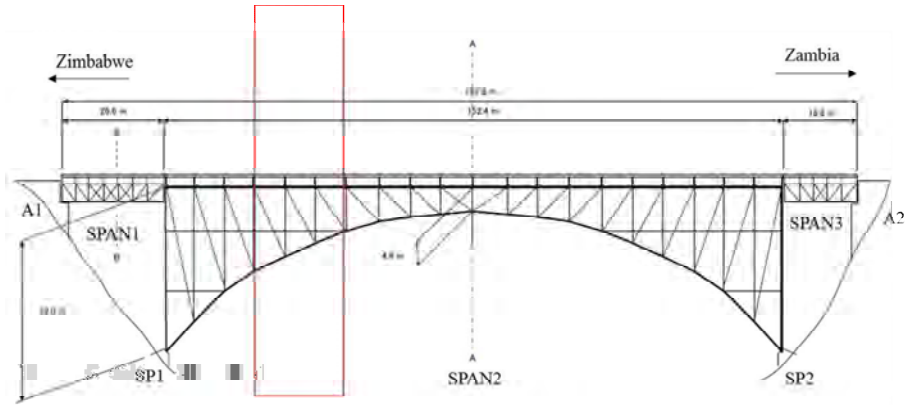
SECONDALY MEMBER							
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (Seal)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Rupture						
Overall Rating							

SPAN No.	Span 2, Section2

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material	Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK						
Steel	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Paint Peel Off					
	Missing element					
Asphalt	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					
MAIN MEMBER						
Steel Girder (Left)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder (Right)	Corrosion					
	Cracking					
	Deformation / Buckling					
	Abnormal Vibration					
	Loose Connection					
	Paint Peel Off					
	Missing element					
Steel Girder Cross Section	Corrosion					
	Missing bolts					
	Deformation / Buckling					
	Cracking					
	Paint Peel Off					
Abutment	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water Leakage					
Springing	Cracking					
	Spalling/Scaling/Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					

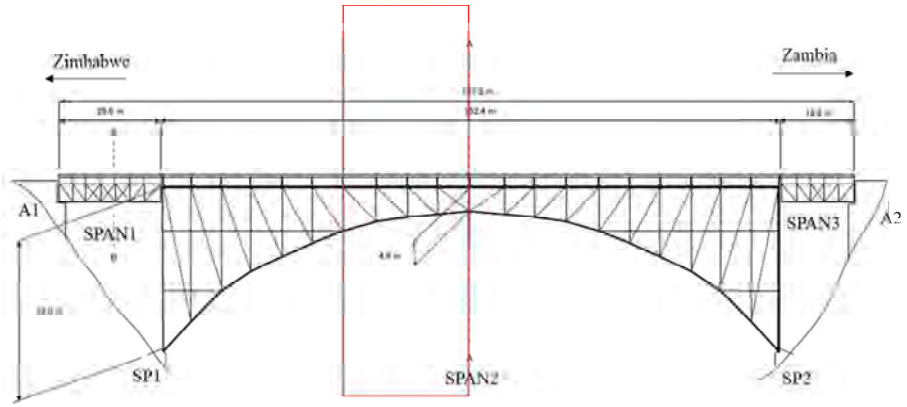
SECONDALY MEMBER							
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (Seal)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Rupture						
Overall Rating							

SPAN No.	Span 2, Section3

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

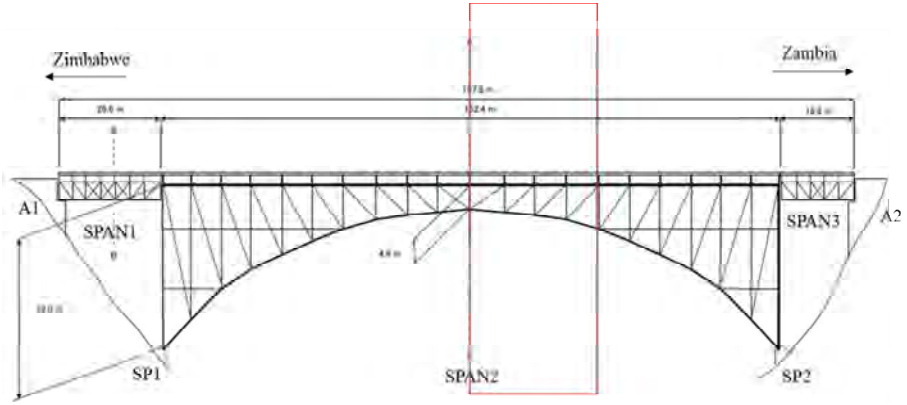
SECONDALY MEMBER							
Draine Pipes	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Waterway	Flood debris accumulation						
	Siltation						
	Vegetation growth						
Bearing	Corrosion						
	Loose Connection						
	Abnormal Displacement						
	Paint Deterioration						
	Bed (support) damage						
Left Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Right Railing	Corrosion						
	Loose Connection						
	Impact / Accidnet Damage						
	Paint Peel Off						
Expansion Joint (Seal)	Water leakage						
	Abnormal Space/Noise						
	Difference in elevation						
	Rupture						
Overall Rating							

SPAN No.	Span 2, Section4

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

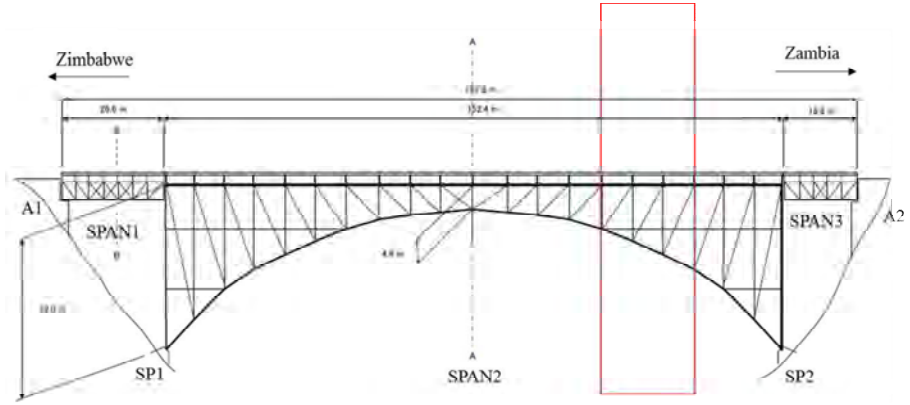
SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Rupture					
Overall Rating							

SPAN No.	Span 2, Section5

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

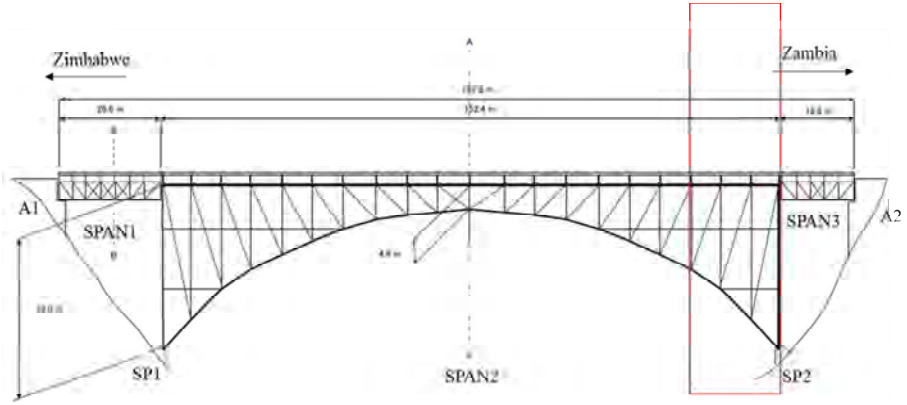
SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Rupture					
Overall Rating							

SPAN No.	Span 2, Section5

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing SP2		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

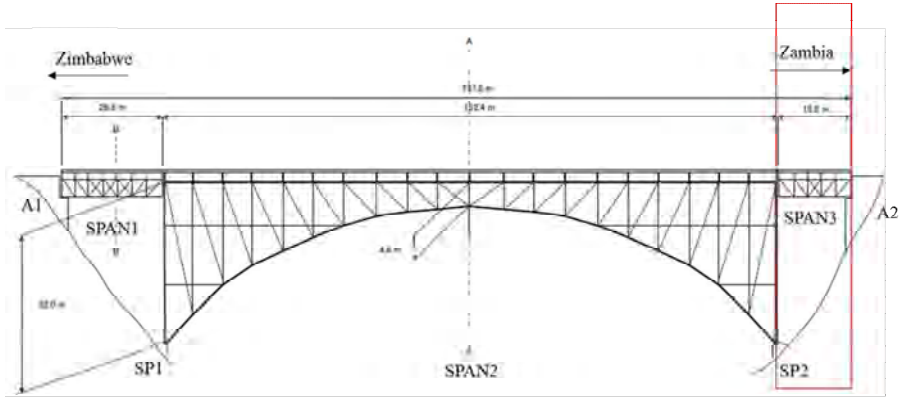
SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Rupture					
Overall Rating							

SPAN No.	Span 3

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Paint Peel Off					
		Missing element					
Asphalt		Potholes					
		Shoving					
		Rutting					
		Cracking					
		Raveling					
MAIN MEMBER							
Steel Girder (Left)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section		Corrosion					
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment A2		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

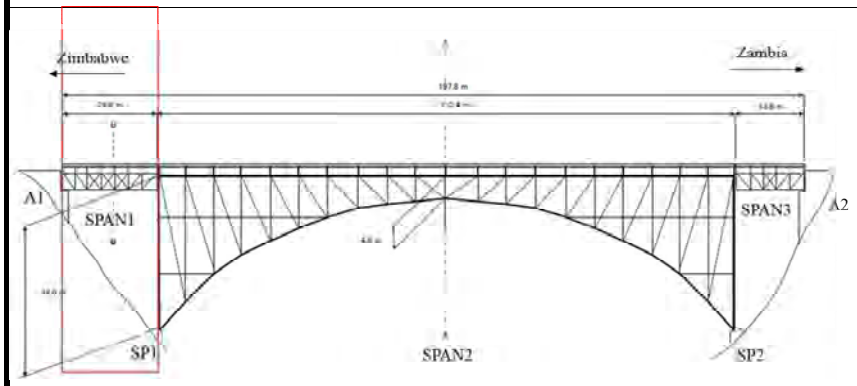
SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Rupture					
Overall Rating							

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	1	



Railing (left side)

Expansion Joint and Deck Concrete

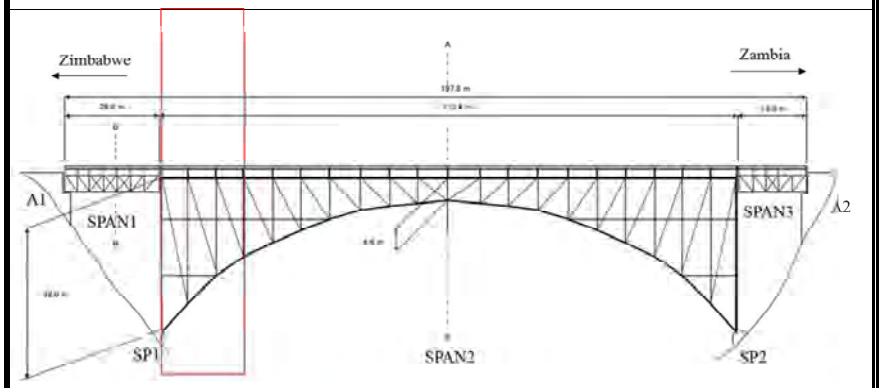
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	1



Railing (left side)

Expansion Joint and Deck Concrete

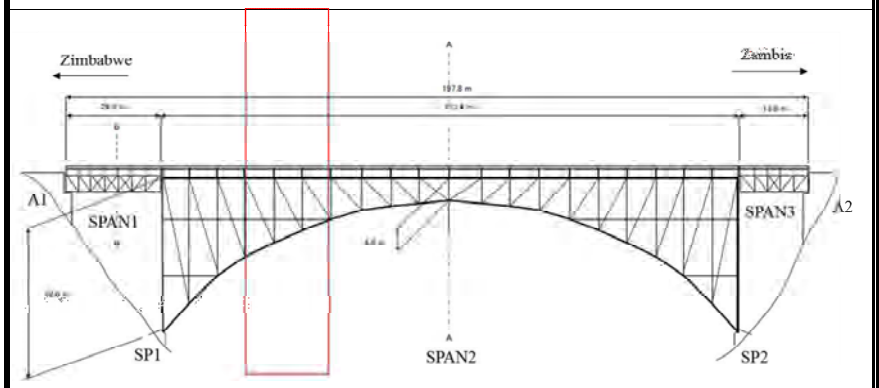
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	2



Railing (left side)

Expansion Joint and Deck Concrete

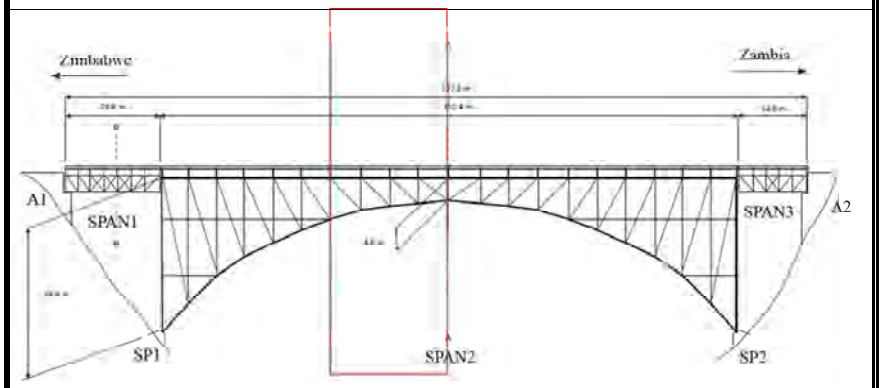
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	3



Railing (left side)

Expansion Joint and Deck Concrete

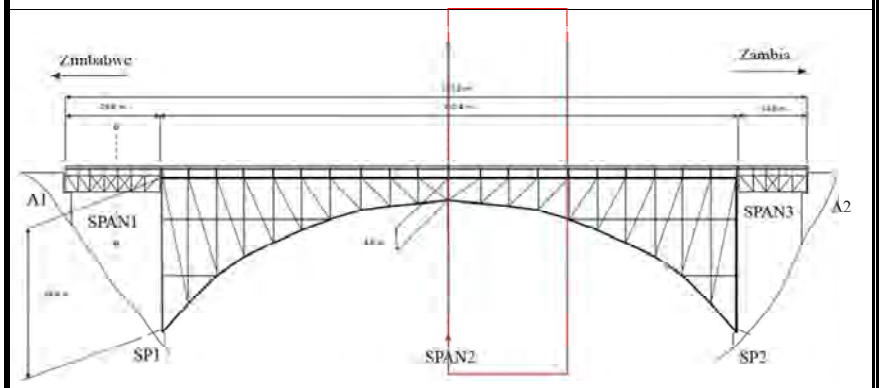
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	4



Railing (left side)

Expansion Joint and Deck Concrete

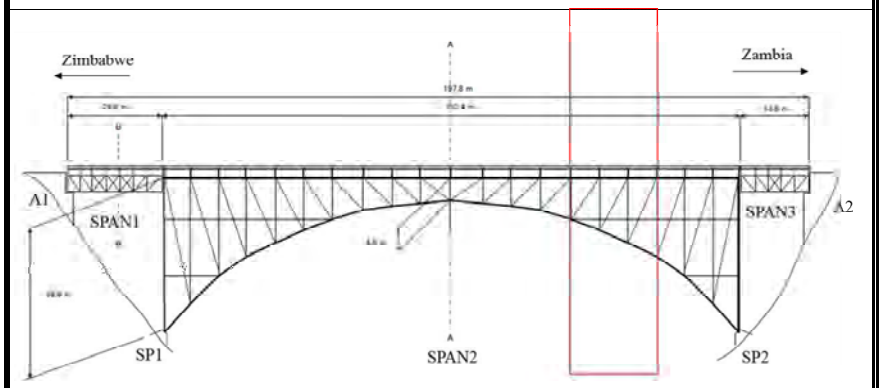
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	5



Railing (left side)

Expansion Joint and Deck Concrete

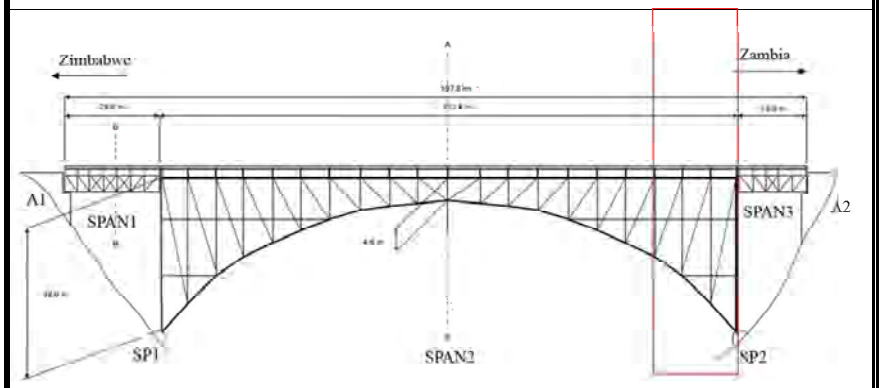
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	2	Section	6



Railing (left side)

Expansion Joint and Deck Concrete

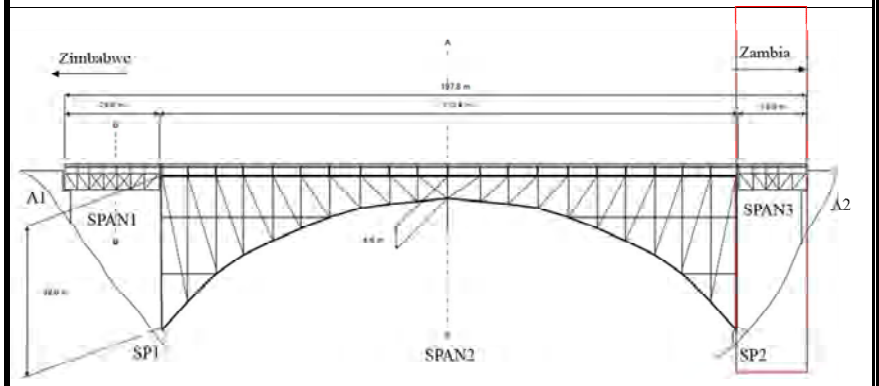
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span	3



Railing (left side)

Expansion Joint and Deck Concrete

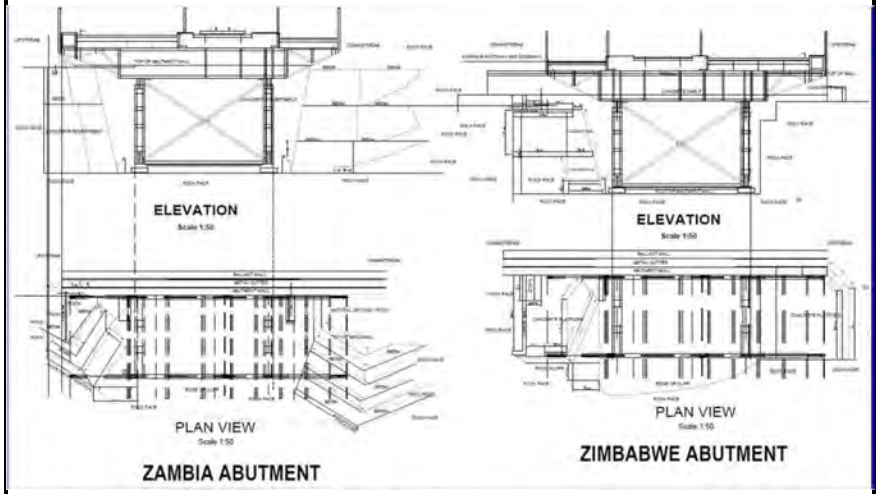
Railing (right side)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span		



A2

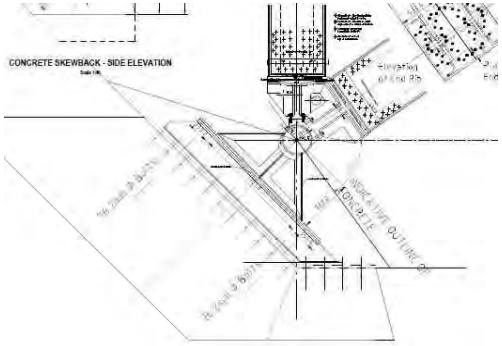
A1

【Damage Drawing】

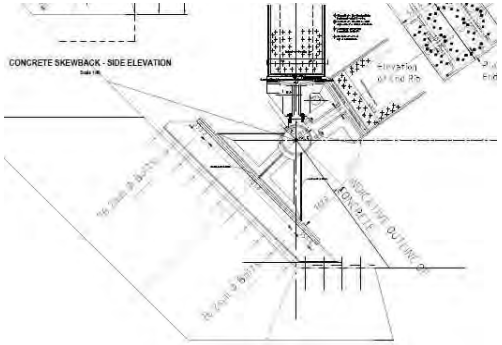
Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Span		



SP1



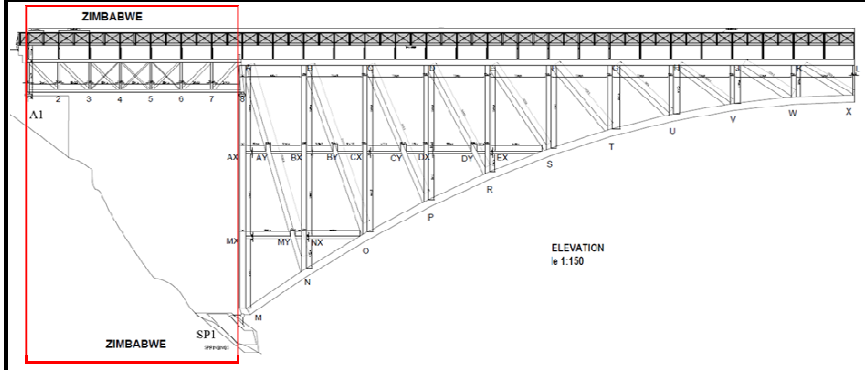
SP2

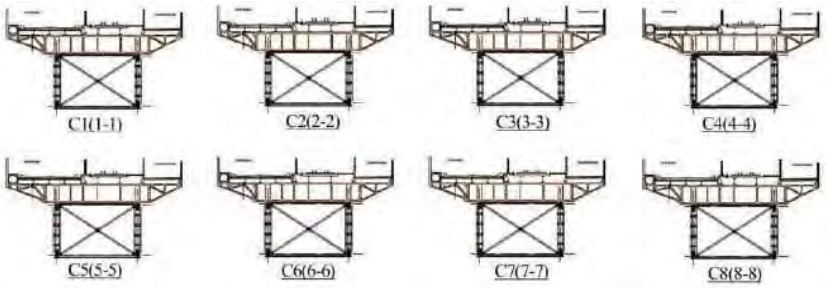
【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Truss	Main cable	



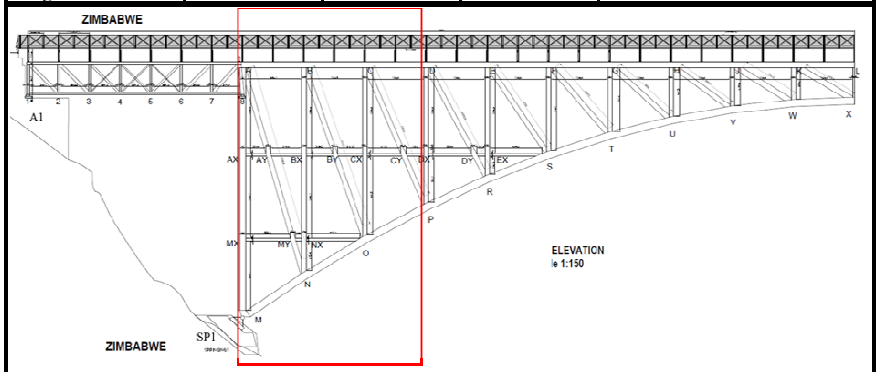


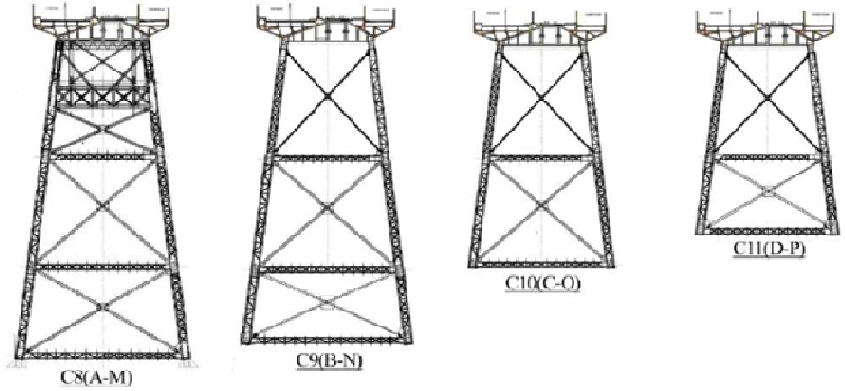
【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Truss	Main cable	



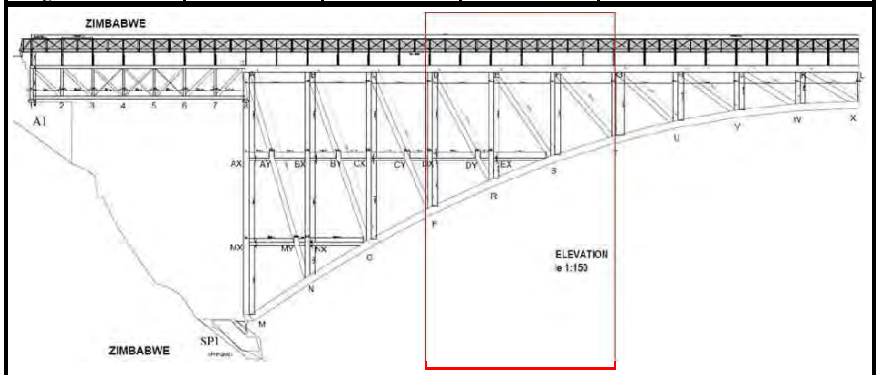


【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Truss	Main cable	



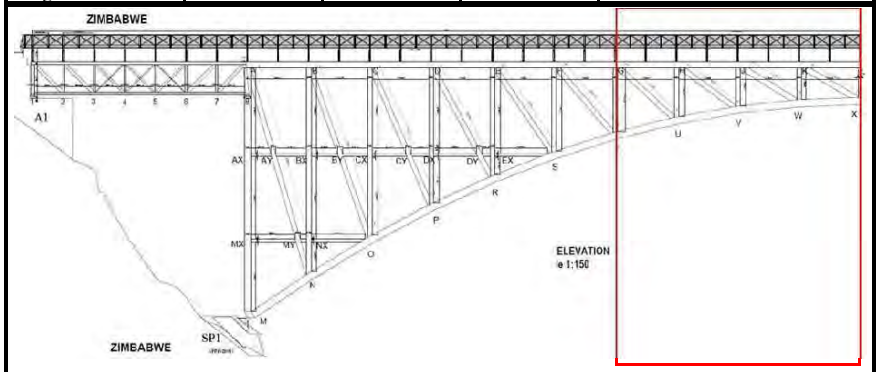


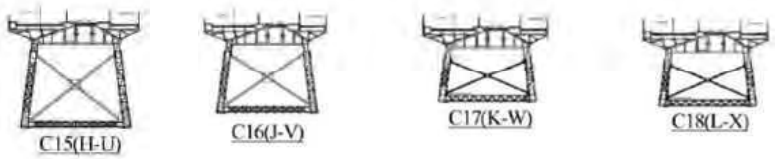
【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Truss	Main cable	



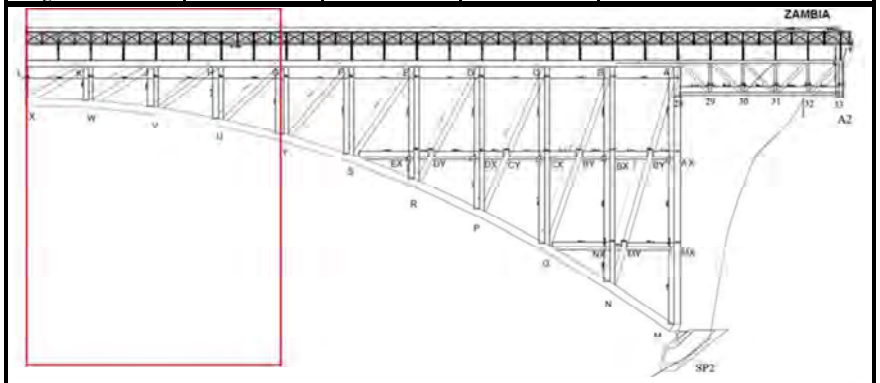


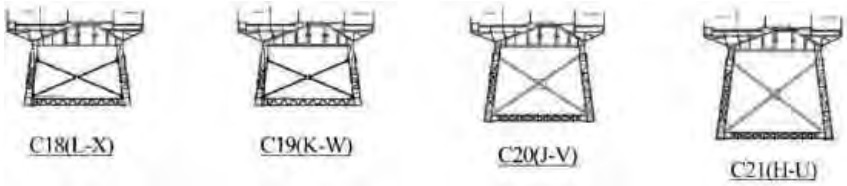
【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

Span No:

Bridge Number		Truss	Main cable	



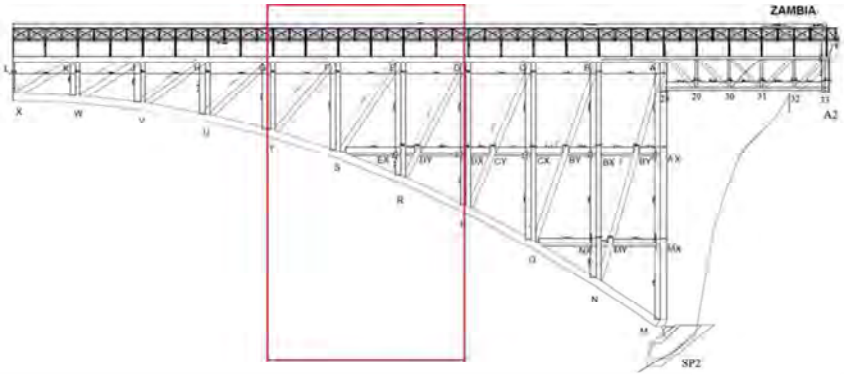


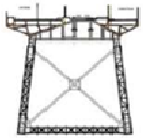
【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

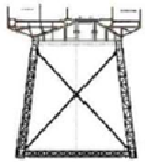
Span No:

Bridge Number		Truss	Main cable	

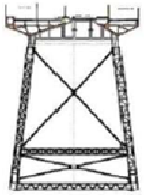




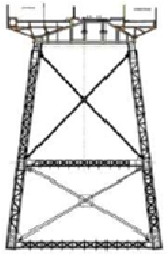
C22(G-T)



C23(F-S)



C24(E-R)



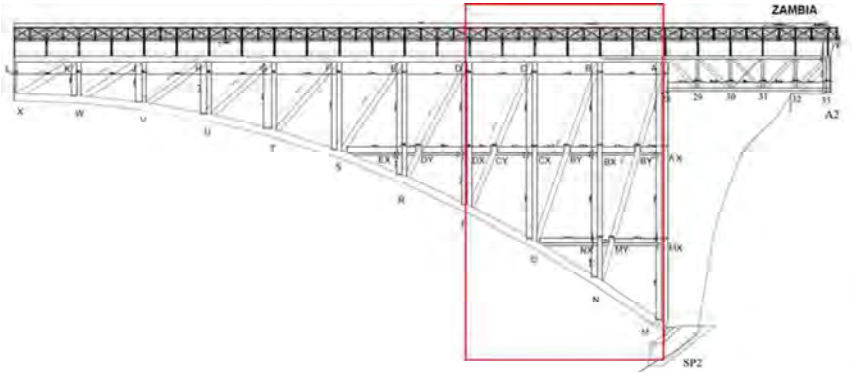
C25(D-P)

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

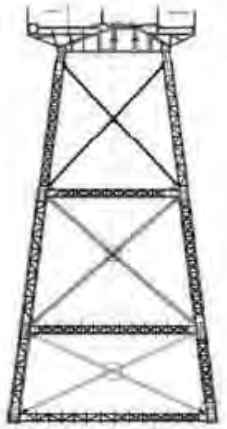
Span No:

Bridge Number		Truss	Main cable	

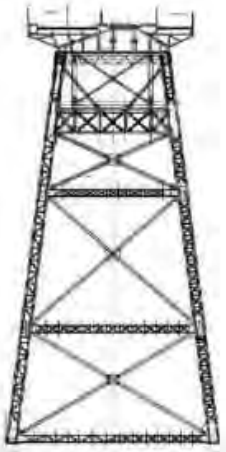




C26(C-O)



C27(B-N)



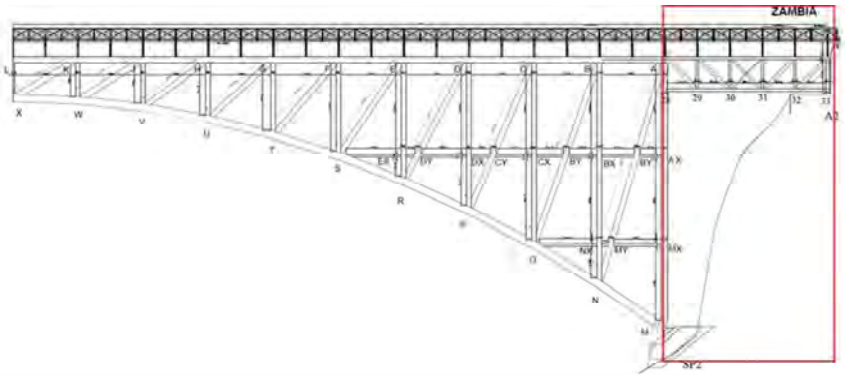
C28(A-M)

【Damage Drawing】

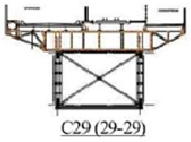
Bridge ID:		Bridge NAME:	Victoria Falls

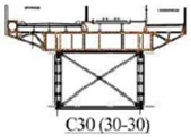
Span No:

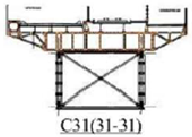
Bridge Number		Truss	Main cable	

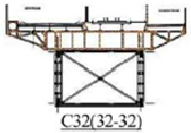


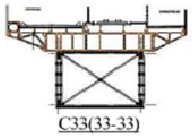

C28(28-28)


C29 (29-29)


C30 (30-30)


C31(31-31)


C32(32-32)


C33(33-33)

【Photograph】

Bridge ID:		Bridge NAME:	Victoria Falls

Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment
Photo Number		Span		Conponent Name		Type of Damage	
Photograph				Location Map			Comment

APPENDIX-A-4-3

GEOMETRICAL INSPECTION FORM

GEOMETRICAL INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Victoria Falls
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE INSPECTOR COMMENT

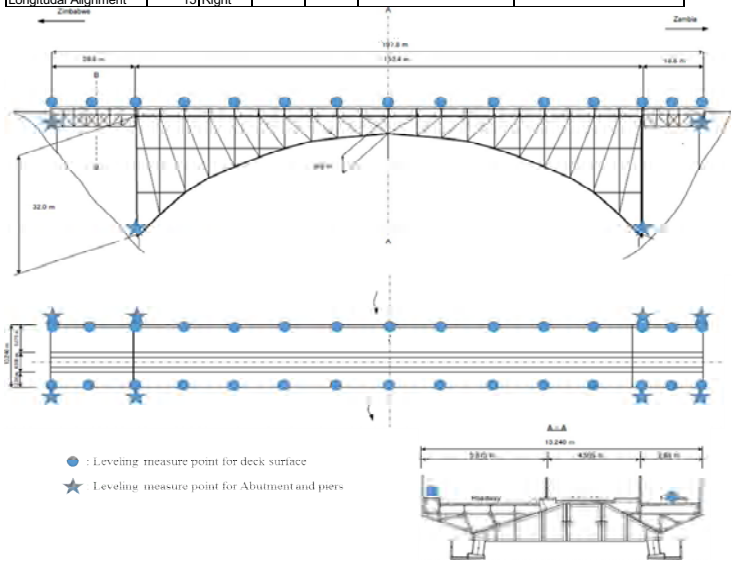
Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

Bridge ID:		Bridge NAME:	Victoria Falls

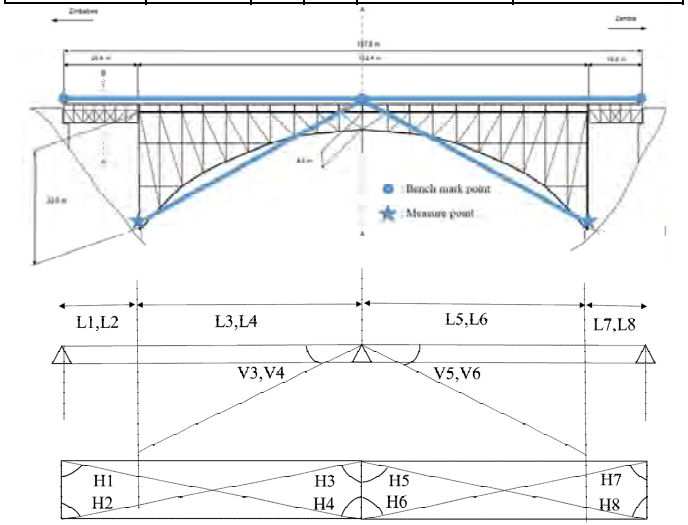
Leveling

Element	Place		1905	2022	Difference	Remark
Abutment 1	Left					
	Right					
Abutment 2	Left					
	Right					
Springing 1	Left					
	Right					
Springing 2	Left					
	Right					
Longitudal Alignment	1	Left				
Longitudal Alignment	2	Left				
Longitudal Alignment	3	Left				
Longitudal Alignment	4	Left				
Longitudal Alignment	5	Left				
Longitudal Alignment	6	Left				
Longitudal Alignment	7	Left				
Longitudal Alignment	8	Left				
Longitudal Alignment	9	Left				
Longitudal Alignment	10	Left				
Longitudal Alignment	11	Left				
Longitudal Alignment	12	Left				
Longitudal Alignment	13	Left				
Longitudal Alignment	14	Left				
Longitudal Alignment	15	Left				
Longitudal Alignment	1	Right				
Longitudal Alignment	2	Right				
Longitudal Alignment	3	Right				
Longitudal Alignment	4	Right				
Longitudal Alignment	5	Right				
Longitudal Alignment	6	Right				
Longitudal Alignment	7	Right				
Longitudal Alignment	8	Right				
Longitudal Alignment	9	Right				
Longitudal Alignment	10	Right				
Longitudal Alignment	11	Right				
Longitudal Alignment	12	Right				
Longitudal Alignment	13	Right				
Longitudal Alignment	14	Right				
Longitudal Alignment	15	Right				



Bridge ID:		Bridge NAME:	Victoria Falls

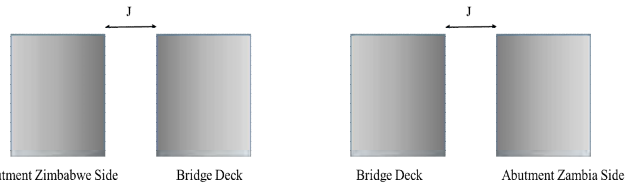
Measure	Place	1905	2021	Difference	Remark
Angle (Vertical)	L1tanV1				
	L2tanV2				
	L3tanV3				
	L4tanV4				
Angle (Vertical)	L5tanV5				
	L6tanV6				
	L7tanV7				
	L8tanV8				
Angle (Holizontal)	L1/tanH1				
	L2/tanH2				
	L3/tanH3				
	L4/tanH4				
Angle (Holizontal)	L5/tanH5				
	L6/tanH6				
	L7/tanH7				
	L8/tanH8				



Bridge ID:		Bridge NAME:	Victoria Falls

Expansion Joint

Measure	Place		1905	2022	Difference	Remark		
Abutment 1	expansion Joint	J						
Abutment 2	expansion Joint	J						



APPENDIX-B SAMPLE OF INSPECTION FORMS

FORM1: INVENTORY INSPECTION FORM
FORM2: PERIODIC INSPECTION FORM

LOCATION

	Bridge ID	T1-005
	Bridge Name	
	Road Name	
	Road ID	
	Location	
A1	GPS: S	15.90469°
	GPS: E	027.67237°
A2	GPS: S	15.90515°
	GPS: E	027.67221°

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	✓
	1945 – 1970	
	Post 1970	

DESIGN LOAD

Available?	Yes	
	No	✓
If yes, insert as:		

BRIDGE DESCRIPTION

Type of Bridge	Continious
Superstructure	I-Girder
Substructure	Solid Wall
Foundation	unknown

DESIGN STANDARD

Available?	Yes	
	No	✓
If yes, insert as:		

Province	Southen
Rever Name	KAREYA

BRIDGE GEOMETRY

Bridge length, (m)		36.0
Bridge width, (m)		10.0
Number of lanes		2.0
Number of spans		3.0
Width of carriageway, (m)		6.8
Width of island(s), (m)		
Width of shoulder, (m)	Left	0.3
	Right	0.3
Sidewalk width, (m)	Left	1.3
	Right	1.3

TERRAIN CROSSED

River or waterway (fresh water)	✓
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

Utility Identification No.	Light 1	2	3	Right 4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY	
SUBMITTED BY:	

Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

GENERAL SPAN INFORMATION

Span Number	1
Length of span, (m)	11.4
Skew (in Degrees)	90
Number of main members	6

MAIN MEMBER TYPE

Girder - Also composite girder form	✓
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	✓
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	2
Length of span, (m)	13.2
Skew (in Degrees)	90
Number of main members	6

MAIN MEMBER TYPE

Girder - Also composite girder form	✓
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	✓
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	3
Length of span, (m)	11.4
Skew (in Degrees)	90
Number of main members	6

MAIN MEMBER TYPE

Girder - Also composite girder form	✓
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	✓
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	
	Yes
	No ✓
	Not known

CONTINUITY

	L	H
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

L Low chainage end
H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	
	Yes
	No ✓
	Not known

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✓
Masonry	
Other	

RAILING TYPE

	L	R
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side
R Right side

SPAN COMMENTS

Pier Number	1
Pier height, (m)	5.6

PIER TYPE

Wall	✓
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	✓
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✓

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✓
Not known	

PIER COMMENTS

Pier Number	2
Pier height, (m)	5.8

PIER TYPE

Wall	✓
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	✓
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✓

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✓
Not known	

PIER COMMENTS

Abutment Number	A-1
Abutment height, (m)	1.5

ABUTMENT TYPE

Solid wall	✓
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✓
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	✓
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✓

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	✓

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✓
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	A-2
Abutment height, (m)	1.5

ABUTMENT TYPE

Solid wall	✓
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✓
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	✓
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✓

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✓
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✓
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

	A-1

WING WALL TYPE	L	R
Solid wall	✓	✓
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete	✓	✓
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known	✓	✓

WING WALL LENGTH

Left, (m)	1.5
Right, (m)	1.5

BRIDGE APPROACH COMMENTS

	A-2

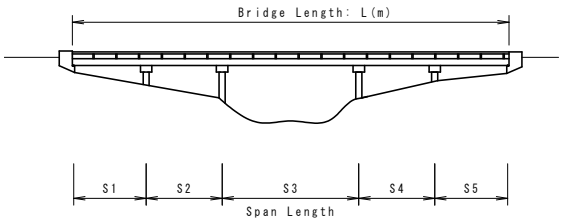
WING WALL TYPE	L	R
Solid wall	✓	✓
Protected slope		
Other		
None		

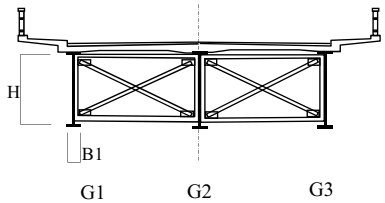
WING WALL MATERIAL	L	R
Concrete	✓	✓
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known	✓	✓

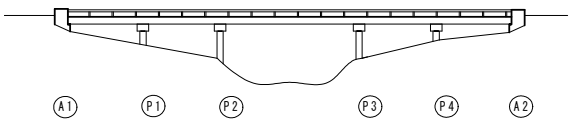
WING WALL LENGTH	
Left, (m)	1.5
Right, (m)	1.5

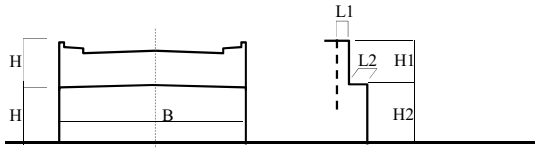
BRIDGE APPROACH COMMENTS

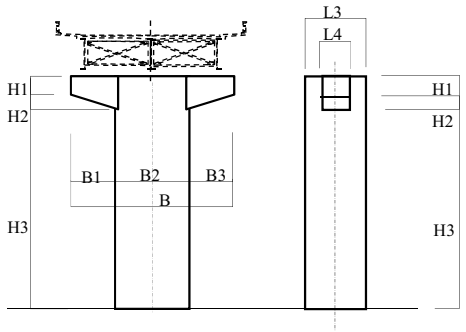




Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S	11.4	
	H	0.71	
	B1	0.255	
S2	S	13.2	
	H	0.71	
	B1	0.255	
S3	S	11.4	
	H	o.71	
	B1	0.255	
S4	S		
	H		
	B1		
S5	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		
	S		
	H		
	B1		

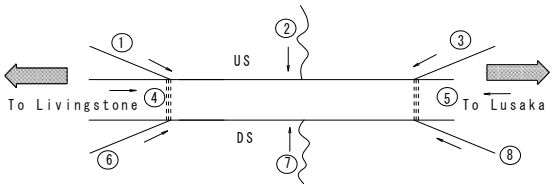






Abutment and Pier Measurement			
Height and Width			
No.	Component	L (m)	Remarks
A1	H1	1.1	
	H2	0.4	
	B	9	
	L1		
	L2	0.45	
P1	H1	1	
	H2	0	
	H3	4.6	
	B	6.1	
	B1	1.67	
	B2	6.1	
	B3	1.67	
	L3	0.7	
	L4		
P2	H1	0.9	
	H2	0	
	H3	4.9	
	B	6.1	
	B1	1.67	
	B2	6.1	
	B3	1.67	
	L3	0.7	
	L4		
P3	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
P4	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
	H1		
	H2		
	H3		
	B		
	B1		
	B2		
	B3		
	L3		
	L4		
A2	H1	1.1	
	H2	0.4	
	B	9	
	L1		
	L2	0.45	

【Photograph】



①



⑤



②



⑥



③



⑦



④



⑧



PERIODIC INSPECTION FORM

LOCATION	
Bridge ID	T1-005
Bridge Name	
Road Name	
Road ID	
Location	

Province	
Rever Name	KALEYA

BRIDGE DESCRIPTION	
Type of Bridge	Simply Sapported
Superstructure	I Shaped Girder
Substructure	Solid Type
Foundation	unknown
Total Number of Span	3
Total Number of Abutment	2
Total Number of Pier	2

BRIDGE OVERALL RATING	
Good	
Fair	
Poor	
Bad	✓

LEVEL OF INSPECTION	
Full conmplete inspection	
Partial inspection only:	
BIV not available	✓
Other reason	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPAN No.	

(one set of forms foe each pier)

Bridge ID

Bridge NAME

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking		3		Bad	Bad
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN MEMBER(GIRDER)							
Steel Girder/		Corrosion		1	15	Fair	Fair
		Cracking					
		Deformation/Buckling					
		Abnormal vibration					
		Loose connection					
		Paint peel off					
Substructure							
Abutment		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier		Cracking					
		Spalling/Scaling/Disintegration					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Foundation (Steel Type)		Corrosion					
		Cracking					
		Deformation/Buckling					
		Tilt/Settlement					
		Scouring					
Overall Rating							Bad

PERIODIC INSPECTION FORM

Steel Bridge

Bridge ID: Bridge NAME:

Span No:1

Conponent	Defect Found Type	Raiting Good	Fair	Poor	Bad	Comment
Concrete Deck	Cracking				✓	1.2mm
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Steel Girder	Corrosion		✓			15%
	Cracking					
	Deformation/Buckling					
	Abnormal vibration					
	Loose connection					
	Paint peel off					
	Missing element					
Abutment	Cracking					
	Spalling/scalling/disintegration					
	Rebar exposure/corrosion					
	Delamination					
	Honeycomb					
	Tilt/Settlement					
Pier	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Waterway	Flood debris accumulation					
	Siltation					
	Vegetation growth					
Bearing(Steel)	Corrosion					
	Loose connection					
	Abnormal Displacement					
	Paint deterioration					
	Bed (support) damage					
Bearing(Rubber)	Bulging					
	Abnormal displacement					
	Bed (support) damage					
Foundation(Concrete)	Cracking					
	Spalling,Scaling,Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
Slope Protection	Damage on containing wire					
	Bank erosion					
	Slope erosion					
Wing Wall	Cracking					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Bridge Approach	Depression					
Expansion joint(Steel)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Displacement					
	Cracking					
Expansion joint(Rubber)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Rupture					
Expansion joint(Asphalt)	Water leakage					
	Abnormal space/noise				✓	
	Difference in elevation					
	Deteriotated sealant				✓	
Railing(Steel)	Corrosion				✓	80%
	Loose connection					
	Impact/Accident Damage			✓		
	Paint peel off					
Railing(Concrete)	Corrosion					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Asphalt wearing surface	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling		✓			

PERIODIC INSPECTION FORM

Steel Bridge

Bridge ID: Bridge NAME:

Span No:2

Conponent	Defect Found Type	Raiting Good	Fair	Poor	Bad	Comment
Concrete Deck	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Steel Girder	Corrosion		✓			15mm%
	Cracking					
	Deformation/Buckling					
	Abnormal vibration					
	Loose connection					
	Paint peel off					
	Missing element					
Abutment	Cracking					
	Spalling/scalling/disintegration					
	Rebar exposure/corrosion					
	Delamination					
	Honeycomb					
	Tilt/Settlement					
Pier	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Waterway	Flood debris accumulation					
	Siltation					
	Vegetation growth					
Bearing(Steel)	Corrosion					
	Loose connection					
	Abnormal Displacement					
	Paint deterioration					
	Bed (support) damage					
Bearing(Rubber)	Bulging					
	Abnormal displacement					
	Bed (support) damage					
Foundation(Concrete)	Cracking					
	Spalling,Scaling,Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
Slope Protection	Damage on containing wire					
	Bank erosion					
	Slope erosion					
Wing Wall	Cracking					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Bridge Approach	Depression					
Expansion joint(Steel)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Displacement					
	Cracking					
Expansion joint(Rubber)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Rupture					
Expansion joint(Asphalt)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Deteriotated sealant				✓	
Railing(Steel)	Corrosion				✓	80%
	Loose connection					
	Impact/Accident Damage					
	Paint peel off					
Railing(Concrete)	Corrosion					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Asphalt wearing surface	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					

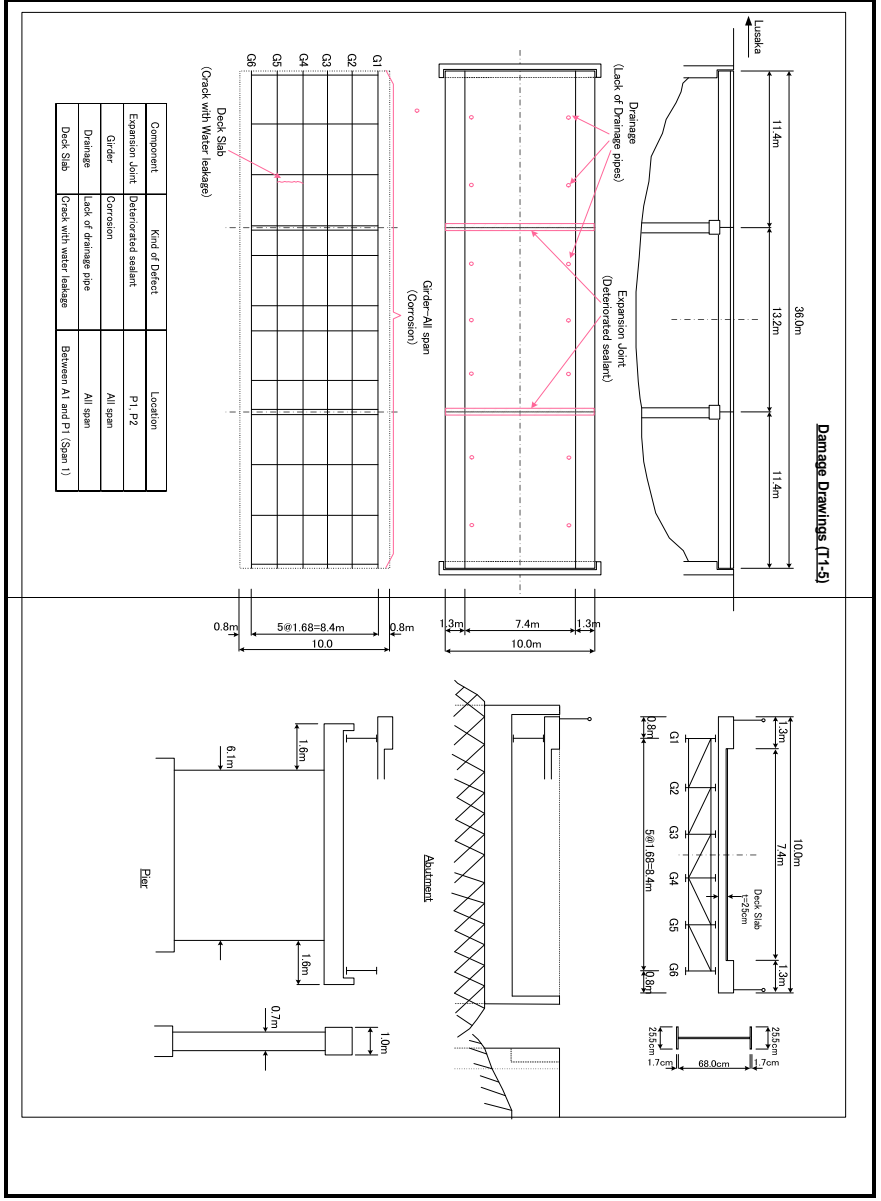
PERIODIC INSPECTION FORM

Steel Bridge
Bridge ID: Bridge NAME:
Span No:3

Conponent	Defect Found Type	Raiting Good	Fair	Poor	Bad	Comment
Concrete Deck	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Water leakage					
	Abnormal Vibration					
Steel Girder	Corrosion	✓				10%
	Cracking					
	Deformation/Buckling					
	Abnormal vibration					
	Loose connection					
	Paint peel off					
	Missing element					
Abutment	Cracking					
	Spalling/scalling/disintegration					
	Rebar exposure/corrosion					
	Delamination					
	Honeycomb					
	Tilt/Settlement					
Pier	Cracking					
	Spalling/scalling/disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Honeycomb					
	Tilt/Settlement					
Waterway	Flood debris accumulation					
	Siltation					
	Vegetation growth					
Bearing(Steel)	Corrosion					
	Loose connection					
	Abnormal Displacement					
	Paint deterioration					
	Bed (support) damage					
Bearing(Rubber)	Bulging					
	Abnormal displacement					
	Bed (support) damage					
Foundation(Concrete)	Cracking					
	Spalling,Scaling,Disintegration					
	Delamination					
	Rebar exposure/corrosion					
	Tilt/Settlement					
	Scouring					
Slope Protection	Damage on containing wire					
	Bank erosion					
	Slope erosion				✓	
Wing Wall	Cracking					
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Bridge Approach	Depression					
Expansion joint(Steel)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Displacement					
	Cracking					
Expansion joint(Rubber)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Rupture					
Expansion joint(Asphalt)	Water leakage					
	Abnormal space/noise					
	Difference in elevation					
	Deteriotated sealant					
Railing(Steel)	Corrosion					
	Loose connection					
	Impact/Accident Damage			✓		
	Paint peel off					
Railing(Concrete)	Corrosion				✓	80%
	Delamination/Disintegration					
	Impact/Accident Damage					
	Rebar expure/corrosion					
	Water leakage					
Asphalt wearing surface	Potholes					
	Shoving					
	Rutting					
	Cracking					
	Raveling					

【Damage Drawing】

Bridge ID:	T1-5	Bridge NAME:	
Span No:			
Bridge Number		Span	

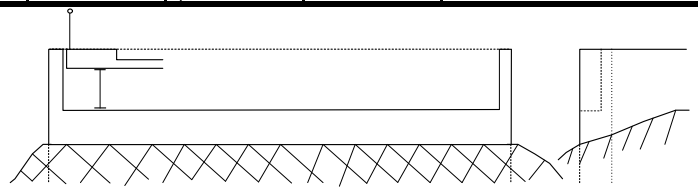


【Damage Drawing】

Bridge ID:	T1-5	Bridge NAME:	

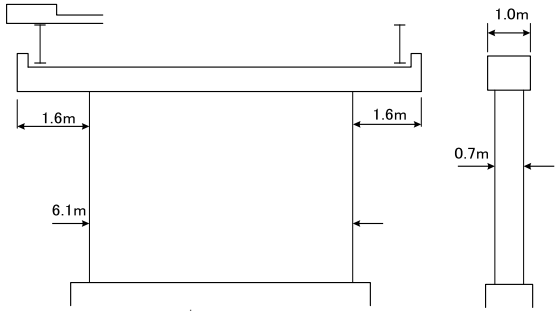
Span No:

Bridge Number		Span		



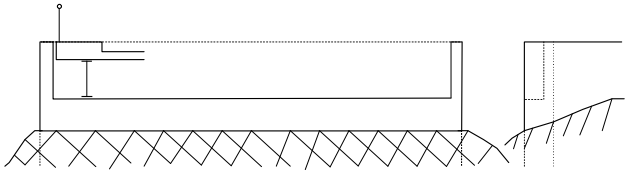
Abutment

A1



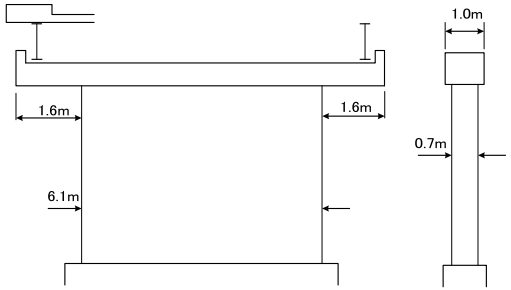
A1

Pier



Abutment

A2



Pier

【Photograph】

Bridge ID:	T1-005	Bridge NAME:	

Photo Number		Span		Conponent Name		Type of Damage	



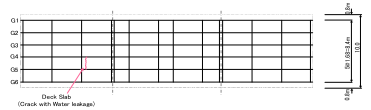


Photo Number		Span		Conponent Name		Type of Damage	



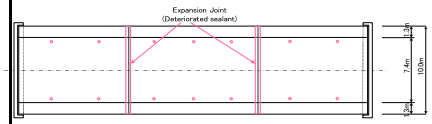


Photo Number		Span		Conponent Name		Type of Damage	



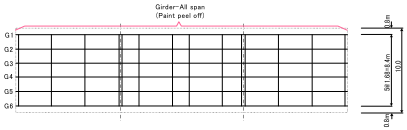
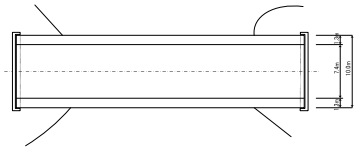


Photo Number		Span		Conponent Name		Type of Damage	





APPENDIX-B-1-1

SAMPLE OF INVENTORY INSPECTION FORM

LOCATION

	Bridge ID	
	Bridge Name	Chirundu
	Road Name	
	Road ID	
	Location	
A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	✔
	Insert year if known	2002

DESIGN LOAD

Available?	Yes	✔
	No	
If yes, insert as:		BS HA, HB45

BRIDGE DESCRIPTION

Type of Bridge	Continious
Superstructure	PC-box Girder
Substructure	solid wall / wall
Foundation	spread footing / steel pipe sheet pile

DESIGN STANDARD

Available?	Yes	✔
	No	
If yes, insert as:		BS5400

Province	Lusaka
Rever Name	Zambezi

BRIDGE GEOMETRY

Bridge length, (m)		400
Bridge width, (m)		103
Number of lanes		1-1
Number of spans		3
Width of carriageway, (m)		4
Width of island(s), (m)		1.15
Width of shoulder, (m)	Left	1.15
	Right	1.14
Sidewalk width, (m)	Left	0.75
	Right	0.75

TERRAIN CROSSED

River or waterway (fresh water)	✔
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	✔
Bridge inspection vehicle	
Ladder	✔
Binoculars	✔
Safety Belt / Harness	✔
Geologist Hammer	✔
Oxygen meter	✔
Camera	✔
Hard Hat with Headlight	✔
Other(meter tape, safety shoes, gloves, total station)	✔ total station

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	✔
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	✔

END OF WARRANTY PERIOD

Insert year of end of warranty period	–

LIGHTING TO BRIDGE

yes or no	No

INTERVAL OF LIGHTING POLES

Left, (m)	-
Right, (m)	-

AS-BUILT DRAWING

Available?(yes, no or unknown)	yes
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	no
If yes, insert year of widening.	-
Bridge strengthened? (yes or no)	no
If yes, insert year of strengthening	–
Bridge retrofitted? (yes or no)	no
If yes, insert year of seismic retrofitting	–
Bridge lengthened? (yes or no)	no
If yes, insert year of lengthening	–

SUPERSTRUCTURE WIDENING FORM

Widened left side	-
Widened right side	-
Widened both side	-

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing berige	-
Same detail / modified material	-
Different details	-

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	-
Girder	-
Box girder	-
Slab	-
Voided slab	-
Demontable (Bailey type)	-
Truss	-
Trestle	-
Cable stayed	-
Suspension	-
Arch	-
Portal frame	-
Other structure	-

SUPERSTRUCTURE WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF PIER WIDENING

Widening original piers	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

TYPE OF ABUTMENT WIDENING

Widerning original abutments	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

PIER / ABUTMENT WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF STRENGTHENING

Main member reinforcement	-
Deck reinforcement	-
Additional piers	-
Substrucutre reinforcement	-
Other	-

TYPE OF SEISMIC RETROFIT

Sleeves to columns	-
Lateral restraints	-
Longitudinal restraints	-
Beam continuity	-
Deck continuity	-
Other	-

TYPE OF LENGTHENING

Low chainage end, original and widening	-
Low chainage ehd, widened part only	-
High chainage end, original and widening	-
High chainage end, widened part only	-

GENERAL SPAN INFORMATION

Span Number	1
Length of span, (m)	119.85
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	✔
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	✔
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	2
Length of span, (m)	160
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	✔
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	✔
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	119.85
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	✔
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	✔
	No	
	Not known	

CONTINUITY	**L**	**H**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

L Low chainage end

H High chainage end

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side

R Right side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	24

PIER TYPE

Wall	✔
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	steel pipe sheet pile
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	22

PIER TYPE

Wall	✔
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	steel pipe sheet pile
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**1**
Abutment height, (m)	8.85

ABUTMENT TYPE

Solid wall	✔
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✔
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	✔
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	✔
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**2**
Abutment height, (m)	13.85

ABUTMENT TYPE

Solid wall	✔
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✔
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	✔
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	✔
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	**1**

WING WALL TYPE	**L**	**R**
Solid wall	✔	✔
Protected slope		
Other		
None		

WING WALL MATERIAL	**L**	**R**
Concrete	✔	✔
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	**L**	**R**
Spread footing	✔	✔
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

Left, (m)	6.85
Right, (m)	6.85

BRIDGE APPROACH COMMENTS

Abutment Number	2

WING WALL TYPE	L	R
Solid wall	✔	✔
Protected slope		
Other		
None		

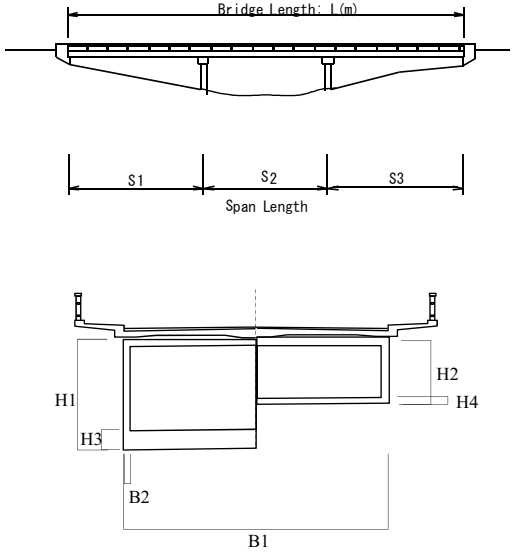
WING WALL MATERIAL	L	R
Concrete	✔	✔
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing	✔	✔
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

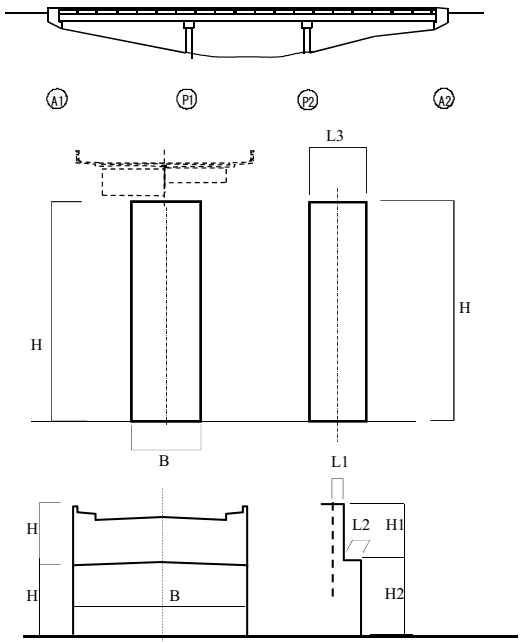
WING WALL LENGTH

Left, (m)	11.85
Right, (m)	11.85

BRIDGE APPROACH COMMENTS

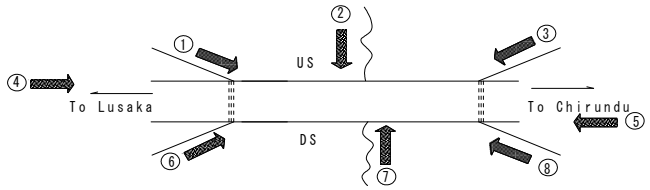


Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S	119.85	
	H1	8.5	
	H2	4	
	H3	1.1	
	H4	0.25	
	B1	5.5	
	B2	0.4	
S2	S	160	
	H1	8.5	
	H2	4	
	H3	1.1	
	H4	0.25	
	B1	5.5	
	B2	0.4	
S3	S	119.85	
	H1	8.5	
	H2	4	
	H3	2.1	
	H4	0.25	
	B1	5.5	
	B2	0.4	



Height and Width			
No.	Component	L (m)	Remarks
A1	H1	5.08	
	H2	1.902	
	B	10.3	
	L1	0.7	
	L2	1.8	
P1	H	24	
	B1	7	
	L3	4	
P2	H	22	
	B1	7	
	L3	4	
A2	H1	5.05	
	H2	6.932	
	B	10.3	
	L1	0.7	
	L2	1.8	

【Photograph】



①



②



③



④



⑤



⑥



⑦ No Photo (no boat)

⑧



APPENDIX-B-1-2

SAMPLE OF PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Chirundu
Road Name	
Road ID	
Location	

Province	
Rever Name	

BRIDGE DESCRIPTION

Type of Bridge	Continuous
Superstructure	PC-Box Girder
Substructure	solid wall / wall
Foundation	spread footing / steel pipe sheet pile
Total Number of Span	3
Total Number of Abutment	2
Total Number of Pier	2

BRIDGE OVERALL RATING

Good	
Fair	
Poor	✔
Bad	

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	✔
Partial inspection only:	
BIV not available	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	✔
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Chirundu

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D:Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1	Bridge ID	
(one set of forms for each pier)		Bridge NAME	Chirundu

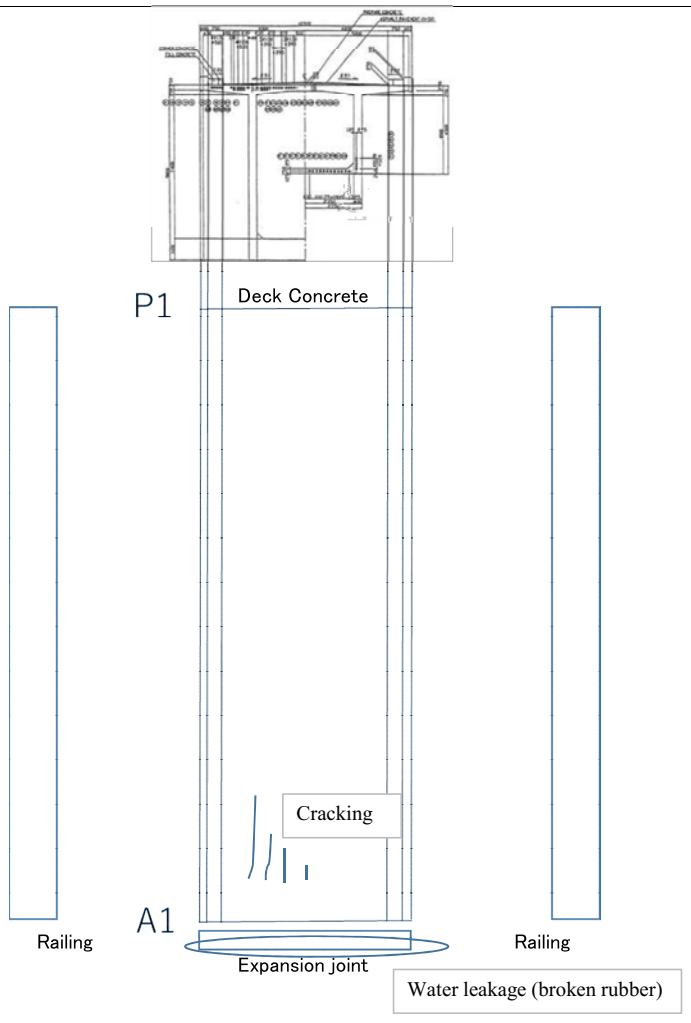
Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete	×	Cracking	Poor	-	-	Poor	2
	×	Spalling/Scaling/Disintegration	Poor	area	15	Fair	
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN / SECONDARY MEMBER							
Concrete Girder	×	Cracking	Good	-	-	Good	1
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
MAIN STRUCTURE							
Abutment (A1)	×	Cracking	Poor	-	-	Poor	2
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (P1)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
WATERWAY							
River Water	×	Flood debris accumulation	3	area	33	Fair	1
		Siltation					
		Vegetation growth					
BEARING / RESTRAINT							
Steel		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
FOUDATION							
Concrete Pile		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
RAILING /WINGWALL							
Steel (Left side)		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Steel (Right side)		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
BRIDGE APPROACH							
Embankment		Depression					
		Slope erosion					
Expansion Joint							
Steel	×	Water leakage	3	area	50	Poor	2
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
ANCHORAGE (INSIDE BOX GIRDER)							
Concrete		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
Overall Rating							Poor

【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span	1

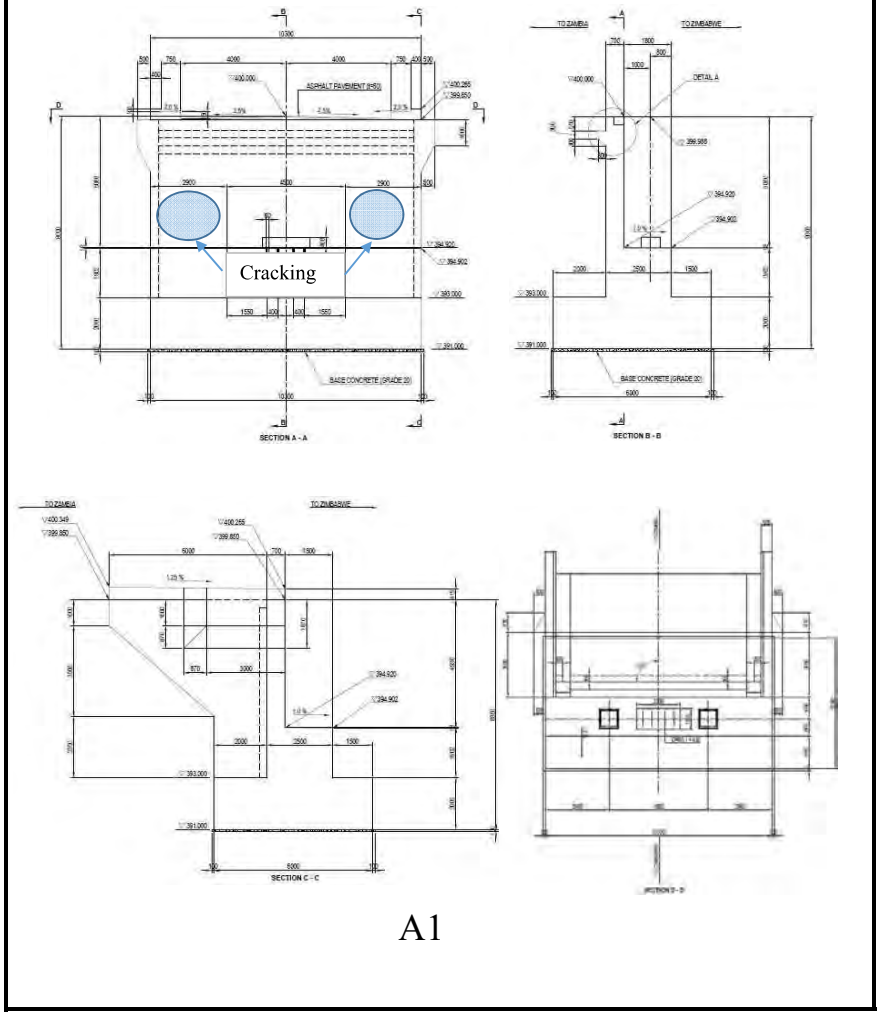


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

Span No:

Bridge Number		Span		

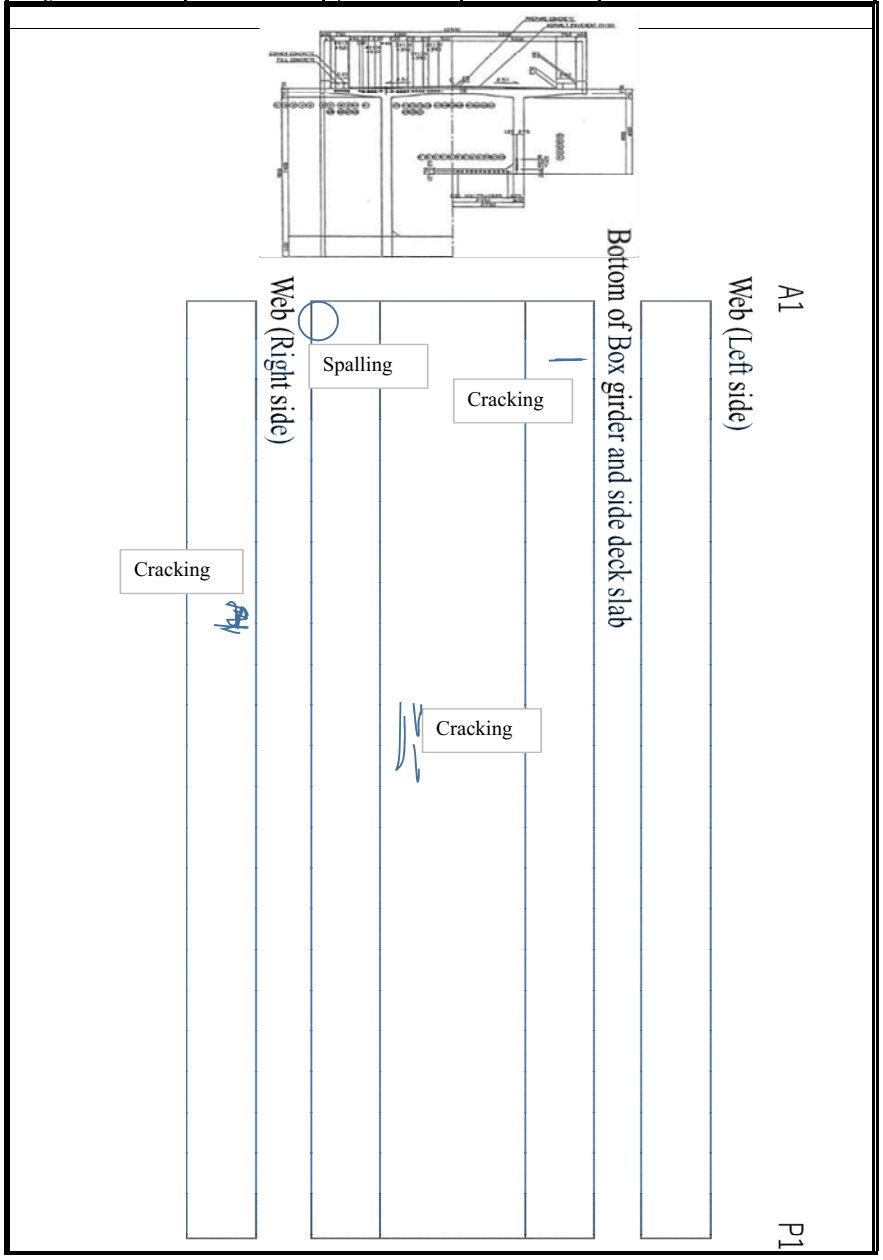


【Damage Drawing】

Bridge ID:		Bridge NAME:	Chirundu

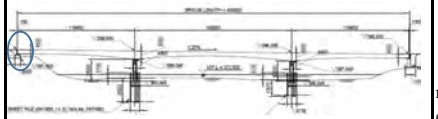
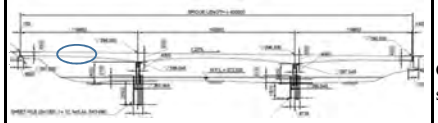
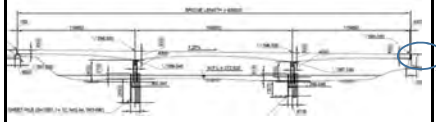
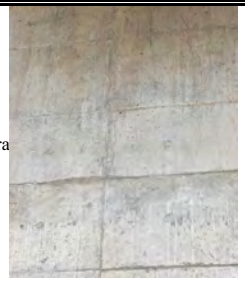
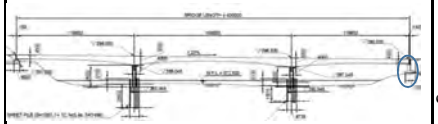
Span No:

Bridge Number		Span	1



【Photograph】

Bridge ID:		Bridge NAME:	Chirundu

Photo Number		Span		Conponent Name		Type of Damage	
							Comment rubber at expansion joint is broken
Photo Number		Span		Conponent Name		Type of Damage	
							Comment Cracking at road surface
Photo Number		Span		Conponent Name		Type of Damage	
							Comment Alligator clack on approach road surface
Photo Number		Span		Conponent Name		Type of Damage	
Photogra 							Comment craking at A2

APPENDIX-B-2-1

SAMPLE OF INVENTORY INSPECTION FORM

LOCATION

Bridge ID		
Bridge Name	Luangwa	
Road Name		
Road ID		
Location		
A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	✔
	Post 1970	
	Insert year if known	1968

DESIGN LOAD

Available?	Yes	
	No	✔
If yes, insert as:		

BRIDGE DESCRIPTION

Type of Bridge	Cable Stayed
Superstructure	2-boxes Girder
Substructure	solid wall / steel pipe
Foundation	spread footing

DESIGN STANDARD

Available?	Yes	
	No	✔
If yes, insert as:		

Province	Lusaka
Rever Name	Zambezi

BRIDGE GEOMETRY

Bridge length, (m)		302
Bridge width, (m)		11.75
Number of lanes		1
Number of spans		3
Width of carriageway, (m)		1.44*2
Width of island(s), (m)		0.778*2
Width of shoulder, (m)	Left	0.778
	Right	0.778
Sidewalk width, (m)	Left	1.44
	Right	1.44

TERRAIN CROSSED

River or waterway (fresh water)	✔
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

INSPECTOR COMMENTS

Date of Field Inspection	
ACCOMPLISHED BY:	
SUBMITTED BY:	

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	✔
Bridge inspection vehicle	
Ladder	✔
Binoculars	✔
Safety Belt / Harness	✔
Geologist Hammer	✔
Oxygen meter	✔
Camera	✔
Hard Hat with Headlight	✔
Other(meter tape, safety shoes, gloves, total station)	✔ total station

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	✔
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	✔

END OF WARRANTY PERIOD

Insert year of end of warranty period	–

LIGHTING TO BRIDGE

yes or no	yes

INTERVAL OF LIGHTING POLES

Left, (m)	
Right, (m)	

AS-BUILT DRAWING

Available?(yes, no or unknown)	no
If yes, insert location (Ex.Regional Office, Planning Division)	

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	no
If yes, insert year of widening.	-
Bridge strengthened? (yes or no)	yes
If yes, insert year of strengthening	–
Bridge retrofitted? (yes or no)	no
If yes, insert year of seismic retrofitting	–
Bridge lengthened? (yes or no)	no
If yes, insert year of lengthening	–

SUPERSTRUCTURE WIDENING FORM

Widened left side	-
Widened right side	-
Widened both side	-

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing berige	-
Same detail / modified material	-
Different details	-

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	-
Girder	-
Box girder	-
Slab	-
Voided slab	-
Demontable (Bailey type)	-
Truss	-
Trestle	-
Cable stayed	-
Suspension	-
Arch	-
Portal frame	-
Other structure	-

SUPERSTRUCTURE WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF PIER WIDENING

Widening original piers	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

TYPE OF ABUTMENT WIDENING

Widerning original abutments	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

PIER / ABUTMENT WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF STRENGTHENING

Main member reinforcement	
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	-
Lateral restraints	-
Longitudinal restraints	-
Beam continuity	-
Deck continuity	-
Other	-

TYPE OF LENGTHENING

Low chainage end, original and widening	-
Low chainage ehd, widened part only	-
High chainage end, original and widening	-
High chainage end, widened part only	-

GENERAL SPAN INFORMATION

Span Number	**1**
Length of span, (m)	40
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	✔
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?		
	Yes	
	No	✔
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

W Western side
E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?		
	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side
R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**2**
Length of span, (m)	222
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	✔
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?		
	Yes	
	No	✔
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

W Western side
E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?		
	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side
R Right side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	40
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	
Deck truss	
Cable supported	✔
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	✔
Built-Up (Plate) girder	

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**W**	**E**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

W Western side
E Eastern sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	
Other	
None	✔

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**L**	**R**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

L Left side
R Right side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	

PIER TYPE

Wall	✔
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	✔
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	spread footin
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	

PIER TYPE

Wall	✔
Single column	
Multiple columns	
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	✔
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	spread footin
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
None	
Other	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	1
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	✔
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✔
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	✔
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	✔
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	2
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	✔
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✔
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	✔
Bored pile	
Driven piles	
Caisson	
Other	
Not known	

BEARING TYPE

Elastomeric pad	✔
Steel plate	
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	✔
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	✔
Concrete	
Paving	
Other	
None	

ABUTMENT COMMENTS

Abutment Number	1

WING WALL TYPE

	L	R
Solid wall	✔	✔
Protected slope		
Other		
None		

WING WALL MATERIAL

	L	R
Concrete	✔	✔
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE

	L	R
Spread footing	✔	✔
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

Left, (m)	12.592
Right, (m)	12.592

BRIDGE APPROACH COMMENTS

Abutment Number	2

WING WALL TYPE	L	R
Solid wall	✔	✔
Protected slope		
Other		
None		

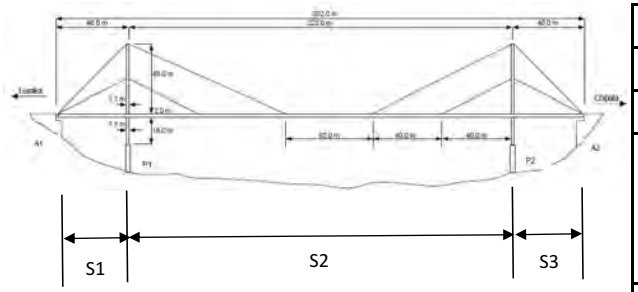
WING WALL MATERIAL	L	R
Concrete	✔	✔
Masonry		
Timber		
Gabions or mattresses		
Other		

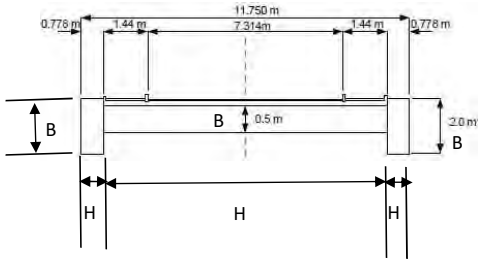
WING WALL FOUNDATION TYPE	L	R
Spread footing	✔	✔
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known		

WING WALL LENGTH

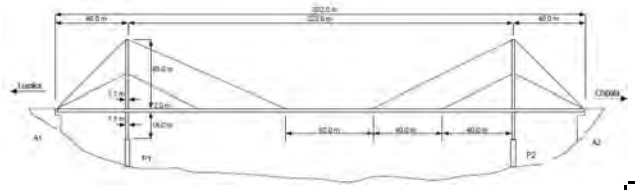
Left, (m)	4.9
Right, (m)	1.95

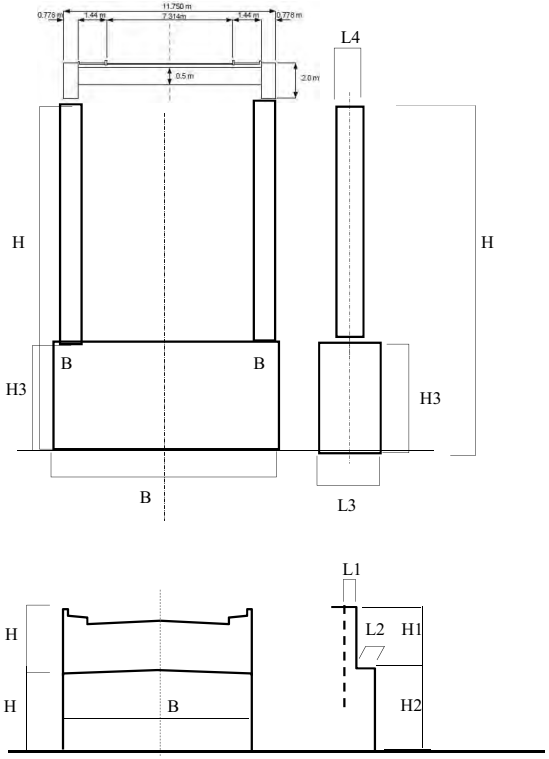
BRIDGE APPROACH COMMENTS





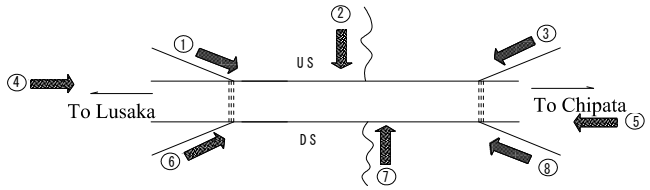
Steel Girder Measurement			
Depth of Girder and Flange Width			
Section	Component	l(m)	Remarks
S1	S	40	
	H1	0.778	
	H2	10.194	
	H3	0.778	
	B1	2.0	
	B2	0.5	
	B3	2.0	
S2	S	222	
	H1	0.778	
	H2	10.194	
	H3	0.778	
	B1	2.0	
	B2	0.5	
	B3	2.0	
S3	S	40	
	H1	0.778	
	H2	10.194	
	H3	0.778	
	B1	2.0	
	B2	0.5	
	B3	2.0	





Height and Width			
No.	Component	L (m)	Remarks
A1	H1	3.5	
	H2		
	B	12.83	
	L1	0.49	
	L2	2.33	
P1	H		
	H3	8.76	
	B1	13.86	
	B2	1.18	
	B3	1.18	
	L3	1.7	
	L4	1.0	
P2	H		
	H3	8.76	
	B1	13.86	
	B2	1.18	
	B3	1.18	
	L3	1.7	
	L4	1.0	
A2	H1	1.924	
	H2		
	B	17.86	
	L1	1.95	
	L2	6.5	

【Photograph】



①



②

No Photo (no boat)

③



④



⑤



⑥



⑦



⑧



APPENDIX-B-2-2

SAMPLE OF PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Luangwa
Road Name	
Road ID	
Location	

Province	
Rever Name	Zambezi

BRIDGE DESCRIPTION

Type of Bridge	Cable Stayed
Superstructure	2 box girder
Substructure	solid wall/steel pipe
Foundation	spred footing
Total Number of Span	3
Total Number of Abutment	2
Total Number of Pier	2

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	✔

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	✔
BIV not available	✔
Access restricted	
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	✔
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Luangwa

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1

(one set of forms for each pier)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete	×	Cracking	3	-	-	Bad	3
	×	Spalling/Scaling/Disintegration	2	Area	26	Poor	
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
MAIN MEMBER							
Steel Box Girder (Left)	×	Corrosion	1	Area	15	Fair	1
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Box Girder (Right)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
Abutment	×	Cracking	3	-	-	Bad	3
	×	Spalling/Scaling/Disintegration	2	Area	10	Fair	
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (concrete)	×	Cracking	2	-	-	Poor	2
	×	Spalling/Scaling/Disintegration	2	Area	15	Fair	
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					
Pier (steel)		Corrosion					
		Cracking					
		Deformation / Buckling					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Substructure							
Waterway	×	Flood debris accumulation	3	Area	25	Fair	1
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Foundation (Concrete Type)		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Tilt/Settlement					
		Scouring					
Left Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing		Corrosion					
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (steel)		Water leakage					
		Abnormal Space/Noise					
		Difference in elevation					
		Displacement					
		Cracking					
Overall Rating							Bad

Cable No.	C1L1

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							Good

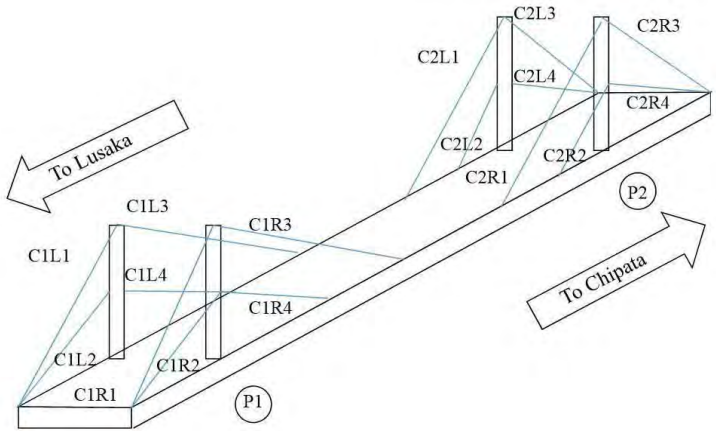
Cable No.	C1L2

(one set of forms for each Cable)

Bridge ID

Bridge NAME Luangwa

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
Main Member							
Cable		Vibration					
		Alignment /Deformation					
Steel Anchorage At Girder	×	Corrosion	1	area	10	Fair	1
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Steel Anchorage At Tower		Corrosion					
		Missing Bolts					
		Deformation Buckling					
		Cracking					
Overall Rating							Fair

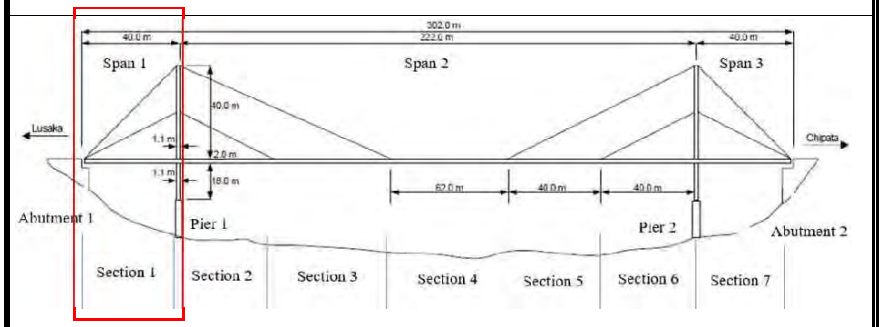


【Damage Drawing】

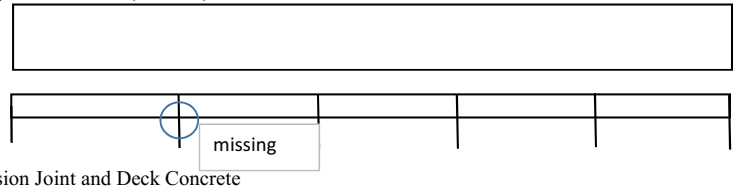
Bridge ID:		Bridge NAME:	Luangwa

Span No:

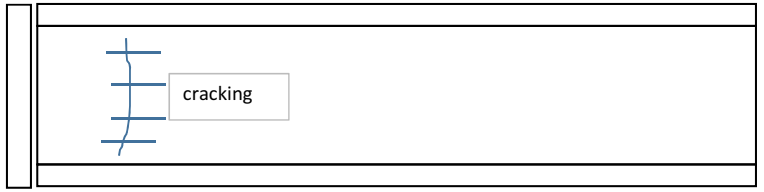
Bridge Number		Span	1	Section	1



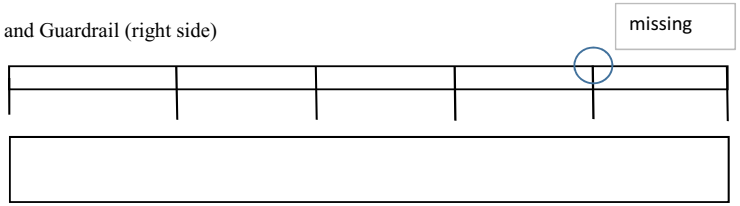
Railing and Guardrail (left side)



Expansion Joint and Deck Concrete



Railing and Guardrail (right side)

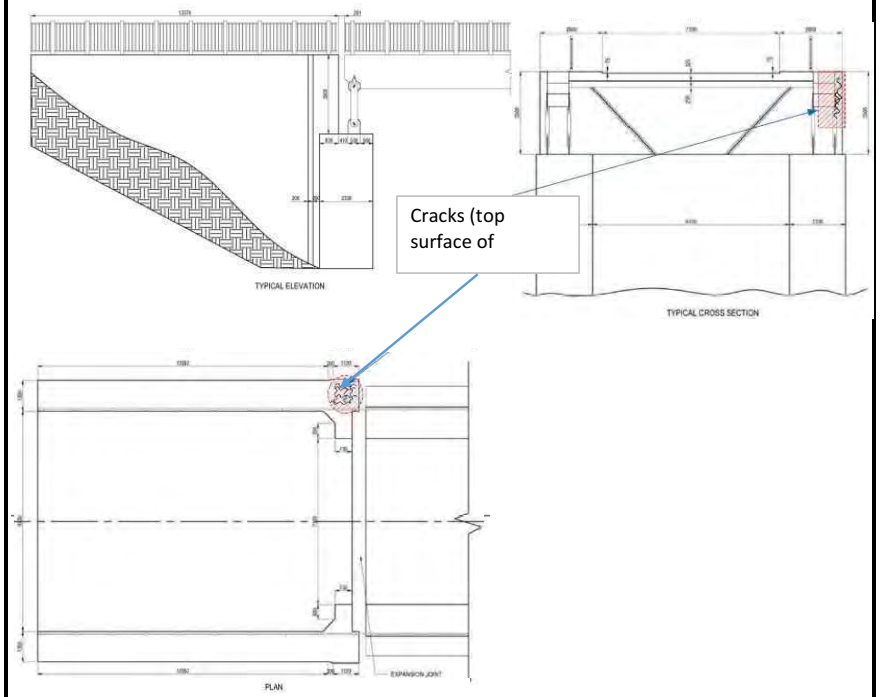


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span		



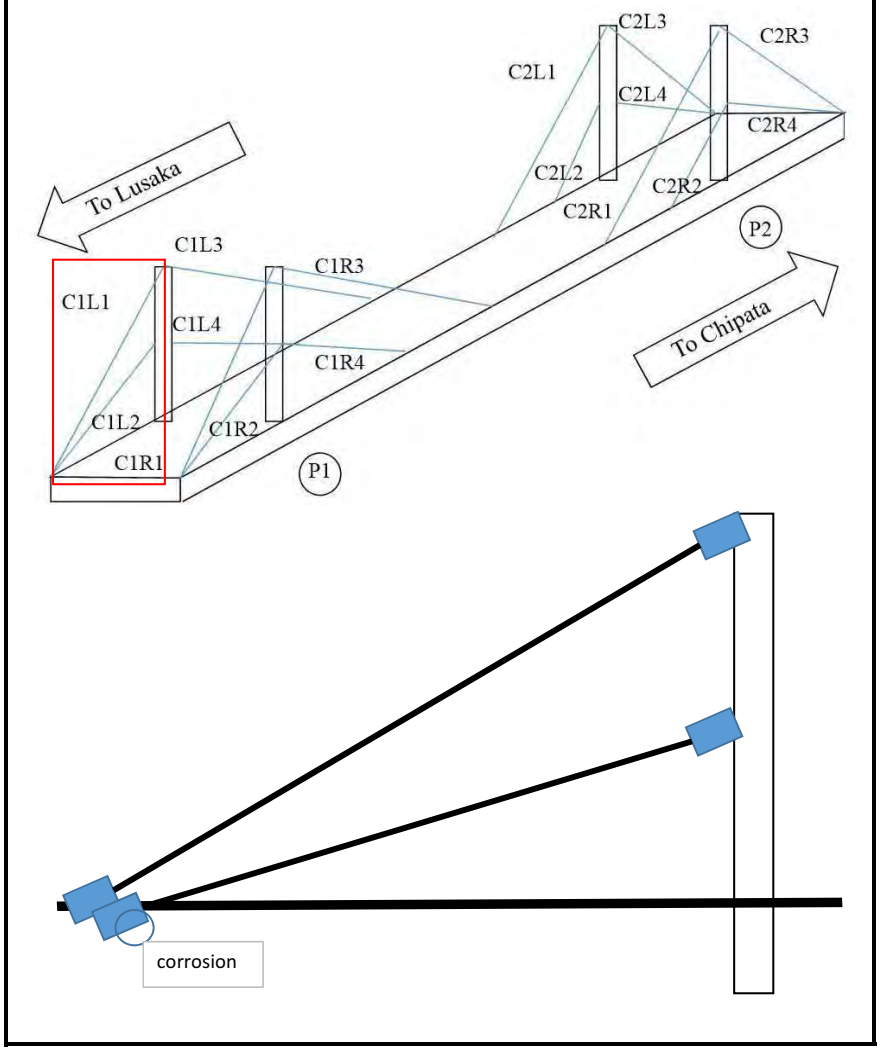
A1

【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Cable	C1L1 C1L2	

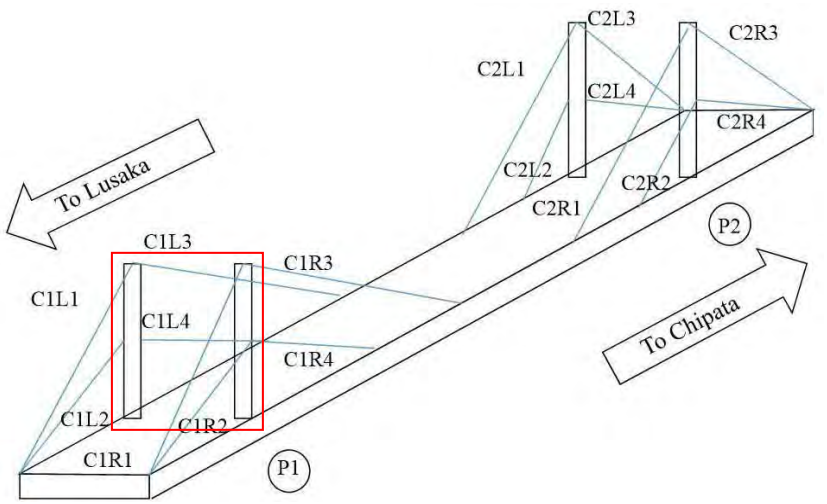


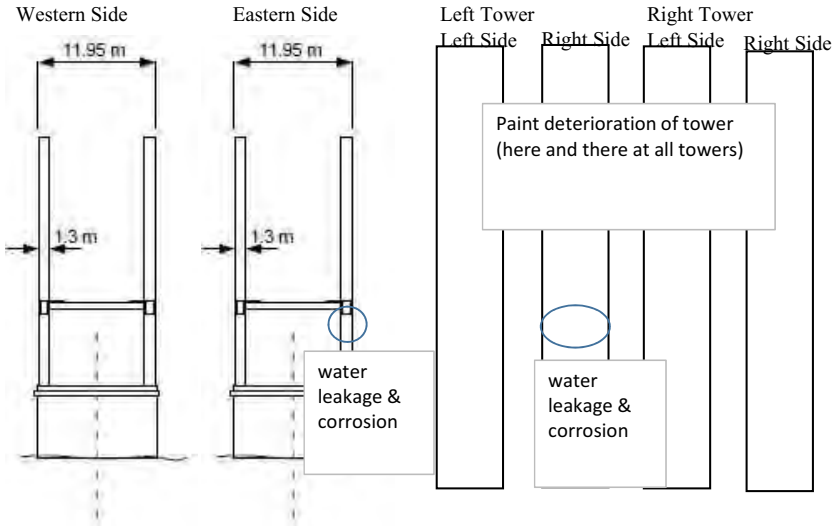
【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Tower		



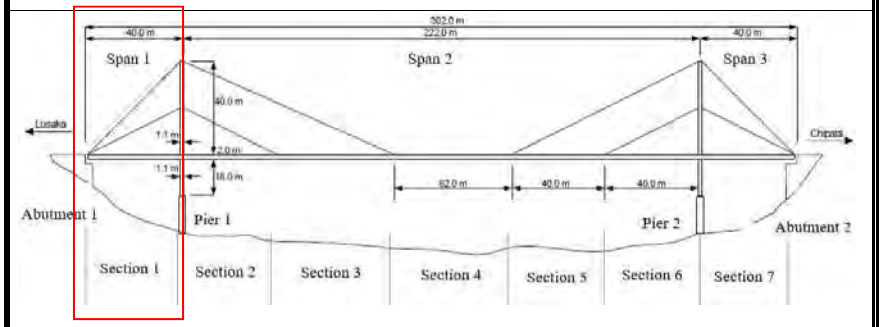


【Damage Drawing】

Bridge ID:		Bridge NAME:	Luangwa

Span No:

Bridge Number		Span	1	Section	1



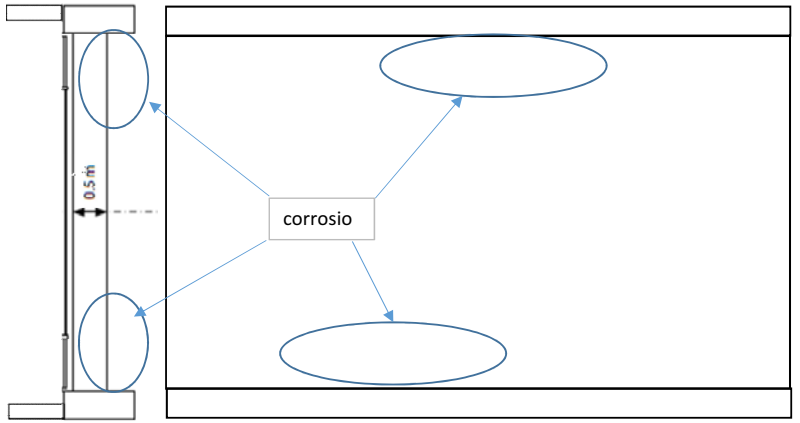
Right Girder

Right Side

Left Side

Deck Slab

Bottom of the Girder



Bottom of the Girder

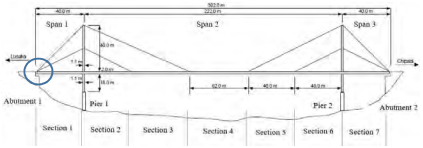
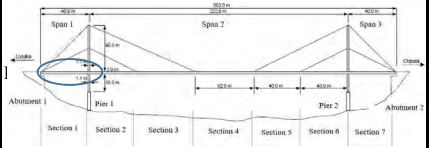
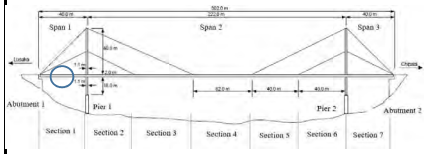
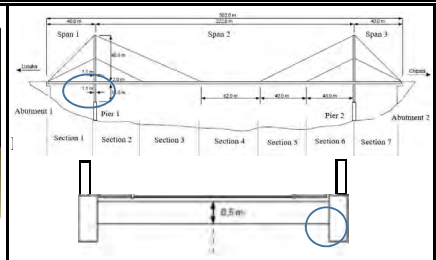
Left Girder

Right Side

Left Side

【Photograph】

Bridge ID:		Bridge NAME:	Luangwa

Photo Number		Span		Conponent Name		Type of Damage		
								Comment craks are observed on the top surface of western side A1
Photo Number		Span		Conponent Name		Type of Damage		
								Comment Many cracks are observed on the top surface of deck slab
Photo Number		Span		Conponent Name		Type of Damage		
								Comment Missing bolts on right guardrail
Photo Number		Span		Conponent Name		Type of Damage		
								Comment Corrosion is observed at the edge of lower flange on the main girder

APPENDIX-B-3-1

SAMPLE OF INVENTORY INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Otto Beit
Road Name	
Road ID	
Location	

A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

BRIDGE DESCRIPTION

Type of Bridge	Suspension
Superstructure	Truss
Substructure	Multipule colums
Foundation	-

BRIDGE GEOMETRY

Bridge length, (m)		320
Bridge width, (m)		10.5
Number of lanes		1
Number of spans		1
Width of carriageway, (m)		5.49
Width of island(s), (m)		0.9141*2
Width of shoulder, (m)	Left	0.914
	Right	0.914
Sidewalk width, (m)	Left	0.764
	Right	0.764

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	✔
	1945 – 1970	
	Post 1970	
	Insert year if known	1939

DESIGN LOAD

Available?	Yes	
	No	✔
If yes, insert as:		

DESIGN STANDARD

Available?	Yes	
	No	✔
If yes, insert as:		

Province	Lusaka
Rever Name	Zambezi

TERRAIN CROSSED

River or waterway (fresh water)	✔
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

INSPECTOR COMMENTS

Date of Field Inspection
ACCOMPLISHED BY:
SUBMITTED BY:

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	✔
Bridge inspection vehicle	✔
Ladder	✔
Binoculars	✔
Safety Belt / Harness	✔
Geologist Hammer	✔
Oxygen meter	
Camera	✔
Hard Hat with Headlight	✔
Other(meter tape, safety shoes, gloves, total station)	✔ total station

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	✔
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	✔

END OF WARRANTY PERIOD

Insert year of end of warranty period	–

LIGHTING TO BRIDGE

yes or no	no

INTERVAL OF LIGHTING POLES

Left, (m)	
Right, (m)	

AS-BUILT DRAWING

Available?(yes, no or unknown)	yes, partly
If yes, insert location (Ex.Regional Office, Planning Division)	RDA HQ

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	no
If yes, insert year of widening.	-
Bridge strengthened? (yes or no)	no
If yes, insert year of strengthening	–
Bridge retrofitted? (yes or no)	yes
If yes, insert year of seismic retfofitting	–
Bridge lengthened? (yes or no)	no
If yes, insert year of lengthening	–

SUPERSTRUCTURE WIDENING FORM

Widened left side	-
Widened right side	-
Widened both side	-

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing bridge	-
Same detail / modified material	-
Different details	-

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	-
Girder	-
Box girder	-
Slab	-
Voided slab	-
Demontable (Bailey type)	-
Truss	-
Trestle	-
Cable stayed	-
Suspension	-
Arch	-
Portal frame	-
Other structure	-

SUPERSTRUCTURE WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF PIER WIDENING

Widening original piers	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

TYPE OF ABUTMENT WIDENING

Widerning original abutments	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

PIER / ABUTMENT WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF STRENGTHENING

Main member reinforcement	
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	-
Lateral restraints	-
Longitudinal restraints	-
Beam continuity	-
Deck continuity	-
Other	-

TYPE OF LENGTHENING

Low chainage end, original and widening	-
Low chainage ehd, widened part only	-
High chainage end, original and widening	-
High chainage end, widened part only	-

GENERAL SPAN INFORMATION

Span Number	**1**
Length of span, (m)	320
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✔
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✔

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

ZMBS Zambian side

ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✔
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✔
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side

W Right side

※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**2**
Length of span, (m)	-
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✔
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✔

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✔
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✔
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**3**
Length of span, (m)	-
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✔
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✔

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✔
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✔
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**4**
Length of span, (m)	-
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✔
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✔

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✔
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✔
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	**5**
Length of span, (m)	-
Skew (in Degrees)	90
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✔
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✔

MAIN MEMBER MATERIAL

Timber	
Steel	✔
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✔	✔
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✔
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✔
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✔
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	
Other	
None	

DECK MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✔	✔
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zimbabwe side

SPAN COMMENTS

GENERAL PIER INFORMATION

Pier Number	1
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	✔
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	✔

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	✔

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	2
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	✔
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	✔

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	✔

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL PIER INFORMATION

Pier Number	3
Pier height, (m)	

PIER TYPE

Wall	
Single column	
Multiple columns	✔
Single pile bent	
Multiple pile bent	
Other	
Not known	

PIER MATERIAL

Timber	
Steel	
Concrete	✔
Masonry	
Other	

PIER FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Caisson	
Other	
Not known	✔

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
None	
Other	
Not known	✔

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	
Other	
None	✔

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✔
Not known	

PIER COMMENTS

GENERAL TOWER DATA

Tower Number	1
Tower height, (m)	

TOWER TYPE

Solid wall	
Truss	✔
Other	
Not known	

TOWER MATERIAL

Concrete	
Steel	✔
Timber	
Masonry	
Gabions	
Other	

TOWER FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✔

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	✔

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	✔
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	✔
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	✔

ABUTMENT COMMENTS

GENERAL TOWER DATA

Tower Number	**2**
Tower height, (m)	

TOWER TYPE

Solid wall	
Truss	✔
Other	
Not known	

TOWER MATERIAL

Concrete	
Steel	✔
Timber	
Masonry	
Gabions	
Other	

TOWER FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✔

BEARING TYPE

Elastomeric pad	
Steel plate	
Metal rocker	
Other	
None	
Not known	✔

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	✔
Rubber	
None (open gap)	
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	✔
Steel sheet piling	
Concrete sheet piling	
Other	
None	
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	✔

ABUTMENT COMMENTS

Anchorage Number	**1**

ANCHORAGE TYPE

Solid wall	✔
Inside the ground	
Other	
None	

ANCHORAGE MATERIAL

Concrete	✔
Masonry	
Timber	
Gabions or mattresses	
Other	

ANCHORAGE FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	✔

ANCHORAGE LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Anchorage Number	2

ANCHORAGE TYPE

Solid wall	✔
Inside the ground	
Other	
None	

ANCHORAGE MATERIAL

Concrete	✔
Masonry	
Timber	
Gabions or mattresses	
Other	

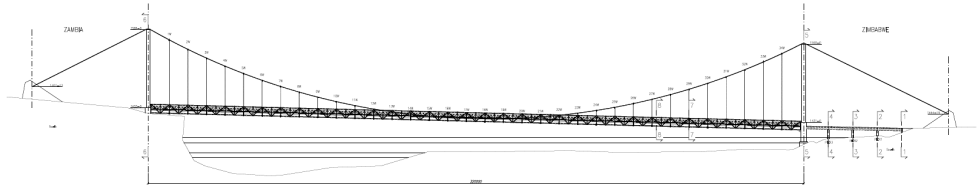
ANCHORAGE FOUNDATION TYPE

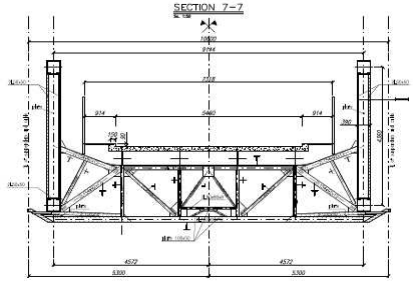
Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	✔

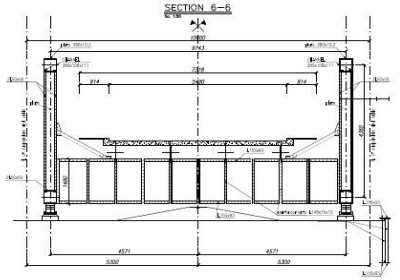
ANCHORAGE LENGTH

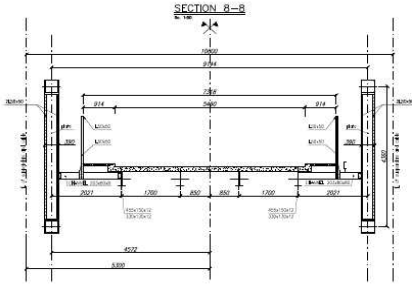
Left, (m)	
Right, (m)	

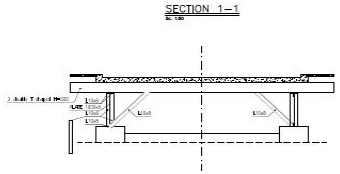
BRIDGE APPROACH COMMENTS

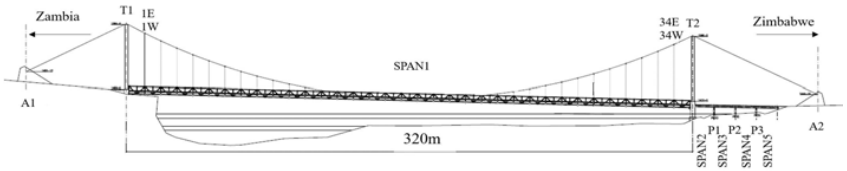


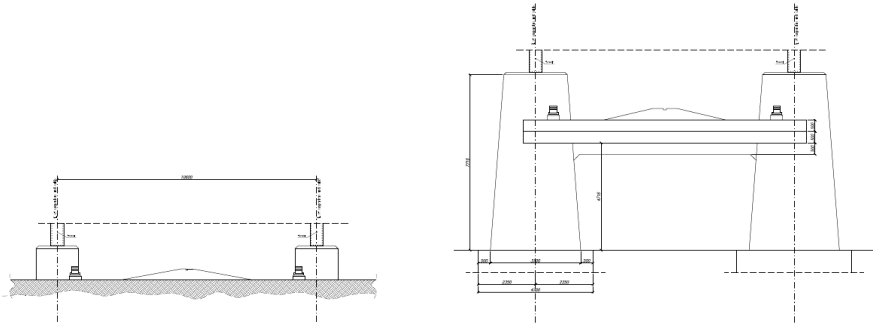




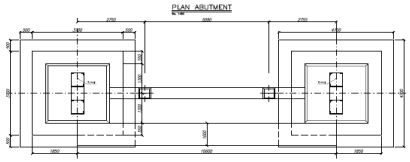


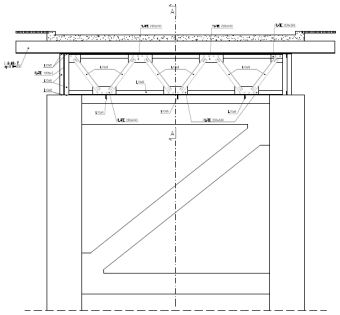


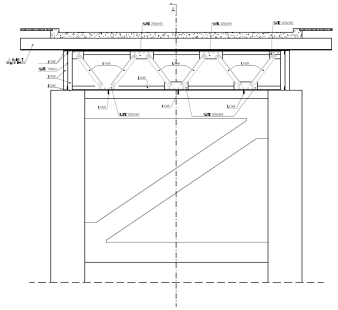

Zambia
T1
1E
1W
34E
34W
T2
Zimbabwe
SPAN1
A1
320m
P1
P2
P3
SPAN2
SPAN3
SPAN4
SPAN5
A2

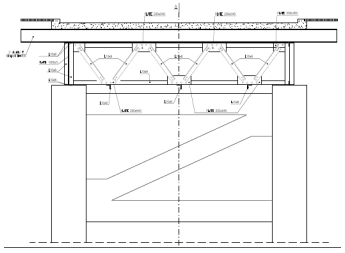


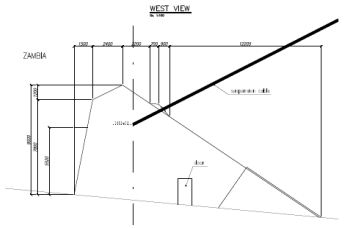

PLAN ABUTMENT

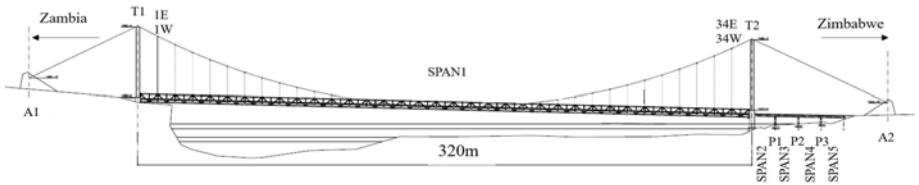

PLAN ABUTMENT

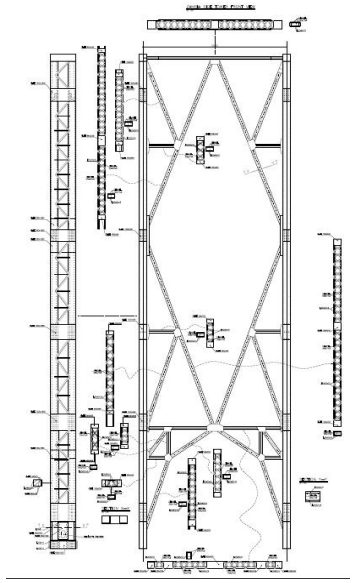


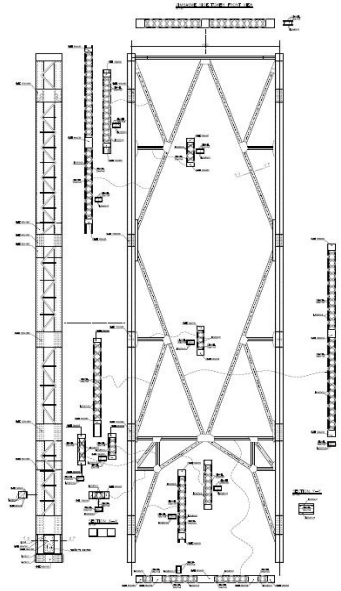




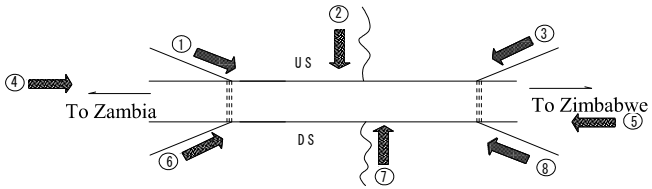

WEST VIEW
ZAMBIA


Zambia
T1
1E
1W
34E
34W
T2
Zimbabwe
SPAN1
A1
320m
P1
P2
P3
SPAN2
SPAN3
SPAN4
SPAN5
A2





【Photograph】



① No Photo (no boat)	② No Photo (no boat)
③ No Photo (no boat)	④ 
⑤ 	⑥ 
⑦ 	⑧ 

APPENDIX-B-3-2

SAMPLE OF PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION	
Bridge ID	
Bridge Name	Otto Beit
Road Name	
Road ID	
Location	
Province	
Rever Name	Zambezi

BRIDGE DESCRIPTION	
Type of Bridge	Suspension
Superstructure	I girder
Substructure	Multiple columns
Foundation	Not known
Total Number of Span	5
Total Number of Abutment	0
Total Number of Pier	3
Total Number of Anchorage	3

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	✔

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	✔
BIV not available	✔
Access restricted	✔
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	
Major maintenane	✔
Upgrading	
Replacement	
Emergency repair work	✔

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	✔
Scour and erosion	
Exsessibe maintenance required	✔
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:	Bridge NAME:	Otto Beit

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

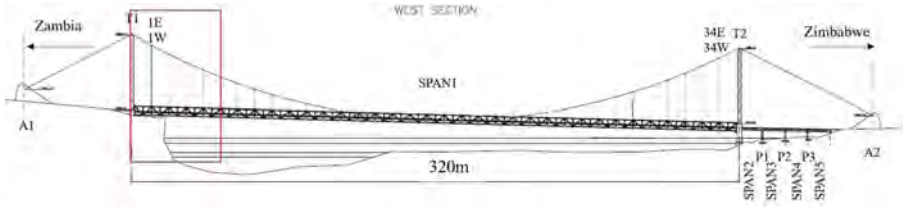
DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1, Section 1	Bridge ID	
(one set of forms for each pier)		Bridge NAME	Otto Beit

Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Concrete		Cracking	cannot inspect because no access				
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water leakage					
		Abnormal Vibration					
Asphalt	×	Potholes	3	Area	20	Poor	3
	×	Shoving	1	Area	15	Fair	
		Rutting					
	×	Cracking	3			Bad	
		Raveling					
MAIN MEMBER							
Steel Girder (Left)	×	Corrosion	1	Area	10	Fair	1
		Cracking					
	×	Deformation / Buckling	2	Area	15	Fair	
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder (Right)	×	Corrosion	1	Area	15	Fair	1
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Tower Zambian side		Corrosion					1
		Missing bolts					
		Deformation / Buckling					
		Cracking					
	×	Paint Peel Off	1	Area	5	Fair	
Cable Saddle		Corrosion	cannot inspect because no access				
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint peel off					
Cable and Rope		Vibration					1
		Alignment / Deformation					
		Cracking					
	×	Delamination / Scaling	2	Area	10	Fair	
		Water Leakage					
Cable Anchorage	×	Corrosion	0	Area	5	Fair	1
		Deformation					
		Loose Connection					
		Missing Bolts					
Anchorage Block A1	×	Cracking	2	–	–	Poor	2
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Pier (concrete) T1	×	Cracking	1	–	–	Fair	1
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Anchorage Housing A1	×	Debris accumulation	1	Area	30	Fair	2
		Vegetation growth					
	×	Door locking	2			Poor	
Draine Pipes	×	Flood debris accumulation	3	Area	45	Poor	2
		Siltation					
		Vegetation growth					
Waterway	×	Flood debris accumulation	1	Area	5	Good	0
		Siltation					
		Vegetation growth					
Bearing		Corrosion	cannot inspect because no access				
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing	×	Corrosion	1	Area	10	Good	0
	×	Loose Connection	2	Area	5	Good	
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing	×	Corrosion	1	Area	35	Fair	1
		Loose Connection					
		Impact / Accidnet Damage					
	×	Paint Peel Off	1	Area	5	Good	
Expansion Joint (steel)		Water leakage					1
		Abnormal Space/Noise					
	×	Difference in elevation	1	Area	5	Good	
	×	Displacement	1	Area	15	Fair	
		Cracking					
Overall Rating							Bad

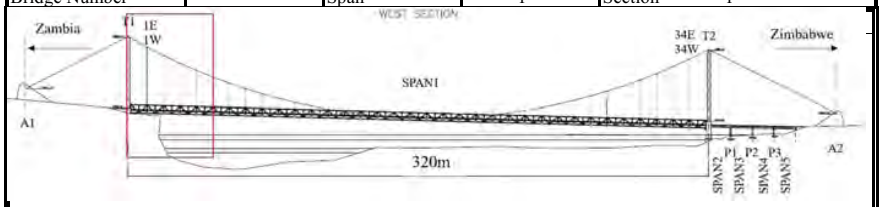


【Damage Drawing】

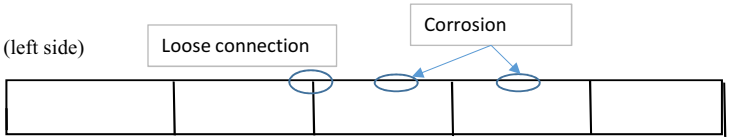
Bridge ID:		Bridge NAME:	Otto Beit

Span No:

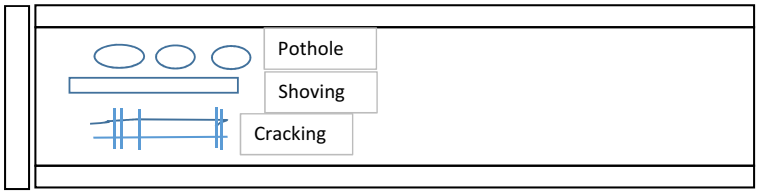
Bridge Number		Span	1	Section	1



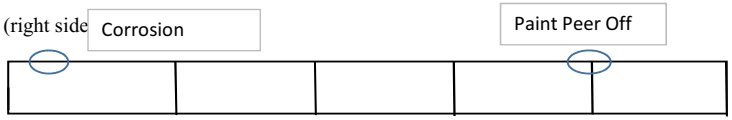
Railing (left side)



Expansion Joint and Deck Concrete



Railing (right side

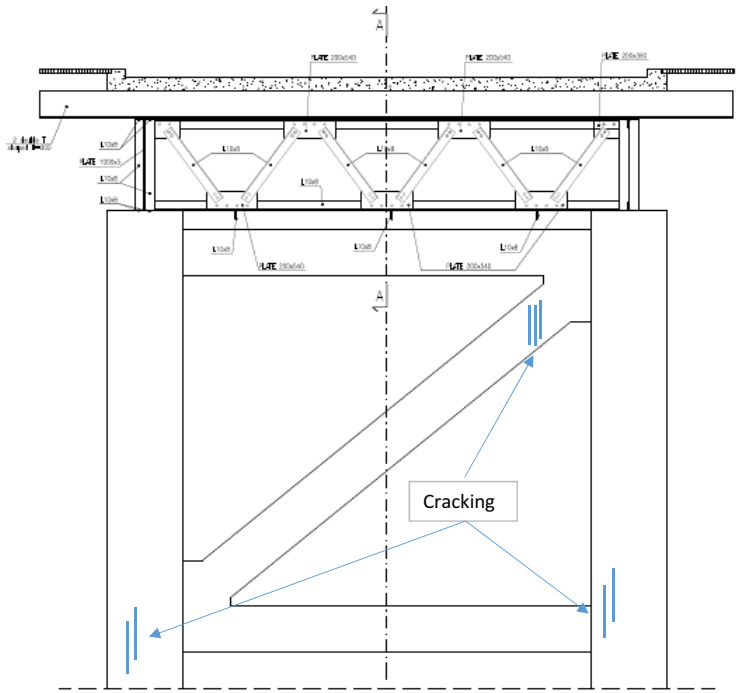


【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Biet

Span No:

Bridge Number		Span		



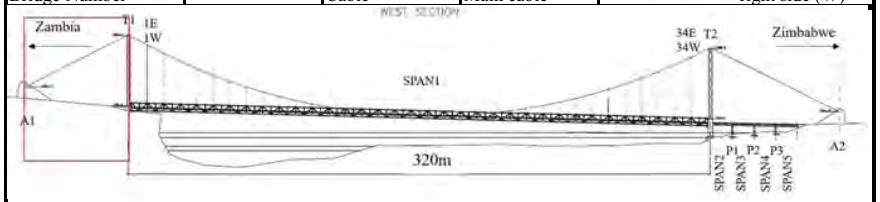
P1

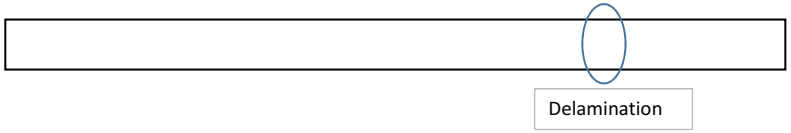
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable	right side (W)



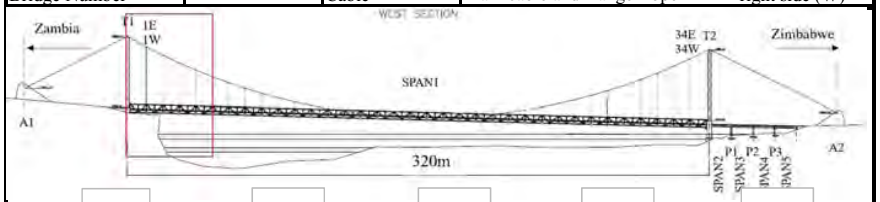


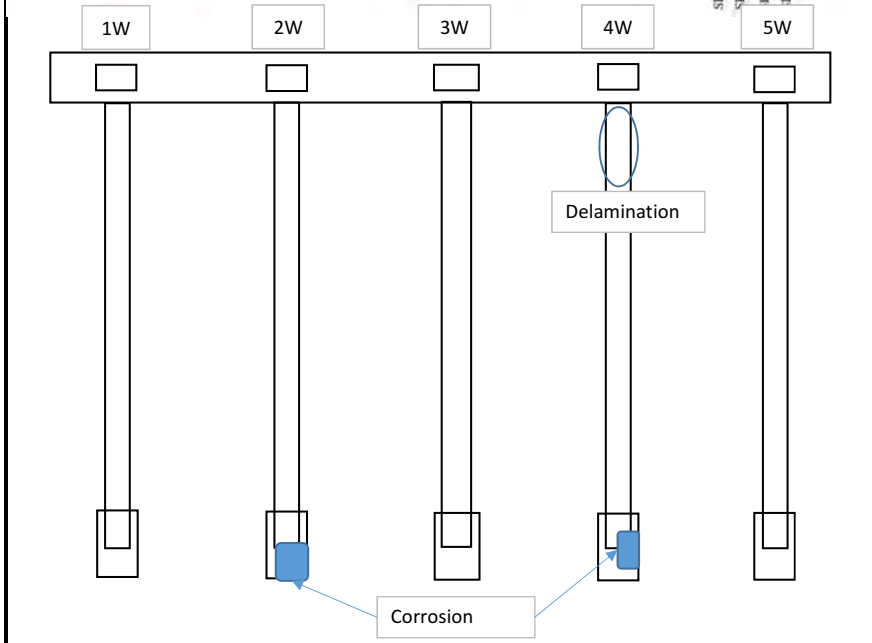
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Cable	Main cable and Hanger rope	right side (W)



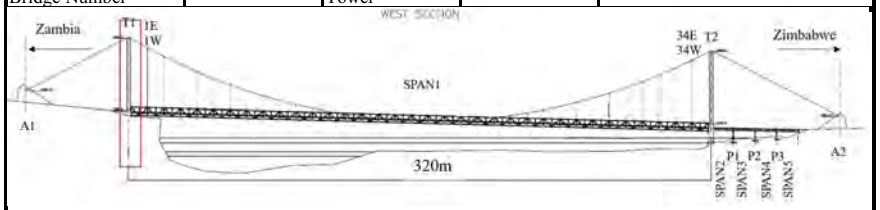


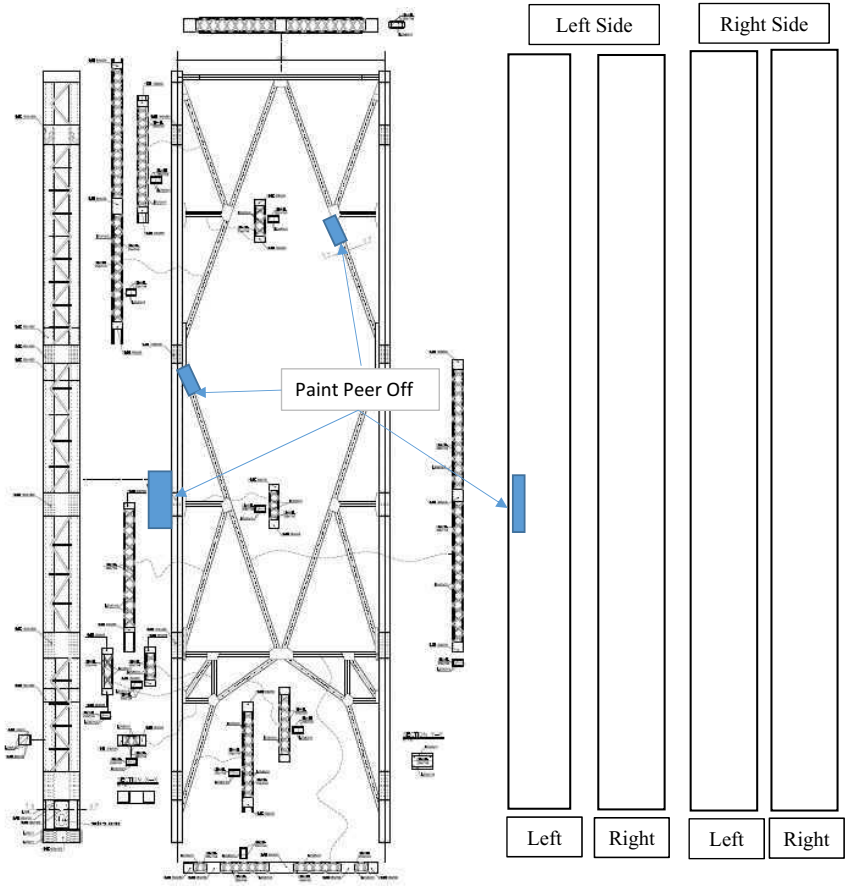
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

Bridge Number		Tower		



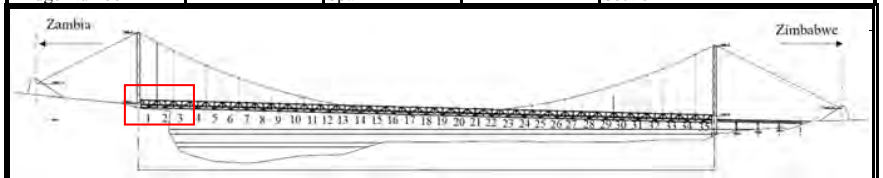


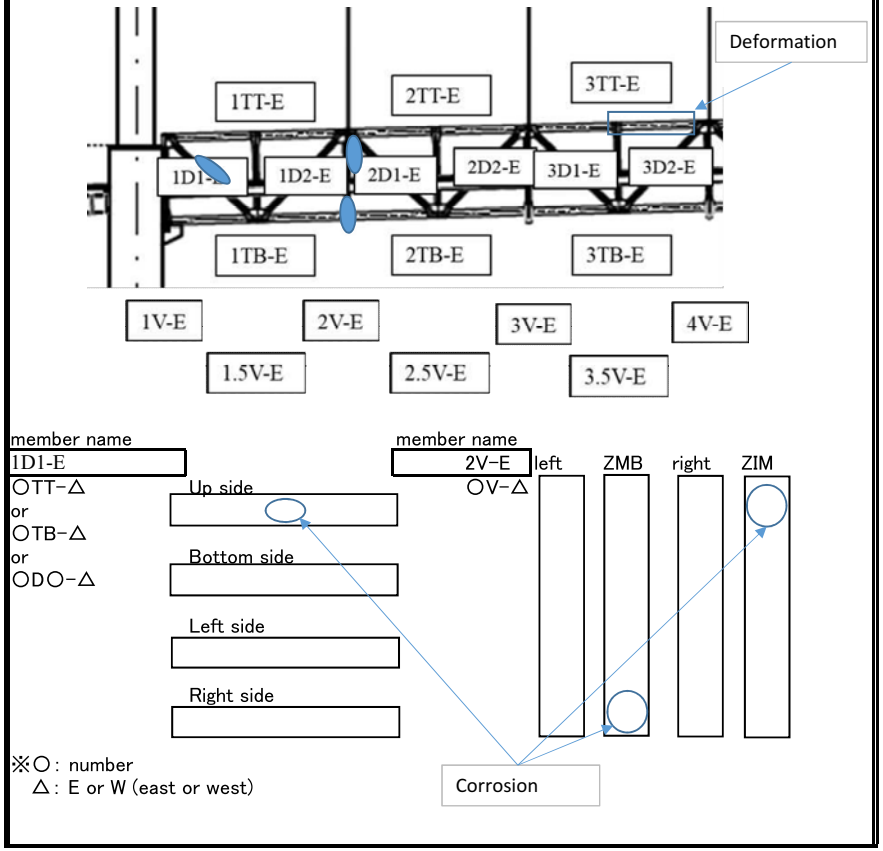
【Damage Drawing】

Bridge ID:		Bridge NAME:	Otto Beit

Span No:

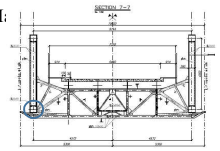
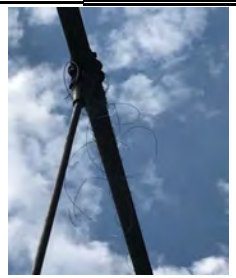
Bridge Number		Span		Section





【Photograph】

Bridge ID:		Bridge NAME:	Otto Beit

Photo Number		Span		Conponent Name		Type of Damage	
						Comment big pothols are observed on the top surface near Zambian side	
Photo Number		Span		Conponent Name		Type of Damage	
			 Location M: 			Comment Corrosion are observed on the bottom steel girder at east side	
Photo Number		Span		Conponent Name		Type of Damage	
						Comment Cable rapping is delaminated in E29	
Photo Number		Span		Conponent Name		Type of Damage	
						Comment There is no door at the Anchorage at Zimbabwen side and much trash scattered in the anchorage.	

APPENDIX-B-4-1

SAMPLE OF INVENTORY INSPECTION FORM

LOCATION

	Bridge ID	
	Bridge Name	Victoria Falls
	Road Name	
	Road ID	
	Location	
A1	GPS: S	
	GPS: E	
A2	GPS: S	
	GPS: E	

BRIDGE DESCRIPTION

Type of Bridge	Steel Arch
Superstructure	Steel Truss
Substructure	Solid Wall
Foundation	-

BRIDGE GEOMETRY

Bridge length, (m)		198.9
Bridge width, (m)		13.2
Number of lanes		road 1/railway 1
Number of spans		3
Width of carriageway, (m)		4.7
Width of island(s), (m)		2.7/4.5/0.7
Width of shoulder, (m)	Left	3.3
	Right	1.3
Sidewalk width, (m)	Left	2.7
	Right	0.7

PUBLIC UTILITIES CARRIED

	Light			Right		
Utility Identification No.	1	2	3	4	5	6
Electricity						
Gas						
Telephone						
Oil, fuel						
Water						
Sewage						
Other						

YEAR OF CONSTRUCTION OF BRIDGE

Year of construction	unknow	
	1945 – 1970	
	Post 1970	
	Insert year if known	1905

DESIGN LOAD

Available?	Yes	
	No	✓
If yes, insert as:		

DESIGN STANDARD

Available?	Yes	
	No	✓
If yes, insert as:		

Province	Southern
Rever Name	Zambezi

TERRAIN CROSSED

River or waterway (fresh water)	✓
Railway	
Road	
Open ground	
Swamp	
Other	

Up to three (3) types of terrain may be select

INSPECTOR COMMENTS

Date of Field Inspection
ACCOMPLISHED BY:
SUBMITTED BY:

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

SPECIAL INSPECTION REQUIREMENTS

Boat	✓
Bridge inspection vehicle	✓
Ladder	✓
Binoculars	✓
Safety Belt / Harness	✓
Geologist Hammer	✓
Oxygen meter	
Camera	✓
Hard Hat with Headlight	✓
Other(meter tape, safety shoes, gloves, total station)	✓

GENERAL BRIDGE DATA

Height clearance	Over(bridge structure over)	yes	
		no	
			m
If yes, give clearance(m)	Over(bridge structure over)	yes	
		no	
			m

TRAFFIC DIRECTION

Two way	✓
one way in direction of increasing chainage	
one way in direction of decreasing chainage	

TYPE OF BRIDGE

Standard Bridge	
Special Bridge	✓

END OF WARRANTY PERIOD

Insert year of end of warranty period	–

LIGHTING TO BRIDGE

yes or no	yes

INTERVAL OF LIGHTING POLES

Left, (m)	not known
Right, (m)	not known

AS-BUILT DRAWING

Available?(yes, no or unknown)	yes, partly
If yes, insert location (Ex.Regional Office, Planning Division)	RDA HQ

BRIDGE MODIFICATION SHEET

MODIFICATION TYPE

Bridge widened? (yes or no)	yes
If yes, insert year of widening.	1930
Bridge strengthened? (yes or no)	yes
If yes, insert year of strengthening	1963 etc.
Bridge retrofitted? (yes or no)	no
If yes, insert year of seismic retfofitting	
Bridge lengthened? (yes or no)	no
If yes, insert year of lengthening	

SUPERSTRUCTURE WIDENING FORM

Widened left side	not known
Widened right side	not known
Widened both side	not known

SUPERSTRUCTURE WIDENING DETAIL

Same detail / material as existing bridge	not known
Same detail / modified material	not known
Different details	not known

SUPERSTRUCTURE WIDENING TYPE

Cantilever box girder	
Girder	
Box girder	
Slab	
Voided slab	
Demontable (Bailey type)	
Truss	✓
Trestle	
Cable stayed	
Suspension	
Arch	
Portal frame	
Other structure	

SUPERSTRUCTURE WIDENING MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

TYPE OF PIER WIDENING

Widening original piers	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

TYPE OF ABUTMENT WIDENING

Widerning original abutments	-
Bored pile bents	-
Driven pile bents	-
Coping widening	-
Other	-

PIER / ABUTMENT WIDENING MATERIAL

Timber	-
Steel	-
Concrete	-
Masonry	-
Other	-

TYPE OF STRENGTHENING

Main member reinforcement	✓
Deck reinforcement	
Additional piers	
Substrucutre reinforcement	
Other	

TYPE OF SEISMIC RETROFIT

Sleeves to columns	-
Lateral restraints	-
Longitudinal restraints	-
Beam continuity	-
Deck continuity	-
Other	-

TYPE OF LENGTHENING

Low chainage end, original and widening	-
Low chainage ehd, widened part only	-
High chainage end, original and widening	-
High chainage end, widened part only	-

GENERAL SPAN INFORMATION

Span Number	**1**
Length of span, (m)	270.8
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✓
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✓

MAIN MEMBER MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

ZMBS Zambian side

ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✓
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side

W Right side

※Looking in Zambia side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	2
Length of span, (m)	152.4
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✓
Deck truss	
Cable supported	
Arch	✓

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✓

MAIN MEMBER MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✓
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zambia side

SPAN COMMENTS

GENERAL SPAN INFORMATION

Span Number	3
Length of span, (m)	19.4
Skew (in Degrees)	
Number of main members	

MAIN MEMBER TYPE

Girder - Also composite girder form	
Cantilever girder continuous	
Cantilever girder with suspended span	
Slab	
Voided slab	
Demountable (Bailey type)	
Through truss	✓
Deck truss	
Cable supported	
Arch	

GIRDER FORM

I beam	
Rectangular beam	
Tee beam	
Box girder	
Built-Up (Plate) girder	✓

MAIN MEMBER MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

MAIN MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

CONTINUITY	**ZMBS**	**ZIMS**
Fixed		
Continuous		
Simply supported	✓	✓
Not supported		
Not known		

ZMBS Zambian side
ZIMS Zimbabwe sida

SECONDARY MEMBER TYPE

Transverse/longitudinal girders	✓
Other	
None	

SECONDARY MEMBER MATERIAL

Masonry	
Concrete	
Steel	✓
Timber	
Other	

SECONDARY MEMBER PRESTRESSED?	Yes	
	No	✓
	Not known	

OTHER MEMBER TYPE

Diaphragms	
Bracings	✓
Other	
None	

DECK MATERIAL

Timber	
Steel	✓
Concrete	
Masonry	
Other	

RAILING TYPE	**E**	**W**
Concrete wall		
Concrete wall and top rail		
Concrete posts and rails		
Steel posts and rails	✓	✓
Aluminium posts and rails		
Timber posts and rails		
Masonry wall		
Other		
None		

E Left side
W Right side
※Looking in Zambia side

SPAN COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**1**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	✓
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✓
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	
Steel plate	✓
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	✓
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✓
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	✓

ABUTMENT COMMENTS

GENERAL ABUTMENT DATA

Abutment Number	**2**
Abutment height, (m)	

ABUTMENT TYPE

Solid wall	✓
Pile bent	
Other	
None (cantilever superstructure)	
None (superstructure on ground)	
Not known	

ABUTMENT MATERIAL

Concrete	✓
Steel	
Timber	
Masonry	
Gabions	
Other	

ABUTMENT FOUNDATION

Spread footing	
Bored pile	
Driven piles	
Caisson	
Other	
Not known	✓

BEARING TYPE

Elastomeric pad	
Steel plate	✓
Metal rocker	
Other	
None	
Not known	

EXPANSION JOINT TYPE

Continuous deck	
Steel plate	
Rubber	
None (open gap)	✓
Other	
None	

SCOUR PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Steel sheet piling	
Concrete sheet piling	
Other	
None	✓
Not known	

SLOPE PROTECTION

Dumped riprap	
Grouted riprap	
Gabions or mattresses	
Concrete	
Paving	
Other	
None	✓

ABUTMENT COMMENTS

Abutment Number	1

WING WALL TYPE	L	R
Solid wall	✓	✓
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete	✓	✓
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known	✓	✓

WING WALL LENGTH	
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Abutment Number	2

WING WALL TYPE	L	R
Solid wall	✓	✓
Protected slope		
Other		
None		

WING WALL MATERIAL	L	R
Concrete	✓	✓
Masonry		
Timber		
Gabions or mattresses		
Other		

WING WALL FOUNDATION TYPE	L	R
Spread footing		
Bored piles		
Driven piles		
Other		
None (attached to abutment)		
Not known	✓	✓

WING WALL LENGTH	
Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Springing Number	1

SPRINGING TYPE

Solid wall	✓
Protected slope	
Other	
None	

SPRINGING MATERIAL

Concrete	✓
Masonry	
Timber	
Gabions or mattresses	
Other	

SPRINGING FOUNDATION TYPE

Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	✓

SPRINGING LENGTH

Left, (m)	
Right, (m)	

BRIDGE APPROACH COMMENTS

Springing Number	2

SPRINGING TYPE

Solid wall	✓
Protected slope	
Other	
None	

SPRINGING MATERIAL

Concrete	✓
Masonry	
Timber	
Gabions or mattresses	
Other	

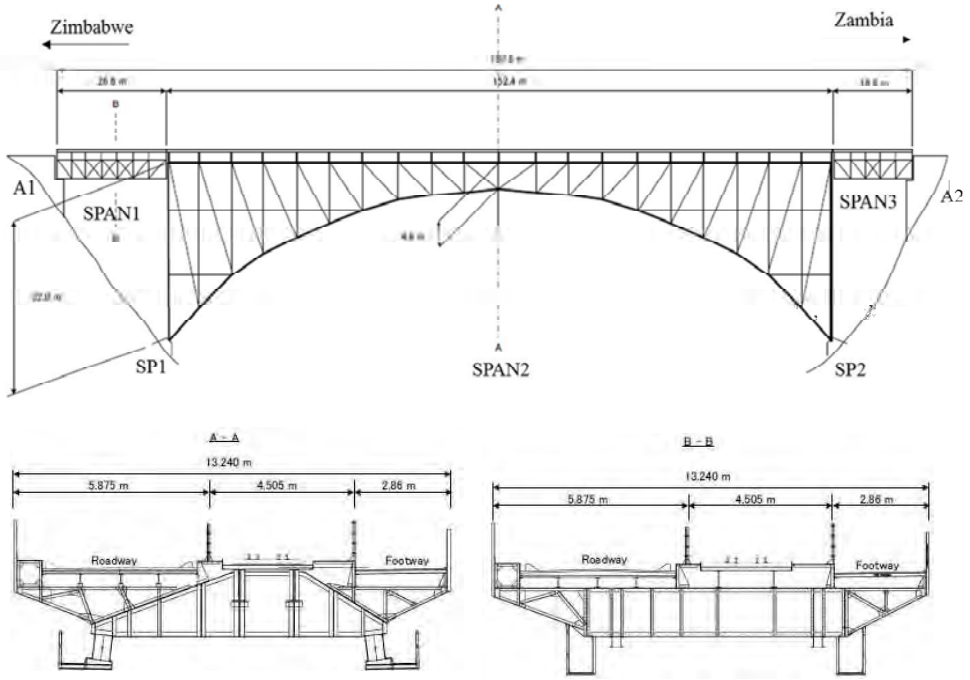
SPRINGING FOUNDATION TYPE

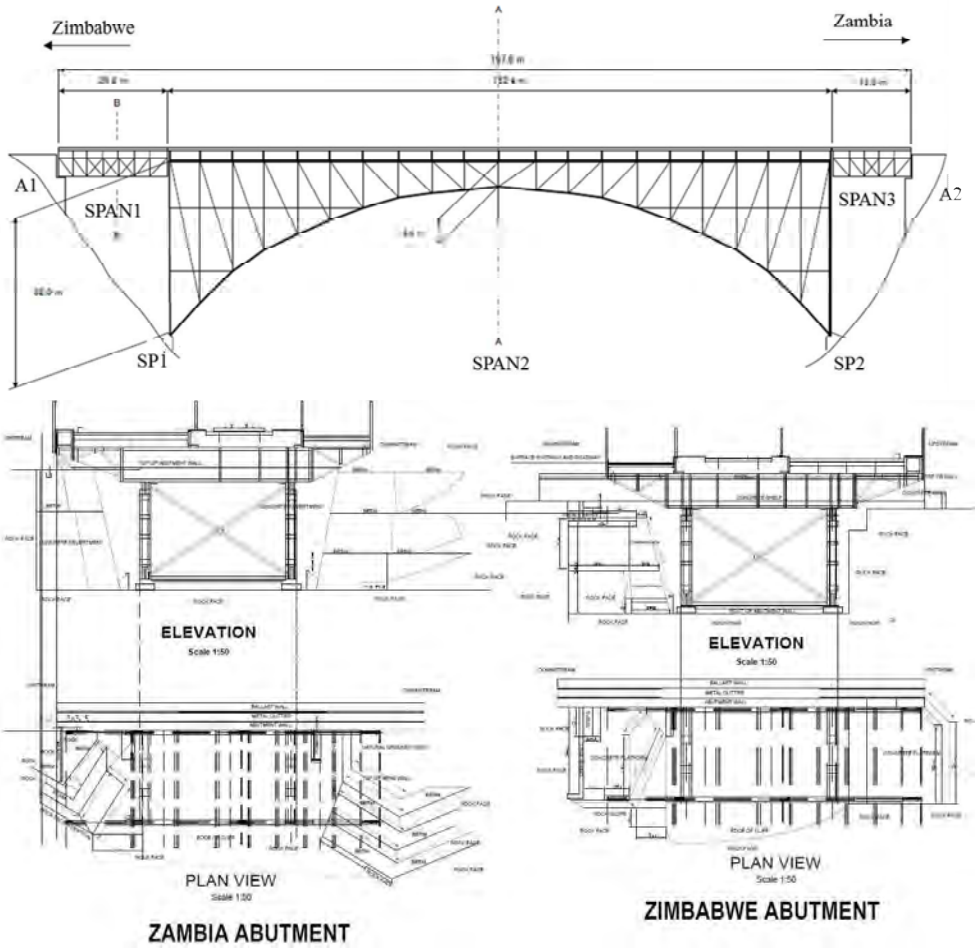
Spread footing	
Bored piles	
Driven piles	
Other	
None (attached to abutment)	
Not known	✓

SPRINGING LENGTH

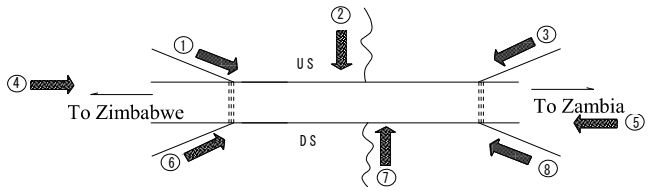
Left, (m)	
Right, (m)	

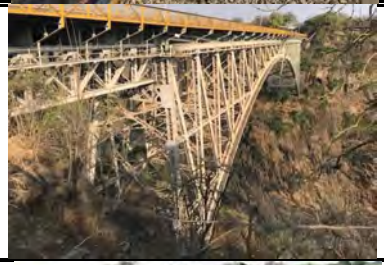
BRIDGE APPROACH COMMENTS





【Photograph】



① No Photo	② No Photo (no boat)
③ No Photo	④ 
⑤ 	⑥ 
⑦ No Photo (no boat)	⑧ 

APPENDIX-B-4-2

SAMPLE OF PERIODIC INSPECTION FORM

PERIODIC INSPECTION FORM

LOCATION

Bridge ID	
Bridge Name	Victoria Falls
Road Name	
Road ID	
Location	

Province	Southern
Rever Name	Zambezi

BRIDGE DESCRIPTION

Type of Bridge	Steel Arch
Superstructure	Steel Truss
Substructure	solid wall
Foundation	Not known
Total Number of Span	3
Total Number of Abutment	2
Total Number of Pier	0
Total Number of Springing	2

BRIDGE OVERALL RATING

Good	
Fair	
Poor	
Bad	

LEVEL OF INSPECTION

Full conmplete inspection(direct visually)	
Full conmplete inspection(using drone)	
Partial inspection only:	✓
BIV not available	✓
Access restricted	✓
Bridge works in progress	
Affected natural disaster	
Other reason	

RECOMMENDED ACTION

Routine maintenance only	✓
Major maintenane	
Upgrading	
Replacement	
Emergency repair work	

REASON FOR RECOMMENDATION

Bridge inadequate for traffic	
Flooding	
Safety	
Bridge deterioration	✓
Scour and erosion	
Exsessibe maintenance required	
Other	

BRIDGE INSPECTOR COMMENT

Date of Field Inspection		
ACCOMPLISHED BY:		
SUBMITTED BY:		

⇦ Insert Name, Pision, Signature, and Date of Signing
Initial all other pages

PERIODIC INSPECTION FORM

【Repair Pecord】

Bridge ID:		Bridge NAME:	Victoria Falls

Major Maintenane

DATE	MAJOR MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

LEGEND(Type) A: Repair damage, B: Protective measuremens, C: Strengthen, D, Replace, E: None

ROUTINE MAINTENANCE

DATE	ROUTINE MAINTENANCE			IMPLEMENTATION			INSPECTOR
	TYPE	SCOPE	COST	START	COMPLETION	STATUS	COMMENT

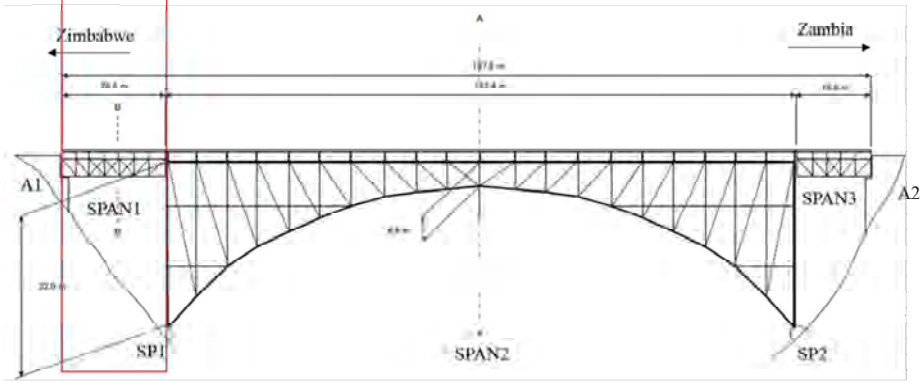
LEGEND(Type) A: Sweeping and cleaning, B: Repairs to pavement, C: Repairs to concrete component
D: Repairs to steel component, E: Painting bridge component, F: Replace / install bolts
G: Others(specify)

SPAN No.	Span 1

(one set of forms for each pier)

Bridge ID

Bridge NAME Victoria Falls



Type of Material		Type of Damage	Severity of Defect	Affected Unit	Affected %	Damage Rating	Attribute Condition State
DECK							
Steel		Corrosion	1	Area	15	Fair	1
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
	×	Paint Peel Off	0	Good	3	Good	
		Missing element					
Asphalt	×	Potholes	3	Area	15	Fair	2
		Shoving					
		Rutting					
	×	Cracking	2			Poor	
		Raveling					
MAIN MEMBER							
Steel Girder (Left)	×	Corrosion	1	Area	10	Fair	1
		Cracking					
	×	Deformation / Buckling	2	Poor	5	Fair	
		Abnormal Vibration					
		Loose Connection					
	×	Paint Peel Off	0	Good	2	Good	
		Missing element					
Steel Girder (Right)	×	Corrosion	1	Area	5	Fair	1
		Cracking					
		Deformation / Buckling					
		Abnormal Vibration					
		Loose Connection					
		Paint Peel Off					
		Missing element					
Steel Girder Cross Section	×	Corrosion	1	Area	2	Good	0
		Missing bolts					
		Deformation / Buckling					
		Cracking					
		Paint Peel Off					
Abutment A1	×	Cracking	1	-	-	Fair	1
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Water Leakage					
Springing		Cracking					
		Spalling/Scaling/Disintegration					
		Delamination					
		Rebar exposure/corrosion					
		Honeycomb					
		Tilt/Settlement					

SECONDALY MEMBER							
Draine Pipes		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Waterway		Flood debris accumulation					
		Siltation					
		Vegetation growth					
Bearing		Corrosion					
		Loose Connection					
		Abnormal Displacement					
		Paint Deterioration					
		Bed (support) damage					
Left Railing	×	Corrosion	1	Area	10	Good	0
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Right Railing	×	Corrosion	1	Area	10	Good	0
		Loose Connection					
		Impact / Accidnet Damage					
		Paint Peel Off					
Expansion Joint (Seal)		Water leakage					1
	×	Abnormal Space/Noise	3	Area	15	Fair	
	×	Difference in elevation	1	Area	10	Good	
		Rupture					
Overall Rating							2

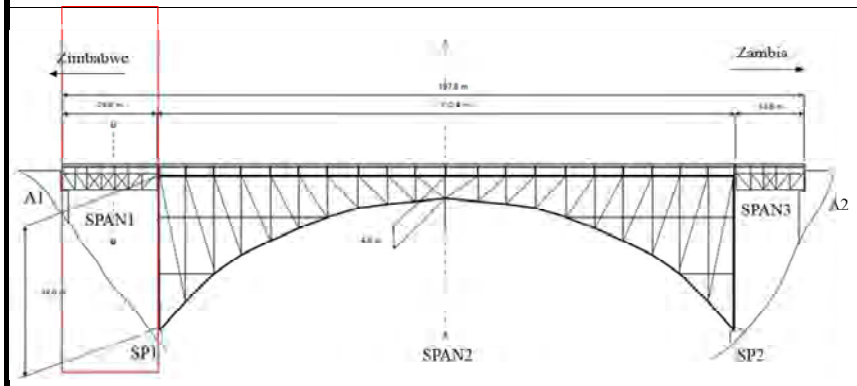
cannot inspect because no access

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

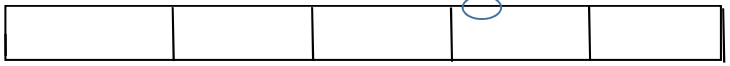
Span No:

Bridge Number		Span	1	

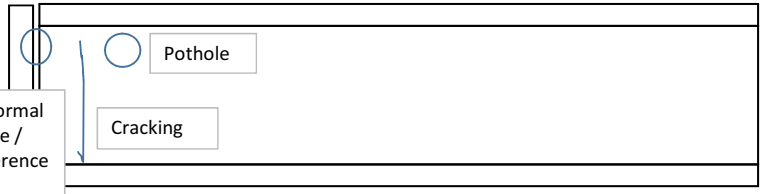


Railing (left side)

Corrosion



Expansion Joint and Deck Concrete

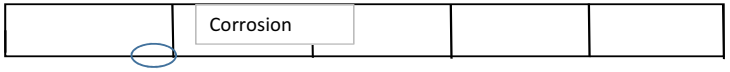


Pothole

Cracking

Abnormal Space / Difference in

Railing (right side)



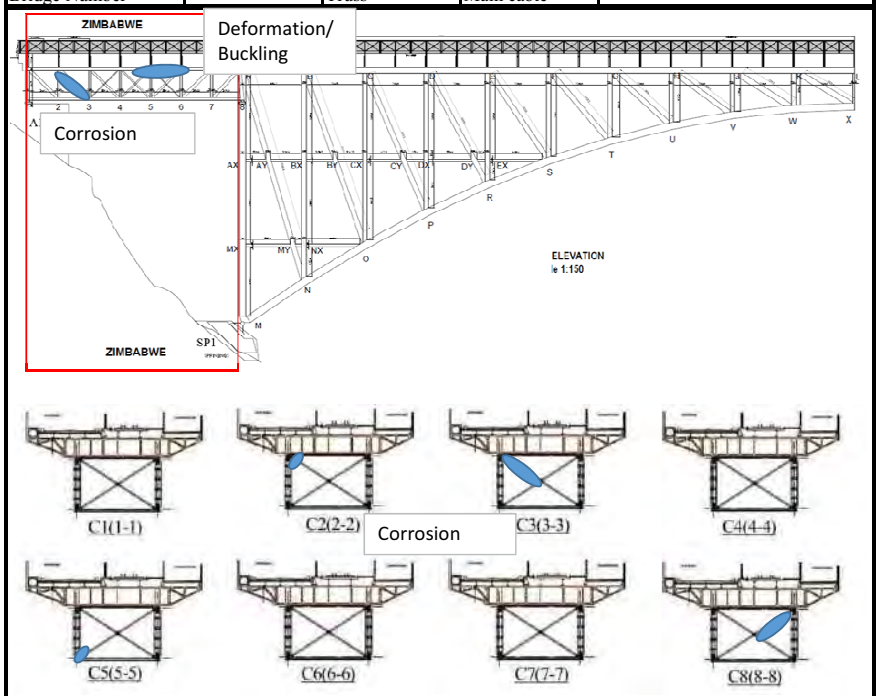
Corrosion

【Damage Drawing】

Bridge ID:		Bridge NAME:	Victoria Falls

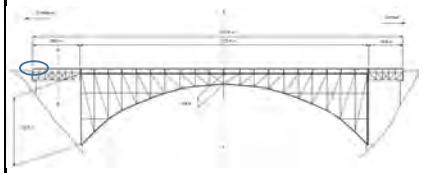
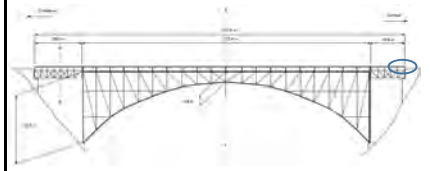
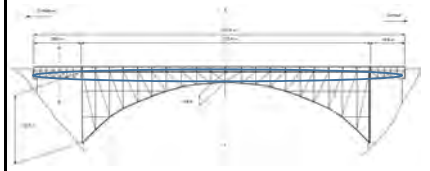
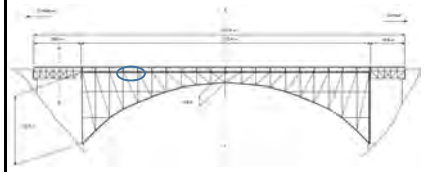
Span No:

Bridge Number		Truss	Main cable	



【Photograph】

Bridge ID:		Bridge NAME:	Victoria Falls

Photo Number		Span		Conponent Name		Type of Damage	
Photograph							Comment Different in elevation and pothole on asphalt are observed at Zimbabwen side
Photo Number		Span		Conponent Name		Type of Damage	
P							Comment Clacks in asphalt are obserced at Zambian side
Photo Number		Span		Conponent Name		Type of Damage	
P							Comment Many corroion in steel deck slab due to falling water are observed under the most of the sideway area.
Photo Number		Span		Conponent Name		Type of Damage	
Photogr							Comment Some menbers are derfomed by heavy load.

APPENDIX-C BRIDGE CONDITION RATING CRITERIA

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN	BRIDGE ATTTRIBUTE	DECK (1/2)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
CONCRETE Deck Slab	0 - Good	1 Cracking	Hairline crack or no crack
		2 Spalling Scaling Disintegration	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	
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm
		2 Spalling Scaling Disintegration	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 ot 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 Scaling Disintegration	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 Scaling Disintegration	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 ATTTRIBUTE	DECK (2/2)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
TIMBER Deck Slab	0 - Good	1 Decay/Splitting/Cracking	Not visible
		2 Disconnection	Timber deck/running board intact, connectors in good condition
	1 - Fair	1 Decay/Splitting/Cracking	Fungi attack is visible, minor cracking/splitting
		2 Disconnection	Connectors are damaged but timber deck/running board still intact
	2 - Poor	1 Decay/Splitting/Cracking	Major splitting and cracking
		2 Disconnection	Timber deck/running board connectors are severely damaged
	3 - Bad	1 Decay/Splitting/Cracking	Severe splitting and cracking
		2 Disconnection	Timber deck/running board totally disconnected or missing

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN	BRIDGE ATTTRIBUTE	MAIN/SECONDARY MEMBER(1/3)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
CONCRETE Girder	0 - Good	1 Cracking	Hairline crack or no crack
		2 Spalling Scaling Disintegration	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
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm
		2 Spalling Scaling Disintegration	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
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, spacing is <500mm to >= 200mm
		2 Spalling Scaling Disintegration	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
	3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm
		2 Spalling Scaling Disintegration	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

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN	BRIDGE ATTTRIBUTE	MAIN/SECONDARY MEMBER(2/3)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
STEEL Girder /Truss	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
		7 Missing element	No element missing
	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
		7 Missing element	No Dtected
	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
		7 Missing element	No Dtected
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/rusting 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 > 3pcs. on primary member joints
		6 Paint peel off	Surface area affected is > 30% in a member
		7 Missing element	Element missing
Bailey Demount-able	0 - Good	1 Corrosion	Loose rust formation and pitting in the paint surface, no section loss
		2 Loose connection	No bolts missing, <= 10% of fasteners loose
		3 Deformation/Buckling	No deformation on bridge components
	1 - Fair	1 Corrosion	Loose rust formation with scales/flakes, <= 10% section loss
		2 Loose connection	Loose fasteners is > 10% to <= 20%, falling out of bolts in > 1 pc. on joints
		3 Deformation/Buckling	Partial deformation on secondary members only
	2 - Poor	1 Corrosion	Stratified rust with pitting of metal surface, >10% to <=20% section loss
		2 Loose connection	Loose fasteners >20% <=30%, bolts fall out in > 3pc on sec. mem. joints
		3 Deformation/Buckling	Partial deformation on primary members
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/rusting through > 20% section loss
		2 Loose connection	> 30% fasteners loose, bolts fall out in > 3pc on primary member joints
		3 Deformation/Buckling	Outstanding deformation due to buckling or partial yielding

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN	BRIDGE ATTTRIBUTE	MAIN/SECONDARY MEMBER(3/3)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
MASONRY Arch	0 - Good	1 Fretting Abrasion	Mortar loss from the joints in few places to a depth of 20mm
		2 Cracking	No damage
		3 Material displacement/loss	Stones or bricks intack in good condition
		4 Bulging	No damage
	1 - Fair	1 Fretting Abrasion	Mortar loss from joints over an extended area, depth is >20mm <=50mm
		2 Cracking	<= 3mm wide with no water leakage
		3 Material displacement/loss	Stones or bricks starting to be displaced
		4 Bulging	Slight bulging
	2 - Poor	1 Fretting Abrasion	Extensive loss of mortar resulting in the loss of few stones
		2 Cracking	> 3mm to <= 5mm wide with slight water leakage
		3 Material displacement/loss	Loss of some stones or bricks
		4 Bulging	Small range of bulging
	3 - Bad	1 Fretting Abrasion	Mortar becomes ineffective
		2 Cracking	> 5mm wide around the bearing or step in the face of masonry
		3 Material displacement/loss	Extensive loss of stones endangering the stability of structure
		4 Bulging	Serious bulging near cracks
TIMBER Beam	0 - Good	1 Decay/Splitting/Cracking	Not visible
		2 Disconnection	No disconnection
	1 - Fair	1 Decay/Splitting/Cracking	Decay starting to form, minor cracking and splitting is visible
		2 Disconnection	Connectors are slightly damage but still intact
	2 - Poor	1 Decay/Splitting/Cracking	Decay is very visible, presence of major cracks and splitting
		2 Disconnection	Connectors are damaged and members are disintegrating
	3 - Bad	1 Decay/Splitting/Cracking	Decay in advance stage, severe cracking and splitting
		2 Disconnection	Members are totally disconnected or missing

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	MAIN STRUCTURE (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 Scaling Disintegration	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 Tilt/Settlement	Not visible
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm
		2 Spalling Scaling Disintegration	Affected area is > 150mm to <= 300mm wide in any direction. or depth is 25mm to 50mm
		3 Delamination	Delaminated area measuring > 150mm to <= 300mm 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 Tilt/Settlement	Not visible
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, 2 directions, spacing is <500mm to >= 200mm
		2 Spalling Scaling Disintegration	Affected area is > 300mm to <= 600mm wide in any direction, or depth is 50mm to 100mm
		3 Delamination	Delaminated area measuring >300mm to <= 600mm wide 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 Tilt/Settlement	Not visible
	3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm
		2 Spalling Scaling Disintegration	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 > 1000cm wide and corroded
		5 Honeycomb	Affected area is >600mm wide in any direction
		6 Tilt/Settlement	Detected

BRIDGE CONDITION RATING CRITERIA

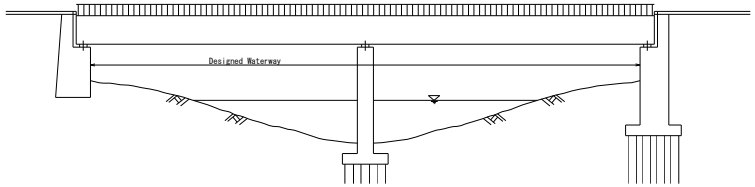
BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	MAIN STRUCTURE (2/2)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
MASONRY Wall	0 - Good	1 Fretting Abrasion	Mortar loss from the joints in few places to a depth of 20mm
		2 Cracking	No damage
		3 Material displacement/loss	Stones or bricks intack and in good condition
		4 Bulging	No damage
	1 - Fair	1 Fretting Abrasion	Mortar loss from joints over an extended area, depth is >20mm <=50mm
		2 Cracking	<= 3mm wide with no water leakage
		3 Material displacement/loss	Stones or bricks starting to be displaced
		4 Bulging	Slight bulging
	2 - Poor	1 Fretting Abrasion	Extensive loss of mortar resulting in the loss of few stones
		2 Cracking	> 3mm to <= 5mm wide with slight water leakage
		3 Material displacement/loss	Loss of some stones or bricks
		4 Bulging	Small range of bulging
	3 - Bad	1 Fretting Abrasion	Mortar becomes ineffective
		2 Cracking	> 5mm wide around the bearing or step in the face of masonry
		3 Material displacement/loss	Extensive loss of stones endangering the stability of structure
		4 Bulging	Serious bulging near cracks
TIMBER Pile	0 - Good	1 Decay/Splitting/Cracking	Not visible
		2 Disconnection	No disconnection
	1 - Fair	1 Decay/Splitting/Cracking	Decay starting to form, minor cracking and splitting is visible
		2 Disconnection	Connectors are slightly damage but still intact
	2 - Poor	1 Decay/Splitting/Cracking	Decay is very visible, presence of major cracks and splitting
		2 Disconnection	Connectors are damaged and members are disintegrating
	3 - Bad	1 Decay/Splitting/Cracking	Decay in advance stage, severe cracking and splitting
		2 Disconnection	Members are totally disconnected or missing

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	WATERWAY

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
River Water	0 - Good	1 Flood debris accumulation	Loose debris accumulating on piers or bridgebdecks
		2 Siltation	There is little or no change in channel shape
		3 Vegetation growth	There is little or no change in channel shape
	1 - Fair	1 Flood debris accumulation	Debris accumulation in the form of small branches on piers or on the bridge
		2 Siltation	<= 10% of designed waterway area in any span
		3 Vegetation growth	<= 10% of designed waterway area in any span
	2 - Poor	1 Flood debris accumulation	Debris accumulation in the form of large branches or small trees on piers or
		2 Siltation	> 10% to <= 20% of designed waterway area in any span
		3 Vegetation growth	> 10% to <= 20% of designed waterway area in any span
	3 - Bad	1 Flood debris accumulation	Debris accumulation in the form of large trees on piers or on the bridge
		2 Siltation	> 20% of designed waterway area in any span
		3 Vegetation growth	> 20% of designed waterway area in any span



BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	BEARING/RESTRAINT

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 Loose connection	Up to 20% of fasteners loose or missing in one location
		3 Abnormal Displacement	No abnormal displacement
		4 Paint deterioration	No damage
		5 Bed (support) damage	No damage
	1 - Fair	1 Corrosion	Loose rust formation w/ scales/flakes define areas of rust <= 10% section loss
		2 Loose connection	20% to 40% of fasteners loose or missing in one location
		3 Abnormal Displacement	Bearing has been displace by <= 10%
		4 Paint deterioration	Paint system starts to fail
		5 Bed (support) damage	Partial (<= 50% of area at one location) cracking or spalling
	2-Poor	1 Corrosion	Stratified rust with pitting of metal surface, > 10% to <= 20% section loss
		2 Loose connection	> 40% to <= 60% of fasteners loose or missing in one location
		3 Abnormal Displacement	Bearing has been displaced by > 10% to <= 20%
		4 Paint deterioration	Paint system have failed and is not effective
		5 Bed (support) damage	Wide range (> 50% of area at one location) cracking/spalling
	3 - Bad	1 Corrosion	Extensive rusting with local perforation, > 20% section loss
		2 Loose connection	> 60% of fasteners loose or missing in one location
		3 Abnormal Displacement	Bearing has been displaced by > 20%
		4 Paint deterioration	Paint system has completely failed
		5 Bed (support) damage	Major splitting of bearing block, which loses bearing function
RUBBER	0 - Good	1 Bulging	No bulging
		2 Abnormal displacement	No abnormal displacement
		3 Bed (support) damage	No damage
	1 - Fair	1 Bulging	Slight bulging is noticeable
		2 Abnormal displacement	Bearing has been displace by <= 10%
		3 Bed (support) damage	Partial (<= 50% of area at one location) cracking or spalling
	2 - Poor	1 Bulging	Minor bulging is noticeable
		2 Abnormal displacement	Bearing has been displaced by > 10% to <= 20%
		3 Bed (support) damage	Wide range (> 50% of area at one location) cracking/spalling
	3 - Bad	1 Bulging	Severe crack, abnormal bulge, worn out and aged
		2 Abnormal displacement	Bearing has been displaced by > 20%
		3 Bed (support) damage	Major splitting of bearing block which losses bearing function

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	FOUNDATION	
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
CONCRETE Pile	0 - Good	1 Cracking	Hairline crack or no crack	
		2 Spalling Scaling Disintegration	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 Tilt/Settlement	Not visible	
		6 Scouring	No scouring	
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm	
		2 Spalling Scaling Disintegration	Affected area is > 150mm to <= 300mm wide in any direction. or depth is 25mm to 50mm	
		3 Delamination	Delaminated area measuring > 150mm to <= 300mm in any direction	
		4 Rebar exposure/corrosion	Main rebar exposed is <= 500mm wide, corroded or flaking only	
		5 Tilt/Settlement	Not visible	
		6 Scouring	Minor scouring	
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, 2 directions, spacing is <500mm to >= 200mm	
		2 Spalling Scaling Disintegration	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 Tilt/Settlement	Visible	
		6 Scouring	Foundation is exposed up to the bottom of footing or cassion	
	3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm	
		2 Spalling Scaling Disintegration	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 Tilt/Settlement	Very visible	
		6 Scouring	Foundation is exposed bellow the footing/cassion	

BRIDGE ELEMENT	PIER	BRIDGE ATTTRIBUTE	SCOUR PROTECTION	
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
CONCRETE, MASONRY, GROUTED Rip Rap	0-Good	1 Cracking	No cracking or hairline cracks	
		2 Bank erosion	<= 10% loss of embankment materials	
		3 Slope erosion	<= 5% loss of embankment materials directly supporting foundation	
	1 - Fair	1 Cracking	Narrow cracks	
		2 Bank erosion	> 10% to <= 30% loss of embankment materials	
		3 Slope erosion	> 5% to <= 15% loss of embankment materials directly supporting foundation	
	2-Poor	1 Cracking	With spalling	
		2 Bank erosion	> 30% to <= 40% loss of embankment materials	
		3 Slope erosion	> 15% to <= 20% loss of embankment materials directly supporting foundation	
	3 - Bad	1 Cracking	Severe cracks	
		2 Bank erosion	> 40% loss of embankment materials	
		3 Slope erosion	> 20% loss of embankment materials directly supporting foundation	

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	ABUTMENT	BRIDGE ATTTRIBUTE	SLOPE/BANK PROTECTION	
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT		
		TYPE OF DAMAGE	CONDITION	
GABION MATTRESSES	0 - Good	1 Damage on containing wire	No damage	
		2 Bank erosion	<= 10% loss of embankment materials	
		3 Slope erosion	<= 5% loss of embankment materials directly supporting foundation	
	1 - Fair	1 Damage on containing wire	Protective paint is peeling off	
		2 Bank erosion	> 10% to <= 30% loss of embankment materials	
		3 Slope erosion	> 5% to <= 15% loss of embankment materials directly supporting foundation	
	2 - Poor	1 Damage on containing wire	Containing wires are heavily corroded with some broken portion	
		2 Bank erosion	> 30% to <= 40% loss of embankment materials	
		3 Slope erosion	> 15% to <= 20% loss of embankment materials directly supporting foundation	
	3 - Bad	1 Damage on containing wire	Containing wires severely damaged and is no longer functioning	
		2 Bank erosion	> 40% loss of embankment materials	
		3 Slope erosion	> 20% loss of embankment materials directly supporting foundation	
STEEL Sheet Pile	0-Good	1 Corrosion	Only loose rust formation can be observed, paint system still effective	
		2 Bank erosion	<= 20% loss of embankment materials	
		3 Slope erosion	<= 5% loss of embankment materials directly supporting foundation	
	1 - Fair	1 Corrosion	Protective paint system has failed, some section loss due to corrosion	
		2 Bank erosion	> 10% to <= 30% loss of embankment materials	
		3 Slope erosion	> 5% to <= 15% loss of embankment materials directly supporting foundation	
	2-Poor	1 Corrosion	Corrosion in advanced stage, large section loss	
		2 Bank erosion	> 30% to <= 40% loss of embankment materials	
		3 Slope erosion	> 15% to <= 20% loss of embankment materials directly supporting foundation	
	3 - Bad	1 Corrosion	Severe corrosion and no longer effective	
		2 Bank erosion	> 40% loss of embankment materials	
		3 Slope erosion	> 20% loss of embankment materials directly supporting foundation	

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN/ABUTMENT	BRIDGE ATTTRIBUTE	RAILING/WINGWALL

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
CONCRETE	0 - Good	1 Cracking	Hairline or no crack
		2 Delamination/Disintegratio	Delaminated area measuring <= 150mm in any direction
		3 Impact/Accident Damage	Not visible
		4 Rebar exposure/corrosion	No damage
		5 Water leakage	Not visible
	1 - Fair	1 Cracking	Cracks are <=0.3mm wide in more than 500mm intervals
		2 Delamination/Disintegratio	Delaminated area measuring > 150mm to <= 300mm in any direction
		3 Impact/Accident Damage	Minor damage on component with no impact
		4 Rebar exposure/corrosion	Rebars partially exposed, <= 500mm width
		5 Water leakage	Water leak in 1 spot has an area of <= 20mm wide
	2 - Poor	1 Cracking	Cracks are > 0.3mm to <=0.5mm wide in less than 500mm interval
		2 Delamination/Disintegratio	Delaminated area measuring > 300mm to <= 600mm in any direction
		3 Impact/Accident Damage	Accident damage has minor impact
		4 Rebar exposure/corrosion	Main rebars exposed between > 500mm to <= 1000mm
		5 Water leakage	Water leak is visible in > 2 to 5 locations
	3 - Bad	1 Cracking	Cracks are more than 0.5mm wide
		2 Delamination/Disintegratio	Delaminated area measuring > 600mm in any direction
		3 Impact/Accident Damage	Post or rails totally shifted out of position or missing.
		4 Rebar exposure/corrosion	Main rebars exposed in > 1000mm width, and corroded
		5 Water leakage	Water leak is visible in > 5 locations
STEEL	0 - Good	1 Corrosion	Loose rust formation and pitting in the paint surface. No noticeable section loss
		2 Loose connection	No bolts missing, <= 10% of fasteners loose
		3 Impact/Accident Damage	Not visible
		4 Paint peel off	Surface area affected is <= 10%
	1 - Fair	1 Corrosion	Loose rust formation with scales/flakes, <= 10% section loss
		2 Loose connection	Loose fasteners is > 10% to <= 20%, falling out of bolts in > 1 pc on joints
		3 Impact/Accident Damage	Minor damage on component with no impact
		4 Paint peel off	Surface area affected is >10% to <= 20%
	2 - Poor	1 Corrosion	Stratified rust with pitting of metal surface, >10% to <=20% section loss
		2 Loose connection	Loose fasteners >20% <=30%, bolts fall out in > 3pc on sec. mem. joints
		3 Impact/Accident Damage	Accident damage has minor impact
		4 Paint peel off	Surface area affected is > 20% to <= 30%
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/rusting through > 20% section loss
		2 Loose connection	> 30% fasteners loose, bolts fall out in > 3pc on primary member joints
		3 Impact/Accident Damage	Post or rails totally shifted out of position or missing.
		4 Paint peel off	Surface area affected is > 30%

BRIDGE ELEMENT	ABUTMENT	BRIDGE ATTTRIBUTE	BRIDGE APPROACH

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
EMBANKMENT	0-Good	1 Depression	No Depression
	1 - Fair	1 Depression	Slight depression: mean dfference is <=25mm in elevation
	2-Poor	1 Depression	Serious depression: mean difference is > 25mm to <= 50mm in elevation and 1.0m wide
	3 - Bad	1 Depression	Outstanding depression: mean difference is > 50mm in elevation and 1.0m wide

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	EXPANSION JOINT (1/2)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
POURABLE SEALS Sealant Asphalt	0 - Good	1 Water leakage	No leakage
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is <= 10mm at expansion gap
		4 Deteriorated Sealant	Not detected
	1 - Fair	1 Water leakage	Detected area measures up to 25%, and 1m below the bearing shelf
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 10mm to <= 20mm at expansion gap
		4 Deteriiorated Sealant	Sealer starting to flow out of the joint
	2 - Poor	1 Water leakage	Detected area measure > 25% to <= 50%
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 20mm to <= 30mm at expansion gap
		4 Deteriorated Sealant	Overfilled sealer heavily impacted by traffic
	3 - Bad	1 Water leakage	Detected area > 50%
		2 Abnormal space/noise	Detected
		3 Difference in elevation	Difference in elevation is > 30mm at expansion gap
		4 Deteriorated Sealant	Pourable joint sealant maybe almost completely lost.
STEEL	0 - Good	1 Water leakage	No leakage
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is <= 10mm at expansion gap
		4 Displacement	Bolts/anchorage/armoring firmly in place
		5 Cracking	No cracks
	1 - Fair	1 Water leakage	Detected area measures up to 25%, and 1m below the bearing shelf
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 10mm to <= 20mm at expansion gap
		4 Displacement	Slight loosening of bolts/anchorage/armoring but still in place
		5 Cracking	Spot cracking on Secondary members only
	2 - Poor	1 Water leakage	Detected area measure > 25% to <= 50%
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 20mm to <= 30mm at expansion gap
		4 Displacement	Bolts/anchorage/armoring may have failed
		5 Cracking	Spot cracking on primary bridge components
	3 - Bad	1 Water leakage	Detected area > 50%
		2 Abnormal space/noise	Detected
		3 Difference in elevation	Difference in elevation is > 30mm at expansion gap
		4 Displacement	Pourable joint sealant maybe almost completely lost.
		5 Cracking	Cracking on primary members especially in welded parts

BRIDGE ELEMENT	PIER/ABUTMENT	BRIDGE ATTTRIBUTE	EXPANSION JOINT (2/2)

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
RUBBER	0 - Good	1 Water leakage	No leakage
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is <= 10mm at expansion gap
		4 Rupture	Fine or hairline crack detected on rubber seal
	1 - Fair	1 Water leakage	Detected area measures up to 25%, and 1m below the bearing shelf
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 10mm to <= 20mm at expansion gap
		4 Rupture	Minor crack detected on rubber seal
	2 - Poor	1 Water leakage	Detected area measure > 25% to <= 50%
		2 Abnormal space/noise	Not detected
		3 Difference in elevation	Difference in elevation is > 20mm to <= 30mm at expansion gap
		4 Rupture	Wide or large crack detected on rubber seal
	3 - Bad	1 Water leakage	Detected area > 50%
		2 Abnormal space/noise	Detected
		3 Difference in elevation	Difference in elevation is > 30mm at expansion gap
		4 Rupture	Rubber seal dislodge or peel off from location

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT BRIDGE ATTRIBUTE **ASPHALT WEARING SURFACE**

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Asphalt	0 - Good	1 Potholes	Slight and shallow potholes or no damage
		2 Shoving	< 10mm in depth or no damage/defects
		3 Rutting	< 10mm in depth or no damage/defects
		4 Cracking	If alligator cracks area measuring <= 10% or no crack
		5 Raveling	< 10mm in depth or no damage/defects
	1 - Fair	1 Potholes	Holes measuring < 200mm in any direction or 10mm - 30mm in depth
		2 Shoving	10mm - 20mm in depth and corrugation < 30mm in deviation
		3 Rutting	10mm - 20mm in depth
		4 Cracking	If alligator cracks area measuring > 10% to < 15%
		5 Raveling	10mm - 20mm in depth
	2 - Poor	1 Potholes	Holes measuring 200mm-400mm in any direction or 30mm-50mm in depth
		2 Shoving	20mm - 30mm in depth and corrugation > 30mm in deviation
		3 Rutting	20mm - 30mm in depth
		4 Cracking	If alligator cracks area measuring > 15% to < 20%
		5 Raveling	20mm - 30mm in depth
	3 - Bad	1 Potholes	Holes measuring > 400mm in any direction or > 50mm in depth
		2 Shoving	> 30mm in depth
		3 Rutting	> 30mm in depth
		4 Cracking	If alligator cracks area measuring > 20%
		5 Raveling	> 30mm in depth

APPENDIX-C-1-1

BRIDGE CONDITION RATING CRITERIA

ON SPECIAL BRIDGE

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	SPAN	BRIDGE ATTTRIBUTE	ANCHORAGE (INSIDE BOX GIRDER)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
CONCRETE	0 - Good	1 Cracking	Hairline crack or no crack
		2 Spalling Scaling Disintegration	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
	1 - Fair	1 Cracking	<= 0.3mm, 1 direction, spacing > 500mm
		2 Spalling Scaling Disintegration	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 ot 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
	2 - Poor	1 Cracking	> 0.3mm to <= 1.0mm, 2 directions, spacing is <500mm to >= 2000mm
		2 Spalling Scaling Disintegration	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
	3 - Bad	1 Cracking	> 1.0mm, 2 directions, spacing is < 200mm
		2 Spalling Scaling Disintegration	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

APPENDIX-C-2-1

CONDITION RATING CRITERIA

ON SPECIAL BRIDGE

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	TOWER	BRIDGE ATTTRIBUTE	MAIN / SECONDARY MEMBER (1/3)

MATERIAL TYPE	COND. 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 Mssing bolts	No bolts missing
		3 Deformation / Buckling	No deformation on bridge components
		4 Cracking	Not Detected
		5 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 Mssing bolts	Falling out of bolts in >1 piece
		3 Deformation / Buckling	Partial deformation on secondary members only
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is >10% to <= 20% in a member
	2 - Poor	1 Corrosion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
		2 Mssing bolts	Falling out of bolts in >2 pieces
		3 Deformation / Buckling	Partial deformation on primary members
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is > 20% to <= 30% in a member
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/ rusting through >20% section loss
		2 Mssing bolts	Falling out of bolts in >3 pieces
		3 Deformation / Buckling	Outstanding deformation due to buckling or partial yielding
		4 Cracking	Detected
		5 Paint peel off	Surface area affected is > 30% in a member

BRIDGE ELEMENT	ANCHORAGE	BRIDGE ATTTRIBUTE	MAIN / SECONDARY MEMBER (2/3)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Steel	0 - Good	1 Missing bolts	No bolts missing
	1 - Fair	1 Missing bolts	Falling out of bolts in >1 piece
	2 - Poor	1 Missing bolts	Falling out of bolts in >2 pieces
	3 - Bad	1 Missing bolts	Falling out of bolts in >3 pieces

BRIDGE ELEMENT	CABLE	BRIDGE ATTTRIBUTE	MAIN / SECONDARY MEMBER (3/3)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Steel	0 - Good	1 Vibration	Not Detected
		2 Alignment/ Deformation	Not Detected
		3 Corrosion	Loose rust formation and pitting in the paint surface, no section loss
	1 - Fair	1 Vibration	Not Detected
		2 Alignment/ Deformation	Not Detected
		3 Corrosion	Loose rust formation with scales / flakes, <=10% section loss
	2 - Poor	1 Vibration	Not Detected
		2 Alignment/ Deformation	Not Detected
		3 Corrosion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
	3 - Bad	1 Vibration	Detected the excessive or abnormal vibration of stay cable during the passage of heavy loads or excessive vibration caused by wind in comparison with adjacent cables by visual inspection or touch or engineering judgment
		2 Alignment/ Deformation	Detected the apprent diffence in the sag of the cable
		3 Corrosion	Extensive rusting w/ local perforation/ rusting through >20% section loss

APPENDIX-C-3-1

CONDITION RATING CRITERIA

ON SPECIAL BRIDGE

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	TOWER	BRIDGE ATTTRIBUTE	MAIN MEMBER (1/5)

MATERIAL TYPE	COND. 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 Mssing bolts	No bolts missing
		3 Deformation / Buckling	No deformation on bridge components
		4 Cracking	Not Detected
		5 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 Mssing bolts	Falling out of bolts in >1 piece
		3 Deformation / Buckling	Partial deformation on secondary members only
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is >10% to <= 20% in a member
	2 - Poor	1 Corrosion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
		2 Mssing bolts	Falling out of bolts in >2 pieces
		3 Deformation / Buckling	Partial deformation on primary members
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is > 20% to <= 30% in a member
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/ rusting through >20% section loss
		2 Mssing bolts	Falling out of bolts in >3 pieces
		3 Deformation / Buckling	Outstanding deformation due to buckling or partial yielding
		4 Cracking	Detected
		5 Paint peel off	Surface area affected is > 30% in a member

BRIDGE ELEMENT	CABLE SADDLE	BRIDGE ATTTRIBUTE	MAIN MEMBER (2/5)

MATERIAL TYPE	COND. 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 Mssing bolts	No bolts missing
		3 Deformation / Buckling	No deformation on bridge components
		4 Cracking	Not Detected
		5 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 Mssing bolts	Falling out of bolts in >1 piece
		3 Deformation / Buckling	Partial deformation on secondary members only
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is >10% to <= 20% in a member
	2 - Poor	1 Corrosion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
		2 Mssing bolts	Falling out of bolts in >2 pieces
		3 Deformation / Buckling	Partial deformation on primary members
		4 Cracking	Not Detected
		5 Paint peel off	Surface area affected is > 20% to <= 30% in a member
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/ rusting through >20% section loss
		2 Mssing bolts	Falling out of bolts in >3 pieces
		3 Deformation / Buckling	Outstanding deformation due to buckling or partial yielding
		4 Cracking	Detected
		5 Paint peel off	Surface area affected is > 30% in a member

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	CABLE AND ROPE	BRIDGE ATTTRIBUTE	MAIN MEMBER (3/5)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Steel	0 - Good	1 Vibration	Not Detected
		2 Alignment / Deformation	Not Detected
		3 Cracking	Not Detected
		4 Delamination / Scaling	Not Detected
		5 Water leakage	Not Detected
	1 - Fair	1 Vibration	Not Detected
		2 Alignment / Deformation	Not Detected
		3 Cracking	Not Detected
		4 Delamination / Scaling	Not Detected
		5 Water leakage	Not Detected
	2 - Poor	1 Vibration	Not Detected
		2 Alignment / Deformation	Not Detected
		3 Cracking	Detected crack, but no ecposed wire and no corrosion
		4 Delamination / Scaling	Detected delamination of covering, but no ecposed wire and no corrosion
		5 Water leakage	Not Detected
	3 - Bad	1 Vibration	Detected the excessive or abnormal vibration of stay cables during the passage of heavy loads or excessive vibration caused by wind in comparison with adjacent cables by visual inspection or touch or engineering judgement
		2 Alignment / Deformation	Detected the apprent difference in the sag of the cable
		3 Cracking	Detected Crack and wire exprosure, corrosion
		4 Delamination / Scaling	Detected dekamination of covering and wire exprosure, corrosion
		5 Water leakage	Detected in the connection with anchorage parts

BRIDGE ELEMENT	CABLE ANCHORAGE	BRIDGE ATTTRIBUTE	MAIN MEMBER (4/5)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
STEEL	0 - Good	1 Corrsion	Loose rust formation and pitting in the paint surface, no section loss
		2 Deformation	No deformation on bridge components
		3 Loose connection	No bolts missing, <=10% in a member
		4 Missing bolts	No bolts missing
	1 - Fair	1 Corrsion	Loose rust formation with scales / flakes, <=10% section loss
		2 Deformation	Partial deformation on secondary members only
		3 Loose connection	Loose fasteners is > 10% to <=20%, falling out of bolts in > 1 pc. on joints
		4 Missing bolts	Falling out of bolts in >1 piece
	2 - Poor	1 Corrsion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
		2 Deformation	Partial deformation on primary members
		3 Loose connection	Loose fasteners is < 20% to <=30%, falling out in > 3 pc. on sec. mem. joints
		4 Missing bolts	Falling out of bolts in >2 pieces
	3 - Bad	1 Corrsion	Extensive rusting w/ local perforation/ rusting through >20% section loss
		2 Deformation	Outstanding deformation due to buckling or partial yielding
		3 Loose connection	>30% fasteners loose, bolts fall out in > 3pcs. on praimary member joints
		4 Missing bolts	Falling out of bolts in >3 pieces

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	ANCHOR BLOCK	BRIDGE ATTTRIBUTE	MAIN MEMBER (5/5)

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Concrete	0 - Good	1 Cracking	Hairline crack or no crack
		2 Spalling / Scaling / Disintegration	Affected are 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
	1 - Fair	1 Cracking	<= 0.3mm, spacing > 500mm
		2 Spalling / Scaling / Disintegration	Affected are is 150mm to 300mm wide in any direction or depth is 25mm to 50mm
		3 Delamination	Delaminated area measuring > 150mm to <= 300mm in any direction
		4 Rebar exposure / corrosion	Main rebar exposed is <= 50mm2 wide, corroded of flaking only
		5 Honeycomb	Affected area is > 150mm to <= 300mm wide in any direction
		6 Water leakage	Water leakage in 1 spot has an area of <= 200mm wide
	2 - Poor	1 Cracking	0.3mm to <= 1.0mm, spacing < 500mm to >= 200mm
		2 Spalling / Scaling / Disintegration	Affected are 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 > 50mm2 wide to <= 100mm2 wide, corroded
		5 Honeycomb	Affected area is > 300mm to <= 600mm wide in any direction
		6 Water leakage	Water leakage in 1 spot has an area of > 200mm to <=500mm wide
	3 - Bad	1 Cracking	> 1.0mm, spacing is < 200mm
		2 Spalling / Scaling / Disintegration	Affected are 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 > 100mm2 wide, corroded
		5 Honeycomb	Affected area is >600mm wide in any direction
		6 Water leakage	Water leakage in 1 spot has an area of > 500mm wide

BRIDGE ELEMENT	ANCHORAGE HOUSING	BRIDGE ATTTRIBUTE	SECONDARY MEMBER

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
CONCRETE	0 - Good	1 Debris accumulation	Loose debris accumulating on piers or bridgebdecks
		2 Vegetation growth	There is little or no change in channel shape
		3 Door locking	No Damage & Be locked
	1 - Fair	1 Debris accumulation	Debris accumulation in the form of small branches
		2 Vegetation growth	<= 10% of designed waterway area in any span
		3 Door locking	Some Damage & not be locked
	2 - Poor	1 Debris accumulation	Debris accumulation in the form of large branches or small trees
		2 Vegetation growth	> 10% to <= 20% of designed waterway area in any span
		3 Door locking	Door not closing
	3 - Bad	1 Debris accumulation	Debris accumulation in the form of large trees
		2 Vegetation growth	> 20% of designed waterway area in any span
		3 Door locking	No Door

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	BRIDGE ATTRIBUTE	ASPHALT WEARING SURFACE

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Asphalt	0 - Good	1 Potholes	Slight and shallow potholes or no damage
		2 Shoving	< 10mm in depth or no damage/defects
		3 Rutting	< 10mm in depth or no damage/defects
		4 Cracking	If alligator cracks area measuring <= 10% or no crack
		5 Raveling	< 10mm in depth or no damage/defects
	1 - Fair	1 Potholes	Holes measuring < 200mm in any direction or 10mm - 30mm in depth
		2 Shoving	10mm - 20mm in depth and corrugation < 30mm in deviation
		3 Rutting	10mm - 20mm in depth
		4 Cracking	If alligator cracks area measuring > 10% to < 15%
		5 Raveling	10mm - 20mm in depth
	2 - Poor	1 Potholes	Holes measuring 200mm-400mm in any direction or 30mm-50mm in depth
		2 Shoving	20mm - 30mm in depth and corrugation > 30mm in deviation
		3 Rutting	20mm - 30mm in depth
		4 Cracking	If alligator cracks area measuring > 15% to < 20%
		5 Raveling	20mm - 30mm in depth
	3 - Bad	1 Potholes	Holes measuring > 400mm in any direction or > 50mm in depth
		2 Shoving	> 30mm in depth
		3 Rutting	> 30mm in depth
		4 Cracking	If alligator cracks area measuring > 20%
		5 Raveling	> 30mm in depth

BRIDGE ELEMENT	BRIDGE ATTRIBUTE	DRAINE PIPES

MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Concrete	0 - Good	1 Flood debris accumulation	Loose debris accumulating on piers or bridgebdecks
		2 Siltation	There is little or no change in channel shape
		3 Vegetation growth	There is little or no change in channel shape
	1 - Fair	1 Flood debris accumulation	Debris accumulation in the form of small branches on piers or on the bridge
		2 Siltation	<= 10% of designed waterway area in any span
		3 Vegetation growth	<= 10% of designed waterway area in any span
	2 - Poor	1 Flood debris accumulation	Debris accumulation in the form of large branches or small trees on piers or
		2 Siltation	> 10% to <= 20% of designed waterway area in any span
		3 Vegetation growth	> 10% to <= 20% of designed waterway area in any span
	3 - Bad	1 Flood debris accumulation	Debris accumulation in the form of large trees on piers or on the bridge
		2 Siltation	> 20% of designed waterway area in any span
		3 Vegetation growth	> 20% of designed waterway area in any span

APPENDIX-C-4-1

CONDITION RATING CRITERIA

ON SPECIAL BRIDGE

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT: SPAN BRIDGE ATTRIBUTE: **DECK**

MATERIAL TYPE	COND. 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	Not Detected
		3 Deformation/Buckling	No deformation
		4 Abnormal Vibration	Not Detected
		5 Paint peel off	Surface area affected is <= 10% in a member
		6 Missing element	No element missing
	1 - Fair	1 Corrosion	Loose rust formation with scales / flakes, <=10% section loss
		2 Cracking	Not Detected
		3 Deformation/Buckling	No deformation
		4 Abnormal Vibration	Not Detected
		5 Paint peel off	Surface area affected is >10% to <= 20% in a member
		6 Missing element	No element missing
	2 - Poor	1 Corrosion	Stratigied rust with pitting of metal surface, >10% to <=20% section loss
		2 Cracking	Not Detected
		3 Deformation/Buckling	Partial deformation
		4 Abnormal Vibration	Not Detected
		5 Paint peel off	Surface area affected is > 20% to <= 30% in a member
		6 Missing element	No element missing
	3 - Bad	1 Corrosion	Extensive rusting w/ local perforation/ rusting through >20% section loss
		2 Cracking	Detected
		3 Deformation/Buckling	Outstanding deformation due to buckling or partial yielding
		4 Abnormal Vibration	Detected
		5 Paint peel off	Surface area affected is > 30% in a member
		6 Missing element	Element Missing

BRIDGE ELEMENT BRIDGE ATTRIBUTE: **ASPHALT WEARING SURFACE**

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Asphalt	0 - Good	1 Potholes	Slight and shallow potholes or no damage
		2 Shoving	< 10mm in depth or no damage/defects
		3 Rutting	< 10mm in depth or no damage/defects
		4 Cracking	If alligator cracks area measuring <= 10% or no crack
		5 Raveling	< 10mm in depth or no damage/defects
	1 - Fair	1 Potholes	Holes measuring < 200mm in any direction or 10mm - 30mm in depth
		2 Shoving	10mm - 20mm in depth and corrugation < 30mm in deviation
		3 Rutting	10mm - 20mm in depth
		4 Cracking	If alligator cracks area measuring > 10% to < 15%
		5 Raveling	10mm - 20mm in depth
	2 - Poor	1 Potholes	Holes measuring 200mm-400mm in any direction or 30mm-50mm in depth
		2 Shoving	20mm - 30mm in depth and corrugation > 30mm in deviation
		3 Rutting	20mm - 30mm in depth
		4 Cracking	If alligator cracks area measuring > 15% to < 20%
		5 Raveling	20mm - 30mm in depth
	3 - Bad	1 Potholes	Holes measuring > 400mm in any direction or > 50mm in depth
		2 Shoving	> 30mm in depth
		3 Rutting	> 30mm in depth
		4 Cracking	If alligator cracks area measuring > 20%
		5 Raveling	> 30mm in depth

BRIDGE CONDITION RATING CRITERIA

BRIDGE ELEMENT	Springing	BRIDGE ATTTRIBUTE	MAIN MEMBER

MATERIAL TYPE	COND. STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Concrete	0 - Good	1 Cracking	Hairline crack or no crack
		2 Spalling / Scaling / Disintegration	Affected are 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 Tilt / settlement	Not visible
	1 - Fair	1 Cracking	<= 0.3mm, spacing > 500mm
		2 Spalling / Scaling / Disintegration	Affected are is 150mm to 300mm wide in any direction or depth is 25mm to 50mm
		3 Delamination	Delaminated area measuring > 150mm to <= 300mm in any direction
		4 Rebar exposure / corrosion	Main rebar exposed is <= 50mm2 wide, corroded of flaking only
		5 Honeycomb	Affected area is > 150mm to <= 300mm wide in any direction
		6 Tilt / settlement	Not visible
	2 - Poor	1 Cracking	0.3mm to <= 1.0mm, spacing < 500mm to >= 200mm
		2 Spalling / Scaling / Disintegration	Affected are 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 > 50mm2 wide to <= 100mm2 wide, corroded
		5 Honeycomb	Affected area is > 300mm to <= 600mm wide in any direction
		6 Tilt / settlement	Not visible
	3 - Bad	1 Cracking	> 1.0mm, spacing is < 200mm
		2 Spalling / Scaling / Disintegration	Affected are 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 > 100mm2 wide, corroded
		5 Honeycomb	Affected area is >600mm wide in any direction
		6 Tilt / settlement	Detected

BRIDGE ELEMENT	BRIDGE ATTRIBUTE	DRAINE PIPES

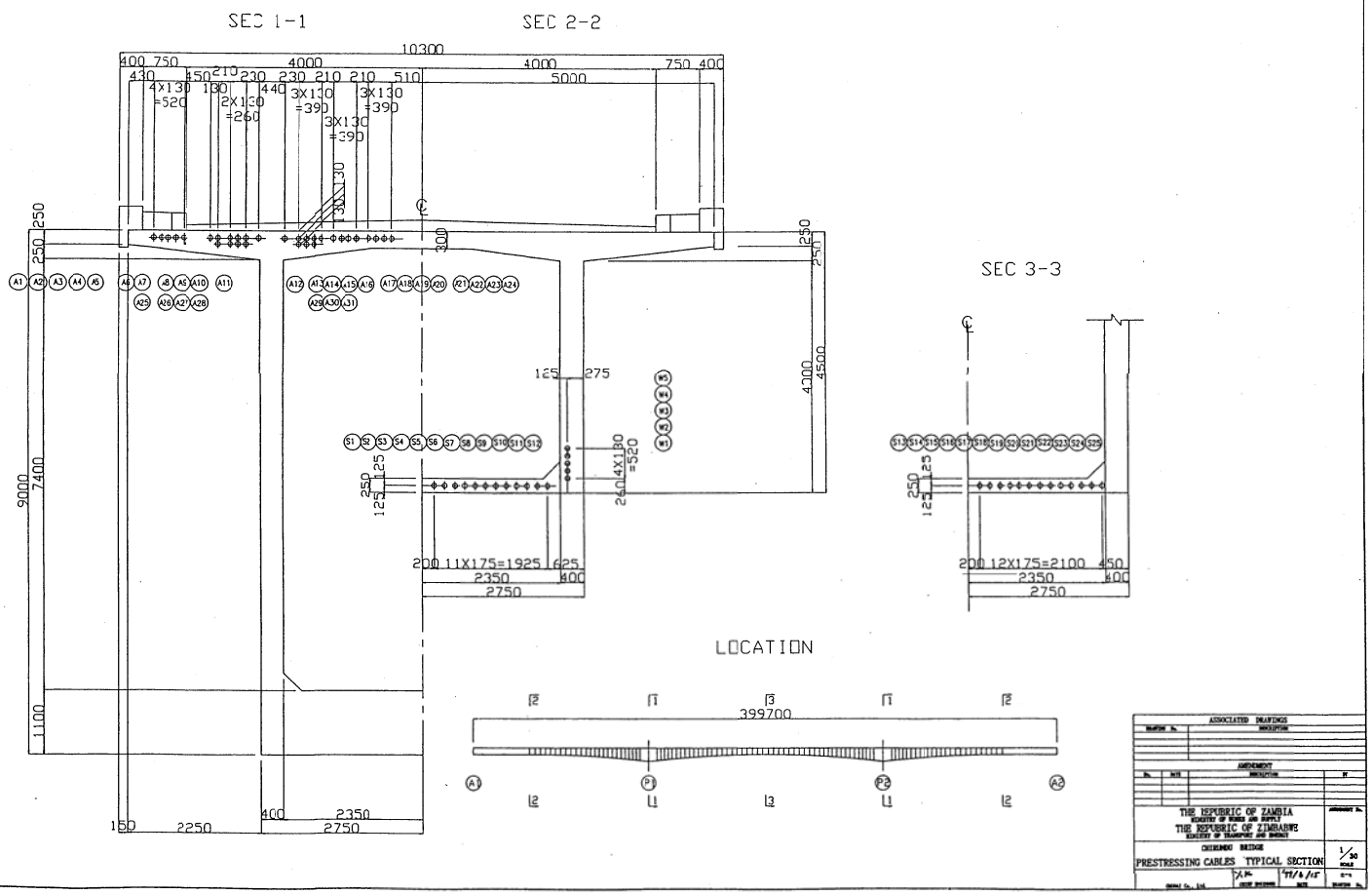
MATERIAL TYPE	CONDITION STATE	SEVERITY OF DEFECT	
		TYPE OF DAMAGE	CONDITION
Concrete	0 - Good	1 Flood debris accumulation	Loose debris accumulating on piers or bridgebdecks
		2 Siltation	There is little or no change in channel shape
		3 Vegetation growth	There is little or no change in channel shape
	1 - Fair	1 Flood debris accumulation	Debris accumulation in the form of small branches on piers or on the bridge
		2 Siltation	<= 10% of designed waterway area in any span
		3 Vegetation growth	<= 10% of designed waterway area in any span
	2 - Poor	1 Flood debris accumulation	Debris accumulation in the form of large branches or small trees on piers or
		2 Siltation	> 10% to <= 20% of designed waterway area in any span
		3 Vegetation growth	> 10% to <= 20% of designed waterway area in any span
	3 - Bad	1 Flood debris accumulation	Debris accumulation in the form of large trees on piers or on the bridge
		2 Siltation	> 20% of designed waterway area in any span
		3 Vegetation growth	> 20% of designed waterway area in any span

APPENDIX D-1-1

Arrangements of PC Cables

PRESTRESSING CABLES TYPICAL SECTION

S=1: 30



ASSOCIATED DRAWINGS

DRAWING No.	DESCRIPTION

AMENDMENT

No.	DATE	DESCRIPTION	BY

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

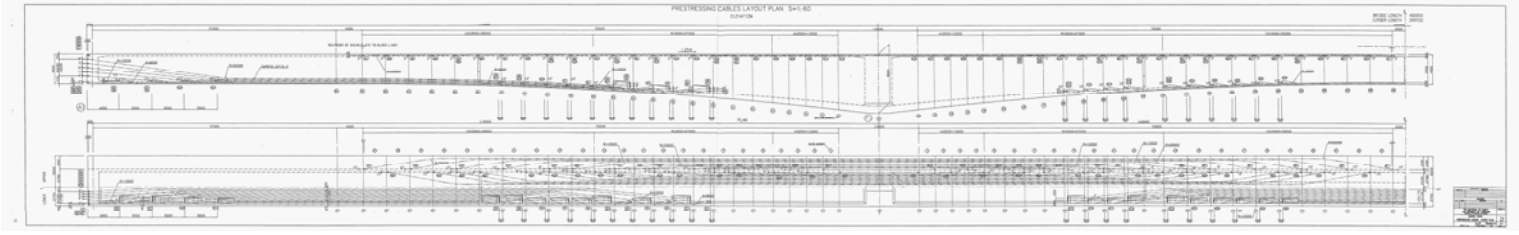
CHIRUNDU BRIDGE

PRESTRESSING CABLES TYPICAL SECTION

1/30 SCALE

DRAWN Dr. Ltd. | CHIEF DRAUGHTSMAN | DATE | DRAWING No.

D2

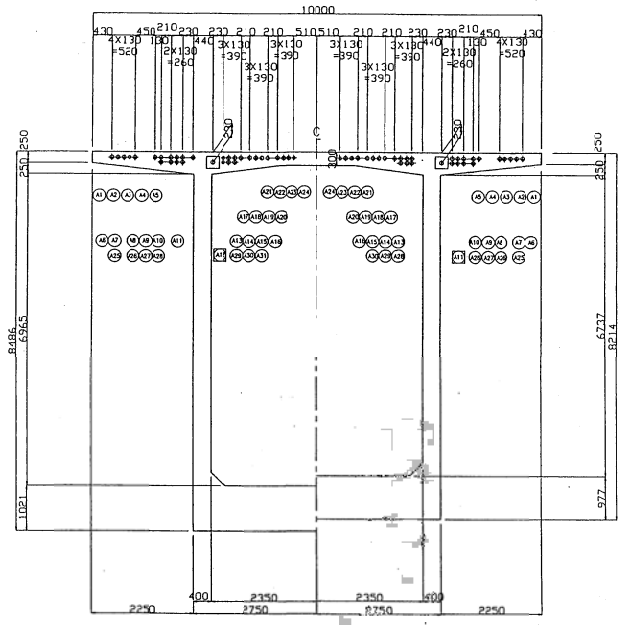


D3

PRESTRESSING CABLES ARRANGEMENT SECTION (1)

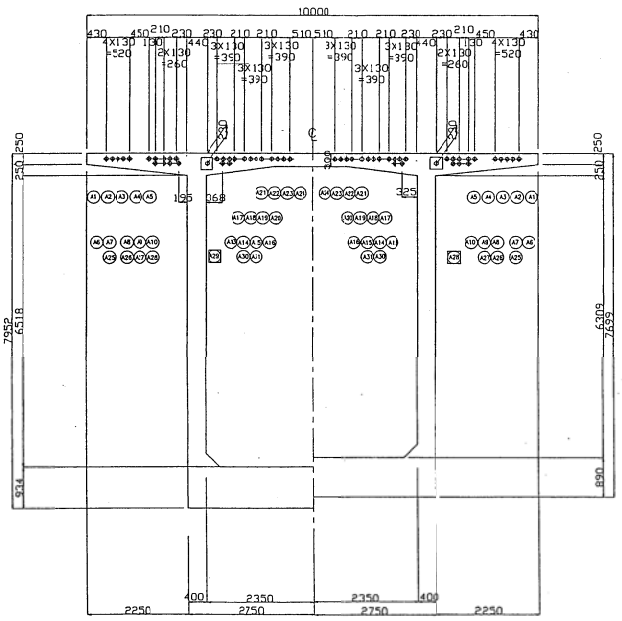
S=1: 40

SEC 1-1 (0L) (0R)



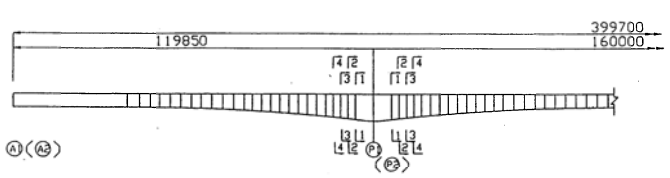
SEC 2-2 (1L) (1R)

SEC 3-3. (2L) (2R)



SEC 4-4 (3L) (3R)

LOCATION



ASSOCIATED DRAWINGS	
DRAWING No.	DESCRIPTION

AMENDMENT		
No.	DATE	DESCRIPTION

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

PRESTRESSING CABLES ARRANGEMENT SECTION (1)

SCALE 1/40

DESIGN DRAWN CHECK DATE 21/6/17

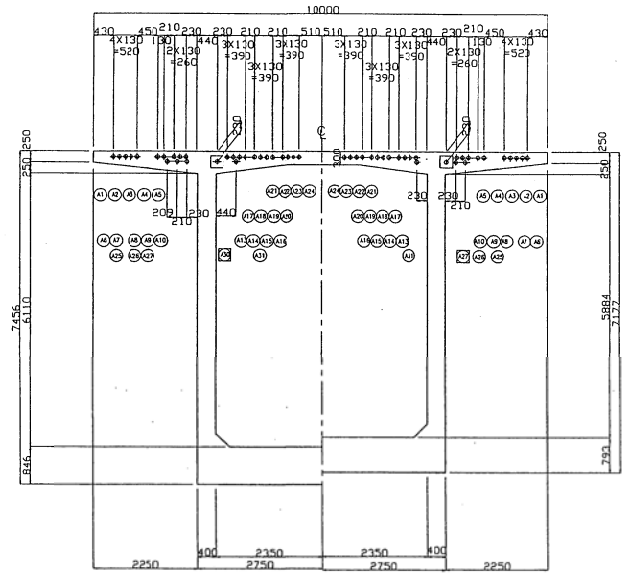
DRAWING No. D-4

D4

PRESTRESSING CABLES ARRANGEMENT SECTION (2)

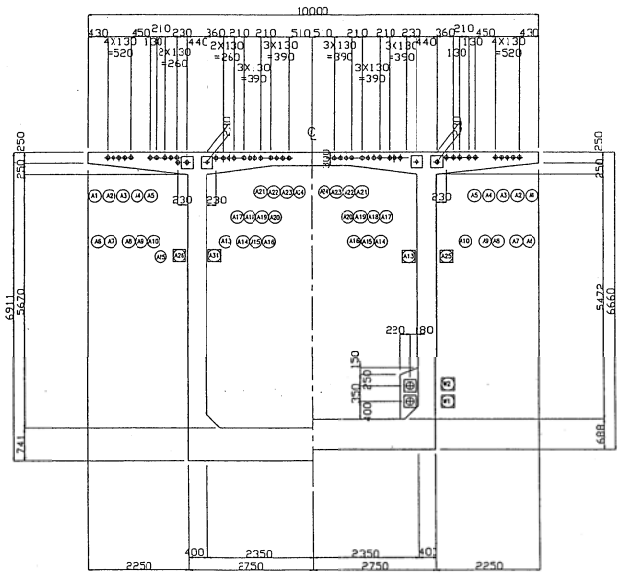
S=1: 40

SEC 1-1 (4L) (4R)



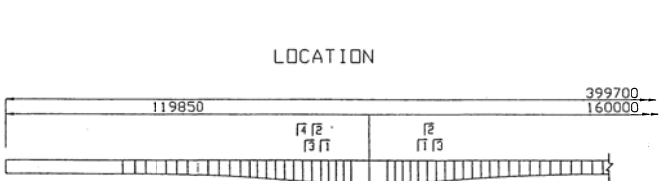
SEC 2-2 (5L) (5R)

SEC 3-3 (6L) (6R)



SEC 4-4 (7L)

LOCATION



ASSOCIATED DRAWINGS	
DRAWING No.	DESCRIPTION

AMENDMENT		
No.	DATE	DESCRIPTION

THE REPUBLIC OF ZAMBIA
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THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

PRESTRESSING CABLES ARRANGEMENT SECTION (2)

SCALE 1/40

DESIGN DRAWN CHECK DATE 21/6/17

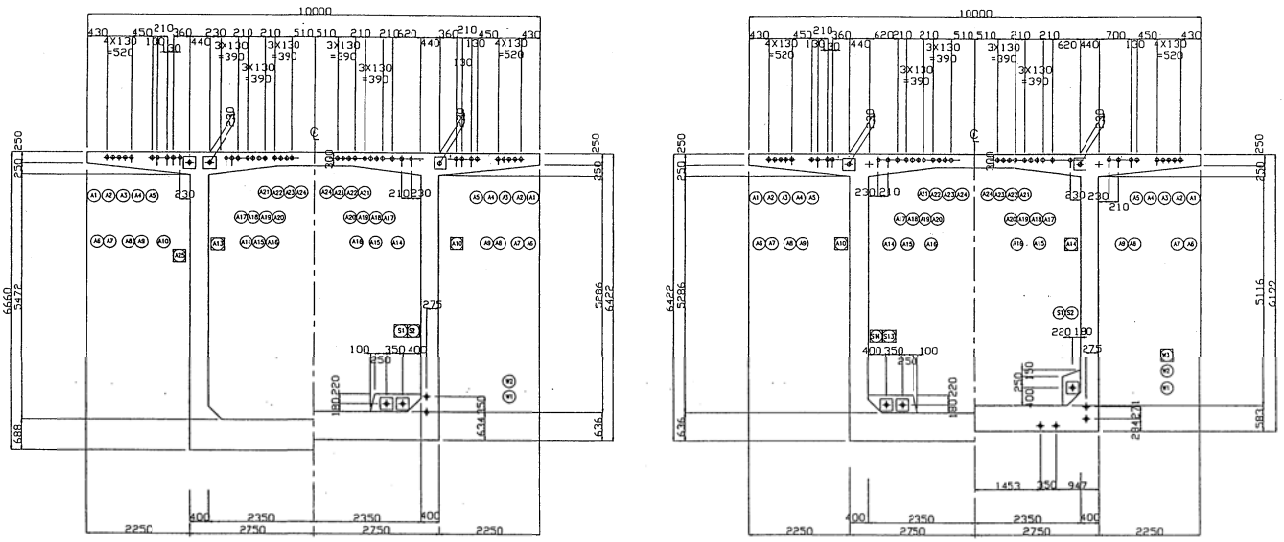
DRAWING No. D-5

D5

PRESTRESSING CABLES ARRANGEMENT SECTION (3)

S=1: 40

SEC 1-1 (7R) SEC 2-2 (8L) SEC 3-3 (8R) SEC 4-4 (9L)



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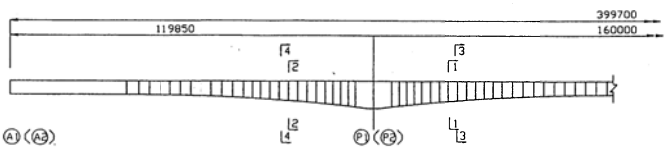

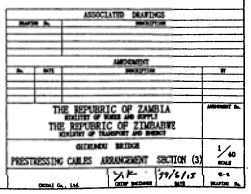

D6

PRESTRESSING CABLES ARRANGEMENT SECTION (4)

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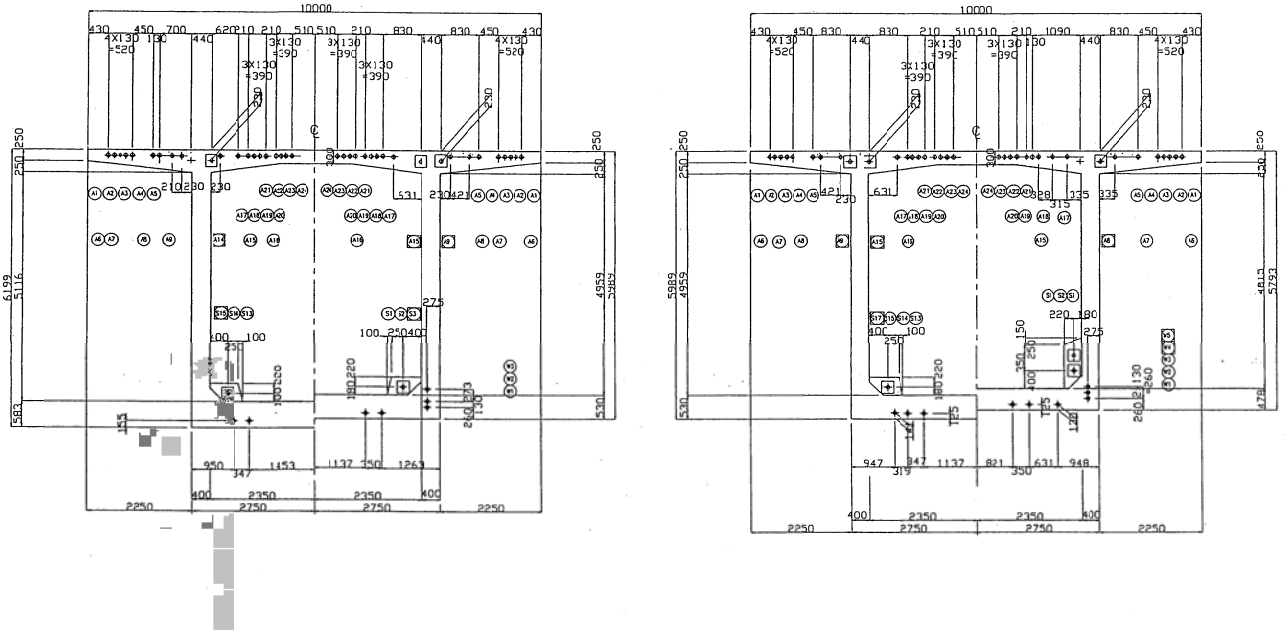
SEC 1-1 (9R) SEC 2-2 (10L) SEC 3-3 (10R) SEC 4-4 (11L)



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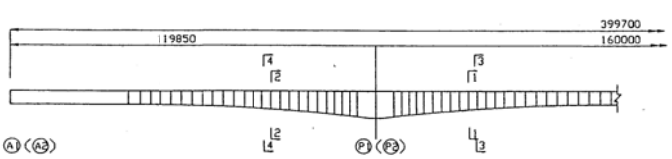

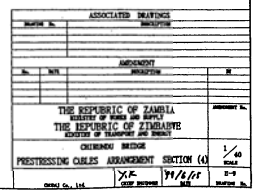

D7

PRESTRESSING CABLES ARRANGEMENT SECTION (5)

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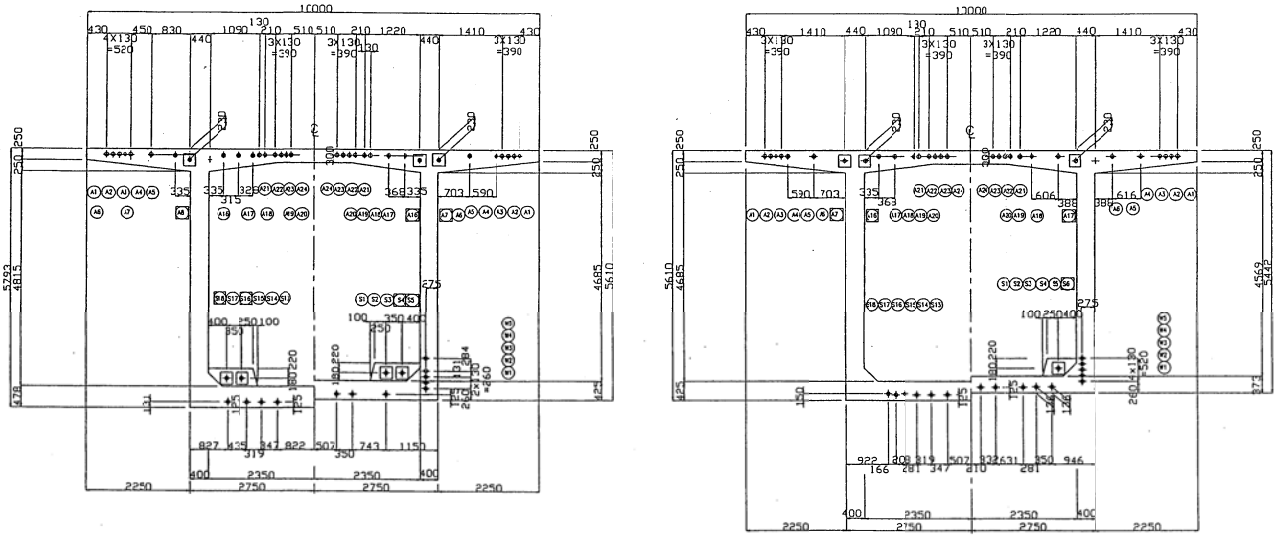
SEC 1-1 (1R) SEC 2-2 (2L) SEC 3-3 (2R) SEC 4-4 (3L)



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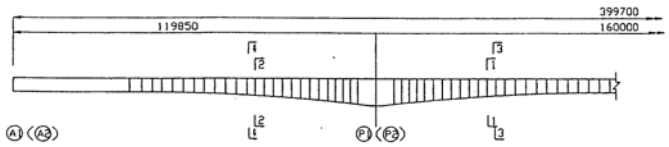

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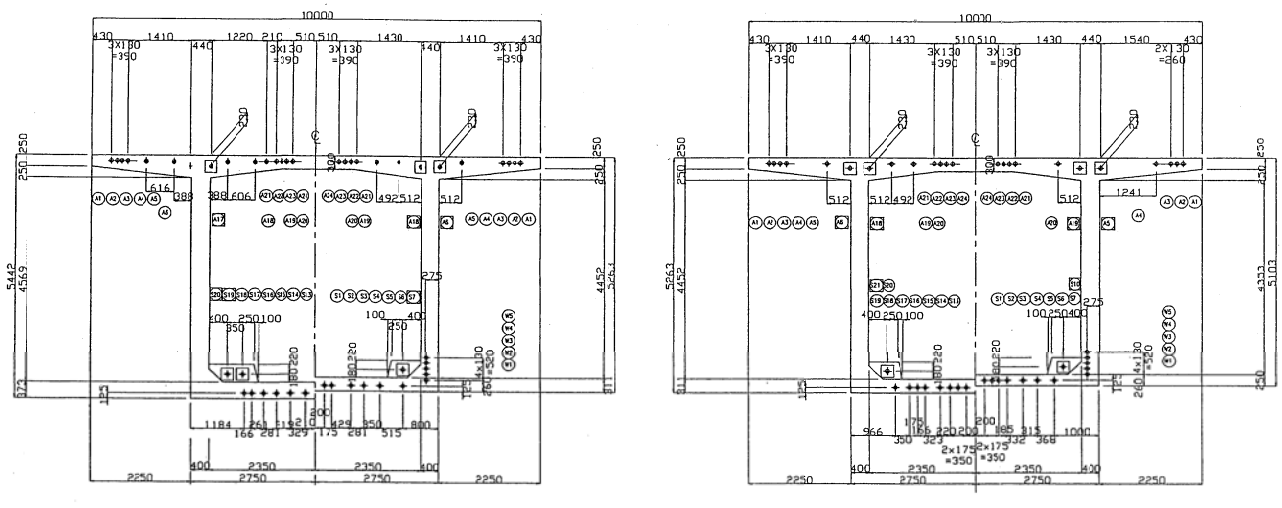
CHIRUNDU BRIDGE
PRESTRESSING CABLES ARRANGEMENT SECTION (5)
SCALE 1/40

D8

PRESTRESSING CABLES ARRANGEMENT SECTION (6)

S=1: 40

SEC 1-1 (3R) SEC 2-2 (4L) SEC 3-3 (4R) SEC 4-4 (5L)



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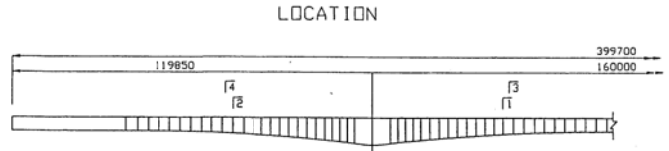

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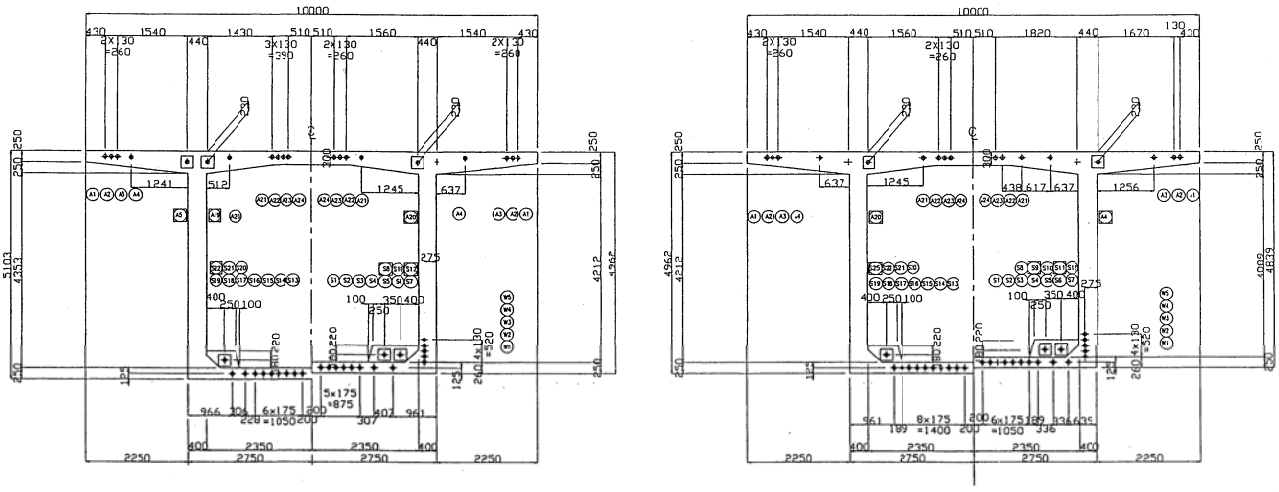
PRESTRESSING CABLES ARRANGEMENT SECTION (6)
SCALE 1/40

D9

PRESTRESSING CABLES ARRANGEMENT SECTION (7)

S=1: 40

SEC 1-1 (5R) SEC 2-2 (5L) SEC 3-3 (6R) SEC 4-4 (7L)



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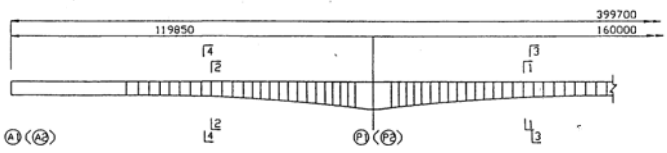

ASSOCIATED DRAWINGS

AMENDMENT

THE REPUBLIC OF ZAMBIA
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THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

PRESTRESSING CABLES ARRANGEMENT SECTION (7)

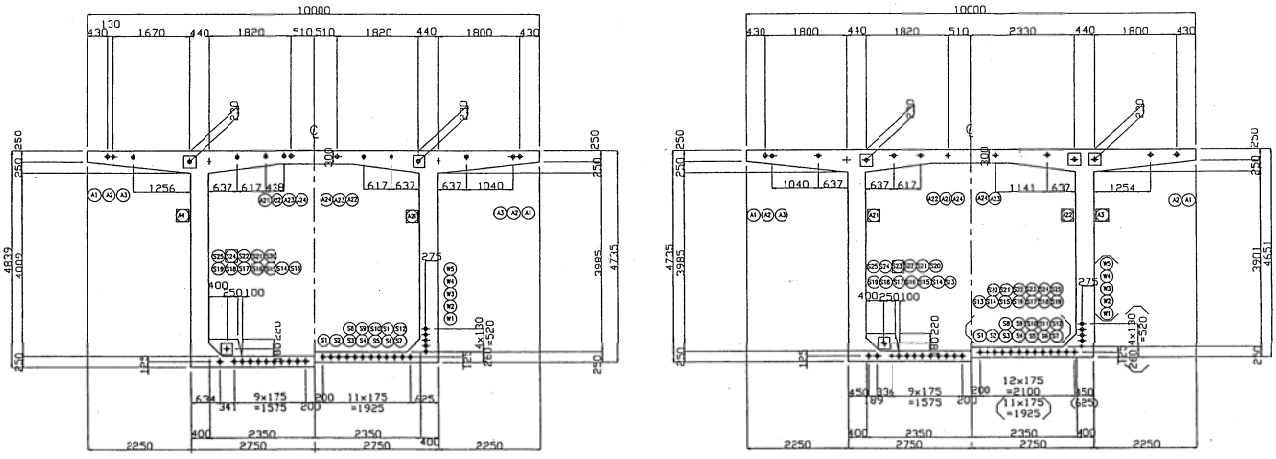
1/40 SCALE

D10

PRESTRESSING CABLES ARRANGEMENT SECTION (8)

S=1: 40

SEC 1-1 (7R) SEC 2-2 (8L) SEC 3-3 (8R) SEC 4-4 (9L) (9R)



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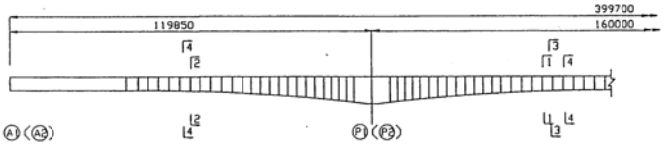


ASSOCIATED DRAWINGS

AMENDMENT

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

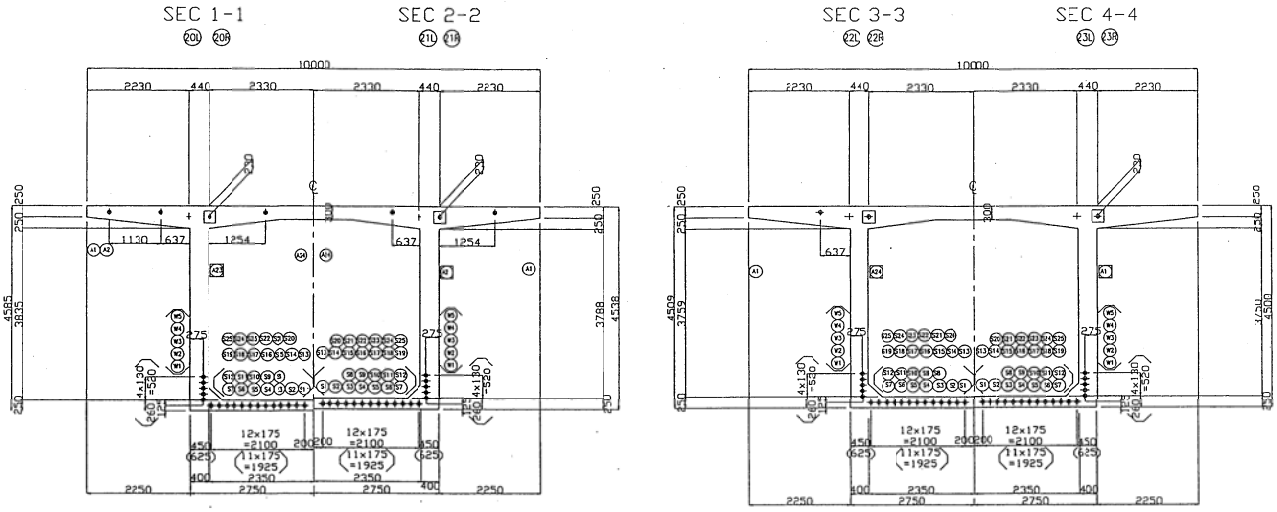
PRESTRESSING CABLES ARRANGEMENT SECTION (8)

1/40 SCALE

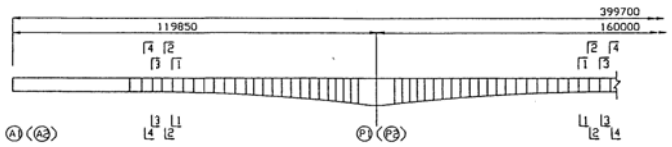
D11

PRESTRESSING CABLES ARRANGEMENT SECTION (9)

S=1: 40



LOCATION



ASSOCIATED DRAWINGS

AMENDMENT

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

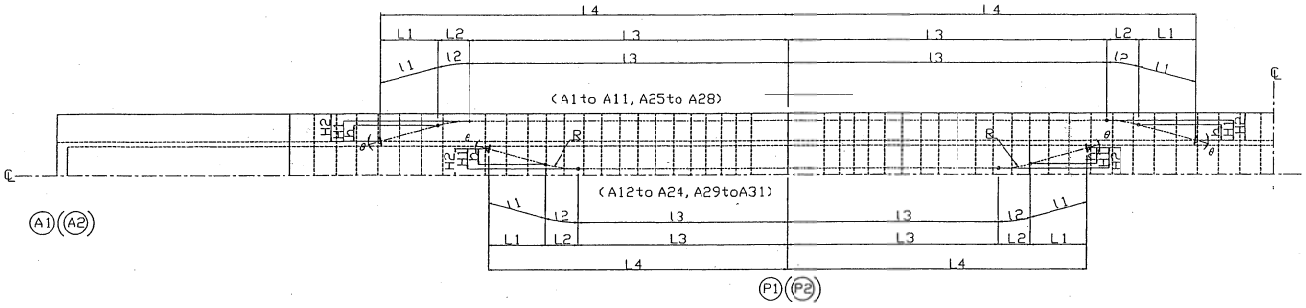
PRESTRESSING CABLES ARRANGEMENT SECTION (9)

SCALE 1/40

Oriental Co., Ltd. | Y.F | 99/6/15 | K-11

D12

PRESTRESSING CABLES DIMENSION TABLE (1)



CANTILEVER CABLES

NUM	L1	L2	L3	L4	l1	l2	l3	2Σl	H1	H2	h	R	θ(°)
A1	8,485	3,473	65,992	77,950	8,616	3,491	65,992	156,197	1,800	2,230	1,496	20,000	10
A2	7,748	3,473	59,729	70,950	7,868	3,491	59,729	142,175	1,670	2,230	1,366	20,000	10
A3	7,011	3,473	53,466	63,950	7,119	3,491	53,466	128,151	1,540	2,230	1,236	20,000	10
A4	6,273	3,473	47,204	56,950	6,370	3,491	47,204	114,129	1,410	2,230	1,106	20,000	10
A5	7,723	2,783	39,444	49,950	7,799	2,793	39,444	100,071	1,260	2,230	1,085	20,000	8
A6	7,376	1,045	38,029	46,450	7,417	1,047	38,029	92,986	830	2,230	775	10,000	6
A7	6,139	1,045	32,766	39,950	6,173	1,047	32,766	79,972	700	2,230	645	10,000	6
A8	6,659	693	29,593	36,950	6,675	698	29,593	73,932	490	2,230	466	10,000	4
A9	4,800	693	28,452	33,950	4,812	698	28,452	67,924	360	2,230	336	10,000	4
A10	2,941	693	24,311	27,950	2,948	698	24,311	55,914	230	2,230	206	10,000	4
A11			8,450	8,450			8,450	16,900	0	2,230	0		
A12			5,950	5,950			5,950	11,900	0	2,330	0		
A13	2,941	693	21,311	24,950	2,948	698	21,311	49,914	230	2,330	206	10,000	4
A14	4,800	693	25,452	30,950	4,812	698	25,452	61,924	360	2,330	336	10,000	4
A15	6,659	693	26,593	33,950	6,675	698	26,593	67,932	490	2,330	466	10,000	4
A16	5,378	1,045	33,527	39,950	5,408	1,047	33,527	79,964	620	2,330	565	10,000	6
A17	7,376	1,045	34,529	42,950	7,417	1,047	34,529	85,986	830	2,330	775	10,000	6
A18	8,613	1,045	36,792	46,450	8,660	1,047	36,792	92,998	960	2,330	905	10,000	6
A19	6,371	2,783	40,796	49,950	6,434	2,793	40,796	100,045	1,090	2,330	895	20,000	8
A20	7,296	2,783	43,371	53,450	7,368	2,793	43,371	107,063	1,220	2,330	1,025	20,000	8
A21	6,387	3,473	50,590	60,450	6,486	3,491	50,590	121,133	1,430	2,330	1,126	20,000	10
A22	7,124	3,473	53,353	63,950	7,234	3,491	53,353	128,155	1,560	2,330	1,256	20,000	10
A23	7,861	3,473	56,116	67,450	7,982	3,491	56,116	135,177	1,690	2,330	1,386	20,000	10
A24	8,599	3,473	62,378	74,450	8,732	3,491	62,378	149,201	1,820	2,330	1,516	20,000	10
A25	9,662	693	14,590	24,950	9,686	698	14,590	49,948	700	2,230	676	10,000	4
A26	6,659	693	14,593	21,950	6,675	698	14,593	43,932	490	2,230	466	10,000	4
A27	4,800	693	13,452	18,950	4,812	698	13,452	37,924	360	2,230	336	10,000	4
A28	2,941	693	9,811	13,450	2,948	698	9,811	26,914	230	2,230	206	10,000	4
A29	2,941	693	7,311	10,950	2,948	698	7,311	21,914	230	2,330	206	10,000	4
A30	4,800	693	10,452	15,950	4,812	698	10,452	31,924	360	2,330	336	10,000	4
A31	6,659	693	14,593	21,950	6,675	698	14,593	43,932	490	2,330	466	10,000	4

ASSOCIATED DRAWINGS

AMENDMENT

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

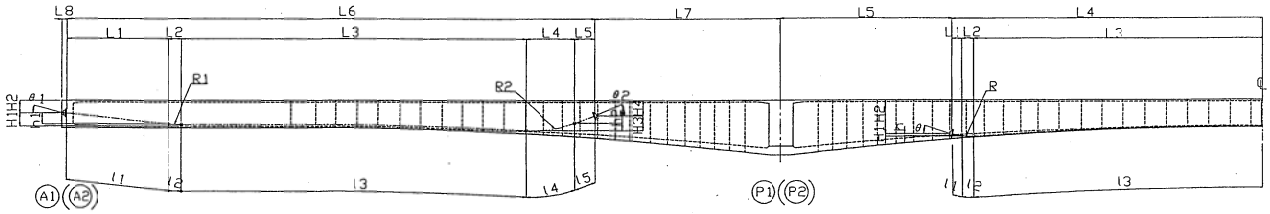
PRESTRESSING CABLES DIMENSION TABLE (1)

SCALE N-18

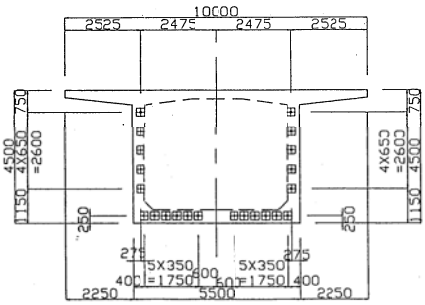
Oriental Co., Ltd. | Y.F | 99/6/15

D13

PRESTRESSING CABLES DIMENSION TABLE (2)



END SECTION S =1: 60



NOTE ; CABLE LENGTH IS NOT INCLUDE HORIZONTAL DEFLECTIONS

CENTRE SPAN CABLES

NUM	L1	L2	L3	L4	L5	l1	l2	l3	2XΣl	H1	H2	h	R	θ(°)
S13	1,801	1,947	47,752	51,500	28,500	1,829	1,955	47,779	103,126	420	5,577	318	8,000	10
S14	1,801	1,947	47,752	51,500	28,500	1,829	1,955	47,779	103,126	420	5,577	318	8,000	10
S15	1,664	1,906	44,930	48,530	31,500	1,690	1,913	44,952	97,110	398	5,408	293	8,000	10
S16	1,344	1,836	39,320	42,500	37,500	1,365	1,843	39,335	85,086	346	5,112	237	8,000	10
S17	1,498	1,878	42,124	45,500	34,500	1,521	1,885	42,142	91,096	371	5,253	264	8,000	10
S18	1,344	1,836	39,320	42,500	37,500	1,365	1,843	39,335	85,086	346	5,112	237	8,000	10
S19	1,022	1,752	33,726	36,500	43,500	1,038	1,759	33,735	73,065	293	4,871	180	8,000	10
S20	1,022	1,752	33,726	36,500	43,500	1,038	1,759	33,735	73,065	293	4,871	180	8,000	10
S21	806	1,710	30,484	33,000	47,000	818	1,717	30,490	66,051	257	4,756	142	8,000	10
S22	616	1,668	27,216	29,500	50,500	626	1,676	27,220	59,043	226	4,652	109	8,000	10
S23	816	1,528	16,656	19,000	61,000	829	1,536	16,657	38,044	264	4,292	144	8,000	10
S24	733	1,584	20,183	22,500	57,500	744	1,592	20,185	45,041	248	4,393	129	8,000	10
S25	674	1,626	23,700	26,000	54,000	684	1,634	23,703	52,041	237	4,513	119	8,000	10

SIDE SPAN CABLES

NUM	L1	L2	L3	L4	L5	L6	L7	L8	l1	l2	l3	l4	l5	Σl	H1	H2	H3	H4	h1	h2	R1	R2	θ1(°)	θ2(°)
S1	3,405	349	83,688	1,947	1,801	91,190	28,500	160	3,407	349	83,703	1,955	1,829	91,243	125	4,250	420	5,577	119	318	10,000	8,000	2	10
S2	3,405	349	83,688	1,947	1,801	91,190	28,500	160	3,407	349	83,703	1,955	1,829	91,243	125	4,250	420	5,577	119	318	10,000	8,000	2	10
S3	3,405	349	78,060	1,378	1,498	85,190	34,500	160	3,407	349	78,070	1,885	1,521	85,232	125	4,250	371	5,253	119	264	10,000	8,000	2	10
S4	3,405	349	72,455	1,794	1,187	79,190	40,500	160	3,407	349	72,481	1,801	1,205	79,223	125	4,250	320	4,984	119	209	10,000	8,000	2	10
S5	2,169	1,389	67,961	1,794	1,187	74,500	40,500	4,850	2,202	1,396	67,967	1,801	1,205	74,571	504	3,996	320	4,984	382	209	8,000	8,000	10	10
S6	3,405	349	69,662	1,752	1,022	76,190	43,500	160	3,407	349	69,666	1,759	1,038	76,219	125	4,250	293	4,871	119	180	10,000	8,000	2	10
S7	1,749	1,389	57,346	1,710	806	63,000	47,000	9,850	1,776	1,396	57,349	1,717	818	63,056	430	4,070	257	4,756	308	142	8,000	8,000	10	10
S8	2,169	1,389	55,142	1,626	674	61,000	54,000	4,850	2,202	1,396	55,143	1,634	684	61,059	504	3,996	237	4,513	382	119	8,000	8,000	10	10
S9	1,749	1,389	47,045	1,584	733	52,500	57,500	9,850	1,776	1,396	47,046	1,592	744	52,554	430	4,070	248	4,393	308	129	8,000	8,000	10	10
S10	1,749	1,389	49,078	1,868	616	54,500	50,500	14,850	1,776	1,396	49,080	1,676	826	54,554	430	4,070	226	4,652	308	109	8,000	8,000	10	10
S11	1,749	1,389	37,045	1,584	733	42,500	57,500	19,850	1,776	1,396	37,046	1,592	744	42,554	430	4,070	248	4,393	308	129	8,000	8,000	10	10
S12	3,405	349	59,636	1,626	674	65,690	54,000	160	3,407	349	59,637	1,634	684	65,711	125	4,250	237	4,513	119	119	10,000	8,000	2	10
W1	12,031	1,395	74,210	1,395	5,159	94,190	25,500	160	12,060	1,396	74,228	1,396	5,172	94,252	890	3,350	361	5,540	841	361	20,000	10,000	4	4
W2	15,246	1,743	69,078	1,395	6,728	94,190	25,500	160	15,304	1,745	69,095	1,396	6,744	94,284	1,410	2,700	470	5,190	1,334	470	20,000	10,000	5	4
W3	17,320	2,091	63,724	994	4,061	88,190	31,500	160	17,415	2,094	63,738	995	4,083	88,305	1,930	2,050	127	5,189	1,820	142	20,000	10,000	6	2
W4	18,740	2,437	58,145	907	1,961	82,190	37,500	160	18,881	2,443	58,155	908	1,982	82,349	2,450	1,400	59	4,892	2,301	68	20,000	10,000	7	2
W5	19,748	2,783	54,376	907	4,376	82,190	37,500	160	19,942	2,793	54,384	908	4,379	82,406	2,970	750	144	4,542	2,775	153	20,000	10,000	8	2

ASSOCIATED DRAWINGS

DRAWING No.	DESCRIPTION

AMENDMENT

No.	DATE	DESCRIPTION	BY

THE REPUBLIC OF ZAMBIA
MINISTRY OF WORKS AND SUPPLY
THE REPUBLIC OF ZIMBABWE
MINISTRY OF TRANSPORT AND ENERGY

CHIRUNDU BRIDGE

PRESTRESSING CABLES DIMENSION TABLE (2)

DESIGNED: Oriental Consulting Co., Ltd. | CHECKED: Y.K. | DATE: 99/6/17 | DRAWING No. D.15

D14

D15

APPENDIX D-1-2

ADDITIONAL MATERIAL DEFECTS ON SPECIAL BRIDGE

Appendix D-1-2 Additional Materials Defects on Special Bridge

1. General

This appendix describes the defects that are normally found in Asphalt Wearing Surface. Each defect is described and the causes producing it are identified.

2. Asphalt wearing surface

The asphalt wearing surface is the surface on which vehicle traffic and pedestrian travel. Asphalt wearing surface plays an important role to protect the deck slab.

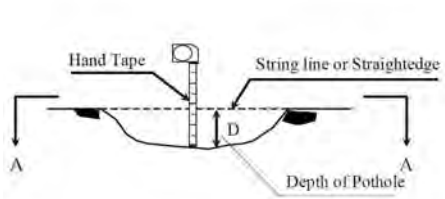
Defects on asphalt wearing surface are often due to poor composition of asphalt, lack of quality control, improper application procedure, and / or destructive harsh environment.

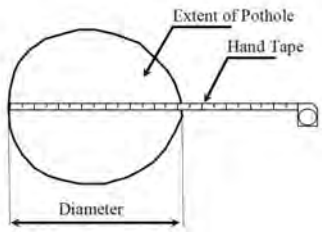
The following defects commonly found on Asphalt Wearing Surface are follow.

- Potholes
- Shoving
- Rutting
- Cracking
- Raveling

2.1 Potholes

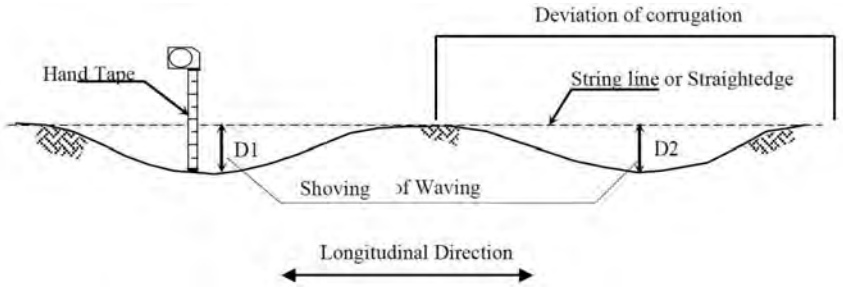
Potholes are bowl-shaped holes in the pavement caused by the penetration of water through the pavement due to heavy rains and breaking up of the pavement due to subsequent traffic action. Pavements already deteriorated with defects such as alligator cracking and raveling are prone to the occurrence of potholes.





2.2 Shoving

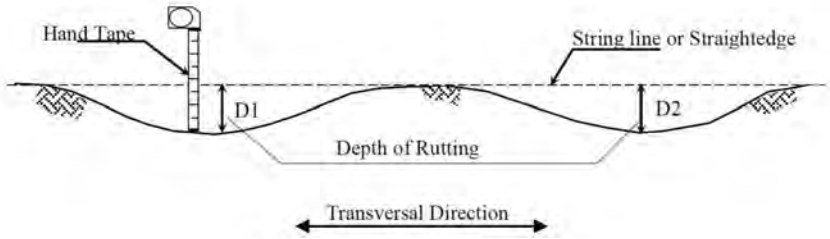
Shoving is defined as the unevenness of the roughness on the carriageway surface along the longitudinal of the road. This deformation, as it progresses, will lead to an increasingly severe impact loading under traffic, particularly at joints. It is usually the result of the combined effects of traffic and warm weather. Blisters are found in the surface during warm weather while traffic normally prevents them from rising.



2.3 Rutting

Rutting is defined as the unevenness on the carriageway surface in the transverse direction of the road. This deformation is caused by continuous heavy wheel loads passing along the carriageway in the longitudinal direction.

Rutting progresses rapidly in warm weather and does indicate failure of the surfacing materials. The main effect is that it prevents water to drain from the carriageway and in some severe cases, prevent vehicles from leaving the rut affected depressed areas, causing a temporary loss of control on the vehicle. In some instances, the combined effect with rain makes breaking extremely difficult with a strong possibility of the vehicle aquaplaning.



2.4 Cracking

A crack is a linear fracture extending partially or completely through the pavement. Cracking in pavements may be caused by any or a combination of the following factors: the action of vehicular wheel loading, poor quality of material, compaction, placement and drainage. It also includes temperature susceptibility of the asphalt cement binder and reflection cracks, due to the extension of cracks on the surface below the pavement.

Cracks are distinguished by its appearance and direction. The following types of cracks are commonly observed on the pavement surface.

- Longitudinal
- Transverse
- Alligator

Longitudinal cracks are roughly parallel to the direction of the traffic and may be situated

at or near the center of the wheel tracks, centerline of roadway, mid-lane or along pavement edges.

Transverse cracks are approximately at to the pavement centerline and may extend partially of completely across the pavement.

Alligator cracks form a network of multi-sided polygons or blocks resembling the skin of an alligator. The block sizes typically range from 50mm to 500mm. They may occur anywhere in the pavement surface and may be accompanied by depressions in the surface. For this type of crack, the Condition Rating such as the severity of defect and condition state will be determined only by measuring its area.

2.5 Raveling

Raveling is one of the abrasions of Bituminous Pavements. It is defined as the loss of the wearing surface exposing the aggregates. Rough surface is caused by the segregation of course aggregates from the mixture.

APPENDIX D-2-1

ADDITIONAL MATERIAL DEFECTS ON SPECIAL BRIDGE

Cable elements

Attributes of Cable are:

- Anchorage at Tower
- Cable

The above-listed attributes are used in structures for external pre-stressing system.

The following defects are commonly observed in cable attributes.

Anchorage	: Corrosion, Missing Bolts, Deformation, Cracking and Water Leakage
Cable	: abnormal Vibration, Alignment Deformation, Cracking, Water Leakage, Corrosion and Delamination

Cable is produced in factory and transported in the site. The Cable is the primary structural component of a Cable Stayed Bridge. It is very important to check whether the above-listed defects are present in comparison with the adjacent cable by visual inspection, sensory or engineering judgement.

Abnormal vibration and alignment deformation of cable are caused by the combination of conditions of materials, construction method, environmental aspects, structural characteristic and concentrated external force. The resonance is a serious problem though it hardly occurs at the same time because of the small difference in length of each cable.

Cracks on the surface of cable should be located and checked. When there is water leakage, there is a possibility of corrosion and section loss of cable. Water leakage from the connection with anchorage and cable is dangerous defect. Water proof sealing and rubber cover should be inspected carefully.

Water leakage at the anchorage and cable has a dangerous effect, therefore when these defects are observed, it must be referred to an expert of a specialized investigation company immediately so that an appropriate inspection can be undertaken.

APPENDIX D-3-1

ADDITIONAL MATERIAL DEFECTS ON SPECIAL BRIDGE

Cable elements

Attributes of Cable are:

- Main Cable
- Hanger rope
- Tower and splay saddle
- Cable band
- Anchor bolt

The above-listed attributes are used in structures for suspension of the girder.

The following defects are commonly observed in cable attributes.

Main Cable and Hanger Rope : Abnormal Vibration, Alignment deformation, Cracking, Water Leakage, Corrosion and Delamination

Steel Attributes : Corrosion, Missing Bolts, Deformation, Cracking and Paint peer off

2 cables with parallel wires is adopted in a main cable of Otto Beit Bridge. Wires are covered by wrapping. Main cable was inspected in 2016 and repair plan was proposed shown in Figure G-1.

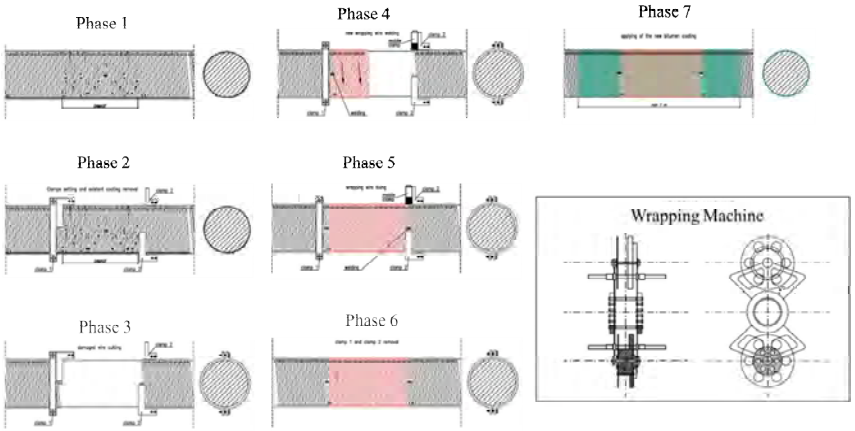


Figure G-1 the repair phase in main cable (proposed plan)

Spiral strands is adopted in a hanger rope of Otto Beit Bridge. Wires are galvanized for the protection against corrosion. Hanger rope was also inspected in 2016 and repair plan was proposed shown in Figure G-2.

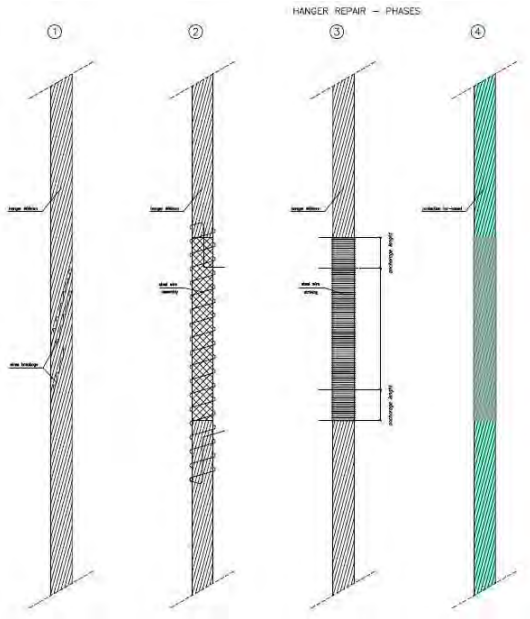


Figure G-2 the repair phase in Hanger rope (proposed plan)

Cable and rope is the primary structural component of a Suspension Bridge. It is very important to check whether the above-listed defects are present in comparison with adjacent cable by visual inspection, sensory or engineering judgment.

Abnormal vibration and alignment deformation of cable and rope are caused by the combination of conditions of material, construction method, environmental aspects, structural characteristic and concentrated external force. The resonance is a serious problem though it hardly occurs at the same time because of the small difference in length of each cable.

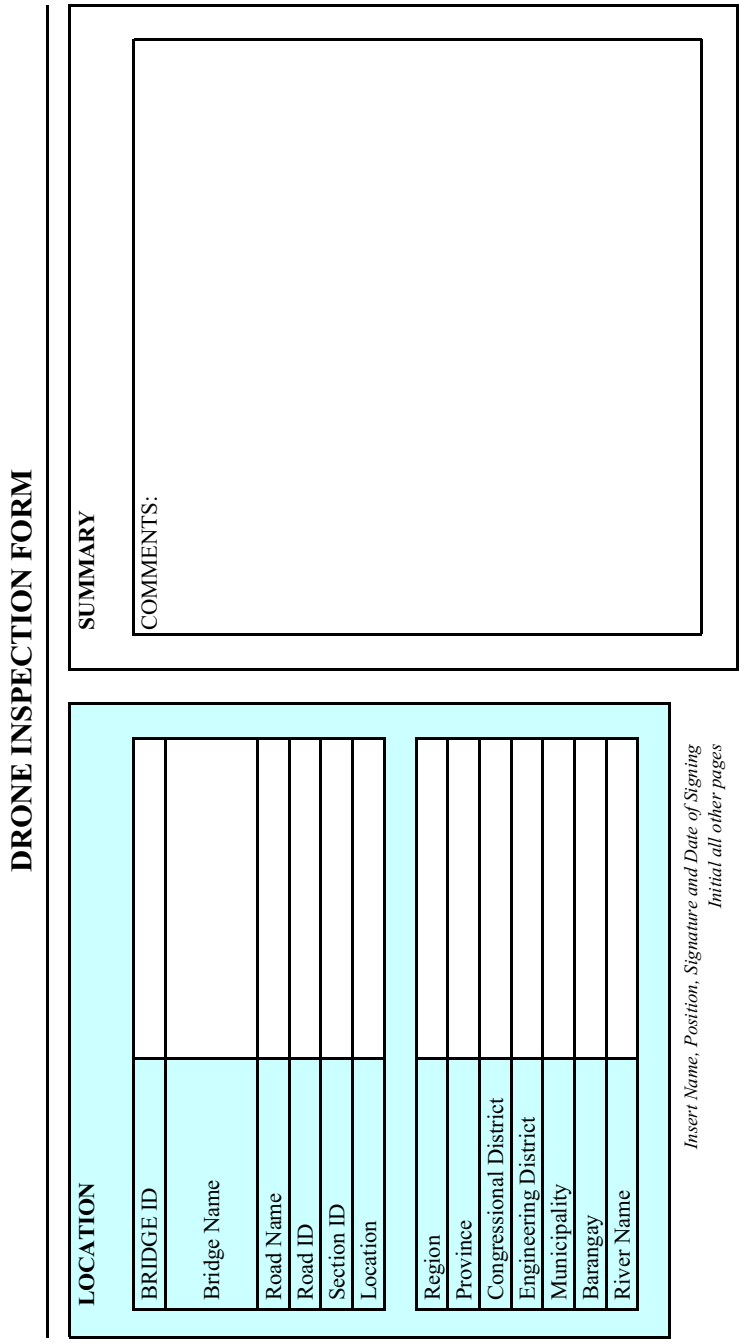
Cracks and peer off on the surface of cable and rope should be located and checked. When there is water leakage, there is a possibility of corrosion and section loss of cable and rope. Water leakage from the connection with anchorage (anchor bolt) and cable is dangerous defect. Water proof sealing and rubber cover should be inspected carefully.

Water leakage at the anchor bolt and cable has a dangerous effect, therefore when these defects are observed, it must be referred to an expert of a specialized investigation company immediately so that an appropriate inspection can be undertaken.

The steel element around anchorage and tower is very important to sustain bridge and these members are stressed with heavy load from cable and rope. The tower and anchorage is supporting every dead and live load through the cable and rope. Excessive stress from cable hanger rope will cause the bridge to collapse. Cracking and buckling should be inspected carefully.

APPENDIX-E DRONE INSPECTION FORM

FORM1: LOCATION and SUMMARY
FORM2: INSPECTION OF PARTS (EX. MAIN CABLE)



Bridge ID. | **Bridge Name**

Target Part (MAIN CABLE)

	Photo	Defects	Recommended Action
P3 -A2 (Left)			
P3-A2 (Right)			

※Names and locations of parts and materials should be changed depending on the inspection target.