

TMH19

**MANUAL FOR THE VISUAL
ASSESSMENT OF ROAD
STRUCTURES**

Draft Standard (DS)

**PART A: ROAD STRUCTURE MANAGEMENT
INFORMATION**

August 2020

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Foreword

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Comments on this Draft Standard should be provided in writing and e-mailed to admin.coto@durban.gov.za

Please note:

This document and its various Parts will only be available in electronic format.

The Draft Standard (DS) will be made available for download on the South African National Roads Agency SOC Ltd (SANRAL) and Department of Transport websites.

The MS Word version of this document is available from Michael Roux at mproux@csir.co.za.

Preface

Road authorities in South Africa have an obligation to plan, design, construct and maintain the road network, to protect the public investment in the road infrastructure, to ensure the continued functionality of the transportation system and to promote the safety of traffic on the road network. Authorities also have the obligation to provide a reliable, effective, efficient and integrated transport system that supports the sustainable economic and social development of the country.

Road structures are an integral part of the road network. This Manual provides the official requirement for the visual assessment of road structures on the South African road network. It provides requirements and supporting information for the inventory data capturing, explains the inspection methodology and describes how and by whom inspections for the visual assessment of road structures have to be carried out. It further addresses repair costs calculations.

Structures covered by this manual include:

- Bridges;
- Culverts;
- Retaining Walls;
- Gantries;
- Tunnels;
- Low level bridges;
- Light Masts; and
- Low level river crossings.

The inspection methodology described in this manual is a defects-based system and involves the identification of visual defects on structures and rating these defects in terms of degree, extent of occurrence and relevancy.

The relevancy of defects is very important in the rating process and is considered in terms of structural and functional integrity and the safety of the road user.

This manual is a companion document to the TMH22 Manual on Road Asset Management. The TMH22 manual includes sections on how inspection ratings are used to calculate condition indices for road structures at network level and how to calculate the current asset value of these road structures.

Overview of the Manual

TMH19 consists of two separate parts, Part A and Part B.

Part A: Road Structure Management Information covers the following topics:

- Structure Class and Type Definitions;
- Overview of Road Structures Management System (RSMS);
- Inventory Information;
- The DER Rating System;
- Overview of Defects on Structures;
- Inspection Items and Inspection Sheets;
- Inspection Procedure and Quality Assurance; and
- Repair Cost Calculations.

The following additional information is supplied in the appendices:

- Detail of the inventory information that can be captured per structure type, indicating required and optional items;
- Inspection forms to be used for the various structure types; and
- Remedial work activity lists for the various structure types.

Part B is a visual assessment manual intended for use as reference document by structure inspectors to reduce the amount of subjectivity involved in the inspection process. It can also assist in the training of inspectors. It includes sections with photos of defects on the structural elements for the various structure types. These photos are intended to mainly illustrate the Degree rating, but the Extent, Relevancy and Urgency ratings are also shown as examples of these ratings. Descriptions of the various defects are provided.

Abbreviations

BMS	Bridge Management System
COTO	Committee of Transport Officials
D	Degree
DER	Degree-Extent-Relevancy
E	Extent
GPS	Global Positioning System
HD	holding down
L	litre
LS	lump sum
MS	make safe
R	Relevancy
RCB	Roads Coordinating Body
RSMS	Road Structures Management System
TMH	Technical Methods for Highways
U	Urgency
UBIU	under-bridge inspection unit
UPS	uninterruptible power supply
vpd	vehicles per day

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1 Structure Class and Type Definitions

1.1 Introduction

This manual covers the following road related structures:

- Bridges;
- Culverts;
- Retaining Walls;
- Gantries;
- Tunnels;
- Low level bridges;
- Low level river crossings; and
- Light Masts.

Road structures are defined in terms of structure class and structure type. The structure class defines the magnitude of the structure and the risk associated with the structure, while the structure type defines the characteristics of the structure and therefore the type of inventory and inspection sheets that are used to capture inventory data and to carry out inspections. The structure classes and structure types covered by this manual are presented in Table 1.

Table 1 Structure Classes and Types

Structure Class	Structure Type
Bridge	Bridge (General)
	Bridge (Arch)
	Bridge (Cable)
	Bridge (Cellular)
Major Culvert	Culvert (Major)
Retaining Wall	Retaining Wall
Gantry	Gantry
Road Tunnel	Road Tunnel
(usually considered part of road asset)	Culvert (Lesser)
	Light Mast

1.2 Structure Classes

1.2.1 Bridge

A structure is classified as a bridge if one or more of the following criteria are satisfied:

- Any single span (as measured horizontally at the soffit along the road or rail centre line between the faces of its supports) is equal to or greater than 6 m; or
- The individual clear spans (as measured horizontally at the soffit along the road or rail centre line between the faces of its supports) exceed 1.5 m and the overall length measured between abutment faces exceeds 20 m; or
- The opening height, which is the maximum vertical distance measured from the streambed or structure floor at the inlet or from the top of any base, to the soffit of the superstructure, is equal to or greater than 6 m; or
- The total cross-sectional opening is equal to or larger than 36 m²; or
- The structure is a road-over-rail, or rail-over-road structure, even if the span is less than 6 m.

Refer to Figure 1 for a visual representation of the classification criteria for a bridge.

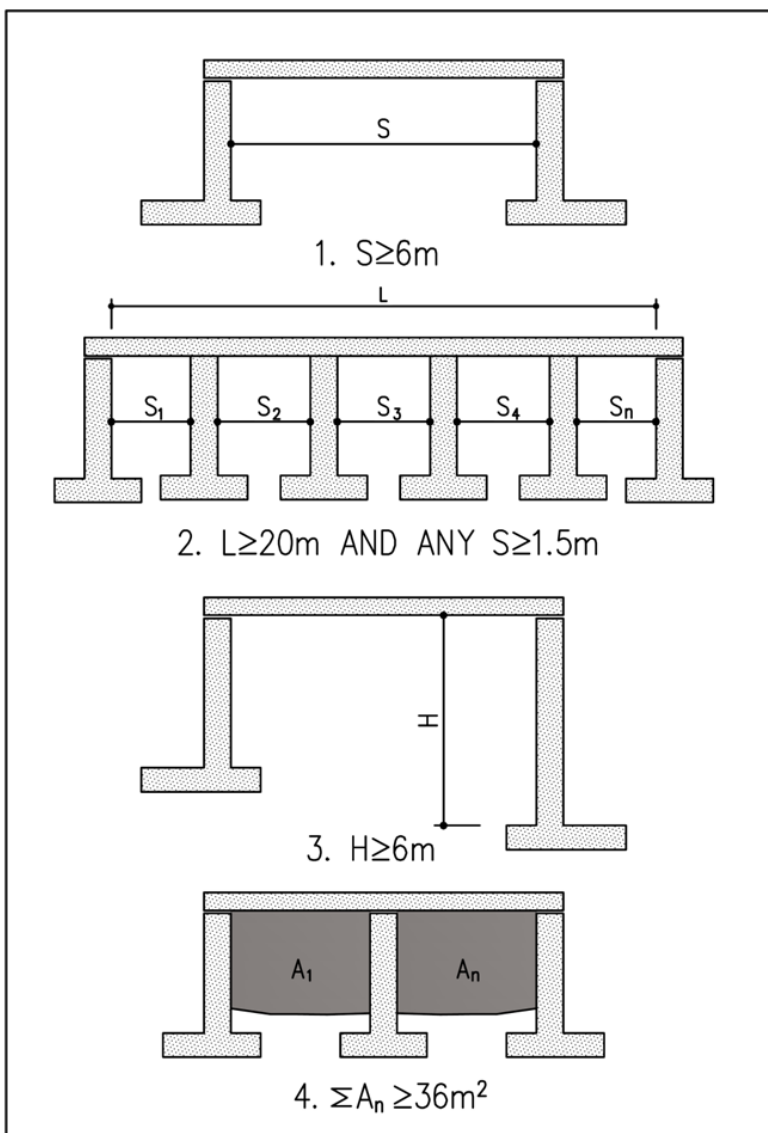


Figure 1 Bridge Classification

1.2.2 Major Culvert

A culvert is a structure (normally “buried” with road fill or road slabs on top) consisting of “cellular” units. A cellular unit can typically be described as an “opening” where, in general, the overall cell length is greater than the cell width. Elements such as separate deck slabs, abutments/piers, foundations, etc. are not clearly identifiable while elements such as invert slabs, apron slabs, cut-off walls etc. are normally present.

A Major Culvert is a cellular structure with dimensions less than those defining a bridge, but with any clear span length (as measured horizontally at the soffit perpendicular to the faces of its supports) equal to or larger than 2.1 m, or diameter equal to or larger than 2.1 m, or a culvert with a total cross-sectional opening equal to or larger than 5 m². A visual representation of the classification criteria for a Major Culvert is presented in Figure 2.

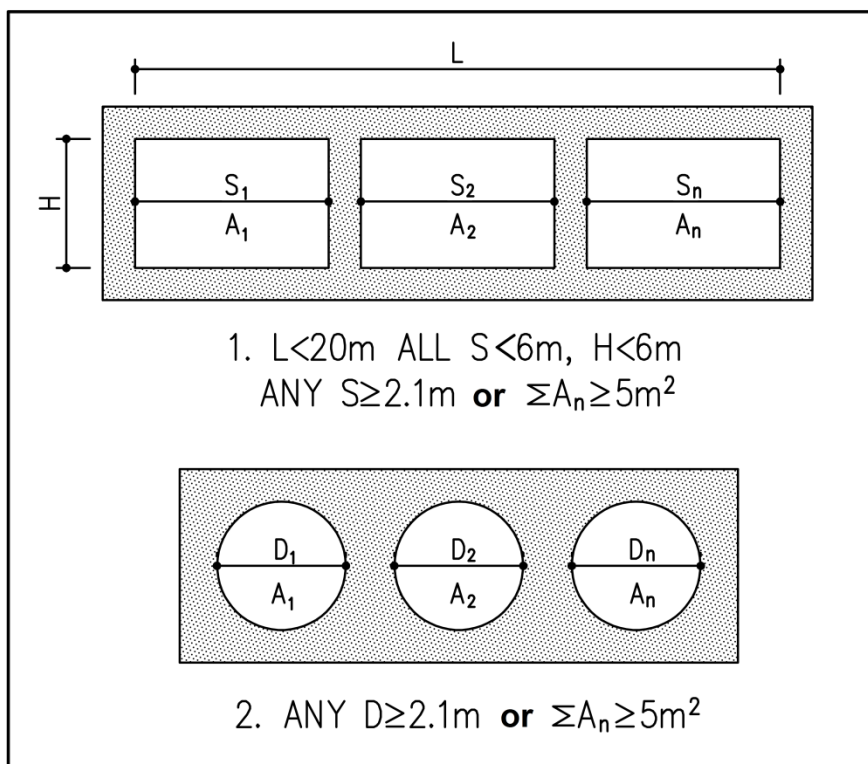


Figure 2 Major Culvert Classification Criteria

All culverts smaller than that defined as a Major Culvert are classified as **Lesser Culverts**. Lesser culvert is not a structure class, as these small culverts are considered a component of the road asset class. The structure type Culvert (Lesser) is however included in this manual in order to provide guidance to road maintenance staff that have to inspect lesser culverts as part of routine road maintenance inspections.

1.2.3 Retaining Wall

A retaining wall is a structure that resists the lateral pressure of soil when there is a change in ground elevation. When the angle of the wall to the horizontal exceeds 70°, the structure is generally considered to be a wall; otherwise it is considered to be a slope. In the context of road structures, a wall with a

height in excess of 2.0 m is considered a retaining wall for the purposes of this manual.

Sloped walls (angle of the wall to the horizontal does not exceed 70°) are generally the precast block or gabion wall type and assessment of such structures may require the input of a geotechnical engineer.

Design codes generally require retaining walls to be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. They are normally designed for a safety factor of 1.5 against lateral sliding and overturning.

Typical retaining wall types include:

- Gravity
- Cantilevered
- Piling walls
- Anchored walls
- Patented earth retaining systems e.g. block walls
- Soil nailed walls (normally in combination with sprayed concrete) with or without facades
- Soil strengthened or stabilized
- Gabions meshes
- Mechanically stabilized earth (Reinforced Earth or geotextile reinforced earth)
- Cellular confinement systems (Geocells)
- Stone pitching or other slope stabilization paving system

1.2.4 Gantry

A gantry, generally an overhead road sign structure, is a traffic sign assembly on which various information signs or signals are mounted. Gantries are usually built on highly trafficked roads with several lanes, where signs posted only on the side of the road would be difficult for motorists to see.

Gantries may be cantilevered or one sided or they may be bridges with support columns on both sides.

1.2.5 Road Tunnel

For the purposes of management and inspection of road structures, a road tunnel is a structure that accommodates road vehicles and is defined as a bored tunnel constructed in-situ without removing the ground above.

Long cut-and-covered tunnels constructed in a shallow trench may, in special cases, be defined as a road tunnel by the Road Authority.

1.2.6 Light Mast

A light mast comprises a tall pole, mast or column with light fittings at the top that illuminate a designated area. Light masts are also sometimes called high masts or lighting towers.

The assessment of light masts described in this manual relates to structural integrity. The electrical installations, etc. are excluded.

Similar masts may be assessed as a group, for example, masts within a one kilometre distance or masts at a specific interchange.

A light mast should be assessed as a single mast if its height exceeds 40 m.

1.3 Structure Types

1.3.1 Structure Class Bridge

For inspection purposes, the following bridge types have been identified:

- Bridge (General);
- Bridge (Arch);
- Bridge (Cable); and
- Bridge (Cellular).

1.3.1.1 Bridge (General)

A general bridge type structure is a structure consisting of separate and clearly identifiable elements such as deck slabs, deck expansion joints, abutments, piers and foundation footings. Elements such as invert slabs, apron slabs, cut-off walls are normally not present. A bridge type structure normally has a concrete deck as roadway.

1.3.1.2 Bridge (Arch)

An arch bridge type structure includes solid spandrel filled arches; open ribbed spandrel arches; and open spandrel arches.

1.3.1.3 Bridge (Cable)

A cable bridge type structure includes suspension bridges; cable stayed bridges and extradosed bridges.

1.3.1.4 Bridge (Cellular)

A cellular bridge type structure is a bridge consisting of “cellular” units, but complying with the classification criteria for a bridge (see Section 1.2.1). A cellular unit can typically be described as an “opening” where, in general, the overall cell length is greater than the cell width. Elements such as separate deck slabs, abutments/piers, foundations, etc. are not clearly identifiable while elements such as invert slabs, apron slabs, cut-off walls etc. are normally present.

1.3.2 Structure Class Major Culvert

The structure class Major Culvert contains only one structure type, namely Culvert (Major).

1.3.3 Retaining Wall

The structure class Retaining Wall contains only one structure type, namely Retaining Wall.

1.3.4 Gantry

The structure class Gantry contains only one structure type, namely Gantry.

1.3.5 Road Tunnel

The structure class Road Tunnel contains only one structure type, namely Road Tunnel.

1.3.6 Low-level River Crossings

A low-level river crossing is a submersible road structure designed in such a way so as to experience no or limited damage when overtopped. This type of structure is appropriate when the inundation of a road for short periods is acceptable. The types of low-level river crossings are low-level bridges, causeways and drifts.

1.3.6.1 Low-level Bridges

A low level bridge for crossing a river is a special case of either the Bridge (General) or the Bridge (Cellular) types. This type of bridge normally has kerbs or guide blocks instead of handrails or parapets. For purpose of inspections either the "Bridge (General)" or "Bridge (Cellular)" form should be used and Item 11 "parapet/handrail" will normally be marked as "Not Applicable". If kerbs or guide blocks are present, these can be inspected under Item 10 "kerbs/sidewalks".

1.3.6.2 Causeways and drifts

A causeway consists of a suitable submersible surface layer over which vehicles may drive when crossing a river. The structure has openings under the roadway allowing the passage of "normal" river flow underneath. The openings may be circular, rectangular, arched, semi-circular or similar in shape. These structures are also referred to as vented fords in the literature.

A drift or a ford is defined as a specially prepared surface for vehicles to drive over when crossing a river. A drift does not contain any constructed openings underneath the riding surface for the passage of water.

The floods that can pass over these structures are normally quite high and comparable with the floods passing through major culverts. For purpose of inspections a "Culvert (Major)" form should be used where the inspection items include for example apron slabs, scour protection works, road slabs etc. Reference should be made to Table 9 in Section 6.2. In the case of drifts the "Cell" items" will be marked as "Not Applicable".

2 Overview of Road Structure Management Systems

2.1 General

A comprehensive database is the first building block and heart of a Road Structures Management System (RSMS). The database must provide for the storage and retrieval of the following types of data:

- Inventory data;
- Inspection data;
- Condition analysis data;
- Deterioration analysis data; and
- Remedial activities and repair cost data.

2.2 Inventory Data

The first step in the implementation of a structures database is to compile an inventory of all structures. The inventory consists of a list of all structures within the network with comprehensive details of the type and location of the structure, construction materials, major dimensions, clearances, etc. This information is obtained from as-built drawings, design reports and confirmed and measured in the field. In the absence of as-built drawings and design reports, this information must be collected by way of measurements on site.

Inventory data remains mostly static, except when modifications or improvements are carried out on the structure or associated roads or services.

The collection and capturing of inventory data can be costly and only data required for decision-making should be collected. Certain inventory data items are considered essential and are indicated as required items in this document, while other inventory data items are considered as optional. The reporting needs of the Road Authority would inform which of the optional inventory data items need to be collected.

2.3 Inspection Data

Inspection data is collected during the visual inspection of structures. Each structure must be appraised at network level with respect to its condition of serviceability and safety. Inspections are carried out by completing standard inspection forms per structure type. These inspection forms list all the inspection items applicable to the particular structure type.

Inspection data is captured per date and the database must allow for storing multiple inspections.

An inspection data module has the following functionality:

- Input and viewing of inspection data;
- Input and viewing of inspection photos; and
- Viewing of inspection sheets.

2.4 Condition Analysis

The inspection data collected during the visual inspection of structures is used to calculate various indices for each structure.

The indices that can be calculated are:

- Average Condition Index;
- Priority Condition Index;
- Functional Index; and
- Combined Condition Index.

2.4.1.1 Average Condition Index

The Average Condition Index (ACI) is an indication of the overall condition of the structure and can be used to rank structures in terms of average condition and to allocate structures to condition categories. The change in the average condition indices over time provides an indication of the effectiveness of the Road Authority's maintenance programme.

2.4.1.2 Priority Condition Index

The Priority Condition Index (PCI) is used to place structures in order of priority for maintenance, rehabilitation and reconstruction activities. It is designed to identify structures with the greatest need for repair to be given the highest priority.

2.4.1.3 Functional Index

A Functional Index provides an indication of the level of service offered by a road structure. The aspects that are addressed in a Functional Index for road structures are capacity; riding quality; user risk; road safety; and availability.

2.4.1.4 Combined Condition Index

The Combined Condition Index is a weighted combination of the Structure Priority Condition Index and the Structure Functional Index.

The formulas to calculate these indices are not included in this manual, but can be found in the TMH22 manual on road asset management.

2.5 Deterioration Analysis

Structures generally have a long lifespan and deteriorate slowly. There is also a variation in the materials used in the construction of structures. These factors make it difficult to develop accurate deterioration prediction models.

When defects are left to deteriorate, structures may collapse; therefore all critical defects need to be monitored and accounted for in the RSMS. With inspections carried out on five-yearly cycles, critical defects would be identified and can be attended to in time to prevent further deterioration.

2.6 Repair Costs

During the inspection procedure repair activities are identified and the quantities for repair are estimated. This, together with the unit rate for the repair activity is used to calculate the cost of repair, from which the total required maintenance and repair costs can be calculated.

Repair activities are also given an urgency rating during the inspection procedure. This provides a way of applying time limits to the repair requirements.

This information can then be used by the Road Authority for global budgetary purposes after adjustment for P&G items; planning, design and overhead costs; and VAT as described in the TMH22 manual on road asset management.

2.7 Validation

After data has been entered into the RSMS, it is essential that the data is validated to ensure the integrity thereof. This applies to both inventory and inspection data.

Verification is carried out firstly to confirm that all required data have been captured and secondly to confirm that all captured data is valid.

3 Inventory Information

3.1 Numbering of Structures

Each structure must have a unique number. The number should be displayed on the structure in a visible position. It is recommended that a Road Authority first identify all structures and allocate unique numbers to each structure and then physically attach the numbers to the structures prior to proceeding with the capture of inventory and inspection data.

3.2 Location Details

Adequate location details need to be captured to accurately identify the location of the structure. The location detail that is captured should also accommodate the Road Authority's reporting needs. If, for example, the Road Authority has to report on the condition of structure per maintenance region, or per ward, such location information must be captured. Some location items can be imported from other management systems by creating a link with such systems. For example, if a Road Authority has a Road Referencing System or Road Network Information system, information such as the maintenance region, political region, road name, etc. can be imported if the two systems are linked by road number and chainage.

Certain location details are Road Authority specific and should cater for the specific Road Authority's definitions and requirements.

Location details will differ in some ways for national, provincial and municipal road authorities. The GPS coordinates of a structure are common to all authorities. These coordinates should be captured at the beginning and the end of the structure, except for cantilevered gantries and light masts, where only one set of coordinates are captured. Coordinates must be captured as hh:mm:ss.s to a minimum of 5 m accuracy in the WGS84 format.

For national and provincial road authorities, the location details that could be captured are as follows:

- Route/Road Number;
- Section Number;
- Chainage km;
- Road Name/Description;
- Province;
- District;
- Municipality;
- Maintenance Region;
- Maintenance Depot;
- Elevation;
- Status (Indicates the current status of the structure, e.g. existing, demolished, planned, etc.);
- GPS Coordinates: Longitude (East) and Latitude (South); and
- Ownership (Indicates which authority is the owner of the structure).

For municipal authorities, the location details that could be captured are as follows:

- Road/Street Name;
- Route Number
- Town;
- Suburb;
- Ward;
- Maintenance Region;
- Maintenance Depot;
- Elevation;
- GPS Coordinates: Longitude (East) and Latitude (South);
- Status (Indicates the current status of the structure, e.g. existing, demolished, planned, etc.); and
- Ownership (Indicates which authority is the owner of the structure).

3.3 Structure Orientation

Structure orientation indicates whether the structure is orientated primarily north-south; east-west; northeast-southwest; or northwest-southeast, based on true north. The convention for indicating the orientation of the different road structures types is as follows:

- The orientation of bridges and major culverts are indicated according to the centre line of the feature over the structure (usually a road);
- The orientation of a retaining wall is indicated according to the centreline of the road along which the retaining wall is located;
- The orientation of a gantry is indicated perpendicular to the centreline of the road on which the gantry is located; and
- The orientation of a road tunnel is indicated according to the centreline of the road through the tunnel.

3.4 Inventory Items per Structure Type

For inventory and inspection purposes, each structure type is divided into a number of inventory items. The numbers of items per structure type are summarised in Table 2.

Table 2 Number of Inventory Items per Structure Type

Structure Type	Number of Items
Bridge (General)	21
Bridge (Arch)	21
Bridge (Cable)	21
Bridge (Cellular)	14
Culvert (Major)	14
Culvert (Lesser)	5
Retaining Wall	7
Gantry	8
Road Tunnel	8

3.4.1 Bridge (General; Arch; & Cable) Inventory Items

The 21 inventory items for Bridge (General; Arch; & Cable) are as follows:

General Items:

1. Approach embankments
2. Guardrails
3. Waterway
4. Approach embankment protection work
5. Abutment foundations
6. Abutments
7. Wing/retaining walls
8. Surfacing
9. Superstructure drainage
10. Kerbs/sidewalks
11. Parapets/handrails

Support Items:

12. Pier protection works
13. Pier foundations
14. Piers & columns
15. Bearings
16. Support drainage
17. Expansion joints

Span Items:

18. Longitudinal members in the deck
19. Transverse members in the deck
20. Deck slab

Miscellaneous Item:

21. Items not covered under Items 1 to 20

3.4.2 Bridge (Cellular) and Culvert (Major) Inventory items

The 14 inventory items for Bridge (Cellular) and Culvert (Major) are as follows:

General Items:

1. Apron slabs & cut off walls
2. Wing / return / head walls
3. Scour protection works (in river)
4. Embankments
5. Waterway
6. Road slabs
7. Roadway joints
8. Guardrails
9. Parapets/handrails

Cell Items:

10. Walls
11. Top slab

12. Invert slab
13. Cell displacement

Miscellaneous Item:

14. Items not covered under items 1 to 13

3.4.3 Culvert (Lesser) Inventory Items

The 4 inventory items for a Culvert (Lesser) are as follows:

1. Inlet Works
2. Outlet Works
3. Barrel(s)
4. Waterway

3.4.4 Retaining Wall Inventory Items

The 7 inventory items for a Retaining Wall are as follows:

General Items:

1. External Drainage
2. Slope Protection

Wall Items:

3. Walls
4. Joints
5. Internal Drainage
6. Foundations

Miscellaneous Item:

7. Items not covered under items 1 to 6

3.4.5 Gantry Inventory Items

The 8 inventory items for a Gantry are as follows:

General Items:

1. Guardrails

Gantry Items:

2. Foundations
3. HD Bolts and Base Plates
4. Vertical Members
5. Horizontal Members
6. Sign Face
7. Sign Fasteners

Miscellaneous Item:

8. Items not covered under items 1 to 7

3.4.6 Road Tunnel Inventory item

The 9 inventory items for a Road Tunnel are as follows:

Portal Items:

1. Portals
2. Slope Protection
3. Rock Fall Protection

General Items:

4. Drainage
5. Road Surface

Tunnel Bore Items

6. Lining
7. Joints

Miscellaneous Items:

8. Operational Services
9. Items not covered under items 1 to 8

3.5 Numbering of Sub-items

The numbering of sub-items can be Road Authority specific, but there are generally two conventions for the numbering of sub-items - one for national and provincial road authorities and one for municipal road authorities. National and provincial road authorities use road chainages to define their networks and usually number sub-items according to increased chainage, while municipal road authorities usually number sub-items according to the structure orientation.

3.5.1 Bridge (General; Arch; and Cable)

Abutments, piers and spans are numbered numerically, for example: Abutment 1, Abutment 2; Pier 1, Pier 2, Pier 3; and Span 1, Span 2, Span 3.

For national and provincial road authorities, Abutment 1 would be the abutment at the bridge end with the lowest chainage value; Pier 1 would be the pier closest to Abutment 1; and Span 1 would be the span that starts at Abutment 1. Where the bridge crosses the national or provincial road authority's road, numbering would be done from left to right when looking in the direction of increased chainage on the national or provincial road. Abutment 1 would therefore be the abutment on the left hand side.

For municipal authorities, the convention for the numbering of abutments relative to the structure orientation is as follows:

Structure Orientation:	Abutment 1 is at the:
North-South	Northern end
East-West	Western end
Northeast-Southwest	North-eastern end
Northwest-Southeast	North-western end

Pier 1 would be the pier closest to Abutment 1; and Span 1 would be the span that starts at Abutment 1.

3.5.2 Bridge (Cellular); Culvert (Major) and Culvert (Lesser)

Embankments and cells are numbered numerically, for example: Embankment 1, Embankment 2; and

Cell 1; Cell 2; Cell 3.

For national and provincial road authorities, embankments would be numbered from left to right when looking in the direction of increased chainage on the national or provincial road. Embankment 1 would therefore be the embankment on the left hand side. Cells are numbered in the direction of increasing chainage. Cell 1 would thus be the cell at the structure end with the lowest chainage value.

For municipal authorities, the convention for the numbering of embankments relative to the structure orientation is as follows:

Structure Orientation:	Embankment 1 is on the:
North-South	Western side
East-West	Northern side
Northeast-Southwest	North-western side
Northwest-Southeast	South-western side

For municipal authorities, the convention for the numbering of cells relative to the structure orientation is as follows:

Structure Orientation:	Cell 1 is at the:
North-South	Northern end
East-West	Western end
Northeast-Southwest	North-eastern end
Northwest-Southeast	North-western end

For cellular bridges and major culverts that are not buried structures (usually low-level river crossings), the convention for the numbering of the embankments changes, as in these cases the orientation of the embankments would be perpendicular to the orientation of the structure.

For national and provincial road authorities, Embankment 1 would then be the embankment at the structure end with the lowest chainage value.

For municipal authorities, the convention for the numbering of embankments relative to the structure orientation is then as follows:

Structure Orientation:	Embankment 1 is at the:
North-South	Northern end
East-West	Western end
Northeast-Southwest	North-eastern end
Northwest-Southeast	North-western end

3.5.3 Retaining Wall

Retaining walls inventory items do not have sub-items.

3.5.4 Gantry

Vertical members and spans are numbered numerically, for example: Vertical Member 1, Vertical

Member 2; and Span 1, Span 2.

For national and provincial road authorities, vertical members and spans would be numbered from left to right when looking in the direction of increased chainage on the national or provincial road. Vertical Member 1 would thus be the vertical member on the left hand side and Span 1 would then be the horizontal member that starts at Vertical Member 1.

For municipal authorities, the convention for the numbering of the vertical members relative to the structure orientation is as follows:

Structure Orientation:	Vertical Member 1 is at the:
North-South	Northern end
East-West	Western end
Northeast-Southwest	North-eastern end
Northwest-Southeast	North-western end

Span 1 would then be the horizontal member that starts at Vertical Member 1.

3.5.5 Road Tunnel

Portals and Segments are numbered numerically, for example: Portal 1, Portal 2; and Segment 1; Segment 2; Segment 3.

For national and provincial road authorities, Portal 1 would be the portal at the tunnel end with the lowest chainage value; and Segment 1 would be the segment that starts at Portal 1.

For municipal authorities, the convention for the numbering of portals relative to the structure orientation is as follows:

Structure Orientation:	Portal 1 is at the:
North-South	Northern end
East-West	Western end
Northeast-Southwest	North-eastern end
Northwest-Southeast	North-western end

Segment 1 would be the segment that starts at Portal 1.

3.6 Inventory Data Required for Structures

In addition to the structure number and location details, certain other required inventory information must be recorded for structures. This information should preferably be recorded from “as-built” drawings and design and contract reports. Where no “as-built” drawings and reports of the structure are available, these required inventory data must be measured on site.

The required inventory information per structure type is the following:

3.6.1.1 Bridge (General, Arch, Cable)

- Bridge type;
- Number of spans;
- Number of piers;
- Number of abutments;
- Number of arches;
- Number of cable groups;
- Overall structure length;
- Overall structure width;
- Total deck area;
- Maximum pier height;
- Maximum abutment height;
- Minimum width of roadway between kerbs;
- Paved width of approach road;
- Minimum vertical clearances; and
- Angle of skew (see Figure 3).

3.6.1.2 Bridge (Cellular) and Culvert (Major)

- Number of cells;
- Overall structure length;
- Overall structure width;
- Maximum Cell Size: Width;
- Maximum Cell Size: Height;
- Total opening area;
- Average cell length;
- Maximum height of fill;
- Total plan area;
- Minimum width of roadway; and
- Paved width of approach road.

3.6.1.3 Retaining Wall

- Wall type;
- Length of wall;
- Maximum height of wall;
- Total area of wall in elevation.

3.6.1.4 Gantry

- Gantry type;
- Height of vertical members;
- Span of horizontal members; and
- Total length of vertical and horizontal members.

3.6.1.5 Road Tunnel

- Tunnel type;
- Length of tunnel;
- Width of tunnel;
- Height of tunnel; and
- Tunnel cross-sectional area.

3.6.1.6 Light Mast

- Group of masts or a single mast;
- Location of the first mast and the last mast in a linear group or of three masts on the outer extremities of a group such as light masts at an interchange;
- Number of masts in the group;
- Foundation type;
- Light mast type;
- Light mast material (e.g. galvanized steel); and
- Light mast height;

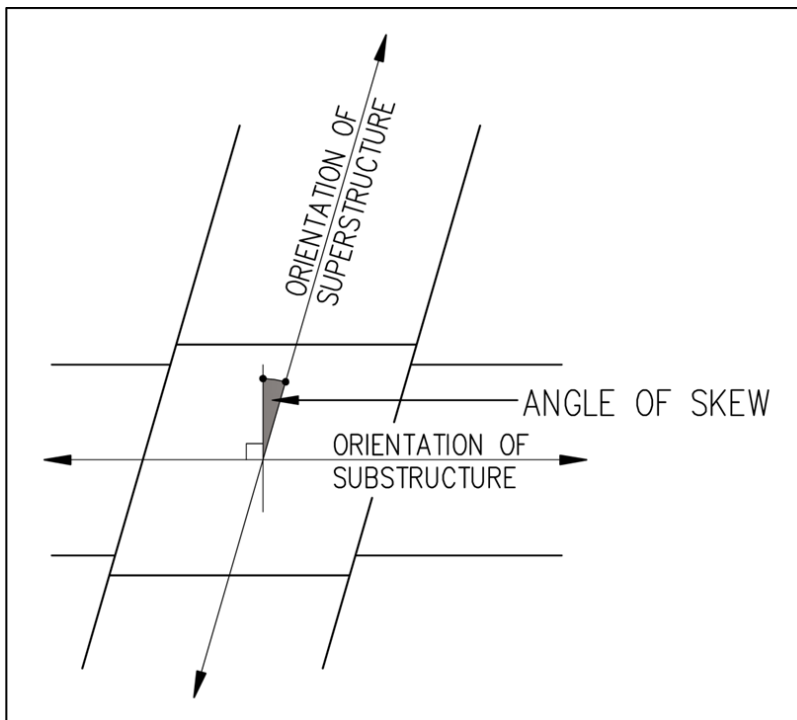


Figure 3 Angle of Skew

3.7 Additional Inventory Data for Structures

A more extensive range of inventory information that can be recorded is listed per structure type in Appendix A1. To collect and maintain data can be costly and the Road Authority must take care when deciding what additional information to collect. This should once again accommodate the Road Authority's reporting needs.

3.8 Required Inventory Photos

In order to ensure consistency of photos, a defined set of inventory photos is required. These photos must be uniquely numbered and it is recommended that all photos be geo-tagged.

3.8.1 Bridge (General; Arch; and Cable)

- View 1: Bridge in elevation (must show total length of bridge, full pier heights and abutments. If necessary several photos can be taken and combined electronically).
- View 2: Bridge in elevation from opposite side.
- View 3: Bridge from upper approach (looking along centre line of road or as close as possible to centre line).
- View 4: Bridge from upper approach (opposite end).
- View 5: View taken from the top of the bridge of feature crossed (road, rail or upstream river view)
- View 6: View taken from the top of the bridge of feature crossed (road, rail or downstream river view).
- View 7: Deck edge to show profile of deck cantilever soffit.
- View 8: Opposite deck edge to show profile of deck cantilever soffit.
- View 9: Underside of deck (photo of each type if different deck types).
- View 10: Typical pier (photo of each type if different pier types).
- View 11: Typical abutment (photo of each type if different abutment types).
- View 12: Bridge number as seen from main route on which bridge is defined.
- View 13: Other bridge number adjacent to other road or rail.
- View 14: Typical parapet elevation.
- View 15: Typical roadway joint.
- View 16: Any other salient feature

3.8.2 Bridge (Cellular)

- View 1: Bridge inlet in elevation (show total number of cells);
- View 2: Bridge outlet in elevation (show total number of cells and apron slab);
- View 3: Bridge from upper approach (in direction of increasing chainage);
- View 4: Bridge from opposite end of approach (in direction of decreasing chainage).
- View 5: View taken from the top of fill of feature crossed (road or upstream river view);
- View 6: View taken from the top of fill of feature crossed (road or downstream river view);
- View 7: View of inside of bridge barrel showing roof walls & floor.
- View 8: Bridge number.
- View 9: Any other salient feature.

3.8.3 Culvert (Major)

- View 1: Culvert inlet in elevation (show total number of cells);
- View 2: Culvert outlet in elevation (show total number of cells and apron slab);

- View 3: Culvert from upper approach (in direction of increasing chainage);
- View 4: Culvert from opposite end of approach (in direction of decreasing chainage).
- View 5: View taken from the top of fill of feature crossed (road or upstream river view);
- View 6: View taken from the top of fill of feature crossed (road or downstream river view);
- View 7: View of inside of culvert barrel showing roof walls & floor.
- View 8: Culvert number.
- View 9: Any other salient feature.

3.8.4 Culvert (Lesser)

- View 1: Culvert inlet in elevation.
- View 2: Culvert from upper approach.
- View 3: View taken from the top of fill of feature crossed.
- View 4: View of inside of culvert barrel showing roof walls & floor.
- View 5: Culvert number.

3.8.5 Retaining Wall

- View 1: Wall in elevation start area.
- View 2: Wall in elevation mid area.
- View 3: Wall in elevation end area.
- View 4: Wall from on-coming approach.
- View 5: Wall from out-going approach.
- View 6: Embankment/terrain above the wall.
- View 7: Embankment/terrain below the wall.
- View 8: Structure number.

3.8.6 Gantry

- View 1: Gantry in elevation.
- View 2: Sign face front side.
- View 3: Sign face back side.
- View 4: Left Column.
- View 5: Right column.
- View 6: Beam.
- View 7: Holding down bolts left column.
- View 8: Holding down bolts right column.
- View 9: Plinth and foundation left side.
- View 10: Plinth and foundation right side.
- View 11: Structure number.

3.8.7 Road Tunnel

View 1: Tunnel headwall elevation at start.

View 2: Tunnel headwall elevation at end.

View 3: Slope above tunnel at start.

View 4: Slope above tunnel at start.

View 5: View inside tunnel.

View 6: View of road surface with movement joint.

View 7: View of movement joint in wall.

View 8: Structure number.

3.8.8 Light mast

View 1: Light mast in elevation.

View 2: Holding down bolts.

View 3: Plinth and foundation.

View 4: Light fitting zoomed in.

View 5: Any special features relating to the light fitting access system.

View 6: Access hatch external covering.

View 7: Access hatch internal fittings.

View 8: Any other salient feature.

Note: In the case of a group of masts a representative photo of one mast within the group of similar masts should be provided.

4 The DER Rating System

4.1 Description of the DER Rating System

The rating system used for the visual inspection of structures is referred to as the DER rating system. The essence of this system is to identify defects on a structure and to rate these defects. The inspector only has to focus on the defects on a structure and is not required to rate the condition of each inspection item or the structure as a whole.

DER refers to the degree (D); extent (E); and relevancy (R) of a defect as described below:

D degree of defect:	How bad or severe is the defect.
E extent of defect:	How widespread is the defect on the inspection item being inspected.
R relevancy of defect:	The consequence of the defect with regards the structural or functional integrity of the inspection item or the safety of the user of the structure.

Degree

The DEGREE rating is a visual rating that defines the severity of the defect. It is not clouded by the need to consider the consequence of the defect with regards the inspection item and structure concerned. Rating the degree of the defect separately also allows for the monitoring of the deterioration of the defect over time.

Extent

The EXTENT of the defect goes hand in hand with the DEGREE, in that it expresses how extensive is the identified defect spread out on the element being inspected.

Relevancy

The RELEVANCY rating defines the relevancy of the defect with regards the safety of the user and the structural or functional integrity of the element and consequently of the structure being inspected. This rating requires the inspector to understand how the structure behaves, how the defect will interfere with the load path through the structure and how it will impact on the safety of pedestrians, motorists and truckers, and whoever else uses the structure. It is considered to be the most difficult to rate and for it to be of benefit it requires inspectors with the appropriate design and rehabilitation experience on the structure type being assessed.

By considering the three aspects of the defect separately, the inspector can concentrate on each aspect without confusing one with the other and consequently rate the defect with more accuracy. It simplifies the rating procedure and in the end provides a more realistic description of the true condition of the structure to the Road Authority.

4.2 DER Rating Values

D, E and R ratings are essentially a four point rating system, namely 1; 2; 3; or 4. For the degree rating, additional values can be allocated, namely 0; X; and U.

Road Structure Management Part A.4: The DER Rating System

A degree rating of 0 is used to indicate that there are no visible defects on the inspection item.

A degree rating of X is used to indicate that the inspection item is not applicable to that structure. For example on a one span bridge, the inspection item “pier” is not applicable.

A Degree rating of U is used when it is not possible to inspect the inspection item, such as bearings that are inaccessible. This should not be used frequently. Foundations below ground level should generally not be marked as “unable to inspect”. The inspector should look at evidence or the lack of evidence of defects relating to the foundation and rate the foundation accordingly.

The allowable DER rating values are summarised in Table 3.

Table 3 Allowable DER Values

Rating	D (Degree)	E (Extent)	R (Relevancy)	
X	Not applicable			
U	Unable to inspect			
0	No visible defects			
1	Minor	Local	Minimum	No structural integrity or safety issues
2	Moderate	More than local	Moderate	Some possible structural integrity or safety issues
3	Warning	Less than general	Major	Structural integrity or safety compromised
4	Severe	General	Critical	Potentially a serious impact on structural integrity and/or user safety

For each inspection item, a D rating has to be allocated. If the D rating is 0; X; or U, then no E rating and R ratings are given. If the D rating is 1; 2; 3 or 4, an E rating and R Rating have to be given. These rating requirements are summarised in Table 4.

Table 4 DER-ratings Requirements

Degree	Extent	Relevancy	Interpretation
X	Leave blank	Leave blank	Item not applicable
U	Leave blank	Leave blank	Not able to inspect item
0	Leave blank	Leave blank	No defects visible on item
1, 2, 3 or 4	Must be entered	Must be entered	Visible defect(s) present on item

There is a restriction that the R-rating cannot be more than one point higher than the D-rating. Certain D & R combinations are therefore not valid, as indicated in Table 5.

Table 5 Allowable Degree and Relevancy Combinations

D&R	R=1	R=2	R=3	R=4
D=1	1-1	1-2	Not valid	Not valid
D=2	2-1	2-2	2-3	Not valid
D=3	3-1	3-2	3-3	3-4
D=4	4-1	4-2	4-3	4-4



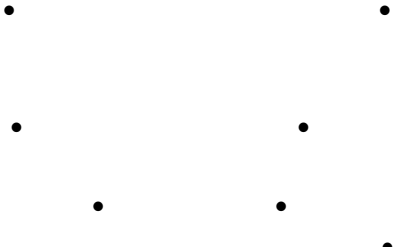

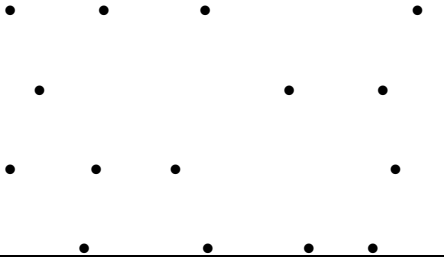
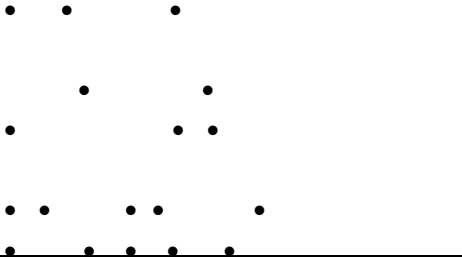
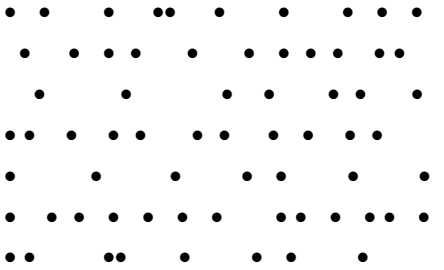
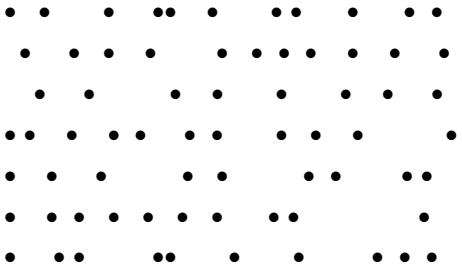
4.3 Procedure for Rating of Defects

Each inspection item (and sub-item) must be inspected. During the inspection, all defects on the item being inspected are identified. The inspector then has to decide which one of the identified defects is the worst defect. This would usually be the defect with the highest relevancy rating. The defect identified as the worst defect is then rated in terms of D, E and R. This becomes the rating for that inspection item or sub-item.

The rest of the identified defects on the inspection item or sub-item are recorded for maintenance/repair purposes, but are not rated in terms of D, E and R.

4.4 Illustration of Extent Rating

A diagrammatical illustration of Extent (E) is given in the table below:

E = 1		
Description	Local	
E = 2		
Description	More than local	
E = 3		
Description	Less than general	
E = 4		
Description	General	

5 Overview of Defects on Structures

5.1 Introduction

The identification of defects on structures forms the basis of the management system. Relevant defects that have consequences with regards the safety of users and the structural or functional integrity of the structure must be identified and rated.

The main types of defects are:

- Deficiencies;
 - Design deficiencies;
 - Construction deficiencies; and
 - Material performance related deficiencies.
- Damage; and
- Deterioration.

5.2 Types of Defects

5.2.1 Defects related to design deficiencies

Defects which are associated with deficiencies in:

- Design assumptions;
- Analysis;
- Design calculations;
- Detailing; and
- Geotechnical assumptions.

5.2.2 Defects related to construction deficiencies

Defects which are associated with construction deficiencies, such as:

- Incorrect placement of reinforcement;
- Lack of cover;
- Inadequate curing; and
- Poor workmanship and quality control.

A common defect associated with a construction deficiency is honeycombing. Honeycombed concrete occurs when there are water leakages from the formwork during the placing of concrete or from badly compacted concrete. Honeycombing becomes evident immediately after striking of formwork and should be repaired by the contractor at the time of construction. If left unrepaired, it could lead to corrosion of reinforcement or to the reduction in the load carrying capacity of the structural element concerned

5.2.3 Defects related to material performance deficiencies

These types of defect are normally noticed as abnormal deflections, cracking and other problems soon after or even during construction.

5.2.4 Defects related to damage

Damage is caused by a number of events, such as:

- Fire;
- Natural elements (earthquakes, floods, etc.);
- Foundation settlement;
- Impact;
- Scour;
- Constraint;
- Undermining and
- Overloading.

5.2.5 Defects related to deterioration

Deterioration of a structure can be caused by a number of factors, such as:

- Delamination;
- Spalling;
- Cracking;
- Carbonation;
- Chloride penetration;
- Efflorescence and discolouration;
- Alkali-aggregate reaction;
- Other chemical attack; and
- Corrosion and fatigue of structural steel.

5.2.5.1 *Delamination and Spalling*

Delamination occurs when a surface layer of concrete separates from the member mass. The primary cause is corrosion of the reinforcement. It can also be caused by fire. A spall is formed when delaminated material becomes dislodged.

5.2.5.2 *Cracking*

Reinforced concrete is designed with the knowledge that concrete will crack under tensile stresses. In many cases cracking does not present a problem and no treatment is required.

Cracks can form before hardening of concrete due to:

- Early frost damage;
- Plastic shrinkage;
- Plastic settlement; or

- Construction related movement.

Cracks can form after hardening of concrete due to:

- Drying shrinkage;
- Corrosion of reinforcement;
- Alkali-aggregate reaction;
- Freeze and thaw cycles;
- Thermal contraction;
- Structural reasons; and
- Creep

Table 6 Crack Width Ranges for Structural Concrete

Description of Crack	Width of Crack
Hairline	< 0.1 mm
Narrow	0.1 - 0.3 mm
Medium	0.3 - 0.7 mm
Wide	> 0.7 mm

5.2.5.3 Carbonation

Corrosion of reinforcement is inhibited in the presence of a strong alkaline environment by the formation of a film of iron oxide on the surface of the embedded reinforcement. Carbonation takes place when carbon dioxide in the air reacts with the calcium hydroxide in the concrete to neutralize the alkaline environment. The protective layer is thus neutralized by carbonation.

The rate of carbonation depends on the permeability of the concrete, relative humidity, concentration of carbon dioxide present and the seasonal drying and wetting cycles.

5.2.5.4 Chloride penetration

Chloride penetration is normally present in structures exposed to a marine environment or in structures subject to the use of de-icing salts to melt snow and ice on road surfaces (not common in southern Africa).

Chloride can also be present in concrete through the use of chloride contaminated sand (such as beach sand) to manufacture the concrete.

5.2.5.5 Efflorescence and discolouration

Efflorescence is evidenced by white deposits that sometimes leach out of concrete. It results from migration of salts in solution to the surface of the concrete where they crystallize. It can sometimes be visible as stalactites hanging from the deck soffit.

Efflorescence does not influence the durability of the concrete.

5.2.5.6 Alkali-aggregate reaction

Alkali-aggregate reaction occurs when water-soluble alkalis released from the hydrating cement react with the aggregate to form a gel. The gel swells when it absorbs water. The concrete cracks if the swell pressure exceeds the tensile strength of the concrete.

5.2.5.7 Chemical attack

Acid rain is generally the most common cause of chemical attack in bridge structures in southern Africa. Acid rain is found in heavily air polluted zones where emissions of sulphur dioxide and nitrogen oxide react with water molecules in the atmosphere to produce acids. Accelerated deterioration will occur in concrete surfaces that are exposed to these acids.

5.2.5.8 Corrosion and fatigue of steel

When the corrosion protection system fails, steel corrodes with the resultant loss of structural strength. Cyclic loading may cause fatigue cracking which can result in sudden failure with little warning.

5.3 Common Bridge Defects

5.3.1 Rotation of Abutments, Wingwalls and Retaining Walls

Abutments, wingwalls and retaining walls founded on spread footings on compressible materials are likely to rotate because of the following reasons:

- Imbalance in forces acting behind and in front of the abutment or walls;
- The material behind the abutment or walls has a tendency to be compacted more than in front;
- If skidding, braking, temperature and earthquake forces are taken by the abutment, this will aggravate the forward rotation of the abutment; and
- Triangular stress distribution under the abutment footing. The higher pressure being in the front of the base.

For all of the above reasons it is important to look for tell-tale signs, which would indicate the forward rotation. These could be the following:

- Closing up of expansion joints at abutments;
- At abutments, the gap between the back wall and the deck has closed up;
- Excessive movement of abutment bearings towards the abutment back wall. This could be seen in mechanical as well as elastomeric bearings;
- Locking in of locating keys in skew decks;
- Secondary stresses resulting in unusual cracks in adjacent deck; and
- Large rotations of skew decks.

5.3.2 Longitudinal Members (Bridges)

- Spalled concrete in the vicinity of bearings could indicate high edge pressures;
- The outermost beams in overpasses of beam and slab construction are particularly vulnerable to damage from over height vehicles. The minimum clearance should be checked at these points;

- A map of cracking of the main members should be produced, so that the implications in terms of strength and durability can be carefully examined. Diagonal cracks close to supports could indicate an incipient shear failure, whereas evenly spread vertical cracks at centre of span could indicate normal flexural cracks. All reinforced concrete members under tension action are likely to crack. The size and penetration of cracks need to be investigated to determine if the cracking is severe; and
- The effects of temperature differences should be considered at an early stage in investigations.

Prestressed concrete bridges should be given special attention and checked for the following additional defects:

- Longitudinal cracks in the flanges close to the supports may indicate insufficient transverse reinforcement, while transverse cracks in beams could indicate serious loss of prestress or the incorrect original positioning of the prestressing cables;
- Spalling or cracking of concrete may also occur near bearings or cable anchorages often due to inadequate design; and
- In box girders with access openings, the interior faces of flanges and webs need to be examined for signs of cracking.

5.3.3 Transverse Members (Bridges)

Defects in transverse members are similar to longitudinal members except that the relevancy of the defects is likely to be lower. This is because of transverse members being treated as secondary to the longitudinal members in the design of decks. Should a failure occur in transverse members, the loads would transfer to the longitudinal members and the deck would be saved.

Where the transverse members are being used as the main structural member, such as in the case of supports to bearings or end blocks to external prestress cables, they are to be treated similarly to the longitudinal members.

5.3.4 Decks and Slabs

The following types of defect occur typically on decks and slabs:

- Cracking - structural, restrained, shrinkage and temperature, material (bad mix or chemical attack) and workmanship (construction);
- Scaling - loss of mortar and aggregate on horizontal surfaces exposed to the weather and traffic and on other surfaces caused by frost or chloride damage;
- Spalling - loss of concrete between fracture surfaces;
- Corrosion of reinforcement - leads to discolouration of surfaces and in extreme cases to cracking and spalling
- Leakage - occurs at construction joints, where there is risk of cracking in thin component sections of the deck, e.g. at kerbs and in in-situ concrete topping over or between prestressed beams.
- Leaching - Seepage of water through cracks and voids in the hardened concrete may dissolve out calcium hydroxide and other constituent materials in the concrete. Most evident on the soffit of decks and take the form of staining, efflorescence or encrustation at cracks. It can

present a corrosion threat to reinforcement, because of the gradual loss of alkalinity of the concrete.

- Porous or pervious concrete - Ingress of water leads to corrosion of reinforcement. More susceptible to chemical attack. Occurs where good compaction of concrete is difficult, as in densely reinforced slabs and in corners of formwork.
- Wear of deck surface - Where deck forms the running surface for traffic.
- Excessive deformation, deflection or vibration - Deck too slender and under-designed.
- Accidental damage - Most common is from damage to overpasses by over height vehicles.
- Chemical attack - Occurs in aggressive industrial environments or in coastal regions. Causes surface crumbling.

5.3.5 Foundations

Specialist work is required when the foundation material under a base is to be re-instated. Because of the restricted space, it is difficult to obtain proper compaction, so mass concrete or soilcrete is often used.

When considering the stability of the abutment, wall or pier it is important to establish whether the foundation is piled or on spread footings and what the founding material is. The structural integrity of a pile cap where the piles are founded on rock will be less affected with regards to undermining when compared to a spread footing founded on sand

Settlements in foundations can be checked by visual sighting along railings and walls, noting both the vertical and horizontal alignment.

Shallow pile caps have a tendency to develop vertical tension cracks between two adjacent piles. These cracks sometimes extend into the columns. Such cracks must be monitored as they can cause the collapse of the pier and the bridge if there is corrosion of the reinforcement.

5.3.6 Scour Damage

Scour damage will not affect structural integrity of structure in the following cases:

- Where spread footings are founded directly onto competent rock and the design allows for the flood forces to act on the full height of the pier and superstructure and overturning is resisted by the mass of the structure; and
- Foundations on piles where piles are founded on or in competent rock and the design has taken account of realistic scour depths under the action of corresponding hydrodynamic forces.

Structural integrity may be affected in the following cases:

- Spread footings founded on erodible material such as a boulder layer;
- Piled foundations which depend partly or fully on friction rather than fully end bearing; and
- Piled foundations which have been designed as end bearing piles founded on erodible material such as a boulder layer.

Other important aspects to be aware of when inspecting foundations in a river:

- The effect of scour will be greatest on pier foundations located on the outside of a bend;
- Should a second bend exist just upstream of the bend at the structures, but is in the opposite direction scouring will be further increased;
- A very sandy river bed will be more susceptible to scour;
- The location, lateral dimensions and depth of scour holes should be noted and, if possible, recorded photographically;
- Scouring is often aggravated by changes in the river's regime due to natural and man-made causes, such as earth slippage, property development and removal of sand from the river just upstream of the bridge;
- Wall type piers designed for a given direction of flow will become more susceptible to scour should the river change its flow path.

5.4 **Ancillary Bridge Elements**

Ancillary bridge elements include the following:

- Expansion joints;
- Bearings;
- Parapets and end blocks;
- Drainage;
- Embankment protection; and
- Surfacing

5.4.1 **Typical expansion joint defects**

- Inadequate allowance for movement;
- Poor detail at kerbs and sidewalks;
- Armoured edges of joints not continuous;
- Poor quality materials used in asphaltic plug type joints, resulting in segregation of aggregate and binder leaving permeable stone pockets;
- "Press fit" joints working out of joint over time;
- Epoxy nosing failure;
- Loosening or movement of the joint and its components;
- Irregularity of vertical profile. One part of the joint may become vertically displaced relative to the other;
- Leakage of water through joints;
- Cracking of surfacing at buried joints.

5.4.2 **Typical bearing defects**

- Corrosion;
- Delamination;
- Seizure;
- Deformation;
- Movement capacity exceeded;

- Incorrect orientation;
- Overloaded; and
- Plinth failure.

5.4.3 Typical parapet and end block defects

- Lack of concrete cover to reinforcement and general concrete defects;
- Collision / impact damage;
- Guardrail not attached to end block;
- Top rail missing;
- Expansion joint and inspection eye cover plates missing;
- Corrosion of steel items;
- Failed guardrail fixing to parapet ; and
- Inadequate handrail height.

5.4.4 Typical drainage defects

- Blocked drainage/weep holes;
- No drainage or weep holes provided;
- Scuppers not extended below soffit;
- Drainage outlets not extended through walls;
- No drainage provided to deck voids;
- Blowing of water on structure;
- Inadequate falls on surfacing and deck, preventing the drainage of water to drainage; and
- No drains in void formers. In voided decks drains should be provided to remove water from the lowest points of voids.

5.4.5 Typical embankment protection defects

- Embankment erosion;
- Inadequate side drain, gutter and down chutes;
- Damaged gabion boxes and mattresses;
- Settlement of protection works;
- Missing protection works; and
- Unwanted vegetation.

5.4.6 Typical Surfacing Defects

The defects most commonly experienced with surfacing on decks are:

- Cracking;
- Excessive deformation; and
- Loss of skid resistance.

5.5 Typical Defects on Steel Structures

- Corrosion;

- Cracking;
- Fracture;
- Excessive vibration and noise;
- Deformation and deflection;
- Buckling, kinking, warping and waviness;
- Loose bolts and rivets;
- Deterioration of the protective system;
- Excessive wear; and
- Accumulation of water in closed members.

5.6 Typical Defects on Cellular Bridges and Major Culverts

Typical defects on cellular bridges and major culverts over and above those listed in section 5.2 include:

- Rotation of headwalls and wingwalls;
- Cracking of concrete elements;
- Spalling of concrete elements;
- Corrosion of reinforcement;
- Undermining of apron slabs, invert slabs, and foundations;
- Scaling due to loss of mortar and aggregate on inverts slabs;
- Silting-up or blockages of cells;
- Rotation of cells; and
- Erosion of embankments.

5.7 Typical Retaining Wall Defects

Typical defects on retaining walls over and above those listed in section 5.2 include:

- Excessive movements;
- Piling defects;
- Post tensioned anchor defects;
- Block wall defects;
- Soil nail defects;
- Sprayed concrete defects;
- Defects in soil strengthening or stabilization;
- Defects in gabions meshes and boxes;
- Loss of gabion stones; and
- Defects in mechanically stabilized earth.

5.8 Typical Gantry Defects

Typical defects in gantries include:

- Corrosion of steel elements;
- Loose and missing nuts on anchor bolts;

- Snapped anchor bolt shafts;
- Corrosion of the welded site connection;
- Deterioration of paint system;
- Traffic impact or collision damage;
- Failed welds;
- Failed steel element;
- Damaged or deteriorated sign boards; and
- Foundation and plinth concrete cracks and spalls.

5.9 Typical Road Tunnel Defects

Typical defects in road tunnels over and above those listed in section 5.2 include:

- Excessive movements;
- Excessive water seepage;
- Damage to concrete including impact and rock-fall damage;
- Defects to road surface;
- Expansion joint defects;
- Lighting defects;
- Defects in steep cuttings;
- Electrical defects;
- Ventilation system defects; and
- Air quality.

The following items generally only apply to major tunnels (e.g. the Huguenot Tunnel) and can be grouped as “Operational Services”:

- Tunnel monitoring defects (CCTV, fire and smoke detectors, computers, etc.);
- Traffic control defects (variable speed signs, variable message signs, traffic lights, booms, electronic control, etc.);
- Communication system defects (Emergency lighting, PA system, etc.)
- Ventilation system defects (Vents, fans, electronic control etc.);
- Power supply defects (cabling, switchgear, UPS, generators etc.); and
- Water supply defects (Water treatment, storage tanks, pumps, water pipes, fire hydrants, electronic control, etc.).

5.10 Typical Light Mast Defects

Typical defects in light masts include:

- Inadequate foundation system (light mast leaning);
- Foundation and plinth concrete cracks and spalls;
- Loose and missing anchor bolts nuts;
- Snapped anchor bolt shafts;
- Failed welds due to, for example, fatigue;
- Failed steel sections due to, for example, inadequate thickness or strength;

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- Deterioration of the corrosion protection system;
- Corrosion of steel elements;
- Traffic impact or collision damage;
- Defective light fittings and fixings;
- Defective light fitting access system;
- Defective electrics and cabling;
- Defective access hatch to electrical controls; and
- Inadequate cable theft preventative measures.

6 Inspection Items and Inspection Sheets

6.1 Introduction

For inspection purposes, a structure is divided into a number of inspection items. Inspection items are predefined structural elements and ancillary items that are typically assessed separately to determine their condition. The conditions of the items are consolidated to determine the condition of the structure. In some cases, items are made up of discrete yet similar parts (e.g. bridge piers). For the purpose of the condition assessment, these parts or “sub-items” are assessed individually. The condition of such an item is based on the condition of the sub-items. The number of inspection items is a function of the structure type, while the number of sub-items is generally a function of the size of the structure, such as the number of bridge spans or culvert cells.

6.2 Inspection Items per Structure Type

Defects are identified and rated at inspection item level and where applicable at sub-item level. The number of inspection items per structure type is summarised in Table 7.

Table 7 Number of Inspection Items per Structure Type

Structure Type	Number of Inspection Items
Bridge (General)	21
Bridge (Arch)	21
Bridge (Cable)	21
Bridge (Cellular)	14
Culvert (Major)	14
Culvert (Lesser)	5
Retaining Wall	7
Gantry	8
Road Tunnel	8

The actual inspection items per structure type are listed in Table 8 to Table 13 in the next section.

6.3 Inspection Sub-items per Structure Type

For inspection items that consist of sub-items, defects are rated at the sub-item level. For example, for a Bridge (General) type structure, one of the inspection items is “Abutment”. Most bridges have two abutments and each abutment is inspected separately. The inspection item “Abutment” would therefore have two sub-items, namely “Abutment 1” and “Abutment 2”.

The inspection items per structure type for Bridge (General), Bridge (Arch) and Bridge (Cable) with the number of sub-items per inspection item are summarised in Table 8 and for Bridge (Cellular) and Culvert (Major) in Table 9.

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Table 8 Inspection Items and Sub-items for Bridge (General, Arch and Cable)

Inspection Item		Number of Sub-items		
		Bridge - General	Bridge – Arch	Bridge – Cable
General Items:				
1	Approach embankments	No. of Abutments	No. of Abutments	No. of Abutments
2	Guardrails	Not applicable	Not applicable	Not applicable
3	Waterway	Not applicable	Not applicable	Not applicable
4	Approach embankment protection work	No. of Abutments	No. of Abutments	No. of Abutments
5	Abutment foundations	No. of Abutments	No. of Abutments	No. of Abutments
6	Abutments	No. of Abutments	No. of Abutments	No. of Abutments
7	Wing/retaining walls	No. of Abutments	No. of Abutments	No. of Abutments
8	Surfacing	Not applicable	Not applicable	Not applicable
9	Superstructure drainage	Not applicable	Not applicable	Not applicable
10	Kerbs/sidewalks	Not applicable	Not applicable	Not applicable
11	Parapets/handrails	Not applicable	Not applicable	Not applicable
Support Items:				
12	Pier protection works	No. of Piers	No. of Piers plus No. of Springings	No. of Piers plus No. of Pylons
13	Pier foundations	No. of Piers	No. of Piers plus No. of Springings	No. of Piers plus No. of Pylons
14	Piers & columns	No. of Piers	No. of Piers plus No. of Springings	No. of Piers plus No. of Pylons
15	Bearings	No. of Piers plus No. of Abutments	No. of Piers plus No. of Abutments plus No. of Springings	No. of Piers plus No. of Abutments plus No. of Pylons
16	Support drainage	No. of Piers plus No. of Abutments	No. of Piers plus No. of Abutments plus No. of Springings	No. of Piers plus No. of Abutments plus No. of Pylons
17	Expansion joints	No. of Piers plus No. of Abutments	No. of Piers plus No. of Abutments plus No. of Springings	No. of Piers plus No. of Abutments plus No. of Pylons
Span Items:				
18	Longitudinal members in the deck	No of Spans	No. of Spans plus No. of Arches	No. of Spans plus No. of Cable Groups*
19	Transverse members in the deck	No of Spans	No. of Spans plus No. of Arches	No. of Spans
20	Deck slab	No of Spans	No. of Spans plus No. of Arches	No. of Spans
Miscellaneous Item:				
21	Items not covered under Items 1 to 20	Not applicable	Not applicable	Not applicable

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Inspection Item	Number of Sub-items		
	Bridge - General	Bridge – Arch	Bridge – Cable
*A Cable Group is defined as the cables supporting a span of a cable type bridge or the cables extended to an anchorage point or anchorage chamber behind a bridge abutment where no span is supported. Examples of Cable Groups are the main suspension cables and hangers supporting a span of a suspension bridge, the stay cables supporting a span of a cable stayed bridge or the hangers supporting a span of an arch bridge			

Table 9 Inspection Items and Sub-items for Bridge (Cellular) and Culvert (Major)

Inspection Item		Number of Sub-items
General Items:		
1	Apron slabs & cut off walls	No. of embankments
2	Wing / return / head walls	No. of embankments
3	Scour protection works (in river)	No. of embankments
4	Embankments	No. of embankments
5	Waterway	Not applicable
6	Road slabs	Not applicable
7	Roadway joints	Not applicable
8	Guardrails	Not applicable
9	Parapets/handrails	Not applicable
Cell Items:		
10	Walls	No. of Cells
11	Top slab	No. of Cells
12	Invert slab	No. of Cells
13	Cell displacement	No. of Cells
Miscellaneous Item:		
14	Items not covered under items 1 to 13	Not applicable

The inspection items for structure type Culvert (Lesser) are summarised in Table 10.

Table 10 Inspection Items and Sub-items for Culvert (Lesser)

Inspection Item		Number of Sub-items
1	Inlet Works	Not applicable
2	Outlet Works	Not applicable
3	Barrel(s)	Not applicable
4	Waterway	Not applicable
5	Embankments	Not applicable

The inspection items for structure type Retaining Wall are summarised in Table 11.

Table 11 Inspection Items and Sub-items for Retaining Wall

Inspection Item		Number of Sub-items
General Items:		
1	External Drainage	Not applicable
2	Slope Protection	Not applicable
Wall Items		
3	Walls	Not applicable
4	Joints	Not applicable
5	Internal Drainage	Not applicable
6	Foundations	Not applicable
Miscellaneous Item:		
7	Items not covered under items 1 to 6	Not applicable

The inspection items for structure type Gantry are summarised in Table 12.

Table 12 Inspection Items and Sub-items for Gantry

Inspection Item		Number of Sub-items
General Items:		
1	Guardrails	Not applicable
Gantry Items		
2	Foundations	No. of Vertical Members
3	HD Bolts and Base Plates	No. of Vertical Members
4	Vertical Members	No. of Vertical Members
5	Horizontal Members	No. of Horizontal Members
6	Sign Face	No. of Horizontal Members
7	Sign Fasteners	No. of Horizontal Members
Miscellaneous Item:		
8	Items not covered under items 1 to 7	Not applicable

The inspection items for structure type Road Tunnel are summarised in Table 13.

Table 13 Inspection Items and Sub-items for Road Tunnel

Inspection Item		Number of Sub-items
Portal Items		
1	Portals	No. of Portals
2	Slope Protection	No. of Portals
3	Rock Fall Protection	No. of Portals
General Items		
4	Drainage	Not applicable
5	Road Surface	Not applicable
Tunnel Bore Items		
6	Lining	No. of Panels
7	Joints	No. of Panels

	Inspection Item	Number of Sub-items
	Miscellaneous Item:	
8	Operational Services (see 5.9)	No. of operational services
9	Items not covered under items 1 to 8	Not applicable

6.4 Inspection Forms

Inspection data is collected during the visual inspection of structures. Inspections are carried out by completing standard inspection forms per structure type. These inspection forms list all the inspection items and sub-items applicable to the particular structure type.

Examples of inspection forms for the following structure types are presented in Appendix A3:

- Bridge (General);
- Bridge (Arch);
- Bridge (Cable);
- Bridge (Cellular);
- Culvert (Major);
- Retaining Wall;
- Gantry; and
- Road Tunnel.

Appendix A3 also includes inspection forms for routine inspections, normally carried out by routine road maintenance staff, of the following structure or inspection types:

- Culvert (Lesser);
- Waterway Inspection; and
- Light Mast.

The inspection forms included in Appendix A3 can be downloaded from the SANRAL website in MS Excel and pdf format.

6.5 Structure Orientation Sketches

A structure orientation sketch should be provided with each inspection to indicate the orientation of the structure and the numbering of the sub-items. This sketch can be drawn in the space provided on the inspection form or as a separate scanned sketch if the space provided on the inspection form is not adequate. The scanned structure orientation sketch should be saved as an inspection photo. Examples of structure orientation sketches are presented in Figure 4.

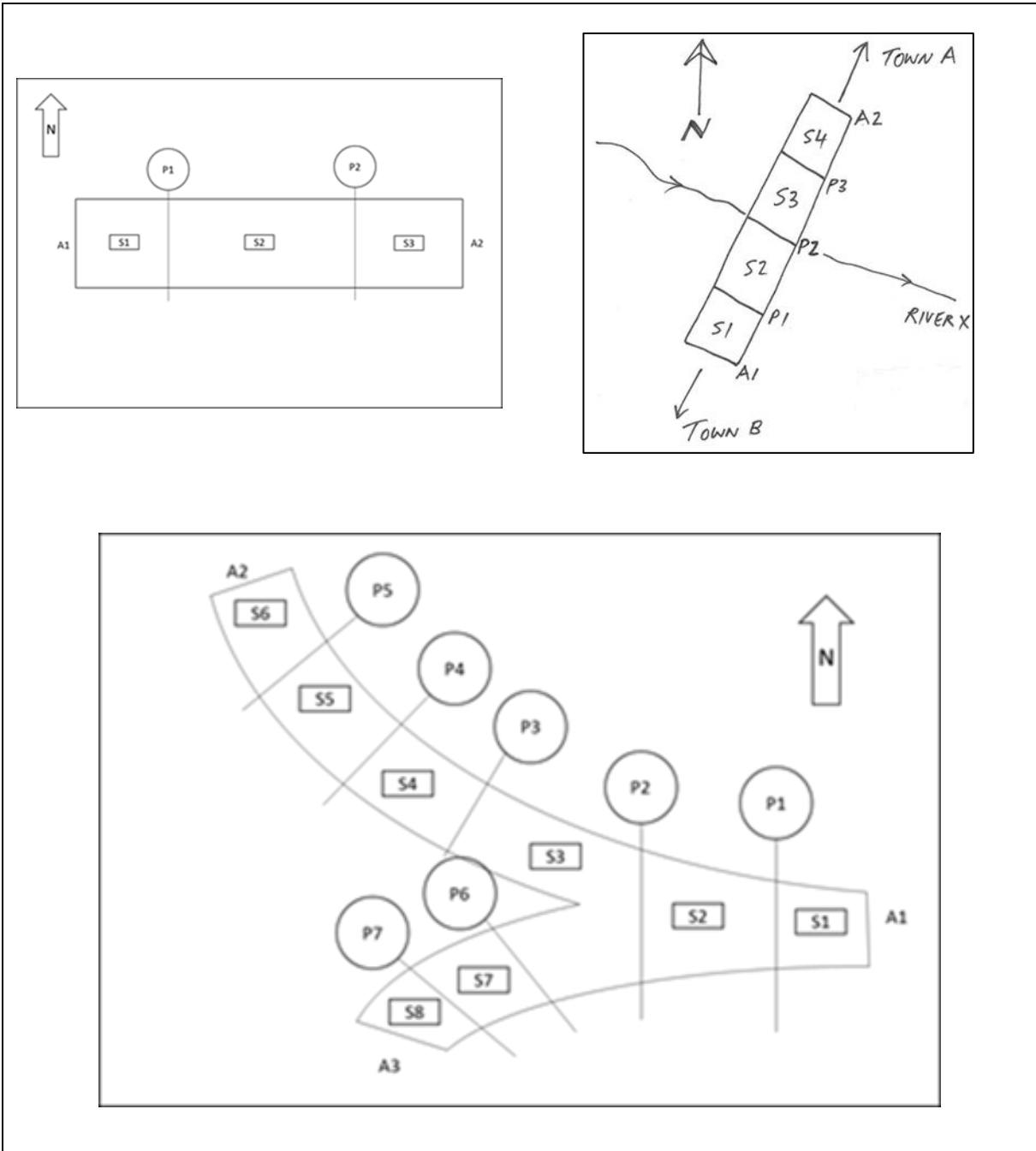


Figure 4 Examples of Structure Orientation Sketches

7 Inspection Procedure and Quality Assurance

7.1 Types of Inspections

7.1.1 Principal Inspections

A Principal Inspection is a comprehensive visual inspection of the whole structure and forms the basis of the road structure management system. It has to be carried out by suitably qualified personnel experienced in structural design and maintenance. Principal Inspections should be carried out every 5 years.

7.1.2 Partial Inspections

During a Partial Inspection, only certain inspection items are inspected. One reason is that on some structures certain inspection items can only be inspected with the use of specialised access equipment, such as the Under Bridge Inspection Unit.

Partial Inspections are usually combined with inspection data for the remaining inspection items from the most recent Principal Inspection to calculate the various condition indices for the structure.

7.1.3 Completion Inspections

Completion Inspections are carried out after the completion of maintenance or rehabilitation on a structure, either by the client or by the consultant that was responsible for the maintenance/rehabilitation project. The purpose of this inspection is to assign new ratings to those inspection items that have been repaired or rehabilitated. Depending on the extent of the maintenance work, Completion Inspections can take the form of a Principal Inspection or a Partial Inspection. Completion Inspections are also carried out after the completion of a new structure and in this case will be carried out as a Principal Inspection.

7.2 Inspections to be Carried Out by Routine Road Maintenance Staff

7.2.1 Culvert (Lesser) Inspections

Inspections of lesser culvert should be carried out at least once a year and can be carried out by routine road maintenance staff after attending a training course. These inspections must be carried out using the Culvert (Lesser) inspection form, included in Appendix A3. The required remedial activities must be recorded using the remedial activity list for Culvert (Lesser) included in Appendix A4.

7.2.2 Waterway Inspections

Waterway inspections refer to inspections to be carried out on all structures crossing a waterway. These inspections should be carried out at least once a year or after any significant storm event. Such inspections can be carried out by routine road maintenance staff after attending a training course. These inspections must be carried out using the Waterway inspection form, included in Appendix A3. The required remedial activities must be recorded using the applicable remedial activities from the remedial activity lists for bridges and culverts included in Appendix A4.

7.2.3 Light Mast Inspections

Inspections of light mast should be carried out at least once a year and can be carried out by routine road maintenance staff after attending a training course. These inspections must be carried out using the Light Mast inspection form, included in Appendix A3. The required remedial activities must be recorded using the remedial activity list for light masts included in Appendix A4. A suitably defined mast number as well as GPS co-ordinates should be used to identify a single mast with a unique defect.

7.3 Requirements for Accreditation of Inspectors

Inspectors will be accredited through the COTO Structures Sub-committee as either Senior Bridge Inspectors; Bridge Inspectors; or Culvert Inspector. Only accredited inspectors will be allowed to carry out visual assessments of road structures. The requirements to be accredited includes professional registration requirements; design experience requirements; and training requirements.

7.3.1 Professional registration and design experience requirements

7.3.1.1 *Bridge Inspector*

Professional Engineers who have an absolute minimum of 5 years bridge and culvert design experience obtained during the last 25 years or Professional Technologists who have a minimum of 10 years bridge and culvert design experience obtained during the last 25 years. Experience put forward must be personal design experience and does not include signing off designs done by others. Managers in charge of structural design, who do not have the required years of personal design experience themselves, do not qualify. Time spent on site does not qualify as design experience towards accreditation.

7.3.1.2 *Senior Bridge Inspector*

Professional Engineers with a minimum of 15 years full time personal bridge design experience accumulated over their career. Professional Technologists with 20 years' experience of a similar senior/team leading nature in bridge design will also be considered. Applicants, at the COTO Structures Subcommittee Accreditation Panel's discretion, may be required to attend an interview to confirm their eligibility. It is of utmost importance that the applicant also has personal design experience in continuous prestressed bridges as well extensive other experience. Ideally such a candidate will also be in a senior position involving the overseeing and advising of more junior bridge designers. As such, the candidate will have made bridges and the management of bridges their full time career and will be conversant with all aspects of the management of road structures from design through to construction, maintenance and repair. The design experience put forward must be personal experience and does not include merely signing off designs done by others. Managers in charge of design sections, who do not have the required years of personal design experience themselves, do not qualify.

7.3.1.3 *Road Tunnel Inspector*

The requirement for this category is for the inspector to be an accredited Senior Bridge Inspector.

7.3.1.4 *Culvert Inspector*

A qualified technician, technologist or engineer with an absolute minimum of 5 years bridge and culvert design experience obtained during the last 20 years. Structural design experience will also be

considered. Time spent on site does not qualify as design experience towards accreditation.

7.3.1.5 Retaining Wall Inspector

The requirement for this category is for the inspector to be at least an accredited Culvert Inspector.

7.3.1.6 Gantry Inspector

The requirement for this category is for the inspector to be at least an accredited Culvert Inspector.

7.3.2 Training requirements for all inspector grades

In addition to the above experience and qualification, a person applying for accreditation to the COTO Structures Sub-committee Accreditation Panel must have attended a course recognized by the COTO Structures Subcommittee. The COTO-recognised Bridge Inspector Course presented for the purpose of registering as a COTO Accredited Senior Bridge Inspector, Bridge Inspector or Culvert Inspector shall be a two day course combining theory, practical and an examination. The content thereof shall be aligned with the TMH19 document and pre-approved by the COTO Structures Subcommittee. The course convenor or primary presenter shall be an accredited Senior Bridge Inspector. As part of the COTO Structures Subcommittee accredited course, candidates will write an exam. Applicants applying for accreditation must have passed this exam. The examination shall be independently set and marked by an organisation approved by the COTO Structures Subcommittee. The issued certificate reflecting the approved exam result by an approved examiner is the only COTO Structures Subcommittee recognised certificate that may be issued for the purpose of applying for accreditation.

The required experience must have already been obtained before attending the course. The required design experience is a key requirement towards accreditation as an inspector. Those that have the required experience at the time of attending the course, but are not professionally registered at that time, may apply for accreditation as soon as they have obtained professional registration. Applications in such cases should be received not later than 12 months of the course attendance. This time period allowed may be extended in special cases at the sole discretion of the COTO Structures Sub-committee Accreditation Panel.

The professional responsibility of the inspector is paramount, because when failures occur, the inspection data often will form part of court cases. Inspectors assume a serious responsibility when they are accredited and inspect structures on behalf of a client.

The COTO Structures Subcommittee reserves the right to require accredited inspectors to attend refresher courses from time to time for their accreditation to remain valid. Generally this would be the case if a 10-year period has lapsed since accreditation and the accredited inspector has not undertaken inspections in that period. Each case will however be considered on its merits.

7.3.3 Summary of required inspector grade per structure class

The required inspector grade per structure class is summarised in Table 14. Special or strategic bridges are bridges classified as such by a particular road authority.

Table 14 Summary of required inspector grade per structure class

Structure Class	Senior Bridge Inspector	Bridge Inspector	Culvert Inspector
Special or Strategic Bridge	✓	✗	✗
Bridge	✓	✓	✗
Major Culvert	✓	✓	✓
Retaining Wall	✓	✓	✓
Gantry	✓	✓	✓
Road Tunnel	✓	✗	✗

7.4 Requirements for Lesser Culvert, Light Mast and Waterway Inspectors

7.4.1 Lesser Culvert Inspector

The requirement to inspect a lesser culvert is a suitable technical person trained in the use of the rating system and inspection form.

7.4.2 Light Mast Inspector

The requirement to inspect a light mast is a suitable technical person trained in the use of the rating system and inspection form.

7.4.3 Waterway Inspector

The requirement to carry out a waterway inspection is a suitable technical person trained in the use of the rating system and inspection form.

7.5 Procedure for Visual Inspections

Prior to commencing with a round of inspections, the Road Authority should arrange an orientation meeting with all the inspectors. During this orientation meeting, the specific requirements of the Road Authority must be communicated to the inspectors. This should include a list of inventory data items that have to be captured or confirmed during the inspection. An important issue to be clarified during the orientation meeting is how to deal with structural elements not complying with current specifications or requirements. For example, the parapets and handrails on older bridges might not comply with current specifications and the Road Authority must give guidance on whether this should be rated as a defect in itself or whether the inspector should only rate defects present on the current parapet or handrail.

The next step is for inspectors to study any available drawings and inventory data of the structure prior to carrying out the visual inspection. This will assist the inspector in understanding how the structure behaves as a result of temperature variation, settlement, rotation, live and dead loads etc. and facilitate the identification of the causes of various defects.

When arriving on site, a walkthrough of the structure should be done to obtain a general appreciation of the condition of the structure. During the walkthrough some of the required inventory photos (see Section 3.8) could also be taken.

The inspection forms (see Section 6.4) are specific to the structure type and cover all items applicable to the type of structure. The inspector selects an item with which to start the inspection and then proceeds through the structure in a systematic manner. Using a bridge as an example, the inspector may start with one of the approaches of the bridge, followed by the sub-structure, bearings and deck soffit, then the opposite approach and finally the top of the bridge deck, including parapets, guardrail, surfacing and deck joints, ensuring that no items or sub-items are overlooked.

When evaluating an inspection item, the inspector must identify all visible defects on the item. The inspector must decide which of these defects is the most severe for the item under consideration and must then allocate a Degree (D), Extent (E) and Relevancy (R) rating to the most severe defect. The most severe defect would usually be the one with the highest Relevancy rating.

If a defect is critical to the structural integrity such that collapse is imminent or where public safety risk is considered high, such a defect should be recorded as Make Safe (MS) and should receive immediate attention. The inspector should immediately alert the authorities to implement appropriate safety measures to ensure the safety of the user. The “Make Safe” box on the inspection form must be ticked and proof of the communication should be kept, clearly indicating the Road Authority and person(s) contacted.

Once the inspector has rated the most severe defect for the item, the remedial work sheet can be completed. Each defect type applicable to the inspection item, including the most severe defect, must be allocated at least one remedial activity item from the applicable remedial activity list with the estimated quantity and an urgency rating.

The next step is to photograph all the defect types applicable to the inspection item. One photo may be sufficient to record a type of defect, but in many cases a close-up photo of the defect and one taken a few metres away showing its location in relation to the item or structure would be necessary. The photographic record sheet must be completed to record each photo. This contains a brief description of the defect and the direction in which the photo was taken. Each photo should be uniquely numbered and it is recommended that all photos be geo-tagged.

The inspector then moves to the next inspection item and repeats the process. Before leaving the site, the inspector must ensure that the inspection sheet has been completed in full i.e. there should be ratings for each item on the inspection form and remedial activities for all defects. If an element has no defects; is not applicable; or is unable to be inspected, the appropriate value of D = 0; X; or U must be recorded under the degree rating for such an element. The D-rating must not be left blank.

If cracks exist, it is sometimes beneficial to draw a freehand sketch of the crack pattern. This can provide useful information in determining probable causes. Such a sketch can be scanned or photographed and captured as a defect photo.

Inspections must be carried out during daylight, as it is easy to overlook defects, especially cracks, when the light starts to fade. Culverts must be lit up when inspecting inside the barrels.

Equipment and material that are required for inspections include the following:

- Clipboard, pencil and eraser
- Notebook
- As-built drawings (if available)
- Torch
- Binoculars
- Digital camera (GPS enabled)
- Handheld GPS device (minimum of 5 m accuracy; WGS84 format)
- Access equipment, e.g. 6 m ladder
- Gumboots (for culvert inspections)
- Laser distance meter
- Crack width gauge
- Tape measure and
- Measuring wheel
- High-visibility vest
- Non-skid shoes/boots
- Amber flashing light

7.6 Requirements for Additional Inspections

Allowance has been made at the bottom of the inspection forms for identifying further inspections that may be required. The intention is that where there is clearly a problem with the structure that cannot be sufficiently identified with a visual inspection, the need and requirements for an additional inspection can be described.

Typically this would be used in the following situations:

- Where a bridge is in a poor condition and the inspector can only get access to some of the spans due to, for example, deep water, the inspector can request that a further inspection be done using the Under-bridge Inspection Unit (UBIU) or a boat. Where the bridge is in good condition and there is no indication, using binoculars, that the spans that cannot be inspected are in a poor condition, it is not necessary to have further inspections;
- Where there are signs that a structure may collapse and a more detailed assessment of the remaining strength is required, this can be indicated here. For example, if a culvert has a severe crack in the soffit, this could be due to insufficient reinforcement in the top slab on the one hand, or damage during construction on the other. The former is more critical than the latter and can be identified by exposing and measuring the reinforcement across the crack; and
- Where a problem on a structure falls outside the expertise of the inspector, further inspections can be requested. An example would be a significant geotechnical failure to a retaining wall or a tunnel.

7.7 Quality Assurance

The Quality Assurance for visual assessments includes Quality Control and Quality Acceptance components.

Quality Control is an internal responsibility of the agent carrying out the assessment. These agents can be the authorities own teams carrying out an in-house assessment or external service providers appointed for the assessment. Visual assessments carried out by individuals without up to date accreditation must be rejected. The accredited inspector is responsible for the quality control of the data submitted to the Road Authority.

Quality acceptance is an external responsibility and must be undertaken by an organisation independent of the assessment agent. Quality acceptance comprises the assessment of a representative sample of at least 5% of all structures assessed. These results must be compared with the assessment results for accuracy.

The checking procedure must include checking of the calculated indices and the degree, extent and relevancy rating for individual defects. To ensure efficiency and minimise the losses that may be incurred, the quality assurance checks must be completed within 2 weeks of completion of the assessments in an area.

7.8 Occupational Health and Safety Requirements

Inspectors must at all times comply with all the relevant Occupational Health and Safety legislation. The safety of the inspector and the traveling public must always be priority and inspectors should take note of the following safety aspects:

- Always wear a safety vest and light coloured clothing;
- Non-skid shoes are essential;
- Always keep office staff informed of which structures will be inspected on a daily basis in case of an emergency;
- Carry out inspections during daylight;
- Ensure culverts are lit up when inspecting inside the barrels;
- Always take an assistant with when doing inspections;
- Take care when inspecting culverts in areas prone to flash floods;
- No rope access may be used during inspections, unless the inspector has specifically been trained for this; and
- Ladders must be used in the correct and safe manner.

When entering an enclosed space, special care is required. This especially applies to service culverts and box-girder bridges which are not well-ventilated. There may be harmful gasses being released from the service or insufficient oxygen present as concrete gives off carbon dioxide due to the on-going chemical reaction and concrete can also absorb oxygen. Before the inspection, the structure must be opened up and allowed to ventilate. Furthermore, the inspector must have an assistant on the outside and keep in constant communication with him during the inspection. If the communication breaks down, the assistant must take immediate action to get the inspector out of structure.

7.9 Inspection Photos

Inspection photographs are taken to indicate the location and details of defects. Inspection photos have no set form and are based on the discretion of the inspector. At least one photo of each type of defect on an inspection item is required. In many cases more than one photo of a defect would be required to illustrate the defect adequately in terms of location and detail of the defect itself. A close-up view of the defect and a view of the defect in relation to the overall structure or inspection item are required in most cases.

It is important to record adequate information per inspection photo during the inspection to be able to link the correct photo(s) to the correct defect on the correct structure. The camera photo numbers are the only link between the structure, the defects and the inspection photos and it is recommended that the camera photo number and relevant photo details are entered on a photo record sheet as the photos are taken. Cameras that have “GPS tagging” functionality will assist with linking photos to the correct structure, but cannot assist in linking the photo to the correct defect.

Each inspection photo must have a description attached to it in which the defect and the position of the defect are described, e.g. “0.2 mm bending crack in deck slab of Span 2”.

When taking photographs of cracks, it is useful to outline the cracks with chalk or to include an object in the photo to provide scale, such as a ruler or crack width gauge.

8 Repair Cost Calculations

8.1 Introduction

All defects identified during the inspection process have to be recorded for maintenance or repair purposes. The following information has to be recorded per defect type per inspection item:

- Item Number;
- Position of Defect;
- Activity;
- Quantity;
- Urgency; and
- MS (Make Safe) (if applicable)

8.1.1 Item Number

Item number refers to the inspection item where the defect occurs. For example, if a crack occurs on a pier, the item number for the remedial activity to repair the crack would be “Item 14: Piers and Columns”.

8.1.2 Position of Defect

Position of defect describes where on the inspection item the defect occurs and is indicated by way of a code. For example, if a crack occurs on pier 2 of a five span bridge, the item number would be “Item 14: Piers and Columns”, while the position of the defect (the crack in this case) would be indicated as “P2” (for Pier 2). If similar cracks occur on all piers, the position of the defect would be indicated as “AP” (for all piers).

8.1.3 Activity

Activity refers to the remedial activity required to repair the defect. For a crack, for example, the remedial activity would be “Seal Crack”. Each remedial activity has an associated unit of measurement and unit rate. For example, for the activity “Seal Crack”, the unit of measurement is m (metre) and the unit rate R 590/m (2016 value).

8.1.4 Quantity

Quantity is the estimated quantity to repair the defect. Inspections are done at a network level and these quantities are estimated as accurately as possible and in most cases not measured. The estimated quantity multiplied by the unit rate provides the estimated cost to repair the defect.

8.1.5 Urgency

Urgency refers to when the defect should be repaired. The Urgency is indicated by way of the Urgency Rating, which is a numerical rating as described in Section 8.2. The urgency rating is used to allocate the cost to repair a defect to a specific budget period. The urgency rating must relate to the relevancy rating. For example, a defect with a high relevancy rating would also have a high urgency to be repaired.

8.1.6 Make Safe

If a defect is critical to the structural integrity such that collapse is imminent or where public safety risk is considered high, such a defect should be recorded as Make Safe (MS) and should receive immediate attention. The inspector should immediately alert the authorities to implement appropriate safety measures to ensure the safety of the user. Proof of the communication should be kept clearly indicating the Road Authority and person(s) contacted.

The “Make Safe” box on the inspection form must be ticked.

8.2 Urgency Ratings

The available Urgency (U) ratings are presented in Table 15.

Table 15 Available Urgency (U) Ratings

U-Rating	Description	Remarks
1	Routine	Use for remedial activities that have been identified as routine activities by the Road Authority.
2	Within 10 years	With a five year inspection cycle, these are defects that only need to be repaired after the next round of principle inspections.
3	Within 5 years	These are defects that should be repaired before the next round of principle inspections.
4	As soon as possible	These are defects that should be repaired as soon as possible. In practical terms, it could take up to two years from the time that a defect is identified during an inspection until a contractor is on-site to carry out the repair. Defects where public safety risk is considered high and that have to receive immediate attention will get an urgency rating of 4, but has to be marked as a “Make Safe” item and treated accordingly.
R	Record only	This urgency rating is used for defects for which no remedial work is envisaged. Such defects would have a D-rating of 1 or 2 and an R-rating of 1.
0	Monitor only	This urgency rating is used for defects for which remedial work is not envisaged for the foreseeable future. A monitoring frequency must be indicated (e.g. 12, 24, 36 months). This urgency rating should not be used frequently, as it is not always practical for a Road Authority to monitor defects on structures, especially where the structures are dispersed over a wide area, as is the case for national and provincial roads authorities.

8.3 Remedial Activities

Remedial Activity lists are available for each structure type. These activity lists are included in this document in Appendix A4.

8.4 Position Codes

In order to indicate the position of a defect and therefore also the position of the remedial activity, use should be made of standardised position codes. Examples of position codes for the various structure types are presented in Table 16 to Table 21. If a similar defect occurs on both abutments, for example spalling, the position code of the remedial activity "Repair Spall" would be indicated as "BA" for "Both Abutments". The quantity of the remedial activity would then be the total volume of spalling to be repaired on both abutments.

Table 16 Position Codes for Remedial Activities on Bridges (General; Arch; and Cable)

Code	Description	Examples
A	Abutment	Abutment 1: A1; Abutment 2: A2; Both Abutments: BA
Ar	Arch	Arch 1: Ar1; Arch 1 to Arch 3: Ar1-Ar3; Arch 1 and Arch 3: Ar1,Ar3
E	Embankment	Embankment 1: E1; Both Embankments: BE
G	General	
P	Pier	Pier 1: P1; Piers 1 to 3: P1-P3; Piers 1, 3 and 4: P1,P3,P4; All Piers: AP
S	Span	Span 1: S1; Spans 1 to 3: S1-S3; Spans 1, 3 and 4: S1,S3,S4; All Spans: AS
Sp	Springing	Springing 1: Sp1; Springing 1 to Springing 3: Sp1-Sp3; Springing 1 and Springing 3: Sp1,Sp3
Py	Pylon	Pylon 1: Py1; Pylon 2 to 4: Py2-Py4; Pylon 1 and 3: Py1,Py3
CG	Cable Group	Cable Group 1: CG1; Cable Group 1 and 3: CG1,CG4

Table 17 Position Codes for Remedial Activities on Bridges (Cellular) and Culverts (Major)

Code	Description	Examples
C	Cell	Cell 1: C1; Cell 1 to Cell 3: C1-C3; Cell 2 and Cell 4: C2,C4; All cells: AC
E	Embankment	Embankment 1: E1; Both embankments: BE
G	General	
Ap	Approach	Approach 1: Ap1; Approach 2: Ap2; Both approaches: BAp

Table 18 Position Codes for Remedial Activities on Culverts (Lesser)

Code	Description	Examples
C	Cell	Cell 1: C1; Cell 1 to Cell 3: C1-C3; Cell 2 and Cell 4: C2,C4; All cells: AC
E	Embankment	Embankment 1: E1; Both embankments: BE
G	General	

Table 19 Position Codes for Remedial Activities on Retaining Walls

Code	Description	Examples
W	Wall	Wall 1: W1

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Code	Description	Examples
E	Embankment	Embankment 1: E1
G	General	
Ap	Approach	Approach 1: Ap1
W	Wall	Wall 1: W1
E	Embankment	Embankment 1: E1

Table 20 Position Codes for Remedial Activities on Gantries

Code	Description	Examples
Vm	Vertical Member	Vertical Member 1: Vm1, Vertical Members 1 and 2: Vm1-Vm2
S	Span	Span 1: S1; Spans 1 to 3: S1-S3; Spans 1 and 3: S1,S4; All Spans: AS
G	General	

Table 21 Position Codes for Remedial Activities on Road Tunnels

Code	Description	Examples
Po	Portals	Portal 1: Po1; Portal 2: Po2; Both portals: BPo
Pa	Panels	Panel 1: Pa1, Panel 2 to 4: Pa2-Pa4; All panels: Apa
G	General	

Table 22 Position Codes for Remedial Activities on Light Masts

Code	Description	Examples
M	Mast	Mast 1: M1; Mast 2: M2
MG	Mast Group	Mast Group 1: MG1
G	General	

Appendices

Appendix A1. Inventory Information per Structure Type

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Table A1.1 Common Inventory Items (R = Required and O = Optional)

Item	Bridge (General/Arch/Cable)	Bridge (Cellular)	Culvert (Major)	Culvert (Lesser)	Retaining Wall	Gantry	Tunnel
Location Details							
Route/Road Number	R	R	R	R	R	R	R
Section Number	R	R	R	R	R	R	R
Chainage km	R	R	R	R	R	R	R
Road Name/Description	R	R	R	R	R	R	R
Class Of Road	R	R	R	R	R	R	R
District/Province/Municipality	O	O	O	O	O	O	O
Region/Suburb	O	O	O	O	O	O	O
Other Authority	O	O	O		O	O	O
Primary Feature Over	O	O	O	O			
Primary Feature Over Name	O	O	O	O			
Primary Feature Over Road Number	O	O	O	O			
Primary Feature Over Road km	O						
Secondary Feature Over	O	O	O				
Secondary Feature Over Name	O	O	O				
Primary Feature Under	O	O	O	O			
Primary Feature Under Name	O	O	O				
Primary Feature Under Road Number	O						
Primary Feature Under Road km	O						
Secondary Feature Under	O	O	O				
Secondary Feature Under Name	O	O	O				
Other/Old Bridge Number	O	O					
Elevation	O	O	O	O			O
Structure Orientation	R	R	R	O	R	R	R
Direction of River Flow	O	O	O	O			
Approach Embankment Orientation	R						
Embankment Orientation		R	R				
Survey System	R	R	R	R	R	R	R
GPS Coordinates: Longitude	R	R	R	R	R	R	R
GPS Coordinates: Latitude	R	R	R	R	R	R	R
Status	R	R	R	R	R	R	R
Ownership	R	R	R	R	R	R	R
Contract details							
Design Engineers	O	O	O		O	O	O

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Item	Bridge (General/Arch/Cable)	Bridge (Cellular)	Culvert (Major)	Culvert (Lesser)	Retaining Wall	Gantry	Tunnel
Contractor	O	O	O		O	O	O
Contract No.	O	O	O		O	O	O
Contract/Construction Cost	O	O	O		O	O	O
Year Completed	R	R	R		R	R	R
Completion Period	O	O	O		O	O	O
Escalated Cost	O	O	O		O	O	O
Total Cost	O	O	O		O	O	O
Design Characteristics							
Design Live Loading	O	O	O				
Percentage Increase Due to Overloading	O	O	O				
Design Codes	O	O	O				
Temperature Range	O						
Temperature Gradient	O						
Wind Loads	O						
Frequency.	O						
Warrant History.		O	O				
Hydraulic Data							
Class Of Road	O	O	O				
Catchment Area (The Catchment Area Of The River Up To The Point Where The Structure Crosses The River)	O	O	O				
Flood Calculation Method	O	O	O				
Twenty Year Return Period Flood (Q20)	O	O	O				
Design Return Period (T)	O	O	O				
Design Peak Discharge (QT)	O	O	O				
Peak Discharge (Q2T)	O	O	O				
Regional Maximum Flood (QRMF)	O	O	O				
Average Slope (S)	O	O	O				
Natural Design Flood Level (NDFL)	O	O	O				
Natural Design Flow Depth (NDFD)	O	O	O				
Natural Design Flow Velocity (Vn)	O	O	O				
Backwater (Δh)	O	O	O				
Design High Flood Level (DHFL) For QT	O	O	O				
Design High Flood Level (DHFL) For Q2T:	O	O	O				

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Item	Bridge (General/Arch/Cable)	Bridge (Cellular)	Culvert (Major)	Culvert (Lesser)	Retaining Wall	Gantry	Tunnel
Design Flow Velocity (Vn2)	○	○	○				
Required Freeboard	○	○	○				
Level Of Shoulder Break Point (SBP)	○	○	○				
Drainage							
Support Drainage	○						
Superstructure Drainage	○						
Road Surface Drainage	○	○	○				○
Cell Drainage		○	○				
Wing/Return Wall Drainage	○	○	○				
Seepage Drains	○	○	○				
Minimum Horizontal Clearances							
The Minimum Horizontal Clearance	○	○	○				
The Date	○	○	○				
The Position	○	○	○				
Minimum Vertical Clearances							
The Minimum Vertical Clearance	R	○	○			R	R
The Date Recorded	R	○	○			R	R
The Position Where Recorded	R	○	○			R	R
Services in/on/under Structure							
Service Type	○	○	○		○		○
Service Description	○	○	○		○		○
Service Location	○	○	○		○		○
Service Responsible Authority	○	○	○		○		○
Road Configuration, Traffic Volumes and Surfacing							
Class of Road	R	R	R		R	R	R
Number of Carriageways	○	○	○		○	○	○
Number of Lanes/Dimensions	○	○	○		○	○	○
Number of Shoulders/Dimensions	○	○	○		○	○	○
Number of Sidewalks/Dimensions	○	○	○		○	○	○
Annual Average Daily Traffic	○	○	○		○	○	○
Year ADT Recorded	○	○	○		○	○	○
Percentage Heavy Vehicles	○	○	○		○	○	○

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Item	Bridge (General/Arch/Cable)	Bridge (Cellular)	Culvert (Major)	Culvert (Lesser)	Retaining Wall	Gantry	Tunnel
Detour Length	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				<input type="radio"/>
Minimum Class of Detour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				<input type="radio"/>
Surfacing on Deck	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Surfacing on Approaches.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Archive Details							
Project Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Correspondence File Reference Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strip Map Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawing Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawing Title	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawing Location	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drawing Type	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfilm Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfilm Title	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Microfilm Location	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maintenance Agreements and Responsibilities							
Responsibilities	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Share of Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Agreement Number	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Agreement Location	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Maintenance History							
Details	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Designer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Contractor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Year Completed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Widening, Strengthening and Retrofitting							
Details	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Designer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Contractor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Year Completed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				
Cost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>				

Table A1.2 Inventory Items Specific to Bridge (General/Arch/Cable)

Item	Required or Optional		
	Bridge (General)	Bridge (Arch)	Bridge (Cable)
General Features			
Bridge Type	R	R	R
Number of Spans	R	R	R
Number of Piers	R	R	R
Number of Abutments	R	R	R
Number of Arches		R	
Number of Cable Groups			R
Facility Carried	O	O	O
Bridge Description	O	O	O
Deck Construction Method	O	O	O
Parapet/Handrail Type	O	O	O
Approach Slabs	O	O	O
Abutment Galleries	O	O	O
fcu Slabs	O	O	O
fcu Beams	O	O	O
fcu Piers	O	O	O
fcu Abutments	O	O	O
fcu Arches		O	
Dimensions, Geometry and Road Clearances			
Overall Structure Length	R	R	R
Overall Structure Width	R	R	R
Total Deck Area (normally L x W)	R	R	R
Angle of Skew	R	R	R
Single/Dual Carriageway Over	O	O	O
Direction of Traffic	O	O	O
Minimum Width of Roadway between Kerbs	R	R	R
Width of Approach Road	R	R	R
Vertical Alignment	O	O	O
Horizontal Alignment	O	O	O
Camber/Crossfall	O	O	O
Structural Features			
Deck			
Deck Position	R	R	R
Deck Type	O	O	O
Deck Material	O	O	O
Deck Depth (Average)	O	O	O
Deck Depth (Maximum)	O	O	O

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Item	Required or Optional		
	Bridge (General)	Bridge (Arch)	Bridge (Cable)
Deck Depth (Minimum)	O	O	O
Span Length	O	O	O
Deck Soffit Profile	O	O	O
Arches			
Arch Position		R	
Arch Type		O	
Arch Material		O	
Arch Span		R	
Arch Rise		O	
Arch Thickness at Crown		O	
Arch Thickness at Springing		O	
Bearings			
Bearing Position	R	R	R
Bearing Type	O	O	O
Bearings Fixity	O	O	O
Expansion Joints			
Expansion Joint Position	R	R	R
Expansion Joint Type	O	O	O
Expansion Joint Direction of Movement	O	O	O
Piers			
Pier Position	R	R	R
Pier Type	O	O	O
Pier Material	O	O	O
Pier Foundation Type	O	O	O
Pier Founding Material	O	O	O
Pier Maximum Height	R	R	R
Pier Foundation Maximum Depth	O	O	O
Abutments			
Abutment Position	R	R	R
Abutment Type	O	O	O
Abutment Material	O	O	O
Abutment Foundation Type	O	O	O
Abutment Founding Material	O	O	O
Abutment Maximum Height	R	R	R
Abutment Foundation Maximum Depth	O	O	O
Springings			
Springing Position		R	
Springing Material		O	
Springing Foundation Type		O	
Springing Founding Material		O	

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Item	Required or Optional		
	Bridge (General)	Bridge (Arch)	Bridge (Cable)
Cable Groups			
Cable Group Position e.g. span no. and/or abutment no. (backstay)			R
Cable Group Type e.g. suspension, stay, hanger			O
Cable Group Material			O
Cable Group Size			O
Wing/Retaining Walls			
Wing/Retaining Wall Position	R	R	R
Wing/Retaining Wall Type	O	O	O
Wing/Retaining Wall Material	O	O	O
Wing/Retaining Wall Foundation Type	O	O	O
Wing/Retaining Wall Founding Material	O	O	O
Wing/Retaining Wall Maximum Height	O	O	O
Wing/Retaining Wall Foundation Maximum Depth	O	O	O
Embankment Protection			
Embankment Position	R	R	R
Embankment Protection Type	O	O	O
Embankment Protection Material	O	O	O
Embankment Protection Thickness	O	O	O
Embankment Protection Slope	O	O	O
Factors Influencing Field Inspection			
Access Factors: Piers	O	O	O
Access to Bearings	O	O	O
Access to Inside of Box Girder	O	O	O
Access to Deck Soffit	O	O	O
Access to Abutment Galleries	O	O	O
Traffic Volume	O	O	O
Availability of Drawings	O	O	O
General Information	O	O	O

Table A1.3 Inventory Items Specific to Bridge (Cellular) and Culvert (Major)

Item	Required or Optional
General Features	
Number of Cells	R
Cell Type	O
Purpose of Bridge	O
Parapet/Handrail Type	O
Inlet/Outlet Walls Type	O
Causeway	O
Buried Structure	O
Bridge Road Slabs	O
Approach Road Slabs	O
Floor Slope	O
fcu Cells – Precast	O
fcu Cells – In-situ	O
fcu Apron Slabs & Cut-off Walls	O
fcu Wing/Retaining Walls	O
fcu Road Slabs	O
Dimensions, Geometry and Road Clearances	
Overall Structure Length	R
Overall Structure Width	R
Total Plan Area	R
Average Cell Length	R
Total Opening Area	R
Maximum Cell Size: Width	R
Maximum Cell Size: Height	R
Maximum Fill Height	R
Minimum Clear Width	O
Angle of Skew	O
Single/Dual Carriageway Over	O
Direction of Traffic	O
Minimum Width of Roadway	R
Width of Approach Road	R
Vertical Alignment	O
Horizontal Alignment	O
Camber/Crossfall	O
Minimum Depth of Fill Over	O
Slope of Invert Slab	O
Structural Features	
Cells	

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Item	Required or Optional
Cell Position	R
Cell Material: Walls	O
Cell Material: Top Slab	O
Cell Foundation Type	O
Cell Founding Material	O
Cell Internal Width	O
Cell Internal Height	O
Invert Slabs	
Invert Slab Position	R
Invert Slabs Type	O
Invert Slabs Material	O
Invert Slabs Thickness	O
Apron Slabs	
Apron Slab Position	R
Apron Slab Material	O
Apron Slab Thickness	O
Cut-off Walls	
Cut-off Wall Position	R
Cut-off Wall Material	O
Cut-off Wall Width	O
Cut-off Wall Depth	O
Dissipators	
Dissipators Position	R
Dissipator Type	O
Dissipator Material	O
Wing/Retaining Walls	
Wing/Retaining Wall Position	R
Wing/Retaining Wall Type	O
Wing/Retaining Wall Material	O
Wing/Retaining Wall Foundation Type	O
Wing/Retaining Wall Founding Material	O
Wing/Retaining Wall Maximum Height	O
Wing/Retaining Wall Foundation Maximum Depth	O
Embankment Protection	
Embankment Position	R
Embankment Protection Type	O
Embankment Protection Material	O
Embankment Protection Thickness	O
Embankment Protection Slope	O
Factors Influencing Field Inspection	

Item	Required or Optional
Access to Bridge/Culvert	O
Effective Cell Opening	O
Traffic Volume	O
Availability of Drawings	O
General Information	O

Table A1.4 Inventory Items Specific to Culvert (Lesser)

Item	Required or Optional
General Features	
Number of Cells	R
Culvert Type	O
Inlet/Outlet Walls Type	O
Floor Slope	O
Dimensions, Geometry and Road Clearances	
Overall Structure Length	O
Overall Structure Width	O
Overall Cell Length	O
Maximum Cell Size: Width	R
Maximum Cell Size: Height	R
Maximum Fill Height	O
Minimum Depth of Fill Over	O
Slope of Invert Slab	O
Structural Features	
Cells	
Cell Position	R
Cell Material: Walls	O
Cell Material: Top Slab	O
Cell Material: invert Slab	O
Cell Internal Width	R
Cell Internal Height	R
Apron Slabs	
Apron Slab Position	R
Apron Slab Material	O
Apron Slab Thickness	O
Cut-off Walls	
Cut-off Wall Position	R
Cut-off Wall Material	O
Cut-off Wall Width	O

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Item	Required or Optional
Cut-off Wall Depth	O
Dissipators	
Dissipators Position	R
Dissipator Type	O
Dissipator Material	O
Wing/Retaining Walls	
Wing/Retaining Wall Position	R
Wing/Retaining Wall Type	O
Wing/Retaining Wall Material	O
Wing/Retaining Wall Foundation Type	O
Wing/Retaining Wall Founding Material	O
Wing/Retaining Wall Maximum Height	O
Wing/Retaining Wall Foundation Maximum Depth	O
Embankment Protection	
Embankment Position	R
Embankment Protection Material	O
Embankment Protection Thickness	O
Embankment Protection Slope	O
Factors Influencing Field Inspection	
Traffic Volume	O
General Information	O

Table A1.5 Inventory Items Specific to Retaining Walls

Item	Required or Optional
General Features	
Wall Type	R
Description (in terms of its function)	O
Construction method	O
Slope Angle	O
Retained Material	O
fcu Foundations	O
fcu Walls	O
fcu Sprayed Concrete	O
fcu Precast Members	O
Dimensions, Geometry and Road Clearances	
Overall Length of Wall	R
Maximum Wall Height	R
Total Area of Wall in Elevation	R
Minimum Horizontal Clearance from Roadway Yellow Line	O
Structural Features	
Wall	
Wall material	O
Joints	
Wall Joints Type	O
External Drains	
External Drain Type	O
Internal Drainage	
Wall Drainage System Type	O
Wall Drainage System Size	O
Seepage Drain Type	O
Seepage Drain Size	O
Slope Protection	
Slope Protection Type	O
Slope Protection Material	O
Slope Protection Thickness	O
Embankment Protection Slope	O
Foundations	
Foundation type	O
Founding material	O
Wall foundation maximum depth	O
Factors Influencing Field Inspection	

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Item	Required or Optional
Access factors: Bottom of wall	○
Access factors: Top of wall	○
Traffic Volume	○
Availability of Drawings	○
General Information	○

Table A1.6 Inventory Items Specific to Gantries

Item	Required or Optional
General Features	
Gantry Type	R
Gantry Material	O
fcu Foundations	O
fcu Plinths	O
fst Structural steel	O
fst Anchor Bolts	O
Dimensions, Geometry and Road Clearances	
Total Length of Horizontal and Vertical Members	R
Left plinth projection	O
Within median barrier structure	O
Right plinth projection	O
Sign face length	O
Sign face height	O
Structural Features	
Foundations	
Foundation Position	R
Foundation Type	O
Founding Material	O
Gantry Foundation Maximum/Minimum Depth	O
Vertical Members	
Vertical Member Position	R
Vertical Member Type	O
Vertical Member Material	O
Vertical Member Height	R
Vertical Member Size	O
Type of Corrosion Protection	O
Horizontal Member	
Horizontal Member Position	R
Horizontal Member Type	O
Horizontal Member Material	O
Span of Horizontal Member	R
Horizontal Member Size	O
Type of Corrosion Protection	O
Sign Face	
Position of Sign	R
Type of Sign Face	O

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Item	Required or Optional
Type of Corrosion Protection	O
Sign Fasteners	
Position of Size	R
Type of Sign Fasteners	O
Type of Corrosion Protection	O
HD Bolts and Base Plates	
Position of HD Bolts and Base	R
Size of HD Bolts	O
Size of Base Plate	O
Type of Corrosion Protection	O
Factors Influencing Field Inspection	
Access factors: Gantry	O
Traffic Volume	O
Availability of Drawings	O
General Information	O

Table A1.7 Inventory Items Specific to Road Tunnels

Item	Required or Optional
General Features	
Tunnel Type	R
Description in terms of its Function	O
Material Bored Through	O
fcu Tunnel lining.	O
Dimensions, Geometry and Road Clearances	
Length of Tunnel	R
Width of Tunnel	R
Height of Tunnel	R
Tunnel Cross-sectional Area	R
Structural Features	
Lining	
Lining Position	R
Bore Lining Material	O
Joints	
Joint Position	R
Expansion Joints to Road Surface and Walls	O
Drainage	
Tunnel Wall Drainage System Type	O
Slope Protection	
Slope Position	R
Slope Protection Type	O
Slope Protection Material	O
Slope Protection Thickness	O
Slope Angle	O
Portals	
Portal Position	R
Portal Type	O
Factors Influencing Field Inspection	
Access factors: Tunnel bore	O
Access factors: Portals	O
Traffic Volume	O
Availability of Drawings	O
General Information	O

Table A1. 8 Inventory Items Specific to Light Masts

Item	Required or Optional
General Features	
Group of masts or single mast	R
Light mast or mast group location	R
Number of masts in the group	R
Foundations	
Foundation Type	R
Founding Material	O
Light Mast Foundation Maximum/Minimum Depth	O
Plinth projection	O
Within median barrier structure (Y/N)	O
f_{cu} Foundations	O
f_{cu} Plinths	O
HD Bolts and Base Plates	
Gusset plate description	O
Size of HD bolts	O
Size of base plate	O
f_{st} Anchor Bolts	O
Masts	
Light Mast Type	R
Light Mast Material	R
Light Mast Height	R
Mast Size e.g. diameter	O
f_{st} Structural steel	O
Type of Corrosion Protection	O
Light fittings and fixings	
Type of light fitting	O
Type of light fixing	O
Number of lights, bulbs or fittings	O
Access hatch to electrical controls	
Does a hatch exist Y/N	O
Hatch type and size	O
Light fitting access system	
Type of light fitting access system	O
Cable theft preventative measures	
Are cable theft preventative measures in place Y/N	O
Factors Influencing Field Inspection	
Access factors	O
Traffic Volume	O
Availability of Drawings	O
General Information	O

Appendix A2. Examples of Relevancy and Urgency Ratings

Introduction

Relevancy (R) – Considers the consequence of the defect with regards the structural/functional integrity of the inspection item or the safety of the user of the structure

The possible values for R are given in the table below:

R - Relevancy			
Minimum	Moderate	Major	Critical
1	2	3	4

Urgency (U) - Considers possible future events which could adversely affect defects and provides a way of applying direct time limits on the requirement to do the repairs

The possible values for U are given in the table below:

U – Urgency					
Record purposes only	Monitor only	Routine	< 10 years	< 5 years	ASAP
R	0	1	2	3	4

Concrete Items (Structural)

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 6 Abutments
- Bridge (General/Arch/Cable) Item 7 Wing/Retaining Walls
- Bridge (General/Arch/Cable) Item 14 Piers and Columns
- Bridge (General/Arch/Cable) Item 18 Longitudinal Members in Deck
- Bridge (General/Arch/Cable) Item 19 Transverse Members in Deck
- Bridge (General/Arch/Cable) Item 20 Deck Slab
- Bridge (Cellular) Item 1 Apron Slabs and Cut-off Walls
- Bridge (Cellular) Item 2 Wing/Return/Head Walls
- Bridge (Cellular) Item 6 Road Slabs
- Bridge (Cellular) Item 10 Walls
- Bridge (Cellular) Item 11 Top Slab
- Bridge (Cellular) Item 12 Invert Slab
- Culvert (Major) Item 1 Apron Slabs and Cut-off Walls
- Culvert (Major) Item 2 Wing/Return/Head Walls
- Culvert (Major) Item 6 Road Slabs
- Culvert (Major) Item 10 Walls
- Culvert (Major) Item 11 Top Slab
- Culvert (Major) Item 12 Invert Slab
- Retaining Wall Item 3 Walls

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- Road Tunnel Item 1 Portals
- Road Tunnel Item 6 Lining

Activity Description	Range of "R"	Remarks	U	R
Repair spalled concrete	1 to 4	Spalling is local and will not affect the structural integrity (SI) of the element	3	1
		Spalling is severe and the SI of the element will be affected	4	4
Seal, repair cracks > 0.3	1 to 4	Cracks are < 0.3 mm and there are no signs of leaching or leakage	-	-
		Cracks show signs of leaching or leakage, are local and will not affect the SI of the element	2	1
		Cracks show signs of leaching or leakage, are local and will not affect the SI of the element but there are signs of corrosion of reinforcement	3	2
		Cracks are global and show signs of corrosion of reinforcement but will not affect the SI of the element	4	3
		Cracks are local or global and will affect the SI of the element, i.e. where there is a possibility of collapse or where there are clear signs of badly corroded reinforcement	4	4
Repair honeycombed concrete	1 to 4	Honeycombing is superficial. Cover to the reinforcement is reduced but there are no signs of corrosion.	1	1
		Reinforcement is exposed but there are no signs of corrosion. The SI of the element will not be affected.	3	2
		Reinforcement is exposed and there are clear signs of corrosion. The SI of the element will be affected	4	4
Remove & reconstruct backwall at abutment	2 & 3	The severity of the rotation and movements of the abutment would determine whether it would be necessary to relieve stresses by removing and reconstructing the backwall	2	2
			3	3
Apply protective coating	1	After repairs to extend the life of the element	1	1
		Cover to reinforcement is substandard over extensive areas. To improve the durability of the element a protective coating is applied	1	1
		Concrete found to be very porous. A protective coating is used to protect the reinforcement from chloride attack and/or carbonation	2	1
Apply surface sealer/paint	1 & 2	To lengthen the life of a structure and will usually be applied after extensive repair to a structure.	2	2
		If concrete is found to be very porous and where there is a need to protect the reinforcement against future corrosion.	2	2

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Activity Description	Range of "R"	Remarks	U	R
		Where concrete is found to be under-strength and there is a need to increase its durability	1	1
Repair wear in riding surface if deck is unsurfaced	1 to 3	Rutting due to vehicular traffic: < 10 mm and local or global	R	1
		Rutting due to vehicular traffic: > 10 mm and local	2	2
		Rutting due to vehicular traffic: > 10 mm and global	3	3
Waterproof top surface	2 & 3	Evidence of reflection cracking or deformation of the surfacing material which could indicate slip between the asphalt layer and a waterproofing material if present	2	2
		Clear evidence of chemical attack to concrete i.e. where ingress of water will cause rapid deterioration of the concrete such as in AAR	3	2
		Evidence of leaching and leaking causing corrosion to reinforcement	4	3

Concrete Items (Non-structural)

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 10 Kerbs/Sidewalks
- Bridge (General/Arch/Cable) Item 11 Parapets and Handrails
- Bridge (Cellular) Item 9 Parapets and Handrails
- Culver (Major) Item 9 Parapets and Handrails

Activity Description	Range of "R"	Remarks	U	R
Repair spalled concrete	1 & 3	Spalling is local and will not affect the integrity of the element	1	1
		Spalling is severe and the integrity of the element will be affected (kerbs)	3	2
		Spalling is severe and the integrity of the element will be affected (parapets and handrails)	3	3
Seal, repair cracks > 0.3 mm	1 to 3	Cracks are < 0.3 mm	-	-
		Cracks are > 0.3 mm, are local and will not affect the integrity of the element	1	1
		Cracks are > 0.3 mm, are local and will not affect the integrity of the element, but there are signs of corrosion of reinforcement	2	2
		Cracks are global and show signs of corrosion of reinforcement but will not affect the integrity of the element	3	2

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Activity Description	Range of "R"	Remarks	U	R
		Cracks are local or global, there are clear signs of badly corroded reinforcement and the integrity of the element will be affected	3	3
Repair honeycombed concrete	1 to 3	Honeycombing is superficial. Cover to the reinforcement is reduced but there are no signs of corrosion.	1	1
		Reinforcement is exposed but there are no signs of corrosion. The integrity of the element will not be affected.	2	1
		Reinforcement is exposed and there are clear signs of corrosion. The integrity of the element will be affected (kerbs)	3	2
		Reinforcement is exposed and there are clear signs of corrosion. The integrity of the element will be affected (parapets and handrails)	3	3

Foundations

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 5 Abutment Foundations
- Bridge (General/Arch/Cable) Item 13 Pier Foundations
- Retaining Wall Item 6 Foundations
- Gantry Item 2 Foundations
- Light Mast Item 1 Foundations and Plinths

Activity Description	Range of "R"	Remarks	U	R
Backfill/ underpin foundations undermined by erosion or scour	2 to 4	The stability of the foundation is not endangered and the SI of the supported element is not affected	3	2
		The stability of the foundation may be endangered and the SI of the supported element will become affected should there be a further significant increase in scour	4	3
		The stability of the foundation is endangered and the SI of the supported element is affected and there is danger of collapse	4	4
Repair spalled concrete	1 & 3	Spalling is local and will not affect the SI of the foundation	1	1
		Spalling is severe and the SI of the foundation will be affected	3	3
Seal, repair cracks > 0.3 mm	1 to 3	Cracks are < 0.3 mm	-	-
		Cracks are > 0.3 mm, are local and will not affect the SI of the foundation	1	1

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Activity Description	Range of "R"	Remarks	U	R
		Cracks are > 0.3 mm, are local and will not affect the SI of the foundation, but there are signs of corrosion of reinforcement	2	2
		Cracks are global and show signs of corrosion of reinforcement but will not affect the SI of the foundation.	3	2
		Cracks are local or global, there are clear signs of badly corroded reinforcement and the SI of the foundation will be affected	3	3
Repair honeycombed concrete	1 to 3	Honeycombing is superficial. Cover to the reinforcement is reduced but there are no signs of corrosion.	1	1
		Reinforcement is exposed but there are no signs of corrosion. The SI of the foundation will not be affected.	2	1
		Reinforcement is exposed and there are clear signs of corrosion. The SI of the foundation will be affected.	3	3

Embankments

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 1 Approach Embankment
- Bridge(Cellular) Item 4 Embankments
- Culvert (Major) Item 4 Embankments

Activity Description	Range of "R"	Remarks	U	R
Down chutes - replace	3	If not replaced could lead to severe erosion of embankment	4	3
Down chutes - clean	1 & 2	Blocked up due to accumulation of silt or debris	1	1
		Inadequate to cater for water flow	3	2
Inlets/outlets - renew	3	If not replaced could lead to severe erosion of embankment	4	3
Inlets/outlets - clean	1 & 2	Blocked up due to accumulation of silt or debris	1	1
		Inadequate to cater for water flow	3	2
Erosion and scour damage - backfill	1 to 4	Erosion and scour are unlikely to affect stability of embankment	1	1
		Erosion and scour are highly likely to cause collapse in embankments but will not affect safety of traffic	3	2
		Erosion and scour are highly likely to cause collapse which will endanger the traffic on the embankment	4	4
Settlement - rectify	1 & 3	Minor settlement of road	1	1

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Activity Description	Range of "R"	Remarks	U	R
		Settlement of road may cause discomfort to user	3	2
		Settlement of road may cause accidents	4	3

Slope Protection

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 4 Approach Embankment Protection Works
- Retaining Wall Item 2 Slope Protection
- Road Tunnel Item 2 Slope Protection
- Road Tunnel Item 3 Rock Fall Protection

Activity Description	Range of "R"	Remarks	U	R
Renew/repair protection works (gabion boxes, stone pitching etc.)	1 to 3	Minor damage to protection works caused by settlement of embankment, vegetation, vandalism etc.	1	1
		Portions of the protection works have been damaged, displaced or removed locally by floodwaters	4	2
		Large portions have been damaged, displaced or removed by floodwaters	4	3

Bearings

These defects are applicable to the following inspection item:

- Bridge (General/Arch/Cable) Item 15 Bearings

Activity Description	Range of "R"	Remarks	U	R
Clean bearings	1	Dirt and debris may impair movement	1	1
Corrosion protection of bearing	1 & 2	Touching up of paint-work needed	1	1
		Corrosion causing excessive frictional forces between substructure and superstructure	3	2
Reset bearings	1 to 3	Minor adjustment needed in bearing alignment	2	1
		Key ways and thrust plates are not properly engaged and are binding causing large forces to be transmitted to substructure	3	2
		Bearing at limit of movement capacity and further movement expected	4	3
Replace elastomeric bearing	2	Tearing, cracking or splitting of exposed edges	2	2
		Excessive bulging and distortion indicating under-design	2	2

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Activity Description	Range of "R"	Remarks	U	R
Replace mechanical bearing	3	Very badly corroded bearing where the movement and support capabilities have been impaired	3	3
		Distortions in top or bottom adapter plates causing restrictions in the movement capabilities of bearing	3	3
Reinstate horizontal force capacity of bearing	1 to 3	Anchor bolts badly corroded	2	1
		Relative movement between the bearing seating and the supporting structure	3	3
		Shear keys have either failed or caused spalling of concrete to reduce their capacity to provide restraint to the structure	3	3
Tighten anchor bolts	1	Anchor bolts loose	1	1
Repair bearing plinths	2 to 4	Spalling of edges where bearings have been placed too close to edges	2	2
		Vertical crack caused by the bursting forces as a result of excessive bearing loads or inadequate strength (under designed)	4	4
		Corrosion of reinforcement caused by lack of cover	3	2
		Spalling of concrete in vicinity of holding down bolts, caused by excessive horizontal forces or corrosion of bolts	3	3

Expansion Joints

These defects are applicable to the following inspection item:

- Bridge (General/Arch/Cable) Item 17 Expansion Joints

Activity Description	Range of "R"	Remarks	U	R
Repair or replace concrete or synthetic nosing	1-4	Some slight spalling and cracking of the joint but no signs of it posing a danger to traffic	2	1
		Some spalling and cracking of the joint but does not pose a danger to traffic	3	2
		Parts of the nosing are coming loose but in small pieces. Claws and steel or aluminium components are no longer firmly fixed	4	3
		Parts of the nosing is coming loose in large pieces, claws and steel or aluminium components are loose, etc. any of which can pose a danger to traffic	4	4
	1 to 4	Signs of some minor leaking but no consequential damage to bearings, concrete, steel, etc. below	R	1

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Activity Description	Range of "R"	Remarks	U	R
Refit or replace elastomer element or replace sealant		Signs of more extensive leaking but no damage to bearings, concrete, steel, etc. below	3	2
		Extensive signs of leaking with damage to bearings, concrete, steel, etc. below	3	4
		Extensive leaking has caused significant damage such as bearings seizing, extensive concrete spalling, prestressing anchors corroding, etc.	4	4
Repair or replace asphaltic plug joint	1 to 4	Some deterioration such as some small cracks, slight rutting etc.	R	1
		More extensive deterioration such as some cracks, rutting etc.	3	2
		Large cracks, deep rutting, some loss of joint causing holes	3	3
		Deep rutting and large holes presenting a danger to traffic	4	4
Joint cover plates (replace and refit)	1 to 4	Slight deterioration to cover plates	R	1
		More deterioration to cover plates, loose bolts, plates missing over small gaps less than 40 mm etc.	3	2
		Bolts missing, plates missing over gaps less than 150 mm, etc.	3	3
		Plates standing out at a dangerous angle, missing plates over large gaps, etc. any of which present a danger to traffic or pedestrians	4	4
Clean joint of all loose material and debris	1 & 2	Routine maintenance activity. R rating would be determined by the extent to which the loose material and debris is preventing the expansion joint from fulfilling its function	1	1 2

Structural Steel Members

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 18 Longitudinal Members in Deck
- Bridge (General/Arch/Cable) Item 19 Transverse Members in Deck
- Bridge (General/Arch/Cable) Item 20 Deck Superstructure
- Gantry Item 4 Vertical Members
- Gantry Item 5 Horizontal Members
- Light Mast Item 3 Mast

Activity Description	Range of "R"	Remarks	U	R
Gouging out of weld & re-welding	1 to 4	The value of "R" chosen shall depend on whether a delay in carrying out a repair will or will not lead to a		

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Activity Description	Range of "R"	Remarks	U	R
		Rail severed from post and therefore no longer performing its function, but not protruding into the oncoming traffic.	4	3
		Rail severed from post and therefore no longer performing its function and protruding into the oncoming traffic	4	4
Attach rail to end block	2 & 3	No danger of oncoming traffic to collide with the end block	2	2
		Danger of oncoming traffic to collide with the end block	3	3
Provide wood spacer blocks	2	Wood spacers are either damaged or missing	3	2
Reseal wood spacer blocks	1	Protective maintenance needed on wood spacer blocks	1	1
Replace broken posts	2 & 3	One post is broken at a location	3	2
		Two adjacent posts are broken at a location	4	2
		Three or more posts are broken at a location	4	3
Replace missing bolts	2	Some of the bolts are missing or damaged and need to be replaced	3	2

Surfacing

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 8 Surfacing
- Road Tunnel Item 5 Road Surface

Activity Description	Range of "R"	Remarks	U	R
Resurface or patch surfacing on deck	1 to 3	The defects in the surfacing are not likely to cause an accident on the bridge/culvert	1	1
		The defects in the surfacing could cause an accident on the bridge/culvert	3	3

Waterway

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 3 Waterway
- Bridge(Cellular) Item 5 Waterway
- Culvert (Major) Item 5 Waterway
- Culvert (Lesser) Item 4 Waterway

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Activity Description	Range of "R"	Remarks	U	R
Clear waterway	1 to 4	Flood debris needs to be cleared from piers for fear of floods imposing excessive flood forces.	1	1
		Waterway is overgrown with vegetation	2	2
		Waterway has been reduced due to debris accumulation or build-up of sediment but overtopping will not occur	3	3
		Waterway has been severely reduced due to debris accumulation or built up of sediment which may cause overtopping of the structure.	4	4
Repair scour damage	2 to 4	Erosion and scour is unlikely to affect stability of an adjacent pier or abutment foundation.	3	2
		Erosion and scour is highly likely to cause collapse of an adjacent pier or abutment foundation.	4	4

Scour Protection

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 12 Pier Protection Works
- Bridge (Cellular) Item 3 Scour Protection (in river)
- Culvert (Major) Item 3 Scour Protection (in river)

Activity Description	Range of "R"	Remarks	U	R
Renew/repair protection works (gabion boxes; stone pitching; etc.)	1 to 3	Minor damage to protection works caused by settlement, vegetation, vandalism etc...	1	1
		Portions of the protection works have been damaged, displaced or removed locally by floodwater	4	2
		Large portions of the protection works have been damaged, displaced or removed by floodwater	4	3

Miscellaneous Items

These defects are applicable to the following inspection items:

- Bridge (General/Arch/Cable) Item 21 Miscellaneous Items
- Bridge (Cellular) Item 14 Miscellaneous Items
- Culvert (Major) Item 14 Miscellaneous Items
- Retaining Wall Item 7 Miscellaneous Items
- Gantry Item 8 Miscellaneous Items
- Road Tunnel Item 9 Miscellaneous Items
- Light Mast Item 8 Miscellaneous Items

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Activity Description	Range of "R"	Remarks	U	R
Cover slabs, manhole covers, lids, etc.	1 to 4	Smaller covers missing or broken, not creating a hazard	1	1
		Larger covers missing or broken, not creating a hazard	1	2
		Covers missing, creating a hazard for vehicles or pedestrians but not in direct path of vehicles or pedestrians	3	3
		Large covers missing, creating an immediate hazard for vehicles or pedestrians	4	4
Access chamber doors, gallery doors, access holes to deck soffit - missing or damaged:	1 to 4	Posing no danger, no access to an habitable area	1	1
		Potentially dangerous or posing a risk to the structure	3	3
		Dangerous, or people living inside structure and lighting fires, damaging the structure, etc.	4	4
People living in structure:	1 to 4	Small group of people with no erected structures	3	1
		Larger group of people with structures but not posing any risk	3	2
		Habitation causing obstructions or, fire or safety risk	4	3
		Dense habitation creating a high fire or safety risk	4	4
Missing vertical clearance signs:	1 to 4	No signs with vertical clearance less than 5.0 m	1	1
		No signs with vertical clearance less than 4.9 m	1	2
		No signs with vertical clearance less than 4.8 m	3	3
		No signs with vertical clearance less than 4.8 m with beam-and-slab deck	3	4
Road signs – missing or damaged:	1 to 4	River name, information signs	1	1
		Warning signs, hazard signs but not posing a safety risk	1	3
		Warning signs, hazard signs posing a safety risk	4	4
Services and street lighting:	1 to 4	Services not attached properly, missing cover plates but not posing a risk	3	1
		Missing cover plates exposing wiring, damaged lighting posing some difficulty to pedestrians, etc.	3	2
		Exposed live wires, leaking sewerage, etc.	4	4
	1 to 4	Small holes, posing no danger	1	1

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Activity Description	Range of "R"	Remarks	U	R
Fencing – missing or damaged:		Posing a significant danger such as livestock getting onto the road or pedestrians crossing an extremely busy road	4	4
Structure number plate:	2	Damaged structure number plate	1	2
		Missing structure number plate	1	2
Animal infestation including bats, bees, wasps, snakes, etc.	1 to 3	Slight infestation, not posing a risk to people or the structure	3	1
		Dangerous infestation or causing damage to the structure such as guano causing corrosion	3	3

Appendix A3. Inspection Forms per Structure Type

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Inspection Form L1: Light Mast

ROAD AUTHORITY		STRUCTURE TYPE		LIGHT MAST NUMBERS			LOCATION SKETCH																	
		LIGHT MAST		From																				
				To																				
INSPECTION INFORMATION																								
Inspection Type		Inspector Name			Firm		Date (dd/mm/yyyy)																	
GPS COORDINATES																								
Latitude (South)						Longitude (East)																		
DD	MM	SS.s	DD	MM	SS.s																			
Group of masts or single mast Y/N																								
LOCATION DETAIL																								
Road No.		Road km		Road Name			Region/Depot																	
STRUCTURE INFORMATION																								
Light Mast Height		No. of Masts in Group		Foundation Type		Light Mast Type		Light Mast Material		Year Constructed														
INSPECTION RATINGS																								
INSPECTION ITEM	1. FOUNDATIONS AND PLINTH			2. H D BOLTS AND BASE PLATES			3. MAST			4. LIGHT FITTINGS AND FIXINGS			5. ACCESS HATCH TO CONTROLS			6. LIGHT FITTINGS ACCESS SYSTEM			7. CABLE THEFT PREVENTION			8. MISCELLANEOUS ITEMS		
	POSITIONS	D	E	R	D	E	R	D	E	R	D	E	R	D	E	R	D	E	R	D	E	R	D	E
Group of light masts																								
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Appendix A4. Remedial Activities per Structure Type

Road Structure Management Part A: Appendix A4

Table A4.1 Remedial Activities for Bridges (General, Arch, Cable)

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Approach Embankment	01.116. Repair concrete sidedrain/gutter/downchute	m	1 460	Yes
01. Approach Embankment	01.155. Earth backfill	m ³	580	Yes
01. Approach Embankment	01.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
01. Approach Embankment	01.157. Mass concrete backfill	m ³	5 120	
01. Approach Embankment	01.158. Rock backfill	m ³	2 570	
01. Approach Embankment	01.201. Clean downchutes/sidedrains	m	140	Yes
01. Approach Embankment	01.357. Replace kerbs or berms	m	880	Yes
01. Approach Embankment	01.358. Replace cover slabs and lids	no	2 880	Yes
01. Approach Embankment	01.359. Replace sidedrain/gutter/downchutes	m	1 460	Yes
01. Approach Embankment	01.362. Replace inlet/outlet structures	no	8 540	Yes
01. Approach Embankment	01.363. Install kerbs or berms	m	880	Yes
01. Approach Embankment	01.402. Clear bush	m ²	80	Yes
01. Approach Embankment	01.404. Remove trees (girth < 500 mm)	no	700	Yes
01. Approach Embankment	01.405. Remove trees (girth > 500 mm)	no	2 880	Yes
01. Approach Embankment	01.504. Repair settlement (asphalt fill)	m ³	8 540	Yes
01. Approach Embankment	01.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Guardrail	02.451. Attach guardrail to endblock	no	2 880	Yes
02. Guardrail	02.452. Cut bolts for pedestrian safety	no	320	Yes
02. Guardrail	02.455. New guardrail (single and double)	m	880	Yes
02. Guardrail	02.463. Repair guardrail (realign, bolt replacement, etc.)	m	580	Yes
02. Guardrail	02.466. Replace bolts and washers	no	320	Yes
02. Guardrail	02.467. Replace posts (steel or timber)	no	580	Yes
02. Guardrail	02.468. Replace reflectors	no	140	Yes
02. Guardrail	02.469. Reverse laps in guardrails	no	1 460	Yes
02. Guardrail	02.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Waterway	03.151. Backfill scour damage (earth)	m ³	880	Yes
03. Waterway	03.152. Backfill scour damage (mass concrete)	m ³	7 110	
03. Waterway	03.153. Backfill scour damage (rock)	m ³	5 120	
03. Waterway	03.156. Gabion (mattresses and boxes)	m ³	2 880	Yes

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
03. Waterway	03.207. Clear debris	m ³	700	Yes
03. Waterway	03.209. Clear siltation	m ³	580	Yes
03. Waterway	03.404. Remove trees (girth < 500 mm)	no	700	Yes
03. Waterway	03.405. Remove trees (girth > 500 mm)	no	2 880	Yes
03. Waterway	03.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Approach Embankment Protection Works	04.155. Earth backfill	m ³	580	Yes
04. Approach Embankment Protection Works	04.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
04. Approach Embankment Protection Works	04.157. Mass concrete backfill	m ³	5 120	
04. Approach Embankment Protection Works	04.158. Rock backfill	m ³	2 570	
04. Approach Embankment Protection Works	04.159. Stone pitching	m ²	880	Yes
04. Approach Embankment Protection Works	04.160. Interlocking blocks	m ²	450	Yes
04. Approach Embankment Protection Works	04.401. Apply weed killer/ant poison and remove growth	m ²	80	Yes
04. Approach Embankment Protection Works	04.403. Grassing	m ²	140	Yes
04. Approach Embankment Protection Works	04.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Abutment Foundations	05.101. Apply protective coating	m ²	450	
05. Abutment Foundations	05.102. Apply silanes	m ²	450	
05. Abutment Foundations	05.106. Construct earth berms for access	m ³	880	
05. Abutment Foundations	05.108. Cut back reinforcement (tie rods) and make good	no	210	
05. Abutment Foundations	05.118. Repair spall (including honeycombing)	L	700	
05. Abutment Foundations	05.120. Seal cracks	m	700	
05. Abutment Foundations	05.155. Earth backfill	m ³	580	Yes
05. Abutment Foundations	05.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
05. Abutment Foundations	05.157. Mass concrete backfill	m ³	5 120	
05. Abutment Foundations	05.158. Rock backfill	m ³	2 570	
05. Abutment Foundations	05.161. Underpinning (describe under Remarks)	no	71 280	
05. Abutment Foundations	05.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Abutments	06.101. Apply protective coating	m ²	450	
06. Abutments	06.102. Apply silanes	m ²	450	
06. Abutments	06.103. Clean concrete surface	m ²	140	
06. Abutments	06.104. Concrete (reinforced)	m ³	11 410	
06. Abutments	06.105. Concrete (mass)	m ³	11 410	

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
06. Abutments	06.108. Cut back reinforcement (tie rods) and make good	no	210	
06. Abutments	06.114. Reconstruct backwall (re-instate gap)	m ³	21 370	
06. Abutments	06.115. Repair anchor heads	no	8 540	
06. Abutments	06.118. Repair spall (including honeycombing)	L	700	
06. Abutments	06.120. Seal cracks	m	700	
06. Abutments	06.122. Stabilise wall with ground/rock anchors	m ²	7 110	
06. Abutments	06.154. Construct masonry wall	m ²	1 460	
06. Abutments	06.202. Clean drainage	m	140	Yes
06. Abutments	06.207. Clear debris	m ³	700	Yes
06. Abutments	06.309. Reinststate expansion gap	m	14 270	
06. Abutments	06.311. Remove/repair cladding/bearing protection plates	m	1 460	Yes
06. Abutments	06.314. Replace joint sealant	m	320	Yes
06. Abutments	06.355. Repair weep holes	no	1 460	
06. Abutments	06.618. Service and repair gully doors/manholes	no	4 310	Yes
06. Abutments	06.653. Access-using scaffold (> 10 m)	no	7 110	
06. Abutments	06.654. Access-using scaffold (< 10 m)	no	4 310	
06. Abutments	06.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
06. Abutments	06.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
06. Abutments	06.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
06. Abutments	06.953. Ad-hoc item (describe under Remarks)	no	1 000	
07. Wing/ Retaining Walls	07.101. Apply protective coating	m ²	450	
07. Wing/ Retaining Walls	07.102. Apply silanes	m ²	450	
07. Wing/ Retaining Walls	07.103. Clean concrete surface	m ²	140	
07. Wing/ Retaining Walls	07.104. Concrete (reinforced)	m ³	11 410	
07. Wing/ Retaining Walls	07.105. Concrete (mass)	m ³	11 410	
07. Wing/ Retaining Walls	07.108. Cut back reinforcement (tie rods) and make good	no	210	
07. Wing/ Retaining Walls	07.118. Repair spall (including honeycombing)	L	700	
07. Wing/ Retaining Walls	07.120. Seal cracks	m	700	
07. Wing/ Retaining Walls	07.122. Stabilise wall with ground/rock anchors	m ²	7 110	
07. Wing/ Retaining Walls	07.155. Earth backfill	m ³	580	Yes
07. Wing/ Retaining Walls	07.156. Gabion (mattresses and boxes)	m ³	2 880	Yes

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
07. Wing/ Retaining Walls	07.157. Mass concrete backfill	m ³	5 120	
07. Wing/ Retaining Walls	07.158. Rock backfill	m ³	2 570	
07. Wing/ Retaining Walls	07.161. Underpinning (describe under Remarks)	no	71 280	
07. Wing/ Retaining Walls	07.207. Clear debris	m ³	700	Yes
07. Wing/ Retaining Walls	07.309. Reinstate expansion gap	m	14 270	
07. Wing/ Retaining Walls	07.314. Replace joint sealant	m	320	Yes
07. Wing/ Retaining Walls	07.355. Repair weep holes	no	1 460	
07. Wing/ Retaining Walls	07.607. Monitor (movements, rotations, etc.) (5 year period)	no	28 520	
07. Wing/ Retaining Walls	07.653. Access-using scaffold (> 10 m)	no	7 110	
07. Wing/ Retaining Walls	07.654. Access-using scaffold (< 10 m)	no	4 310	
07. Wing/ Retaining Walls	07.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
07. Wing/ Retaining Walls	07.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
07. Wing/ Retaining Walls	07.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
07. Wing/ Retaining Walls	07.953. Ad-hoc item (describe under Remarks)	no	1 000	
08. Surfacing	08.117. Repair concrete topping	m ³	7 110	
08. Surfacing	08.207. Clear debris	m ³	700	Yes
08. Surfacing	08.209. Clear siltation	m ³	580	Yes
08. Surfacing	08.501. Crack seal (asphalt)	m	80	Yes
08. Surfacing	08.502. Resurface or patch	m ²	700	Yes
08. Surfacing	08.505. Shape surfacing at scuppers	no	700	Yes
08. Surfacing	08.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
08. Surfacing	08.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
08. Surfacing	08.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
08. Surfacing	08.953. Ad-hoc item (describe under Remarks)	no	1 000	
09. Superstructure Drainage	09.206. Clear channel	m	140	Yes
09. Superstructure Drainage	09.208. Clear scuppers	no	320	
09. Superstructure Drainage	09.351. Construct new scuppers	no	5 750	
09. Superstructure Drainage	09.353. Extend scupper below deck soffit	no	2 880	
09. Superstructure Drainage	09.354. Repair scuppers	no	2 880	
09. Superstructure Drainage	09.361. Replace grid inlet	no	7 110	
09. Superstructure Drainage	09.365. Seal leaking pipes	no	2 880	

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
09. Superstructure Drainage	09.653. Access-using scaffold (> 10 m)	no	7 110	
09. Superstructure Drainage	09.654. Access-using scaffold (< 10 m)	no	4 310	
09. Superstructure Drainage	09.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
09. Superstructure Drainage	09.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
09. Superstructure Drainage	09.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
09. Superstructure Drainage	09.953. Ad-hoc item (describe under Remarks)	no	1 000	
10. Kerbs / Sidewalks	10.101. Apply protective coating	m ²	450	
10. Kerbs / Sidewalks	10.102. Apply silanes	m ²	450	
10. Kerbs / Sidewalks	10.118. Repair spall (including honeycombing)	L	700	
10. Kerbs / Sidewalks	10.120. Seal cracks	m	700	
10. Kerbs / Sidewalks	10.207. Clear debris	m ³	700	Yes
10. Kerbs / Sidewalks	10.314. Replace joint sealant	m	320	Yes
10. Kerbs / Sidewalks	10.357. Replace kerbs or berms	m	880	Yes
10. Kerbs / Sidewalks	10.363. Install kerbs or berms	m	880	Yes
10. Kerbs / Sidewalks	10.366. Install/replace concrete channel	m	450	
10. Kerbs / Sidewalks	10.568. Replace service duct cover	no	2 880	
10. Kerbs / Sidewalks	10.609. Provide sidewalk	m ²	1 460	Yes
10. Kerbs / Sidewalks	10.614. Repair sidewalk surface (blocks, screed etc.)	m ²	700	Yes
10. Kerbs / Sidewalks	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
10. Kerbs / Sidewalks	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
10. Kerbs / Sidewalks	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
10. Kerbs / Sidewalks	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
11. Parapet	11.101. Apply protective coating	m ²	450	
11. Parapet	11.102. Apply silanes	m ²	450	
11. Parapet	11.103. Clean concrete surface	m ²	140	
11. Parapet	11.104. Concrete (reinforced)	m ³	11 410	
11. Parapet	11.113. Concrete (precast)	m ³	17 130	
11. Parapet	11.118. Repair spall (including honeycombing)	L	700	
11. Parapet	11.120. Seal cracks	m	700	
11. Parapet	11.309. Reinststate expansion gap	m	14 270	
11. Parapet	11.314. Replace joint sealant	m	320	Yes

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
11. Parapet	11.453. Install full height pedestrian balustrade	m	2 880	
11. Parapet	11.454. New endblocks	no	14 270	
11. Parapet	11.456. New pedestrian parapet	m	4 740	
11. Parapet	11.457. New traffic barrier (Concrete F-Shape/NJ)	m	10 730	
11. Parapet	11.458. New/repair steel railing	m	2 880	
11. Parapet	11.459. Paint steel rails	m ²	700	
11. Parapet	11.462. Realign handrails	m	2 880	
11. Parapet	11.464. Repair/replace guardrail fixings	no	2 130	Yes
11. Parapet	11.465. Repair/replace handrail posts	no	1 460	
11. Parapet	11.569. Replace service duct cover	no	2 880	
11. Parapet	11.651. Access-using hanging basket for outer surface	no	28 520	
11. Parapet	11.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
11. Parapet	11.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
11. Parapet	11.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
11. Parapet	11.953. Ad-hoc item (describe under Remarks)	no	1 000	
12. Pier Protection Works	12.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
12. Pier Protection Works	12.157. Mass concrete backfill	m ³	5 120	
12. Pier Protection Works	12.158. Rock backfill	m ³	2 570	
12. Pier Protection Works	12.460. Provide guardrail protection	m	880	Yes
12. Pier Protection Works	12.461. Provide F-shape NJ barrier protection	m	10 730	
12. Pier Protection Works	12.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
12. Pier Protection Works	12.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
12. Pier Protection Works	12.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
12. Pier Protection Works	12.953. Ad-hoc item (describe under Remarks)	no	1 000	
13. Pier Foundations	13.101. Apply protective coating	m ²	450	
13. Pier Foundations	13.102. Apply silanes	m ²	450	
13. Pier Foundations	13.104. Concrete (reinforced)	m ³	11 410	
13. Pier Foundations	13.105. Concrete (mass)	m ³	11 410	
13. Pier Foundations	13.106. Construct earth berms for access	m ³	880	
13. Pier Foundations	13.118. Repair spall (including honeycombing)	L	700	
13. Pier Foundations	13.120. Seal cracks	m	700	

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
13. Pier Foundations	13.155. Earth backfill	m ³	580	Yes
13. Pier Foundations	13.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
13. Pier Foundations	13.157. Mass concrete backfill	m ³	5 120	
13. Pier Foundations	13.158. Rock backfill	m ³	2 570	
13. Pier Foundations	13.161. Underpinning (describe under Remarks)	no	71 280	
13. Pier Foundations	13.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
13. Pier Foundations	13.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
13. Pier Foundations	13.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
13. Pier Foundations	13.953. Ad-hoc item (describe under Remarks)	no	1 000	
14. Piers & Columns	14.101. Apply protective coating	m ²	450	
14. Piers & Columns	14.102. Apply silanes	m ²	450	
14. Piers & Columns	14.103. Clean concrete surface	m ²	140	
14. Piers & Columns	14.104. Concrete (reinforced)	m ³	11 410	
14. Piers & Columns	14.108. Cut back reinforcement (tie rods) and make good	no	210	
14. Piers & Columns	14.118. Repair spall (including honeycombing)	L	700	
14. Piers & Columns	14.120. Seal cracks	m	700	
14. Piers & Columns	14.207. Clear debris	m ³	700	Yes
14. Piers & Columns	14.310. Remove cladding - bearing plates	m	700	Yes
14. Piers & Columns	14.653. Access-using scaffold (> 10 m)	no	7 110	
14. Piers & Columns	14.654. Access-using scaffold (< 10 m)	no	4 310	
14. Piers & Columns	14.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
14. Piers & Columns	14.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
14. Piers & Columns	14.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
14. Piers & Columns	14.953. Ad-hoc item (describe under Remarks)	no	1 000	
15. Bearings	15.251. Jacking - complicated (provide jack support work)	no	57 020	
15. Bearings	15.252. Jacking - simple (flat jacks)	no	14 270	
15. Bearings	15.253. Refurbish (corrosion protection, anchor bolts, etc.)	no	4 310	
15. Bearings	15.254. Repair bearing plinth	no	7 110	
15. Bearings	15.255. Replace - elastomeric	no	4 310	
15. Bearings	15.256. Replace - mechanical	no	7 110	
15. Bearings	15.257. Re-seat	no	5 750	

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
15. Bearings	15.258. Service bearing (clear obstructions, etc.)	no	7 110	Yes
15. Bearings	15.653. Access-using scaffold (> 10 m)	no	7 110	
15. Bearings	15.654. Access-using scaffold (< 10 m)	no	4 310	
15. Bearings	15.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
15. Bearings	15.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
15. Bearings	15.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
15. Bearings	15.953. Ad-hoc item (describe under Remarks)	no	1 000	
16. Support Drainage	16.205. Clear blocked drainage	no	700	Yes
16. Support Drainage	16.360. Replace drainage	m	5 750	
16. Support Drainage	16.953. Ad-hoc item (describe under Remarks)	no	1 000	
17. Expansion Joints	17.203. Clean joint of loose material	m	320	
17. Expansion Joints	17.301. Install silicon/bituminous seal	m	1 140	
17. Expansion Joints	17.302. Joint cover plates (replace and refit)	no	3 560	
17. Expansion Joints	17.304. New 40mm claw	m	14 270	
17. Expansion Joints	17.305. New 80mm claw	m	14 270	
17. Expansion Joints	17.306. New asphalt plug joint	m	5 750	
17. Expansion Joints	17.307. New multi element joint	m	42 770	
17. Expansion Joints	17.308. Refurbish (paint, etc.) metal claw/rail	m	700	
17. Expansion Joints	17.312. Repair concrete at joint up-turns	L	700	
17. Expansion Joints	17.313. Repair concrete nosing	m	2 880	
17. Expansion Joints	17.315. Replace glands of claw joint	m	2 130	
17. Expansion Joints	17.316. Replace pressfit seal with silicone	m	1 460	
17. Expansion Joints	17.317. Service multi-element joint	m	14 270	
17. Expansion Joints	17.602. Bolts to cover plates	no	390	Yes
17. Expansion Joints	17.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
17. Expansion Joints	17.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
17. Expansion Joints	17.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
17. Expansion Joints	17.953. Ad-hoc item (describe under Remarks)	no	1 000	
18. Longitudinal Members	18.101. Apply protective coating	m ²	450	
18. Longitudinal Members	18.102. Apply silanes	m ²	450	
18. Longitudinal Members	18.103. Clean concrete surface	m ²	140	

Road Structure Management Part A: Appendix A4

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
18. Longitudinal Members	18.104. Concrete (reinforced)	m ³	11 410	
18. Longitudinal Members	18.108. Cut back reinforcement (tie rods) and make good	no	210	
18. Longitudinal Members	18.110. Jacking - complicated (provide jack support work)	no	57 020	
18. Longitudinal Members	18.111. Jacking - simple (flat jacks)	no	14 270	
18. Longitudinal Members	18.118. Repair spall (including honeycombing)	L	700	
18. Longitudinal Members	18.120. Seal cracks	m	700	
18. Longitudinal Members	18.123. Strengthening (using plates, carbon fibre, etc.)	m ²	57 020	
18. Longitudinal Members	18.352. Drill drainage holes	no	4 310	
18. Longitudinal Members	18.520. Cable anchorage refurbishment for cables up to 100 mm diameter	no	12 460	
18. Longitudinal Members	18.521. Cable anchorage refurbishment for cables 100 mm to 200 mm diameter	no	14 950	
18. Longitudinal Members	18.522. Cable anchorage refurbishment for cables greater than 200 mm diameter	no	24 910	
18. Longitudinal Members	18.523. Cable replacement up to 100 mm diameter	m	6 240	
18. Longitudinal Members	18.524. Cable replacement 100 mm to 200 mm diameter	m	12 460	
18. Longitudinal Members	18.525. Cable replacement greater than 200 mm diameter	m	18 690	
18. Longitudinal Members	18.526. Access to pylon head for repair (crane or other means)	Sum	62 250	
18. Longitudinal Members	18.527. Install vandalism tubes to cables	no	31 140	
18. Longitudinal Members	18.528. Additional (corrosion) protection for cables (painting, wrapping or sheathing a cable)	m	12 460	
18. Longitudinal Members	18.553. Corrosion protection to steel cables	m	700	
18. Longitudinal Members	18.576. Structural steel - re-torque bolts	no	390	Yes
18. Longitudinal Members	18.653. Access-using scaffold (> 10 m)	no	7 110	
18. Longitudinal Members	18.654. Access-using scaffold (< 10 m)	no	4 310	
18. Longitudinal Members	18.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
18. Longitudinal Members	18.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
18. Longitudinal Members	18.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
18. Longitudinal Members	18.953. Ad-hoc item (describe under Remarks)	no	1 000	
19. Transverse Members	19.101. Apply protective coating	m ²	450	
19. Transverse Members	19.102. Apply silanes	m ²	450	
19. Transverse Members	19.103. Clean concrete surface	m ²	140	
19. Transverse Members	19.104. Concrete (reinforced)	m ³	11 410	
19. Transverse Members	19.108. Cut back reinforcement (tie rods) and make good	no	210	
19. Transverse Members	19.110. Jacking - complicated (provide jack support work)	no	57 020	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
19. Transverse Members	19.111. Jacking - simple (flat jacks)	no	14 270	
19. Transverse Members	19.118. Repair spall (including honeycombing)	L	700	
19. Transverse Members	19.120. Seal cracks	m	700	
19. Transverse Members	19.123. Strengthening (using plates, carbon fibre, etc.)	m ²	57 020	
19. Transverse Members	19.352. Drill drainage holes	no	4 310	
19. Transverse Members	19.553. Corrosion protection to steel cables	m	700	
19. Transverse Members	19.653. Access-using scaffold (> 10 m)	no	7 110	
19. Transverse Members	19.654. Access-using scaffold (< 10 m)	no	4 310	
19. Transverse Members	19.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
19. Transverse Members	19.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
19. Transverse Members	19.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
19. Transverse Members	19.953. Ad-hoc item (describe under Remarks)	no	1 000	
20. Decks and Slabs	20.101. Apply protective coating	m ²	450	
20. Decks and Slabs	20.102. Apply silanes	m ²	450	
20. Decks and Slabs	20.103. Clean concrete surface	m ²	140	
20. Decks and Slabs	20.104. Concrete (reinforced)	m ³	11 410	
20. Decks and Slabs	20.108. Cut back reinforcement (tie rods) and make good	no	210	
20. Decks and Slabs	20.110. Jacking - complicated (provide jack support work)	no	57 020	
20. Decks and Slabs	20.111. Jacking - simple (flat jacks)	no	14 270	
20. Decks and Slabs	20.118. Repair spall (including honeycombing)	L	700	
20. Decks and Slabs	20.120. Seal cracks	m	700	
20. Decks and Slabs	20.123. Strengthening (using plates, carbon fibre, etc.)	m ²	57 020	
20. Decks and Slabs	20.125. Waterproofing of top surface	m ²	1 460	
20. Decks and Slabs	20.207. Clear debris	m ³	700	Yes
20. Decks and Slabs	20.352. Drill drainage holes	no	4 310	
20. Decks and Slabs	20.551. Paint steelwork	m ²	700	
20. Decks and Slabs	20.553. Corrosion protection to steel cables	m	700	
20. Decks and Slabs	20.556. Structural steel - remove all rivets and replace with bolts	no	1 460	
20. Decks and Slabs	20.557. Structural steel - remove all rivets and replace	no	1 460	
20. Decks and Slabs	20.558. Structural steel - replace bolts, washers etc.	no	450	Yes
20. Decks and Slabs	20.559. Replace structural steel member	t	85 530	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
20. Decks and Slabs	20.577. Structural steel - sand blast to white metal	m ²	700	
20. Decks and Slabs	20.578. Strengthen structural steel member	t	85 530	
20. Decks and Slabs	20.653. Access-using scaffold (> 10 m)	no	7 110	
20. Decks and Slabs	20.654. Access-using scaffold (< 10 m)	no	4 310	
20. Decks and Slabs	20.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
20. Decks and Slabs	20.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
20. Decks and Slabs	20.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
20. Decks and Slabs	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
21. Miscellaneous Items	21.119. Repair support plinths	L	390	
21. Miscellaneous Items	21.554. Corrosion protection to masts	m ²	1 460	
21. Miscellaneous Items	21.570. Replace cover plates on street lights	no	1 460	
21. Miscellaneous Items	21.601. Bolts (miscellaneous)	no	210	Yes
21. Miscellaneous Items	21.604. Install clearance sign	no	7 110	Yes
21. Miscellaneous Items	21.606. Install fencing	m	880	Yes
21. Miscellaneous Items	21.610. Rebuild/repair access chamber	no	21 370	Yes
21. Miscellaneous Items	21.612. Remove people using structure as habitat	LS	42 770	Yes
21. Miscellaneous Items	21.613. Repair service hangers (lighting etc.)	no	5 750	
21. Miscellaneous Items	21.615. Repair sign gantries	no	42 770	
21. Miscellaneous Items	21.616. Repair signpost connections	no	1 460	Yes
21. Miscellaneous Items	21.617. Replace road signs	m ²	2 310	Yes
21. Miscellaneous Items	21.619. Service structure lights	no	1 460	Yes
21. Miscellaneous Items	21.620. Install structure number plate	no	5 000	
21. Miscellaneous Items	21.953. Ad-hoc item (describe under Remarks)	no	1 000	

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Table A4.2 Remedial Activities for Bridge (Cellular) and Culvert (Major)

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Apron Slabs & Cut Off Walls	01.101. Apply protective coating	m ²	450	
01. Apron Slabs & Cut Off Walls	01.102. Apply silanes	m ²	450	
01. Apron Slabs & Cut Off Walls	01.104. Concrete (reinforced)	m ³	11 410	
01. Apron Slabs & Cut Off Walls	01.105. Concrete (mass)	m ³	11 410	
01. Apron Slabs & Cut Off Walls	01.108. Cut back reinforcement (tie rods) and make good	no	210	
01. Apron Slabs & Cut Off Walls	01.118. Repair spall (including honeycombing)	L	700	
01. Apron Slabs & Cut Off Walls	01.120. Seal cracks	m	700	
01. Apron Slabs & Cut Off Walls	01.155. Earth backfill	m ³	580	Yes
01. Apron Slabs & Cut Off Walls	01.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
01. Apron Slabs & Cut Off Walls	01.157. Mass concrete backfill	m ³	5 120	
01. Apron Slabs & Cut Off Walls	01.158. Rock backfill	m ³	2 570	
01. Apron Slabs & Cut Off Walls	01.207. Clear debris	m ³	700	Yes
01. Apron Slabs & Cut Off Walls	01.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Wing / Ret / Head Walls	02.101. Apply protective coating	m ²	450	
02. Wing / Ret / Head Walls	02.102. Apply silanes	m ²	450	
02. Wing / Ret / Head Walls	02.103. Clean concrete surface	m ²	140	
02. Wing / Ret / Head Walls	02.104. Concrete (reinforced)	m ³	11 410	
02. Wing / Ret / Head Walls	02.105. Concrete (mass)	m ³	11 410	
02. Wing / Ret / Head Walls	02.108. Cut back reinforcement (tie rods) and make good	no	210	
02. Wing / Ret / Head Walls	02.118. Repair spall (including honeycombing)	L	700	
02. Wing / Ret / Head Walls	02.120. Seal cracks	m	700	
02. Wing / Ret / Head Walls	02.122. Stabilise wall with ground/rock anchors	m ²	7 110	
02. Wing / Ret / Head Walls	02.155. Earth backfill	m ³	580	Yes
02. Wing / Ret / Head Walls	02.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
02. Wing / Ret / Head Walls	02.157. Mass concrete backfill	m ³	5 120	
02. Wing / Ret / Head Walls	02.158. Rock backfill	m ³	2 570	
02. Wing / Ret / Head Walls	02.161. Underpinning (describe under Remarks)	no	71 280	
02. Wing / Ret / Head Walls	02.207. Clear debris	m ³	700	Yes
02. Wing / Ret / Head Walls	02.355. Repair weep holes	no	1 460	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
02. Wing / Ret / Head Walls	02.607. Monitor (movements, rotations, etc.) (5 year period)	no	28 520	
02. Wing / Ret / Head Walls	02.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Scour Protection Works	03.104. Concrete (reinforced)	m ³	11 410	
03. Scour Protection Works	03.105. Concrete (mass)	m ³	11 410	
03. Scour Protection Works	03.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
03. Scour Protection Works	03.157. Mass concrete backfill	m ³	5 120	
03. Scour Protection Works	03.158. Rock backfill	m ³	2 570	
03. Scour Protection Works	03.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Embankment/s	04.116. Repair concrete sidedrain/gutter/downchute	m	1 460	Yes
04. Embankment/s	04.155. Earth backfill	m ³	580	Yes
04. Embankment/s	04.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
04. Embankment/s	04.157. Mass concrete backfill	m ³	5 120	
04. Embankment/s	04.158. Rock backfill	m ³	2 570	
04. Embankment/s	04.159. Stone pitching	m ²	880	Yes
04. Embankment/s	04.160. Interlocking blocks	m ²	450	Yes
04. Embankment/s	04.201. Clean downchutes/sidedrains	m	140	Yes
04. Embankment/s	04.357. Replace kerbs or berms	m	880	Yes
04. Embankment/s	04.358. Replace cover slabs and lids	no	2 880	Yes
04. Embankment/s	04.359. Replace sidedrain/gutter/downchutes	m	1 460	Yes
04. Embankment/s	04.362. Replace inlet/outlet structures	no	8 540	Yes
04. Embankment/s	04.363. Install kerbs or berms	m	880	Yes
04. Embankment/s	04.401. Apply weed killer/ant poison and remove growth	m ²	80	Yes
04. Embankment/s	04.402. Clear bush	m ²	80	Yes
04. Embankment/s	04.403. Grassing	m ²	140	Yes
04. Embankment/s	04.404. Remove trees (girth < 500 mm)	no	700	Yes
04. Embankment/s	04.405. Remove trees (girth > 500 mm)	no	2 880	Yes
04. Embankment/s	04.504. Repair settlement (asphalt fill)	m ³	8 540	Yes
04. Embankment/s	04.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Waterway	05.151. Backfill scour damage (earth)	m ³	880	Yes
05. Waterway	05.152. Backfill scour damage (mass concrete)	m ³	7 110	
05. Waterway	05.153. Backfill scour damage (rock)	m ³	5 120	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
05. Waterway	05.156. Gabion (mattresses and boxes)	m ³	2 880	Yes
05. Waterway	05.207. Clear debris	m ³	700	Yes
05. Waterway	05.209. Clear siltation	m ³	580	Yes
05. Waterway	05.404. Remove trees (girth < 500 mm)	no	700	Yes
05. Waterway	05.405. Remove trees (girth > 500 mm)	no	2 880	Yes
05. Waterway	05.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Road Slabs	06.101. Apply protective coating	m ²	450	
06. Road Slabs	06.102. Apply silanes	m ²	450	
06. Road Slabs	06.104. Concrete (reinforced)	m ³	11 410	
06. Road Slabs	06.105. Concrete (mass)	m ³	11 410	
06. Road Slabs	06.117. Repair concrete topping	m ³	7 110	
06. Road Slabs	06.118. Repair spall (including honeycombing)	L	700	
06. Road Slabs	06.120. Seal cracks	m	700	
06. Road Slabs	06.155. Earth backfill	m ³	580	Yes
06. Road Slabs	06.157. Mass concrete backfill	m ³	5 120	
06. Road Slabs	06.158. Rock backfill	m ³	2 570	
06. Road Slabs	06.207. Clear debris	m ³	700	Yes
06. Road Slabs	06.501. Crack seal (asphalt)	m	80	Yes
06. Road Slabs	06.503. Resurface or patch asphalt	m ²	700	Yes
06. Road Slabs	06.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
06. Road Slabs	06.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
06. Road Slabs	06.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
06. Road Slabs	06.953. Ad-hoc item (describe under Remarks)	no	1 000	
07. Roadway Joints	07.203. Clean joint of loose material	m	320	
07. Roadway Joints	07.207. Clear debris	m ³	700	Yes
07. Roadway Joints	07.301. Install silicon/bituminous seal	m	1 140	
07. Roadway Joints	07.302. Joint cover plates (replace and refit)	no	3 560	
07. Roadway Joints	07.303. Monitor (movements, rotations, etc.) (5 year period)	no	28 520	
07. Roadway Joints	07.304. New 40mm claw	m	14 270	
07. Roadway Joints	07.306. New asphalt plug joint	m	5 750	
07. Roadway Joints	07.308. Refurbish (paint, etc.) metal claw/rail	m	700	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
07. Roadway Joints	07.312. Repair concrete at joint up-turns	L	700	
07. Roadway Joints	07.315. Replace glands of claw joint	m	2 130	
07. Roadway Joints	07.316. Replace pressfit seal with silicone	m	1 460	
07. Roadway Joints	07.602. Bolts to cover plates	no	390	Yes
07. Roadway Joints	07.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
07. Roadway Joints	07.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
07. Roadway Joints	07.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
07. Roadway Joints	07.953. Ad-hoc item (describe under Remarks)	no	1 000	
08. Guardrails	08.451. Attach guardrail to endblock	no	2 880	Yes
08. Guardrails	08.452. Cut bolts for pedestrian safety	no	320	Yes
08. Guardrails	08.455. New guardrail (single and double)	m	880	Yes
08. Guardrails	08.463. Repair guardrail (realign, bolt replacement, etc.)	m	580	Yes
08. Guardrails	08.466. Replace bolts and washers	no	320	Yes
08. Guardrails	08.467. Replace posts (steel or timber)	no	580	Yes
08. Guardrails	08.468. Replace reflectors	no	140	Yes
08. Guardrails	08.469. Reverse laps in guardrails	no	1 460	Yes
08. Guardrails	08.953. Ad-hoc item (describe under Remarks)	no	1 000	
09. Parapets / Handrails	09.101. Apply protective coating	m ²	450	
09. Parapets / Handrails	09.102. Apply silanes	m ²	450	
09. Parapets / Handrails	09.103. Clean concrete surface	m ²	140	
09. Parapets / Handrails	09.104. Concrete (reinforced)	m ³	11 410	
09. Parapets / Handrails	09.112. New endblocks	no	14 270	
09. Parapets / Handrails	09.113. Concrete (precast)	m ³	17 130	
09. Parapets / Handrails	09.118. Repair spall (including honeycombing)	L	700	
09. Parapets / Handrails	09.120. Seal cracks	m	700	
09. Parapets / Handrails	09.314. Replace joint sealant	m	320	Yes
09. Parapets / Handrails	09.453. Install full height pedestrian balustrade	m	2 880	
09. Parapets / Handrails	09.456. New pedestrian parapet	m	4 740	
09. Parapets / Handrails	09.457. New traffic barrier (Concrete F-Shape/NJ)	m	10 730	
09. Parapets / Handrails	09.458. New/repair steel railing	m	2 880	
09. Parapets / Handrails	09.459. Paint steel rails	m ²	700	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
09. Parapets / Handrails	09.462. Realign handrails	m	2 880	
09. Parapets / Handrails	09.464. Repair/replace guardrail fixings	no	2 130	Yes
09. Parapets / Handrails	09.465. Repair/replace handrail posts	no	1 460	
09. Parapets / Handrails	09.466. Replace bolts and washers	no	320	Yes
09. Parapets / Handrails	09.568. Replace service duct cover	no	2 880	
09. Parapets / Handrails	09.651. Access-using hanging basket for outer surface	no	28 520	
09. Parapets / Handrails	09.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
09. Parapets / Handrails	09.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
09. Parapets / Handrails	09.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
09. Parapets / Handrails	09.953. Ad-hoc item (describe under Remarks)	no	1 000	
10. Walls	10.101. Apply protective coating	m ²	450	
10. Walls	10.102. Apply silanes	m ²	450	
10. Walls	10.103. Clean concrete surface	m ²	140	
10. Walls	10.104. Concrete (reinforced)	m ³	11 410	
10. Walls	10.105. Concrete (mass)	m ³	11 410	
10. Walls	10.108. Cut back reinforcement (tie rods) and make good	no	210	
10. Walls	10.115. Repair anchor heads	no	8 540	
10. Walls	10.118. Repair spall (including honeycombing)	L	700	
10. Walls	10.120. Seal cracks	m	700	
10. Walls	10.122. Stabilise wall with ground/rock anchors	m ²	7 110	
10. Walls	10.314. Replace joint sealant	m	320	Yes
10. Walls	10.355. Repair weep holes	no	1 460	
10. Walls	10.654. Access-using scaffold (< 10 m)	no	4 310	
10. Walls	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
11. Top Slab	11.101. Apply protective coating	m ²	450	
11. Top Slab	11.102. Apply silanes	m ²	450	
11. Top Slab	11.103. Clean concrete surface	m ²	140	
11. Top Slab	11.104. Concrete (reinforced)	m ³	11 410	
11. Top Slab	11.108. Cut back reinforcement (tie rods) and make good	no	210	
11. Top Slab	11.118. Repair spall (including honeycombing)	L	700	
11. Top Slab	11.120. Seal cracks	m	700	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
11. Top Slab	11.123. Strengthening (using plates, carbon fibre, etc.)	m ²	57 020	
11. Top Slab	11.352. Drill drainage holes	no	4 310	
11. Top Slab	11.654. Access-using scaffold (< 10 m)	no	4 310	
11. Top Slab	11.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
11. Top Slab	11.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
11. Top Slab	11.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
11. Top Slab	11.953. Ad-hoc item (describe under Remarks)	no	1 000	
12. Invert Slab	12.101. Apply protective coating	m ²	450	
12. Invert Slab	12.102. Apply silanes	m ²	450	
12. Invert Slab	12.104. Concrete (reinforced)	m ³	11 410	
12. Invert Slab	12.105. Concrete (mass)	m ³	11 410	
12. Invert Slab	12.117. Repair concrete topping	m ³	7 110	
12. Invert Slab	12.118. Repair spall (including honeycombing)	L	700	
12. Invert Slab	12.120. Seal cracks	m	700	
12. Invert Slab	12.155. Earth backfill	m ³	580	Yes
12. Invert Slab	12.157. Mass concrete backfill	m ³	5 120	
12. Invert Slab	12.158. Rock backfill	m ³	2 570	
12. Invert Slab	12.207. Clear debris	m ³	700	Yes
12. Invert Slab	12.953. Ad-hoc item (describe under Remarks)	no	1 000	
13. Cell Deformation	13.104. Concrete (reinforced)	m ³	11 410	
13. Cell Deformation	13.105. Concrete (mass)	m ³	11 410	
13. Cell Deformation	13.109. Demolish and reconstruct	m ³	14 270	
13. Cell Deformation	13.121. Stabilise cell using precast beams	m ³	14 270	
13. Cell Deformation	13.654. Access-using scaffold (< 10 m)	no	4 310	
13. Cell Deformation	13.702. Traffic accommodation-Low (< 10 000 vpd)	LS	128 290	
13. Cell Deformation	13.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	213 810	
13. Cell Deformation	13.704. Traffic accommodation-High (> 40 000 vpd)	LS	285 060	
13. Cell Deformation	13.953. Ad-hoc item (describe under Remarks)	no	1 000	
14. Miscellaneous Items	14.570. Replace cover plates on street lights	no	1 460	
14. Miscellaneous Items	14.601. Bolts (miscellaneous)	no	210	Yes
14. Miscellaneous Items	14.604. Install clearance sign	no	7 110	Yes

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
14. Miscellaneous Items	14.605. Install culvert markers	no	5 750	Yes
14. Miscellaneous Items	14.606. Install fencing	m	880	Yes
14. Miscellaneous Items	14.612. Remove people using structure as habitat	LS	42 770	Yes
14. Miscellaneous Items	14.617. Replace road signs	m ²	2 310	Yes
14. Miscellaneous Items	14.619. Service structure lights	no	1 460	Yes
14. Miscellaneous Items	14.620. Install structure number plate	no	5 000	
14. Miscellaneous Items	14.621. Construct pedestal for culvert number	no	2 880	
14. Miscellaneous Items	14.953. Ad-hoc item (describe under Remarks)	no	1 000	

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Table A4.3 Remedial Activities for Culverts (Lesser)

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Inlet Works	01.101. Apply protective coating	m ²	280	
01. Inlet Works	01.102. Apply silanes	m ²	210	
01. Inlet Works	01.103. Clean concrete surface	m ²	70	
01. Inlet Works	01.104. Concrete (reinforced)	m ³	5 400	
01. Inlet Works	01.108. Cut back reinforcement (tie rods) and make good	no	70	
01. Inlet Works	01.118. Repair spall (including honeycombing)	L	140	
01. Inlet Works	01.120. Seal cracks	m	280	
01. Inlet Works	01.155. Earth backfill	m ³	280	Yes
01. Inlet Works	01.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
01. Inlet Works	01.157. Mass concrete backfill	m ³	2 440	
01. Inlet Works	01.158. Rock backfill	m ³	820	
01. Inlet Works	01.160. Interlocking blocks	m ²	420	Yes
01. Inlet Works	01.207. Clear debris	m ³	140	Yes
01. Inlet Works	01.355. Repair weep holes	no	210	
01. Inlet Works	01.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
01. Inlet Works	01.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
01. Inlet Works	01.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
01. Inlet Works	01.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Outlet Works	02.101. Apply protective coating	m ²	280	
02. Outlet Works	02.102. Apply silanes	m ²	210	
02. Outlet Works	02.103. Clean concrete surface	m ²	70	
02. Outlet Works	02.104. Concrete (reinforced)	m ³	5 400	
02. Outlet Works	02.108. Cut back reinforcement (tie rods) and make good	no	70	
02. Outlet Works	02.118. Repair spall (including honeycombing)	L	140	
02. Outlet Works	02.120. Seal cracks	m	280	
02. Outlet Works	02.155. Earth backfill	m ³	280	Yes
02. Outlet Works	02.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
02. Outlet Works	02.157. Mass concrete backfill	m ³	2 440	
02. Outlet Works	02.158. Rock backfill	m ³	820	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
02. Outlet Works	02.160. Interlocking blocks	m ²	420	Yes
02. Outlet Works	02.207. Clear debris	m ³	140	Yes
02. Outlet Works	02.355. Repair weep holes	no	210	
02. Outlet Works	02.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
02. Outlet Works	02.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
02. Outlet Works	02.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
02. Outlet Works	02.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Barrel/s	03.101. Apply protective coating	m ²	280	
03. Barrel/s	03.102. Apply silanes	m ²	210	
03. Barrel/s	03.103. Clean concrete surface	m ²	70	
03. Barrel/s	03.104. Concrete (reinforced)	m ³	5 400	
03. Barrel/s	03.105. Concrete (mass)	m ³	5 400	
03. Barrel/s	03.108. Cut back reinforcement (tie rods) and make good	no	70	
03. Barrel/s	03.109. Demolish and reconstruct	m ³	5 930	
03. Barrel/s	03.117. Repair concrete topping	m ³	3 370	
03. Barrel/s	03.118. Repair spall (including honeycombing)	L	140	
03. Barrel/s	03.120. Seal cracks	m	280	
03. Barrel/s	03.124. Strengthening of slab	m ²	26 920	
03. Barrel/s	03.155. Earth backfill	m ³	280	Yes
03. Barrel/s	03.157. Mass concrete backfill	m ³	2 440	
03. Barrel/s	03.158. Rock backfill	m ³	820	
03. Barrel/s	03.202. Clean drainage	m	70	Yes
03. Barrel/s	03.207. Clear debris	m ³	140	Yes
03. Barrel/s	03.314. Replace joint sealant	m	140	Yes
03. Barrel/s	03.352. Drill drainage holes	no	70	
03. Barrel/s	03.355. Repair weep holes	no	210	
03. Barrel/s	03.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
03. Barrel/s	03.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
03. Barrel/s	03.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
03. Barrel/s	03.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Waterway	04.151. Backfill scour damage (earth)	m ³	280	Yes

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
04. Waterway	04.152. Backfill scour damage (mass concrete)	m ³	2 440	
04. Waterway	04.153. Backfill scour damage (rock)	m ³	820	
04. Waterway	04.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
04. Waterway	04.207. Clear debris	m ³	140	Yes
04. Waterway	04.209. Clear siltation	m ³	140	Yes
04. Waterway	04.404. Remove trees (girth < 500 mm)	no	280	Yes
04. Waterway	04.405. Remove trees (girth > 500 mm)	no	680	Yes
04. Waterway	04.953. Ad-hoc item (describe under Remarks)	no	1 000	

Road Structure Management Part A: Appendix A4

Table A4. 4 Remedial Activities for Retaining Walls

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. External Drainage	01.116. Repair concrete sidedrain/gutter/downchute	m	680	Yes
01. External Drainage	01.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
01. External Drainage	01.201. Clean downchutes/sidedrains	m	70	Yes
01. External Drainage	01.206. Clear channel	m	70	Yes
01. External Drainage	01.357. Replace kerbs or berms	m	280	Yes
01. External Drainage	01.359. Replace sidedrain/gutter/downchutes	m	680	Yes
01. External Drainage	01.360. Replace drainage	m	140	
01. External Drainage	01.361. Replace grid inlet	no	550	
01. External Drainage	01.363. Install kerbs or berms	m	280	Yes
01. External Drainage	01.366. Install/replace concrete channel	m	210	
01. External Drainage	01.653. Access-using scaffold (> 10 m)	no	1 350	
01. External Drainage	01.654. Access-using scaffold (< 10 m)	no	680	
01. External Drainage	01.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
01. External Drainage	01.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
01. External Drainage	01.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
01. External Drainage	01.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Slope Protection	02.152. Backfill scour damage (mass concrete)	m ³	280	
02. Slope Protection	02.153. Backfill scour damage (rock)	m ³	2 440	
02. Slope Protection	02.155. Earth backfill	m ³	820	Yes
02. Slope Protection	02.156. Gabion (mattresses and boxes)	m ³	280	Yes
02. Slope Protection	02.158. Rock backfill	m ³	1 350	
02. Slope Protection	02.159. Stone pitching	m ²	820	Yes
02. Slope Protection	02.160. Interlocking blocks	m ²	420	Yes
02. Slope Protection	02.401. Apply weed killer/ant poison and remove growth	m ²	420	Yes
02. Slope Protection	02.402. Clear bush	m ²	50	Yes
02. Slope Protection	02.403. Grassing	m ²	60	Yes
02. Slope Protection	02.404. Remove trees (girth < 500 mm)	no	50	Yes
02. Slope Protection	02.405. Remove trees (girth > 500 mm)	no	280	Yes
02. Slope Protection	02.453. Install full height pedestrian balustrade	m	680	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
02. Slope Protection	02.621. Backfill scour damage (earth)	m ³	2 700	Yes
02. Slope Protection	02.653. Access-using scaffold (> 10 m)	no	1 350	
02. Slope Protection	02.654. Access-using scaffold (< 10 m)	no	680	
02. Slope Protection	02.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
02. Slope Protection	02.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
02. Slope Protection	02.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
02. Slope Protection	02.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Wall	03.101. Apply protective coating	m ²	280	
03. Wall	03.102. Apply silanes	m ²	210	
03. Wall	03.103. Clean concrete surface	m ²	70	
03. Wall	03.104. Concrete (reinforced)	m ³	5 400	
03. Wall	03.105. Concrete (mass)	m ³	5 400	
03. Wall	03.108. Cut back reinforcement (tie rods) and make good	no	70	
03. Wall	03.113. Concrete (precast)	m ³	8 080	
03. Wall	03.115. Repair anchor heads	no	8 080	
03. Wall	03.118. Repair spall (including honeycombing)	L	140	
03. Wall	03.120. Seal cracks	m	280	
03. Wall	03.122. Stabilise wall with ground/rock anchors	m ²	1 350	
03. Wall	03.123. Strengthening (using plates, carbon fibre, etc.)	m ²	13 470	
03. Wall	03.653. Access-using scaffold (> 10 m)	no	1 350	
03. Wall	03.654. Access-using scaffold (< 10 m)	no	680	
03. Wall	03.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
03. Wall	03.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
03. Wall	03.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
03. Wall	03.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Joints	04.203. Clean joint of loose material	m	70	
04. Joints	04.301. Install silicon/bituminous seal	m	280	
04. Joints	04.302. Joint cover plates (replace and refit)	no	1 890	
04. Joints	04.309. Reinststate expansion gap	m	6 740	
04. Joints	04.314. Replace joint sealant	m	140	Yes
04. Joints	04.653. Access-using scaffold (> 10 m)	no	1 350	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
04. Joints	04.654. Access-using scaffold (< 10 m)	no	680	
04. Joints	04.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
04. Joints	04.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
04. Joints	04.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
04. Joints	04.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Internal Drainage	05.205. Clear blocked drainage	no	70	Yes
05. Internal Drainage	05.207. Clear debris	m ³	140	Yes
05. Internal Drainage	05.209. Clear siltation	m ³	140	Yes
05. Internal Drainage	05.352. Drill drainage holes	no	70	
05. Internal Drainage	05.355. Repair weep holes	no	210	
05. Internal Drainage	05.360. Replace drainage	m	140	
05. Internal Drainage	05.365. Seal leaking pipes	no	350	
05. Internal Drainage	05.653. Access-using scaffold (> 10 m)	no	1 350	
05. Internal Drainage	05.654. Access-using scaffold (< 10 m)	no	680	
05. Internal Drainage	05.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
05. Internal Drainage	05.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
05. Internal Drainage	05.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
05. Internal Drainage	05.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Foundation	06.105. Concrete (mass)	m ³	5 400	
06. Foundation	06.157. Mass concrete backfill	m ³	2 440	
06. Foundation	06.158. Rock backfill	m ³	820	
06. Foundation	06.161. Underpinning (describe under Remarks)	no	13 470	
06. Foundation	06.607. Monitor (movements, rotations, etc.) (5 year period)	no	13 470	
06. Foundation	06.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
06. Foundation	06.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
06. Foundation	06.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
06. Foundation	06.953. Ad-hoc item (describe under Remarks)	no	1 000	
07. Miscellaneous	07.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
07. Miscellaneous	07.456. New pedestrian parapet	m	4 450	
07. Miscellaneous	07.457. New traffic barrier (Concrete F-Shape/NJ)	m	6 740	
07. Miscellaneous	07.458. New/repair steel railing	m	1 630	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
07. Miscellaneous	07.459. Paint steel rails	m ²	420	
07. Miscellaneous	07.551. Paint steelwork	m ²	420	
07. Miscellaneous	07.568. Replace service duct cover	no	280	
07. Miscellaneous	07.601. Bolts (miscellaneous)	no	70	Yes
07. Miscellaneous	07.602. Bolts to cover plates	no	140	Yes
07. Miscellaneous	07.606. Install fencing	m	820	Yes
07. Miscellaneous	07.609. Provide sidewalk	m ²	680	Yes
07. Miscellaneous	07.620. Install structure number plate	no	1 350	
07. Miscellaneous	07.953. Ad-hoc item (describe under Remarks)	no	1 000	

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Table A4.5 Remedial Activities for Gantries

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Guardrails	01.455. New guardrail (single and double)	m	420	Yes
01. Guardrails	01.460. Provide guardrail protection	m	420	Yes
01. Guardrails	01.462. Realign handrails	m	140	
01. Guardrails	01.463. Repair guardrail (realign, bolt replacement, etc.)	m	140	Yes
01. Guardrails	01.464. Repair/replace guardrail fixings	no	280	Yes
01. Guardrails	01.466. Replace bolts and washers	no	40	Yes
01. Guardrails	01.467. Replace posts (steel or timber)	no	280	Yes
01. Guardrails	01.468. Replace reflectors	no	70	Yes
01. Guardrails	01.469. Reverse laps in guardrails	no	140	Yes
01. Guardrails	01.551. Paint steelwork	m ²	420	
01. Guardrails	01.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
01. Guardrails	01.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
01. Guardrails	01.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
01. Guardrails	01.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Foundations	02.101. Apply protective coating	m ²	280	
02. Foundations	02.102. Apply silanes	m ²	210	
02. Foundations	02.103. Clean concrete surface	m ²	70	
02. Foundations	02.104. Concrete (reinforced)	m ³	5 400	
02. Foundations	02.105. Concrete (mass)	m ³	5 400	
02. Foundations	02.108. Cut back reinforcement (tie rods) and make good	no	70	
02. Foundations	02.118. Repair spall (including honeycombing)	L	140	
02. Foundations	02.120. Seal cracks	m	280	
02. Foundations	02.151. Backfill scour damage (earth)	m ³	280	Yes
02. Foundations	02.155. Earth backfill	m ³	280	Yes
02. Foundations	02.157. Mass concrete backfill	m ³	2 440	
02. Foundations	02.158. Rock backfill	m ³	820	
02. Foundations	02.159. Stone pitching	m ²	420	Yes
02. Foundations	02.160. Interlocking blocks	m ²	420	Yes
02. Foundations	02.607. Monitor (movements, rotations, etc.) (5 year period)	no	13 470	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
02. Foundations	02.620. Install structure number plate	no	1 350	
02. Foundations	02.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
02. Foundations	02.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
02. Foundations	02.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
02. Foundations	02.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. H D Bolts and Base Plates	03.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
03. H D Bolts and Base Plates	03.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	
03. H D Bolts and Base Plates	03.551. Paint steelwork	m ²	420	
03. H D Bolts and Base Plates	03.555. Gouging out of weld and re-welding (SB)	m	40 370	
03. H D Bolts and Base Plates	03.558. Structural steel - replace bolts, washers etc.	no	70	Yes
03. H D Bolts and Base Plates	03.591. Strengthen structural steel member	t	40 370	
03. H D Bolts and Base Plates	03.601. Bolts (miscellaneous)	no	70	Yes
03. H D Bolts and Base Plates	03.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
03. H D Bolts and Base Plates	03.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
03. H D Bolts and Base Plates	03.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
03. H D Bolts and Base Plates	03.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Vertical Member	04.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
04. Vertical Member	04.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	
04. Vertical Member	04.551. Paint steelwork	m ²	420	
04. Vertical Member	04.555. Gouging out of weld and re-welding (SB)	m	40 370	
04. Vertical Member	04.558. Structural steel - replace bolts, washers etc.	no	70	Yes
04. Vertical Member	04.591. Strengthen structural steel member	t	40 370	
04. Vertical Member	04.601. Bolts (miscellaneous)	no	70	Yes
04. Vertical Member	04.604. Install clearance sign	no	1 350	Yes
04. Vertical Member	04.654. Access-using scaffold (< 10 m)	no	680	
04. Vertical Member	04.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
04. Vertical Member	04.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
04. Vertical Member	04.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
04. Vertical Member	04.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Horizontal Member	05.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
05. Horizontal Member	05.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
05. Horizontal Member	05.551. Paint steelwork	m ²	420	
05. Horizontal Member	05.555. Gouging out of weld and re-welding (SB)	m	40 370	
05. Horizontal Member	05.558. Structural steel - replace bolts, washers etc.	no	70	Yes
05. Horizontal Member	05.591. Strengthen structural steel member	t	40 370	
05. Horizontal Member	05.601. Bolts (miscellaneous)	no	70	Yes
05. Horizontal Member	05.604. Install clearance sign	no	1 350	Yes
05. Horizontal Member	05.654. Access-using scaffold (< 10 m)	no	680	
05. Horizontal Member	05.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
05. Horizontal Member	05.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
05. Horizontal Member	05.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
05. Horizontal Member	05.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Sign Face	06.404. Remove trees (girth < 500 mm)	no	280	Yes
06. Sign Face	06.405. Remove trees (girth > 500 mm)	no	680	Yes
06. Sign Face	06.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
06. Sign Face	06.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	
06. Sign Face	06.551. Paint steelwork	m ²	420	
06. Sign Face	06.555. Gouging out of weld and re-welding (SB)	m	40 370	
06. Sign Face	06.558. Structural steel - replace bolts, washers etc.	no	70	Yes
06. Sign Face	06.591. Strengthen structural steel member	t	40 370	
06. Sign Face	06.601. Bolts (miscellaneous)	no	70	Yes
06. Sign Face	06.617. Replace road signs	m ²	2 160	Yes
06. Sign Face	06.621. Repair road signs whilst fixed to gantry	m ²	2 160	Yes
06. Sign Face	06.622. Repair road signs by removing, transport to workshop, repairing and re-erecting	m ²	5 400	Yes
06. Sign Face	06.623. Repair sign face lettering	no	140	
06. Sign Face	06.654. Access-using scaffold (< 10 m)	no	680	
06. Sign Face	06.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
06. Sign Face	06.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
06. Sign Face	06.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
06. Sign Face	06.953. Ad-hoc item (describe under Remarks)	no	1 000	
07. Sign Fasteners	07.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
07. Sign Fasteners	07.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
07. Sign Fasteners	07.551. Paint steelwork	m ²	420	
07. Sign Fasteners	07.555. Gouging out of weld and re-welding (SB)	m	40 370	
07. Sign Fasteners	07.558. Structural steel - replace bolts, washers etc.	no	70	Yes
07. Sign Fasteners	07.591. Strengthen structural steel member	t	40 370	
07. Sign Fasteners	07.601. Bolts (miscellaneous)	no	70	Yes
07. Sign Fasteners	07.654. Access-using scaffold (< 10 m)	no	680	
07. Sign Fasteners	07.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
07. Sign Fasteners	07.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
07. Sign Fasteners	07.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
07. Sign Fasteners	07.953. Ad-hoc item (describe under Remarks)	no	1 000	
08. Miscellaneous Items	08.457. New traffic barrier (Concrete F-Shape/NJ)	m	6 740	
08. Miscellaneous Items	08.461. Provide F-shape NJ barrier protection	m	6 740	
08. Miscellaneous Items	08.615. Repair sign gantries	no	40 370	
08. Miscellaneous Items	08.953. Ad-hoc item (describe under Remarks)	no	1 000	

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Table A4.6 Remedial Activities for Road Tunnels

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Portal	10.101. Apply protective coating	m ²	280	
01. Portal	10.102. Apply silanes	m ²	210	
01. Portal	10.103. Clean concrete surface	m ²	70	
01. Portal	10.104. Concrete (reinforced)	m ³	5 400	
01. Portal	10.105. Concrete (mass)	m ³	5 400	
01. Portal	10.108. Cut back reinforcement (tie rods) and make good	no	70	
01. Portal	10.113. Concrete (precast)	m ³	8 080	
01. Portal	10.118. Repair spall (including honeycombing)	L	140	
01. Portal	10.120. Seal cracks	m	280	
01. Portal	10.653. Access-using scaffold (> 10 m)	no	1 350	
01. Portal	10.654. Access-using scaffold (< 10 m)	no	680	
01. Portal	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
01. Portal	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
01. Portal	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
01. Portal	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. Slope Protection	02.114. Reconstruct backwall (re-instate gap)	m ³	8 080	
02. Slope Protection	10.113. Concrete (precast)	m ³	13 470	
02. Slope Protection	10.115. Repair anchor heads	no	8 080	
02. Slope Protection	10.116. Repair concrete sidedrain/gutter/downchute	m	680	Yes
02. Slope Protection	10.118. Repair spall (including honeycombing)	L	140	
02. Slope Protection	10.120. Seal cracks	m	280	
02. Slope Protection	10.122. Stabilise wall with ground/rock anchors	m ²	1 350	
02. Slope Protection	10.155. Earth backfill	m ³	280	Yes
02. Slope Protection	10.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
02. Slope Protection	10.157. Mass concrete backfill	m ³	2 440	
02. Slope Protection	10.158. Rock backfill	m ³	820	
02. Slope Protection	10.159. Stone pitching	m ²	420	Yes
02. Slope Protection	10.401. Apply weed killer/ant poison and remove growth	m ²	50	Yes
02. Slope Protection	10.403. Grassing	m ²	50	Yes

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
02. Slope Protection	10.653. Access-using scaffold (> 10 m)	no	1 350	
02. Slope Protection	10.654. Access-using scaffold (< 10 m)	no	680	
02. Slope Protection	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
02. Slope Protection	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
02. Slope Protection	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
02. Slope Protection	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Rockfall Protection	10.104. Concrete (reinforced)	m ³	5 400	
03. Rockfall Protection	10.105. Concrete (mass)	m ³	5 400	
03. Rockfall Protection	10.113. Concrete (precast)	m ³	8 080	
03. Rockfall Protection	10.115. Repair anchor heads	no	8 080	
03. Rockfall Protection	10.118. Repair spall (including honeycombing)	L	140	
03. Rockfall Protection	10.120. Seal cracks	m	280	
03. Rockfall Protection	10.154. Construct masonry wall	m ²	1 350	
03. Rockfall Protection	10.156. Gabion (mattresses and boxes)	m ³	1 350	Yes
03. Rockfall Protection	10.606. Install fencing	m	820	Yes
03. Rockfall Protection	10.653. Access-using scaffold (> 10 m)	no	1 350	
03. Rockfall Protection	10.654. Access-using scaffold (< 10 m)	no	680	
03. Rockfall Protection	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
03. Rockfall Protection	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
03. Rockfall Protection	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
03. Rockfall Protection	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Drainage	10.202. Clean drainage	m	70	Yes
04. Drainage	10.205. Clear blocked drainage	no	70	Yes
04. Drainage	10.206. Clear channel	m	70	Yes
04. Drainage	10.352. Drill drainage holes	no	70	
04. Drainage	10.360. Replace drainage	m	140	
04. Drainage	10.365. Seal leaking pipes	no	350	
04. Drainage	10.653. Access-using scaffold (> 10 m)	no	1 350	
04. Drainage	10.654. Access-using scaffold (< 10 m)	no	680	
04. Drainage	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
04. Drainage	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
04. Drainage	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
04. Drainage	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Road Surface	10.501. Crack seal (asphalt)	m	40	Yes
05. Road Surface	10.502. Resurface or patch	m ²	420	Yes
05. Road Surface	10.504. Repair settlement (asphalt fill)	m ³	4 720	Yes
05. Road Surface	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
05. Road Surface	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
05. Road Surface	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
05. Road Surface	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Lining	10.101. Apply protective coating	m ²	280	
06. Lining	10.102. Apply silanes	m ²	210	
06. Lining	10.103. Clean concrete surface	m ²	70	
06. Lining	10.104. Concrete (reinforced)	m ³	5 400	
06. Lining	10.105. Concrete (mass)	m ³	5 400	
06. Lining	10.108. Cut back reinforcement (tie rods) and make good	no	70	
06. Lining	10.113. Concrete (precast)	m ³	8 080	
06. Lining	10.118. Repair spall (including honeycombing)	L	140	
06. Lining	10.120. Seal cracks	m	280	
06. Lining	10.653. Access-using scaffold (> 10 m)	no	1 350	
06. Lining	10.654. Access-using scaffold (< 10 m)	no	680	
06. Lining	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
06. Lining	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
06. Lining	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
06. Lining	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
07. Joints	10.203. Clean joint of loose material	m	70	
07. Joints	10.301. Install silicon/bituminous seal	m	280	
07. Joints	10.309. Reinstate expansion gap	m	6 740	
07. Joints	10.653. Access-using scaffold (> 10 m)	no	1 350	
07. Joints	10.654. Access-using scaffold (< 10 m)	no	680	
07. Joints	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
07. Joints	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
07. Joints	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
07. Joints	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
08. Operational Service	10.653. Access-using scaffold (> 10 m)	no	1 350	
08. Operational Service	10.654. Access-using scaffold (< 10 m)	no	680	
08. Operational Service	10.702. Traffic accommodation-Low (< 10 000 vpd)	LS	121 100	
08. Operational Service	10.703. Traffic accommodation-Medium (10 000 - 40 000 vpd)	LS	148 000	
08. Operational Service	10.704. Traffic accommodation-High (> 40 000 vpd)	LS	188 370	
08. Operational Service	10.953. Ad-hoc item (describe under Remarks)	no	1 000	
09. Miscellaneous Items	10.604. Install clearance sign	no	1 350	Yes
09. Miscellaneous Items	10.609. Provide sidewalk	m ²	680	Yes
09. Miscellaneous Items	10.616. Repair signpost connections	no	420	Yes
09. Miscellaneous Items	10.617. Replace road signs	m ²	2 160	Yes
09. Miscellaneous Items	10.619. Service structure lights	no	210	Yes
09. Miscellaneous Items	10.620. Install structure number plate	no	1 350	
09. Miscellaneous Items	10.953. Ad-hoc item (describe under Remarks)	no	1 000	

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Table A4.7 Remedial Activities for Light Mast Group

Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
01. Foundations and Plinth	20.118. Repair spall (including honeycombing)	L	140	
01. Foundations and Plinth	20.120. Seal cracks	m	280	
01. Foundations and Plinth	20.155. Earth backfill	m ³	280	Yes
01. Foundations and Plinth	20.157. Mass concrete backfill	m ³	2 440	
01. Foundations and Plinth	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
02. HD Bolts and Base Plates	20.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
02. HD Bolts and Base Plates	20.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	
02. HD Bolts and Base Plates	20.551. Paint steelwork	m ²	420	
02. HD Bolts and Base Plates	20.555. Gouging out of weld and re-welding (SB)	m	40 370	
02. HD Bolts and Base Plates	20.558. Structural steel - replace bolts, washers etc.	no	70	Yes
02. HD Bolts and Base Plates	20.591. Strengthen structural steel member	t	40 370	
02. HD Bolts and Base Plates	20.601. Bolts (miscellaneous)	no	70	Yes
02. HD Bolts and Base Plates	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
03. Mast	20.549. Corrosion protection repair. Full removal of existing paint & rust	m ²	550	
03. Mast	20.550. Corrosion protection repair. Prepare existing painted surfaces	m ²	420	
03. Mast	20.551. Paint steelwork	m ²	420	
03. Mast	20.555. Gouging out of weld and re-welding (SB)	m	40 370	
03. Mast	20.558. Structural steel - replace bolts, washers etc.	no	70	Yes
03. Mast	20.591. Strengthen structural steel member	t	40 370	
03. Mast	20.601. Bolts (miscellaneous)	no	70	Yes
03. Mast	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
04. Light Fittings and Fixings	04.801. Repair light fittings and fixings	no	2 700	
04. Light Fittings and Fixings	04.802. Repair light fittings and fixings	no	5 400	
04. Light Fittings and Fixings	04.803. Replace lights or bulbs	no	1 350	Yes
04. Light Fittings and Fixings	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
05. Access Hatch to controls	05.821. Repair access hatch to electrical controls	no	2 700	
05. Access Hatch to controls	05.822. Replace access hatch to electrical controls	no	5 400	
05. Access Hatch to controls	05.823. Repair access hatch locking device	no	1 350	
05. Access Hatch to controls	05.824. Repair electrical controls	no	2 700	

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Inspection Item	Remedial Activity	Unit	Unit Cost (Apr 2019 Rand value)	Routine Maintenance
05. Access Hatch to controls	05.825. Replace electrical controls	no	5 400	
05. Access Hatch to controls	20.953. Ad-hoc item (describe under Remarks)	no	1 000	
06. Light Fittings Access System	06.830. Repair light fittings access system	no	4 050	
06. Light Fittings Access System	06.831. Replace light fittings access system	no	8 080	
06. Light Fittings Access System	06.832. Ad-hoc item (describe under Remarks)	no	1 000	
07. Cable Theft Prevention	07.840. Introduce cable theft preventative measures	no	4 050	
07. Cable Theft Prevention	07.841. Repair cable theft preventative measures	no	2 030	
07. Cable Theft Prevention	07.842. Ad-hoc item (describe under Remarks)	no	1 000	Yes
08. Miscellaneous Items	20.953. Ad-hoc item (describe under Remarks)	no	1 000	