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Appendix C - Examples of briefs and scopes for Level 3 investigations

1.1 Introduction

1.1.1 Purpose
To provide guidance on the preparation of a Brief and a Scope of work for a Level 3 investigation.

This Appendix provides examples of what should be included in the Brief, and what might be included in the Scope of the investigation for the examples given in Part 2 – Section 4.3.

1.1.2 Field investigations
Scope items relating to safety, site access and traffic management are similar for all examples and may include all or some of the following as required (note that the phrasing is as it might appear in the actual scope):

- submit a plan of the investigation for approval by the Superintendent prior to commencement of the investigation. The plan should include as a minimum:
  - the type of visual inspection that is planned (e.g. close-up, hands-on inspection, remote inspection by binoculars etc)
  - the extent and nature of destructive and/or non-destructive testing
  - method(s) of access
  - identification of areas of the structure that may require special means of access or where access is restricted
  - limitations on public access and access controls that may be required
  - traffic management requirements
  - Safe Work Method Statements (SWMS)
- provide access for the investigation
- obtain traffic management approval(s)
- obtain environmental approval(s) (if these are not provided by VicRoads)
- conduct the investigation in accordance with the approved plan
- report the results of the investigation in the specified format within the specified time period. Reporting must include the Level 2 inspection requirements and forms for component condition and recording of photographs. Details of testing must also be included.

1.1.3 Advice
The Principal Engineer Structures must be consulted for technical input to the development of proposals for Level 3 investigations, for ongoing advice during investigations and for review of completed investigation reports. Input and advice from other disciplines relevant to the investigation shall be obtained from Geotechnical Services and Construction Materials as appropriate.

Early involvement by Asset Services ensures that the Level 3 investigations are focused to concerns relevant to the structure; it reduces potential of testing not relevant to the structure, removes structural analysis on components which do not need assessment and ensures the thoroughness of Level 3 investigation minimising potential for rework onsite.

The Region should consult other authorities such as water, utilities and rail (where access for the investigation requires the agreement of these authorities or their input). The Region should manage operational issues for Level 3 investigations including traffic management plans and access equipment.
1.2 Examples of Level 3 investigations

1.2.1 Response to incident, accident or natural event

Note: It may be necessary to respond rapidly if a serious incident or natural event occurs which threatens the safety or stability of a structure. Given the nature of serious incidents and natural events (such as flooding), the need for a rapid response will restrict the time available for planning of the inspection. In that case, it may not be possible to prepare a formal and detailed brief or scope. The inspection should then be conducted with the following brief in mind and, above all, with proper regard for the safety of those conducting the inspection.

If the initial inspection (by maintenance personnel for example) identifies damage that could compromise structural safety or performance, a planned Level 3 inspection is required. This may, in-turn, lead to a more detailed and targeted Level 3 investigation to determine the full extent and magnitude of the damage.

The Brief for a planned investigation should include:

- background information and the results of previous inspections of the damage or similar damage to the structure
- clear identification of the damaged components of the structure including the specific area(s) that require investigation
- the end purpose of the investigation report - for example:
  - to determine if the structure can safely continue in operation
  - to determine the nature and extent of repairs required to ensure that structure is safe for use
  - to determine the nature and extent of longer term maintenance or rehabilitation works
- requirements for visual, destructive and/or non-destructive testing (e.g. bottom flange of steel beam must be visually inspected close-up for deformation due to vehicle impact)
- results of recent Level 2 inspections of the structure
- all available drawings of the relevant parts of the structure
- any previous reports on the relevant parts of the structure
- an outline scope of the Level 3 investigation.

The Scope might include:

- provide recommendations on the type of investigation that is required and an explanation of how these investigations will achieve the purpose described in the brief
- submit a plan of the investigation for approval by the Superintendent prior to commencement of the investigation. The plan should include as a minimum:
  - the extent of investigation, preferably by reference to a drawing of the structure
  - any unique characteristics and features of the structure that must be investigated
  - the method for recording the results of the investigation

Structural, geotechnical, hydraulic and/or materials engineering investigations may be required to undertake a comprehensive assessment of the damage to the structure.

Examples of investigations can include:

Impact damage from road, and rail vehicles or water vessels:

- survey measurements, non-destructive testing (NDT) and sampling of material from deformed steel beams
- exploration of the depth of damage to timber or concrete beams or piers, including determination of damage to prestressing tendons using NDT or more invasive methods such as carefully controlled removal of concrete to expose tendon ducts and tendons
- investigation of damage to abutments and deflection walls and barriers protecting abutments
- investigation of damage to foundations
- assessment of damage to bearings, expansion joints, other mechanical components and their restraining systems
- assessment of damage to bridge and bridge approach barriers, their connections and the supporting structure.

Fire or explosion damage:

- exploration of depth of heat-affected zone in concrete and timber components using NDT and/or intrusive methods
- exploration of crack extent, width and depth in concrete and masonry or brick structures
- exploration of heat damage/deformation and change in material properties in all types of material including coatings

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• assessment of prestressing tendons and other high strength steel components that are susceptible to heat damage such as Carbon Fibre Reinforced Polymer (CFRP) and bonding materials
• assessment of other steel components such as barriers and their coatings
• assessment of displacement (absolute and relative) of bearings and superstructures
• examination of colour change in concrete components.

Flood damage:
• Investigation of damage to piers, abutments and bridge superstructures from debris impact (floating trees, vehicles and vessels for example)
• Investigation of lateral movement or uplift of bridge superstructure and bearings due to debris loading and buoyancy effects
• Investigation of scour of river-bed under and adjacent to foundations, which may not be evident until after the flood-waters subside
• Investigation of aggradation of river-bed adjacent to foundations and superstructures
• Investigation of damage to approach embankments and beaching.

Note that excess pore pressure and draw down effects can cause failure, rotation or settlement of abutments, retaining walls, other structures and the river-banks

Earthquake damage:

Note - all structures might suffer severe vertical and or lateral accelerations and movements.

• bridges could suffer bearing displacement, closure or opening of gaps between adjacent components causing spalling or failure of concrete members, distortion or tearing of steel members, damage to expansion joints, settlement and rotation of foundations, piers and abutments due to soil liquefaction
• retaining walls, large sign structures, high mast lighting arms and other structures reliant on soil-structure interaction could become unstable and suffer damage or failure of main components as a result of settlement, rotation or collapse
• masonry culverts, arches and retaining walls and other non-ductile structures are likely to suffer severe cracking of masonry and mortar joints, settlement of foundations, rotation of approach walls and settlement of the contained roadway.

1.2.2 Response to Level 1 or Level 2 inspection

The **Brief** must include:
• a description of the problem identified in the Level 2 inspection
• the end purpose of the investigation report - for example:
  o to determine if the structure can safely continue in operation
  o to determine the nature and extent of repairs required to ensure that structure is safe for use
  o to determine the nature and extent of longer term maintenance or rehabilitation works
• details of departures from the problems identified in the Level 2 inspection
• a copy of the Level 2 inspection report in which the problem was identified
• requirements for visual, destructive and/or non-destructive testing
• drawings of the relevant parts of the structure
• previous reports on the relevant parts of the structure
• an outline scope of the Level 3 investigation.

The **Scope** might include:
• provide recommendations for the visual inspections and in-depth engineering investigations required and an explanation of how these investigations will achieve the purpose described in the brief
• submit for approval a plan for conduct of the investigation prior to commencement. The plan should include, as a minimum:
  o the extent of investigation, preferably defined by reference to a drawing of the structure
  o identification of the unique characteristics and features of the structure that is to be investigated
  o information about similar defects in other bridges, similar components in this structure or other structures including likely causes of the defect, extent of defect and probability of further deterioration or expansion of defect and successful investigations and repairs that have been implemented in similar situations
  o method for recording the results of the inspection
• structural, geotechnical, hydraulic and/or materials engineering investigations as required to complete a comprehensive assessment of the issue identified by the Level 1 or 2 inspection
• report the results of the inspections in the agreed format and within the specified time period.

1.2.3 Programmed Level 3 investigations

1.2.3.1 Introduction

As detailed in Part 2 Section 4.3, programmed Level 3 investigations are required for both individual structures and defined classes of structure.

A range of Level 3 investigations are required for structures in the categories of Monitor Structures, Complex Structures and Heritage and Historic Structures (as described in Part 2 Section 5) in order to inform the development of structure-specific management plans. Structure-specific management plans include ongoing inspection and maintenance requirements. This may form or be part of a Conservation Management Plan for Heritage and Historic Structures.

The management plan may be required to specify:

• specialist equipment for access or monitoring the performance and condition of the following components:
  o beams and other components at height or over water that cannot be accessed by normal means
  o interiors of box girders
  o piles and other components underwater
  o welded and bolted connections in steel structures using non-destructive methods such as ultrasonic testing
  o the requirements for periodic inspection of the structures as part of the Monitor program*.

*Based structure being one of the typical classes of structures included in the Monitor program or to monitor the ongoing performance of a particular structure or component.

• The requirements for periodic investigation of Complex Structures to ensure that the performance of unusual, fracture critical and other details are monitored appropriately

• The requirements for monitoring the condition of structures and parts of structures that are heritage listed

Management plans must define the scope, frequency and structure-specific safety issues to ensure the continuing safe performance of these structures. They must also include specific provisions for the management of risk and to inform the maintenance, rehabilitation and replacement requirements for these structures.

In instances where a management plan does not exist, a Level 3 investigation may be required to develop the scope for the programmed Level 3 investigations of an individual structure.

Maintenance, strengthening, widening or replacement activities relevant to the structure may change the status of the structure and requirement for ongoing programmed Level 3 investigations.

The following examples are provided for each of these categories.

1.2.3.2 Monitor Structure investigations

As described in Part 2 Section 5.1, VicRoads has identified a number of different classes of bridges and major culverts that are included in the category of Monitor Structures.

Bridges with either full width or part width superstructures comprised of cast-insitu reinforced concrete tee beams, flat slabs, 1950s and 1960s series reinforced concrete u-slabs and prestressed concrete planks without reinforced concrete overlays have been categorised as having Monitor Structure status. VicRoads has developed deep understanding of these form of structures based on extensive investigations and has an internal process to inspect the critical areas and components.

Bridges and major culverts that are constructed from brick or stone masonry or have principal components, such as piers and abutments constructed from masonry are all categorized as having Monitor Structure status. The technical aspects of Level 3 investigations of these structures are based on Level 2 inspections by experienced engineers in the first instance. In addition, limited geometric surveys may be undertaken to confirm that wing-walls have not settled or rotated significantly or that arches have not flattened. Significant cracks through the mortar and/or masonry shall be recorded and mapped and areas of water penetration and efflorescence shall also be recorded. These details shall be recorded and photographed using the Level 2 reporting format for reference in subsequent inspections to determine whether any observed defect is stable or deteriorating. Further Level 3 investigations may be implemented following the above initial inspections, that might include the use of Demountable Mechanical Strain (demec) gauges, laser survey and other survey techniques, to monitor crack widths and lengths, settlements and rotations of walls, abutments piers and arches and similar. Cores may be taken to determine mortar and masonry material properties and condition, wall and arch thicknesses,
backfill material properties and depth between approach walls and similar. Limited backhoe exploration might also be considered. Such investigations may be undertaken in conjunction with analytical analysis of the structure, using conventional structural analysis or specialised masonry arch analysis software.

Corrugated metal pipe and arch structures are also categorised as Monitor Structures. Reference is made to Part 3 Section 1.2.7 which provides guidance on safety during both inspection and repair of these structures. Reference is also made Appendix H which provides guidance on investigating the condition of existing structures, including surrounding backfill material, water quality and presence or evidence of water borne abrasive materials. VicRoads Bridge Technical Note 015 “Code of Practice Buried corrugated metal structures” provides advice on investigating culvert inverts and retrofitting reinforced concrete inverts. In other instances, where culvert condition is poor and complete replacement is not practical or extremely expensive, such as under high fills or beneath major highways and freeways, consideration may be given to use of a full perimeter concrete grout lining, provided adequate waterway area is still provided. The above considerations provide a basis for developing the safety and technical aspects of the Brief and Scope for Level 3 investigations into the condition and alternative repair and replacement options for buried corrugated metal (steel or aluminium) arches and pipes.

Specific technical guidance still needs to be developed for the inspection of steel girder bridges retrofitted with non-composite precast concrete deck panels or composite cast-in-situ or combination precast and cast-in-situ concrete decks. In the former case, Level 3 investigations should include detailed inspection of the connections of the precast panels to the steel I girder flanges. These connections may vibrate loose, corrode, suffer from fatigue failure, local cracking or failure of the concrete slabs or pullout of the steel connections or similar. Attention should also be given to uneven seating of precast panels over multiple steel I girders. In the case of retrofitted composite, part precast deck panels, attention should be given to uneven seating and signs of gaps between the steel girders and precast panels, evidence of corrosion or fracture of connections, where visible, evidence of cracked or spalled concrete. In both instances, consideration might be given to installation of instrumentation to investigate any differential movement between the girders and the concrete deck slabs. The Brief and Scope need to consider the above technical aspects, in conjunction with other features of the specific structure, in conjunction with other general considerations listed in other examples, including access to undertake these investigations.

Large cantilever and gantry sign structures and high mast lighting structures have also been added to the category of Monitor Structures, because of the fracture critical nature of the baseplate connections to the arms and foundations. VicRoads BTN 2010/001 “Design of Steel Cantilever and Portal Sign Structures and High Mast Light Poles”, provides guidance on the design of new structures and gives some insight into potential problem areas of existing structures. VicRoads Asset Services - Construction Materials team shall be consulted when developing Level 3 investigations of these structures.

This Manual provides guidance on visual inspection into the condition of the base plates, connection details, grout pads and foundations supporting these structures. Level 3 investigations will generally include structural assessment of the individual structure or a number of similar structures for the purpose of determining the adequacy of the structure under prescribed (AS5100) loading requirements. The use of ultrasonic testing or other non-destructive testing techniques will also commonly be required. This may be followed by design of details for strengthening, replacement or modification of existing components. Level 3 investigations might also include instrumentation of individual structures to monitor stress ranges over a period of time from the local environment (wind speed, direction, gust frequency), wind loading from adjacent large high vehicles or similar parameters. The Brief and Scope of such investigations may be part of a VicRoads or Austroads investigation into the performance of these structures given the common interest of all road authorities.

As stated in Part 2 Section 5.1, the classification of Monitor Structure may be used to include any structure that has a particular component or other feature that requires either short term or ongoing engineering surveillance. Such structures do not include those that are considered to be sufficiently complex or unusual to justify inclusion in Complex Structures nor have features that justify classification as Heritage and Historic Structures.

Such structures might include those with:

- difficult access and requirement for specialised equipment and/or traffic/railway control
- a problem with a specific component or components that requires engineering surveillance, such as moving elastomeric bearings, fatigue susceptible steel components or connection details, hydraulic scour or similar issues, geotechnical movement, concrete degradation requiring periodic testing and similar.

The technical aspects of the Brief and Scope for the Level 3 investigations or development of a management plan as part of a Monitor program should be developed taking into consideration all information known about the individual structure under consideration and other similar structures, if any.

The Brief should include:

- a background that describes the basis for classification of the structure (or class of structure) as a Monitor Structure, including the details of any known or suspected deficiency;
• if available, a description of how any known or suspected deficiency would manifest itself in the structure (e.g. specific cracking, increasing deflection);
• definition of the parts of the structure that are to be investigated;
• prescriptive requirements, if any, for visual, destructive and/or non-destructive testing (e.g. all components must be visually inspected close-up hands-on; two cores must be taken per pile);
• results of the most recent Level 2 inspection of the structure (or a representative structure for the class);
• all available drawings of the relevant parts of the structure (or a representative structure for the class);
• any previous reports on the relevant parts of the structure (or a representative structure for the class);
• an outline scope of the Level 3 investigation.

The Scope might include:
• investigate and advise how any known or suspected deficiency would manifest itself in the structure (if this information is not provided in the brief);
• provide recommendations on the type of investigations are to be undertaken and an explanation as to how these inspections will achieve the purpose described in the brief;
• submit for approval a plan for undertaking the inspection prior to commencement. The plan should include, as a minimum:
  o the extent of inspection, preferably defined by reference to a drawing of the structure;
  o identification of any unique characteristics and features of the structure that must be investigated;
  o method for recording the results of the inspection.
• undertake the investigations in accordance with the approved plan;
• report the results of the investigations in the agreed format and within a specified time period;
• provide a report with recommendations on the monitoring to be undertaken, including as a minimum:
  o the specific areas to be monitored;
  o the method of monitoring including specific recommendations on what to observe and/or measure;
  o the frequency of monitoring;
  o an explanation as to how the monitoring will keep an eye on the known or suspected deficiency.
• summarise the management plan in the form of a fully defined brief and scope to be used for future investigations of the structure (or class of structure).

1.2.3.3 Complex Structure inspections

The Principal Engineer Structures is responsible for classifying a structure as a Complex Structure. Classification as a Complex Structure is an acknowledgment that a Level 2 inspection is unlikely to provide sufficient information to form an accurate opinion on the condition of the structure. Examples of structures that could be classified as Complex Structures include:
• structures with unusual structural details such as pin and hanger assemblies
• cable-stayed or suspension structures
• moveable bridges
• structures where the location or configuration means that structure specific construction is required to provide inspection access.

The Brief should include:
• a background that describes the basis for classification of the structure as a Complex Structure, including any specific inspection requirements for the parts of the structure that would not be covered by a Level 2 inspection
• definition of the parts of the structure that are to be inspected
• prescriptive requirements, if any, for visual, destructive and/or non-destructive testing
• all available drawings of the relevant parts of the structure
• any previous reports on the relevant parts of the structure
• an outline scope of the Level 3 investigation.

The Scope might include:
• provide recommendations on the type of inspections to be undertaken and an explanation as to how these inspections will achieve the purpose described in the brief;

• submit for approval a plan for undertaking the inspection prior to commencement of any inspection activity. The plan should include, as a minimum:
  o the extent of investigation, preferably defined by reference to a drawing of the structure
  o the type of visual inspection that will be undertaken (e.g. close-up hands-on inspection, remote inspection by binoculars etc)
  o method for recording the results of the inspection.

• report the results of the investigations in the agreed format and within a specified time period. Provide a management plan for inspection of the structure, including as a minimum:
  o an inspection plan for all aspects of the structure, including those within and outside the scope of a Level 2 inspection
  o a definition of condition ratings 1 to 4 for components that are not included in the this manual
  o specific recommendations on what to observe and/or measure.

• summarise the management plan in the form of a fully defined brief and scope to be used for future investigations of the structure

• undertake the investigations in accordance with the approved plan.

1.2.3.4 Heritage and Historic Structures inspections

It is envisaged that the inspection of unused or bypassed bridges will be undertaken as a Level 1 or a Level 2 inspection. However, there may be particular circumstances related to heritage requirements on an unused or bypassed bridge that require a specific inspection plan to be implemented. In this case the inspection should be undertaken as a Level 3 investigation

The Brief should include:
• a background paper that describes the basis for heritage classification of the structure and a copy of the protection requirements for the structure;
• definition of the parts of the structure that are to be investigated;
• prescriptive requirements, if any, for visual, destructive and/or non-destructive testing (e.g. all components must be visually inspected close-up hands-on; two cores must be taken per pile);
• all available drawings of the relevant parts of the structure;
• any previous reports on the relevant parts of the structure;
• an outline scope of the Level 3 investigation.

The Scope might include:
• provide recommendations on the type of investigations to be undertaken and an explanation as to how these inspections will achieve the purpose described in the brief;
• submit for approval a plan for undertaking the investigations prior to commencement. The plan should include, as a minimum:
  o the extent of inspection, preferably defined by reference to a drawing of the structure;
  o identification of any unique characteristics and features of the structure that must be inspected;
  o method for recording the results of the inspection.
• undertake the inspections in accordance with the approved plan;
• report the results of the investigations in the agreed format and within a specified time period;
• summarise the management plan in the form of a fully defined brief and scope to be used for future investigations of the structure.

1.2.3.5 Handover bridge inspections

Handover inspections require cooperation between the project or organisation responsible for constructing or delivering the structure, and the asset owner. The party accepting the structure should normally arrange the handover inspection, however the party currently responsible for the structure should be given notice and invitation to attend.

The Brief should include:
• details of the contractual requirements for quality and completeness of the structure
• certified as-built documentation of the structure that is to be handed over
• details of any recorded defects and the dispositions of those defects
• what the investigation report will be used for (e.g. practical completion; close out of defects)
• prescriptive requirements, if any, for visual, destructive and/or non-destructive testing (e.g. all components must be visually inspected close-up hands-on; hardness testing of metals)
• an outline scope of the Level 3 investigation.

The **Scope** might include:

• provide recommendations on the type of investigations to be undertaken and an explanation as to how these investigations will achieve the purpose described in the brief
• submit for approval a plan for undertaking the investigation prior to commencement. The plan should include, as a minimum:
  o the extent of inspection, preferably defined by reference to a drawing of the structure
  o method for recording the results of the inspection.
• undertake the inspections in accordance with the approved plan
• report the results of the investigations in the agreed format and within a specified time period.

### 1.2.4 Detailed condition rating of a structure

The **Brief** should include:

• a description, in as much detail as is available, of the proposed program of works;
• what the investigation report will be used for such as:
• assessing the degree of physical and chemical deterioration of components, the structure as a whole or categories of similar structures in different environments or subjected to different traffic volumes and mix;
• estimating the ongoing rate of deterioration and remaining life without intervention;
• assessing alternative intervention timings for various maintenance, strengthening or replacement options;
• determining the condition and material properties of components of the structure as part of undertaking a load capacity assessment and possibly a subsequent strengthening design for the structure;
• assessing the importance of the condition of the components to be investigated to the structural integrity, load carrying capacity and ongoing maintenance requirements for the structure.
• prescriptive requirements, if any, for visual, destructive and/or non-destructive testing;
• results of the Level 2 inspections of the structure, over a period of time, with particular emphasis on recent inspections;
• all available drawings of the relevant parts of the structure;
• any previous reports on the relevant parts of the structure;
• an outline scope of the Level 3 investigation.

The **Scope** might include:

• provide recommendations on the type of investigations to be undertaken and an explanation as to how these will achieve the purpose described in the brief.
• submit for approval a plan for undertaking the investigations prior to commencement of any activity. The plan should include, as a minimum:
  o the extent of investigations, preferably defined by reference to a drawing of the structure;
  o method for recording the results of the inspection;
  o report the results of the investigations in the agreed format and within a specified time period.

### 1.2.5 Load capacity assessment of a structure

The **Brief** should include:

• the loads that the structure is to be assessed and rated for (e.g. design vehicle loads – design standard vehicles, legal vehicles, permit vehicles)
• the standard or guidelines that are to be used for the rating. The default standard is **AS5100.7 Bridge Assessment**
• any specified variations from the standard or guidelines such as:
  o site specific load factors
  o site specific multiple vehicle loading requirements
  o structure specific fatigue assessment requirements
  o specific design or marked lane requirements to be used in the assessment.

• whether the structural assessment is to:
  o be based on a desk-top analytical structural assessment only, using design drawings
  o include specified Level 3 field investigations to determine data to be used in the structural assessment.

• what any load rating will be used for, including determining the adequacy of the structure for:
  o current or future freight vehicles
  o a specific permit vehicle; or
  o class of special purpose vehicle.

• results of the most recent Level 2 inspections of the structure

• all available drawings of the relevant parts of the structure

• all relevant as-constructed information available for the structure including:
  o structure geometry, such as span lengths, beam spacing, skew, asphalt thickness and similar
  o geotechnical information including bore logs, foundation levels and similar.

• any previous reports on the relevant parts of the structure

• traffic data including traffic volumes and mix, weigh-in-motion data, projected growth estimates and other relevant information

• an outline scope of the Level 3 investigation.

The **Scope** might include:

• provide recommendations on the method to be used for the load rating including:
  o analytical methods and assumptions to be used for desk-top structural assessment
  o whether field and laboratory investigations are to be used for determining component dimensions, properties or condition
  o whether field instrumentation and load testing of the structure is to be used as part of the structural assessment.

• where load testing is to be undertaken, submit for approval a loading and instrumentation schedule with an explanation as to how load testing undertaken in accordance with the schedule will achieve the purpose described in the brief;

• submit for approval a plan for undertaking the Level 3 investigations prior to commencement of any field activity. The plan should include, as a minimum:
  o the extent of investigations, preferably defined by reference to drawings of the structure
  o the type of visual inspection that will be undertaken
  o the extent and nature of any destructive or non-destructive testing
  o identification of any unique characteristics and features of the structure that must be inspected
  o method for recording the results of the inspection.

• undertake the load testing (where required) in accordance with the approved schedule;

• submit a Design Report which contains, as a minimum:
  o drawings of the structure that were used for the structural assessment calculations
  o condition information on the structure that was used for the structural assessment calculations
  o details of the loads for which the structure was load rated
  o reference standards that were used
  o the design methodology that was employed.
- the results of the load rating calculations.
Appendix D – Management of Heritage and Historic Structures

Statement of Policy
Heritage and Historic Structures shall be maintained to conserve their heritage value subject to consideration of statutory requirements and other community, economic, environmental and social responsibilities.

For the purposes of this policy, heritage bridges include all structures on declared roads which are included on registers of the National Estate, Heritage Council of Victoria, National Trust or the Victorian Environmental Assessment Council, or are being considered for registration.

In addition, VicRoads shall maintain a record of heritage bridges of significance to VicRoads which are not listed in the above register. This includes bridges of regional or local significance that are protected by Council Planning Schemes.

Detailed Requirements and Performance Standards

Heritage Status
There are five classes of heritage status with corresponding obligations on VicRoads' management of bridges under each class. The classes are briefly described below:

Victorian Heritage Register:
Properties on the register are protected by law. Registration means a property cannot be altered without a permit from the Heritage Council. The Heritage Council can place an Interim Preservation Order on places which are under threat of demolition or unsympathetic alteration but are not included in the Register.

National Trust:
Listing imposes no legal obligations, however, it is a key community heritage body and it is usual that discussion and agreement occur before any alteration is undertaken to bridges on its' register.

Victorian Environmental Assessment Council:
The Victorian Environmental Assessment Council was established under the Victorian Environmental Assessment Council Act 2001. The Council undertakes investigations and makes recommendations relating to the protection and ecologically sustainable management of the environment and natural resources of public land. The Victorian Environmental Assessment Council (VEAC) replaces the Environment Conservation Council (ECC) which in turn replaced the Land Conservation Council (LCC). Most recommendations made by the Council refer to the need for sites to be protected under established levels of protection already in existence, e.g. Victorian Heritage Register.

VicRoads:
VicRoads shall identify bridges which are considered by the organisation to be of significant heritage value, or which may be considered for future inclusion on the above registers.

Maintenance Standards
Heritage and Historic Structures shall be maintained to the same functional standards as equivalent non-heritage bridges.

Maintenance treatments shall be adopted which minimise the long term cost of maintenance.

Heritage and Historic Structures shall be maintained in a manner which ensures the heritage characteristics of each bridge are retained, giving consideration to any legal obligations imposed by the heritage classification and other community, environmental and social responsibilities.
Heritage and Historic Structures which lie within a VicRoads road reserve but no longer serve a major traffic function shall be maintained at a functional standard which protects the safety of the public accessing the site (e.g. pedestrians, tourists).

**Funding**
Maintenance of heritage bridges will generally be funded from VicRoads' maintenance program. Proposals for retrofitting of heritage features will be considered as individual projects, with funding sought from non-transport related government sources as appropriate.

**Consultation**
The appropriate heritage authority shall be consulted on proposals which may affect heritage-listed bridges at as early a stage as possible.

**Inspections**
Level 1 and level 2 bridge inspections shall apply to all heritage bridges whether trafficable or not.

**Data Recording**
The Bridge Inventory within the Road Asset System shall be maintained to ensure the heritage classification of each bridge is readily accessible. Details of aspects of each bridge which are deemed by heritage authorities to be essential to maintaining the heritage nature shall also be recorded.

**Key Responsibilities**

**Manager Asset Plans**
- prioritise works of a purely heritage nature and apply for funding under all appropriate government heritage programs
- ensure that level 2 bridge inspections are undertaken on all heritage-listed bridges

**Regional Directors**
- ensure that the heritage classification is maintained in RAS
- ensure that level 1 bridge inspections are undertaken on heritage-listed bridges.
- ensure that all proposals for bridge maintenance and rehabilitation are checked against the heritage status
- consult with appropriate heritage authorities where proposals impact on heritage value.
- obtain necessary permits from heritage authorities where applicable.
Appendix E – Post Flooding Bridge Inspection Report

Road Name: ____________________ Road Number: ______________

Bridge: _____________________

Structure Number: SN______________

Inspection Date: ____/____/____ Time of inspection: _____:_____ 

Inspector: ______________________________________

<table>
<thead>
<tr>
<th>Element</th>
<th>Describe problem/Comment or tick NA (not applicable)</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Approaches (voids in surface, settlement, slippage of embankment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barriers (missing, misaligned, foundation washed away)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerbs (misalignment, settlement)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deck/Beams (holes, missing beams, misalignment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement Joints (missing, displaced)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abutments (displaced, damaged, unsupported)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crossheads (displaced, damaged, unsupported)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piles (missing, displaced, damaged)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pilecaps (displaced, damaged, unsupported)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changes in River Bed (alignment, depth, profile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debris (accumulation on superstructure, lodged in substructure)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterway - comparison of river-bed level to the original design drawings - estimate degree of scour over the life of the structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood level relative to the level of an easily identified datum.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g. 400 mm below beam soffit.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photos:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Comments:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix F – Disused or other hazardous structure checklist

Suggested checklist to be used when assessing a disused or other hazardous structure

<table>
<thead>
<tr>
<th>Site Conditions</th>
<th>Action Taken if Relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of use by the public</td>
<td></td>
</tr>
<tr>
<td>Proximity to population centres and schools</td>
<td></td>
</tr>
<tr>
<td>Public access to areas under the bridge</td>
<td></td>
</tr>
<tr>
<td>Agricultural use (Cattle underpass/ storage)</td>
<td></td>
</tr>
<tr>
<td>Condition Report - Extent of structural defects</td>
<td></td>
</tr>
<tr>
<td>Holes in deck</td>
<td></td>
</tr>
<tr>
<td>Weak and rotten deck timbers / decking</td>
<td></td>
</tr>
<tr>
<td>Missing or damaged handrail</td>
<td></td>
</tr>
<tr>
<td>Weak and rotten supports</td>
<td></td>
</tr>
<tr>
<td>Sharp or splintered timber</td>
<td></td>
</tr>
<tr>
<td>Unguarded drops</td>
<td></td>
</tr>
<tr>
<td>Tripping points</td>
<td></td>
</tr>
<tr>
<td>Heritage status – Is it on the Victorian Heritage Database, Council Heritage Overlay, National Trust Register?</td>
<td></td>
</tr>
<tr>
<td>Cost and practicality of demolition if not Heritage</td>
<td></td>
</tr>
<tr>
<td>Cost and practicality of running repairs</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>Site Conditions</td>
<td>Action Taken if Relevant</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Size, geometry and location of structure</td>
<td></td>
</tr>
<tr>
<td>Depth of flowing water</td>
<td></td>
</tr>
<tr>
<td>Flow capacity (effects of any grill or gate)</td>
<td></td>
</tr>
<tr>
<td>Level of public use</td>
<td></td>
</tr>
<tr>
<td>Proximity to population centres and schools</td>
<td></td>
</tr>
<tr>
<td>Risk of flooding</td>
<td></td>
</tr>
<tr>
<td>Consultation with catchment management authority</td>
<td></td>
</tr>
<tr>
<td>Agricultural use</td>
<td></td>
</tr>
<tr>
<td>Condition Report - Extent of structural defects</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
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</tr>
</tbody>
</table>
# Appendix G - Deck Joint Inspection Checklist

## DECK JOINT INSPECTION CHECK LIST

<table>
<thead>
<tr>
<th align="center">Road Name :</th>
<th align="left">Date: ..........</th>
</tr>
</thead>
<tbody>
<tr>
<td align="center">Crossing :</td>
<td align="left">:----------------</td>
</tr>
<tr>
<td align="center">SN : ......</td>
<td align="left"></td>
</tr>
<tr>
<td align="center">Location on bridge:</td>
<td align="left"></td>
</tr>
</tbody>
</table>

### JOINT TYPE
- Compression seal
- Strip seal
- Finger plate
- Asphallic plug joint
- Modular
- Other (give type) ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

### MANUFACTURER

<table>
<thead>
<tr>
<th align="center">MODEL &amp; SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td align="center">~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~</td>
</tr>
</tbody>
</table>

### ANCHOR BOLTS
- **Yes**
- **No**

<table>
<thead>
<tr>
<th align="left">Type, size &amp; spacing (e.g. 20mm HS hex @ 300mm)</th>
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</thead>
<tbody>
<tr>
<td align="left">~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th align="center">Loose bolts (give details)</th>
<th align="left">Missing bolts (give details)</th>
</tr>
</thead>
<tbody>
<tr>
<td align="center">~~~~~~~~~~~~~~~~~~~~~~~~~~</td>
<td align="left">~~~~~~~~~~~~~~~~~~~~~~~~~~~</td>
</tr>
</tbody>
</table>

### WATER LEAKAGE
- **None**

<table>
<thead>
<tr>
<th align="center">Give details</th>
<th align="left">~~~~~~~~~~~~~~~~~~~~~~~~~~~</th>
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</thead>
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<tr>
<td align="center"><strong>JOINT SEAL</strong></td>
<td align="left"><strong>JOINT SEAL CONDITION</strong></td>
</tr>
<tr>
<td align="center">----------------</td>
<td align="left">-------------------------</td>
</tr>
<tr>
<td align="center">Type</td>
<td align="left">Give details, including comments on debris content</td>
</tr>
<tr>
<td align="center">N/A</td>
<td align="left">..........................................................</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>JOINT WIDTH</strong></th>
<th><strong>JOINT NOSING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>At ....... end ......... mm</td>
<td>Type ...............</td>
</tr>
<tr>
<td>At mid length ......... mm</td>
<td>N/A</td>
</tr>
<tr>
<td>At ....... end ......... mm</td>
<td>..........................................................</td>
</tr>
<tr>
<td>Approximate Temperature .... °C</td>
<td>..........................................................</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>JOINT NOSING CONDITION</strong></th>
<th><strong>OTHER COMMENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Give details ..................</td>
<td>e.g. Noise</td>
</tr>
<tr>
<td>........................................</td>
<td>Riding quality – level</td>
</tr>
<tr>
<td>........................................</td>
<td>Wear/cracking of asphaltic plug</td>
</tr>
<tr>
<td>........................................</td>
<td>Give details ..................</td>
</tr>
<tr>
<td>........................................</td>
<td>........................................</td>
</tr>
</tbody>
</table>
Appendix H – Monitor Structures

The following guidelines relate to individual types of bridges that have been identified as requiring inspection and monitoring.

1.1 U-Slab Bridges without Reinforced Concrete Overlays

These precast reinforced concrete units were introduced in the early 1950s.

(a) 1951 Standard Units

Deficiencies: The 1951 standard units were designed to act as individual units with a minimum depth of pavement material of 175 mm over them. Assessment of these units has indicated a theoretical deficiency in flexural and shear capacity.

Inspection and Monitoring: The legs of these units shall be inspected for flexural cracking, particularly near mid-span and for inclined shear cracking near the supports as shown in Figure 1.1.1.

(b) 1962 Standard Units

Deficiencies: These units were designed to act in conjunction with adjacent units in supporting traffic loads. For this reason, the legs of adjacent units were bolted and cast in place concrete shear keys were provided in the top corners of these units. However, many of these bridges have not performed as expected. This is particularly true of skew bridges where induced torsional loads in the units have not been explicitly provided for. The shear keys have fractured and the bolts have tended to become loose. If either of these actions have occurred, it is highly likely that reflective cracking will be evident in the deck bituminous surfacing.

Inspection and Monitoring: Refer to Figure 1.1.2. These units shall be inspected to determine whether any of the bolts have corroded, worked loose or broken. This shall be recorded and reported so that consideration may be given to the rehabilitation method to be used.

Figure 1.1.1 – U-Slab Side Elevation

These units should also be inspected for any cracks along the centreline or interface between the legs and the upper section. They should be inspected for any signs of cracking or spalling of the concrete from around the reinforcement in the bottom of the legs.

If there is evidence of cracking, the spacing, widths and patterns of cracking shall be recorded and photographed.
They shall also be inspected to determine whether there is any evidence of cracking of the shear keys. This shall be
determined by viewing between the legs of adjacent units from beneath for direct signs of cracking or for any evidence of water
leakage and by looking for evidence of reflective cracking in the deck bituminous surface, along the edges of the precast units.
An inspection shall also be made from beneath the bridge to determine if there is any evidence of differential vertical movement
between the legs of adjacent slabs under traffic loading. Such movement provides an indication of distress in the shear key
concrete.

A thorough inspection shall also be made of the legs of the U-Slabs to determine whether there is any evidence of flexural or
shear cracks. These units should also be inspected for any cracks along the centreline or interface between the legs and the
upper section. They should be inspected for any signs of cracking or spalling of the concrete from around the reinforcement in
the bottom of the legs. If any of the above signs of distress are evident, they shall be recorded in detail and photographed.

1.2 Precast Prestressed Concrete Deck Units (Rectangular Beams)
without Reinforced Concrete Overlays

Both VicRoads (CRB) and the ex Rural Water Commission developed standard precast concrete plank type units for bridging
generally over irrigation channels. These units are pretensioned longitudinally and transversely connected using long
galvanised tie rods (bolts) except for the 10.5 m long units. The 6.0 m and 9.0 m long units have cast in place concrete shear
keys between the units to assist load sharing, whereas the 4.5 m long units have small precast shear keys and the 10.5 m long
units have a composite reinforced concrete overlay. The Rural Water Commission units were based on the VicRoads units with
some minor modifications.

Deficiencies: The theoretical capacities of the 4.5 and 6.0 m span units have been assessed as inadequate.

Inspections and Monitoring: Refer to Figure 1.2. Inspection beneath these bridges will generally be difficult because
irrigation channels are usually operated at near maximum capacity for much of the year. These units shall be inspected to
determine whether there is any evidence of:

- flexural cracking, particularly near midspan
- loss of tension or failure of the transverse bolts
- reflective cracking along the line of the units which may indicate failure of the concrete shear keys
- differential vertical movement between the legs of adjacent slabs under traffic loading which also indicates potential
distress in the shear key concrete.

If access makes it impractical to perform some or all of these inspections, this shall be recorded. An alternative date shall be
determined, with the assistance of the appropriate water authority, at which the water level will be lower to enable an
appropriate inspection to be made.
Figure 1.2 – PSC Unit without concrete overlay

Areas to Inspect for Flexural Cracking

Side Elevation

Cross Section

Detail A

Check that nuts on ends of mild steel tie rods are tight

Inspect for crushing of cast-in situ concrete shear keys and reflective cracking in bituminous surfacing

Inspect for signs of water leakage through shear keys- efflorescence on sides and soffits of slabs

Detail A
1.3 Precast Prestressed DMR Plank Bridges

DMR planks are precast prestressed concrete planks which were developed by the NSW Department of Main Roads. They incorporate a large keyway with a curved profile.

DMR planks have generally been used for greater spans than the rectangular plank, and are mostly designed for MS 18 or T44 loading.

These bridges are generally considered to be able to accommodate Higher Mass Limits vehicles. VicRoads has not carried out any detailed assessments of these bridges.

These bridges usually incorporate a cast-in-place reinforced concrete overlay slab, and the keyways between abutting planks may be either filled with concrete or left empty. Deck overlays 140 mm thick with two layers of reinforcement are considered to perform well, but there are some concerns about the long term performance of bridges using thinner decks and only one layer of reinforcement.

These units shall be inspected to determine whether there is any evidence of:

- flexural cracking, particularly near midspan;
- reflective cracking along the line of the units which may indicate failure of the concrete shear keys
- differential vertical movement between the legs of adjacent slabs under traffic loading which also indicates potential distress in the shear key concrete.

1.4 Cast in Place Reinforced Concrete Flat Slab Bridges

There are approximately 100 of these bridges on the arterial road network and more on the local road network. There are several configurations that have similar span arrangements and concrete dimensions. The reinforcement layouts are also similar, but the spacing details differ substantially between bridges. Thus although a number of these bridges may appear to be identical based upon their concrete dimensions, their load capacities can vary substantially.

The following provides a description of the main categories of flat slab bridges, the types of potential deficiencies anticipated and the most likely locations for inspection. Refer to Figure 1.4.

Type 1a

The span arrangements are 1.5m, 3.6m, one or more 4.57m, 3.6m and 1.5m. The 1.5 m end spans are cantilevers continuous with the internal spans. Some longer bridges have internal expansion joints.

In most bridges the pier columns are built into the superstructure flat slab. However, for many of the longer bridges the piers near the centre of the bridge are built in and provision is made for the continuous slab to slide on the outer piers.

These bridges typically have longitudinal reinforcement at 100 mm centres near the top of the slab over each pier and near the bottom of the slab in the midspan regions. However, the top layer of reinforcement in the midspan region and the bottom layer of reinforcement near each pier is frequently theoretically inadequate.

The critical structural actions are generally induced by loading on the cantilever spans, either in isolation or in conjunction with loading on internal spans.

As a consequence, the critical areas for transverse flexural cracks, are principally:

(a) On the top of the deck near the first pier from each end;
(b) On the bottom of the slab near the second and third piers from each end.

Direct inspection of the top surface of the slab would require removal of some road surfacing material. Instead, inspection shall be made of the kerbs to determine if there is any evidence of flexural cracking from the centreline of the first pier for a length of 1.5 m towards the second pier at each end. In addition, an inspection shall be made of the underside of the deck for a length of 1.5 m each side of the second and third piers at each end. Figure 1.4 shows this information diagrammatically.

In addition, these bridges have minimal transverse reinforcement and as a consequence they frequently develop longitudinal shrinkage and thermal cracks that are visible on either or both the top and bottom surfaces. Although it is important to identify the presence of these cracks, they are not as critical as the transverse flexural cracks referred to above.

Any detected cracks shall be photographed and their location, extent and width carefully measured and recorded.

Type 1b and 1c

These bridges are similar to type 1a, but do not have the 1.5 m cantilever end spans. Instead they comprise 3.6m, one or more 4.57m and 3.6m span arrangements built in at each internal pier and with half or full depth wall abutments at each end.

These bridges generally have greater capacity than Type 1a because they do not have cantilevers. The critical aspects to inspect for these bridges are:

(a) transverse flexural cracking of the kerbs up to 1.5 m each side of the first internal pier at each end
(b) transverse flexural cracking on the bottom of the slab up to approximately 1.5 m each side of the first and second internal piers from each end.

In addition, earth pressure loading on the full depth wall abutments tends to increase the potential for transverse cracking of the deck near the first pier and can lead to torsional cracking in the pier columns of skew bridges.

Type 2
These bridges are similar to Type 1a but have span configurations of 1.5m, 5.5m, one or more 7.0m, 5.5m, and 1.5m. They should be inspected at the same locations as the above Type 1a bridges.

Type 3
The span arrangements are 2.1m, 7.0m, one or more 9.14m, 7.0m and 2.1m. Again the 2.1 m end spans are cantilevers continuous with the internal spans.

These bridges generally have greater capacity than Type 1a, despite their longer span lengths. The concrete slabs are thicker and the reinforcement consists of larger bars, although the spacing and pattern of reinforcement is similar.

Again the principal areas to inspect are as for Type 1a, except that precast concrete kerbs are generally used for these bridge types. Hence, instead of inspecting for cracks in the cast in place kerbs in the region of the first internal pier from each end, inspection for evidence of cracking shall be made on the outside vertical faces of the flat slab in the regions of these piers.

1.5 Cast in Place Reinforced Concrete Tee Beam Bridges
Unlike the cast in place reinforced concrete flat slab bridges, the cast in place reinforced concrete Tee beam bridges cannot readily be categorised into specific groups based upon span configurations or other features. Bridges are simply supported or continuous, haunched or prismatic, orthogonal or skewed, with or without pier and intermediate transverse diaphragms. Apart from these general features most bridges are unique.

For this reason specific directions will be provided for detail inspection and monitoring of individual bridges of this type.

For simply supported bridges, no inspection of the deck for flexural cracking is required because the beams are not continuous over the piers. Beams shall be inspected for flexural cracking in the soffit and the lower parts of the beams in the midspan region and for inclined shear cracking near the ends of each beam.

For continuous bridges, inspections again shall be made for flexural cracking of the beams near midspan, but inclined shear cracking is most likely to occur some 1 to 3 m away from each pier centreline. In addition, inspection shall be made for flexural cracking:

(a) In the beam soffits up to 2 m either side of each pier;
(b) In the deck up to 3 m each side of each pier.

Inspecting the surface of the bridge deck for flexural cracking would again require the removal of road surfacing material. This is not required in the first instance. Instead inspection shall be made of the underside of the deck in the region of each pier to determine whether there is any evidence of cracking through the depth of the slab. This may be detected directly as a visible crack or as efflorescence on the underside of the deck.

Particular attention shall be given to inspection for inclined shear cracks in the beams near the piers of older bridges without transverse diaphragms.
1.6 Precast RC ‘I’ Beam Bridges with Cast in Place Decks

Precast I beams were introduced in the early 1950s. Early versions used normal structural grade reinforcement, whilst in later versions high strength reinforcement was used. Generally these bridges have been found to have adequate load capacity to accommodate Higher Mass Limit vehicles.

Inspection of the superstructure should include a general check for flexural and shear cracking in the beams and cracking of the deck at the ends of the bridge.

1.7 Precast Prestressed Concrete NAASRA ‘I’ Beam Bridges with Cast in Place Decks

These standard beams cover a range of spans and were designed for MS18 loading. Spot checks on these bridges have found that they would have adequate load capacity to accommodate Higher Mass Limits vehicles. Some of these bridges have been found by SA Highways Department to be substandard with respect to crack width under serviceability loading.

Beam spacing should be checked in comparison to the standard MS18 design arrangement. If spacing is greater than standard, then a thorough load rating assessment should be carried out.

Inspection of the superstructure should include a general check for flexural and shear cracking in the beams and cracking of the deck at the ends of the bridge.

1.8 Precast Prestressed Concrete Trough Girder Bridges with Cast in Place Decks

Prestressed trough girders are precast and prestressed U shaped beams which have a cast-in-place composite reinforced concrete deck on top.

These units have usually been designed for MS18 or T44 loading, and are generally considered to have adequate load capacity to accommodate Higher Mass Limits vehicles.

Inspection of the superstructure should include a general check for flexural and shear cracking.

1.9 Cast in Place Prestressed Concrete Voided Slab Bridges

Prestressed concrete voided slab bridges have a cast-in-place post-tensioned concrete superstructure, and usually incorporate circular voids.

These units have usually been designed for MS18 or T44 loading and as such should generally be able to accommodate Higher Mass Limits vehicles. However, consideration should be given to the effects of multiple vehicles in the same or adjacent lanes for long span, continuous bridges.

Prestressed concrete voided slab bridges are one-off structures, and each should be inspected and assessed individually.

1.10 Cast in Place Prestressed Concrete Box Girder Bridges

Concrete box girder bridges have a cast-in-place post-tensioned concrete or reinforced concrete superstructure.

These bridges have usually been designed for MS18 or T44 vehicular loading, and should generally be able to accommodate Higher Mass Limits vehicles. However, consideration should be given to the effects of multiple vehicles in the same or adjacent lanes for long span, continuous bridges.

Box girder bridges are one-off structures, and each should be inspected and assessed individually.

1.11 Rolled Steel Girders with Timber Deck Bridges

Typically, these bridges comprise 610 mm by 190 mm (24 in x 7.5 in) RSJ girders at 1.8 m (6 ft) centres. They have generally been found to have inadequate load capacity for Higher Mass Limit vehicles for spans exceeding around 10 m.

It is generally adequate to use the 1976 NAASRA Bridge Design Specification (Reference 3) rules to determine the load distribution to beams.

Many of these bridges do not incorporate transverse bracing to the girders, so the compression flange will have low compressive strength due to transverse buckling considerations.

Inspection should include checking for termites, splitting or rot in crossbeams and deck timbers and corrosion of steelwork.
1.12 Rolled Steel Girders with Cast in Place RC Deck Bridges
Where shear connectors have been provided to achieve composite action, these bridges have generally been found to have adequate load capacity for Higher Mass Limits vehicles. Some of these types of structures do not incorporate shear connectors. In such cases the deck should be considered as non-composite when assessing bending and shear strength.

Inspection should include checking for loss of composite action, cracking of the deck near the ends of the bridge, and corrosion of steelwork.

1.13 Concrete Encased Steel Rail Girder Bridges
The Victorian state rail authority constructed a large number of these bridges which are now the responsibility of VicRoads and local government. There are two main types of these bridges:

(a) Type A - the concrete is intended to perform structurally to create a composite section;
(b) Type B - the concrete is intended to act only as a non-structural medium to support the steel beams and provide a vehicular riding surface.

Type A usually incorporate concrete of reasonable quality and may incorporate a layer of steel reinforcement above the rails. Type B usually do not incorporate a layer of reinforcement and often the concrete is of poor quality. These bridges should be treated as a non-composite steel structures.

These types of structure have generally been assessed as marginal to adequate. In many instances, the substructure is extremely light and this raises questions about its ability to resist road vehicle braking loads. Individual assessment is generally required for each bridge.

Checking should include inspection for distress in superstructure and substructure.

1.14 Fabricated Metal Girder Bridges
Riveted plate girders and lattice girders may be of wrought iron or steel. It is important to establish which material has been used since the strength of wrought iron is substantially less than that of steel. Visual examination may not be reliable as a means to differentiate between wrought iron and steel and hence samples should be taken for laboratory metallurgical examination.

The condition and tightness of rivets and bolts can have a significant impact on performance and this is difficult to assess accurately. Load testing may be justified to more accurately assess performance, particularly where the bridge is important for current transport or heritage reasons and the cost of replacement is high.

Fabricated metal girder bridges are one-off structures and each should be assessed separately.

1.15 Timber Stringers with Timber Deck Bridges
Timber structures assessments should be carried out in accordance with AS 5100.8: Rehabilitation and strengthening of existing bridges.

In order to carry out detailed assessments of timber bridges, it is essential to have data on recent drilling inspections to determine the available effective cross section since pipe rot is common.

These bridges are generally likely to be inadequate for Higher Mass Limit vehicles. Inspection should include checking for termites, splitting or rot in crossbeams and deck timbers.

Drilling of timber stringers should be undertaken to check for pipe rot.

1.16 Reinforced Concrete, Stone Masonry and Brick Arch Bridges
Several years ago, VicRoads test-loaded and analysed a small number of old reinforced concrete arch bridges. Some of these bridges were found to have adequate strength for the design loadings of the time, whilst others did not.

The load carrying capacity of arch bridges is critically dependent on the material properties, including the stiffness and strength of the soil which interacts with the footings, and the soil above the arch rib. Consequently, structural analysis methods cannot be relied upon to accurately assess load capacity unless foundation site investigation and laboratory testing of materials is undertaken to enable modelling of soil-structure interaction.

Simple visual inspection of arches does not always yield a reliable indication in regard to load capacity. It should be noted that any flattening of the shape of an arch over a relatively short distance, in some cases around 1.5 m (particularly in the region near the crown) should be taken as an indication that the structure is showing signs of distress, and should be subject to detailed investigations. A simple load test may be appropriate for such structures.
1.17 Bridge Substructures

Figure 1.17 shows an elevation of a typical multiple column pier. These should all be inspected for evidence of flexural cracking in the columns and crosshead as well as shear cracking in the crosshead near the intersections with the columns.

1.18 Buried Corrugated Metal Structures

Buried Corrugated Metal Structures (BCMS) without a structural lining are on the Monitor program as they are considered high risk. This is due to variable and accelerated rate of corrosion of BCMS once the protective coating on the buried metal corrugated pipe is damaged by impact, abrasion or deteriorated with age. Aggressive environments will further accelerate the corrosion process such as brackish water or proximity to heavy industry. The loss of metal lining thickness and deformations to the overall appearance of the structure lead to loss of structural capacity.

Locations to inspect include the splash zone, invert of the BCMS, overall shape of the structure checking for degree of rusting, section loss (holes) and deformation. Refer Figure 1.18.1 and 1.18.2 for examples of BCMS corrosion.

Inspection of a severely corroded BCMS is a high risk activity and the Occupational Health & Safety risks need to be addressed based on the unique location of each site prior to inspection and modified to suit site conditions. The inspection must be aborted if there is any safety concern that cannot be managed with the available equipment and a further visit should be planned only when all outstanding safety concerns have been satisfactorily resolved. A risk assessment used in the past for inspection of BCMS is outlined in Table 1.18.

It is expected that a suitably qualified and experienced inspector will determine whether it is safe to enter a corrosion-damaged (possibly propped) BCMS for inspection and any subsequent resulting maintenance works.

A suitably qualified and experienced inspector is defined as a person who:

1. in the opinion of the Principal Engineer Structures, has sufficient experience and engineering knowledge of the structural features of BCMS and, in particular, the possible modes of failure; and
2. is qualified to perform level 3 inspections as defined in the VicRoads Bridge Inspection Manual; or
3. is authorised to make an inspection by the Principal Structures Engineer or by the Asset Manager in consultation with the Principal Engineer Structures.
Examples of corrosion-damaged BCMS

Figure 1.18.1 - SN8616 Bulleen Road
BCMS inspected on the 13th December 2006 by SW Consultants P/L and found to be unsafe for concrete lining unless it is propped. The upper limit of corrosion-affected metal on the water-side is clearly visible.

Figure 1.18.2 - Warburton/Woods Point Rd, Brahams Creek
The invert in this case has corroded away and water is flowing below the original invert level. The upper limit of corrosion-affected metal on the water-side is clearly visible.
<table>
<thead>
<tr>
<th>Item</th>
<th>Feature</th>
<th>Hazard</th>
<th>Risk</th>
<th>Possible Controls</th>
</tr>
</thead>
</table>
| 1    | Unstable BCMS  
- Propped (tommed)  
- Deformed  
- Corroded / missing areas of metal  
Or any of these in combination | Collapse of the BCMS  
Falling objects | Crush injuries  
Suffocation  
Drowning  
Being struck by falling objects | Assess individual circumstances  
Abandon inspection  
Arrange safety inspection  
Reporting  
Warning Signs  
Barricading  
Propping / temporary support  
Remedial work  
Recording |
| 2    | BCMS | Confined Space | Poor access and egress (particularly in an emergency) | Assess individual circumstances  
Manage in accordance with Occupational Health and Safety (Confined Spaces) Regulations together with VicRoads confined spaces procedures |
| 3    | Difficult access into BCMS | Working at Height  
Uneven Surfaces (Slips, Trips and Falls) | Falling (into water)  
Injuries to joints and limbs | Assess individual circumstances  
Clear vegetation  
Use ladder  
Provide lighting  
Use appropriate footwear  
No lone-working |
| 4    | Water | Working in near to water | Drowning | Assess individual circumstances  
Avoid deep and / or fast flowing water  
Monitor weather conditions and avoid entering water-courses prone to flash-flooding  
No lone-working |
<table>
<thead>
<tr>
<th></th>
<th>Corroded / missing areas of metal</th>
<th>Sharp metal edges</th>
<th>Laceration</th>
<th>Assess individual circumstances</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Gloves, boots, helmet)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Provide lighting</td>
</tr>
<tr>
<td>5</td>
<td>Voids in and behind BCMS walls</td>
<td>Venomous creatures</td>
<td>Snake or insect bites</td>
<td>Assess individual circumstances</td>
</tr>
<tr>
<td></td>
<td>caused by corrosion and erosion</td>
<td></td>
<td></td>
<td>No lone-working</td>
</tr>
<tr>
<td></td>
<td>- Surrounding area</td>
<td></td>
<td></td>
<td>Provide lighting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Avoid probing by hand into hidden voids / dark areas</td>
</tr>
<tr>
<td>6</td>
<td>Debris or water in invert (invert</td>
<td>Hidden corrosion-damaged metal surfaces</td>
<td>As items 1 and 5</td>
<td>Assess individual circumstances</td>
</tr>
<tr>
<td></td>
<td>condition obscured)</td>
<td></td>
<td></td>
<td>Clear debris and enter in stages only if safe to proceed</td>
</tr>
</tbody>
</table>

Table 1.18 Main risks to be aware of when undertaking BCMS inspections

Note: This is a list of the main hazards and is not exhaustive. A Risk Assessment based on site-specific conditions is necessary in order to identify all hazards that may be present.
Appendix I - References

VicRoads (Various), Bridge Technical Notes, VicRoads Website.


New Zealand Transport Agency 2009, Bridge and Other Structures Inspection Policy, New Zealand Transport Agency, Auckland NZ.


FHWA 2011, National Bridge Inspection Standards (NBIS), CFR Section 23, Highways, part 650, subpart C, FHWA, Washington DC.


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