Contents

PART ONE - ROAD STRUCTURE INSPECTION POLICY ........................................................................................................6

1.1 Scope and Objectives ....................................................................................................................................................7
1.2 Road Structure Information ...........................................................................................................................................8
1.3 Occupational Health and Safety ...................................................................................................................................8
1.4 Structure Definitions ..................................................................................................................................................8

PART TWO - ROAD STRUCTURE INSPECTION PROCEDURES ...........................................................................10

1 General ........................................................................................................................................................................11
  1.1 Types of inspection ................................................................................................................................................11
  1.2 Occupational Health and Safety ..............................................................................................................................11

2 Level 1 – Routine maintenance inspection ....................................................................................................................13
  2.1 Purpose ....................................................................................................................................................................13
  2.2 Scope .....................................................................................................................................................................13
  2.3 Frequency of inspections .........................................................................................................................................13
  2.4 Inspector requirements ...........................................................................................................................................14
  2.5 Inspection procedure ............................................................................................................................................14
    2.5.1 Preparation for site inspection ........................................................................................................................14
    2.5.2 Extent of Level 1 inspections ..........................................................................................................................14
      (i) Structural integrity issues ................................................................................................................................14
      (ii) Routine maintenance issues .........................................................................................................................17
  2.6 Data recording .......................................................................................................................................................18

3 Level 2 – Structure condition inspections ....................................................................................................................19
  3.1 Purpose ....................................................................................................................................................................19
  3.2 Scope .....................................................................................................................................................................19
  3.3 Frequency of inspections .........................................................................................................................................19
  3.4 Inspector prequalification and auditing ...................................................................................................................19
  3.5 Inspection procedure ............................................................................................................................................20
    3.5.1 Preparation for site inspection ........................................................................................................................20
    3.5.2 Site inspection ................................................................................................................................................20
    3.5.3 Extent of inspection ........................................................................................................................................20
    3.5.4 Photography ..................................................................................................................................................21
  3.6 Data recording .......................................................................................................................................................22
    3.6.1 Bridge inspector’s sheet ....................................................................................................................................22
    3.6.2 Condition rating sheet ...................................................................................................................................22
      3.6.2.1 Condition rating of components .............................................................................................................22
      3.6.2.2 Predefined components ..........................................................................................................................22
      3.6.2.3 Undefined components ..........................................................................................................................23
    3.6.3 Structure defect sheet ......................................................................................................................................23
    3.6.4 Structure information sheet ............................................................................................................................23
    3.6.5 Structure inventory and photographic record sheet ..........................................................................................23
      3.6.5.1 Bridge and major culvert inventory data ...............................................................................................24
        3.6.5.1.1 Location of components ..................................................................................................................24
        3.6.5.1.2 Widenings ........................................................................................................................................24
        3.6.5.1.3 Joined Bridges ...............................................................................................................................25
        3.6.5.1.4 Global Positioning System (GPS) ....................................................................................................25
        3.6.5.1.5 Photographic record ......................................................................................................................26
        3.6.5.1.6 Measurements and quantities to be confirmed during the inspection ...........................................26
      3.6.5.2 Roadside structure inventory data ............................................................................................................27
        3.6.5.2.1 Major sign structures and high mast lighting structures ...............................................................27
4 Level 3 – Engineering investigations

4.1 Introduction
- Purpose
- Scope
- Definitions
- Categories for Level 3 investigations
- Categories of Level 3 investigation
- Preamble
- Response to individual accident or natural event
- Response to Level 1 or Level 2 inspection
- Programmed Level 3 investigations
- Detailed condition rating
- Load capacity assessment of structures
- Asset management of structures
- Data recording

5 Inspection Requirements for Specific Categories of Structures

5.1 Monitor inspections
- Purpose
- Definitions
- History
- Inspection and Monitoring
- Management of Monitor Structures

5.2 Complex Structures

5.3 Inspection of Timber Bridges with timber and/or steel stringers
- Introduction
- Technical Items
  - Timber Piles/Piers and Abutments
  - Timber Cross-Heads
  - Timber Corbels
  - Timber Stringers
  - Steel Beams
  - Timber Deck
  - Bridge Barriers and Handrails
  - Bridge Waterway and Scour
  - Traffic
- Recommendations

5.4 Investigation of Bridges without Drawings
- Introduction
- Procedure

5.5 Heritage and Historic Structures

5.6 Disused Structures
- Introduction
- Inspection and Maintenance of Signs and Fences
- Data Recording
- Occupational Health and Safety

5.7 Major Sign Structures
- Introduction
- Inspection procedures

5.8 Post Flood Management of Bridges
- Introduction
- Inspections and Assessments
  - General
  - Initial Post Flooding Inspection and Actions

3.6.5.2.2 Noise attenuation walls, visual screen walls and retaining walls
3.6.5.2.3 Emergency Median Barrier Access Gates
5.8.3 Vulnerable Structures ........................................................................................................................................ 48
5.8.4 Reporting ......................................................................................................................................................... 48
5.8.5 Load and Traffic Restrictions ........................................................................................................................ 48
5.8.6 Level 3 Detailed Engineering Inspection and Analysis .................................................................................. 49
5.8.7 Load Assessment .............................................................................................................................................. 49
Part one - Road structure inspection policy
1.1 Scope and Objectives

The purpose of the Road Structures Inspection Manual is to ensure that all structures are systematically inspected for the following reasons:

- to ensure the safety of road-users
- to ensure the structural integrity of bridges and other road structures
- to provide data for:
  - Regional and State asset management programs
  - Bridge capacity assessment
  - Feedback to the design process

The requirements of the Road Structures Inspection Manual apply to the following types of structure for which VicRoads is responsible as defined in the Road Management Act 2004 (symbols shown in brackets are used as prefixes for the numbering of different types of road structure):

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridges and major culverts</td>
<td>SN</td>
</tr>
<tr>
<td>Architectural and historic features</td>
<td>SA</td>
</tr>
<tr>
<td>Emergency boom gates</td>
<td>SB</td>
</tr>
<tr>
<td>Emergency bridging systems</td>
<td>SE</td>
</tr>
<tr>
<td>Emergency median barrier access gates</td>
<td>SG</td>
</tr>
<tr>
<td>High-mast lighting structures</td>
<td>SL</td>
</tr>
<tr>
<td>Concrete pavements on piles</td>
<td>SP</td>
</tr>
<tr>
<td>Retaining walls</td>
<td>SR</td>
</tr>
<tr>
<td>Major signs and gantries structures</td>
<td>SS</td>
</tr>
<tr>
<td>Visual screen walls</td>
<td>SV</td>
</tr>
<tr>
<td>Weigh-bridges</td>
<td>SW</td>
</tr>
<tr>
<td>Noise attenuation walls</td>
<td>SZ</td>
</tr>
</tbody>
</table>

The Road Structures Inspection Manual states the requirements for the following types of inspections:

<table>
<thead>
<tr>
<th>Inspection type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine maintenance inspection</td>
</tr>
<tr>
<td>Condition inspection</td>
</tr>
<tr>
<td>Detailed engineering investigation</td>
</tr>
<tr>
<td>Monitor inspection</td>
</tr>
<tr>
<td>Complex inspection</td>
</tr>
</tbody>
</table>
1.2 Road Structure Information

Inventory and condition information for all declared road structures on the Victorian road network is stored in the Road Asset System (RAS).

1.3 Occupational Health and Safety

Contractors, consultants and inspectors engaged to perform inspections must comply with the requirements of the Victorian Occupational Health and Safety Act (2004), Victorian Occupational Health and Safety Regulations (2017) and VicRoads’ safety requirements specific to inspection contracts.

1.4 Structure Definitions

<table>
<thead>
<tr>
<th>Structure Type And Prefix</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge (SN)</td>
<td>A structure with a minimum span or diameter ≥ 1.8 m or a waterway area ≥ 3 m² for the primary purpose of carrying a road or path over an obstacle.</td>
</tr>
<tr>
<td>Major Culvert (SN)</td>
<td>A structure with a minimum span or diameter ≥ 1.8 m or a waterway area ≥ 3 m² for the primary purpose of carrying water.</td>
</tr>
<tr>
<td>Noise Attenuation Wall (SZ)</td>
<td>A structure that attenuates traffic noise</td>
</tr>
<tr>
<td>Visual Screen Wall (SV)</td>
<td>A structure that serves as a visual screen</td>
</tr>
<tr>
<td>Retaining Wall (SR)</td>
<td>A structure, with the primary purpose of retaining material, that:</td>
</tr>
</tbody>
</table>

- is equal to or greater than 1.5m in height and equal to or steeper than one horizontal to two vertical (63 degrees); or |
- is greater than 0.5m and in the event of structural failure would affect a through traffic roadway. The failure envelope shall be determined by projecting a 45 degree from horizontal. |

Exclusions:

1. Walls extending up to 30m from a bridge abutment are part of the bridge structure. If the wall length exceeds 30m, the remaining section shall be treated as a retaining wall and given a structure number and be subject to a separate inspection regime.
2. Walls at major culvert inlets, outlets and access ramps are part of the major culvert structure.
3. Walls supporting or protecting road-related infrastructure for which VicRoads is not the responsible road authority (service roads, footpaths and other) and walls supporting or protecting non-road infrastructure (adjoining properties, driveways, public transport infrastructure or other).
4. Landscaping treatments (feature walls, garden beds, beaching and paving and other).
<table>
<thead>
<tr>
<th>Major Sign structure (SS)</th>
<th>Cantilever Sign, Pedestal Sign and Butterfly Sign Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Structures with one principal vertical member combined with one or more principal horizontal members designed for the purpose of carrying traffic information signs. The principal members may be trusses.</td>
</tr>
<tr>
<td></td>
<td>This excludes signs designed in accordance to VicRoads Traffic Engineering Manual Supplement to AS1742.2 (TEM Vol 2 Part 2.02).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Portal (gantry) Sign Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures with spans over a roadway consisting of one or more horizontal or sloped principal members supported by at least two principal vertical members. The principal members may be trusses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ITS Sign Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures with one or more principal vertical members designed for the purpose of carrying ITS signs greater than 2 m² in area.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High-mast lighting structure (SL)</th>
<th>Light poles with an overall height exceeding 17 metres.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency median barrier access gate (SG)</td>
<td>Gates which, in an emergency, allow access through median barriers to the opposite carriageway.</td>
</tr>
<tr>
<td>Architectural and historic feature structure (SA)</td>
<td>Architectural or historic feature structure within the road reserve.</td>
</tr>
<tr>
<td>Emergency boom gate (SB)</td>
<td>A moveable barrier similar to those at railway crossings used to control vehicle access through a controlled point.</td>
</tr>
<tr>
<td>Concrete pavement on piles (SP)</td>
<td>Concrete road pavement slab supported on piles, with a minimum span of 1.8 m, which supports a trafficable roadway.</td>
</tr>
<tr>
<td>Emergency bridging system (SE)</td>
<td>A demountable bridge used for emergency or temporary bridging comprising either a proprietary bridging system or other temporary structure.</td>
</tr>
<tr>
<td>Weighbridge (SW)</td>
<td>A permanent structure used to weigh vehicles - excludes weigh-in-motion structures and other mobile sensors.</td>
</tr>
</tbody>
</table>

The following structure types are collectively referred to as Roadside Structures in this Manual - Noise Attenuation Wall, Visual Screen Wall, Retaining Wall, Major Sign structure, High-mast lighting structure, Emergency median barrier access gate and Emergency boom gates.
Part two - Road structure inspection procedures
1 General

1.1 Types of inspection

The Road Structures Inspection Manual includes three levels of inspection:

Level 1 inspections are routine visual inspections which are used to check the general serviceability of a structure and to ensure the safety of road-users. Level 1 inspections may be completed in conjunction with routine road maintenance.

Level 2 inspections are condition inspections which are used to assess and rate the condition of structures and their components.

Level 3 investigations are detailed engineering investigations and assessments of individual structures which are conducted for the following reasons:
- to investigate a significant defect identified during a Level 1 or 2 inspection
- to prepare a detailed report on the condition and/or load carrying capacity of a structure to prepare a detailed report on potential candidate structures for rehabilitation, strengthening, widening or replacement
- to prepare a detailed assessment of the adequacy of a structure for use by current or proposed heavy vehicles
- as part of a more general investigation into the performance or condition of individual structures, classes of structures, structural components and materials in different environments or subjected to different levels of loading.

Monitor Structure inspections are a programmed Level 3 investigation of specific classes of structure in the Monitor Structure inspection program.

Complex Structures are a category of structure for which the standard Level 2 inspection does not provide sufficient information to enable assessment of the condition of bridge components for the whole of the bridge. Structures may be included in this category due to their structural form, the need for special expertise or because of difficult access. Structures in this category require a structure-specific management plan. Structures that require special access or other requirements beyond the scope of Level 1 and 2 inspections may be subjected to a Level 3 investigation or may be treated as a Complex Structure.

1.2 Occupational Health and Safety

Inspectors are responsible for their personal safety and that of others who may be affected by their inspection activities.

Inspections shall be conducted in accordance with the Victorian Occupational Health and Safety Act (2004), The Occupational Health and Safety Regulations (2017), together with other relevant VicRoads safety requirements as stated in the inspection contract or inspection brief. In addition, inspections on the roadway shall be conducted in accordance with the requirements of Code of Practice for Worksite Safety - Traffic Management.

Boats used for inspection and their operation must comply with the requirements of the Marine Safety Act 2010 and any other relevant legal requirements and associated regulations.

If a structural inspection requires access over or under property or assets belonging to another authority (for example rail property), the inspection must comply with the relevant legal, regulatory, or other procedural requirements of the authority including relevant codes of practice. The Safe Work Method Statement for the inspection must include the authority’s requirements.

In order to assist bridge inspectors with the management of safety, VicRoads may provide the following information:
- a list of general hazards which may be encountered during structural inspections
- a list of structure-specific hazards to be included in the structure information issued to Level 2 inspectors.

VicRoads will require the following actions by inspectors as appropriate:
• inspectors commissioned by VicRoads to conduct inspections are to prepare and submit a site-specific Safe Work Method Statement (SWMS) for review and comment by the Superintendent prior to commencement of the inspection
• on their arrival at bridge sites, inspectors are to identify and address any potential hazards not covered in the SWMS
• if a risk cannot be safely managed, the inspection must be postponed and the VicRoads representative advised immediately
• following completion of inspection programs, inspectors must submit an updated list of hazards encountered during the inspections to VicRoads

VicRoads may conduct safety audits and surveillance to ensure that inspectors perform inspections in accordance with the submitted SWMS.
2  **Level 1 – Routine maintenance inspection**

2.1 **Purpose**

Level 1 inspections may be completed in conjunction with routine maintenance of the structure and the adjacent road reserve. The primary purpose of Level 1 inspections is to:

- check for visible defects which might affect the safety of road users and/or the serviceability of a structure
- identify items that may require routine maintenance and/or urgent attention/further investigation.

2.2 **Scope**

The inspection may include the following structure types:

- bridges and major culverts
- roadside structures - including major sign structures, noise attenuation walls, visual screen walls and retaining walls, and high mast lighting structures

The scope of a Level 1 inspection varies with the structure under inspection.

Level 1 inspections must be in accordance with the requirements of VicRoads Standard Specification Section 750 - *Routine Maintenance* including completion of the Level 1 inspection form appropriate to the type of structure being inspected.

The inspection shall include all visible structural components including approaches and waterways at bridges and major culverts. The inspector shall assess and report any significant signs of deterioration, damage, distress or unusual behaviour due to vehicle impact, fire or flood damage*.

The report shall include works that were completed during the inspection together with items that require further maintenance.

The report may include recommendations for further investigation (e.g. a Level 3 investigation).

The report should include photographs of items that require further assessment or maintenance.

*refer to the section 5.8 Post Flood Management of Bridges.

2.3 **Frequency of inspections**

All structures are to be subject to a minimum of 2 inspections per year with a maximum interval of 6 months between successive inspections.

Alternatively, subject to a structure-specific risk assessment, the interval between successive inspections may be increased to a maximum of 1 year. If this option is exercised, the Asset Manager must maintain a register of structures which states the frequency of Level 1 inspection for each structure and record the risk assessment.

Structures identified in Clause 2.2 shall be subject to a Level 1 inspection after events such as a major accident, flood, earthquake or fire*.

Further advice and requirements regarding post-flood inspection and reporting should be obtained from the Asset Manager or Asset Services - Structures if required.

*refer to the section 5.8 Post Flood Management of Bridges.
2.4 Inspector requirements

Level 1 Inspections shall be conducted by personnel employed by the routine maintenance contractor who shall be pre-qualified in the M2-BW category in accordance with the VicRoads Prequalification Scheme. Inspection personnel shall have extensive practical experience in road and bridge routine maintenance. They shall be competent to judge the visual condition of structures and the adjacent road approaches and to complete the Level 1 Inspection report.

The Contractor shall propose Level 1 inspection personnel and their competency shall be assessed by the Region. The minimum requirement shall be determined by the Region but shall be not less than attendance at a briefing to be delivered by the Region.

2.5 Inspection procedure

2.5.1 Preparation for site inspection

Prior to commencing site inspections, the inspector shall obtain the relevant documentation together with the necessary inspection and safety equipment.

Documentation should include a copy of relevant parts of the VicRoads Road Structures Inspection Manual (RSIM) and data from the VicRoads Road Asset System (RAS) for the structures scheduled for inspection.

Safety equipment shall include appropriate traffic management and other safety equipment relevant to routine maintenance and inspections which shall be in accordance with the site-specific Safe Work Method Statement (SWMS) and Safe Operating Procedure (SOP). The inspector shall assess the site prior to commencing the inspection to ensure that the SWMS adequately addresses all hazards. If necessary, the SWMS shall be amended to include any additional hazards that are encountered.

2.5.2 Extent of Level 1 inspections

The inspection shall include all components of the structure above ground or water level.

The following components are excluded:

- the internal parts of box-girders
- inaccessible areas behind abutments
- structures over rail lines
- concrete or steel beams, piers and their crossheads if located in or over permanent water
- components requiring special access equipment to perform the inspection such as boom lifts, under-bridge access units, boats, ladders or scaffolding.

Components and/or parts of the structure not inspected shall be recorded.

Inspectors are expected to use their knowledge and experience to identify maintenance and potential structural integrity issues.

The individual components of the structure shall be visually examined. If issues are identified they shall be categorised as follows:

- routine maintenance to be rectified by the maintenance contractor with no need for further inspection
- structural safety or integrity issues which require further inspection by a suitably experienced engineer
- other defects that are beyond the scope of routine maintenance.

The following section provides a list of typical issues to be identified during a Level 1 inspection.

All components listed in Part 3 - Tables 1.2.1 and 1.2.2 and the structure as a whole shall be assessed for the following issues:

(i) Structural integrity issues

The integrity and stability of a structure can be affected by a number of factors including physical damage (e.g. deformation, cracking) and/or deterioration arising from exposure to an aggressive environment (e.g. salt ingress leading to corrosion) of critical components.
This manual provides descriptions and photographs of different degrees of damage and deterioration of structural components.

The following paragraphs list critical signs of damage and deterioration that could affect structural integrity and which should be included in the inspection report. A brief summary is given of the types of damage which could be observed followed by guidance on the critical locations on structure components that require inspection.

Safety inspections defined in Section 750 are also intended to identify damage affecting structural performance which must be recorded as Hazard Reference H711.

<table>
<thead>
<tr>
<th>Indications of distress, damage or deterioration in critical components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steel components</strong></td>
</tr>
<tr>
<td>• corrosion and cracking of beams, columns and connections</td>
</tr>
<tr>
<td>• distortion (which may be a result of overloading, impact, heat or corrosion)</td>
</tr>
<tr>
<td><strong>Concrete components</strong></td>
</tr>
<tr>
<td>• single or multiple cracks with a width greater than 0.3 mm</td>
</tr>
<tr>
<td>• major spalling or general deterioration of concrete with exposed reinforcement or</td>
</tr>
<tr>
<td>prestressing strands due to vehicle impact, corrosion, abrasion or any other cause</td>
</tr>
<tr>
<td>• heat damage which may include spalling, cracking or failure of components as a</td>
</tr>
<tr>
<td>result of bushfire, vehicle fire, explosion or other cause</td>
</tr>
<tr>
<td>• poorly compacted concrete/concrete which has deteriorated or weakened</td>
</tr>
<tr>
<td><strong>Masonry and brick components</strong></td>
</tr>
<tr>
<td>• substantial loss of mortar</td>
</tr>
<tr>
<td>• cracks (single or multiple) through mortar and/or masonry blocks or bricks</td>
</tr>
<tr>
<td>• substantial efflorescence (white surface deposit) – a sign of water penetration</td>
</tr>
<tr>
<td><strong>Timber components</strong></td>
</tr>
<tr>
<td>• termite activity, rotting, marine borer and other insect attack</td>
</tr>
<tr>
<td>• excessive deflections of beams</td>
</tr>
<tr>
<td>• deformation or settlement of bridge deck</td>
</tr>
<tr>
<td>• buckling or displacement of piles</td>
</tr>
<tr>
<td>• splitting and crushing</td>
</tr>
<tr>
<td>• fracture of cross-beams</td>
</tr>
<tr>
<td>• loss of cross-section</td>
</tr>
<tr>
<td>• fire damage</td>
</tr>
<tr>
<td>• water ingress</td>
</tr>
<tr>
<td>• damage from vehicle impact, stream debris, abrasion or other means</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Critical components for bridges and major culverts</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Superstructure components including beams, slabs, box girders, transverse</td>
</tr>
<tr>
<td>diaphragms and similar components</td>
</tr>
<tr>
<td>• signs of distress including cracking, spalling, deformation, rusting or other</td>
</tr>
<tr>
<td>deterioration</td>
</tr>
<tr>
<td><strong>Substructure pier columns and crossheads</strong></td>
</tr>
<tr>
<td>• signs of distress including cracking, spalling, deformation, or other deterioration</td>
</tr>
<tr>
<td>in columns, crossheads and connections</td>
</tr>
<tr>
<td>• corroded or missing connection components, with particular emphasis on timber and</td>
</tr>
<tr>
<td>steel components</td>
</tr>
<tr>
<td>• movement/displacement of abutments and piers</td>
</tr>
<tr>
<td><strong>Bearings</strong></td>
</tr>
<tr>
<td>• lateral movement or vertical separation</td>
</tr>
<tr>
<td>• bulging or splitting failure of elastomeric bearings</td>
</tr>
<tr>
<td>• severe displacement, corrosion or seizure of steel bearings</td>
</tr>
<tr>
<td>• extrusion of seals in pot bearings</td>
</tr>
<tr>
<td>Critical components for bridges and major culverts</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td><strong>• severe cracking or spalling of supporting pedestals</strong></td>
</tr>
</tbody>
</table>
| **Expansion Joints** | **• loose or missing connection bolts or nuts**
  | **• cracked or missing fingers of finger type joints**
  | **• loose, fractured or corroded angle retainers**
  | **• deteriorated, split or missing joint filler/insert/gland** |
| **Foundations including piles and spread footings** | **• signs of deterioration of exposed sections, substantial settlement, exposure of spread footings in particular by scour or erosion** |
| **Culverts (rectangular, crown units, pipes) and arches** | **• irregular curvature in masonry arch profiles**
  | **• substantial loss of mortar, softening of mortar, missing or displaced masonry blocks**
  | **• significant corrosion or deformation of corrugated metal pipe culverts** |
| **Abutments** | **• tilting, bulging or settlement of wing walls on bridge and culvert approaches** |

<table>
<thead>
<tr>
<th>Critical components for retaining walls</th>
</tr>
</thead>
</table>
| **Retaining wall facing components including masonry blocks or bricks, precast concrete panels, timber sleepers and similar** | **• evidence of tilting or bulging of wall**
  | **• evidence of failed or blocked back-of-wall drainage**
  | **• extended cracks through mortar and masonry components or precast concrete panels** |
| **Supporting components including vertical posts and columns, metal or geo-synthetic anchor strips for reinforced soil walls and similar** | **• evidence of tilting or bulging that might indicate failure of retaining systems in reinforced soil walls**
  | **• evidence of tilting or bulging that might indicate failure of vertical retaining posts or their foundations**
  | **• evidence of movement of retaining walls that has caused permanent closure of expansion joints, and spalling of concrete superstructure or substructure components** |
| **Strip footing and pile foundations** | **• signs of substantial settlement or rotation**
  | **• significant exposure by erosion, settlement or other means** |
| **Crib wall** | **• disintegration of blocks** |
## Typical critical components for noise attenuation and visual screen walls

<table>
<thead>
<tr>
<th>Component</th>
<th>Issues</th>
</tr>
</thead>
</table>
| Noise attenuation and visual screen wall panel | - severe cracking or other deterioration of panel material due to wind or other environmental effects, impact or movement of supporting structures  
- severe deterioration of frame supporting members  
- rotting plywood panels  
- loss of support to panel edges due to relative movement between the panel and its support |
| Connections | - missing, fractured, corroded or other form of failure |
| Supporting barrier systems and similar | - damage or lateral movement due to vehicle impact  
- severe rotation or settlement due to foundation settlement, scour or similar |

## Typical critical components for high mast lighting structures and major sign structures

<table>
<thead>
<tr>
<th>Component</th>
<th>Issues</th>
</tr>
</thead>
</table>
| Base plate bolted and welded connections and mortar packing beneath baseplate | - missing, fractured, severely corroded or loose nuts above and/or below the base plate  
- severely corroded or damaged holding-down bolts  
- fatigue-cracking or corrosion of welds  
- missing, cracked or severely deteriorated mortar packing beneath baseplates  
- distortion of baseplates |
| Supporting columns and cantilever or truss or beam components | - distortion, corrosion or impact damage particularly near connections  
- cracking in members or welds |
| Foundations | - signs of settlement, or exposure of foundations by scour or similar  
- tilting of vertical members indicating failure or excessive movement of pile supports |

(ii) Routine maintenance issues

The following guidance relates to maintenance issues that are to be addressed as part of road maintenance and other issues that are to be reported for further investigation or attention.

The following references are taken from Section 750 of *VicRoads Standard Specification for Routine Maintenance, Part 750.D - Structure Maintenance Requirements* which includes detailed information on completing and reporting Routine maintenance (Level 1) inspections and maintenance works.

The RM700 series of routine maintenance jobs has been developed for structures:

- RM711 Bridge and major culvert maintenance
- RM712 Roadside structures
  - Major sign structures
  - High mast lighting structures
  - Retaining walls
  - Noise attenuation and visual screen walls
- RM415 Stream maintenance

Routine maintenance activities on bridges and other structures
| General | • graffiti and other damage caused by vandalism  
• accident, fire or water damage  
• accumulation of dirt, bird and animal droppings and other debris on components preventing drainage, ponding, rusting of steel, seizure of bearings and other moving parts  
• vegetation growth in structural joints, mortar joints, cracks and other locations on and around structures |
| Drainage | • blocked scuppers and side entry pits on bridges, culverts and approaches  
• scour or settlement of bridge abutment batters, road approaches, behind retaining walls, foundations of bridge piers, sign structures, mast arms, retaining walls and other structures  
• blocked weepholes and signs of water penetration and inadequate drainage behind retaining walls, bridge and culvert wing walls and similar |
| Deck joints | • debris blocking or jamming joints  
• damaged waterproofing seals  
• missing or damaged bolts |
| Bearings | • debris and dirt build up around bearings  
• rusted steel bearings |
| Barriers | • damaged, corroded and missing posts, rails, spacer blocks, and connections  
• approach barrier not constructed or connected |
| Bituminous surfacing on structure roadway, footpaths and approaches | • uneven surface  
• settlement of approaches |
| Signs, lighting and road markings | • missing, damaged or corroded components, supports, connections  
• signs or road markings not legible  
• lights not working |
| Waterways | • blocked with debris and vegetation  
• scour and subsidence requiring beaching or other maintenance |

### 2.6 Data recording

All data obtained from Level 1 inspections shall be recorded on a Level 1 inspection report form as required by Section 750 of VicRoads Standard Specification for Roadworks and Bridgeworks.

If structural integrity issues are identified or further inspection is required, these shall be notified to the Superintendent on the day of the inspection or sooner if the inspector perceives there is immediate danger to the public.
3 Level 2 – Structure condition inspections

3.1 Purpose

The purpose of the Level 2 inspection is to measure and rate the condition of structures in order to:

- identify and prioritise maintenance needs
- assess the effectiveness of past maintenance treatments
- model and forecast changes in condition (deterioration modelling) and residual life
- estimate future requirements for maintenance budgets

3.2 Scope

The scope of the Level 2 inspection includes the following:

- Visual inspection of components to assess their condition using the condition rating system described in Part 3
- Reporting the condition and its extent for each bridge component
- Reporting a condition rating for the overall structure (Bridge Condition Rating)
- Identification of structures and/or components which may require a detailed engineering inspection* (Level 3) due to rapid changes in structural condition or deterioration to condition rating 4
- Identification of components which require closer condition monitoring and observation at the next Level 2 inspection due to rapid changes in structural condition or deterioration to condition rating 3
- Identification of requirement for maintenance practices
- A photographic record of the structure
- Auditing of selected components for structure inventory records
- Reporting of structures that do not have an identification plate

* The recommendation will be reviewed by the Asset Manager in conjunction with Asset Services to determine the extent of investigation needed.

3.3 Frequency of inspections

<table>
<thead>
<tr>
<th>Structure age</th>
<th>Initial inspection</th>
<th>Routine inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>Within 12 months of opening to traffic</td>
<td>2 to 5 year thereafter*</td>
</tr>
<tr>
<td>Existing</td>
<td>Within 12 months of the completion of major maintenance, strengthening and/or widening</td>
<td></td>
</tr>
</tbody>
</table>

* Actual frequency of inspections is determined on a risk basis (Bridge Condition Rating):

<table>
<thead>
<tr>
<th>Bridge Condition Rating</th>
<th>Interval between inspections (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>5</td>
</tr>
<tr>
<td>30 to 60</td>
<td>3</td>
</tr>
<tr>
<td>&gt;60</td>
<td>2</td>
</tr>
</tbody>
</table>

The actual frequency may be varied by VicRoads based on the estimated rate of deterioration of components, environmental conditions, traffic volumes and any completed maintenance, strengthening or replacement of components in poor condition.

3.4 Inspector prequalification and auditing

Level 2 inspections shall be conducted by Level 2 inspectors who are prequalified in accordance with the requirements of VicRoads Prequalification Scheme for the B12 category. Inspectors in this category must have extensive practical experience in either inspection, construction, design, maintenance or repair of road structures. They shall be competent to judge the condition of structures and the importance of visual defects.
Prequalified Level 2 inspectors must:

- complete a Level 2 inspection training course delivered by a registered training organisation approved by VicRoads for this purpose
- successfully complete the assignment accompanying the training course
- attend a VicRoads Level 2 inspection briefing
- submit an application for prequalification to VicRoads
- obtain written confirmation of prequalification from VicRoads

Level 2 inspectors need not be professional bridge engineers, but are required to consult with and take advice from such a person to aid in decision making or interpreting visual defects or unusual structural behaviour.

Inspector performance is subject to ongoing review, including independent audits of completed inspections. If consultation with a qualified engineer is required, details of the consultation, advice received and the name and qualifications of the engineer are to be included in the General Comments box on the Bridge Inspector's Sheet.

Full details of VicRoads’ Prequalification Scheme for the B12 category including eligibility criteria, quality, safety and insurance requirements, are given on the VicRoads website.

3.5 Inspection procedure

3.5.1 Preparation for site inspection

Prior to commencing an inspection, the inspector shall ensure that they have all relevant documentation together with inspection and safety equipment and have made appropriate arrangements with the relevant road, rail or other authorities for access to the structure requiring inspection.

3.5.2 Site inspection

Inspections shall be conducted in a systematic manner. Site inspections must be conducted during daylight hours, unless there are unique circumstances agreed with the Asset Manager. (e.g. rail occupation at night).

The inspector shall:

- inspect and assess the condition of each structural component using the standard condition rating criteria (refer to part 3 of the manual)
- assess the general condition of the structure and record the results of the assessment on the condition rating sheet
- record all components in condition 3 and 4 separately on the structure defects sheet. A photograph of condition state 3 and 4 defects is also required
- record and photograph non-standard components.
- record the components that were not possible to fully inspect
- record any discrepancies in the inventory information provided.

3.5.3 Extent of inspection

The condition inspection is a visual inspection only and covers all components of the structure above ground and water level. The items listed below are not included in the Level 2 inspection program and will be inspected by other means including the Complex and Level 3 inspection programs:

- structural forms and components that require special structural expertise or knowledge such as truss bridges or advice from a metallurgist
- interiors of box girders and any other component that is considered confined space
- inaccessible areas behind abutments
- piles and foundations below ground or water
- components that require special access equipment or traffic management to facilitate inspection
- emergency bridging systems
- emergency median barrier access gates
• emergency boom gates
• concrete pavements on piles
• weigh-bridges
• architectural and historic features

Except where special access equipment or traffic management is required, the individual components of the structure shall be inspected from within 3 m of all surfaces of the component. Where this is not possible, the inspector shall use binoculars or other optical equipment such as a spotting scope to conduct the inspection. In this case, the optical equipment shall be sufficiently powerful and properly adjusted to enable a close-up view of the components being inspected. If binoculars are used, these should be of the Porro-prism type which gives a brighter image than the more compact roof prism type.

Components shall be inspected in good natural or artificial light sufficient to enable fine cracks in concrete to be observed. The inspector may highlight cracking with a water-spray or damp cloth.

Subject to the foregoing restrictions, all bearings at bridge abutments and piers shall be inspected, and bearings for at least one abutment and one pier (where present) shall be inspected at eye level.

The calculated percentage of a component in each condition state shall be based on the total area of the component that can be observed. Where it is estimated that 25% or less of the component is visible, this shall be recorded on the structure information sheet stating the reason why it cannot be fully observed.

Components that are part of bridge widenings shall be assessed and recorded separately to those of the original bridge. Each widening shall be recorded separately and designated as left or right as viewed from the start of the bridge. The start of the bridge is defined as the end of the bridge closest to the start chainage of the road.

The inspection shall include dimensional measurements, numbers of key components and a photographic record.

3.5.4 Photography

Photographs are a vital part of the structural inspection record. The Level 2 inspection includes specific requirements for photographic records. It is important that Level 2 inspectors have a suitable camera and are able to use its features sufficiently to ensure good quality photographs. Photographs should be taken in bright natural light. Flash photography is permitted as detailed below but should only be used when necessary as intense light can obscure fine details such as cracks.

Minimum specification for camera:
• 18Mp APS-C sensor set to the maximum resolution
• date-stamp facility*
• zoom lens to enable close-up photographs
• flash with sufficient power to illuminate subjects in dark areas or deep shadow

* The camera must be set to the correct date and time.

Photographs must:
• include a digital date-stamp
• be taken in natural light unless the defect is in deep shadow or a dark area
• be in sharp focus sufficiently to enable fine details such as cracks in concrete to be observed - blurred images will not be accepted
• be composed so that the subject of the photograph is centralised and occupies the full frame of the image

Photographs shall be taken of all components at condition rating 3 and 4 and of those components that do not fall within the defined component classification.

All photographs taken for inventory purposes and of components with condition rating of 3 or 4 shall be recorded.

All photographs shall be numbered sequentially at each bridge site and recorded in the appropriate record table.

All photographs shall be checked at the structure and repeated if the quality is poor.

Wetting of a cracked concrete surface may be used to highlight crack patterns.
3.6 Data recording

All information obtained from the site inspection shall be recorded on the following data sheets for Level 2 inspections provided in Appendix A:

- bridge inspector’s sheet
- condition rating sheet
- structure defect sheet
- structure information sheet
- structure inventory and photographic record sheet.

The following information describing the structure, its location and details of the inspection shall be recorded:

- region
- road name
- road number
- location (km) from the start of the road
- crossing name and/or feature crossed for bridges and major culverts
- general location description for roadside structures
- structure identification number
- global positioning system location
- any discrepancies in the inventory information for the structure provided to the inspector.

All data recorded during the inspection is to be converted to electronic format and supplied to the Superintendent within 14 days of the inspection. This shall include all information recorded on inspection sheets together with photographs.

3.6.1 Bridge inspector’s sheet

All boxes are to be fully completed.

The inspector shall also make recommendations for future inspections including:

- equipment needed to complete the inspection
- known and observed hazards on site

3.6.2 Condition rating sheet

The following information shall be recorded:

- list of all components of the structure by their unique number reference
- condition of each component and the extent to which it applies
- general condition of all components of the structure including widenings

The method of rating the condition of structure components is given in Part 3.

3.6.2.1 Condition rating of components

The inspector shall make an assessment of the condition of each component in accordance with Part 3.

The inspector shall compare the observed component defects with the description in the condition rating and the accompanying photographs if available.

The proportion of the component in each condition rating shall be determined on the basis of the total component area that is visible. The unit of measurement shown in the condition rating descriptions shall be used to determine the percentage in each condition as described in Part 3.

Part 4 provides further guidance in assessing the condition of components, with descriptions and photos of the 4 condition states for each component.

3.6.2.2 Predefined components

Structure components shall be identified in accordance with Part 3.
The list of component numbers provided in Tables 1.2.1 and 1.2.2 of Part 3 shall be used when recording components of the bridge.

### 3.6.2.3 Undefined components

If a component does not conform to one of the predefined components, its details shall be described in the structure information sheet and the component shall be photographed.

Components which have been identified as ‘undefined’ shall be assigned a component number before the next inspection.

### 3.6.3 Structure defect sheet

Additional information to be recorded for each component assessed to be in Condition 3 or 4:

- component number
- component location, defect and general condition description
- approximate quantity of the component to be used for estimating cost of repairs
- for components in condition 3 or 4, the photograph number recorded on the structure inventory and photographic record sheet

### 3.6.4 Structure information sheet

The inspector is to record any other observations that are not covered by the other sheets including the following:

- posted speed, load or height limits and curfews
- undefined components
- components that cannot be inspected, stating the reason why this is not possible
- components where less than 25% is accessible (e.g. hidden by other components)
- general comments, explanations or significant information

Note – absence of structure number plate is recorded on the condition sheet.

### 3.6.5 Structure inventory and photographic record sheet

Inventory data from the Road Asset System shall be confirmed and any discrepancy recorded.

All photographs taken for inventory purposes and of components which have a condition rating of 3 or 4 are to be recorded.

Photographs at each structure are to be numbered sequentially and recorded in the appropriate record table.
3.6.5.1 Bridge and major culvert inventory data

The inspector is required to check the structure identification number plate (and date plate if separate present), overall measurements, components of the structure and any bridge widenings against data from RAS and also to prepare a photographic record.

3.6.5.1.1 Location of components

Labels describing the positions of components are based on observations from the start of the bridge which is the end of the bridge with the lowest chainage as defined by VicRoads’ Linear Referencing System.

All components are referenced from left to right, including any widening units, when viewed in the forward direction of the road (i.e. increasing chainage).

The following abbreviations are used:

- A: abutment
- P: pier
- C: column or culvert cell number
- B: beam
- S: span
- U: unit number along the cell length of the culvert

Example:

In a three-span bridge with 4 beams in each span:

- abutment 1 is at the start of the bridge and abutment 2 is at the opposite end
- spans 1, 2 and 3 are measured from abutment 1
- the first beam on the extreme left-hand side in span 1 is span 1 - beam 1 (s1 b1)
- the beam on the extreme right in span 2 is span 2 - beam 4 (s2 b4).

Increasing chainage:

<table>
<thead>
<tr>
<th>Abutment 1</th>
<th>Span 1</th>
<th>Span 2</th>
<th>Span 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 B1</td>
<td>S2 B1</td>
<td>S3 B1</td>
<td></td>
</tr>
<tr>
<td>S1 B2</td>
<td>S2 B2</td>
<td>S3 B2</td>
<td></td>
</tr>
<tr>
<td>S1 B3</td>
<td>S2 B3</td>
<td>S3 B3</td>
<td></td>
</tr>
<tr>
<td>S1 B4</td>
<td>S2 B4</td>
<td>S3 B4</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Example - Location of components

3.6.5.1.2 Widenings

Components in the bridge which form part of a widening are identified separately to those in the original bridge by inserting one of the following letters in the widening column on the condition rating sheet:

- L indicating widening on the left
- R indicating widening on the right

Together with a 1 or 2 indicating if this is the first or second widening on the side in question.

The widening column on the condition rating sheet is ignored for beams in the original structure.

If a culvert has been widened with a bridge structure, separate inventory sheets are required for each part of the structure.
3.6.5.1.3 Joined Bridges

- If two adjacent bridges are joined, the joining section is to be treated as a part of the outbound structure (i.e. increasing chainage)
- It is to be termed a ‘joining’ and the structural components of the joining reported in the same manner as a widening
- The inbound structure is to remain unchanged but the presence of the joining is to be noted on the inspector’s sheet
- For continuity purposes, both existing structure numbers are to be maintained.

The joining could be included in the 1/2 column under Widening by inserting J to give 1/2/J and changing Widening to Widening/Joining

3.6.5.1.4 Global Positioning System (GPS)

GPS values for latitude and longitude are measured in decimal degrees to five decimal places using Datum GDA94. These readings are taken at the face of kerb (or barrier if there is no kerb) at the left hand side of Abutment 1 (Figure 3).

For twin bridges on a divided carriageway Abutment 1 will be the first abutment crossed when travelling in the forward direction (i.e. increasing chainage) whereas on the adjacent carriageway Abutment 1 will be the last abutment crossed. For both bridges on the divided carriageway the GPS reading shall be taken at Abutment 1 left face of kerb (or barrier if there is no kerb). Refer to Figure 3.
3.6.5.1.5 Photographic record
The following photographs are required in addition to those showing condition rating 3 and 4 defects:

- a general photograph showing the alignment of the bridge, its width, kerbs and barriers
- one photograph from the side of the bridge showing abutments, piers and the waterway/underbridge area.

The following photographs of the main superstructure components (i.e. beams or girders) are to be taken from underneath or to the side of the structure and are required to show:

- the original structure
- widenings

3.6.5.1.6 Measurements and quantities to be confirmed during the inspection
If requested the Level 2 inspector, shall confirmed the following:

- overall length and width of bridge*
- length of individual spans*
- number of spans
- width of structure between kerbs*
- width available between outer lane markings*
- number of widenings (separate to number of spans)
- length and width of each widening*
- number of main superstructure components i.e. beams, slabs, trusses or arches, for both the original bridge and any widenings - components in widenings are to be reported separately.

*To limit exposure of inspectors to traffic on the road measurements shall only be taken if required by the Asset Manager. Subject to a risk assessment traffic management shall be provided.
On structures where there are kerbs, the width is measured between the kerbs ignoring the centre median if present. If there are no kerbs, the width between the roadside face of the barrier rails is measured.

The length of the bridge is the full length of the deck measured parallel to the road centre-line between the abutment joints or, if the joints are not evident, the intersection of the deck and the approach-road pavement. The approach slabs are not included in the overall length of the bridge.

For arch bridges the length is measured to the back of the buttresses at the ends of the arches or to the junction of the wingwalls with the spandrel walls.

The length of a pedestrian overpass is the total length from abutment to abutment including all ramps. The length of deck also includes any additional ramps that join the bridge. The overall width of the bridge is the width of the main pedestrian structure.

The overall width of the bridge is the width to the outer edges of the bridge including kerbs and footpaths measured perpendicular to the road centreline. The width of identified widenings shall be from the joint in the deck between the widened and original structure to the outside of the bridge or to the start of the next widening. For variable width structures, the minimum widths are to be measured. See Figure 2.

For major culverts, the width or diameter of the individual cell is measured. Where this varies between cells, the main pipe diameter or width of crown is to be measured. This also applies to the cell height where there is variance.

### 3.6.5.2 Roadside structure inventory data

#### 3.6.5.2.1 Major sign structures and high mast lighting structures

The structure numbers are prefixed by SS for major sign structures, SL for high mast lighting structures. General Location is denoted by the chainage (kms) in the forward direction for a single post gantry or lighting structure. The general location for a multi post gantry is denoted by the chainage (kms) of the left most post in the forward direction.

The inspector is required to confirm the inventory dimensions which are given on the structure inventory sheets in Appendix A. Dimensions which are not accessible for measurement such as outreaches can be omitted.

The following photographs are required for each structure:

- a general photograph showing the sign, light or feature and support
- the sign legend or light head as appropriate
- the column and outreach components
- the column base, grout, bolted connections and stiffeners
- components in condition states 3 or 4.

Additional photographs may be required in the case of sign gantries or if the base detail has any unusual features.

#### 3.6.5.2.2 Noise attenuation walls, visual screen walls and retaining walls

The structure numbers are prefixed by SZ for Noise Attenuation Walls, SV for Visual Screen Walls and SR for Retaining Walls.

The wall chainage is the distance measured from the road start. The General Location is either on the freeway or an adjacent ramp.

The length of the wall to be inspected is provided from RAS. If the stated length is incorrect, this is to be reported on the structure information sheet. The inspector should not amend the length.

GPS readings are recorded at the start and end of the wall. The chainage at the start of the wall is also recorded.

The following photographs are required for each structure:

- at the start and end of the wall
- a view along the wall
- any components in condition states 3 or 4.

#### 3.6.5.2.3 Emergency Median Barrier Access Gates

The structure numbers are prefixed by SG for emergency median barrier access gates.
The emergency median barrier access gate chainage is the distance measured from the road start. The General Location is on the freeway.

The length of the emergency median barrier access gate to be inspected is provided from RAS. If the stated length is incorrect or missing, this is to be reported on the structure information sheet. The inspector should not amend the length.

GPS readings are recorded at the start and end of the emergency median barrier access gate. The chainage at the start of the emergency median barrier access gate is also recorded.

The following photographs are required for each structure:

- a general photograph showing the emergency median barrier access gate
- a photo of the emergency median barrier access gate completely opened
- components in condition states 3 or 4.
4 Level 3 – Engineering investigations

4.1 Introduction

4.1.1 Purpose
This section of the RSIM provides guidance to Asset Managers, VicRoads Principal Engineer - Structures and external consultants on Level 3 investigation procedures.

Level 3 investigations are detailed engineering investigations that generally include a combination of field investigation and theoretical analysis which target a specific issue relevant either to an individual structure or to a class of structures. Level 3 reports and data are used as a basis for the assessment of structural management options.

Level 3 investigations are intended to provide detailed knowledge of the condition, load carrying capacity, in-service performance and other characteristics that cannot be obtained from other types of inspection.

AS 5100 Bridge design is the principal reference to be used for Level 3 investigations. AS5100.7 Bridge assessment, supplemented by more bridge-specific data and procedures if available, shall be used to determine load capacity.

Level 3 investigations are conducted by a pre-qualified Proof Engineer.

4.1.2 Scope
A Level 3 investigation is a structure or structural class-specific inspection and/or a structural assessment. The RSIM does not specify a standard Level 3 investigation scope. The scope of a Level 3 investigation is specifically developed for the road structure or class of road structure under investigation.

Level 3 investigations are distinguished from other types of inspection by the following:

- their structure or class-specific scope
- inclusion of matters that are outside the scope of a Level 1 or a Level 2 inspection
- the requirement for the investigation to be conducted by a pre-qualified Proof Engineer.

The objective of this Section is to:

- provide examples of circumstances leading to a Level 3 investigation
- describe a procedure for developing the scope of a Level 3 investigation
- provide guidance regarding the typical activities that might be included in the scope of a Level 3 investigation.

Section 4.2 provides guidance on Quality Control for Level 3 investigations.

Section 4.3 provides a summary of typical reasons for undertaking Level 3 investigations.

Appendix C contains examples to assist with preparation of the brief and scope for typical Level 3 investigations.

4.1.3 Definitions

**Brief** – The brief for a Level 3 investigation is the information to be provided when engaging an external or internal party to undertake a Level 3 investigation. The brief must include a scope for the investigation. The scope can be an outline and the brief can include a requirement to fully develop the scope prior to the investigation.

**Level 3 investigation** - an investigation carried out in accordance with this section.

**Proof Engineering** – an independent engineering review and certification of a structural design by a pre-qualified Proof Engineer in accordance with VicRoads’ Proof Engineering Policy.

**Scope** – a description of the tasks to be performed during the Level 3 investigation.

**Structural assessment** – an assessment by calculation or by load testing of a road structure in accordance with AS5100 Bridge design and/or other relevant standards. The assessment will take into consideration the physical condition of the road structure and will generally include a Level 3 investigation.
4.2 Quality for Level 3 investigations

Level 3 investigations shall be conducted by appropriately experienced engineers who shall either be a member of VicRoads Asset Services Structures section or a consulting engineer prequalified at Proof Engineering level in accordance with VicRoads’ Pre-qualification Scheme.

Level 3 investigations shall comply as a minimum with the procedural requirements for Level 2 inspections.

Structural assessments shall comply as a minimum with the procedural requirements for Proof Engineering (as stated in VicRoads’ Proof Engineering policy) and AS5100.7 Bridge assessment.

If the assessed load-capacity of a structure either exceeds or is less than the capacity as recorded by VicRoads, the assessed capacity must be confirmed by independent Proof Engineering. The Proof Engineer must be pre-qualified in accordance with VicRoads’ Pre-qualification Scheme.

The requirement for Proof Engineering must be included in the scope of the Level 3 investigation.

4.3 Categories of Level 3 investigation

4.3.1 Preamble

The following has been included to provide guidance on the most common categories of Level 3 investigations and representative examples within each category. These categories and examples should be considered as being typical but not an exhaustive list.

These investigations may be specific to an individual structure or may involve an investigation into a common form of structure, component or material.

4.3.2 Response to individual accident or natural event

A Level 3 investigation is required if an incident occurs that potentially affects the integrity or load-carrying capacity of a structure.

Such incidents can include:

- an impact by a motor vehicle, train or river vessel with the substructure or superstructure of a bridge, major culvert, large sign structure or other highway structure
- an explosion or vehicle (hydrocarbon) fire (e.g. from a ruptured fuel tank or a gas service attached to a structure)
- a natural event such as a flood*, bushfire or earthquake or other event that might damage or destabilise a structure (e.g. debris impact or loading, stream flow forces, settlement resulting from scour or collapse of bridge piers, abutments and embankments).

Incidents of this nature will generally be reported to the responsible Asset Manager who shall initiate an immediate Level 1 inspection and/or Level 3 investigation.

The Level 3 investigation may comprise a visual inspection by a suitably experienced bridge engineer to:

- ascertain the visible extent of damage
- consider the need for action to make the structure safe or restrict its use
- record information for further consideration in consultation with other relevant personnel
- recommend further detailed level 3 investigations to evaluate the extent and magnitude of damage.

The Principal Engineer - Structures shall be consulted regarding structural engineering issues and the Asset Manager regarding operational issues.

*refer Section 5.8 Post Flood Management of Bridges

4.3.3 Response to Level 1 or Level 2 inspection

Accidents and other structural damage can go unreported in remote locations. Reliance is placed on Level 1 and Level 2 inspections to identify and report defects which potentially endanger the capacity and stability of structures and thereby initiate a Level 3 investigation.

In less urgent instances, Level 1 and Level 2 inspections identify components that exhibit damage or deterioration (from overloading, repeated loading, physical or chemical damage).

These inspections can initiate a Level 3 investigation to investigate:
• the cause of the defects
• the extent of and predicted rate of deterioration
• the effect on capacity
• the cost and relative benefits of maintenance, extensive rehabilitation, strengthening or replacement of components or entire structures

4.3.4 Programmed Level 3 investigations

Examples situations in which programmed or intermittent Level 3 investigations are required

| Investigation outside of the scope of Level 2 inspections | • investigations requiring specialised access equipment and/or personnel such as elevated work platforms, scaffolding, barges, diving gear, or similar and for investigations on railway property
• the inside of box girders and other areas that are difficult to access or are confined spaces
• underwater inspection of piles and other components
• emergency bridging systems
• emergency median barrier access gates
• emergency boom gates
• concrete pavements on piles
• weigh-bridges
• architectural and historic features |

These investigations can be part of a programmed management system, at regular intervals but less frequently than Level 2 inspections. These inspections shall be scoped as Level 3 investigations.

<table>
<thead>
<tr>
<th>Investigation of bridges and other structures in the following categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor Structures</td>
</tr>
<tr>
<td>Complex Structures</td>
</tr>
<tr>
<td>Heritage and Historic Structures</td>
</tr>
</tbody>
</table>

These investigations may be conducted as part of a routine programmed management system. The scope and frequency of investigations shall be determined for each structure and shall require ongoing review depending upon the performance, intensity of loading, rate of deterioration (if any) maintenance, strengthening, component replacement or similar that potentially influence safety and whole of life costing.
Investigation of bridges and other structures during construction, after completion and at handover from other bridge asset managers/constructors:

- other road authorities
- rail authorities
- water authorities

In the case of existing structures, the Level 3 investigation shall include a detailed site investigation to confirm inventory data and to obtain condition data.

In the case of new structures, it is advantageous to develop and maintain liaison with the bridge asset managers/constructors and to participate in the review of design details and on-site inspections at critical stages. This approach reduces emphasis on final handover inspections. Detailed as-constructed drawings and information is an essential part of the handover process.

The following information is to be obtained from the transferring authority or organisation:

- design details
- as-constructed drawings* and information
- history of maintenance and modifications
- any other available historical records such as flood and/or fire events
- any other relevant information

*Design drawings are to be used if as-constructed drawings are not available.

4.3.5 Detailed condition rating

Level 1 and Level 2 inspections provide data on the observed condition of structural components. Level 3 investigations may be used to evaluate observations from Level 1 and 2 inspections or other condition data that is not visually evident.

Level 3 investigations may include non-destructive testing and/or sampling of materials for laboratory testing.

Examples of non-destructive testing to determine condition data include:

- cover meter measurement of reinforcement cover and sizes to determine approximate loss of section and compare depth of reinforcement against depth of chloride ingress and carbonation
- ultrasonic testing of welds to determine original quality and any fatigue related cracking
- dye penetration testing of steel members to identify the size and extent of fatigue cracks
- carbon-fibre pull-off tests to check bond to the parent material
- ground penetrating radar (GPR) to determine internal details of components such as voids, densities and similar. The use of GPR requires operation and interpretation by expert personnel. The results should generally be taken as indicative only and may require intrusive exploration to confirm GPR findings
- vibration induced testing of components, in particular, Pile Driving Analyser (PDA) testing of piles.
Examples of sampling testing for condition data assessment

| Concrete cores required: | • concrete strength  
| • depth of carbonation  
| • chloride ingress profiles  
| • alkali aggregate reaction (AAR) reactivity and presence. |
| Metal samples required: | • chemical content  
| • material identification  
| • degree of oxidation.  
| • ductility, toughness and fatigue resistance |
| Timber drilling to determine: | • quality of timber  
| • evidence of rot, insect or fungal attack |

The above data may be used to quantify the degree and extent of deterioration of components and materials when:
• determining adjustments to capacity reduction factors when assessing components load capacity  
• identifying deteriorating components  
• assessing the historic rate of deterioration  
• predicting future rates of deterioration and estimated remaining life  
• developing appropriate maintenance, strengthening, protective coating or chemical reaction systems or component replacement strategies to prolong component life and minimize whole of life costs.

4.3.6 Load capacity assessment of structures

Level 3 investigations are commonly used to make an assessment of the load capacity of a structure for the following main reasons:
• rating the load capacity of a structure against current design standards for inclusion in bridge inventory data  
• rating a structure for use by different classes of commercial vehicles that are operating under:  
  o general Access conditions. These vehicles include legally loaded rigid trucks, semi-trailers, truck and trailer combinations and B-Doubles  
  o restricted Access conditions such as Higher Mass Limits semi-trailers and B-Doubles  
  o PBS - Performance Based vehicles such as non-conforming semi-trailers, B-Doubles and truck and trailer combinations  
• rating a structure for use by special purpose vehicles such as all-terrain cranes  
• determining the adequacy of a structure for an individual heavy load platform movement, including:  
  o the strongest path over a bridge or other structure, for the width of the load, in the forward or reverse carriageway direction  
  o the benefits of travelling at reduced speed  
  o any local propping, plating or strengthening required to achieve adequate capacity for the proposed load  
  o consideration to alternative heavy load platform arrangements.

A multi-pronged approach may be taken to load capacity assessment as outlined below:
• theoretical analysis:  
  o simple analysis  
  o high order analysis  
  o analysis based on design drawings
- analysis based on as-constructed data (measured dimensions and material properties corrected for condition deterioration and measured load distributions).

- on-site instrumentation and load-testing including:
  - determination of elastic load distributions
  - measurement of dynamic response
  - measurement of component strains under legally-loaded vehicles
  - measurement of strains in components which are subject to proof-loading (in the region of 80% of ultimate limit state loading) and which are close to the elastic limit to provide improved data about structure strains and stability
  - load-testing of disused structures to destruction.

- laboratory load-testing of:
  - components obtained from redundant structures
  - models of individual components or parts of individual or standard structures.

More detailed information of the process can be found in AS5100.7 Bridge assessment.

4.3.7 Asset management of structures

Management of the road network requires development of strategies for monitoring, maintaining, upgrading and replacing structures in a planned manner that provides maximum economically justifiable access to the network for all categories of road users while minimising whole-of-life costs and working within available budgets.

The following are examples of asset management processes which involve Level 3 investigations:

- detailed load capacity assessments may be required for new or proposed classes of commercial vehicles, such as quad axle semi-trailers and B-Doubles, to determine the adequacy of structures on individual or multiple routes on the network for these vehicles. This might be accompanied by an assessment of the practicality and level of strengthening required for each structure and estimated costs

- development of management plans for structures, categories of structures or networks of structures, that may involve:
  - categorisation of structures into general, monitor or complex or other classification
  - determination of the appropriate scope of level 3 investigations
  - development and review of long term strategies for routine maintenance, strengthening, widening or other forms of upgrading or replacement
  - monitoring the performance and rates of deterioration to enable review of intervention strategies and procedures
  - instrumentation, collection and data analysis including:
    - vehicle volumes, mass and configurations, typically from weigh-in-motion systems
    - the performance of structures in general and critical components under repeated loading by heavy vehicles
    - developing projections for ongoing performance and deterioration of structures under predicted future vehicle loading

4.3.8 Data recording

Completed Level 3 investigation reports shall be submitted to the Superintendent with copies provided to:

- the Asset Manager
- the Principal Engineer - Structures

The Principal Engineer - Structures in conjunction with the Asset Manager will advise Information Management & Technology regarding the information to be recorded in RAS.
5 Inspection Requirements for Specific Categories of Structures

5.1 Monitor inspections

5.1.1 Purpose

The Monitor inspection program (Monitor program) was established to conduct periodic investigations of bridges in the classes which were found to have deficient live-load capacities during the 1997 Mass Limits Review. Other high-risk structures have been added to the list over time. Monitor Structures are checked for the presence of cracking and other signs of structural distress which are indicators that the structure is functioning at or close to its live-load capacity, is near to the end of its useful life, and requires strengthening or replacement without which a load-limit will be required.

The Monitor program is an additional level of inspection which targets structure classes considered to represent the highest risk to VicRoads. The Monitor program also enables VicRoads to allow heavy vehicles to cross bridges at an acceptable level of safety while it progressively upgrades and replaces them at an affordable rate of expenditure.

Monitor inspections are the primary means of ensuring the safety of these classes of structure and are also used to prioritise their strengthening and replacement. Structures in poor condition are given a high priority for strengthening and replacement. Equally, the Monitor program enables an informed judgement of whether strengthening and replacement can be deferred for structures that remain in good condition. For this reason the Monitor program serves as a risk-management tool and as an aid to the economic management of structural assets.

Monitor Structure inspections are visual, non-destructive, inspections of specific components aimed at detection of structural distress that could indicate reduced strength. They include:

- visual observation at arms-length and assessment of the condition of critical components
- photography - in order to compare the condition of critical parts of the structure with previous records.

A list of Monitor Structures is maintained by the Principal Engineer - Structures.

The Monitor list is updated from time-to-time in order to ensure the inclusion of all structures that require Monitor Structure inspections.

5.1.2 Definitions

The Monitor Structure inspection program (Monitor program) is the ongoing program of inspections of structures which were found to have an inadequate live-load capacity during the 1997 Higher Mass Limits Review.

Monitor Structure inspections are carried out periodically and consist of non-destructive detailed inspections of specific components to determine if any structural distress has developed that will reduce the live-load capacity of the structure. Visual observations including photography is conducted in order to compare the condition of critical parts of the structure with previous records. Inspection at within arm’s reach is normally required.

5.1.3 History

During the mid to late 1990s, VicRoads and other State Road Authorities (SRAs) implemented a major program of bridge inspection and load capacity assessment in conjunction with the National Transport Commission/Austroads Mass Limits Review.

Initial analysis by VicRoads and the other SRAs found that a large number of bridges had insufficient live-load capacity for Higher Mass Limits (HML) vehicles (45.5t semi-trailers and 68t B-Doubles). A major national program of bridge load-testing was then implemented. VicRoads and other SRAs proof-load tested a wide range of bridges using a pair of semi-trailers each loaded to a gross mass of approximately 110 tonnes.

VicRoads also conducted the following specific bridge load-tests

- a disused reinforced concrete tee beam bridge (to destruction)
- a disused reinforced concrete flat slab bridge (to destruction)
- laboratory models of approximately 25 reinforced concrete tee beams
- laboratory testing of three 40% full-scale reinforced concrete flat slab bridges
- laboratory testing of three 1950s U-slabs
- laboratory testing of three precast prestressed concrete rectangular beams.
In addition, non-linear finite element analyses were conducted on a number of bridges for comparison with the load-testing results and to assess other bridge types and individual bridges.

As a consequence of this testing and analysis, certain classes of bridge that were initially thought to be inadequate for HML vehicles were found to be satisfactory provided that they remained in good condition. It was concluded that access to these bridge types by HML vehicles could be given subject to periodic inspection to ensure that they remained in good condition. These inspections became known as the Monitor program.

Furthermore, and given the numbers of bridges in these classes, SRAs could not afford to strengthen or replace them in the short term. The Monitor program enables SRAs to replace and strengthen these bridges gradually on a needs basis and to indefinitely defer action on those bridges that remain in good condition.

The initial list of bridge types in the Monitor program comprised:

- reinforced concrete tee beams
- reinforced concrete flat slab bridges, with particular emphasis on the standard 1.5m 3.6m 4.5m (5’ 12’ 15’) and 2.1m 7m 9.1m (7’ 23’ 30’) span arrangements with end cantilevers
- prestressed concrete country roads board and state rivers & water supply commission type precast rectangular beams
- 1950s series u-slab bridges.

Other structures have been added to the Monitor program. The condition of these additional structures can deteriorate over time and limit their live-load capacities. They have been added to the Monitor program in order to manage their safety and serviceability and to prioritise their strengthening and replacement.

These additional structures are derived from the structure classes listed below:

- 1960s series u-slab bridges with bolted legs, cast in situ shear keys between the precast units and without concrete overlay
- 1950s and 1960s steel rail-in-slab bridges
- precast, prestressed DMR plank bridges
- cast-in-place reinforced concrete tee beam bridges
- reinforced concrete I-beams with cast-in-place RC deck bridges
- prestressed concrete NAASRA I beams with RC deck bridges
- precast prestressed concrete trough girder bridges with cast-in-place decks
- cast-in-place prestressed concrete voided slab bridges
- prestressed concrete box girder bridges
- rolled steel girders with timber deck bridges
- fabricated metal girder bridges
- timber stringers with timber deck bridges
- buried corrugated metal structures (pipes and arches)
- masonry arch structures and structures with masonry abutments, piers or similar
- rolled steel joist (RSJ) bridges retrofitted with precast or combination precast and cast in-situ reinforced concrete deck slabs
- large cantilever and gantry sign structures and high mast light arms with bolted base connections
- other individual structures that include components or details that require specific monitoring, such as elastomeric bearings that are moving laterally, retaining walls and abutments that are tilting or settling and similar.

Appendix H – Monitor Structures gives more information on these structures and detailed guidance on the approach to their inspection. It describes at-risk components and areas that should be inspected for signs of distress.
5.1.4 Inspection and Monitoring

Initial inspection is required to establish the structural condition of a structure and whether there has been any significant deterioration of its condition since its construction.

The Monitor program comprises periodical re-inspection to identify any changes in the condition of a structure. The frequency of monitoring inspections depends on the number, disposition and severity of structural defects together with the frequency of commercial vehicles using a bridge. The frequency of monitoring is subject to the Principal Engineer - Structures recommendation.

Defects are recorded on the Level 2 data sheets given in Appendix A (with particular emphasis on flexural and shear cracks) and photographed. Location, extent and width of cracks and, in particular, changes in these defects since the previous inspection are key indicators of possible changes in capacity of the structure which require further investigation.

These defects are given an overall maintenance or strengthening priority rating. The rating is at the discretion of the VicRoads inspecting engineer based on the type and severity of observed defects. The VicRoads inspecting engineer can modify or upgrade the S1 recommendation to “Urgent” and/or seek an immediate imposition of a mass load limit from the Principal Structures Engineer.

The definitions for both categories are provided below:

The Strengthening Priority classification ranges from S1 to S3 with S1 having the highest priority.

**S1 (1st priority - Strengthening works required)**

- Structures that have a high risk of requiring a load limit within the next 2 years because:
  - Structural components have deteriorated, are not acting as designed and may have reduced capacity.
  - There is an immediate threat to level of service, e.g. load capacity, safety, lane configuration and speed restriction.

S1 structures should have ongoing Monitoring inspections at intervals no greater than two years unless more stringent requirements are recommended. Alternatively, Level 3 Inspections could be considered to assess the structure condition and load rating, and the feasibility of strengthening, rehabilitation or replacement works.

**S2 (2nd priority - Strengthening works required)**

- Structures that have a high risk of requiring a load limit within the next 2 to 4 years because:
  - Structural components are showing significant signs of deterioration and structural cracking or corrosion.
  - The structure has progressively deteriorated over recent inspections.
  - A reduced level of service may result if no action is taken.

S2 structures should have ongoing Monitoring inspections at intervals no greater than three years, unless more stringent requirements are recommended.

**S3 (3rd priority - Strengthening works required)**

- Structures that have a high risk of requiring a load limit within the next 4 to 6 years because:
  - Structural components are showing some signs of deterioration and structural cracking that is progressively increasing over time.
  - The level of service is not expected to be reduced in the intervening time between this and future specified Monitor Inspections.

S3 structures should have ongoing Monitoring inspections at intervals no greater than four years, unless more stringent requirements are recommended.
The Maintenance Priority classification ranges from M1 to M3 with M1 having the highest priority.

**M1 (1st priority - Maintenance works required)**

M1 - structures that require maintenance works within 2 years because structural and non structural components have advanced deterioration and/or reduced durability. Failure to address these issues may lead to safety, serviceability or financial risks in the short term.

**M2 (2nd priority - Maintenance works required)**

M2 - structures that require maintenance works within the next 2 to 4 years because structural and non structural components are beginning to show isolated or not so advanced signs of deterioration and/or reduced durability. Failure to address these issues may lead to safety, serviceability or financial risks in the medium term.

**M3 (3rd priority - Maintenance works required)**

M3 - structures that require desirable maintenance works because structural and non structural components are showing minor signs of deterioration and/or reduced durability. Failure to address these issues may lead to safety, serviceability or financial risks in the long term.

5.1.5 Management of Monitor Structures

The majority of the above bridges has been inspected several times since the implementation of this program of inspection.

Inspections done to date have revealed a spectrum of bridge condition/distress ranging from:

- no distress to cracking and other distress that has been present for a long period and is not considered to threaten the structural integrity of the bridge
- cracking and other distress that is of structural significance but which is static or developing at a slow rate
- signs of distress that require short to medium term attention
- signs of distress that require immediate attention.

If the bridge is performing adequately or is deteriorating at a slow rate the frequency of Monitor inspections is reduced. Conversely, if inspections find the condition of the bridge is deteriorating quickly the frequency of inspections is increased.

This program of inspections has enabled a consistent assessment of similar bridges across all regions and enabled informed decisions to be made about the importance of and priorities for replacing and rehabilitating the most deficient bridges.

Monitor inspections are used to inform the program for replacement and strengthening of the most deficient and strategically important structures which can then be removed from the Monitor list. The frequency and number of Monitor inspections is expected to decrease over time as structures are replaced or strengthened and if the remaining Monitor Structures are found to be deteriorating slowly.

However, Asset Managers are required to prioritise replacement, strengthening or maintenance works to include other considerations in addition to the structures condition such as:

- community impacts
- traffic volumes
- commercial vehicle percentage
- bridge geometry and alignment
- proximity of other similar bridges offering economy of scale for strengthening and/or re-construction
- environmental conditions.

5.2 Complex Structures

Complex Structures are:

- individual or classes of bridge (or other road structures) for which the standard level 2 inspection does not provide sufficient information to assess the condition of bridge components
- bridges that require a bridge-specific inspection and management plan.

Structure-specific inspection and management plans are to be prepared by the responsible Asset Manager with advice from the Principal Engineer - Structures.
Structures may be included in the Complex list for a number of reasons:

- **structural form** - e.g. cable, suspension, truss, lifting bridge
- **the size of the structure** - e.g. its length, height or number of spans
- **special knowledge or training** beyond that of a level 2 inspector is required to conduct an inspection - e.g. metallurgical knowledge, FRP strengthening
- **the structure includes fracture-critical or fatigue prone components** - e.g. steel components subjected to cyclic loading, welds, gusset-plates
- **the structure involves new technology or technology in the early phase of use** that is subject to a trial evaluation
- **bridges for which special access provisions are necessary** - e.g. elevated work platforms, scaffolding, barges, diving gear, or similar and for investigations on railway property, or within confined spaces.

Examples of Complex Structure types:

- cable-stayed and suspension bridges
- prestressed concrete segmental bridges
- steel and concrete box girder bridges
- moveable bridges such as bascule, vertical lift span and swing bridges
- through and half-through trusses and girders
- bridges with half joints and drop-in-spans
- riveted wrought iron bridges - e.g. some Melbourne bridges over the Yarra river
- bridges with multiple spans
- high bridges
- bridges over deep (>1m) and large expanses of water
- box-girder bridges
- other structure types with limited or no structural redundancy

The examples of Level 3 investigations, described in 4.3, provide general guidance on the development of appropriate programs of inspection for Complex Structures.

The use of Remotely Operated Vehicles (ROVs) for Complex Structure inspections provides a lower cost and lower occupational health and safety risk option for Asset Managers to perform preliminary inspections in order to determine if a more rigorous inspection at arms-length is required. Asset Services has trialled the use of ROVs on a small sample of Complex Structure inspections instead of using more traditional access equipment options. The use of ROVs for Complex Structure inspections must be guided by an experienced bridge engineer. Asset Services must be consulted to advise on the use of ROVs for Complex Structure inspections as there is currently no framework for their use.

Complex Structure inspections include completion of the Level 2 inspection forms for the whole of the structure. If the condition of specific features of a Complex Structure cannot adequately be assessed and recorded on the standard Level 2 forms, it may be necessary to devise structure-specific forms.

A list of Complex Structures is maintained by the Principal Engineer - Structures. The list is subject to continuous review.

### 5.3 Inspection of Timber Bridges with timber and/or steel stringers

#### 5.3.1 Introduction

This section provides detailed direction for performing inspections of two common bridge types - timber substructures and decks with either timber or steel stringers. The steel beams may be either rolled steel joists (RSJs) or universal beams (UBs).

This section does not cover steel plate girder nor wrought iron girder bridges with timber decks.
5.3.2 Technical Items

5.3.2.1 Timber Piles/Piers and Abutments

Geometry:
- measure diameter of timber piles/piers at piers and abutments at the base, top and sufficient intermediate levels to be able to determine an average and minimum diameter
- measure the diameter and length of any reduced section caused by stream flow abrasion
- seek indication of toe levels from notched markings in piles indicating height above end of pile
- measure spacing of piles at base and at crosshead
- measure size and locations of cross-bracing members (if any)
- measure size and locations of timber cross-head members
- measure the number, size and locations of bolts used to connect members to piles
- note the condition and tightness of such bolts
- measure size, spacings and locations of timber piles driven to retain timber or precast concrete abutment walls and approach wing walls.

Condition:

(a) Pipe rot
- determine effective cross-section of timber piles/piers at:
  - intermediate point between high and low water levels
  - other intermediate points as necessary depending upon amount of pipe rot determined at above location
  - other locations where any evidence of rotting, splitting or similar is present.
- determine effective cross-section by drilling from one side and regularly removing the bit to inspect quality of timber shavings until resistance to drilling indicates a cavity or weaker material and the timber shavings indicate the presence of pipe rot
- measure depth from outside to start of pipe rot
- continue drilling from same side until sound timber is again encountered
- measure depth to this location
- continue drilling through to other side of pile to ensure that no further pipe rot is encountered
- where drill bit is not long enough to perform drilling from one side only, drill along same path from both sides of pile
- seal all drill holes and treat with timber preservatives such as boron rods, plugs etc. the asset manager should be advised of reinstatement method prior to investigation
- draw cross-section showing effective annulus or solid section of sound timber
- check that timber is sound where supporting timber crossheads, particularly where cross-heads are checked into timber piles.

(b) Pest Attack

Check for any evidence of white ants, termites or similar when inspecting the piles by drilling and hitting with a hammer to check for weak spots.

(c) Splitting
- determine if there is any splitting of timber piles
- measure locations and extent
- if necessary, drill to determine extent of splitting.
5.3.2.2 Timber Cross-Heads

Geometry:
- measure size, number and locations of timber crossheads
- measure diameters and locations of bolts attaching cross-heads to piles
- measure size and connection of steel crossheads (if any).
- determine effective load sharing (if any) between steel and timber cross-heads where both are present.

Condition:
- determine soundness of timber crossheads by use of geologists hammer and drilling as necessary
- check for splitting and end rot to determine effective section.

5.3.2.3 Timber Corbels

Geometry:
- measure effective diameter, length and locations of timber corbels
- record connection details to crossheads and stringers.

Condition:
- visually inspect to see if there is any evidence of splitting or rotting
- test for soundness with geologist’s hammer and if necessary by drilling to determine effective diameter.

5.3.2.4 Timber Stringers

Geometry:
- measure effective diameter or sawn dimensions, length, spacings and locations of timber stringers
- particularly note if stringers are located directly over top of piles
- measure effective diameter at each pier, abutment and near the end of each corbel to use in assessing adequacy of shear capacity
- measure effective diameter near mid-span to use in assessing adequacy of flexural capacity.

Condition:
- visually inspect to see if there is any evidence of splitting or rotting
- test for soundness with geologists hammer and if necessary by drilling to determine effective diameter.

5.3.2.5 Steel Beams

Geometry:
- measure web and flange sizes and thicknesses and record beam size and weight, where marked on web of beam
- measure beam numbers, spacings, locations and lengths
- measure sizes and locations of any cross-bracing of members
- measure and record details of welded or bolted connections to beams
- measure and record details of any web stiffeners
- measure and record any details intended to provide complete or partial continuity
- measure and record any details of welded or bolted splices in beams
- measure and record any details provided to increase the strength of the beams e.g. bottom or top plates
- record details of connections of beams to corbels (if any) and crossheads
- note type and measure dimensions and locations of bearings (mortar, steel or elastomeric).

Condition:
- visually inspect to see if there is any evidence of damage or corrosion
• measure thickness of flange or web to determine loss of section at any location that appears to have suffered substantial corrosion.

5.3.2.6 Timber Deck

Geometry:
• measure sizes, spacings and lengths of deck crossbeam members
• record details of connections of crossbeams to longitudinal timber or steel beams
• measure sizes and orientation of timber running planks
• measure width between kerbs and locations relative to main beams
• measure kerb details
• measure deck overhang.

Condition:
• visually inspect to see if there is any evidence of splitting or rotting of timber crossbeams
• inspect to see if any of the bolted connections have become loose or corroded
• test soundness of crossbeams with geologists pick and if necessary by drilling
• assess looseness of timber decking by visual inspection and by observing behaviour under traffic
• inspect for and measure any gaps in the decking.

5.3.2.7 Bridge Barriers and Handrails

Geometry and Structural Details:
• record type, materials and locations of any bridge and pedestrian walkway barriers and rails and posts
• measure sizes, post spacings and extent of barriers
• note type and measure length, height and offset details and termination treatment of any approach barriers
• note and record the number, size and locations of connections of rails to posts and posts to deck or kerb.

Condition:
• visually inspect to see if there is any evidence of damage to barriers and railing
• inspect to see if posts and rails are in sound condition
• inspect to see if foundations for posts are in sound condition.

5.3.2.8 Bridge Waterway and Scour

Waterway area:
• inspect area upstream and downstream as well as in the vicinity of the bridge to see if there is evidence of debris, flattened grass or similar that might indicate a recent flood level
• seek evidence of the size and type of any debris
• seek information from local residents, water or catchment authorities and other sources to determine what flood and discharge records are available (task for asset manager)
• seek information from relevant authorities about any planned development or similar in the catchment that might affect the runoff and design discharge and flood levels at the site (task for asset manager)
• observe and seek information on upstream land use to determine acceptable afflux levels
• observe and investigate natural streambed material and any evidence of scour as part of assessing maximum permissible stream velocities through the bridge site
• determine the type and extent of any beaching
• inspect to determine if there is any evidence of scour or major settlement of such beaching.
• scour or reduction of waterway:
• determine if there is any evidence of scour of the streambed in the vicinity of the bridge and whether such scour has undermined pier or abutment spread footings or pile caps or exposed piles
• Determine depth of exposure of piles and extent of undermining of spread footings or pile caps
• inspect to see if there is any downstream scour that could potentially progress upstream and endanger the bridge foundations
• determine if there is any evidence of reduction in the original waterway area by silting up, build-up of debris or similar.

5.3.2.9 Traffic

Volume:
• ascertain an estimate of the current traffic volume and predicted rates of increase from the bridge owner or other local authorities and by observation.

Mix:
• also try to establish the percentage of commercial vehicles and types of vehicles currently using or likely to use the bridge during its estimated remaining life e.g. milk tankers, grain trucks, local quarry trucks, farm machinery etc.
• determine if it is a tourist or school bus route
• determine the likely presence of pedestrians and bicycles e.g. nearby school, shops, sporting facilities etc.

5.3.3 Recommendations

As part of the inspection, an assessment shall be made of the components of the structure that require:
• maintenance or replacement to reinstate them to sound condition
• strengthening, replacement, widening or similar to upgrade the structure to comply with appropriate standards.

In addition, the benefits and costs of replacing the entire structure to meet current standards shall be assessed. Recommendations shall consider the estimated remaining life of the structure, the loads to which it is likely to be subjected, the cost and practical problems associated with maintaining, upgrading or replacing the structure. Other considerations include environmental sensitivity of area, heritage overlays, network disruption and ability to undertake works safely.

5.4 Investigation of Bridges without Drawings

5.4.1 Introduction

This section provides details of the items to be recorded in a field investigation of bridges without drawings. The objective of this investigation is to obtain the appropriate information to determine the load capacity of the bridge without the need to expose all reinforcement in the bridge.

The location, size and spacing of reinforcement at the critical locations, together with information on bridge condition and strength of materials obtainable on site is sufficient to calculate a load rating for the bridge.

This section does not provide guidelines on structural analysis methods used to determine load capacity of the bridge. This should be carried out in accordance with the AS5100.7 Bridge assessment by an experienced bridge design engineer based on the field data collected in accordance with this section.

5.4.2 Procedure

The bridge inspection report includes details of the current condition of all components of the existing structure.

A field inspection is required to gather the information shown on the appropriate drawings attached to this section. Information is obtained at critical locations based on previous assessments of similar structures. Relevant information may include dimensions, material strength, size, spacing and cover of reinforcing bars in concrete.

For structures built prior to 1950, the strength of reinforcement may exceed the conservative value allowed in AS5100.7 Bridge assessment. Reinforcement strength can be obtained by testing samples taken from the
structures or by site measurement of hardness of reinforcement and correlating hardness with strength values obtained from similar aged reinforcement.

5.5 Heritage and Historic Structures

Heritage or Historic Structures are structures included on the Victorian Heritage Register and/or nominated in VicRoads - Road Asset System (RAS).

VicRoads' Management of Heritage Bridges policy states how VicRoads meets its statutory obligations to identify and conserve bridges and other structures of historic value subject to community, environmental, social and economic considerations.

VicRoads aims to retain the best examples of historic road-related structures and manage them in accordance with conservation plans and heritage legislation.

The Management of Heritage Bridges policy applies to all bridges on declared roads which are included on registers of the Heritage Council of Victoria, National Trust, or Council Heritage Overlays, or which are being considered for registration.

Registered heritage bridges are usually open to vehicular traffic and are maintained to the same performance standards as equivalent non-heritage bridges in a manner that preserves the heritage characteristics of each bridge.

Heritage structures are included in the normal bridge inspection program for level 1 and 2 inspections even if they are not used by traffic.

The list of Heritage and Historic structures is kept in RAS. RAS records the specific details which are essential to maintaining the heritage value of structures in this category. This information is used to prepare structure-specific conservation management plans for individual heritage registered bridges. Heritage Council of Victoria has an information guide titled Conservation Management Plans: Managing Heritage Places (2010) for preparation of plans.

Conservation Management Plans should:

- identify the heritage importance of the structure
- define the heritage features and components to be inspected and reported
- describe the current condition of the structure, outstanding maintenance and resulting threats to the structure
- outline frequency for regular inspections, provide guidance on mechanisms for deterioration and signs of distress in components
- provide guidance for the maintenance and should include appropriate materials, surface treatments and methods for various components

5.6 Disused Structures

5.6.1 Introduction

VicRoads has a responsibility for the management of disused and other potentially hazardous structures within the road reservation. A road bridge which is no longer in use by vehicular traffic (but which may be in use by pedestrians) or a pedestrian bridge no longer used is considered a disused bridge.

If the structure becomes disused for vehicles and remains open to pedestrians with footpath connection it is preferred that the asset be transferred to the relevant Council. VicRoads preference is that disused structures that do not remain open for vehicles or pedestrians be demolished if they are not heritage registered or being nominated for registration.

Disused structures not open to vehicles and pedestrians often have a lower maintenance priority to other structures. As a result, a disused structure could deteriorate to a point where it is unstable or has partially collapsed and, provided that the structure is not subject to statutory or other protection, partial or total dismantling may be necessary in order to properly control the hazard.

Disused structures are included in the normal bridge inspection program for level 1 and 2 inspections even if they are not used by traffic.
5.6.2 Inspection and Maintenance of Signs and Fences

Signs and fences must be inspected and maintained as part of the routine inspection and maintenance program. The adequacy of fencing and signing is reviewed periodically, or if circumstances change, in order to ensure that the level of protection continues to be adequate.

In areas of low population, provision of signing and a simple fence at each end of the bridge is generally provided. In more densely populated areas where there is evidence of frequent unauthorised entry, graffiti, vandalism or where the bridge is in close proximity to a school, it may be necessary to provide more robust fencing and additional signs. Where there is a risk of falling objects and the public has access to the underbridge area, it may be necessary to provide additional fencing to create a fenced ‘no-go’ zone.

Figure 4: Sign on disused structures

5.6.3 Data Recording

It is recommended that a record be kept of any assessment made in relation to a course of action for disused structures. Also, the fencing and signing provisions should be recorded so it can be referenced against for routine inspections and reinstatement purposes after vandalism or severe weather. This information should be provided to the inspectors to check against during inspections to identify any unwanted changes that require fixing.

5.6.4 Occupational Health and Safety

Those responsible for inspection and removal of unstable structures must assess and manage the risks associated with these activities in order to ensure the provision of a safe workplace.

5.7 Major Sign Structures

5.7.1 Introduction

Audit inspections of large, recently constructed cantilever sign structures have indicated an urgent need to inspect the base-connections of all such structures. The audit inspections were implemented in response to the fatigue induced failure of one of these sign structures. Defects detected include fatigue-cracking of holding-down bolts, missing bolts, inadequate or missing washers, buckling of column stiffeners and cracked or missing mortar beneath the base-plates. Preliminary investigations have indicated that these defects most probably have resulted from inadequate design detailing and poor construction practices.

5.7.2 Inspection procedures

Large cantilever and gantry sign structures should be inspected for the presence of the defects listed below:

- cracked or missing holding-down bolts or bolts in other connections
- cracked, incomplete or missing grout under base-plates
- washers missing or too small
- nuts missing, not fully tight or unevenly seated
- nuts fully tight but with less than the specified minimum projection of thread above the nut.
• damaged threads
• cross-threaded nuts
• warping or other distortion in base-plates and other steel components
• cracked welds particularly around the base plate to post and gusset plate connections
• rippling paint which may indicate buckling of the underlying structural steelwork
• corroded components
• vertical members leaning
• evidence of impact damage to any component.

If the inspector finds the foregoing (or any other defects) an immediate report must be made to the appropriate Asset Manager and further advice should be obtained from the Principal Engineer - Structures.

5.8 Post Flood Management of Bridges

5.8.1 Introduction

Early identification of flood-damaged structures is essential to road-safety and to the continuity of the road network. The freight and crane industries, in particular, continue to make permit applications for the movement of heavy vehicles during flood events. Both industries may be involved in flood-recovery activities so it is vital that the safety of movement across a structure is assessed as early as possible. In order to enable permit applications to be processed, inspection of affected structures must be completed as soon as practicable.

This section is intended for use by those who are responsible for the management of bridges over watercourses that are susceptible to damage or destabilising effects as a result of flood events. It should be read in conjunction with, the requirements for Level 1 – Routine Maintenance Inspection. It provides additional requirements for inspection procedures and reporting which are intended to assist with the notification and management of critical damage to bridges after flooding.

5.8.2 Inspections and Assessments

5.8.2.1 General

The requirement to inspect after flood events is stated in Section 750 – Routine Maintenance of the VicRoads Standard Specification for Roadworks and Bridgeworks. In addition to completing Table 750.D021 – Bridge and Major Culvert Routine Maintenance and Inspection Report, a supplementary report sheet for use during post flood inspections only must also be completed. This report is intended to ensure that critical defects caused by flooding are identified, inspected, recorded and reported. A sample Post Flooding Bridge Inspection Report is included in Appendix E – Post Flooding Bridge Inspection Report.

5.8.2.2 Initial Post Flooding Inspection and Actions

Structures over severely flood-affected watercourses and those with known vulnerability to flood-damage are to be given priority. An inspection is to be conducted as soon as safe access to the structure is possible. The inspector should perform an initial visual inspection from a safe position. If the structure is under water and invisible, this must be reported and the structure, together with its approach roads, should be closed.

Other than monitoring, no further action should be taken until the water-level has subsided and the whole of the structure – i.e. the superstructure and substructure including the piles - is visible. If the structure is accessible, the inspector should carefully assess the immediate approaches to the structure and the visible parts of the bridge for following irregularities:

• bridge approaches (voids in surface, settlement, slippage of embankment)
• barriers (missing, misaligned, foundation washed away)
• abutments (displaced, damaged, unsupported, voids)
• deck/beams (holes, missing beams, misalignment)
• kerbs (misalignment, settlement)
• movement joints (missing, displaced)
• crossheads (displaced, damaged, unsupported)
• piles (missing, displaced, damaged)
• pile-caps (displaced, damaged, unsupported)
• changes in river bed (alignment, depth, profile) and visible scouring under bridge foundations
• debris (accumulation on superstructure, lodged in substructure)

If there is any doubt regarding the stability of the structure or the adjacent road embankments, the road must be closed immediately.
5.8.3 Vulnerable Structures

Slender piles of small cross-section and certain types of foundation (e.g. shallow spread foundations) are more vulnerable to undermining by scour.

Timber bridges and concrete beam bridges without overlays are more vulnerable to damage due to the higher deterioration rate of these materials. Timber piles in water should be checked below the water level to ensure the pile condition is adequate. It is acknowledged that visual checking of piles below ground level or bed of river is extremely difficult. If settlement is apparent, the pile condition can be inferred. Excavating around piles is not practical, however non-destructive testing is possible option.

Waterway profile and changes in direction can influence the degree of scour. Bridges on or near to river bends in waterways are more vulnerable to scour damage than those on straight sections.

Flood conditions can accelerate scour and remove large volumes of material around bridge foundations and piles very rapidly.

Buried Corrugated Metal Structures (BCMS) may also be vulnerable to damage as a result of flooding. If the invert of the BCMS is corroded or if the upstream endwall is absent or deficient, flood-waters can flow around the BCMS and wash-away the backfill material. BCMS have been completely washed away in these circumstances leading to an extremely hazardous void in the carriageway. This type of damage can also develop slowly over a period of moderate flow with the final collapse occurring in flood conditions.

5.8.4 Reporting

Any irregularities in the structure, signs of distress or scour damage must be reported to the Principal Engineer - Structures as soon as possible. If there is any doubt about the severity of damage to structure or its stability, a structural inspection by an experienced bridge engineer must be arranged as soon as practicable in order to determine if the load capacity of the bridge has been affected and the necessary course(s) of action. The experienced bridge engineer may be a member of VicRoads Asset Services - Structures or a bridge engineer who is pre-qualified in accordance with VicRoads pre-qualification scheme at the Structures Complex level.

The inspector should photograph the structure, giving particular attention to any irregularities, signs of distress or scour. Copies of the inspection report and the photographs must be sent to:

- the Asset Manager
- the Principal Engineer - structures for the attention of the manager Bridge Assessments
- the Manager Real Time Operations (previously Manager Regional Services Road User Services for statewide permits).

If the whole of the structure can be inspected, it is undamaged and its load-carrying capacity is unaffected, it can be re-opened to traffic. If the bridge barriers are damaged it may be necessary to provide temporary barriers. Accumulations of debris on or against a bridge must be removed. Care must be taken during removal of debris to ensure that the structure remains stable.

If an underwater inspection is required to determine the condition of the foundations and the nature and extent of any damage, it will be necessary to engage a suitably qualified and experienced commercial diver to conduct the inspection. The diver’s qualifications and diving procedures must comply with AS2299 Occupational Diving Operations. The diver must be fully briefed by an experienced bridge engineer regarding the specific requirements for the inspection. The diver must assess the existing site conditions to be safe prior to commencing their underwater inspection.

Alternatively, the use of a remotely operated vehicle (ROV) with appropriate imaging technology can be used to minimise occupational health and safety risk. However, the inspection must still be guided by an experienced bridge engineer. Asset Services - Structures must be consulted prior to commencing to advise whether this approach is suitable for the location and will provide reliable data.

5.8.5 Load and Traffic Restrictions

If there is any uncertainty about the serviceability of the bridge following a flood event, the Principal Engineer - Structures may impose one of the following temporary restrictions pending a structural inspection and a formal load assessment:

- lane closure
- closure to all vehicles and pedestrians
- pedestrians only
- pedestrians and cars only
- pedestrians, cars and light commercial vehicles only
- all legal vehicles excluding permit vehicles.
On completion of the structural inspection and load assessment, the Principal Engineer - Structures may confirm or amend the weight restriction pending repairs or other remedial action. If the Principal Engineer - Structures determines that a weight restriction is not required, the bridge may be opened to all vehicles.

5.8.6 Level 3 Detailed Engineering Inspection and Analysis

A Level 3 Detailed Engineering Inspection is recommended where signs of damage or structural distress are evident. The Level 3 investigation may include a geotechnical investigation and an underwater inspection. Under-water inspections must be conducted as described in clause 5.8.4.

5.8.7 Load Assessment

On the advice of the Principal Engineer - Structures, a load-rating assessment may be required to determine the capacity of the structure. This shall be based on the post-flooding condition of the structure. Load rating shall be conducted in accordance with AS5100 Part 7: Bridge assessment.