# Bridge & Culvert Inspection Requirements for Mines and Ports

**Cris Balmes**[1]

[1]Aspec Engineering Pty Ltd, Brisbane, Australia; cbalmes@aspec.com.au
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## Abstract

Bridges and culverts are important assets in road systems. Their primary purpose is to allow vehicles to safely travel over obstacles such as rivers and drains. Another purpose is to cater for water flow in rivers and drains. Failure to maintain the structural integrity of these assets can lead to the collapse of the structure itself and the adjacent roadway, causing an increase in downtime for traffic and resultant costs. Bridges and culverts for the mining industry have similar functions to those on public roads. However, they may be subject to more onerous conditions from heavy vehicle loadings, changes to road alignments and changes to landscape and stream catchments to suit mining production.

## 1. Introduction

In terms of definition, a bridge is "a structure with a minimum span or diameter ≥ 1.8m or a waterway area ≥ 3m$^2$ for the primary purpose of carrying a road or path over obstacles" [1]. A culvert, is defined as "a structure with the primary purpose of providing a passageway beneath a road or path, usually but not necessarily for stormwater" [2]. This is particularly important in mines where the landscape can change at a frequent rate, causing local traffic access and the flow of waterways to be rediverted constantly. Asset integrity management and maintenance of bridges and culverts is crucial in allowing roads and waterways to operate effectively on mine sites and elsewhere.

## 2. Asset Integrity Management

Asset management is divided into two types: proactive and reactive. Proactive asset management involves a preventative approach to minimise deterioration and preserve structural integrity. This will consist of systematic servicing of a structure on a scheduled basis. Requirements for proactive asset management should be included in the asset owner's specifications. The following documents are also applicable:

- ISO 55000 – Asset Management Set
- IPWEA – International Infrastructure Management Manual
- Austroads – Guide to Asset Management
- Austroads – Guide to Bridge technology

Reactive asset management is a responsive approach involving the identification of major damage or defects observed in the structure. Reactive maintenance is performed when the need for maintenance intervention is necessary to prevent an unsafe situation occurring.

Both asset management types rely on structural inspections.

There are three levels of inspections that are recognised in the management framework [3] and are usually undertaken by a qualified inspector or engineer. These three levels are:

### 2.1 Level 1 – Routine Maintenance

Usually undertaken between 6-12 months, a routine maintenance inspection visually checks the overall serviceability of the structure and identifies any immediate risks to the user. Level 1 inspections generally provide simplistic descriptions of the condition of the structure's main components and are intended to prompt the asset owner if maintenance or a level 2 inspection is required.

### 2.2 Level 2 – Structure Condition

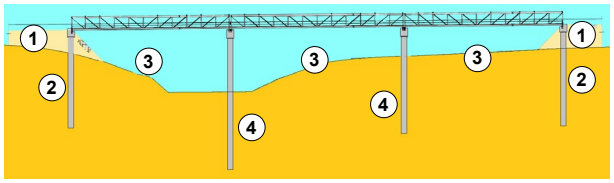
The structure condition inspection places emphasis on the overall condition of the structure based on the complexity and severity of the defects observed. Predominantly done as a visual check, the inspection is usually undertaken between 1-5 years and is done by providing a detailed assessment and defect rating of each component of a bridge or culvert as shown in Figure 1 and Figure 2. This includes a baseline check that is performed within 3 months of commissioning, or as specified by the asset owner's contract documents. Similarly, for any defects found, the asset owner may choose to undertake immediate repairs or escalate the situation to a level 3 inspection.

### 2.3 Level 3 – Engineering

An engineering inspection is an investigative approach to address complex issues found from the previous inspection levels, particularly for areas that are out of the normal scope (e.g. underwater inspections). This is usually undertaken by a qualified structural engineer as a response to a change in loading or from a defect/incident that could affect the overall capacity of the structure. As determined by the level 2 inspection, requirements such as shutdowns or non-destructive testing, such as strain gauging, may be implemented to undertake further testing of the components.

## 2.4 Inspection Components

Figure 1 shows bridge components for inspection.




1. Approach
2. Abutment (includes embankment)
3. Span (main superstructure, deck, handrails)
4. Pier (includes piles, headstocks, bearings)

**Figure 1 Bridge Areas and Components**

Figure 2 shows culvert components for inspection.


1. Embankment
2. Headwall (including wingwalls, if any)
3. Barrel (steel pipe or concrete box)
4. Spillway (includes scour protection / apron)

**Figure 2 Culvert Components**

# 3. Inspector Requirements

Visual inspections for bridges and culverts should be undertaken by a competent inspector that has undergone an approved level 1 and 2 bridge inspection training course with the following competencies [4]:

- RIICSG405D: Carry out inspections of civil structures
- RIIIMG301D: Maintain site records
- RIIRIS301D: Apply risk management processes

In addition, it is also recommended that the inspector has the following (although not limited to):

- Structural/civil/construction background
- First aid training
- Appropriate personal protective equipment (PPE) and equipment (e.g. camera, hammer, binoculars)
- Completion of any site inductions/permits/risk assessments documentations
- Driver's license and approval for driving on site
- Work at heights training/awareness
- Elevated Work Platform (EWP)
- Confined space awareness/training

Any engineering assessments or recommendations provided by the inspector should be supervised by a Registered Professional Engineer with relevant experience in the field.

# 4. Common Defects

Bridges and culverts tend to share common defects as their materials and functionality are typically similar. The common defects found in bridges and culverts include:

For concrete structures:

- Concrete damage
- Concrete cracking
- Concrete spalling
- Delamination

For steel structures:

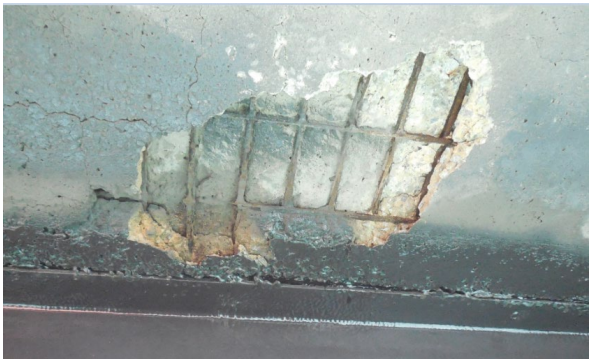
- Steel corrosion (including exposed reinforcement)
- Loss of protective coating
- Steel cracking
- Damage / Deformation

Miscellaneous:

- Missing / loose bolts / fixings
- Weld defects (e.g. cracks, corrosion, undercut, etc.)
- Rotting and infestation (timber structures)
- Displacements / Movements of components
- Erosion / Scouring / Settlement of the ground
- Drainage effectiveness and moisture ingress
- Blockage from sediment / debris / vegetation buildup

For a level 2 inspection, the condition of each defect must be rated based on a severity guideline specified by the client/site standards. The overall condition rating of the structure will depend on both the quantity and quality of defects observed. Depending on the severity of the damage, the recommended actions can vary as below.

- Regular monitoring / maintenance for minor defects
- Full repair and/or replacement for components considered severe/critical as shown in Figure 3.



(a)

(b)

**Figure 3 Concrete damage of the underside of a bridge deck, exposing corroded reinforcement (a) and a collapse of a culvert headwall due to the loosening of the internal steel barrel from ineffective drainage (b)**

The Department of Transport and Main Roads (DTMR) offers standardised servicing requirements for both preventative (proactive) and reactive maintenance on various components of the structure [5]. This can generally be used as a basis for recommending the appropriate action for each defect.

## 5. Inventory

In comparison to commercial sites, industrial sites such as mines have a tendency to constantly change landscape and be prone to highly corrosive environments. Although this means that bridges and culverts tend to be at a younger age, the environment exposure can lead to higher severity of defects.

A mine site can contain over 200 culverts at any given time which are scattered over large distances across the site. The travel time between culverts may take longer than the actual inspection of the culvert. Bridge inspections take a longer time due to scale. Hence, more planning is required to undertake bridge inspections effectively.

As a result, proper inventory management is critical in undertaking the inspection to ensure that resources are allocated efficiently between time and personnel.

Descriptions for inventory items should include the following information (which should be maintained or updated at every level 1 and 2 inspection):

- Name or Tag ID for all assets
- Function, age & environment details (e.g. river/tide levels for accessing the piers)
- Map of all asset locations (including GPS coordinates)
- Structural drawings for out-of-site components (e.g. connections, drainage, bearings, etc).
- Relevant measurement/dimensions
- Relevant survey data

Once the inspections have been undertaken, condition and risk levels can be assigned and determined efficiently for each asset.

## 6. General Requirements for Inspection

In summary, the following requirements are recommended for conducting and managing bridge and culvert asset inspections on a mine or industrial site.

Inspector requirements:

- Undertake a level 1 and 2 bridge inspection training from an approved training course
- Consider the requirements needed for accessing the site and structure (e.g. work at heights, PPE, etc.)
- Recognise the type of defects that occur on bridges and culverts and familiarise with the rating systems specified by the site to assess the level of risk of the structure

Asset Owner requirements:

- Provide an asset inventory of bridges and culverts on the site, and keep the information up-to-date
- Schedule inspections when environmental factors are most favourable (e.g. fine weather or during a shutdown period)
- Establish strategies for proactive maintenance on a scheduled basis, in conjunction with level 1 and 2 inspections.

## 7. References


[1] VicRoads, Road Structures Inspection Manual, Victoria, Australia, 2018.

[2] ARRB Group, Level 1 and 2 Inspection Workshop, Vermont, SA, Australia, 2017.

[3] DTMR, Structures Inspection Manual Part 1: Structures Inspection Policy, QLD Government, 2016.

[4] Australian Government, "Training.gov.au," 2021. [Online]. Available: https://training.gov.au/.

[5] DTMR, *Bridge/Culvert Servicing Manual,* Queensland: State of Queensland, 2008.