Road Structures Inspection Manual

2022

Department of Transport

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Department of Transport's (DoT) Road Structures Inspection Manual

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PART ONE – ROAD STRUCTURE INSPECTION POLICY

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 identify potential issues of a structure and to organise the required remedial works to be undertaken.
- To provide data for:
    - Regional and State asset management programs for inspection, maintenance, remedial, strengthening, etc.
    - Bridge capacity assessment.
    - Feedback to the design process.

The requirements of the Road Structures Inspection Manual apply to the following types of structures for which DoT 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):

Structure type	Prefix
Bridges and major culverts (or underpasses)	SN
Noise attenuation walls	SZ
Visual screen walls	SV
Retaining walls	SR
Major sign structures	SS
High-mast lighting structures	SL
Architectural and historic features	SA
Concrete pavements on piles	SP
Emergency boom gates	SB
Emergency bridging systems	SE
Emergency median barrier access gates	SG
Weigh-bridges	SW

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

Levels of inspection	Inspection type/category
Level 1 Inspection	Routine maintenance inspection
Level 2 Inspection	Condition and defect inspection
Level 3 Inspection and Investigation	Detailed engineering investigation including: • Response to incident, accident, or natural event. • Response to Level 1 or Level 2 Inspection. • Programmed Level 3 Inspection: Monitor Structures Inspections, Complex Structures Inspections, etc. • Detailed condition rating. • Load rating assessment. • Asset management of structures.

2 Road Structure Information

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

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 DoT's safety requirements specific to inspection contracts.

4 Structure Definitions

Structure type and prefix	Definition
Bridge **(SN)**	A structure designed to carry a road or path over an obstacle, with a minimum span or diameter ≥ 1.8 m or a waterway area ≥ 3 m^2.
Major Culvert (including Underpass) **(SN)**	**Major Culvert** A structure with single or multiple cells that allows water to flow under a road, railway, trail, or similar obstruction from one side to the other, with a minimum single span or diameter ≥ 1.8 m or have a single or combined waterway area ≥ 3 m^2.
	Underpass A structure of passage under road, railway, trail, or similar obstruction to facilitate vehicles, pedestrian, cyclists or livestock movement with a minimum single span or diameter ≥ 1.8 m or have a single or combined open area ≥ 3 m^2.
Noise Attenuation Wall **(SZ)**	A structure that attenuates noise that is normally generated by road or rail traffic.
Visual Screen Wall **(SV)**	A structure that serves as a visual screen between two points.
(Major) Retaining Wall (including Reinforced Soil Structure) **(SR)**	A structure constructed to resist pressure from the adjoining ground or to maintain in position a mass of earth, that: • is equal to or higher than 1.5 m with a horizontal to vertical slope of equal to or steeper than 1:2 (63 degrees); or • is greater than 0.8 m and in the event of structural failure would affect a through Shared User Path (SUP), roadway / railway traffic, or supporting structural elements. The failure envelope must be determined by projecting a 45 degree horizontally from the toe of the structure. Exclusions: 1. Walls extending up to 30 m from a bridge abutment are part of the bridge structure. If the wall length exceeds 30 m, the remaining section must 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. Landscaping treatments (feature walls, garden beds, beaching and paving and other).
Major Sign Structure (SS)	**Cantilever Sign (or ITS Sign), Pedestal Sign and Butterfly Sign Structure** Structures with one or more principal vertical members combined with one or more principal horizontal or sloped members designed to carry traffic information (or ITS) signs. The principal members may be of a truss type design. This excludes signs designed in accordance with DoT/VicRoads Traffic Engineering Manual Supplement to AS1742.2 (TEM Vol 2 Part 2.02).
	Portal (Gantry) Sign (or ITS Sign) Structure 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.
	ITS Sign Structure Structures with one or more principal vertical members designed to carry ITS signs with a single or combined area > 2 m^2.
High-mast Lighting Structure (SL)	A structure that supports luminaires at ≥ 15 m height. The height is measured from the highest part of the luminaire to the ground level directly under the luminaire or the adjacent bridge deck level where mounted on a bridge.
Architectural and Historic Feature Structure (SA)	Architectural or historic feature structure within the road reserve.
Concrete Pavement on Piles (SP)	Concrete road pavement slab supported on piles or other footings, with a minimum span ≥ 1.8 m, which supports a trafficable roadway.
Emergency Median Barrier Access Gate (SG)	Gates which, in an emergency, allow access through median barriers to the opposite carriageway.
Emergency Boom Gate (SB)	A moveable barrier similar to those at railway crossings used to control vehicle access through a controlled point.
Emergency Bridging System (SE)	A demountable bridge used for emergency or temporary bridging comprising either a proprietary bridging system or other temporary structure.
Weigh-bridge (SW)	A permanent structure used to weigh vehicles – excludes weigh-in-motion structures and other mobile sensors.

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 Gate.

Refer to Appendix K for example photos of different structure types.

PART TWO – ROAD STRUCTURE INSPECTION PROCEDURES

1 General

1.1 Levels of Inspection

The Road Structures Inspection Manual includes three levels of inspection:

Level 1 Inspections are routine visual inspections help indicate the general serviceability of a structure and to ensure the safety of road-users. The Asset Manager may consider Level 1 Inspections to be completed in conjunction with routine road maintenance.

Level 2 Inspections are condition inspections that help assess and rate the condition of structures and their components. These inspections are more detailed that Level 1 Inspections.

Level 3 Inspections and investigations are detailed engineering investigations and assessments of individual structures carried out for the following reasons:

- To further investigate a significant or targeted defect identified during a Level 1 or Level 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 extensive 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.

1.1.1 Categories of Level 3 Inspection and Investigation

The RSIM does not specify a standard Level 3 Inspection and Investigation scope. The following has been included to provide guidance on the most common categories of Level 3 Inspections and Investigations and some representative examples. These categories and examples should be considered as being typical but not an exhaustive list. Refer to Part 2 Sections 4 and 5 for further details.

- Response to individual incident, accident, or natural event.
- Response to Level 1 or Level 2 Inspection.
- Programmed Level 3 Inspections including:
  - **Monitor Structures Inspections** are a programmed Level 3 Inspections of specific classes of structure as part of the Monitor Structures 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 are categorised as complex due to their structural form. Structures in this category require a structure-specific Structure Risk Management Plan (SRMP).
  - **Heritage and Historic Structures** are structures in the Victorian Heritage Register and/or nominated in DoT Road Asset System (RAS).
- Detailed condition rating.
- Load rating assessment of structures.
- Asset management of structures.

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 must be conducted in accordance with the *Victorian Occupational Health and Safety Act (2004), The Occupational Health and Safety Regulations (2017),* together with other relevant DoT safety requirements as stated in the inspection contract or inspection brief. Furthermore, inspections on the roadway must be conducted in accordance with the requirements of the *Code of Practice for Worksite Safety – Traffic Management (2010)*.

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.

To assist bridge inspectors with the management of safety, DoT may provide the following information:

- A list of general hazards which may be encountered during structural inspections.
- A list of structure-specific hazards in the structure information issued to Level 2 inspectors.
- Structure Asbestos Register which includes the description and location of the structures and components where the presence or likely presence of asbestos.

DoT will require the following actions by inspectors as appropriate:

- Inspectors commissioned by DoT to conduct inspections are to prepare and submit a site-specific Safe Work Method Statement (SWMS) for review and comment by the Superintendent before the 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 DoT representative advised immediately.
- Following completion of inspection programs, inspectors must submit an updated list of hazards encountered during the inspections to DoT.

DoT may conduct safety audits and surveillance to ensure that inspectors perform inspections in following 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, the serviceability of a structure or both.
- Identify items that may require routine maintenance, urgent attention/further investigation or both.
- Report the findings to the Superintendent and Asset Managers by completing the Level 1 Inspection Form.

2.2 Scope

The inspection may include the following structure types:

- Bridges and major culverts.
- Roadside structures – including noise attenuation walls, visual screen walls, retaining walls, major sign structures, high-mast lighting structures, emergency median barrier access gates and emergency boom gates.

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

Level 1 Inspections must be in accordance with the requirements of DoT/VicRoads Standard Specification Section 750 Routine Maintenance including completion of the Level 1 Inspection form appropriate to the type of structure inspected.

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

The report must include works carried out during the inspection, together with items that require further maintenance.

The report may include recommendations for further investigation (e.g. a Level 2 or Level 3 Inspection).

The report must include photographs with a description of items that require further assessment or maintenance.

2.3 Frequency of Inspections

Bridges and major culverts:

- A minimum of 2 No. inspections per year with a maximum interval of 6 months between successive inspections.
- 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.

Roadside structures and other structures:

- Major sign structures – a minimum of 2 No. inspections per year with a maximum interval of 6 months between successive inspections for major sign structures.
- All other structures – an interval between successive inspections of maximum 1 year.
- More stringent requirements can be recommended by Asset Manager in conjunction with Principal Engineer – Structures depending on condition and type of the structures.

Structures identified in Section 2.2 must be subject to a Level 1 Inspection after events such as a major accident, fire, flood or earthquake.

Refer to Section 5.8 Post Flood Management of Bridges and Section 5.9 Post Fire inspection of Bridges for procedure of post-flood and post-fire inspections.

The same general procedures that are routinely undertaken following a flood event must be undertaken following an earthquake. The affected areas in which structures must be inspected based on primary and secondary influence zones are based on the following principles:

- Any structure located in an area showing evidence of earthquake damage must be inspected. Generally, such evidence will not be visible except for large earthquakes.
- All structures, irrespective of condition state, located within the primary influence zone must be inspected.
- Any structure on major highways/freeways or providing a critical link without alternative routes, with any components (except for Miscellaneous Components as detailed in Part 3) are in condition state of 3 or 4, located within the secondary influence zone, must be inspected.

Critical distances from earthquake hypocentre for various magnitude earthquakes		
Earthquake magnitude (Richter scale)	Primary influence zone limiting radius (r1)	Secondary influence zone limiting radius (r2)
5.0	4 km	5 km
5.5	10 km	15 km
6.0	13 km	25 km
6.3	30 km	70 km
6.5	36 km	90 km
7.0	46 km	125 km
7.5	123 km	500 km
8.0	158 km	700 km
8.5	185 km	900 km
9.0	500 km	3500 km

Further advice and requirements regarding post-event inspection and reporting should be obtained from the Asset Manager or DoT Structural Asset Performance Team if required.

2.4 Inspector Requirements

Level 1 Inspections must be conducted by personnel employed by the routine maintenance contractor who must be prequalified in the M2-BW category in accordance with the DoT/VicRoads Prequalification Scheme. Inspection personnel must have practical experience (i.e. minimum 2 years) in road and bridge routine maintenance. They must be competent to judge the visual condition of structures and the adjacent road approaches and to complete the Level 1 Inspection report.

The Contractor must propose Level 1 inspection personnel, and the Region must assess their competency. The minimum requirement must be determined by the Region but must 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

Before commencing site inspections, the inspector must obtain the relevant documentation together with the necessary inspection and safety equipment.

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

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

2.5.2 Extent of Level 1 Inspections

The inspection must 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 parts of the structure not inspected must be recorded.

Inspectors must use their knowledge and experience to identify maintenance and potential structural integrity issues. Any potential structural integrity issue must be reported to the Asset Managers.

The individual components of the structure must be visually examined. If issues are identified, they must 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 must be assessed for the following issues:

(i) Structural integrity issues

The integrity and stability of a structure can be affected by several 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 summary outlines 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.

Indications of distress, damage or deterioration in critical components	
Steel components	• Corrosion and cracking of beams, columns and connections. • Distortion (which may be a result of overloading, impact, heat or corrosion).
Concrete components	• Single or multiple cracks with a width greater than 0.3 mm. • Significant spalling or general deterioration of concrete with exposed reinforcement or prestressing strands due to vehicle impact, corrosion, abrasion or any other cause. • Heat damage which may include spalling, cracking or failure of components as a result of bushfire, vehicle fire, explosion or other cause. • Poorly compacted concrete/concrete which has deteriorated or weakened.
Masonry and brick components	• Substantial loss of mortar. • Cracks (single or multiple) through mortar, masonry blocks or bricks. • Substantial efflorescence (white surface deposit) – a sign of water penetration.
Timber components	• Termite activity, rotting, marine borer and other insect attack. • Excessive deflections of beams. • Connections that are loose or contain heavily rusted bolts. • Missing bolts or connection components. • Deformation or settlement of bridge deck. • Buckling or displacement of piles. • Splitting and crushing. • Fracture of cross-beams. • Loss of cross-section. • Fire damage. • Water ingress. • Damage from vehicle impact, stream debris, abrasion or other means.

Critical components for bridges and major culverts	
Superstructure components including beams, slabs, box girders, transverse diaphragms and similar components	• Signs of distress including cracking, spalling, deformation, rusting or other deterioration.
Substructure pier columns and crossheads	• Signs of distress including cracking, spalling, deformation, or other deterioration in columns, crossheads and connections. • Corroded or missing connection components, with particular emphasis on timber and steel components. • Movement/displacement of abutments and piers.
Bearings	• Lateral movement or vertical separation. • Bulging or splitting failure of elastomeric bearings. • Extensive distortion of elastomeric bearings. • Severe displacement, corrosion or seizure of steel bearings. • Extrusion of seals in pot bearings. • Severe cracking or spalling of supporting pedestals.
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 including Underpasses (rectangular, crown units, pipes) and arches	• Irregular curvature in masonry arch profiles. • Substantial loss of mortar, softening of mortar, missing or displaced masonry blocks. • Cracks in the vertical or horizontal components. • Rust stains. • Spalling of concrete. • Uneven joints between segments as a result of movement. • Significant corrosion or deformation of corrugated metal pipe culverts.
Abutments	• Tilting, bulging or settlement of wingwalls on bridge, culvert and underpass approaches.

Critical components for retaining walls	
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. • Evidence of component deterioration. • Evidence of components being loose. • Evidence of uneven surface finish due to movement of the facings.
Supporting components including vertical posts and columns, metal or geosynthetic 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. • Evidence of deterioration in the components.
Strip footing and pile foundations	• Signs of substantial settlement and/or rotation. • Significant exposure by erosion, settlement or other means.
Crib wall	• Disintegration of blocks. • Movement of the blocks.

Typical critical components for noise attenuation and visual screen walls	
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 of timber components. • Loss of support to panel edges due to relative movement between the panel and its support.
Connections	• Missing, fractured, corroded or other forms of failure. • Loose connections. • Missing components.
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	
Base plate bolted and welded connections and mortar packing beneath baseplate	• Missing, fractured, severely corroded or loose bolts/nuts above and/or below the base plate. • Severely corroded or damaged holding-down bolts. • Fatigue-cracking or corrosion of components and or 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 DoT/VicRoads Standard Specification Section 750 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 maintenance.
  - Bridges.
  - Major culverts and underpasses.
- RM712 Other 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 systems	• 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 weep holes and signs of water penetration and inadequate drainage behind retaining walls, bridge and culvert wingwalls and similar. • Signs of damage and/deterioration of drainage pipe systems.
Deck joints	• Debris blocking or jamming joints. • Damaged waterproofing seals. • Missing or damaged bolts. • Vibrations of expansion joint plates.
Bearings	• Debris and dirt build-up around bearings. • Rusted steel bearings.
Traffic 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. • Missing Raised Reflective Pavement Markers (RRPMs). • Missing linemarkings as a result of maintenance works. • 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 must be recorded on a Level 1 Inspection report form as required by DoT/VicRoads Standard Specification for Roadworks and Bridgeworks Section 750 Routine Maintenance.

Dated photographs are required to be attached with the report form including a general view of the structure from top, side and underside, and a general and close-up view for the defects identified. All photographs must be numbered sequentially at each structure site and recorded with detailed description including the location and relevant defect if applicable.

If structural integrity issues are identified, or further inspection is required, these must be notified to the Superintendent on the day of the inspection if the inspector perceives there is an 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 to:

- Assess the condition of the structures.
- 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).
- Review past Level 2 inspection report and identify any changes in condition.
- Recording sufficient details of the defects to facilitate the load rating assessment* (Level 3 Inspections and Investigations) to evaluate their impact on the safety and integrity of the structure.
- 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 state 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 state 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 DoT Structural Asset Performance Team to determine the extent of investigation needed.*

3.3 Frequency of inspections

Structure age	Initial inspection	follow-up inspection
New	Within 8-24 weeks prior to the end of Defect Liability Period (i.e. between 18-22 months after opening to traffic)	2 to 5 years thereafter*
Existing	Within 8-16 weeks prior to the end of Defect Liability Period (i.e. between 8-10 months of the completion of major maintenance, strengthening and/or widening)	

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

Bridge Condition Rating (BCR)	Interval between inspections (years)
<30	5
30 to 60	3
>60	2

The actual frequency may be varied by DoT 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.

- If any components of the structures (except for Miscellaneous Components as detailed in Part 3) are in condition state 4 at more than 50%, the interval between inspections must be reduced to 2 years.
- If any components of the structures (except for Miscellaneous Components as detailed in Part 3) are in condition states 3 and 4 at more than 50% (where condition state 4 is at less than 50%), the interval between inspections must be reduced to 3 years.
- Where a component of the structure has deteriorated to a point that may affect the structural integrity of the structure, a more specific Level 3 Inspection for the structural component must be conducted to accurately assess the component condition and to determine whether immediate rectifications works are required.

3.4 Quality for Level 2 Inspections

3.4.1 Inspector Prequalification and Auditing

Level 2 Inspections must be conducted by Level 2 inspectors who are prequalified in accordance with the requirements of the DoT/VicRoads Prequalification Scheme for the BI2 category. Inspectors in this category must have extensive hands-on practical experience in either inspection, construction, design, maintenance or repair of road structures. They must also be competent to judge the condition of structures and the importance of visual defects.

Prequalified Level 2 inspectors must:

- Have extensive hands-on practical experience in the inspections and reporting of the condition of structures.
- Complete a Level 2 Inspection training course delivered by a registered training organisation approved by DoT for this purpose or the ARRB Level 2 Bridge Inspection course in Victoria.
- Successfully complete the assignment accompanying the training course.
- Attend a DoT Level 2 inspection accreditation briefing.
- Apply for prequalification to DoT.
- Obtain written confirmation of prequalification from DoT.

Level 2 inspectors need not be professional structural 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, the 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 DoT/VicRoads Prequalification Scheme for the BI2 category including eligibility criteria, quality, safety and insurance requirements, are provided on the DoT/VicRoads website.

3.4.2 Inspection Auditing and Review

3.4.2.1 Auditing

Selected Level 2 Inspection reports as detailed below must be audited by the Asset Manager in conjunction with DoT Structural Asset Performance Team.

Number of inspection reports	Minimum reports to be audited (%)	Note
First 100 reports of the batch	10	• If the total number of reports is less than 100, 10% is to be audited. • During the auditing of the 5% phase, if a report is found to be unsatisfactory, 10% of the next 100 reports are to be audited. • Different inspectors and types of structures are to be audited equitably and can be adjusted by DoT. • All inspectors are to be audited to ensure that all reports produced by different inspectors have been audited.
The next 100 reports of the batch	5	

The audit will comprise a full Level 2 Inspection complete with an updated inspection report if required. The audits will be summarised on a master report sheet for each contractor.

The audit must identify:

- Incomplete or missing forms.
- Missing data.
- Omissions of components.
- Omitted defects.
- Differences in extent or quantity of defect.
- Differences in condition rating.
- Missing date stamps on photographs.
- Missing description on photographs.
- Compliance of the scope of inspection as detailed in the contract document.

The audit must be based on a comparison between the inspector's and the auditor's comments.

The auditor must make concise comments and observations on the inspection. When preparing comments and observations it must be assumed that feedback to contractors will be based on the auditor's comments. Comments and observations must therefore be clearly worded, using objective language then initialled and dated by the auditor.

Where audits have identified that a particular inspector has produced below standard reports on a number of occasions, DoT may suspend or cancel the inspector prequalification and further assessments must not be undertaken until the inspector has re-applied for prequalification and has been approved by DoT.

3.4.2.2 Reviews

All Level 2 Inspection reports must be reviewed by the Asset Manager to make sure the proper procedure is carried out and all required forms are filled with appropriate details.

Where reports are identified to be below standard, the inspection consultant must be contacted and requested to amend the respective reports addressing all the issues identified and re-submit the reports. No payment must be made for sub-standard reports until they are amended and brought up to DoT's acceptable standard.

3.5 Inspection Procedure

3.5.1 Preparation for Site Inspection

Before commencing an inspection, the inspector must 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. All relevant documentation such as access permits, approved site-specific SWMS, etc. must be with the inspectors during the inspection.

The inspector must review the condition report of the structures including the defects and photographs from previous inspections, to identify and compare potential changes in the condition since then.

3.5.2 Site Inspection

Inspections must be conducted systematically. 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 must:

- 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 separately on the structure defects sheet. General view and close up dated photographs of the defect are also taken and included in the inspection report. All defects are to be measured in sufficient details and recorded with the reference location within the components, approximate size and extent of defect.
- As reasonably practicable, mark up the defect on the structure for components in condition states 3 and 4, with black permanent marker or similar, (e.g. crack location, measured width and date) such that the defect can be easily located in future inspection and condition monitored.
- Schematically record and map out all defects in condition states 3 and 4 in the Structure Defect Mapping Sheet and provide details (including the defect extent, details, width, area, etc) in the Structure Defect Sheet.
- Record the changes in defects since the previous inspection.
- Record and photograph non-standard components.
- Record the components that were not possible to inspect fully and the reason why this is not possible.
- Record any discrepancies in the inventory information provided.
- Notify DoT of potential hazard or failure of structure encountered on site (e.g. structure with rapidly deteriorating structural condition or damaged structure that requires immediate attention, other public safety issues, etc.) within 24 hours by telephone followed by an email with a brief description of the potential hazard or failure of structure with supporting photos.

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, unless majority of the structure's components are submerged. 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:

- Structures included in the list of Monitor Structures (refer to Section 5.1) and Complex Structures (refer to Section 5.2), and have been inspected as per the required frequency determined based on the condition and performance of the structures.

- 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.

Except where special access equipment or traffic management is required (refer to Section 3.5.4), the individual components of the structure must be inspected from within 3 m of all surfaces of the component. Where this is not possible, the inspector may use camera with good zoom capability, binoculars or other optical equipment such as a spotting scope to conduct the inspection. The plan to use this equipment to inspect the components outside of 3 m range must be submitted to the Superintendent for approval before commencement of the inspection. In this case, the optical equipment must 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 must be inspected in good natural or artificial light sufficient to enable fine cracks in concrete or other defects to be observed. The inspector may highlight cracking with a water-spray or damp cloth.

All bearings at bridge abutments and piers must be inspected, and bearings for at least one abutment and one pier (where present) must be inspected at eye level.

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

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

The calculated percentage of a component in each condition state must be based on the total area of the component that can be observed.

3.5.4 Special Access

Where the individual component of the structure cannot be inspected from within 3 m of its surface or the optical equipment such as binoculars cannot provide sufficient inspection details, special access equipment or traffic management must be arranged to facilitate the inspection. If the components still cannot be fully inspected with the special access equipment, this must be recorded on the structure information sheet stating the details of the specific components and the reason why it cannot be fully observed. A list of these structures must be submitted to the Superintendent to organise maintenance works if it's due to the covering debris or a follow-up inspection as part of Level 3 Inspection programs.

Special access equipment or traffic management may be required to facilitate the inspection for the following reasons:

- Bridges or components 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.
- The size of the structure – e.g. its length, height, geometry or number of spans.
- The majority of the structure's components (more than 50%) are not visible (e.g. submerged, hidden by other components, etc.).

Examples of structure types with access issues:

- Bridges with multiple spans, e.g. bridges across major roads or waterways.
- Bridges with a complex geometry.
- Bridges over railway property.
- High bridges.

- Bridges over deep (>1m) and large expanses of water.
- Fully/partially submerged structures.

3.5.4.1 Underwater inspections

If majority of the structure's components (more than 50%) are submerged and not visible for two consecutive inspections, an underwater inspection is required to determine the condition of structural components submerged. 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 scope of the diving inspections must be developed by a prequalified Level 2 inspector. The diver must be fully briefed by a prequalified Level 2 inspector regarding the specific requirements for the inspection.

Where the underwater inspection is required after flood or other events which requires a Level 3 Inspection and Investigation, The scope of the diving inspections must be developed by an experienced structural engineer. The diver must be fully briefed by an experienced structural engineer regarding the specific requirements for the inspection. Inspection requirements for specific categories of Level 3 Inspections and Investigations in Section 5 must be complied.

The diving inspections need to include the following tasks as a minimum:

- Prepare prior to the inspection.
  - Plan the inspection for suitable water weather, tidal conditions and currents to ensure site conditions to be safe for the underwater inspection with sufficient visibility of the components to be inspected.
  - Clean underwater structural components and remove marine growth where required.
  - Take the measurements of the relevant structural components.
- Undertake the visual inspection of the underwater structural components for the general condition and defects including cracking, chipping, delamination, spalling and exposed reinforcement, seabed scour, etc.
- Take the photos in accordance with the photography requirements.

3.5.5 Photography

Photographs are a vital part of the structural inspection record. The Level 2 Inspection includes specific requirements for photographic records. Level 2 inspectors must have a suitable camera and be 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 requirements for the camera:

- 8Mp 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 and must be checked prior to the commencement of the inspection.

Photographs must:

- Include a digital date-stamp.
- Be taken in natural light with proper exposure and colour balance that can show component details of the structure clearly 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 – silhouette and blurred images will not be accepted and must be retaken and resubmitted by the inspector at no extra cost to the superintendent.

- Be composed so that the subject of the photograph is centralised and occupies the full frame of the image.

In all instances where defects or deterioration are identified for a structure they should be recorded photographically.

As a baseline, the following general view photographs should be taken for bridges and major culverts/underpasses as applicable:

- Top View* – photographs from each abutment end which clearly show the number of traffic lanes, shoulders kerbs and footpaths, median and/or side traffic barriers system, protective screens etc. Additional photographs are required for the expansion joints.
- Side View – photographs from each elevation of the structure which clearly show the number of spans or cells, the type of superstructure, and the waterway/underbridge area.
- Underside View – photographs of the soffit of each span which show the type and number of main superstructure components.
- Main Substructure Component Elevation View – individual photographs of all wingwalls, abutments and piers (each side) along with the type of support (bearings) of the superstructure.

* These photographs should be taken from the road at the structure approach looking along the length of the bridge.

The following additional specific general view photographs are required for culverts:

- Inside View – One photograph showing the inside of each culvert cell. If the two sides of the culvert are different, photographs of both sides are required.

In addition to the general view photographs of the structures, a general view and close-up view of each defect (material defects and deterioration, performance deficiencies, maintenance needs etc) and of those components that do not fall within the defined component classification.

- The general view of defects should be able to show the reference location of the defects.
- The close-up photographs should be taken at sufficiently close range such that the extent of the defects is clearly visible. The photograph must be taken after the defect has been labelled and the labelling must be clearly readable in the photographs taken.
- Where defects are numerous and not severe (e.g. concrete cracks), a photograph should be taken showing a typical area which represents the condition rating of that element.

All photographs taken for inventory purposes and of components with defects must be recorded and provided to the Asset Managers.

All photographs must be numbered sequentially at each structure site and recorded in the appropriate record table with detailed description including the location and relevant defect number if applicable.

All photographs must be checked at the structure and repeated if the quality is poor or where the detail markings are illegible.

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

3.6 Data Recording

All information obtained from the site inspection must be recorded on the following datasheets for Level 2 Inspections provided in Appendix A:

- Bridge inspector's sheet.
- Condition rating sheet.
- Structure defect and treatment sheet.
- Defect mapping sheet.
- Structure information sheet.
- Structure inventory and photographic record sheet.

The following information describing the structure, its location and details of the inspection must 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.

The inspection results must be supplied to the Superintendent or Region within 14 days of the inspection including:

- All information recorded on inspection datasheets (in Appendix A) together with all photographs.
- All datasheets (in Appendix A) with recorded data from the inspection must be converted to electronic format (e.g. pdf or excel format) to be uploaded to RAS.
- The Contractor must upload all datasheets to the software (Bridge Inspection System) provided by DoT.
- The photographs must also be compiled into one file with the detailed description including the location, view and relevant defect details for each photograph.

The data must be made available to access by the relevant teams in DoT including Asset Manager, Assets and Engineering Division and Regions.

3.6.1 Bridge Inspector's Sheet

All boxes are to be fully completed.

The inspector must 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 must 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. This should include 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 must assess the condition of each component per Part 3.

The inspector must 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 must be determined based on the total visible component area. The unit of measurement shown in the condition rating descriptions must 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 four condition states for each component.

3.6.2.2 Predefined components

Structure components must 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 must be used when recording components of the structure.

3.6.2.3 Undefined components

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

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

3.6.3 Structure Defect & Treatment Sheet and Structure Defect Mapping Sheet

All defects must be clearly recorded such that they can be easily identified and monitored in the future inspections. The information to be recoded must include following items:

- Component number.
- Component location, defect and general condition description including the reference location within the components, approximate size and extent of defect.
  - For components in condition state 3 and 4, every observed defect must be recorded separately for each element.
  - For components in condition state 1 and 2, similar defects can be grouped if the details can be clearly provided, i.e. the spacing between the cracks with number of cracks, total area of the spalling, etc.
  - All defects or deficiencies are to be noted and measured (or estimated where not practical with a note ‘E’) as to size and location. A general location with component number (e.g. S1 B2) and a specific location (e.g. approximately 2.5m from Pier 1) must be recorded. The quantity and condition state of each defect on every component must be recorded on the inspection data collection sheet.

    e.g. Cracks: The length, crack width, and extents must be measured.

    e.g. Spalling: The area must be measured up and dimensioned.
  - In the case where a component cannot be reached for measurement, approximate size, location and a brief description of the defect must be recorded.
  - The changes in defects since the previous inspection are to be recorded where relevant.
  - For noise attenuation walls, visual screen walls and retaining walls longer than 100 m, the latitude and longitude GPS readings of the defect must be recorded.
- Approximate quantity of the defect/component to be used for estimating the cost of repairs.
- The photograph number recorded on the structure inventory and photographic record sheet.
- Component(s) and/or part of component that cannot be inspected, describing the details of the specific components (including but not limited to component numberings, e.g. S1 B2 and the extent not inspected) and the reason why this is not possible.

Additional information to be recorded for each component assessed to be in condition state of 3 or 4:

- Identify maintenance and/or repairs that address a structural issue to prevent further deterioration for components in condition state 3 and 4. Provide the treatment method in accordance with the Bridge Maintenance and Repair Manual and timeframe.
- Where practicable, mark up the defect on the structure for components in condition state 3 and 4, with black permanent marker or similar, (e.g. crack location, measured width and date) such that the defect can be easily located in future inspection and condition monitored.

- The location of the defects must be schematically recorded and mapped out (defect mapping) for all components in condition state 3 and 4. The inspector must label all defects in the Structure Defect Mapping Sheet and detail these (including the defect number, location details, defect extent, width, area, etc) in the Structure Defect Sheet. These must be of such clarity that the defect can be easily identified on site again by looking at the map. All defects must be photographically recorded, referenced, and a condition rating provided. An example of defect mapping is provided for reference in the Structure Defect Mapping Sheet in Appendix A.

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 details of the specific components and the reason why this is not possible.
- Components where less than 50% is accessible (e.g. hidden by other components).
- General comments, explanations or significant information.
- Minimum vertical clearance for structures crossing over roads obtained from laser measurements to determine the lowest vertical clearances of the structure at five assigned locations in each carriageway, as illustrated in Figure 3.6.4, in metres with two decimal places. On-site safety risk assessment is required in accordance with the Safe Work Method Statement (SWMS) to determine whether measurements can be carried out safely.
- The presence (or the likelihood) of asbestos. A detail description and location of the component where the presence or likely presence of asbestos. Where the presence of asbestos is identified it must be reported to the Asset Managers.

Note: Refer to Appendix J – Affixing Locations for ID Plates and Date Plates for the conventional location of the plates. The inspector must keep records to demonstrate they have inspected the correct structure with appropriate photos and notes. Absence of structure number plate is recorded on the condition sheet.

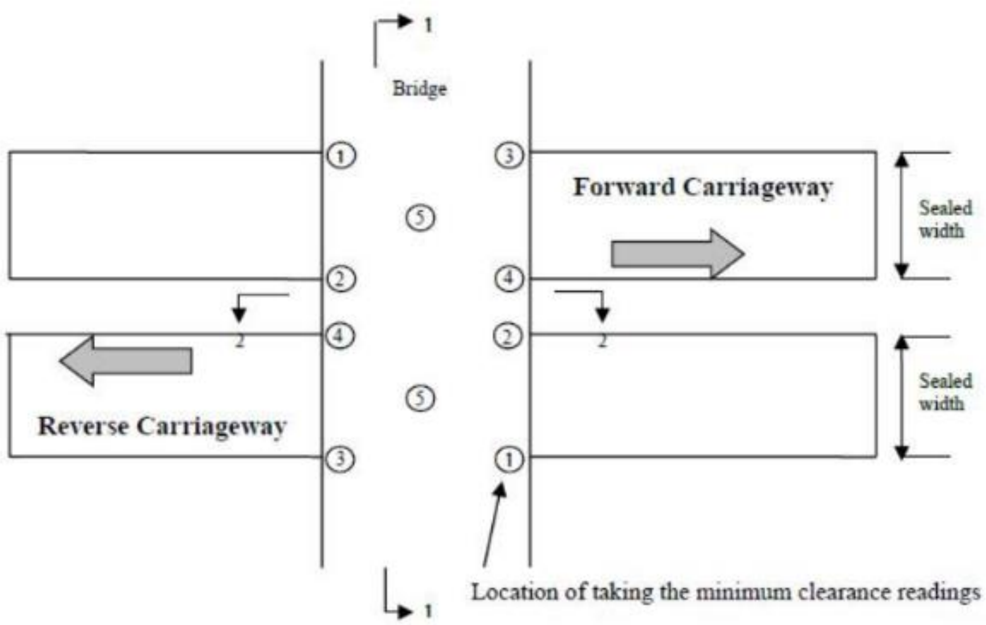


Figure 3.6.4 – Location of taking the minimum clearance readings

3.6.5 Structure Inventory and Photographic Record Sheet

Inventory data from RAS must be confirmed and any discrepancy recorded.

All photographs taken for inventory purposes and of components with defects 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 *DoT/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 →

ABUTMENT 1	SPAN 1	SPAN 2	SPAN 3	ABUTMENT 2
	S1 B1	S2 B1	S3 B1	
	S1 B2	S2 B2	S3 B2	
	S1 B3	S2 B3	S3 B3	
	S1 B4	S2 B4	S3 B4	

Figure 3.6.5.1.1 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.

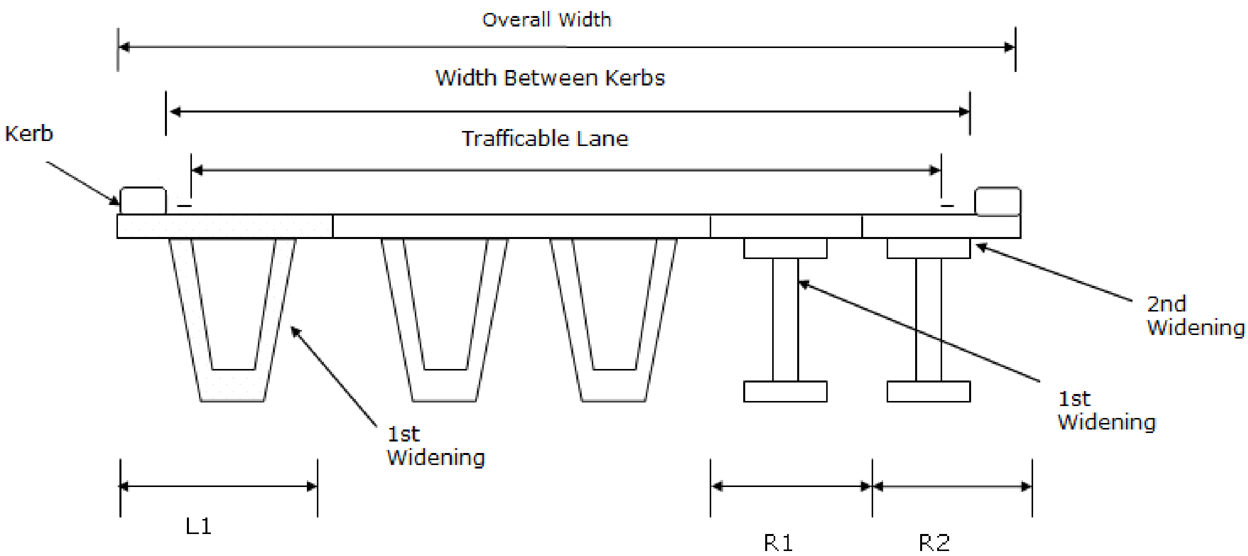


Figure 3.6.5.1.2 Bridge widths (superstructure only)

3.6.5.1.3 Joined bridges

- Infills connected to existing structures and relying on existing substructures
  - If two adjacent bridges are joined, with a structural infill, the joining section is to be treated as part of the structure in the forward direction (i.e. with an increasing linear reference system chainage).
  - Details of the infill are to be included under the existing SN for the outbound structure. 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 retain its existing SN and 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 columns under 'Widening' by adding 'J' to the '1/2' columns to result in '1/2/J' and changing the 'Widening' to 'Widening/Joining'.
- Infills connected or not connected to existing structures and with their own substructure
  - A new SN is to be assigned to the new infill section. Details of the infill are to be recorded under the new SN.
  - Existing structures and details are to retain their exiting SNs.

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 GDA2020. These readings are taken at the face of the kerb (or barrier if there is no kerb) at the left-hand side of Abutment 1 (Figure 3.6.5.1.4). Minor discrepancies with the GPS data recorded RAS may be identified due to the difference between GDA94 and GDA2020.

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). In contrast, on the adjacent carriageway Abutment 1 will be the last abutment crossed. For both bridges on the divided carriageway, the GPS reading must be taken at Abutment 1 left face of the kerb (or barrier if there is no kerb). Refer to Figure 3.6.5.1.4.

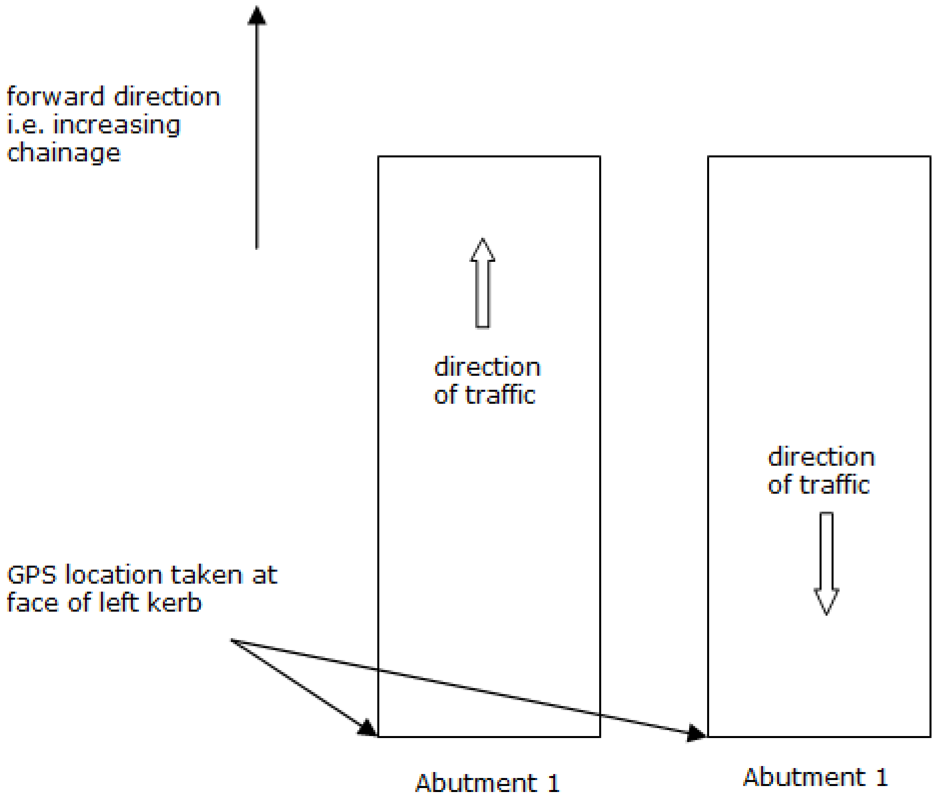


Figure 3.6.5.1.4 GPS location for a dual carriageway

3.6.5.1.5 Photographic record

In addition to the photography requirements from Section 3.5.5, the following photographs of main superstructure components (i.e. beams or girders) must be taken from underneath or the side of the structure and must 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, must confirm the following:

- Overall length and width of the bridge*.
- Length of individual spans*.
- Number of spans/cells.
- 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 must only be taken if required by the Asset Manager. Subject to a risk assessment traffic management must 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 centreline 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.

The length of arch bridges is measured to the back of the buttresses at the ends or to the junction between the wingwalls and spandrel walls.

The length of a pedestrian overpass is the total length from abutment to abutment, including all ramps. The length of the 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 must 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 3.6.5.1.2.

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

The overall length of the whole culvert is the full length of the culvert top slab measured parallel to the road centreline between the intersection of the culvert and the approach-road pavement. The approach slabs are not included in the overall length of the culvert.

The cell width along invert for culvert is the width to the outer edges of the culvert (from inlet to the outlet) measured perpendicular to the road centreline.

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 latitude and longitude GPS readings of each structure must be measured from the left hand side column.

The inspector is required to confirm the inventory dimensions which are given on the structure inventory sheets in Appendix A. Minimum vertical clearance for structures crossing over roads obtained from laser measurements to determine the lowest vertical clearances of the structure at left hand side and right hand side, in metres with two decimal places, to be recorded. Dimensions which are not accessible for measurement such as outreaches can be omitted.

The following photographs are required for each structure:

- A general dated 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.
- A general view and close-up view of each defect.
- Components in condition states of 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 of the wall. The chainage at the start of the wall is also recorded.

The following dated photographs are required for each structure:

- At the start and end of the wall.
- A view along the wall.
- A general view and close-up view of each defect.
- Any components in condition state of 3 or 4.

A noise attenuation wall panel comprising different materials must use a combination of component number and material classifications (P, C, S, T or O) as outlined in Part 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 inspected is to be recorded in RAS. If the stated length is incorrect or missing, this is to be reported on the structure information sheet.

GPS readings are recorded at the start 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 dated photo of the emergency median barrier access gate completely opened.
- A general view and close-up view of each defect.
- Components in condition state of 3 or 4.

4 Level 3 – Engineering Investigations

4.1 Introduction

4.1.1 Purpose

This section of the RSIM provides the requirements to Asset Managers, DoT Structural Engineers and external consultants on Level 3 Inspection and Investigation procedures.

Level 3 Inspections and 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 Inspections and 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.

AS5100:2017 Bridge Design is the principal reference to be used for Level 3 Inspections. AS5100.7 Bridge Assessment, supplemented by more bridge-specific data and procedures if available, must be used to determine load capacity.

Level 3 Inspections and Investigations are to be conducted by a prequalified engineer. Refer to Section 4.2 for the details of prequalification requirement.

4.1.2 Scope

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

Level 3 Inspections and 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.
- Level 3 Inspections and Investigations are to be conducted by a prequalified engineer. Refer to Section 4.2 for the details of prequalification requirement.

The objective of this Section is to:

- Provide examples of circumstances leading to a Level 3 Inspection and Investigation.
- Describe a procedure for developing the scope of a Level 3 Inspection and Investigation.
- Provide guidance regarding the typical activities that might be included in the scope of a Level 3 Inspection and Investigation.

Section 4.2 provides guidance on Quality Control for Level 3 Inspections and Investigations.

Section 4.3 provides a summary of typical reasons for undertaking Level 3 Inspections and Investigations.

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

4.1.3 Definitions

Brief – The brief for a Level 3 Inspection and Investigation is the information to be provided when engaging an external or internal party to undertake a Level 3 Inspection and 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 before the investigation.

Level 3 Inspection – an investigation carried out in accordance with this section.

Proof Engineering – an independent engineering review and certification of a structural design by a prequalified Proof Engineer in accordance with DoT/VicRoads Proof Engineering Policy.

Scope – a description of the tasks to be performed during the Level 3 Inspection and 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 where the scope is not covered under AS5100. The assessment will take into consideration the physical condition of the road structure and will generally include a Level 3 Inspection and Investigation.

Load rating – the process of determining a load-rating factor.

Strengthening – the process of increasing the capacity of a structure or structural components in terms of increased flexural, shear, fatigue or axial strength or ductility or restoring the capacity of weakened elements of structures to their original or greater design capacity, using either active or passive strengthening systems or both.

4.2 Quality for Level 3 Inspections and Investigations

For structures categorised as ‘Complex Structures’ under Section 5.2, all Level 3 Inspections and Investigations must be conducted by appropriately experienced engineers who must either be:

- a DoT Assets and Engineering Division Registered Professional Engineer in Victoria in the relevant area/discipline of the works required; or
- a consulting engineer prequalified at Proof Engineering level in accordance with DoT/VicRoads Prequalification Scheme.

For all other structures, the visual inspections, numerical calculations and structural computer modelling may be delegated to a suitably experienced structural engineer with the condition that:

- The suitably experienced engineer must have extensive hands-on experience in either inspection, construction, design, assessment, maintenance or repair of road structures relevant to the works required.
- The visual inspections must be conducted or guided on site by a structural engineer with minimum 5 years hands-on experience in road structure inspections, design and/or construction of similar structures. Site inspections of road structures must be a part of this experience.
- Review, approval and sign off of the analysis and report must be conducted by a Registered Professional Engineer of DoT Assets and Engineering Division or a Proof Engineer prequalified in accordance with DoT/VicRoads Prequalification Scheme. The responsibility to ensure the compliance of the Level 3 Inspections and Investigations lies fully with the Registered Professional Engineer of DoT or the prequalified Proof Engineer and forms part of the review of prequalification status.

Level 3 Inspections and Investigations must comply as a minimum with the procedural requirements for Level 2 Inspections.

Structural assessments must comply as a minimum with the procedural requirements for Proof Engineering (as stated in DoT/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 equivalent to load status recorded by DoT (i.e. based on approved design load, etc.) by more than 10%, the assessed capacity must be certified by independent Proof Engineering, or approved by Principal Engineer – Structures. The Proof Engineer must be prequalified in accordance with DoT/VicRoads Prequalification Scheme.

The requirement for Proof Engineering must be included in the scope of the Level 3 Inspections and Investigations.

4.2.1 Consultation

Senior Engineers with appropriate experience or the Principal Engineer – Structures must be consulted for technical input to the development of proposals for Level 3 Inspections and Investigations, for ongoing advice during investigations and for review of completed investigation reports. Input and advice from other disciplines relevant to the investigation must be obtained from Geotechnical Services and Construction Materials as appropriate.

Early involvement by DoT Structural Asset Performance Team ensures that the Level 3 Inspections and 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 Inspection and 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 Inspections and Investigations including traffic management plans and access equipment.

4.2.2 Data recording

Completed Level 3 Inspection and Investigation reports must 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 Team regarding the information to be entered in RAS. The Principal Engineer – Structures may elect not to enter all structural information on a particular bridge in RAS.

4.2.3 Review

All Level 3 Inspection and Investigation reports must be reviewed by the Asset Manager in conjunction with DoT Structural Asset Performance Team to make sure the proper procedure is carried out and all requirements and methodology are compliant with the relevant code and guidelines.

4.3 Categories of Level 3 Inspections and Investigations

4.3.1 Preamble

The following has been included to provide guidance on the most common categories of Level 3 Inspections and 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 Incident, Accident or Natural Event

A Level 3 Inspection and 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 must initiate an immediate Level 1 Inspection and/or Level 3 Inspection and Investigation.

The Level 3 Inspection and Investigation may comprise a visual inspection by a suitably experienced structural 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 Inspections to evaluate the extent and magnitude of damage.

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

* Refer Section 5.8 Post Flood Management of Bridges and Section 5.9 Post Fire inspection of Bridges.

4.3.3 Response to Level 1 or Level 2 Inspections

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 Inspection and 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 Inspection and Investigation to investigate:

- The cause of the defects.
- The extent of and predicted rate of deterioration.
- The effect on capacity of the structure.
- The cost and relative benefits of maintenance, extensive rehabilitation, strengthening or replacement of components or entire structures.

4.3.4 Programmed Level 3 Inspections

Examples situations in which programmed or intermittent Level 3 Inspections are required.

Investigation outside of the scope of Level 2 Inspections	• Structural forms and components that require special expertise or knowledge. • The inside of box girders and other areas that are difficult to access or are confined spaces. • Inaccessible areas behind abutments. • Piles and foundation below ground or water.
These investigations can be part of a programmed management system, at regular intervals but less frequently than Level 2 Inspections. These inspections must be scoped as Level 3 Inspections.	

Investigation of bridges and other structures in the following categories	
Monitor Structures	• The most common categories of bridges within this grouping of structures have been the subject of extensive inspections. Refer to Part 2 Section 5.1.
Complex Structures	• This category of structure has been introduced to identify individual structures or families of structures that require structure specific inspection procedures, methods and reporting. Refer to Part 2 Section 5.2.
Heritage and Historic Structures	• Refer to Part 2 Section 5.5.
These investigations may be conducted as part of a routine programmed management system. The scope and frequency of investigations must be determined for each structure and must 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 Inspection and Investigation must 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 along with the provision of a defect listing and mapping.

Level 3 Inspections and Investigations may be used to evaluate observations from Level 1 and Level 2 Inspections or other condition data that is not visually evident. Level 3 Inspection and Investigation are also carried out to inspect and collect specific data on a structure.

Level 3 Inspections and Investigations may include non-destructive testing and/or destructive testing with 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 destructive testing to determine condition data include:

- Taking concrete cores from concrete structures.
- Taking steel samples from steel structures.
- Drilling timber components of structures.
- Removal of components for testing in a laboratory.

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 Rating Assessment of Structures

Level 3 Inspections and 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:
  - General Access conditions. These vehicles include legally loaded rigid trucks, semi-trailers, truck and trailer combinations and B-Doubles.
  - Restricted Access conditions such as Higher Mass Limits semi-trailers and B-Doubles.
  - Performance Based Standards (PBS) vehicle combinations such as non-conforming semi-trailers, B-Doubles and truck and trailer combinations or High Productivity Freight Vehicle (HPFV) 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:
  - The strongest path over a bridge or other structure, for the width of the load, in the forward or reverse carriageway direction.
  - The benefits of travelling at reduced speed.
  - Any local propping, plating or strengthening required to achieve adequate capacity for the proposed load.
  - Consideration to alternative heavy load platform arrangements.

A multi-pronged approach may be taken to load rating assessment as outlined below:

- Theoretical analysis:
  - Simple analysis.
  - High order analysis.
  - 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.

The bridge capacity must be assessed for its current condition based on the findings from the inspection in accordance with AS5100.7 Bridge Assessment. More detailed information of the process and requirements can be found in AS5100.7.

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 Inspections and Investigations:

- Detailed load rating 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 Structure Risk Management Plans (SRMPs) 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 Inspections and 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.

5 Inspection Requirements for Specific Categories of Level 3 Inspections and Investigations

5.1 Monitor Structures 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 DoT. The Monitor program also enables DoT 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 or 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 Structures 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.
- Dated 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 DoT Structural Asset Performance Team with advice from the Principal Engineer – Structures where additional assistance is required. The list must include the strengthening priority and maintenance priority for each structure.

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

5.1.2 Definitions

The **Monitor Structures 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 Structures Inspections are carried out periodically based on the condition of the structures 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, DoT (operating as VicRoads) and other State Road Authorities (SRAs) implemented a major program of bridge inspection and load rating 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 1.5 m, 3.6 m, 4.5 m (5' 12' 15') and 2.1 m, 7 m, 9.1 m (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.
- 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 post-tensioned concrete voided slab bridges.
- Post-tensioned concrete box girder bridges.
- Rolled steel girders with timber deck bridges.
- Rolled steel joist (RSJ) bridges retrofitted with precast or combination precast and cast-in-situ reinforced concrete deck slabs.

- 1950s and 1960s steel rail-in-slab bridges.
- Fabricated metal girder bridges.
- Timber stringers with timber deck bridges.
- Masonry arch structures and structures with masonry abutments, piers or similar.
- Multiple column piers.
- Buried corrugated metal structures (pipes and arches).
- Major 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 of a structure is required to establish the structural condition of the structure and whether there has been any significant deterioration of its condition since its construction or since the last inspection.

The Monitor Program comprises periodical re-inspection to identify any changes in the condition of a structure over time. 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 and mapped on the Level 2 datasheets 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. The quantity or percentage of changes in defects since the previous inspection are required to be recorded.

These defects are given an overall maintenance or strengthening priority rating. The rating is at the discretion of the DoT inspecting engineer based on the type and severity of observed defects. The DoT 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 Engineer – Structures.

The definitions for both categories are provided below:

<u>The Strengthening Priority classification ranges from S1 to S3 with S1 having the highest priority.</u>

S1 (1^{st} priority – Strengthening works required)

S1 – structures that have a high risk of requiring a load limit within the next 2 years because:

- Structural components have deteriorated and are not acting as designed and may have reduced capacity of the structure.
- There is an immediate threat to level of service, e.g. load capacity, safety, lane configuration and speed restriction.

S1-urgent (S1-U) can be adopted for structures identified as a high risk of requiring a load limit within the next year.

S1 structures should have ongoing Monitoring inspections at intervals no greater than two years unless more stringent requirements are recommended by Asset Manager in conjunction with Principal Engineer – Structures.

Where a structure is given a rating of S1, a more specific Level 3 Inspection and investigation must be conducted to assess the structure condition and load rating, and the feasibility of strengthening, rehabilitation or replacement works.

S2 (2nd priority – Strengthening works required)

S2 – 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 with time 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)

S3 – 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 a period of 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.

M1-urgent (M1-U) can be adopted for structures identified as the maintenance/repair works required within the next year.

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 next 4 to 6 years.

5.1.5 Management of Monitor Structures

The majority of the Monitor Structures has been inspected several times since the implementation of this program of inspection.

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

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.
- Impacts to the travelling public.
- 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 Inspections

5.2.1 Definition

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 Structure Risk Management Plan (SRMP).

A list of Complex Structures is maintained by the DoT Structural Asset Performance Team with advice from the Principal Engineer – Structures where additional assistance is required. The list is subject to continuous review.

Structures may be included in the Complex Structures list for the following structural reasons:

- Structural form – e.g. cable, suspension, truss, lifting bridge.
- Special knowledge and/or training beyond that of a Level 2 inspector is required to conduct an inspection of a specific component – 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.

Examples of Complex Structures 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.
- Box-girder bridges.
- Other structure types with limited or no structural redundancy.

5.2.2 Inspection

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

Complex Structures 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.

The inspection must be carried out at intervals no greater than ten years depending on the condition and deterioration of the structures, unless more stringent requirements are recommended by Asset Manager in conjunction with Principal Engineer – Structures.

5.2.2.1 ROVs for inspections

The use of Remotely Operated Vehicles (ROVs) for Complex Structures 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. DoT Structural Asset Performance Team has trialled the use of ROVs on a small sample of Complex Structures inspections instead of using more traditional access equipment options. The scope of the inspection carried out by ROVs for Complex Structures inspections must be developed by an experienced structural engineer. The experienced structural engineer must guide the ROVs operator during the inspection. DoT Structural Asset Performance Team must be consulted to advise on the use of ROVs for Complex Structures inspections as there is currently no framework for their use.

5.2.3 Structure Risk Management Plan (SRMP)

SRMPs are to be prepared by the responsible Asset Manager with advice from the Principal Engineer – Structures. Refer to Appendix I for the SRMP template.

In order to manage and maintain the load status of the structure and to substantially extend the life of the bridge, a specific SRMP is required to be put in place with adequate monitoring and inspection of the critical elements of the bridge for defects and deterioration.

The SRMP reports on the current performance of the structure and the potential failure with an outline of the consequence of most critical failure and provide requirements of inspection and monitoring for specific defects. The SRMP must also specifically recommend any current and future requirements for repairs, strengthening and on-going maintainability.

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 stringers 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.

The geometry and condition of the structure are to be checked by a prequalified inspector in accordance with this section. Refer to Section 4.2 for the details of prequalification requirement of the prequalified engineer.

5.3.2 Technical Items

5.3.2.1 Timber piles/piers and abutments

In relation to the geometry of the structure the following measurements are to be undertaken by the prequalified inspector:

- 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 crosshead 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 wingwalls.

In relation to the condition of the structure the following activities are to be undertaken by the prequalified inspector and recorded with dated photographs of the defects identified:

(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 before investigation.
- Draw cross-section showing effective annulus or solid section of sound timber.
- Check that timber is sound where supporting timber crossheads, particularly where crossheads 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 crossheads

Geometry:

- Measure size, number and locations of timber crossheads.
- Measure diameters and locations of bolts attaching crossheads to piles.
- Measure size and connection of steel crossheads (if any).
- Determine effective load sharing (if any) between steel and timber crossheads 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 must be made of the components of the structure that require:

- Maintenance and/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 must be assessed.

Recommendations must 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 AS5100.7 Bridge Assessment by a prequalified bridge design engineer based on the field data collected in accordance with this section. Refer to Section 4.2 for the details of prequalification requirement of the prequalified engineer.

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 relevant information to develop 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. The relevant information must be collected in detail to allow the development of drawings that detail the as-constructed condition of the structure which will in turn be used to assess the bridge in its entirety and to allow a load rating assessment to be carried out to estimate the capacity of the bridge.

For structures built before 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 Inspections

Heritage or Historic Structures are structures included on the Victorian Heritage Register and/or nominated in RAS.

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

DoT 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 Level 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

DoT 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. DoT 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 that are 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. The Asset Manager must take into account the condition of the structure and the risk it imposes to the public. Where the risk is assessed to be unacceptable then steps are to be taken to ensure that the public are not placed in risk due to the presence of the structure.

Disused structures are included in the normal bridge inspection program for Level 1 and Level 2 Inspections even if they are not used by traffic.

5.6.2 Inspection and Maintenance of Signs and Fences around Structures

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 or a place of gathering, 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 5.6.2: 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. 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 Inspections

5.7.1 Introduction

Major sign structures must all be inspected in a similar way to bridges. Major sign structures deteriorate with time and if not adequately maintain over their design life may pose a threat to the travelling public. Some Major Sign Structures are also prone to fatigue depending on how they were designed.

During inspection of these structures, it was identified that there could be a problem with the hold down bolts and the way they performed over their design life. 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.

The audit inspections were implemented in response to the fatigue induced failure of one of these sign structures. 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.

Where the gantry is supporting a directional sign or a Variable Message Sign, the connection of the sign to the gantry must also be inspected and its condition recorded.

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 of these 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 to be used 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 DoT/VicRoads Standard Specification for Roadworks and Bridgeworks Section 750 Routine Maintenance. 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/Earthquake/Fire Bridge Inspection Report.

The Region or Asset Management team must ensure the safe access to the site prior to the inspections. A site-specific Safe Work Method Statement (SWMS) must be prepared by the personnel attending the site. Emergency response inspections must be conducted in accordance with SWMS and/or on the direction of the Region, incident controller or emergency services.

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 the 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.

The results of the inspection are to be recorded and to be provided to the Asset Manager for review and action where required.

5.8.2.3 Underwater Inspection and ROV

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 scope of the diving inspections must be developed by a an experienced structural engineer. The diver must be fully briefed by an experienced structural engineer regarding the specific requirements for the inspection. The diver must assess the existing site conditions to be safe before commencing their underwater inspection. Refer to Section 3.5.4.1 for additional requirements of underwater inspections.

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 structural engineer. DoT Structural Asset Performance Team must be consulted before commencing to advise whether this approach is suitable for the location and will provide reliable data. Refer to Section 5.2.2.1 for further requirements of inspections with ROV.

5.8.3 Vulnerable Structures

Vulnerable structures are structures with the structural form, waterway profile or materials vulnerable to flooding that require particular attention.

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 recorded and 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 a prequalified structural 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. Refer to Section 4.2 for the details of prequalification requirement of the prequalified engineer.

The inspector must 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 Structural Asset Performance.
- The Manager Real Time Signal Operations (previously Manager Regional Services Road User Services for statewide permits).

The Asset Manager must review the report provided and take appropriate measures to manage the risk and to ensure that no members of the public are placed in danger. Such measures may include placing load restrictions on the structure, implementing lane closures and/or speed limits, completed closure of the structure to the public. The Asset Manager must also consider the placement of warning signs on both sides of the structures.

If the whole of the structure, after inspection, is found to be 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.

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 or closures.
- Closure to all vehicles and pedestrians.
- Pedestrians access only.
- Pedestrians and cars access 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 load restriction pending repairs or other remedial action. If the Principal Engineer – Structures determines that a load restriction is not required, the bridge may be opened to all vehicles.

Where a load restriction is implemented then an assessment of the structure is to take place, the scope of the remedial works in order to remove the load restriction developed and presented to the Asset Manager to be actioned.

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 Inspection may include a geotechnical investigation and an underwater inspection. Under-water inspections must be conducted as outlined in Section 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 where the structure has sustained damage. This must be based on the post-flooding condition of the structure. Load rating must be conducted in accordance with AS5100.7 Bridge Assessment.

5.9 Post Fire inspection of Bridges

5.9.1 Introduction

Similar to flooding, fire can cause different levels of damage to structures, therefore inspection of affected structures must be completed as soon as practicable after a fire event.

This section is intended to be used by those who are responsible for the management of structures that have been exposed to heat and flames from fires caused by bushfire, arson, vehicle accidents, and other causes. It should be read in conjunction with, the requirements for Level 1 – Routine Maintenance Inspection and DoT/VicRoads Technical Note TN102 – Fire Damaged Reinforced Concrete – Investigation, Assessment and Repair. 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 fire impact.

5.9.2 General

The same general procedures as post-flood management of bridges following a flood event (refer to Section 5.8) must be undertaken following a fire.

5.9.3 Inspections and Assessments

5.9.3.1 Initial post fire inspection and actions

Structures located at severely bushfire-affected areas and those with known vulnerability to fire-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 not visible, this must be reported and the structure, together with its approach roads, should be closed.

The same general procedures routinely undertaken following a flood event must be undertaken following a fire.

Additionally, caution must be taken of potential strength reduction of fire damaged components to support an inspector, as well as risks of falling debris loosely attached to the structure after a fire which may fall due to wind, inspector activities, etc. In active bushfire zones, which may still be in effect long after a bushfire has reached its peak, access approval is required and co-ordinated through Asset Manager for individuals inspecting fire damaged bridges.

The main focus of the inspection is to evaluate structural damage caused directly by the fire, however all other bridge concerns also must be identified through the use of the standard routine inspection form including Section 750.D021 Bridge and Major Culvert Routine Maintenance and Inspection Report and Appendix E Post Flooding/Earthquake/Fire Bridge Inspection Report, since they have considerable influence on the final recommendations for repair or replacement of a structure or its components.

Particularly in the case of bushfires, the inspector should assess whether the likelihood of scouring and debris flow has increased post-bushfire, as is common, and should evaluate whether this poses a significant threat to the structure in the near future.

Other than monitoring, no further action should be taken until the fire is out and the whole of the structure 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 following Post-flood Inspection procedure.

In order to adequately inspect various bridge components, special cleaning techniques may be required to remove soot, char, deteriorated coatings, and other debris.

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

5.9.3.2 Components need special attention

Additional to the standard routine bridge inspection forms which contain complete lists of components to be inspected, the following is an ancillary list of typical items that require particular attention when undertaking a post-fire inspection.

Checklist of items for special attention in a post-fire inspection	
Steel	
Item No.	**Description**
1	Steel girders
2	Paint or galvanised coatings
3	Non-skid epoxy deck coatings
4	Welds
5	Bolts
6	Bracing and diaphragms
7	Sheet steel abutments and retaining walls
Concrete	
Item No.	**Description**
1	Deck
2	Beams
3	Substructure components
4	Fibre-reinforced Polymer (FRP) strengthening and bonding materials

Timber	
Item No.	**Description**
1	Refer to Section 5.3
Miscellaneous	
Item No.	**Description**
1	Elastomeric bearings
2	Geotextiles
3	Signs (including delineators)
4	Utilities on bridges
5	Increased scour susceptibility
6	Joint seal
7	Drainage systems
8	Barriers

Bridge coatings can experience different degrees of damage during fire events, depending on the fire intensity and the coating type. When temperatures exceed 400 °C coatings will typically be severely damaged or destroyed.

Distortion and high forces due to thermal expansion during a fire event can cause cracking or distress of welds. It is important to perform a "hands-on" inspection of fillet welds in steel bridges that have had substantial exposure to fire.

One of the main concerns of the behaviour of FRP strengthened concrete members is the fire resistance of the FRP strengthening system at elevated temperatures and its structural performance, especially the bond performance of the epoxy, during and after a fire event. Refer to Appendix B Section 1.1.7 for further details of inspection requirements.

It is common to see bridges that have bearing damage and possible damage with abutment walls following fire events. The thermal expansion (longitudinal and transverse) can be much higher than anticipated by normal bridge temperature changes. Expansion at the bridge ends reflects the integration of the thermal expansion occurring at every section of the bridge. It is therefore possible to see bearing and joint problems away from the locations directly affected by fire. Therefore, all expansion joints and bearings, regardless of location, require thorough inspection and evaluation following a significant fire event. Much of the bridge expansion present at peak temperature will reduce as the bridge cools. Bearings may have suffered damage at the peak expansion point that may not be apparent after the bridge contracts. This is a particular concern for elastomeric or other non-mechanical bearing types.

As wood burns, marked zones of degradation become apparent (if a specimen is thick enough). Wood exposed to temperatures in excess of 280 °C will form a residual char layer. Any charred layer of a wood member has no residual load capacity. A layer of wood below the char layer is subject to some thermal degradation because of exposure to elevated temperature.

PART THREE – CONDITION RATING OF COMPONENTS

1 Introduction

Part 3 provides guidance on the condition rating of structural components. It includes tables of structural components and component numbers and specific guidance on the condition rating of each of these components.

Part 4 provides descriptions of each condition state and photographic examples of the different condition states. Appendix B provides supplementary information regarding defects which are applicable to a variety of materials used in structure components.

1.1 General

1.1.1 Structure Components

DoT uses Road Asset System (RAS) – a computerised inventory system – to store structural inspection and inventory data. Component numbers are a coding system which provides an efficient and consistent format for data recording during inspections which is suitable for data entry into RAS.

The value of structural inspections depends on the quality and consistency of the inspection data and how it is subsequently recorded and reported.

Inspection data is used to inform statewide maintenance, strengthening and rehabilitation programs. For this reason, it is important that inspections are conducted to a consistent and repeatable standard and that data are comparable across the State regardless of who performs the inspection.

In order to ensure consistency of reporting, the RSIM includes standard descriptions for:

- Structural components.
- Different levels of deterioration.
- Degree of aggressiveness of the environment.

1.1.2 Structure Component Types

Components used in the majority of road structures are predefined and described for ease of identification and reporting.

The components are further divided into five categories describing the material from which they are constructed. The five material types are:

- Steel.
- Precast concrete.
- Cast-in-situ concrete.
- Timber and
- Other (all other material types, such as brickwork, masonry, gravel, neoprene, bitumen, cork, malthoid, fibre-reinforced polymer and aluminium).

Steel components include cast and wrought iron materials.

All predefined bridge components are described in Table 1.2.1 ‘Bridge and major culvert components’ and the following figures. This list of components is updated from time-to-time.

Roadside structure components are described in Table 1.2.2.

Inspectors must use the unique component numbers given in the tables and figures to identify and rate the condition of each component of the structure being inspected.

1.2 Structure Components and Material Categories

Table 1.2.1 Bridge and major culvert components

Component name		**Component**				
No.	**Superstructure**	**Steel (S)**	**Precast Concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
1.	Closed web/box girders	1 S	1 P	1 C	1 T	
2.	Open girders/Stringers	2 S	2 P	2 C	2 T	
3.	Through truss	3 S			3 T	
4.	Deck truss	4 S				
5.	Arches	5 S	5 P	5 C	5 T	5 O
6.	Cable/Hangers (not embedded in concrete)	6 S				
7.	Corbels	7S		7C	7 T	
8.	Deck/Slabs	8 S	8 P	8 C	8 T	
9.	Crossbeams/Floorbeams	9 S			9 T	
10.	Longdecking/ Crossdecking/Running planks				10 T	
11.	Thin plated deck support	11 S				
12.	Diaphragms/Bracing	12 S		12 C		
13.	Load bearing diaphragms	13 S		13 C		
14.	Fill/Wearing surface on deck					14 O
15	Fauna bridges	15S		15 C	15 T	15 O

Note:

15S for all steel components
15C for any concrete items including anchor blocks
15T for timber poles
15O for ropes, wires etc

Components not defined

Component name		Component				
No.	**Substructure**	**Steel (S)**	**Precast Concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
20.	Cross heads (non integral with superstructure)	20 S	20 P	20 C	20 T	
21.	Cross heads (integral with superstructure)			21 C		
22.	Column or pile extensions	22 S	22 P	22 C	22 T	
23.	Pier wall			23 C		23 O
24.	Abutment		24 P	24 C	24 T	24 O
	Deck Joints					
30.	Pourable joint seal					30 O
31.	Compression joint seal					31 O
32.	Assembly joint seal					32 O
33.	Open expansion joint	33 S				
34.	Sliding joint	34 S				
35.	Fixed joints					35 O
	Bearings					
40.	Fixed bearings					40 O
41.	Sliding bearings					41 O
42.	Elastomeric/Pot bearings					42 O
43.	Rocker/Roller	43 S				
44.	Mortar pads/High bearing pedestals			44 C		

Components not defined

Component name		Component				
No.	**Miscellaneous**	**Steel (S)**	**Precast Concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
50.	Bridge/Culvert kerb/Footways		50 P	50 C	50 T	50 O
51.	Bridge/Culvert railing/Barriers	51 S	51 P	51 C	51 T	51 O
52.	Bridge approaches					52 O
53.	Batter protection		53 P	53 C		53 C
54.	Waterway			54 C		54 O
55.	Off-structure barriers	55 S	55 P	55 C		55 O
56.	Identification plate	56 S				
58.	Protective coating	58 S				
59.	Deflection walls			59 C		
	Strengthening					
57.	Bonded strengthening systems	57 S				57 O
	Culverts					
60.	Pipe culverts	60 S	60 P			60 O
61.	Box culverts		61 P	61 C		61 O
62.	Arch culverts	62 S	62 P	62 C		62 O
63.	Endwalls/Wingwalls		63 P	63 C		63 O
	Cladding					
64.	Cladding facing/Panels	64 S	64 P	64 C	64 T	64 O
65.	Piles & columns	65 S	65 P			
66.	Connections & supports	66 S				

Note:

50 O for steel kerb units

Components not defined

Table 1.2.2 Roadside structure components

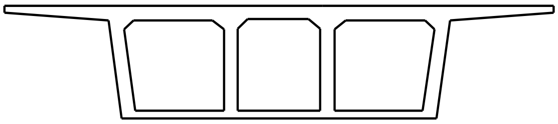
Component name		**Component**				
No.	**Cantilever Signs, Gantries and High Mast Lighting**	**Steel (S)**	**Precast Concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
70.	Footings/Support	70 S	70 P	70 C		
71.	Columns (including bracing between)/Mast	71 S	71 P			
72.	Cantilever arms or gantry beams (incl. connections) or light head supports (incl. bracing)	72 S				
73.	Gantry truss	73 S				
74.	Hold down bolts	74 S				
75.	Baseplates, fittings & mortar pad	75 S		75 C		
76.	Legend (includes VMS message)					76 O
77.	Light head	77 S				
78.	Miscellaneous (including access ladder, platform, etc.)	78 S				
	Noise Attenuation Walls and Visual Screen Walls					
80.	Wall facing/Panels	80 S	80 P	80 C	80 T	80 O
81.	Column & horizontal supports	81 S	81 P		81 T	
82.	Foundations/Foundation Support	82 S	82 P	82 C		
83.	Hold down bolts, baseplates, fittings & mortar pad	83 S		83 C		
	Retaining Walls					
85.	Wall facing/Panels	85 S	85 P	85 C	85 T	85 O
86.	Columns	86 S		86 C	86 T	
87.	Barriers	87 S	87 P	87 C		
88.	Connections and horizontal supports	88 S			88 T	
89.	Drainage system					89 O

Note:

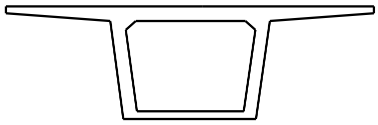
85O for Mortared masonry or stone columns and buttresses

Components not defined

COMPONENT No.

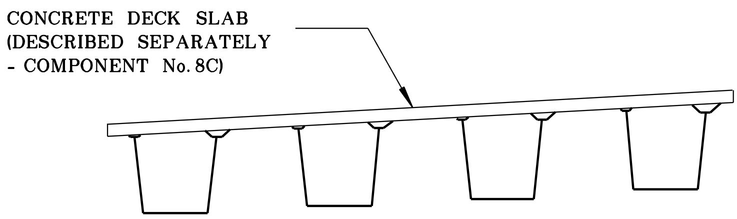


MULTI-CELL PSC BOX



SINGLE-CELL PSC BOX

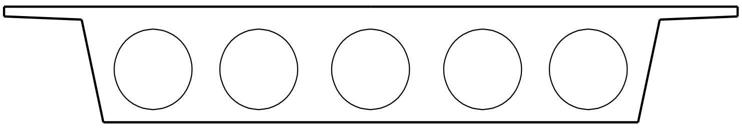
1 P or 1 C



STEEL BOX GIRDER WITH COMPOSITE DECK

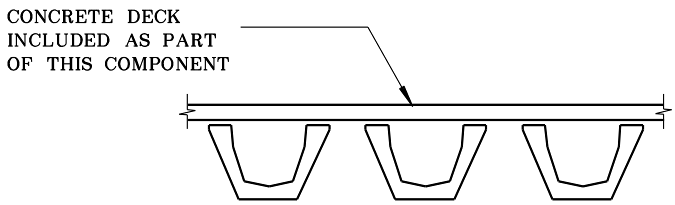
8 C
CONCRETE DECK

1 S
STEEL GIRDER



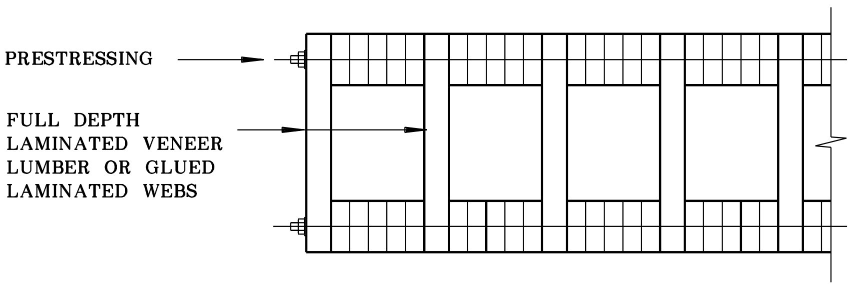
PSC VOIDED SLAB

1 C



PSC U-BEAM/TROUGH BEAM AND RC SLAB

1 P

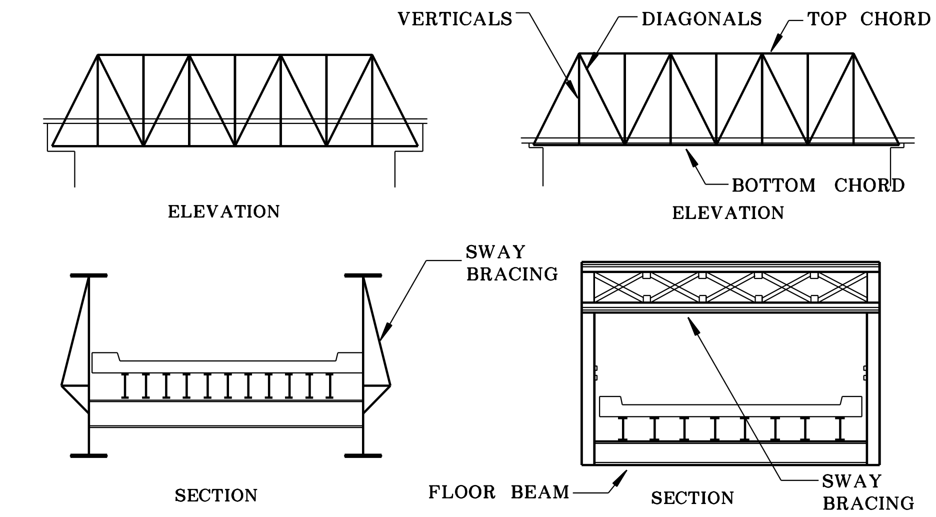


TIMBER CELLULAR DECK SYSTEM

1 T

FIG. 1 - CLOSED WEB / BOX GIRDER

COMPONENT NO.



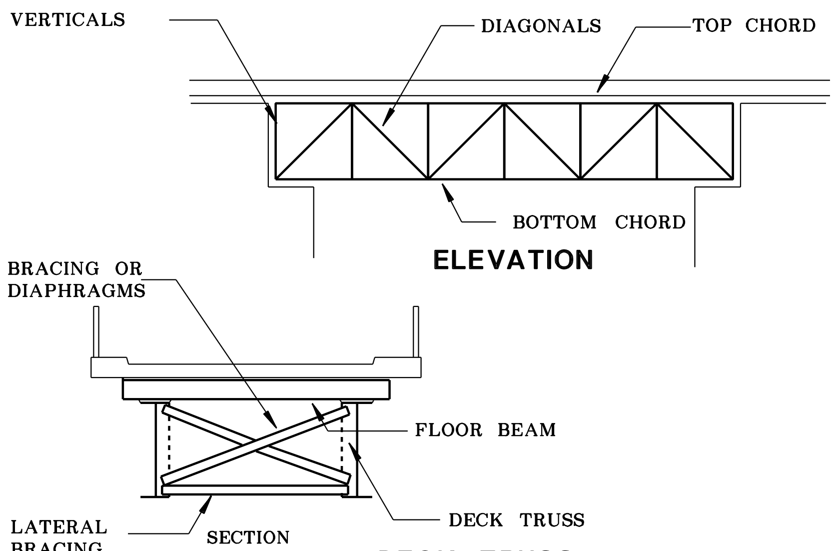
HALF THROUGH (PONY) TRUSS **THROUGH TRUSS**

3 S

TRUSS

9 S

FLOOR BEAM



DECK TRUSS

4 S

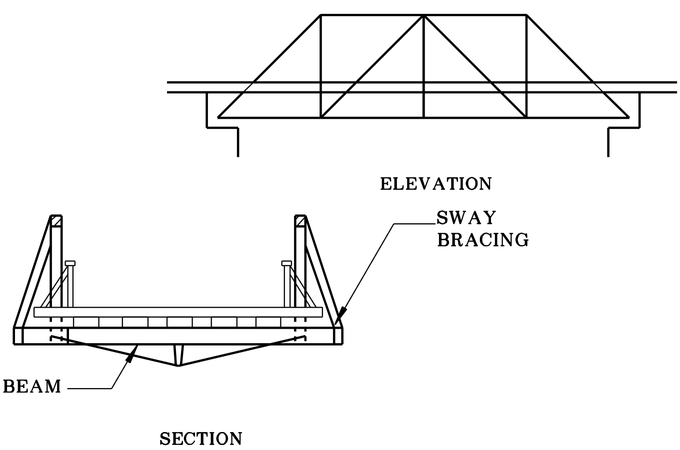
TRUSS

9 S

FLOOR BEAM

12 S

BRACING



HALF THROUGH TIMBER TRUSS

3 T

TRUSS

9 S

FLOOR BEAM

FIG. 3 TRUSS BRIDGES

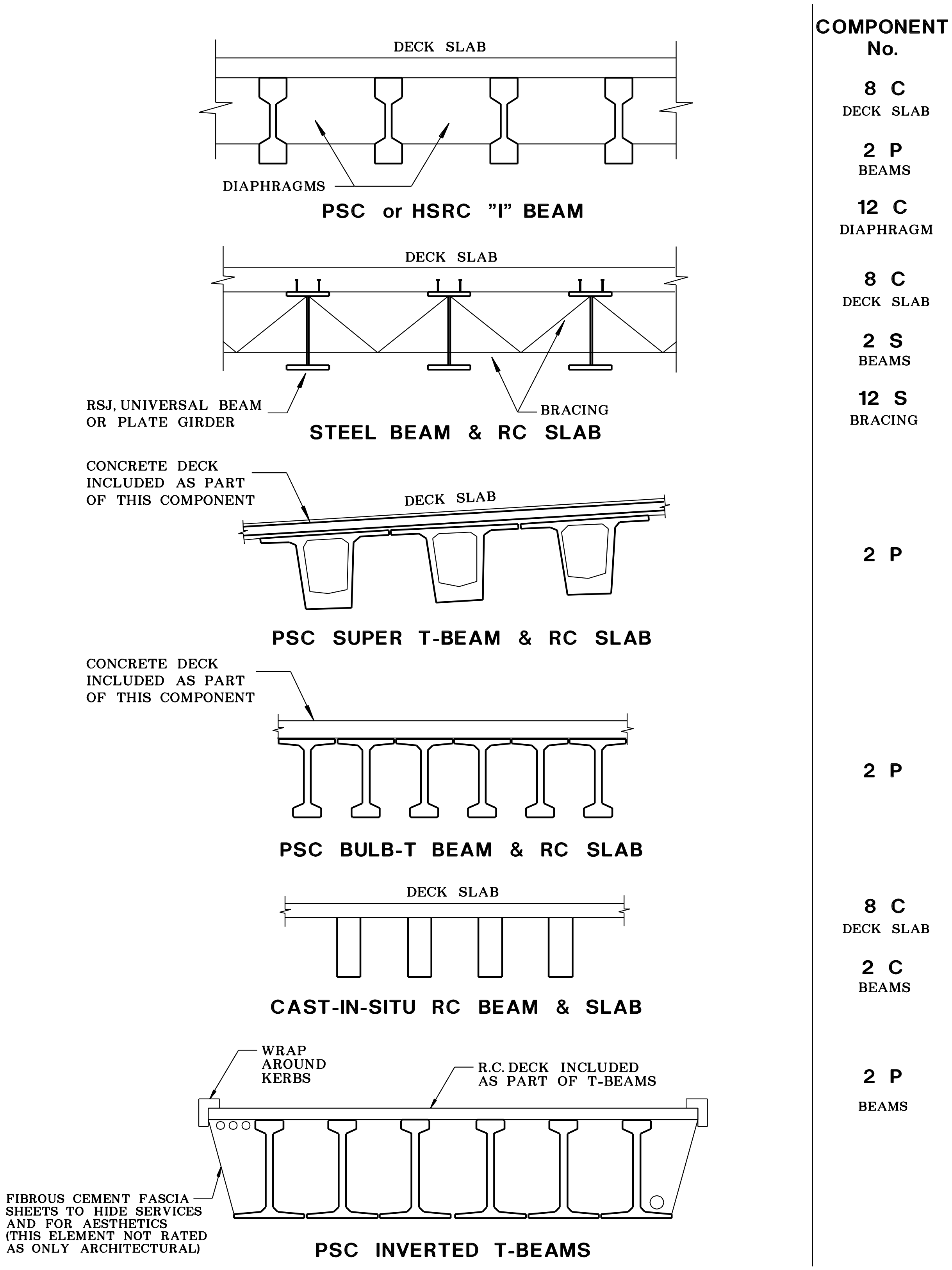
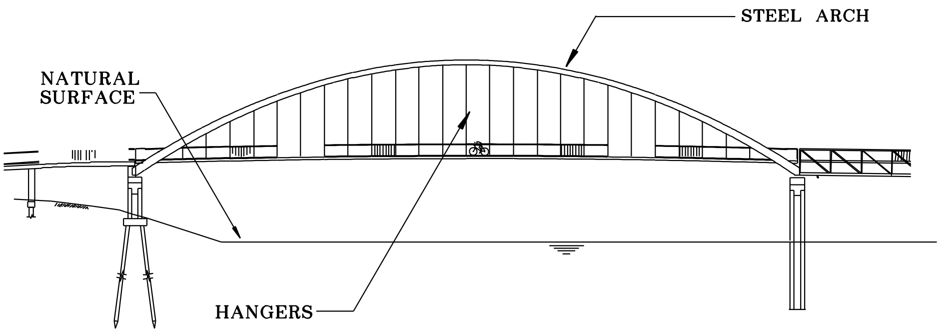


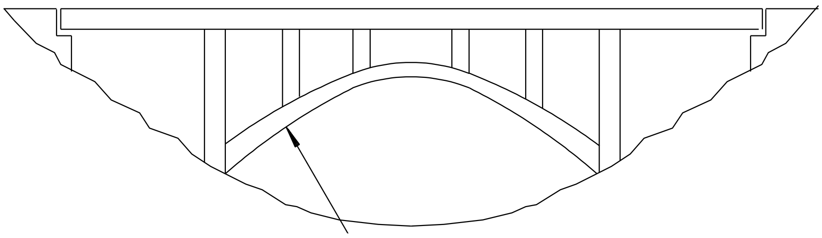
FIG. 2 - OPEN GIRDERS / STRINGERS

	COMPONENT NO.



BOW STRING ARCH

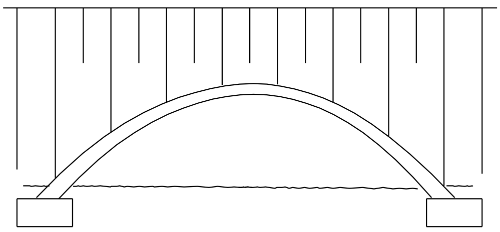
5 S
ARCH
6 S
HANGERS



SPANDREL ARCH

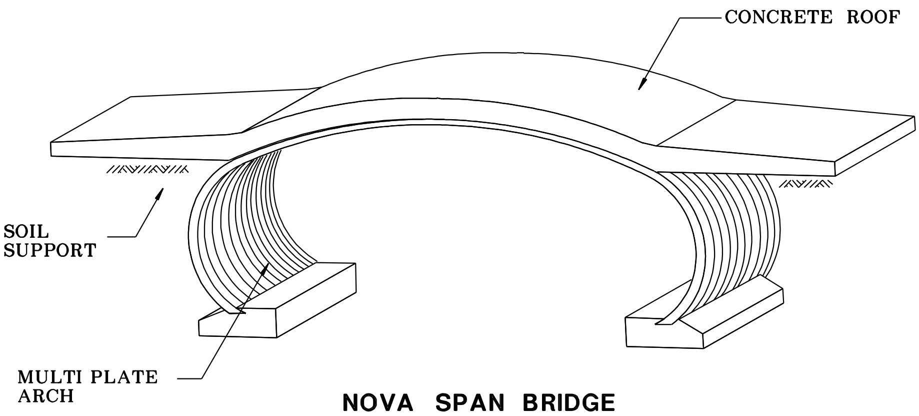
SPANDRAL ARCH

5 C



CONCRETE OR MASONRY BARREL ARCH

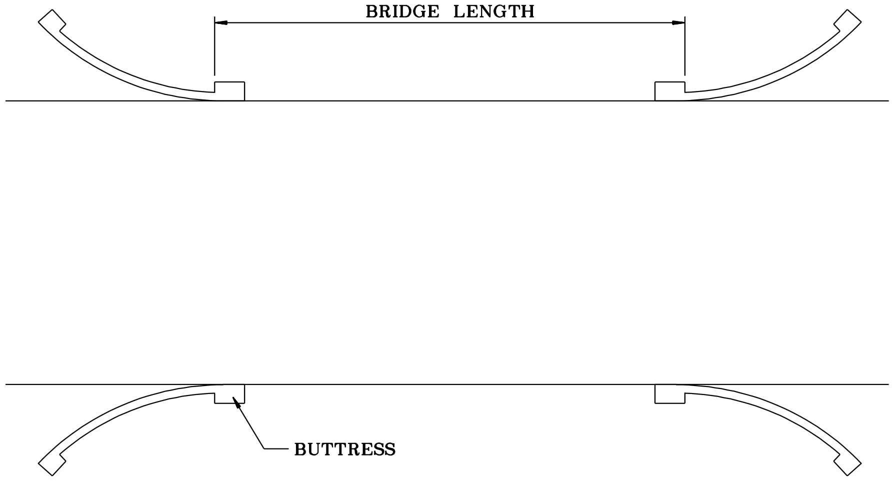
5 C or 5 O



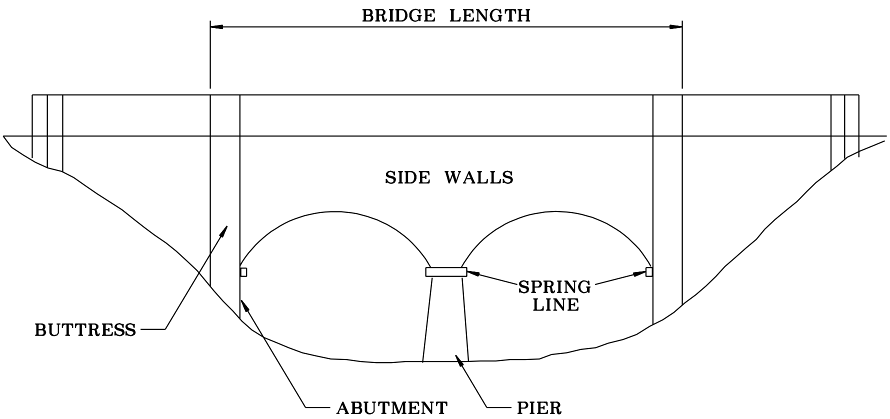
NOVA SPAN BRIDGE

5 S

FIG. 4.1 - ARCHES (Sheet 1 of 2)



PLAN



ELEVATION

FIG. 4.2 ARCHES (Sheet 2 of 2)

COMPONENT NO.

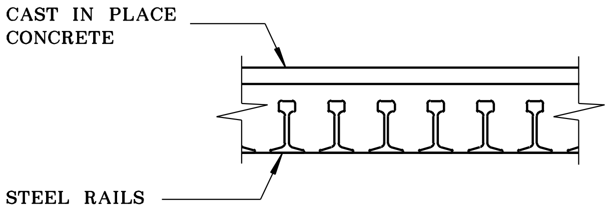
5 C, S or O
ARCHES AND SIDEWALLS

24 C or O
ABUTMENTS

23 C or O
PIERS

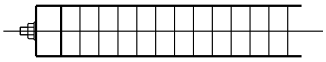
14 O
INFILL AND WEARING SURFACE

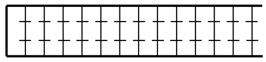
COMPONENT No.



RAILS CAST INTO DECK

8 S

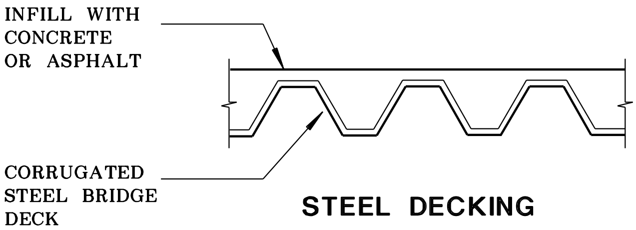




STRESS LAMINATED MINATED

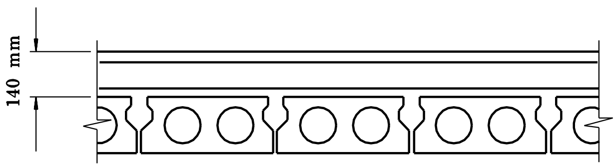
TIMBER DECK

8 T



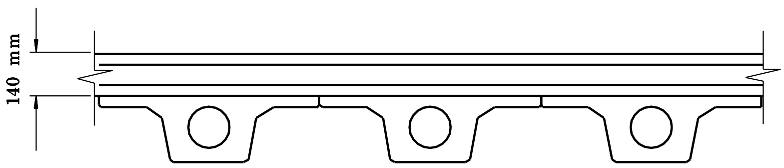
STEEL DECKING

11 S



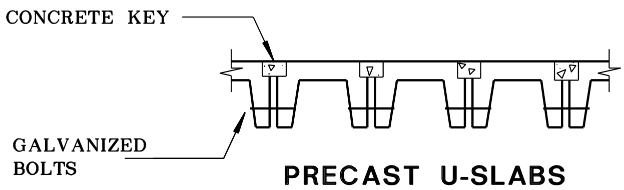
PRECAST PRESTRESSED SLABS & OVERLAY SLAB

8 P



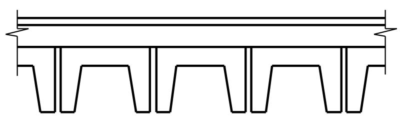
PRECAST PRESTRESSED T-SLABS & OVERLAY SLAB
(less than 18 m span)

8 P



PRECAST U-SLABS

8 P

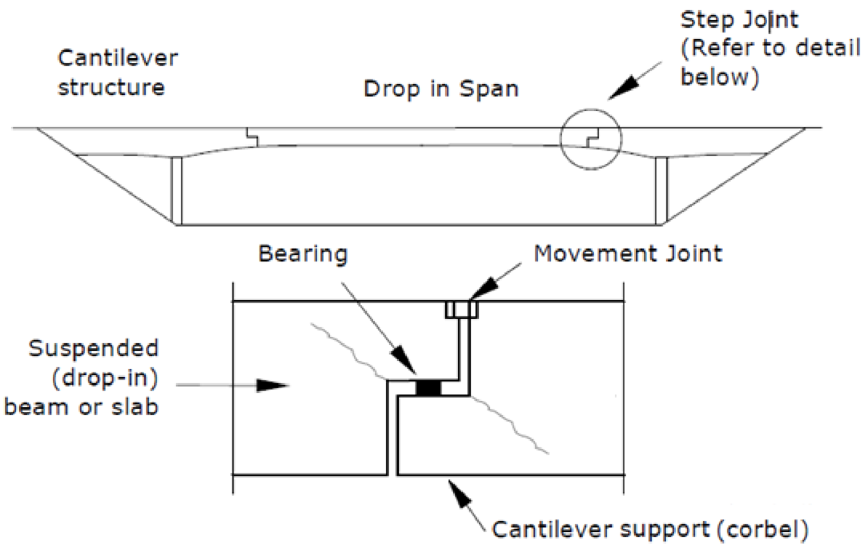


PRECAST U-SLABS & OVERLAY SLABS

8 P

FIG. 5 - DECKS / SLABS & THIN PLATED DECK SUPPORT

COMPONENT
No.

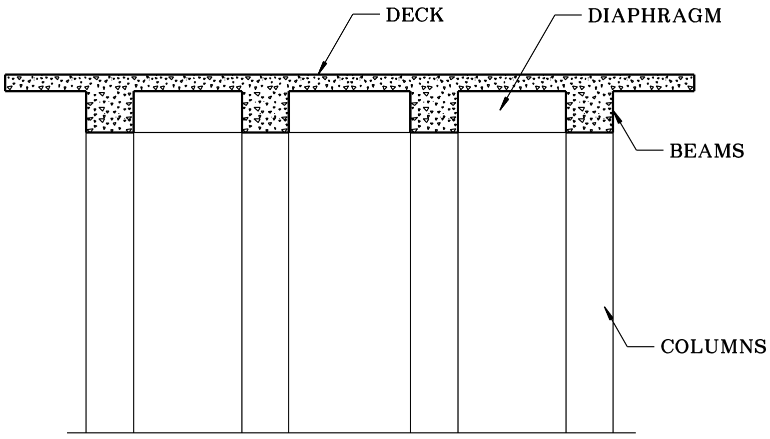


7 C

7 S

FIG 5.1 - STEP JOINT

COMPONENT NO.

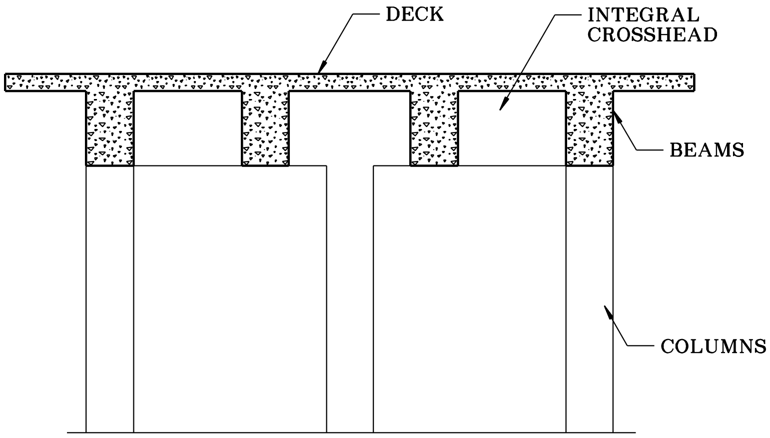


2 C
BEAMS

8 C
DECK

12 C
DIAPHRAGM

22 C
COLUMNS

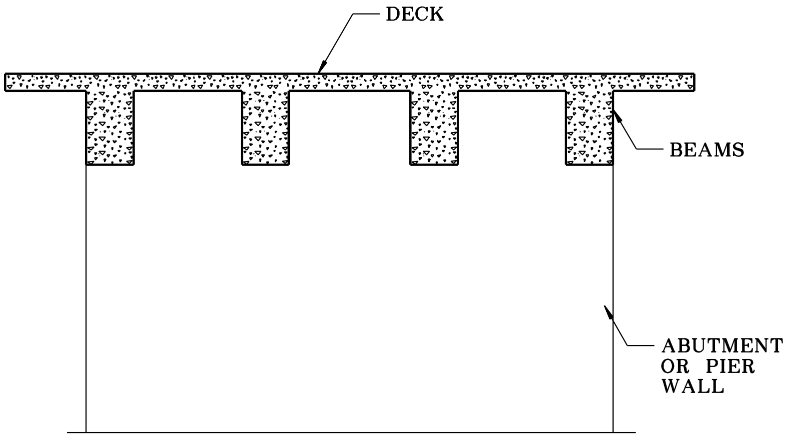


2 C
BEAMS

8 C
DECK

21 C
INTEGRAL CROSSHEAD

22 C
COLUMNS



2 C
BEAMS

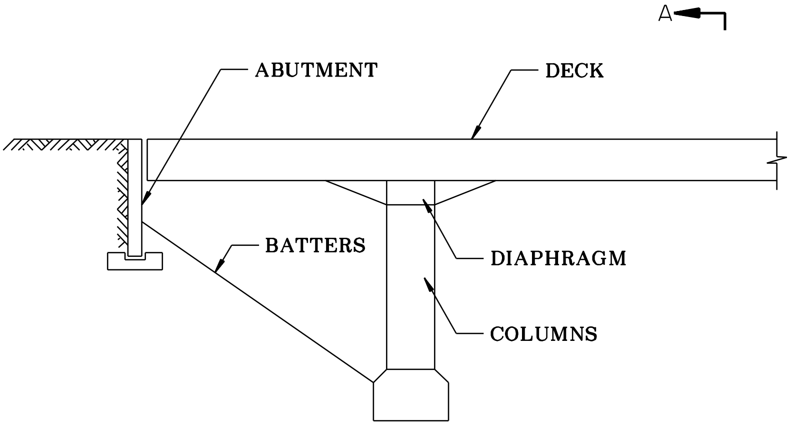
8 C
DECK

23 C
PIER

24 C
ABUTMENTS

FIG. 6 - CAST - INSITU MONOLITHIC R.C. T-BEAM BRIDGES

COMPONENT NO.

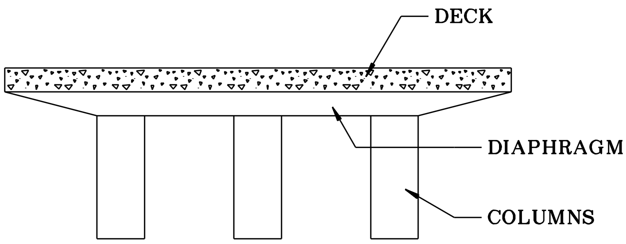


24 P
PRECAST
R.C. PANELS

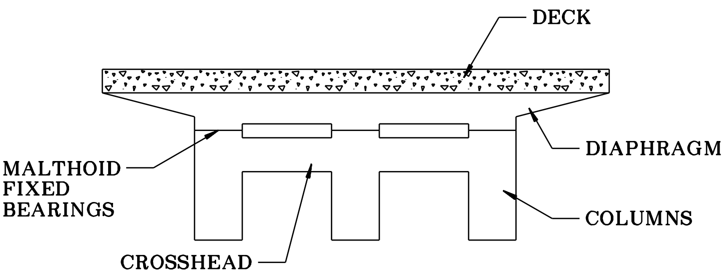
8 C
CAST-INSITU
DECK

12 C
CAST-INSITU
DIAPHRAGM

22 C
COLUMNS



SECTION A - A (TYPE 1)



SECTION A - A (TYPE 2)

8 C
CAST-INSITU
DECK

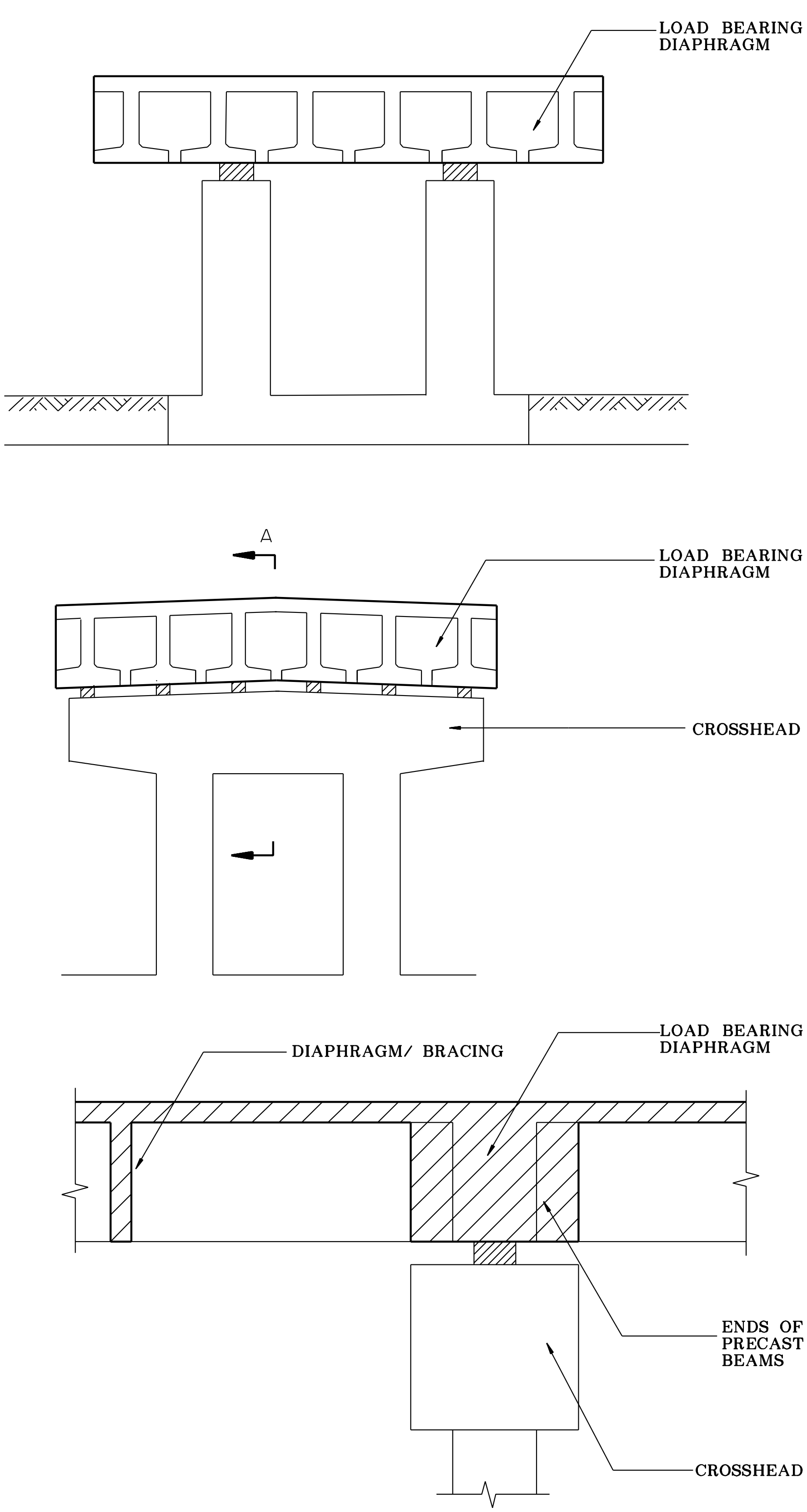
12 C
CAST-INSITU
DIAPHRAGM

20 C
CAST-INSITU
CROSSHEAD

22 C
COLUMNS

40 O
FIXED
BEARING

FIG. 7 - CAST - INSITU FLAT SLAB BRIDGES



COMPONENT No.

13 C
LOAD BEARING DIAPHRAGM

13 C
LOAD BEARING DIAPHRAGM

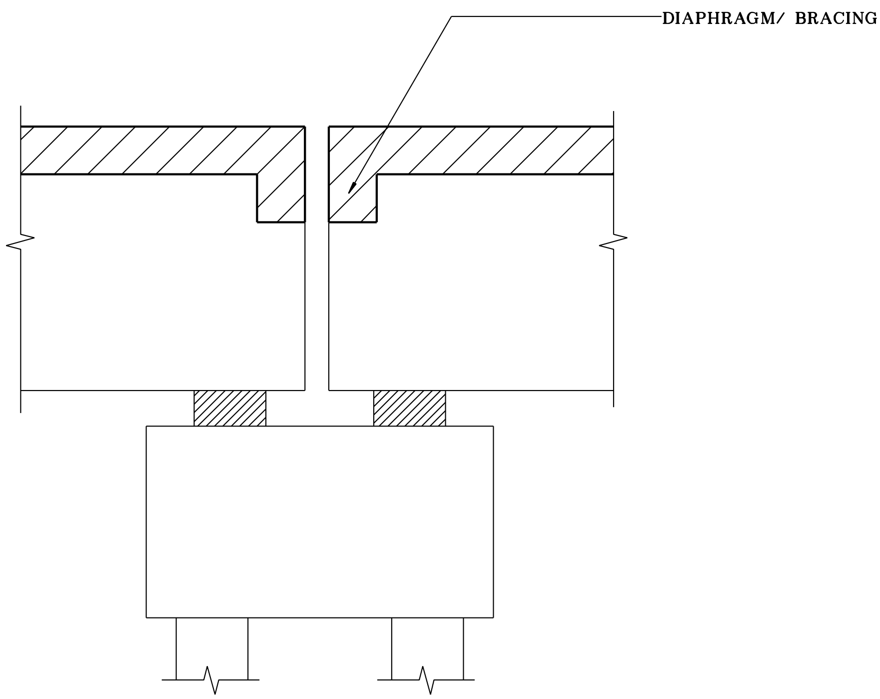
20 C
CROSSHEAD

12 C
DIAPHRAGM/ BRACING

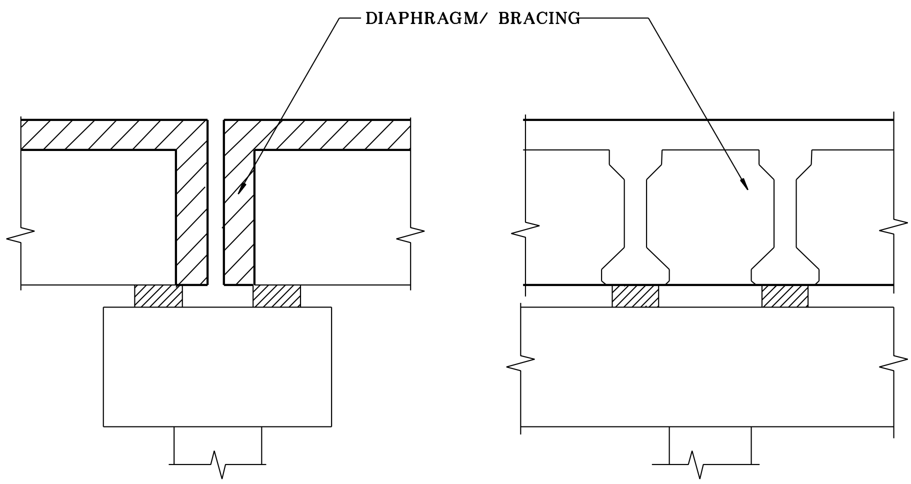
13 C
LOAD BEARING DIAPHRAGM

FIG. 8.1 - LOAD BEARING DIAPHRAGMS & DIAPHRAGM/ BRACING (Sheet 1 of 2)

COMPONENT
No.

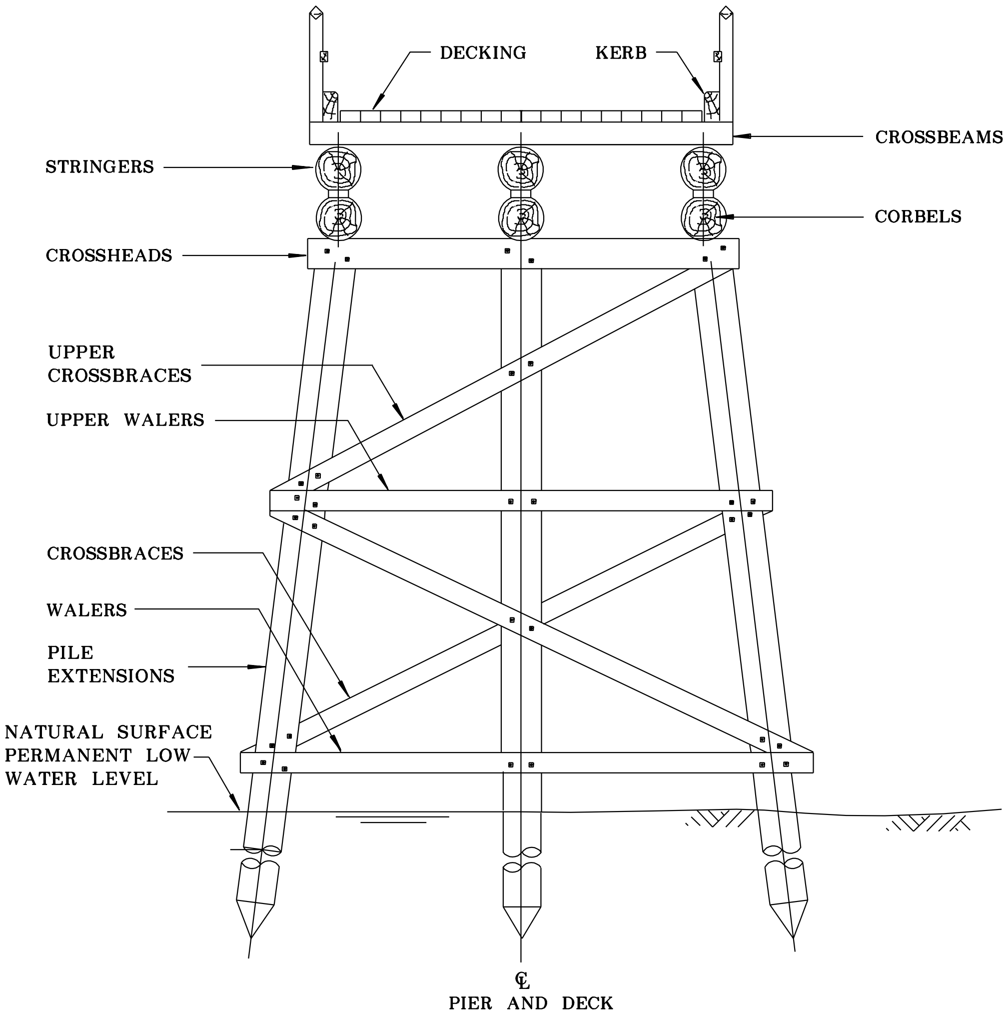


12 C
DIAPHRAGM/
BRACING



12 C
DIAPHRAGM/
BRACING

FIG. 8.2 - LOAD BEARING DIAPHRAGMS & DIAPHRAGM/ BRACING (Sheet 2 of 2)



COMPONENT No.
2 T STRINGERS
7 T CORBELS
9 T CROSS BEAMS
10 T DECKING
20 T CROSS HEAD
22 T PILE EXTENSION, BRACING & WALING
22 T WALING
51 T RAILING

FIG. 9 - TIMBER STRINGER BRIDGE

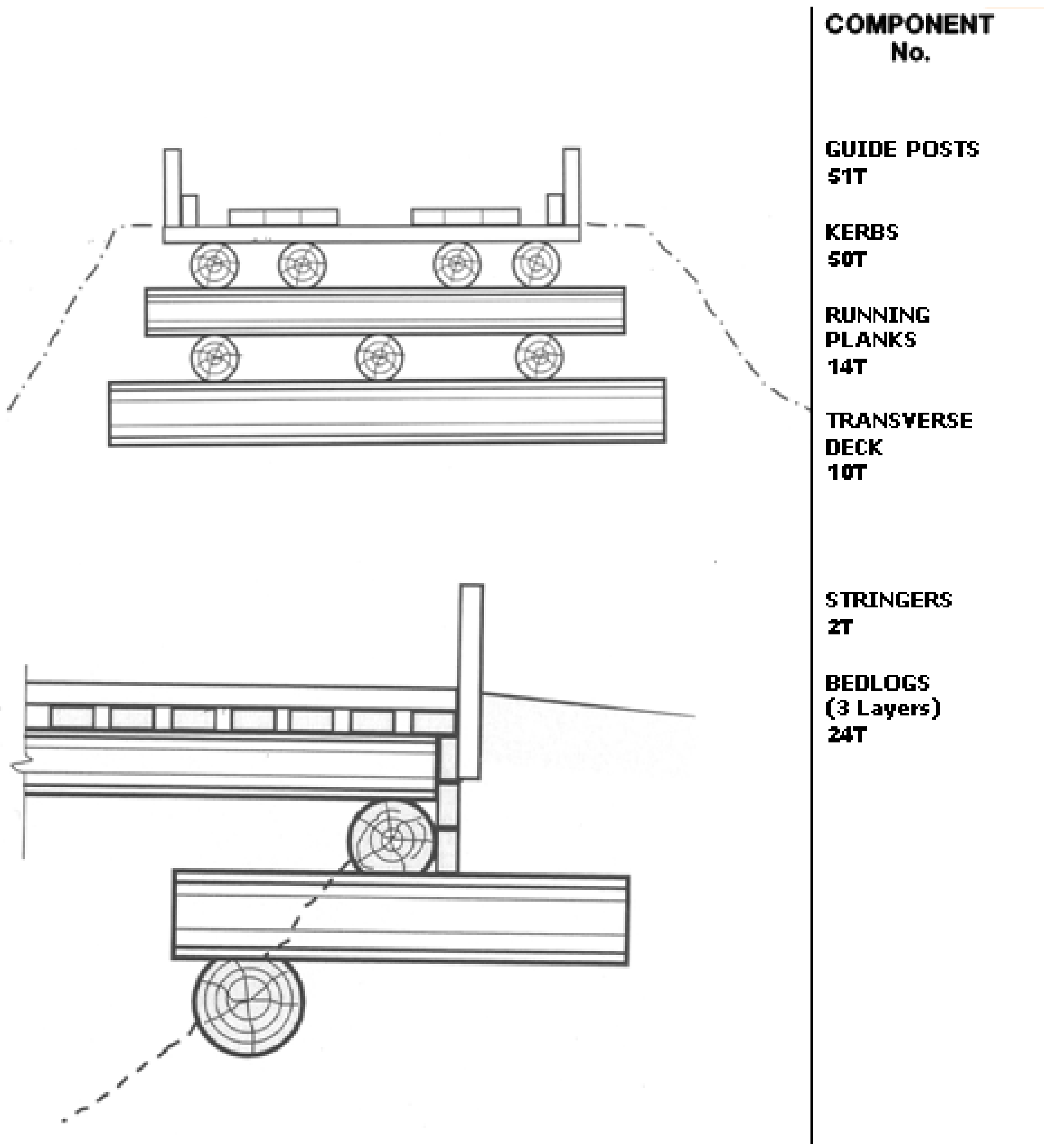
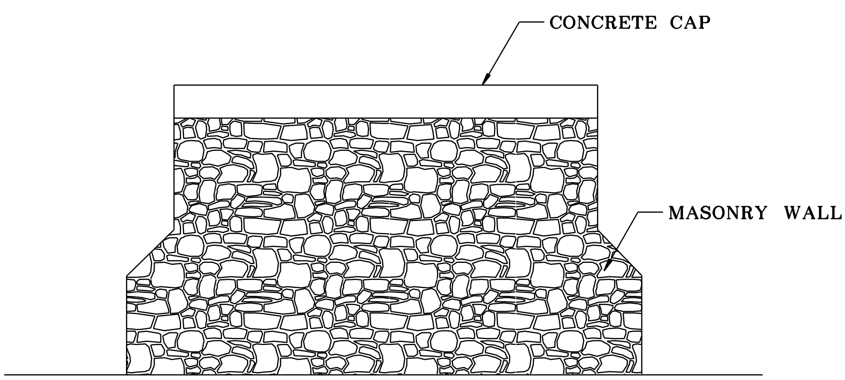
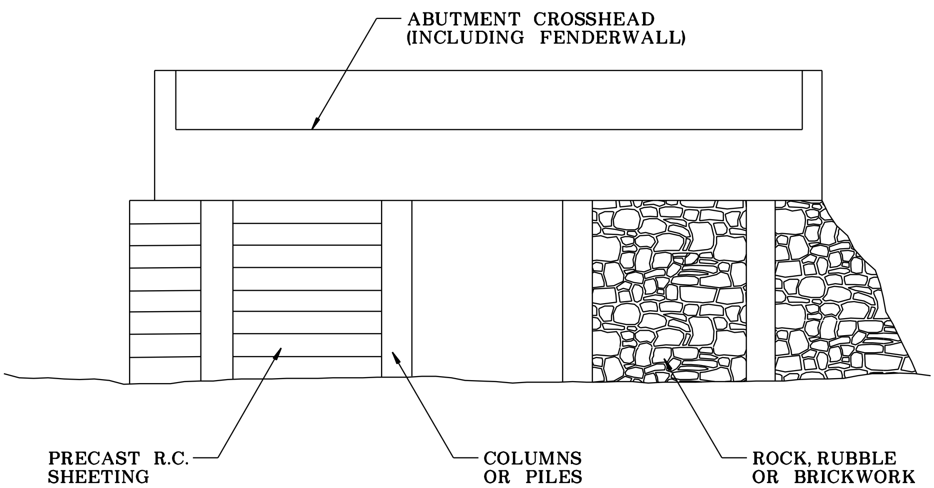


FIG. 10.1A - VICFOREST TYPE TIMBER BRIDGE ABUTMENT





COMPONENT NO.

ABUTMENTS

24 O
MASONRY WALL

20 C
CONCRETE CAP

PIERS

23 O
MASONRY WALL

20 C
CONCRETE CAP

20 C, P or S
CROSSHEADS

22 C, P or S
COLUMNS/PILES

24 C, P S or O
EMBANKMENT RETAINING WORK

FIG. 10.2 - ABUTMENTS

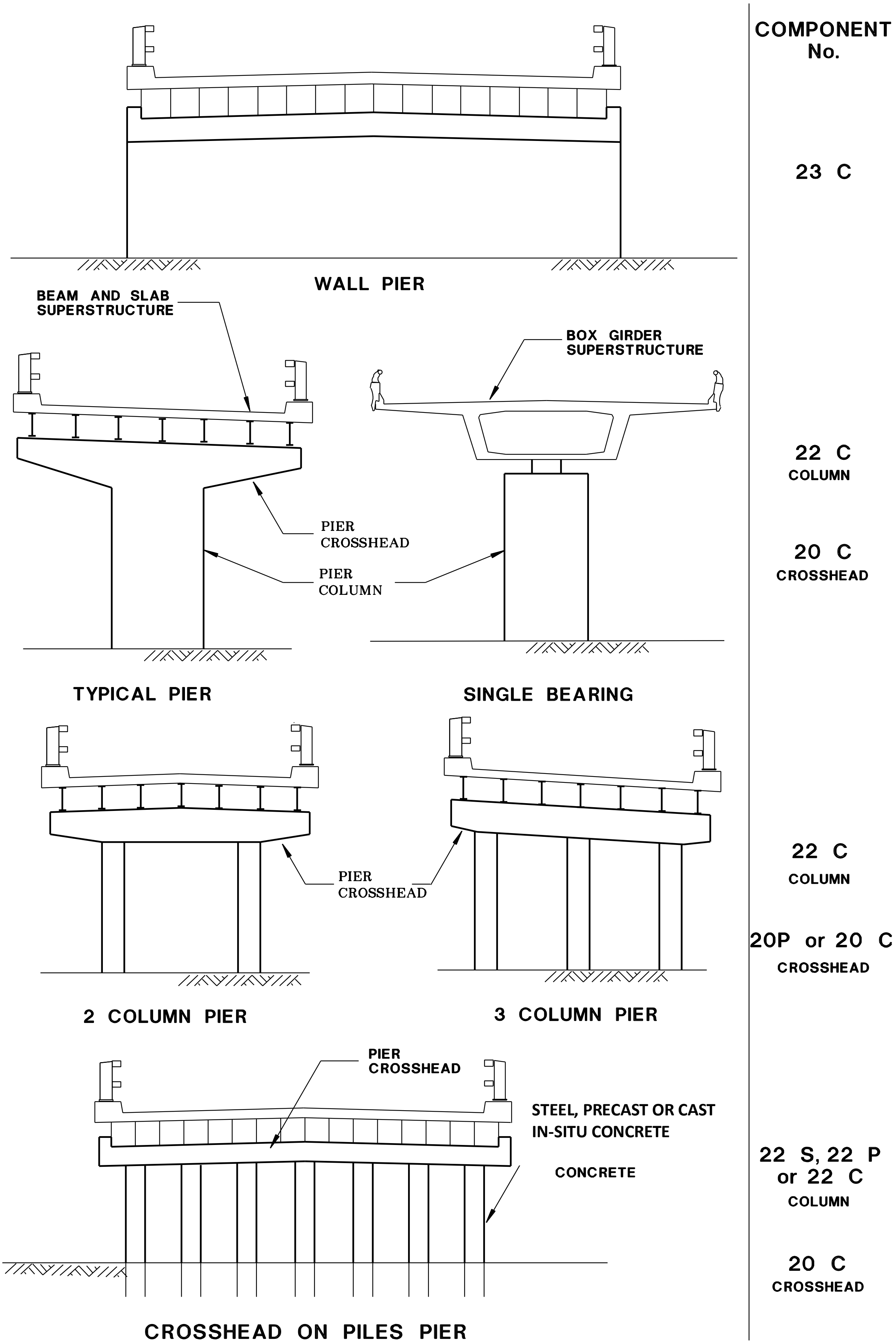
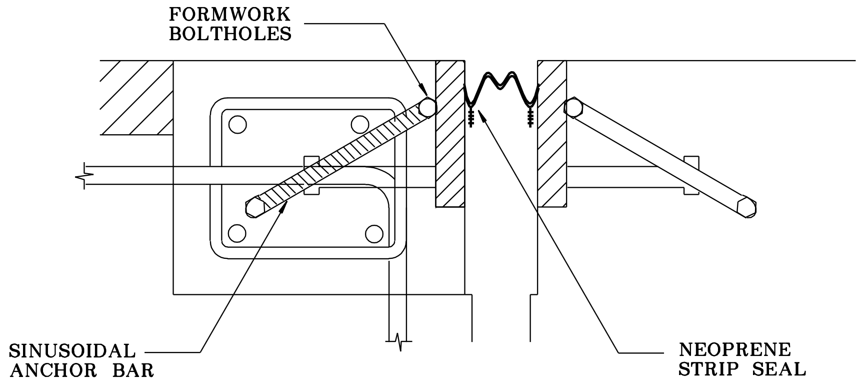

COMPONENT No.
WALL PIER
23 C
BEAM AND SLAB SUPERSTRUCTURE
BOX GIRDER SUPERSTRUCTURE
PIER CROSSHEAD
PIER COLUMN
TYPICAL PIER
SINGLE BEARING
22 C
COLUMN
20 C
CROSSHEAD
PIER CROSSHEAD
2 COLUMN PIER
3 COLUMN PIER
22 C
COLUMN
20P or 20 C
CROSSHEAD
PIER CROSSHEAD
STEEL, PRECAST OR CAST IN-SITU CONCRETE
CONCRETE
CROSSHEAD ON PILES PIER
22 S, 22 P or 22 C
COLUMN
20 C
CROSSHEAD

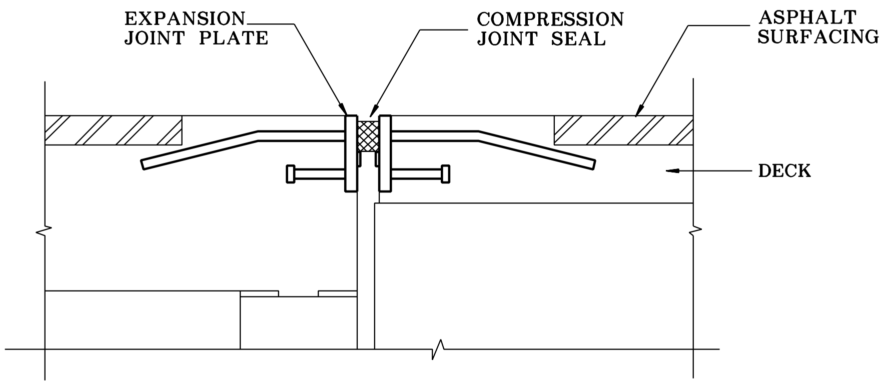
FIG. 11 - PIERS

COMPONENT No.



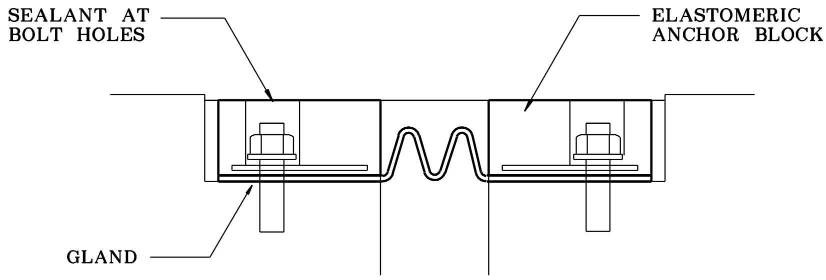
COMPRESSION SEAL JOINT

31 O



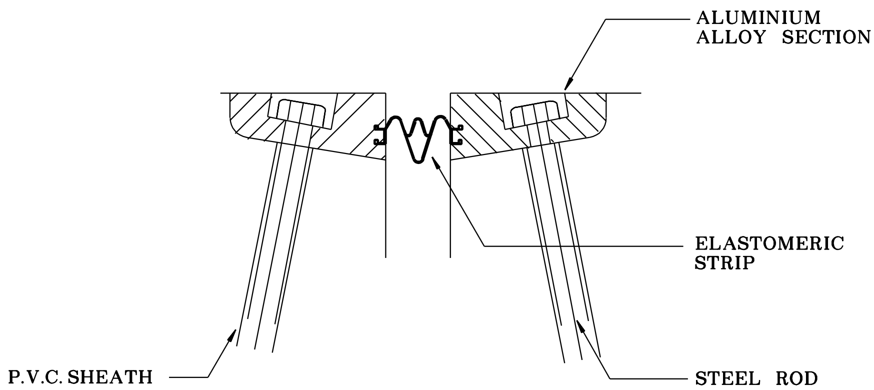
COMPRESSION SEAL JOINT

31 O



ASSEMBLY JOINT SEAL

32 O

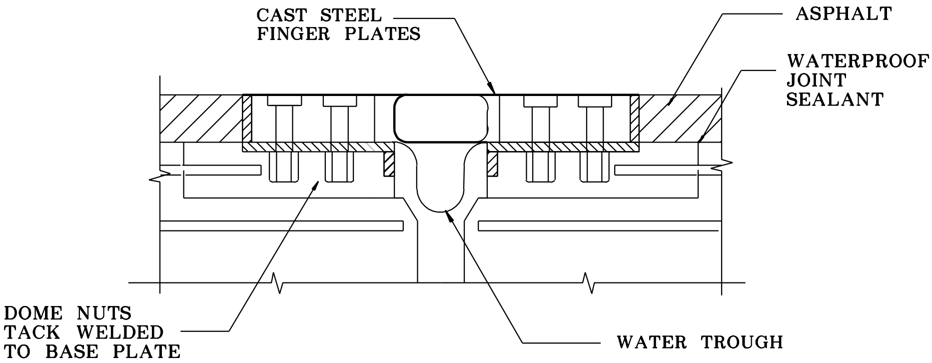


ASSEMBLY JOINT SEAL / STRIP SEAL JOINT

32 O

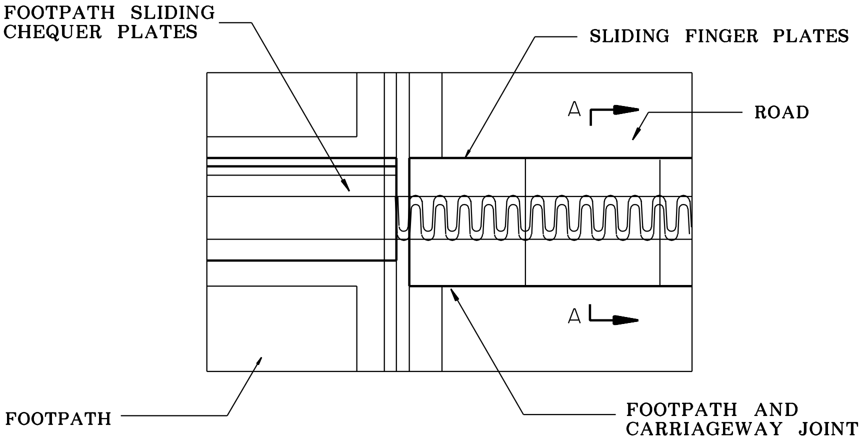
FIG. 12.1 - DECK JOINTS (Sheet 1 of 3)

COMPONENT No.



34 S

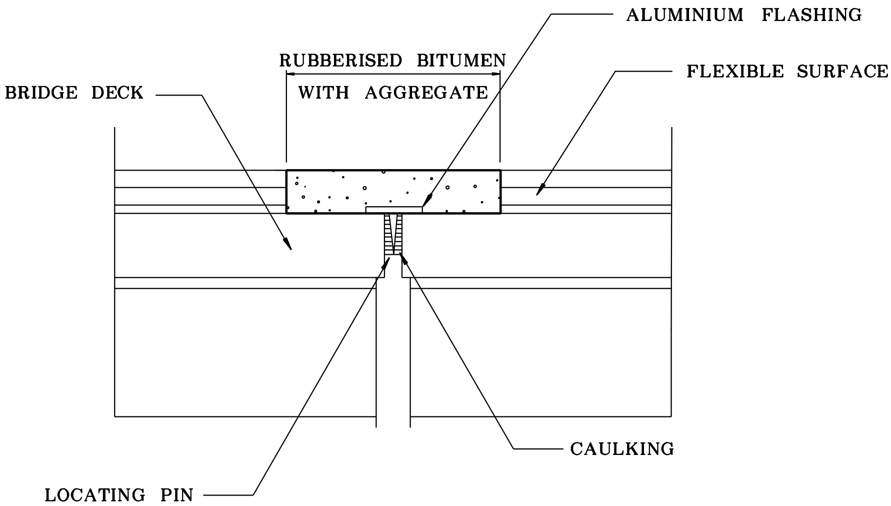
SECTION A-A



34 S
SLIDING PLATE JOINT

34 S
FINGER PLATE JOINT

CANTILEVERED FINGER PLATE & SLIDING JOINTS

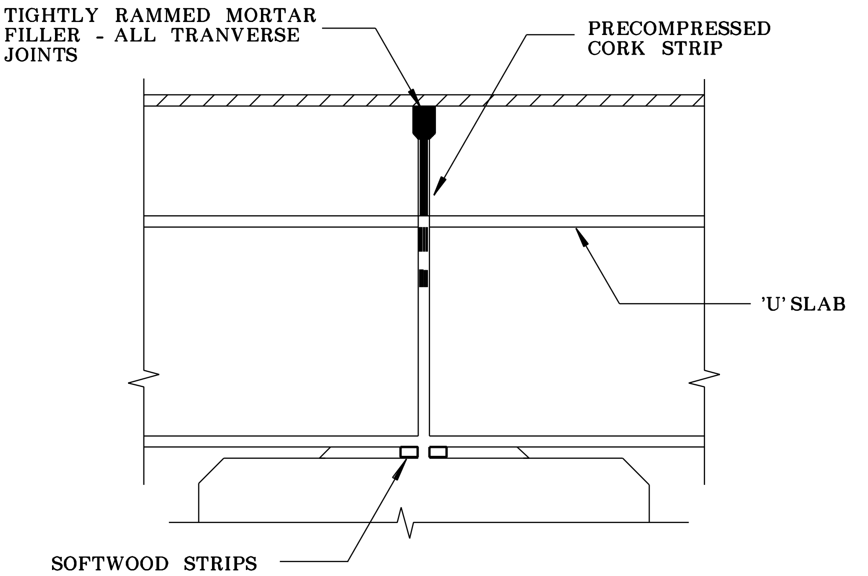


30 O

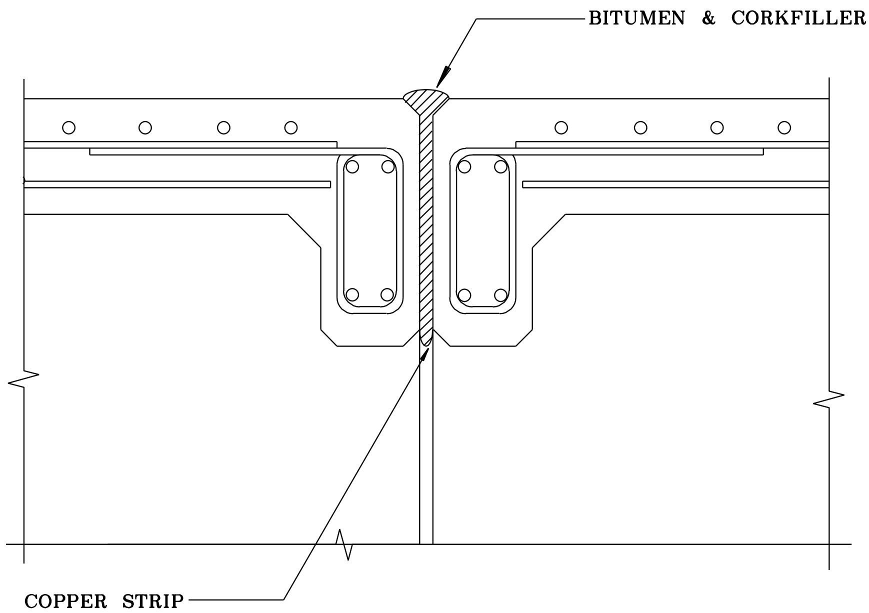
POURABLE JOINT / ASPHALTIC PLUG JOINT

FIG. 12.2 - DECK JOINTS (Sheet 2 of 3)

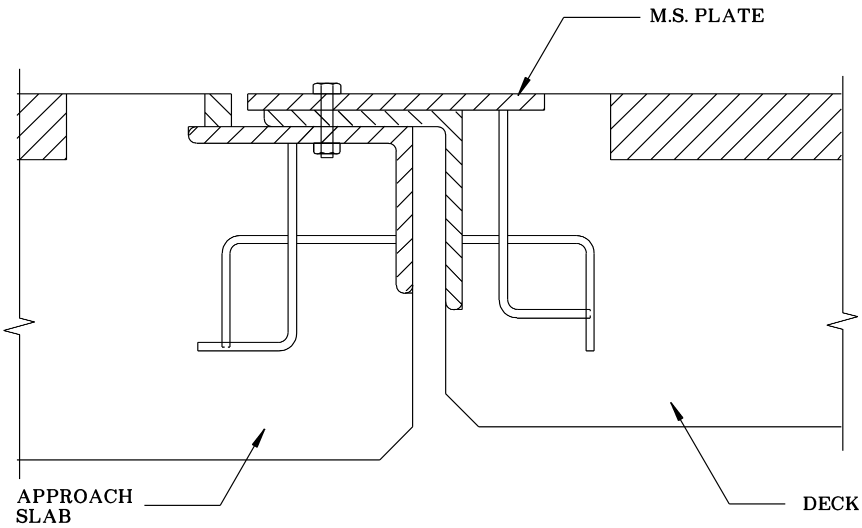
COMPONENT
No.



35 O



30 O



34 S

FIG. 12.3 - DECK JOINTS (Sheet 3 of 3)

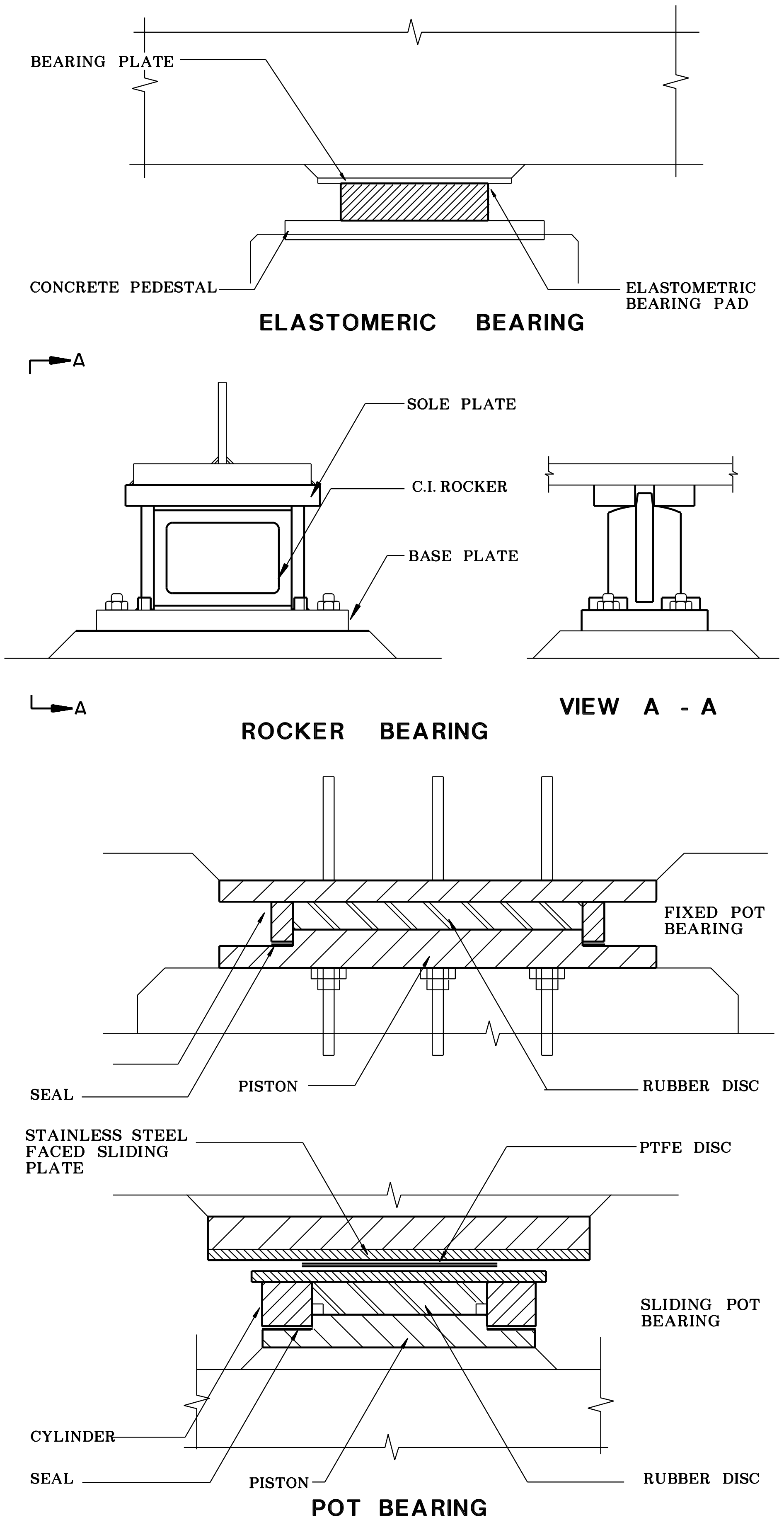
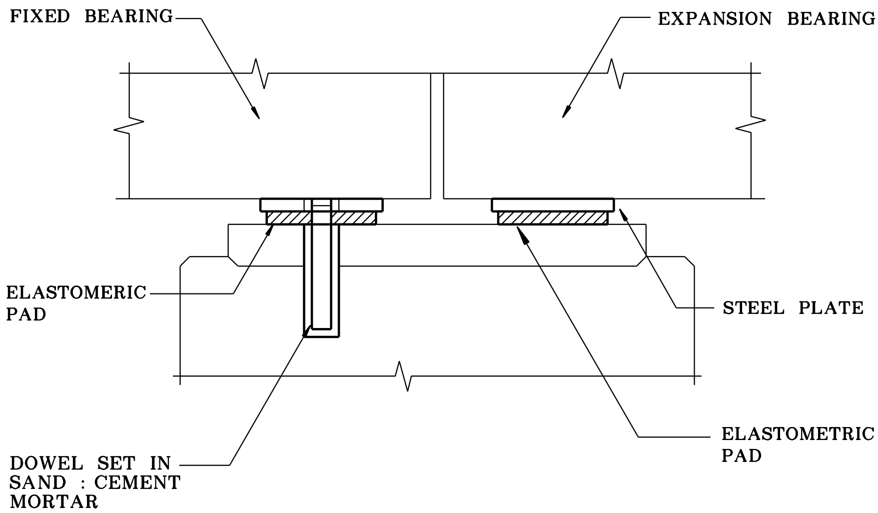
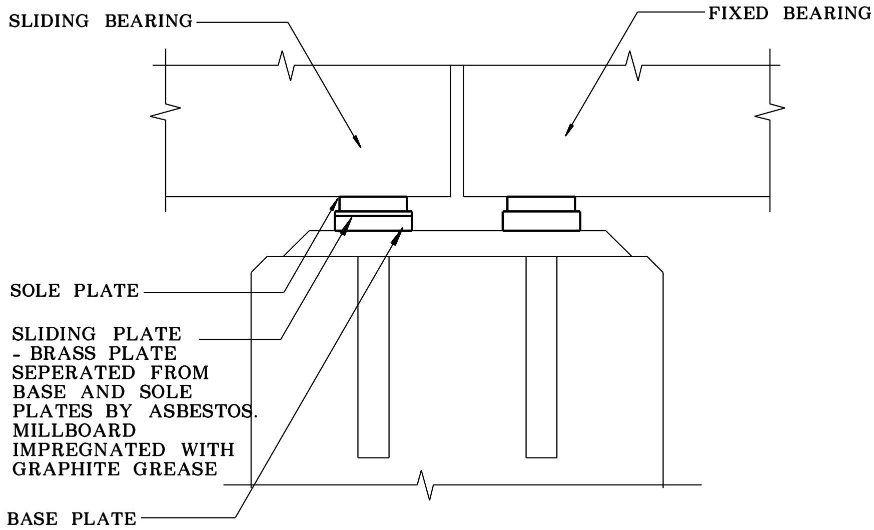


FIG. 13.1 - BEARINGS (Sheet 1 of 2)

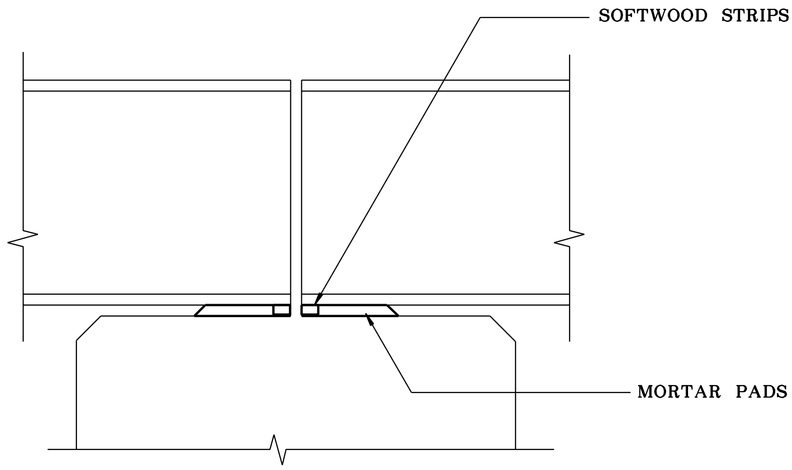
COMPONENT NO.
42 O
43 S
42 O
42 O



ELASTOMERIC PAD BEARING



FIXED AND SLIDING
STEEL PLATE BEARING



MORTAR PAD BEARING

FIG. 13.2 - BEARINGS (Sheet 2 of 2)

COMPONENT No.

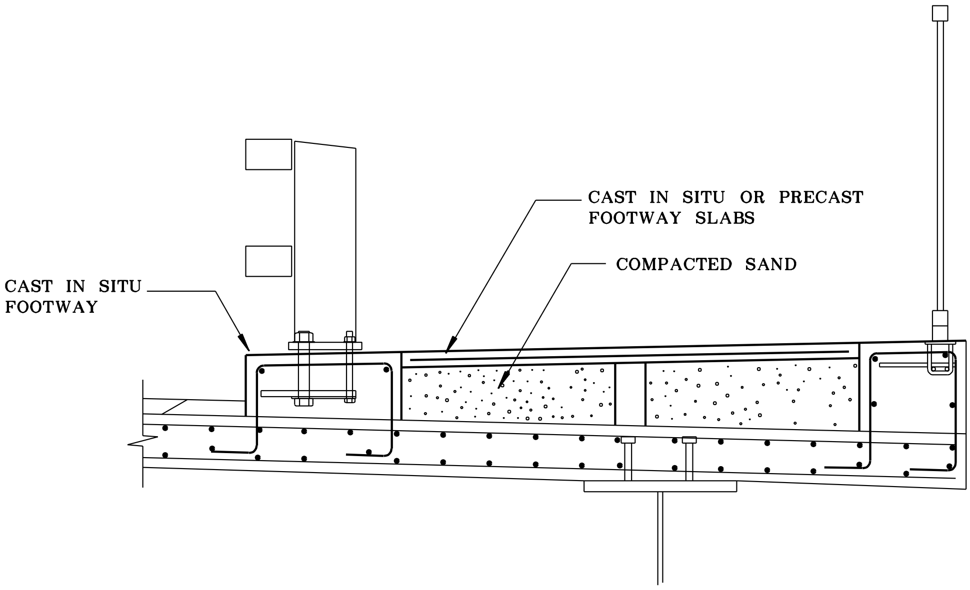
42 O

40 O
FIXED BEARING

41 O
SLIDING BEARING

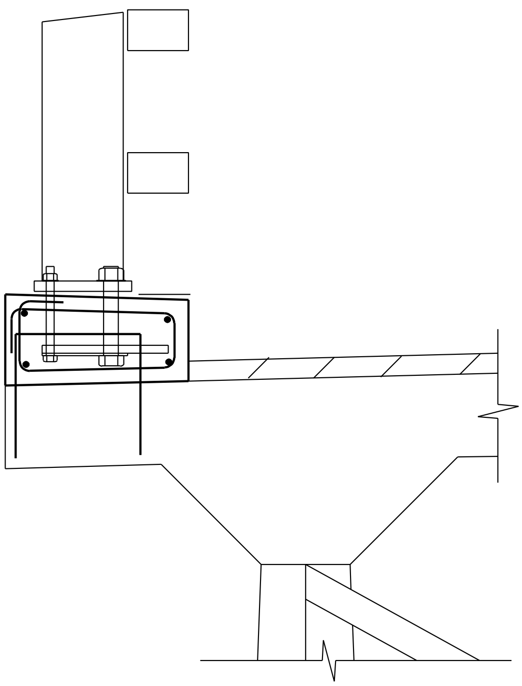
44 C

COMPONENT No.	
51 S	STEEL ROAD BARRIER
51 O	PEDESTRIAN RAIL
50 C	CAST IN SITU FOOTWAY
50 P	PRECAST FOOTWAY



KERB & FOOTWAY

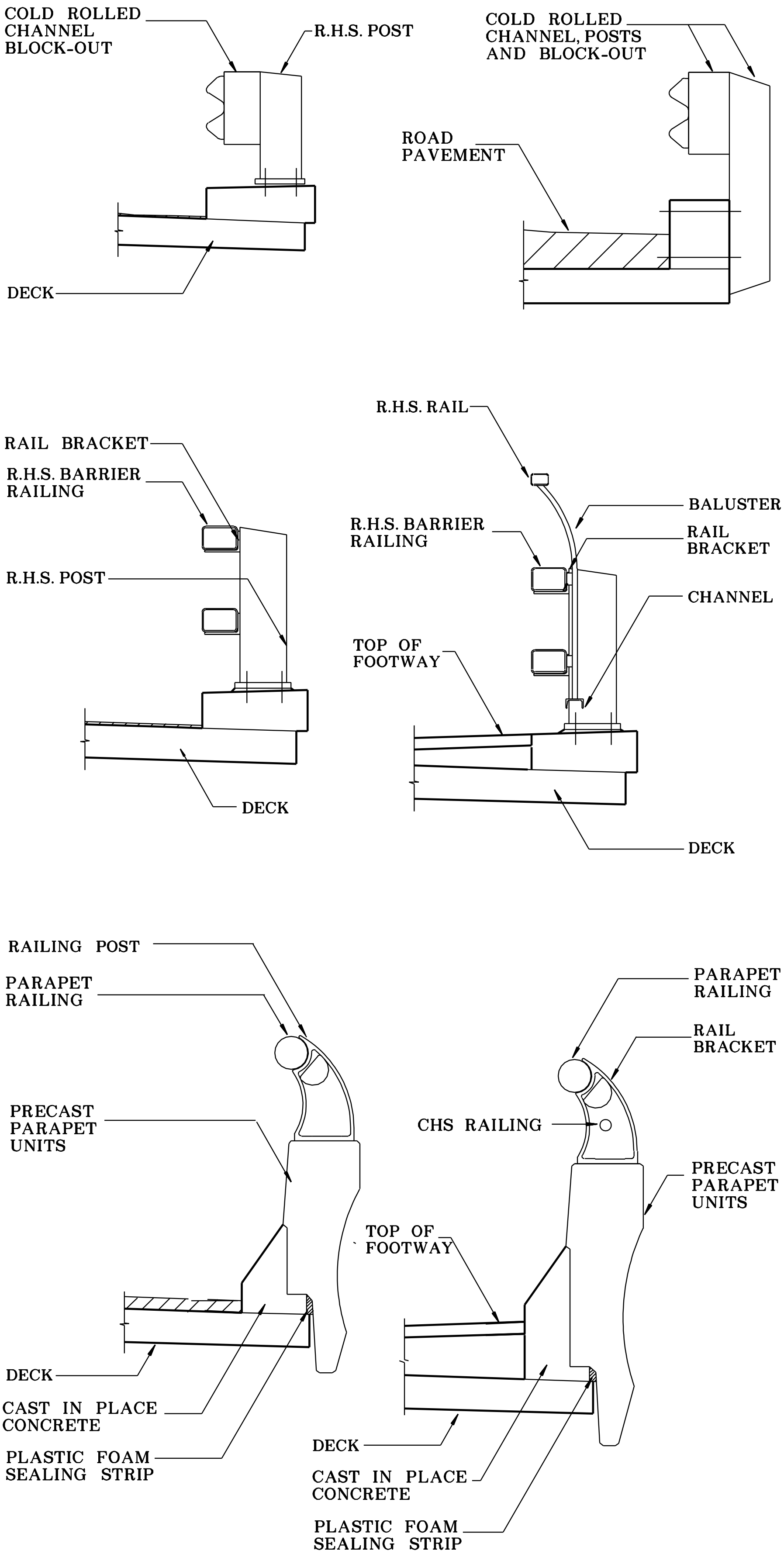
51 S	STEEL BRIDGE BARRIER
50 C	CAST-INSITU KERB



KERB

FIG. 14 - BRIDGE KERBS & FOOTWAYS

COMPONENT No.



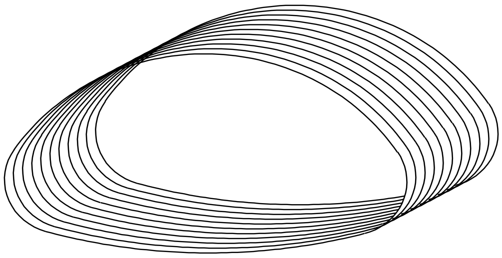
51 S

51 S

51 P

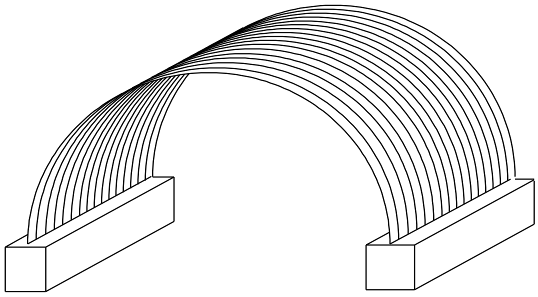
FIG. 15 - BRIDGE RAILING / BARRIER

COMPONENT No.



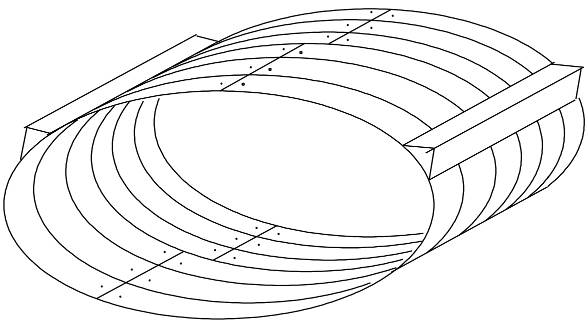
62 S

CORRUGATED STEEL PLATE
PIPE ARCH



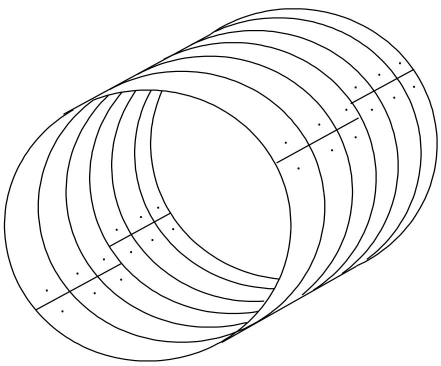
62 S

CORRUGATED STEEL PLATE
OPEN FOOTING ARCH



62 S

CORRUGATED STEEL PLATE
SUPERSPAN ELLIPSE

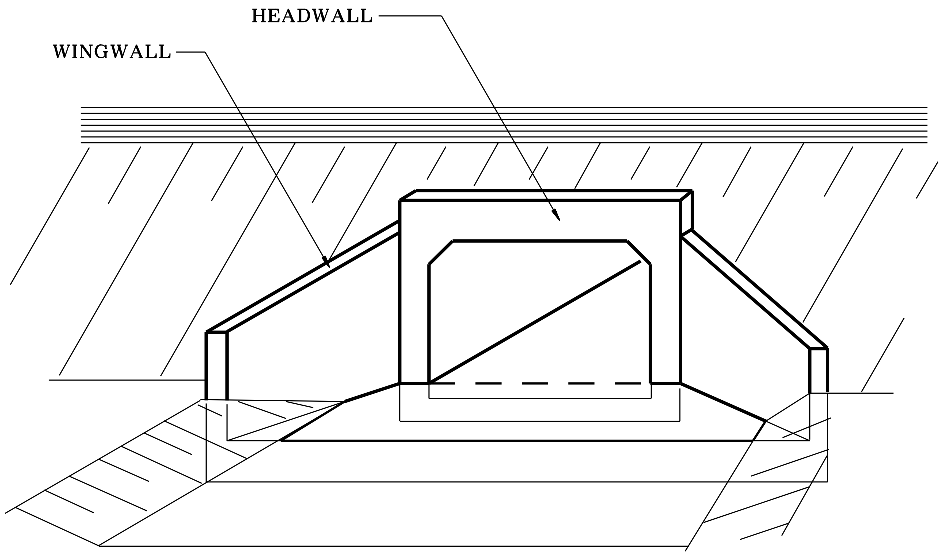


60 S

ROUND CORRUGATED STEEL PLATE

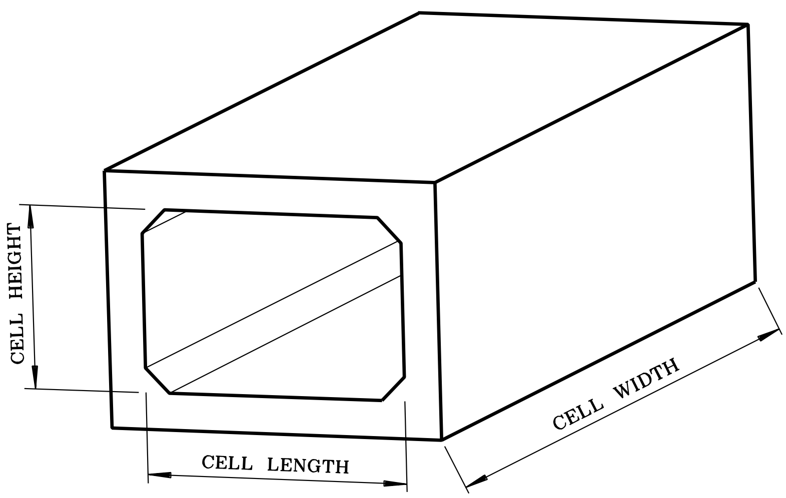
FIG. 16.1 - CULVERTS (Sheet 1 of 2)

COMPONENT No.



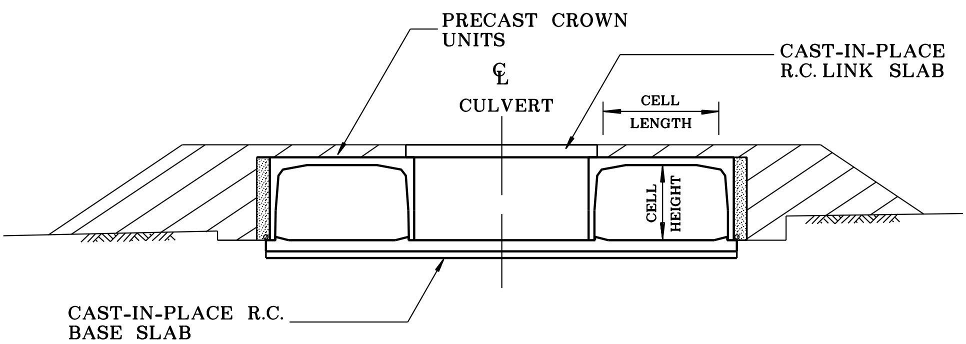
63 P, 63 C or 63 O
WINGWALLS & HEADWALLS

WINGWALL AND HEADWALLS



61 C

CONCRETE CAST-IN-PLACE BOX CULVERT



61 P
CROWN UNITS, LINK SLAB AND BASE SLAB

PRECAST CROWN UNITS

FIG. 16.2 - CULVERTS (Sheet 2 of 2)

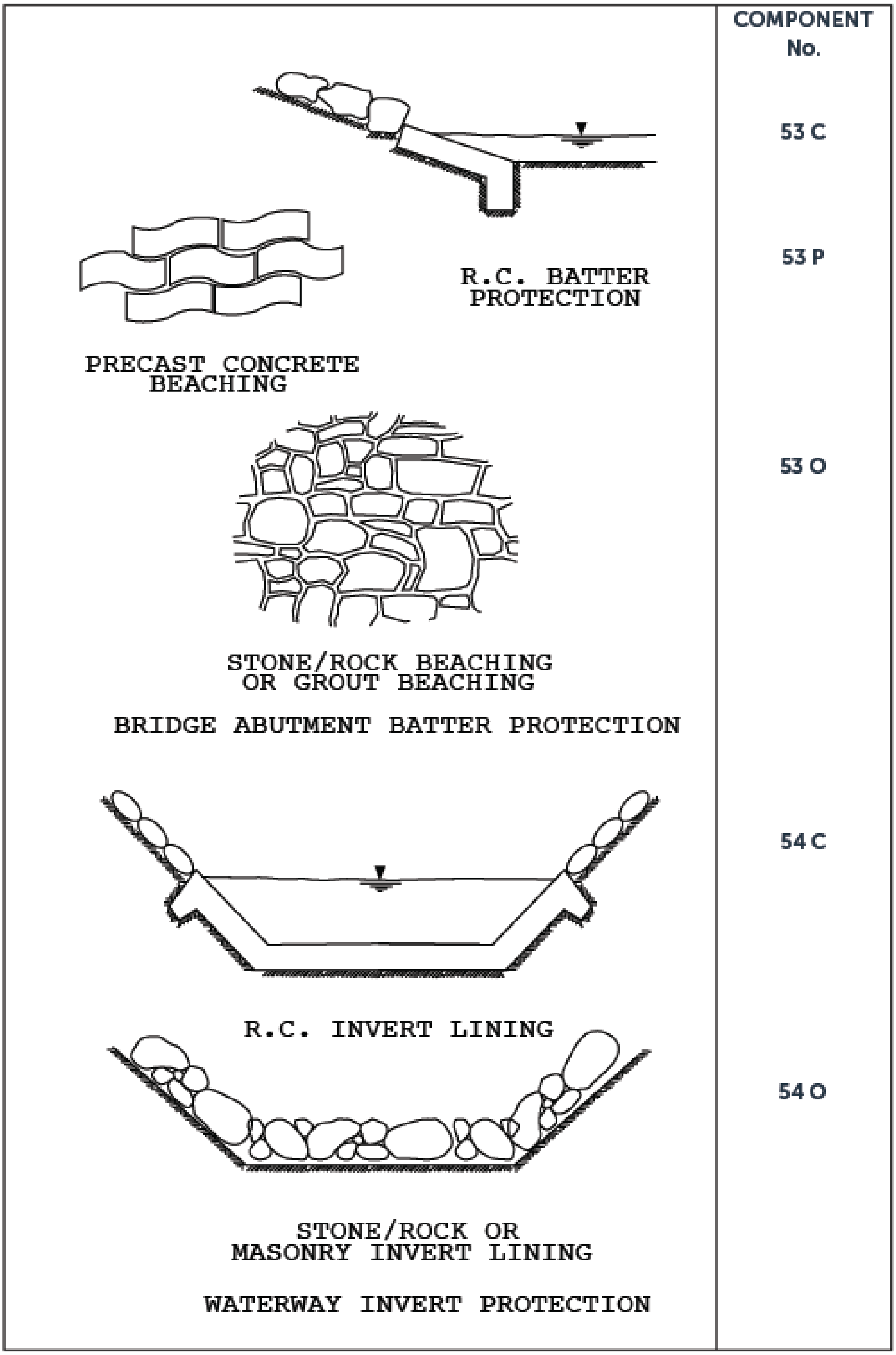


FIG 17 - WATERWAY INVERT PROJECTION

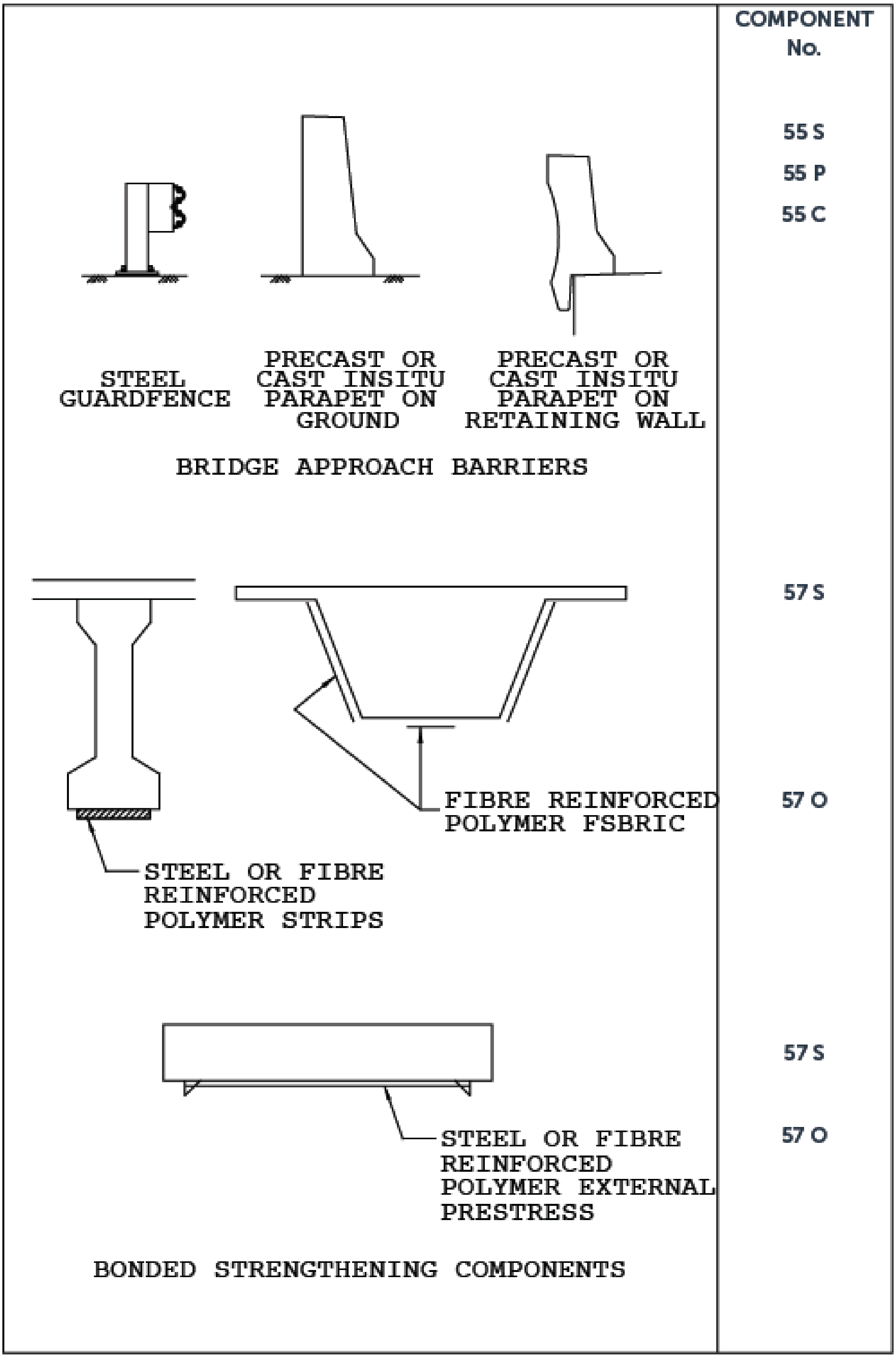


FIG 18 - BONDED STRENGTHENING COMPONENTS

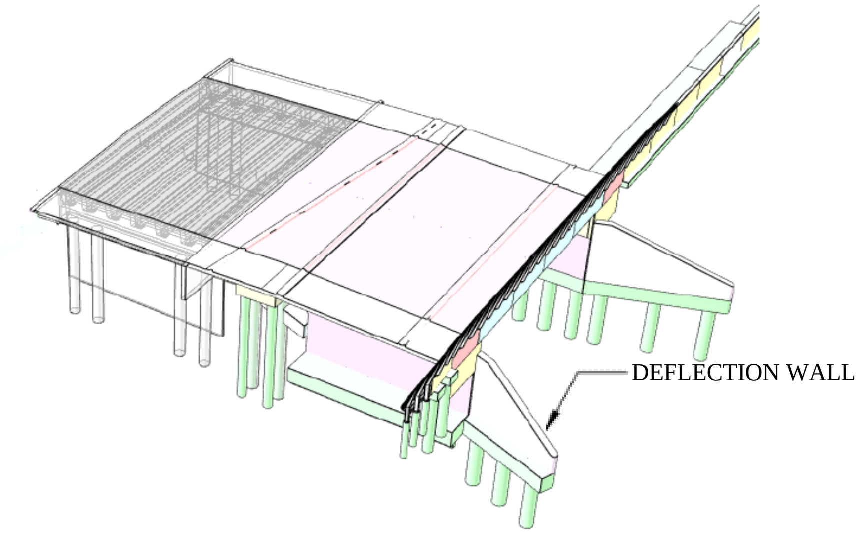
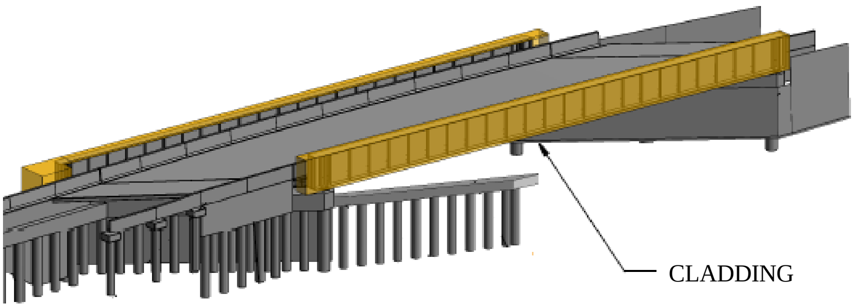
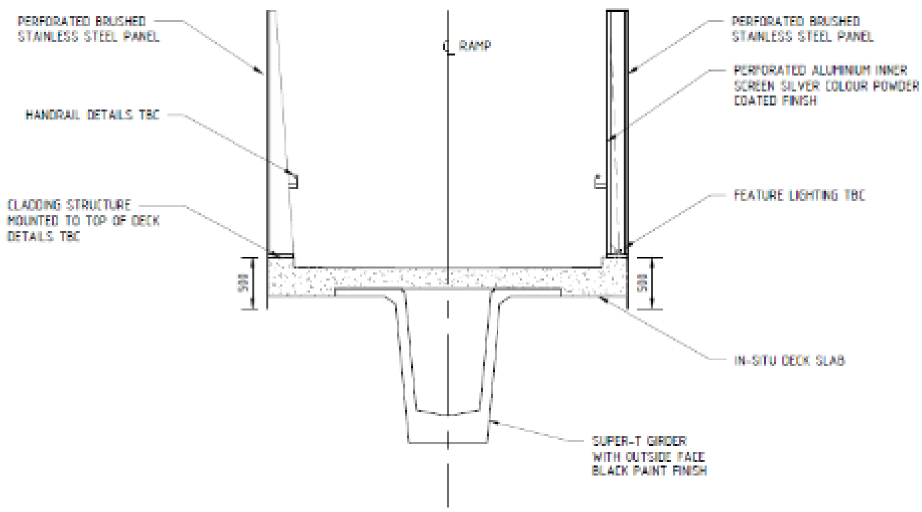
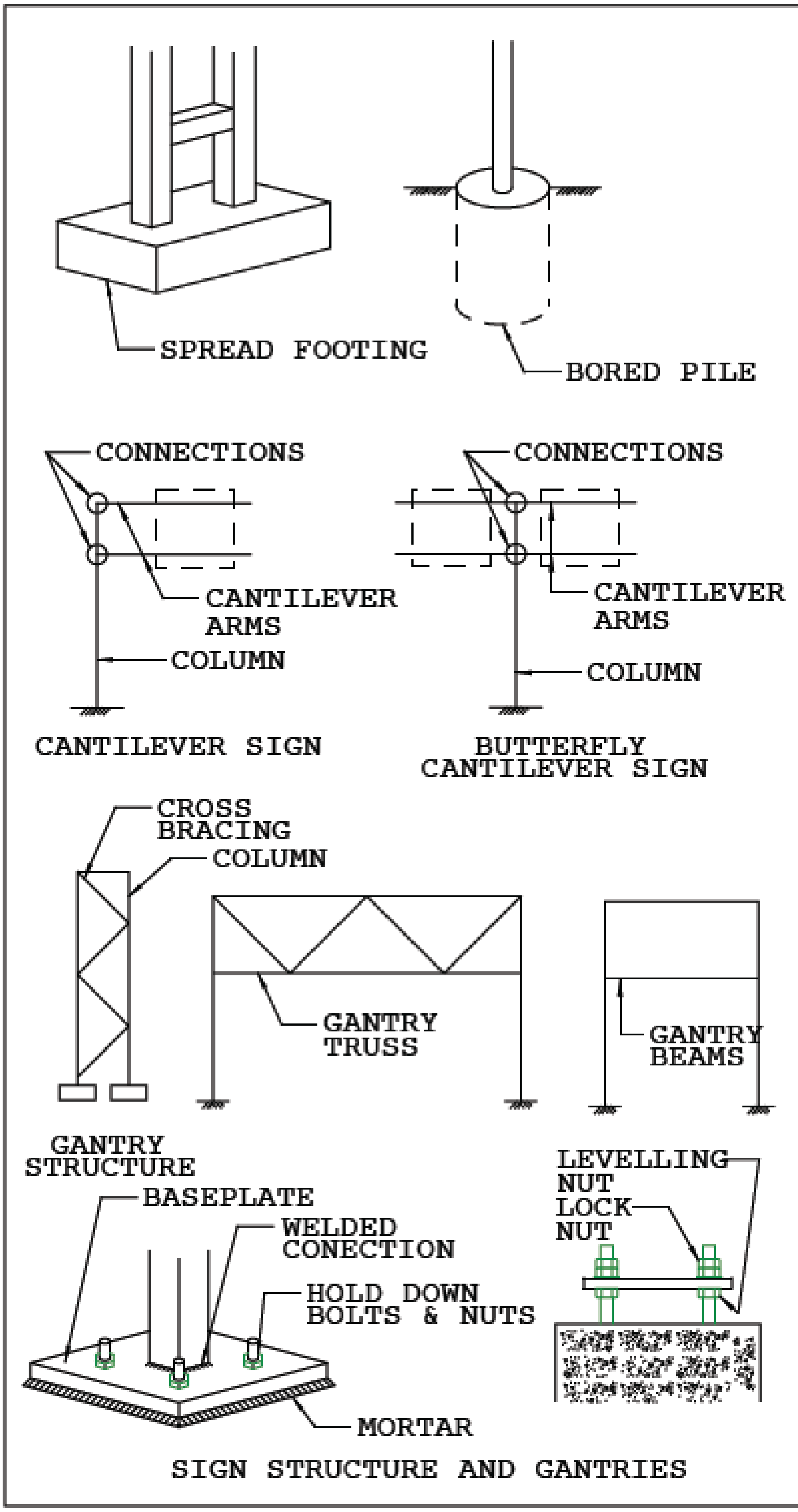
	COMPONENT No.
	59 C
	64 O
	64 S 65 S 66 S

FIG 19 - DEFLECTION WALL AND ON-STRUCTURE CLADDING



COMPONENT No.

70 C
FOOTINGS

71 S
COLUMNS

72 S
CANTILEVER ARMS OR GANTRY BEAMS

71 S
COLUMNS INCLUDING BRACING BETWEEN

73 S
GANTRY TRUSS

74 S
75 S
HOLD DOWN BOLTS, BASEPLATE & FITTINGS

75 C
MORTAR PAD

76 O
LEGEND

FIG 20 - MAJOR SIGN STRUCTURES (Sheet 1 of 2)

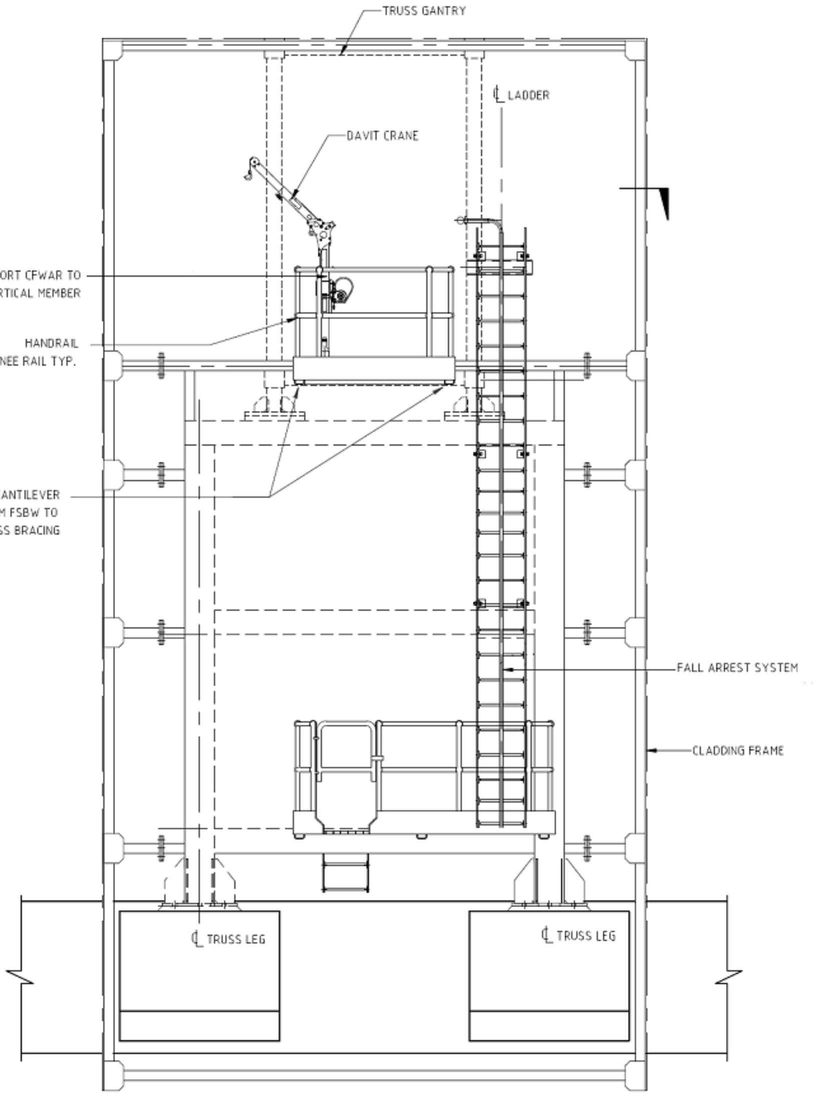
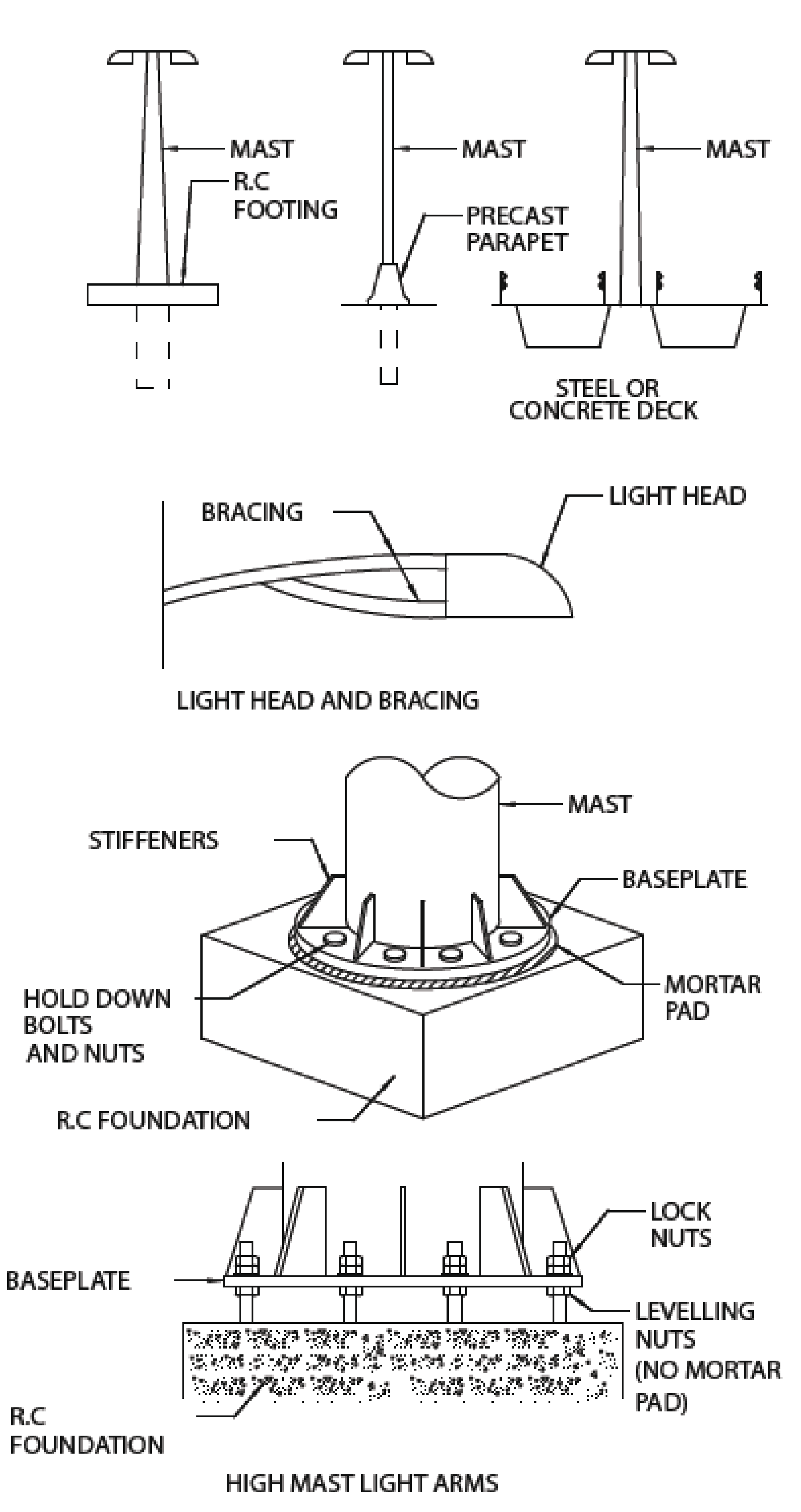
	COMPONENT No.
	**78 S MISCELLANEOUS**

FIG 21 - MAJOR SIGN STRUCTURES (Sheet 2 of 2)



COMPONENT No.

70 C

70 P

70 S

FOOTINGS/ SUPPORT

77 S

LIGHT HEAD

71 S
71 P

MAST

74 S
75 S

HOLD DOWN BOLTS, BASEPLATES & FITTINGS

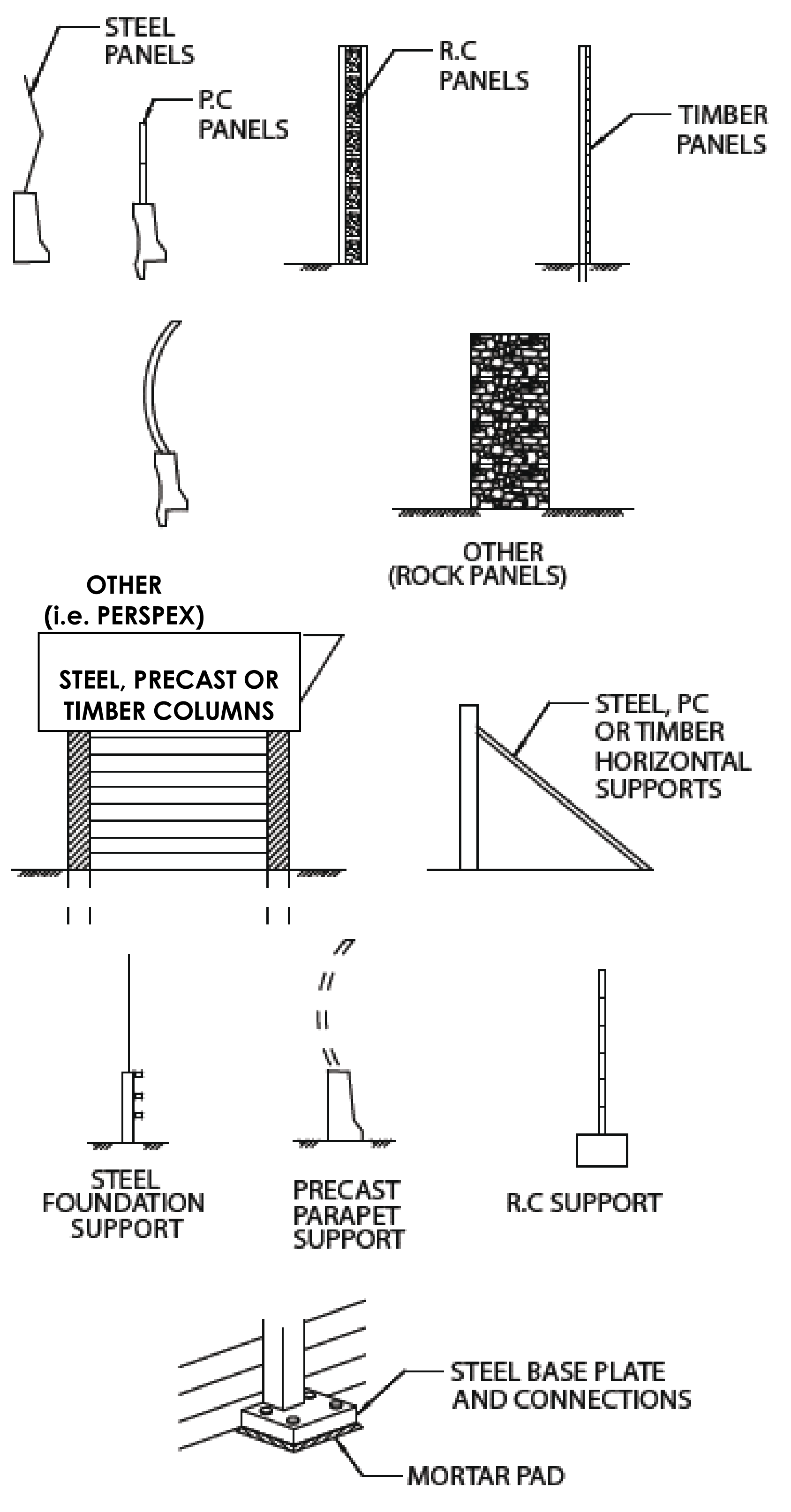
75 C

MORTAR PAD

74 S
75 S

HOLD DOWN BOLTS, BASEPLATES & FITTINGS

FIG 22 - HIGH MAST LIGHT ARMS



COMPONENT No.

80 S

80 P

80 C

85 T

85 O

NOISE ATTENUATION WALL FACING PANELS

81 S

81 P

81 T

81 O

COLUMN/ HORIZONTAL SUPPORT

82 S

82 P

82 C

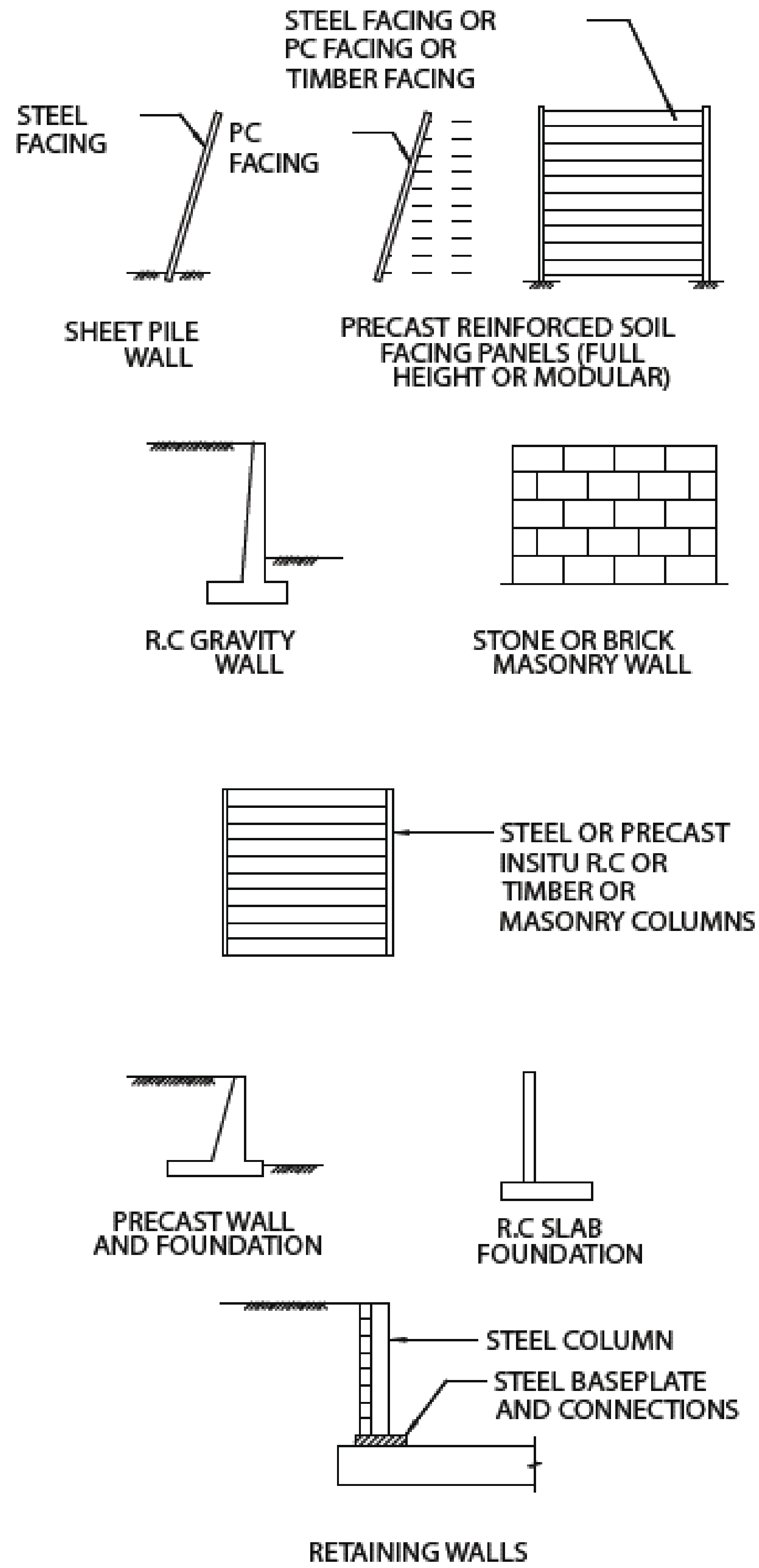
FOUNDATION/ FOUNDATION SUPPORT

83 S
HOLD DOWN BASEPLATE & CONNECTIONS

83 C
MORTAR PAD

NOISE ATTENUATION WALLS AND VISUAL SCREEN WALLS

FIG 23 - NOISE ATTENUATION WALLS AND VISUAL SCREEN WALLS



COMPONENT No.

85 S

85 P

85 C

85 T

85 O

RETAINING WALL FACING PANELS

86 S

86 C

86 T

COLUMNS

87 S
87 P
87 C
BARRIERS (REFER TO 55)

88 S

88 T

CONNECTIONS, HORIZONTAL SUPPORT

89 O
DRAINAGE SYSTEM
(NO DIAGRAM)

FIG 24 - RETAINING WALLS

1.3 Exposure Classification

The exposure classification of each component of the structure is required to assist with the assessment of the likely deterioration or life of the structure.

In the design of the structure, broad exposure classifications were considered when specifying the type of material, protective coating system or amount of cover to reinforcement. However, when that protection or cover is lost, the vulnerable parts of the structure are exposed to the environment leading to the risk of deterioration. The rate of deterioration and hence the time available for repair, rehabilitation or replacement of the component or the structure depends on the aggressiveness of the environment.

Four exposure classifications which approximate to those specified for concrete in AS5100 Bridge Design have been adopted.

They are:

- Relatively benign.
- Mildly aggressive.
- Aggressive.
- Most aggressive.

Exposure classification	Condition description
(1) (AS5100-A)	Relatively benign environment, such as the interior of most structures, and components above ground in inland country locations.
(2) (AS5100-B1)	Mildly aggressive environment such as components above ground in industrial zones or components in contact with fresh water in or next to the normal stream course.
(3) (AS5100-B2)	Aggressive environment such as components above the surrounding ground within 1 km of the coast but not subject to direct salt spray, or timber and steel components in very damp environments such as mountain gullies, ferny areas etc. where accelerated deterioration would be expected.
(4) (AS5100-C1, C2 or U)	Most aggressive environment such as components in tidal or splash zones (C2), or subject to direct salt spray (C1). Other aggressive environments include aggressive soils, salt rich soils, in soft or running water (U).

Accurate assessment of aggressiveness of the soil requires testing. In general soils can be assumed to be non-aggressive unless the structure is in or near to a marine environment or in marshy, foul smelling soils, land fills or industrial waste areas. Structures downstream of farms or which are used for the passage of farm animals can be exposed to animal urine and faeces.

1.4 Condition Rating of Components

1.4.1 Introduction

This section of the manual provides guidance to inspectors on the identification of components and the quantification of the amounts of components in the various condition states using the detailed descriptions which follow. The descriptions do not cover every situation and the inspector should use their knowledge and reasoning to interpret which condition state should apply in a particular situation.

The condition ratings have been developed to describe the following conditions:

Condition state 1. – Component is in good condition with little or no deterioration.

Condition state 2. – Component shows minor deterioration with primary supporting material showing the first signs of being affected.

Condition state 3. – Component shows advancing deterioration and loss of protection to the supporting material which is showing deterioration and minor loss of section. As a result, preventative maintenance may need to be considered by the asset manager to slow the rate of deterioration or improve the component condition.

Condition state 4. – Component shows advanced deterioration, loss of effective section to the primary supporting material, is not performing as designed or is showing signs of distress or overstress. As a result, maintenance, repair or replacement of the component will be required to improve the condition of the component.

Descriptions of the four condition states for each structure component are given in Part 4. The condition states for each component describe possible problems for those components. They do not necessarily describe all defects which may be found. The inspector should use their expert knowledge to interpret which description best fits the particular condition state and the severity and possible consequences of the defect.

In completing the field sheets the inspector should rate the component according to the method of measurement described in Section 1.4.2. For any component which has a condition state of 3 or 4 the description should provide the location of the defect so that an independent person unfamiliar with the structure could be directed to the exact location. The description of the defect must be comprehensive and accurate so that an independent person can have a clear understanding of the description of the problem. The area/amount of the defect must be measured (in the units of measurement for that component) to enable an approximate estimate of the repair or replacement cost to be made. Photographs corresponding to the condition states described are provided in Part 4.

1.4.2 Measurement of Condition Rating

The extent of each condition state affecting a component must be measured as a percentage of the whole component. The percentages in each condition state (1, 2, 3 and 4) must add up to 100% of the whole component.

Each component is quantified as per following table:

Number of units making up the component	(each)
Length of the component	(lin m)
Area of the component	(m^2)

The unit of measurement for each component is indicated in Tables 1.4.2.1 and 1.4.2.2. This unit must be used when the percentage of each condition state is calculated.

When assessing condition rating, the inspector should first determine the worst condition affecting the component (e.g. Condition 4) and its extent, and progress to the best condition (e.g. Condition 1).

(a) When the unit of measurement is based on the area of the component (m^2), the percentage in each condition state is the area affected by the condition divided by the total area of the component multiplied by 100.

$$\text{i.e.} \quad = \quad \frac{\text{Area in Condition State}}{\text{Total Area of Component}} \times 100\%$$

Certain assumptions must be made when rating areas of deteriorated concrete and estimating the affected areas.

It is possible that the damaged area is much larger than the visible cracks or spalls. For an isolated crack or spall, the damaged area is defined by a line 0.25 m all round the crack or spall. If this defect is interconnected with other cracked or spalled areas then the damaged area is defined by area 0.25 m around the combined defects. This also applies to the underside of bridge decks where the deck reinforcement is showing at the concrete surface but no cracking or spalling exists.

i.e.:

- For a small spall the minimum area of deterioration for the condition rating must be 0.25 m^2.
- For a crack across the deck the minimum area will be 0.5 m by the width of the deck.
- For a corner bar crack in a pier wall the deteriorated area will be 0.25 m (or wall thickness if less) by 0.25 m on the wall face by the length of crack plus 0.25 m if the crack commences at the footing or plus 0.5 m if the crack is higher up the wall.

Steel, precast concrete, timber and asphalt areas rated on a square metre percentage basis are based on the area of deterioration visible.

(b) Where the unit of measurement is based on length (lin m) the percentage in each condition is:

$$= \frac{\text{Length in Condition State}}{\text{Total length of Component}} \times 100\%$$

When rating concrete components that are measured in linear metres an estimate of the length of the cracked or spalled concrete is required. A similar approach is then used to that adopted for determining the areas of defective concrete.

If one severe crack occurs through a kerb – say over the pier – and is assessed as Condition 3 the length in that condition is 0.5 m (0.25 m each side of the crack). If the total length of kerb is 100 m the overall assessment would be:

Condition 4 - 0%

Condition 3 - 1%

Condition 2 - 0%

Condition 1 - 99%

If a precast concrete panel is badly cracked or broken, the whole precast panel will require replacement. The length in Condition 4 is then given by the length of the panel.

If a steel component that is measured in linear metres (e.g. box girders (1 S) and trusses (3 S and 4 S)), has cracked welds or defective parts which could affect the strength of the whole member, the whole member should be rated as Condition 4. The Superintendent or Region must be notified that the member is in Condition 4 and advised that an immediate detailed engineering investigation is required.

c) When rating components on an each basis, the measurement of a particular condition rating must be the number of units affected by that condition as a percentage of the total number of units. The most severe condition observed on the unit determines its condition rating.

i.e.: If there are 4 beams in total

- one beam has small areas of Condition 4 and Condition 2 with the remainder of the beam in Condition 1; and
- the other beams are in Condition 1.

the overall assessment would be:

Condition 4 - 25% (i.e. 1 beam)

Condition 3 - 0%

Condition 2 - 0%

Condition 1 - 75% (i.e. 3 beams)

The condition rating and its extent, for each component must be recorded as a percentage of each condition state in the appropriate column on the Condition rating sheet. The quantities of each component and their condition are not required unless specified elsewhere. The accuracy of the percentages determined for each condition state must be within ± 5%.

If components are **missing** or **cannot be observed** these should be noted in the comments section of relevant inspection form. If a structure does not have an approach railing or structure barriers this should be noted on the comments sheet. In both instances, no condition rating is required.

Table 1.4.2.1 Units of measurement for bridge and major culvert components

Component name		Component				
No.	**Superstructure**	**Steel (S)**	**Precast concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
1.	Closed web/box girders	Lin m	Lin m	Lin m	Lin m	
2.	Open girders/Stringers	Each	Each	Each	Each	
3.	Through truss	Lin m			Lin m	
4.	Deck truss	Lin m				
5.	Arches	Lin m	Lin m	Lin m	Lin m	Lin m
6.	Cable/Hangers (not embedded in concrete)	Each				
7.	Corbels	Each		Each	Each	
8.	Deck/Slabs	m^2	Each	m^2	m^2	
9.	Crossbeams/Floorbeams	Each			Each	
10.	Longdecking/ Crossdecking/Running planks				m^2	
11.	Thin plated deck support	m^2				
12.	Diaphragms/Bracing	Each		Each		
13.	Load bearing diaphragms	Each		Each		
14.	Fill/Wearing surface on deck					m^2
15.	Fauna bridges	Each		Each	Each	Each
	Substructure					
20.	Cross heads (non integral with superstructure)	Each	Each	Each	Each	
21.	Cross heads (integral with superstructure)			Each		
22.	Column or pile extensions	Each	Each	Each	Each	
23.	Pier wall			m^2		m^2
24.	Abutment		m^2	m^2	m^2	m^2
	Deck Joints					
30.	Pourable joint seal					Lin m
31.	Compression joint seal					Lin m
32.	Assembly joint seal					Lin m
33.	Open expansion joint	Lin m				
34.	Sliding joint	Lin m				

Component name		**Component**				
No.		**Steel (S)**	**Precast concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
35.	Fixed joint					Lin m
	Bearings					
40.	Fixed bearings					Each
41.	Sliding bearings					Each
42.	Elastomeric/Pot bearings					Each
43.	Rockers/Rollers	Each				
44.	Mortar pads/High bearing pedestals			Each		
	Miscellaneous					
50.	Bridge/Culvert kerbs/Footways		Lin m	Lin m	Lin m	Lin m
51.	Bridge/Culvert railing/Barriers	Lin m	Lin m	Lin m	Lin m	Lin m
52.	Bridge approaches					Each
53.	Batter protection		m^2	m^2		m^2
54.	Waterway invert protection			Each		Each
55.	Off-structure barriers	Lin m	Lin m	Lin m		
56.	Identification plate	Each				
58.	Protective coating	Each				
59.	Deflection walls			Lin m		
	Strengthening					
57.	Bonded strengthening systems	Lin m				Lin m - Strip
	Culverts					
60.	Pipe culverts	Lin m	Lin m			Lin m
61.	Box culverts		Lin m	Lin m		Lin m
62.	Arch culverts	Lin m	Lin m	Lin m		Lin m
63.	Endwalls/Wingwalls		Lin m	Lin m		Lin m
	Cladding					
64.	Cladding facing/Panels	m^2	m^2	m^2	m^2	m^2
65.	Piles & columns	Each	Each			
66.	Connections & supports	Each				

Components not defined

Table 1.4.2.2 Units of measurement for other roadside structure components

Component name		**Component**				
No.	**Cantilever Signs, Gantries and High Mast Lighting**	**Steel (S)**	**Precast concrete (P)**	**Cast-In-Situ Concrete (C)**	**Timber (T)**	**Other (O)**
70.	Footings/Support	Each	Each	Each		
71.	Columns (including bracing between)/Mast	Each	Each			
72.	Cantilever arms or gantry beams (incl. connections) or light head supports (incl. bracing)	Each				
73.	Gantry truss	Lin m				
74.	Hold down bolts	Each				
75.	Base plates, fittings & mortar pad	Each		Each		
76.	Legend (includes VMS message)					Each
77.	Light head	Each				
78.	Miscellaneous (including access ladder, platform, etc.)	Each				
	Noise Attenuation Walls and Visual Screen Walls					
80.	Wall facing/Panels	m^2	m^2	m^2	m^2	m^2
81.	Column & horizontal supports	Each	Each		Each	
82.	Foundation/ Foundation Support	Lin m	Lin m	Lin m		
83.	Hold down bolts, base plates, fittings & mortar pad	Each		Each		
	Retaining Walls					
85.	Wall facing/Panels	m^2	m^2	m^2	m^2	m^2
86.	Column	Each		Each	Each	
87.	Barriers	Lin m	Lin m			
88.	Connections and horizontal support	Each			Each	
89.	Drainage system					Each

Components not defined

PART FOUR – CONDITION STATE GUIDELINES AND PHOTOGRAPHS

1 Condition State Guidelines

1.1 Bridges and Major Culverts

Component 1 S – Closed Web/Box Girders – Steel

Units of measurement: **Linear Metres**

This component includes all closed web steel box girder bridges with concrete or steel deck closing the top of the box or boxes. The steel may be painted or galvanised. The component does not include the deck.

Condition state 1 – Description	**Photo**
• The paint system is generally sound with minor chalking, peeling or curling but no exposure of the metal. • All welds or bolts are in good condition with no corrosion, cracking or loose bolts.	 Steel box of cable stayed bridge in good condition.

Condition state 2 – Description	**Photo**
• Rust spotting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds or bolts are in good condition with no cracking, corrosion or loose bolts.	Not available.

Condition state 3 – Description	Photo
• Some surface pitting present and active corrosion is occurring in isolated areas, but no significant loss of area is occurring to affect the strength of the member as a whole. • Paint system has broken down with surface rusting to 10% and pitting present in a number of locations. • Nuts and bolts may be corroding but are still tight and no cracking of welds has occurred.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and significant loss of section has definitely occurred which may have a detrimental effect on the strength of the member e.g. a flange badly corroded over much of its length. • Welds may be cracked. Nuts or bolts are severely corroded and possibly no longer functioning to full capacity. There is distortion of webs/soffit as a result of vehicular impact. • Protection coating system is completely lost.	Not available.

Component 1 P – Closed Web/Box Girder – Precast Concrete

Units of measurement: **Linear Metres**

This component includes all closed web or box girder bridges constructed of precast units and includes segmental post tensioned box girders and precast prestressed bath tub beams with a cast-in-situ deck to form the closed box shape. This component includes the deck whether precast with the box or cast-in-situ at a later date.

Condition state 1 – Description	Photo
• There may be only minor cracking of the units due to corroding reinforcement or lack of distribution reinforcement but definitely no spalling or cracking of a structural nature or exposure of stressing ducts. • Some minor discolouration or white efflorescence powder may be visible at the former lifting holes.	 Hint of efflorescence and hairline shrinkage cracking.

Condition state 2 – Description	Photo
• There may be a few minor cracks or spalls due to corroding reinforcement in locations but there should be no exposure of any stressing tendons or stressing ducts. • Some minor discolouration or white efflorescence powder may be visible at a few joints between the precast units.	 Horizontal crack at overhang joint allowing staining and heavy efflorescence to occur. Staining and efflorescence can be seen at the precast segment joints.
Condition state 3 – Description	**Photo**
• There may be some delamination or spalling in isolated areas with the stressing tendons or stressing ducts exposed but with little or no corrosion occurring. • Other exposed reinforcement may have corrosion up to 20% of the area of the bars in isolated areas.	Not available.
Condition state 4 – Description	**Photo**
• There may be severe cracking due to structural defects or advanced corrosion of the reinforcement. • Delamination or spalling is present in large areas with heavy corrosion of reinforcing bars. • Stressing tendons exposed in the spalled areas may have corrosion up to 10% of their area. Some strands may also be broken or there may be heavy cracking or failure at the anchorages. • There may also be lateral cracking of the underside of the box at the midspan or heavy cracking in the deck above the supports.	Not available.

Component 1 C – Closed Web/box Girder – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all cast-in-situ, post tensioned concrete box girder and voided slab bridges, and includes the deck as part of the component. Voided slab bridges can be recognised by their shallow depth compared to a box girder. These structures are generally built on, or over freeways and are well suited to spans of 34 to 40 metres. Voided slabs greater than 35 metres will generally have a variable depth due to their massive dead load compared with box girders.

Condition state 1 – Description	Photo
• There may be minor cracking of the girder or deck due to corroding reinforcement or a lack of distribution reinforcement, but there should be no structural cracking or spalling. • Minor discolouration of efflorescence powder may be visible in a few locations.	 Minor hairline shrinkage cracking.
Condition state 2 – Description	**Photo**
• There may be a few minor cracks or spalls due to corroding reinforcement in locations but there should be no exposure of the stressing ducts. • Some minor discolouration or white efflorescence powder may be visible in a few locations.	 Cracking in deck overhang due to lack of distribution steel to distribute high stress forces. Cracks repaired.

Condition state 3 – Description	Photo
• There may be some delaminations or spalling in isolated locations with stressing ducts exposed but with little or no corrosion occurring. • Other exposed reinforcement may have corrosion up to 20% of the area of the bars in isolated areas.	Not available.
Condition state 4 – Description	**Photo**
• There may be severe cracking due to structural defects or advanced corrosion of the reinforcement. • Delamination or spalling is present in large areas with heavy corrosion of reinforcing bars. • Stressing tendons exposed in the spalled areas may have corrosion up to 10% of their area. Some strands may also be broken or there may be heavy cracking or failure at the anchorages. • There may also be lateral cracking of the underside of the box at the midspan or heavy cracking in the deck above the supports.	Not available.

Component 1 T – Closed Web/Box Girders – Timber

Units of measurement: **Linear Metres**

This component refers to box girders constructed of laminated treated timbers to form a series of box shapes. The webs of the boxes are constructed from small glued sections (L.G.L. beams) whilst the top and bottom flanges consist of small section treated timber stressed together by tensioning rods, i.e. a stress laminated timber box girder using small section components.

Condition state 1 – Description	**Photo**
• The timber may have minor cracks, splits or checks, but is fully protected by preservatives with no untreated heartwood. The tensioning rods have adequate stressing and there is no damage to the timber at the stressing plates.	 Timber box girder in good condition (from Netherlands).
Condition state 2 – Description	**Photo**
• Preservative protection may be beginning to dissipate with minor leaching of preservative salts (white powder on underside of deck) and with minor weathering and rot of the timber. Tensioning rods should still be adequately stressed with no damage to the surrounding timber.	Not available.

Condition state 3 – Description	Photo
• Further breakdown of the preservative protection may be occurring with prevalent leaching of preservative salts. Timber is beginning to look well weathered and rotting may be occurring in areas. Stress in the tensioning rods may be inadequate with minor movement between the timber laminations beginning to occur. Deflection of the box girder under heavy load may be increasing.	Not available.
Condition state 4 – Description	**Photo**
• Deterioration of the timber may be well advanced, with rot, crushing of timber laminations and loss of tension in the rods. Movement between timber laminations may be large with splitting of the timber. Deflection of the box girder under load may be beginning to become excessive.	Not available.

Component 2 S – Open Girders/Stringers – Steel

Units of measurement: **Each**

This component includes all girders constructed of wrought iron or steel. The girders may be rolled sections, welded plate girders, riveted girders constructed of plates and angles, or lattice girders using flat sections crossing each other to form the vertical web/webs. The steel can be painted or galvanised.

Condition state 1 – Description	**Photo**
• The paint system is generally sound with only minor chalking, peeling or curling, but with no exposure of metal. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	 Varying depth steel plate girder in good condition.
Condition state 2 – Description	**Photo**
• Spot rusting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	 Rust spotting of steel plate girders.

Condition state 3 – Description	Photo
• Some surface pitting may be present. Active corrosion occurring in isolated areas, but no significant loss of area is occurring to affect the strength of the member as a whole. • The paint system has broken down with rust spotting to 10% and surface pitting. • Nuts and bolts may be corroded but are still tight and no cracking of welds has occurred. • Riveted plates may have very minor movements of 1 to 2 mm but rivets are generally sound.	 Pitting corrosion at bearing stiffener plates.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and loss of section has occurred having a detrimental effect on the strength of the member, i.e. a flange may be badly corroded over a sizeable length. • There may be some cracking of the welds between the plates. • Rivets or bolts may be severely corroded and no longer carrying full load or functioning as intended. • Rivets may be broken or missing allowing excessive movement of plates of made up girders. The paint system has completely broken down.	 Severe pitting corrosion of beam web and flange with loss of section over large area.

Component 2 P – Open Girders/Stringers – Precast Concrete

Units of measurement: **Each**

This component includes a variety of beams and shapes developed over the years using reinforced, prestressed, and on a few occasions post tensioned concrete.

The earliest precast beams consisted of normal strength concrete (20 to 25 MPa) with round steel bars. These beams were first made in 1949 and are rectangular in shape along their entire length.

In the early 1960's, standard precast high strength reinforced concrete "I" beams and prestressed concrete "I" beams were used. These beams were "I" in shape with a rectangular end block each end. Spans for the reinforced beams were 30 to 45 feet (9.1 to 13.7 metres), and for the prestressed beams were 35 to 60 feet (10.6 to 18.3 metres).

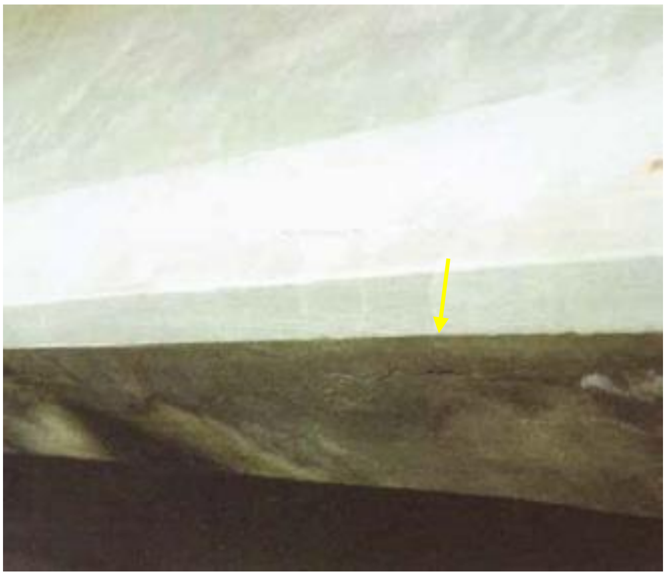
NAASRA beams sections were introduced in 1970 with four standard sections which could accommodate spans of 14 to 30 metres, with modified type 4 beams pushing to 33 metre spans. These beams were "I" shape throughout for easy recognition.

Also during the 1970's, a prestressed inverted "T" beam was developed for use on structures crossing freeways, as the bottom of the flanges when placed against each other formed an aesthetically pleasing flat undersurface to the overpass rather than a dark interrupted underside if formed using "I" beams. Span ranges for these beams were 32 to 36 metres with the design being continuous over the central pier.

In the mid 1980's a new section was introduced called a "bulb-T" section which was basically a "T" shape with a top flange width of 1.2 metres, and the bottom flange of the "T" being a thickened bottom "I" flange to accommodate a large number of stressing strands. These beams were quite deep and could span from 28 to 40 metres.

During 1992 "Super-T" beams were introduced which are basically trapezoidal in shape with a two metre wide flange on top. To reduce the weight of the precast units, a very large polystyrene void is placed inside the trapezoidal box during manufacture.

<table>
<tr><th colspan="2">Reinforced concrete beams</th></tr>
<tr><th>Condition state 1 – Description</th><th>Photo</th></tr>
<tr><td>• The beams are in good condition with only very minor cracking due to corroding reinforcement, shrinkage or lack of curing.</td><td>
Precast high strength reinforced concrete “I” Beams in good condition.</td></tr>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>• Flexural cracking and cracking due to reinforcement corrosion is fine though no rust staining is visible in the cracks.
• A few minor spalls may be present.
• Fine cracking may have occurred at the bearing areas of the beam.</td><td>
Fine flexural cracking between 0.1 mm to 0.3 mm with no rust staining evident.</td></tr>
</table>

Condition state 3 – Description	Photo
• Flexural cracking has increased with cracks in the medium size. • Cracking due to reinforcement corrosion is medium and a number of spalls may have occurred, and/or heavy rust staining is present at the cracks. • Where reinforcement is close together, some delamination of the concrete may have occurred. • Loss of section of any corroding reinforcement is less than 20%. • Medium cracking may have occurred at the ends of the beam affecting the bearing area of the unit.	 Heavy cracking along side and underside of Reinforced Concrete “I” Beam.
Condition state 4 – Description	**Photo**
• Corrosion of the reinforcement is well advanced with loss of bar section greater than 20%. • Flexural cracking in the member may be heavy with the beam noticeably deflecting under load. • Severe spalling may have occurred due to corroding reinforcement or at the ends of the beam at the bearing areas.	Not available.

Prestressed concrete beams	
Condition state 1 – Description	**Photo**
• The beams are in good condition with only very minor cracking due to corroding reinforcement, shrinkage or lack of curing.	Not available.
Condition state 2 – Description	**Photo**
• The beams may have fine cracking due to corroding of reinforcing bars. • There may be a few minor spalls but no rust staining in the cracks. • Stressing strands must not be exposed.	 Minor isolated spall in underside of prestressed "I" Beam.
Condition state 3 – Description	**Photo**
• Cracking has increased in size and a few medium spalls or delaminations may have occurred exposing stressing strands and/or heavy rust staining is present at the cracks. • The stressing strands should only have very minor corrosion whilst non-prestressed reinforcement may have up to 20% loss of section. • Medium cracking may have occurred at the ends of the beam affecting the bearing area of the unit. • Light flexural cracking may exist in the beams.	Not available.

Condition state 4 – Description	Photo
• Delaminations, spalls and corrosion of reinforcement are prevalent with loss of reinforcement section greater than 20%. • Exposed stressing strands may have corrosion up to 10% of their cross section or some strands may have broken. • Heavy cracking or failure of the anchorages may have occurred. Heavy flexural cracking may be present in the beams or in the deck above the supports. • Severe spalling may have occurred due to corroding reinforcement or at the ends of the beam at the bearing areas.	 Severe spalling along bottom of beam with corroding reinforcement.

Component 2 C – Open Girders/Stringers – Cast-in-situ Concrete

Units of measurement: **Each**

This component includes all reinforced concrete beams cast-in-situ, generally before 1950 though a few structures were built as late as 1955 using varying depth beams continuous over pier supports with a larger central span.

These structures were called RC T-beam bridges and are generally continuous monolithic bridges. Though in the late 1930's and during the 1940's a number of simply supported structures were built with beams cast end to end with only a malthoid strip separating them to break the concrete bond. Span ranges were generally small with the longest span being approximately 9 metres (beam shape is always rectangular).

Condition state 1 – Description	**Photo**
• The girders have minor fine cracking due to corroding reinforcement but there should be no shear cracking or spalling of the concrete. • Hair line cracking may exist at the built-in supports or fine vertical shrinkage cracks may appear in the beams due to the locked up movements of the structure.	 Variable depth cast-in-situ RC T-beams in good condition with diaphragm bracing at quarter points of span.

Condition state 2 – Description	Photo
• The girders may have fine flexural and/or shear cracking. • Vertical shrinkage cracks and cracking at built-in supports may be fine. • Longitudinal cracking along the bottom of the beams due to reinforcement corrosion may be of fine size with minor spalling. • The ends of simply supported beams may have fine cracking in the bearing areas due to the bearings or locating dowels.	 Moderate longitudinal cracking in underside of RC T-beam due to corroding reinforcement.
Condition state 3 – Description	**Photo**
• Flexural cracking and shear cracking may be medium sized with minor cracking along the beam deck joint. • Vertical shrinkage cracks and cracking at built-in supports may be medium in size. • Longitudinal cracking may be medium along the bottom of the beams due to reinforcement corrosion and there may be large spalls with delaminated cover concrete. • Exposed reinforcement may have heavy corrosion with section loss up to 20% in areas. The beams may have medium cracking in the bearing areas at the ends of the beams.	 Heavy spalling along underside of beam with heavy corrosion of reinforcement.

Condition state 4 – Description	**Photo**
• Flexural and shear cracking may be heavy with medium cracking along the beam/deck joint. • Vertical shrinkage cracks and cracking at built-in supports may be heavy in size. • Severe spalling or delamination of the underside of the beams may be occurring, with heavy corrosion of the reinforcement with section loss more than 20% in areas. • The beams may have heavy cracking in the bearing area with severe loss of bearing support.	 Heavy shear cracks at each end of span and crack along deck / beam joint. Deck has only partial composite action with beam.

Component 2 T – Open Girders/Stringers – Timber

Units of measurement: **Each**

This component includes all timber stringers including round or hewn timber logs, saw cut timber sections and glue laminated beams.

Condition state 1 – Description	Photo
• The stringers are in good condition with little or no pipe rot or decay. • There may be minor splits or checks having no effect on member strength. • Glued laminated beams have no separation of the laminations and no splits or checks within the laminations.	 Timber stringers in good condition with no splitting or sap rot of outer timber.

Condition state 2 – Description	Photo
• Stringers are in good condition and may have up to 30% of the diameter pipe rot. They may also have minor decay, splitting, checking or crushing but not of sufficient magnitude to affect the strength of the member. • Glue laminated beams have no separation of the laminations but may have minor splits or checks within the laminations but not of sufficient size or magnitude to affect member strength.	 Timber is very wet and has moderate sap rot.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Stringers have a reasonable amount of pipe rot up to 50% of the diameter. They may have large splits or checks, which may have a reduction in strength of the member.
Splits may be separating under load causing crushing of the member, or crushing may be due to water ingress softening the load bearing areas of the timber.
Glued laminated beams may have fine splitting along laminated joints and the outer fibres may be peeling or a fine moment crack may exist in the outer lamination.
There may also be fine splitting within the laminations due to tensile stresses between the fibres.</td><td>
Timber is very wet and has moderate sap rot.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>The timber stringers may have excessive pipe rot up to 70% of the diameter, accompanied by severe splitting or crushing.
Strength of the member has been severely affected and failure may be imminent.
Glued laminated beams have extensive splitting along the lamination joint.
Medium moment cracking of the laminations has also occurred with the outer fibre splitting apart due to tensile stresses, and the beam has partially failed.</td><td>
Stringer has split in two and has failed. A relieving RSJ has been placed alongside.</td></tr>
</table>

Component 3 S – Through T – Steel

Units of measurement: **Linear Metres**

This component includes all steel or wrought iron trusses that are above the deck level of the roadway. The component includes all truss chords (top and bottom), verticals, crossbraces, windbracing or arch braces. This component does not include the floor beams supporting the roadway.

Condition state 1 – Description	**Photo**
• The steelwork is in good condition with no rust spotting of the paint system, though there may be minor chalking, peeling or curling. • There is no accident damage to the trusses or bracing. All welds, bolts and rivets are in good condition with no corrosion, cracking or looseness.	 Steel trusses are in good condition.

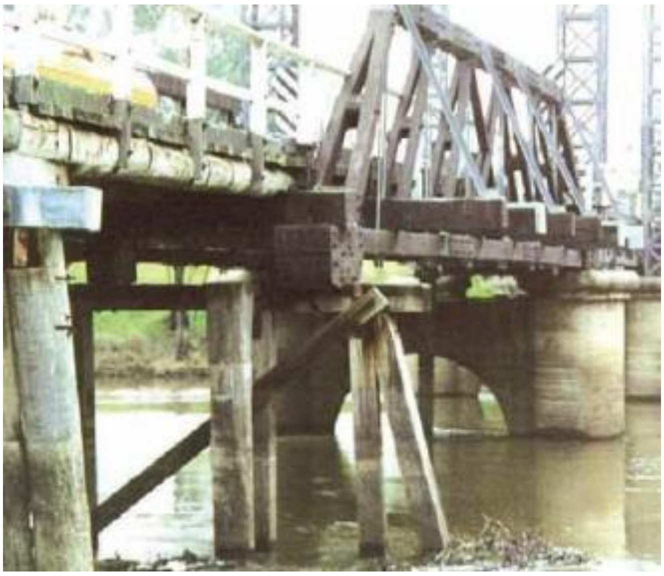
Condition state 2 – Description	**Photo**
• Rust spotting of the paint system to 5% of surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds or bolts are in good condition with no cracking, corrosion or loose bolts. • Minor accident damage of no consequence.	 Minor rusting

Condition state 3 – Description	Photo
• Some surface pitting is present and active corrosion is occurring in isolated areas, but no loss of a whole area is occurring to affect the strength of the member as a whole. • Paint system has broken down with surface rusting to 10% of area and pitting present in a number of locations. • Nuts and bolts may be corroding but are still tight. No cracking of welds has occurred. • Accident damage to truss or overhead bracing is evident and has minor effect on the stiffness of the trusses.	 Truss has surface rusting to 10% of area and pitting in a number of locations.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and some loss of section has definitely occurred which may have a detrimental effect on the strength of the member, i.e. a flange badly corroded over much of its length. • Welds may be cracked. Nuts or bolts are severely corroded and possibly no longer functioning to full capacity. • Accident damage to trusses or overhead bracing is evident and has major effect on strength of the trusses.	Not available.

Component 3 T – Through Truss – Timber

Units of measurement: **Linear Metres**

This component includes all trusses constructed of timber or where the main members are timber. Braces or vertical members in these trusses may be steel rods. The floor beams supporting the roadway between the trusses should not be included in this item.

Condition state 1 – Description	Photo
• The timber is in good condition with no decay. • The timber may have minor cracks, splits or checks having no effect on member strength. All connections are in good condition with all bolting tight. • The trusses are effectively braced laterally at the top. There is no accident damage to the trusses.	 Timber truss in good condition with lateral bracing.

Condition state 2 – Description	Photo
• There may be minor decay of the timber, minor cracks, splits or checks having no effect on member strength. • All connections are in good condition with all bolting tight. There may be minor accident damage having no effect on serviceability or strength of the truss. • The trusses are effectively braced laterally at the top.	 Decay of the top chord of timber truss.

Condition state 3 – Description	Photo
• Decay, splitting, cracks and checks are producing loss of strength of the members especially at the joint where there may also be crushing of the members. • Joint connections may be a little loose but only having minor effect on the serviceability of the truss. • Lateral bracing of the truss at the top may be poor or ineffective allowing the trusses to move laterally under load. • Accident damage to the trusses may have a minor effect on the stiffness of the trusses or strength of some members.	 Rot, splitting and weathering of timber diagonals and lower truss chord.
Condition state 4 – Description	**Photo**
• Decay, splitting and crushing has produced significant loss of strength in some members which affect the serviceability of the truss. • Lateral bracing of the top of the truss is completely ineffective and the top chord may have a large lateral bow in it. • Accident damage to the truss is a major concern affecting the strength of the members and the truss.	 Truss has a large bow in the top chord and vertical members are leaning.

Component 4 S – Deck Truss – Steel

Units of measurement: **Linear Metres**

This component includes all steel or wrought iron trusses that are below the deck level of the roadway. The component includes all truss chords, verticals, crossbraces and windbracing. This component does not include crossbeams or floorbeams supporting the roadway.

<table>
<tr><th>Condition state 1 – Description</th><th>Photo</th></tr>
<tr><td>The paint system is generally sound with minor chalking, peeling or curling but no exposure of the metal.
All welds or bolts in good condition with no corrosion, cracking or loose bolts.</td><td>
Steel deck truss in good condition.</td></tr>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>Rust spotting of the paint system to 5% of surface area is occurring and the paint system is no longer effective.
No corrosion with section loss has occurred.
Welds or bolts are in good condition with no cracking, corrosion or loose bolts.</td><td>
Rust spotting of the paintwork.</td></tr>
</table>

Condition state 3 – Description	Photo
• Some surface pitting is present and active corrosion is occurring in isolated areas, but no loss of area is occurring to affect the strength of the member as a whole. • Paint system has broken down with surface rust spotting to 10% of area and pitting is present in a number of locations. • Nuts and bolts may be corroding but are still tight and no cracking of welds has occurred.	 Pitting corrosion of flange of top chord of truss with approximately 1 mm depth of corrosion.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and some loss of section has definitely occurred which may have a detrimental effect on the strength of the member, i.e. a flange badly corroded over much of its length. Welds may be cracked. • Nuts or bolts are severely corroded and possibly no longer functioning to full capacity. • Paint system has completely broken down.	Not available.

Component 5 S – Arches – Steel

Units of measurement: **Linear Metres**

This component includes all large corrugated multi-plate arches, Superspans, Nova spans or multi-plate underpasses used to pass road or rail traffic through. Smaller units or units used specifically to allow water or cattle traffic through must be considered as culverts.

Condition state 1 – Description	Photo
• The component shows no corrosion of the metal. Any concrete at the base of the arch is in good condition with no cracking or spalling. • All bolts connecting the multiplates are in good condition and are tight. • There is no damage to the component from vehicular traffic.	 Nova span corrugated steel arch in good condition.
Condition state 2 – Description	**Photo**
• The component may show minor spot rusting. • All bolts are tight with no movement of the plates. There is no damage to the component from vehicular impact. • Any concrete at the base of the arch may have minor cracking or spalling due to corroding reinforcement but there should be no cracking due to settlement of the foundations.	Not available.

Condition state 3 – Description	Photo
• The component may show rusting and areas of minor corrosion. Some bolts may be a little loose and some plates may have slipped slightly. • The plate around some bolts may be damaged or torn allowing distortion to occur. The arch may be developing a small flat spot due to movement of a footing. • Accident damage from vehicles is minor and does not affect the structure. • Any concrete at the bottom of the arch may have moderate cracking and spalling due to corroding reinforcement or it may have fine cracking due to minor differential settlement of the foundations.	Not available.
Condition state 4 – Description	**Photo**
• The component may have heavy rusting and corrosion. • Some bolts may have pulled loose and plates have moved or bolts have pulled through the plates. Plates may have crinkled at the bolt line or may have bulged due to earth pressures. • Accident damage may be severe and have a definite effect on the structure. Concrete at the base of the arch may have heavy cracking and spalling due to corroding reinforcement or moderate differential settlement cracking. • The arch may have a large flat spot at the top due to movement of a footing.	Not available.

Component 5 P – Arches – Precast Concrete

Units of measurement: **Linear Metres**

This component includes all precast reinforced concrete arches either in whole sections or with pin joints. Bowstring and spandrel arches are the main type of arch used to pass road or rail traffic through. Smaller three pin arches or units used specifically to allow water or cattle traffic through must be considered as culverts.

Condition state 1 – Description	**Photo**
• The component shows only minor cracking, scaling or efflorescence having no effect on strength.	 Precast concrete arch in good condition.
Condition state 2 – Description	**Photo**
• The component may have minor cracking and spalling due to corroding reinforcement, or simply a construction joint opening up. • Scaling of the concrete surface may be in larger patches with an increase in white efflorescence powder on the surface.	 Minor spalling between precast arch units with reinforcement exposed.

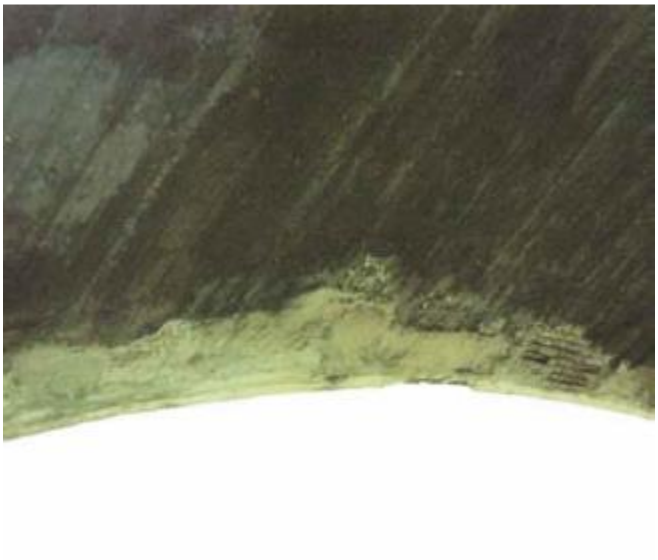
Condition state 3 – Description	Photo
• The component may have medium cracking and spalling due to corroding reinforcement. Scaling and efflorescence may be prevalent. • The arch may be beginning to lose shape with a flat spot at the top due to movement of a footing, or there may be cracking due to slight differential movement of the foundations.	Not available.
Condition state 4 – Description	**Photo**
• There may be heavy cracking and spalling due to corroding reinforcement. • The arch may have lost shape with a large flat spot due to movement of a footing, or there may be heavy cracking due to differential settlement of the foundations. • Accident damage may be severe and having a definite effect on the structure.	Not available.

Component 5 C – Arches – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all cast-in-situ reinforced concrete arches and small portal bridges built pre 1950. Large freeway "portal" bridges may be considered as monolithic structures built according to their superstructure type i.e. flat slab, box girder or voided slab bridges.

Condition state 1 – Description	**Photo**
• The component shows only minor superficial cracking, scaling or efflorescence having no effect on strength.	 Original cast-in-situ RC portal bridge in good condition.

Condition state 2 – Description	**Photo**
• The component may have minor cracking and spalling due to corroding reinforcement, or there may be a fine horizontal crack in the portal wall at the thickening, due to earth pressures on the walls or simply a construction joint opening up. • Scaling of the concrete surface may be in larger patches with an increase in white efflorescence powder on the surface.	 Minor cracking, spalling, moisture and efflorescence on outside of arch soffit.

Condition state 3 – Description	Photo
• The component may have medium cracking and spalling due to corroding reinforcement or there may be a medium size horizontal crack in the portal wall at the thickening. • In arches there may be leakage, staining and spalling at the arch/side wall joint due to wet fill inside the arch. • Scaling and efflorescence may be prevalent. • The arch may be beginning to loose shape with a flat spot at the top due to movement of a footing, or there may be cracking due to slight differential movement of the foundations.	 Moderate spalling at the widening edge of the RC arch and the masonry and brick arch.
Condition state 4 – Description	**Photo**
• There may be heavy cracking and spalling due to corroding reinforcement or horizontal cracking in the portal wall at the thickening. • Scaling and efflorescence may be prevalent and leakage at the arch/side wall joint may be excessive. • The arch may have lost shape with a large flat spot due to movement of a footing, or there may be heavy cracking due to differential settlement of the foundations. • Accident damage may be severe and having a definite effect on the structure.	 Concrete arch cracked and broken at crown.

Component 5 T – Arches – Timber

Units of measurement: **Linear Metres**

This component includes those arch bridges constructed of sawn hardwood or glue laminated timber, where the main action is arching. The actual girders carrying the deck load should be considered as separate items, as should the arrangement to transfer the loads to the arches

Condition state 1 – Description	Photo
• The timber has been well preserved and is in good condition. • There is no separation of laminations and no splits or checks in the timber. • Connections for the transfer of loads are in good condition.	 Timber arch bridge in good condition.

Condition state 2 – Description	Photo
• There is no separation of laminations though the timber may have minor splits or checks, which have no effect on the member strength. • Connections for the transfer of load are good though there may be minor decay in the timber.	Not available.

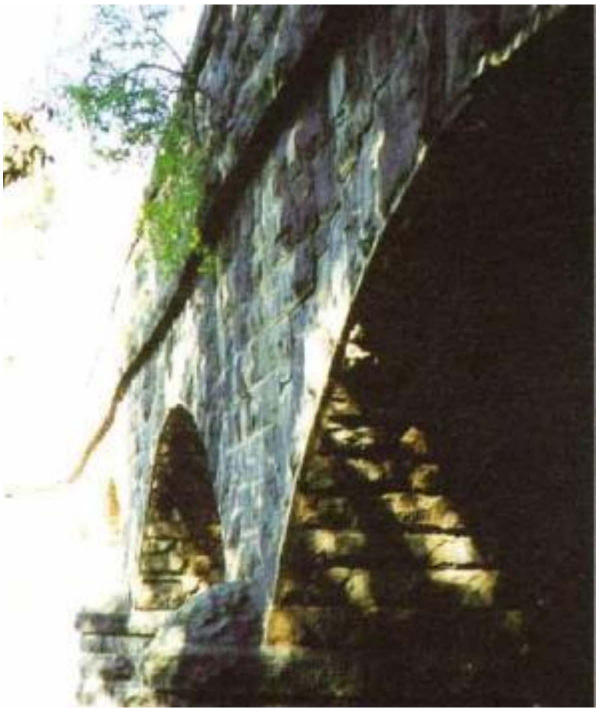
Condition state 3 – Description	Photo
• Glue laminated arches may have fine splitting along the lamination joints and the outer fibres may be peeling or a fine moment crack may exist in the outer lamination. • There may be fine splitting within the laminations due to tensile stresses between the fibres. • Connections for the transfer of load may show medium decay with crushing of the joint, or the connections may be a little loose.	Not available.
Condition state 4 – Description	**Photo**
• Glue laminated arches may have extensive splitting along the laminated joints and have medium moment cracking of the laminations with the outer fibres splitting apart. • The arch may have lost shape. • Connections for the transfer of load may show heavy decay with crushing at the joints or connections may be quite loose.	Not available.

Component 5 O – Arches – Other

Units of measurement: **Linear Metres**

This component includes all arch bridges constructed of masonry or red brick which have earth fill inside. The condition of the road surface should be considered under a separate item and not included as part of this item. The arch sidewalls however should be included as part of this item.

Condition state 1 – Description	Photo
• The component shows little or no deterioration with no cracking of mortar or loss of mortar between the blocks. • There may be small areas of dampness and efflorescence.	 Red brick arches in good condition.
Condition state 2 – Description	**Photo**
• There may be minor cracking of the mortar or minor loss of mortar between the blocks, but not sufficient to affect the strength of the arch. • The shape of the arch is still good and there is no cracking or bulging of the sidewalls. • There may be large areas of dampness and efflorescence.	 Moderate crack at sidewall and moderate loss of mortar between bricks.

Condition state 3 – Description	Photo
• There may be minor cracking or loss of mortar between blocks which has a minor effect on the strength of the arch. • Some soffit blocks may have slipped slightly due to the loss of mortar. • Minor settlements, movements, loss of arch shape, or cracking and minor bulging of the sidewalls may be present, but not of sufficient magnitude to cause concern.	 Loss of mortar, large area of efflorescence and movements of blocks in arch soffit.
Condition state 4 – Description	**Photo**
• There may be severe cracking or loss of mortar between blocks which has a significant effect on the strength of the arch. • Some soffit blocks may have slipped significantly and some blocks may have cracked through or edges broken off. • Abutments or piers may have settled or moved significantly causing a loss of shape of the arch. • Differential settlement of the foundations may have also caused heavy cracking along the arch soffit. • Earth pressure on the sidewall may have caused heavy cracking, movement or large bulging of the blocks to occur.	 Heavy crack in masonry between arch line and side wall with bulging movement of sidewall blocks.

Component 6 S – Cables/Hangers (not embedded in concrete) – Steel

Units of measurement: **Each**

This component includes all steel cables or hangers used to support the deck. The cables may be galvanised, painted, coated or wrapped in grease with a protective outer wrapper, but are not embedded in concrete.

Condition state 1 – Description	Photo
• There is no evidence of rusting or corrosion and any paint system or protective wrapping is in good condition. • There are no signs of distress at anchors, sockets or saddles.	 Steel cables in good condition.

Condition state 2 – Description	Photo
• The cables or hangers may show signs of rust or the protective wrapping may be broken or in poor condition. • There are no signs of distress at anchors or sockets but the saddles may be rusty and in need of lubrication.	 Saddle bracket has some rusting and bolts slightly loose.

Condition state 3 – Description	Photo
• The cables or hangers may be rusty with signs of minor corrosion. • Any paint system, coating or protective wrapping has been lost or is in very poor condition. • Anchors may have minor cracking, sockets may be a little loose or saddles may have fine cracks in the metal. • The cables may have slackened off slightly or the hangers are slipping on the cable. • Cables may be beginning to abrade but there are no wire breakages.	Not available.
Condition state 4 – Description	**Photo**
• The cables or hangers are badly corroded or the hangers are loose and are sliding along the cables. • The cables may have slackened noticeably. • Anchorages may have severely cracked or anchorages have moved or slipped. • Sockets may have loosened or saddles are badly damaged. • Cables may be severely abraded with a number of broken wires.	 Cables are heavily corroded and one wound wire has frayed and broken.

Component 7 S – Corbels – Steel

Units of measurement: **Each**

This component includes the support of the beam with a short cantilever or corbel section in steel.

Condition state 1 – Description	Photo
• The corbels are in good condition with no cracks. • The paint system is generally sound with only minor chalking, peeling or curling, but with no exposure of metal. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	Not available.

Condition state 2 – Description	Photo
• Spot rusting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	Not available.

Condition state 3 – Description	Photo
• Minor cracking developed at the corner of the corbels towards the beams. • Some surface pitting may be present. Active corrosion occurring in isolated areas, but no loss of area is occurring to affect the strength of the member as a whole. • The paint system has broken down with rust spotting to 10% and surface pitting. • Nuts and bolts may be corroded but are still tight and no cracking of welds has occurred. • Riveted plates may have very minor movements of 1 to 2 mm but rivets are generally sound.	Not available.

Condition state 4 – Description	**Photo**
• Medium diagonal shear cracking developed at the corner of the corbels towards the beams.. • Corrosion is well advanced and loss of section has occurred having a detrimental effect on the strength of the member, i.e. a flange may be badly corroded over a sizeable length. • There may be some cracking of the welds between the plates. • Rivets or bolts may be severely corroded and no longer carrying full load or functioning as intended. • Rivets may be broken or missing allowing excessive movement of plates of made up girders. The paint system has completely broken down.	Not available.

Component 7 C – Corbels – Cast-in-situ Concrete

Units of measurement: **Each**

This component includes the support of the beam with a short cantilever or corbel section in concrete.

Condition state 1 – Description	Photo
• The corbels have minor fine cracking due to corroding reinforcement but there should be no shear cracking or spalling of the concrete. • Hair line cracking may exist at the built-in supports or fine vertical shrinkage cracks may appear in the beams due to the locked up movements of the structure.	Not available.

Condition state 2 – Description	Photo
• The corbels may have fine cracking due to corroding reinforcement. • Vertical shrinkage cracks and cracking at built-in supports may be fine. • Longitudinal cracking along the bottom of the beams due to reinforcement corrosion may be of fine size with minor spalling. • The corbels may have fine cracking in the bearing areas due to the bearings or locating dowels.	 Fine cracking with water staining and corroded sole plate of the bearing.

Condition state 3 – Description	Photo
• Minor cracking developed at the corner of the corbels towards the beams. • Vertical shrinkage cracks and cracking at built-in supports may be medium in size. • Longitudinal cracking may be medium along the bottom of the corbels due to reinforcement corrosion and there may be large spalls with delaminated cover concrete. • Exposed reinforcement may have heavy corrosion with section loss up to 20% in areas. • The corbels may have medium cracking in the bearing areas at the ends of the beams.	 Minor cracking at step joint.
Condition state 4 – Description	**Photo**
• Medium cracking developed at the corner of the corbels towards the beams. • Vertical shrinkage cracks and cracking at built-in supports may be heavy in size. • Severe spalling or delamination of the underside of the beams may be occurring, with heavy corrosion of the reinforcement with section loss more than 20% in areas. • The corbels may have heavy cracking in the bearing area with severe loss of bearing support.	Not available.

Component 7 T – Corbels – Timber

Units of measurement: **Each**

This component includes all timber corbels whether they be round or hewn log, or sawn timber blocks.

Condition state 1 – Description	Photo
• The corbels are in good condition with no decay, though there may be minor splits or checks having no effect on strength. • The ends of the corbels show no pipe rot and connections to the substructure and stringers are tight.	 Corbel in good condition as are the corbel blocks beneath the stringer. Corbel has anti-split bolts near the end.
Condition state 2 – Description	**Photo**
• The corbels may have minor decay, splitting, checking or crushing but not of sufficient magnitude to affect their strength. • The stringers may have minor pipe rot of the ends. • Connections to the substructure or stringers may be slightly loose.	 Split corbels and minor piping at the ends

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Corbels may have moderate rot or decay, splitting, checking or crushing which may have a minor effect on strength.
Corbels may have up to 50% pipe rot of the diameter at the ends.
Connections to the substructure or stringers may be quite loose and the corbels are slightly rocking under load.</td><td>
Very severe split in corbel requiring an anti-split bolt near the end.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Heavy rot, decay, splitting, or crushing have a marked effect on the strength and serviceability of the corbel.
Corbels may have in excess of 50% pipe rot of the diameter at the ends.
Connections to the substructure or stringers are very loose and the corbels rock noticeably under load.</td><td>
Upper corbel badly rotted and split in two. Corbel is splitting further apart and crushing under load.</td></tr>
</table>

Component 8 S – Deck/Slabs – Steel

Units of measurement: **Square Metres**

This component includes all deck slabs where steel rail or tramline sections are embedded in concrete. The rails may be spanning longitudinally or be placed laterally on top of the steel girders, and may be placed alongside each other or have a sizeable gap between the rails. The rails may be fully embedded or partially buried up to the top of the rail head, with gravel fill placed on top with asphalt or spayed seal. If the depth of gravel fill is approximately 100 mm or more, it should be considered under a separate item, but if it is substantially less it can be considered as part of this component. Long spans may have steel rail distributors, bare or cast in concrete at midspan to provide for lateral load distribution. The distributors may be considered as part of this component.

This component will also include steel plated deck slabs or planks for pedestrian bridges as well as steps leading up to the crossing span.

Condition state 1 – Description	Photo
• There is no cracking of the concrete infills. The underside of the rails may have minor rusting. • The deck does not deflect excessively under load.	 Steel rails in concrete deck with only minor rusting of the rails.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>

- There may be fine transverse cracks in the infills at midspan but no longitudinal cracking along the rail/concrete interface.
- The rails may be quite rusty but no pitting or corrosion is occurring.
- Distributor rails may be slightly loose or there may be minor cracking and spalling of the concrete encasement.
- The deck is not deflecting excessively under load.
- If thin cover concrete has been cast under the rails then heavy spalling of the cover concrete will occur when the rails rust. This is only of concern when the cover concrete begins to disintegrate in the bearing area.

</td><td>

Minor corrosion of the rail especially at the ends of deck.

</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- There may be medium transverse cracks in the infill concrete coupled with cracking or minor edge spalling along the rail/concrete interface.
- Rails may be moderate rusty with minor corrosion occurring.
- Distributor rails may be quite loose or encasement concrete may be heavily spalled.
- The deck may deflect substantially under load due to some loss of lateral distribution.
- Cover concrete has cracked, spalled or is crushing under the rails at the bearing areas and a mortar or a neoprene rubber strip will need to be placed under the rails.
- Steel deck plates may be loose allowing the plate to move or sit up, causing a tripping hazard for pedestrians.
- Steel steps may be loose, well worn or corroded or cracked at the edges or side beam joint.

</td><td>

Thin concrete cover beneath rail-in-concrete deck has spalled at the abutment revealing heavily corroded steel rails.

</td></tr>
</table>

Condition state 4 – Description	**Photo**
• Heavy cracking, spalling or crumbling of the infill concrete is occurring with loss of strength and lateral distribution. Consequently the deck is deflecting excessively under load. • The rails may be heavily pitted and corroded. Distributor rails will possibly be very loose or have broken away. • If the rails only have concrete up to the head of the rail, the outer rails may separate from the deck as bond is lost between rail and concrete. • These bridges have much reduced capacity due to lack of lateral distribution. • Holes may be found as concrete is pushed through the deck. • Steel steps may be broken and require replacement or re-welding. • Steel deck plates may be very loose and buckled requiring replacement	 Steel rails heavily corroded and concrete infill cracked and breaking up.

Component 8 P – Deck/Slabs – Precast Concrete

Units of measurement: **Each**

This component includes all precast concrete deck slabs and superstructure units forming both the span and the deck. The precast deck slabs include:

- Those slabs produced by Humes and the Waldren Quickdeck units.
- Precast concrete formwork units such as Transfloor precast decks used to support, and made composite with, cast-in-situ decks. Small prestressed formwork slabs are not considered as they are sacrificial once the deck has been cast.
- The superstructure units consist of the Various types of U-slabs used over the years, the various types of prestressed slabs used in the past, the latest design T-slabs up to 18 metres, and the Waldren U-beam and slab unit.
- Where a reinforced concrete overlay is part of the design, the overlay must be considered as part of the component unless the deck is unsealed and the top of the overlay is visible.

Condition state 1 – Description	Photo
• The units are in good condition with only minor faint cracking or minor edge chipping of the units. • Minor efflorescence powder may be visible.	 Precast RC decking slabs in good condition.

Condition state 2 – Description	Photo
• Minor cracks or spalls may be present with only minor reinforcement corrosion. • Some of the hold down bolts for the precast deck slabs may be loose. • Edge spalling of the units may have exposed some reinforcement.	 Minor cracking and spalling of outside of a transversely tensioned prestressed slab.
Condition state 3 – Description	**Photo**
• Medium cracking and spalling may be present with up to 20% loss of section of the reinforcement. • Many of the hold down bolts are loose or missing and the units are moving when loaded, causing heavy edge spalling of the units.	Not available.

Condition state 4 – Description	Photo
• Heavy spalling and advanced corrosion may be present, or the precast deck units are completely loose and moving excessively under load. • Heavy edge spalling or delaminated concrete may be present.	 Severe cracking and spalling of U-slab legs due to chloride ingress corroding the reinforcement.

U-slabs	
In 1951, precast reinforced concrete u-slabs were introduced using normal strength concrete and mild steel bars. These units were designed to carry half a wheel load and the units were completely independent of each other. A sizeable depth of fill placed on top of the units aided in lateral load distribution between the units. The outer units were kerb slabs or they had a kerb cast on top as part of the unit. These outer units were solid in section. Spans ranged from 4 to 20 feet (1.22 to 6.10 metres). High strength reinforced concrete u-slabs were adopted in 1962 and further amended in 1965 with additional steel mesh in the top, altered bolt positions and larger size reinforcement. These slabs have bolts between the legs and a shear key joint concrete between the tops of the slabs. Unlike the earlier slabs, there was no fill on top to aid load distribution; the shear keys and bolts were relied upon to distribute the load between adjoining slabs. These slabs were designed to take 0.47 of a wheel load. If the bolts and shear keys became inoperative these slabs are required to carry a substantially higher loading, estimated to be as high as 0.70 of a wheel load. Spans ranged from 15 to 35 feet (4.5 to 10.5 metres). In 1976 the design load was increased to T44 and it was required to strengthen the u-slabs. To avoid the necessity of a new design and new forms for casting, the shear key and bolts were eliminated to make the units independent. A composite reinforced concrete overlay was cast on site with the u-slabs in place. This overlay not only strengthens the u-slabs but also provides very good lateral distribution of load. Spans were also increased up to 12.0 metres. A few double width u-slab bridges were built with prestressing strands rather than reinforcement but too many problems were experienced with them and they were discontinued. In the 1990's Waldren introduced a precast U – Beam with spans 6 to 12 metres and varying widths 2.4 to 3.0 metres. The deck part of these units overhangs the beams and there is no joint between the units; a sealant is simply poured in the gap between them. The units are a T44 design but act independently, and the sealant often splits or breaks up due to the differential movements.	
Condition state 1 – Description	**Photo**
• The units are in good condition with no moisture or staining between the units, though there may be minor efflorescence powder under the slab section of the beams. • The units may have faint flexural cracking at midspan but there is no spalling. • Bolts between high strength U-Slabs are all tight.	Not available.

Condition state 2 – Description	Photo
- The U-Slabs may have fine flexural cracking of the legs and there may be other minor cracking or spalling due to corroding steel reinforcement. - Moderate moisture and staining between the units indicate the shear key concrete is cracked in high strength U-Slabs bridges and there may be longitudinal cracking of the asphalt on top of the slabs. - Bolts between the units are generally tight though there may be a few loose. - If the bearings are badly positioned at the ends of the U-Slabs, there may be minor cracking in the bearing areas.	Not available.
Condition state 3 – Description	**Photo**
- Medium flexural cracking may be noticed in the U-Slab legs with moderate moisture staining between the units. - The asphalt surface will be moderately cracked and U-Slab bolts will be loose between these units. - The shear key concrete between the tops of the units will be badly cracked. - There may be medium cracking and spalling of the U-Slab legs due to corroding reinforcement. - If bearings are badly positioned at the ends of the U-Slabs there may be moderate cracking in the bearing areas of the U-Slab legs.	 Severe cracking, moisture ingress and white efflorescence powder in top of U-slabs, cracking by over tightening of shear bolts between U-slab legs.

<table>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

Medium flexural cracking may be seen in the U-Slab legs at midspan with heavy moisture staining between the units. The asphalt surface may be heavily cracked with some areas completely broken out.
The shear key concrete between the high strength U-Slabs may be badly cracked and sections may be broken out.
U-Slab bolts will be loose, many with nuts completely missing, or they may have been retightened and badly cracked the top of the slab.
There may be heavy cracking and spalling of the U-Slab legs with heavy corrosion of the reinforcement with section loss of 20% or greater.
There may be heavy cracking of the ends of the U-Slab legs due to badly positioned bearings.

</td><td>

Severe cracking and spalling of U-slab legs due to chloride ingress corroding the reinforcement.
</td></tr>
</table>

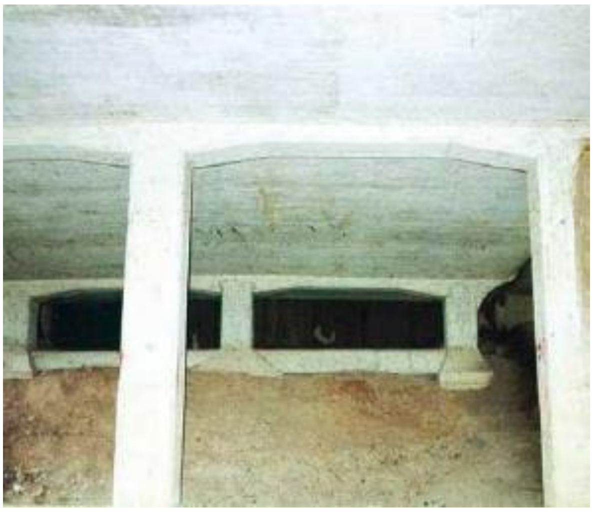
Prestressed slabs	
The first precast prestressed slabs were introduced in 1958 for spans of 15 to 30 feet (4.6 to 9.1 metres). These slabs were held together by transverse tensioning rods which were passed through cored holes, the number of rods varying depending on the span length. The slabs are 620 mm wide and vary in depth between 160 and 315 mm, and have a cast-in-situ shear key between the units at the top. In 1961 a 35 foot (10.7 metres) span prestressed slab was introduced which had two circular voids inside to save weight. Transverse tensioning rods could not be used because of the voids, so a 100 mm thick composite reinforced concrete overlay was added to provide lateral load distribution between the units. The overlay had a joint at each pier, so was not continuous. New South Wales designed prestressed planks were used in the mid-1970s with spans ranging from 7 to 15 metres. These planks have a composite reinforced concrete overlay ranging in depth from 124 to 145 mm and made continuous over 3 spans to eliminate expansion joints and improve rideability over the bridge. Some “wide planks” (1060 mm wide) now have been used to reduce costs. Prestressed “T” slabs were introduced in 1986 replacing U-slabs, and have a circular void inside to reduce the weight of the units. Standard slabs span from 8 to 19 metres with slab depth varying from 250 to 750 mm and top flange width of 1500 mm. An in-situ reinforced concrete overlay 140 mm deep is cast compositely with the units. In 1994 a new prestressed slab was introduced with spans of 8 to 20 metres, width of 1160 mm and structural depths of 350 to 650 mm. These slabs have transverse tensioning rods at 2 metre centres. The slabs have voids inside to reduce weight of the units but are solid in section at each of the transverse tensioning rod locations. There is no shear key concrete or cast-in-situ overlay accompanying these units.	
Condition state 1 – Description	**Photo**
• The units are in good condition with minor moisture staining between the slabs and white efflorescence powder. • The units may have minor faint cracking but no spalling. • The transverse rods are in good condition with no sign of corrosion.	Not available.

Condition state 2 – Description	Photo
• The units may have moderate moisture staining with stalactite growths and efflorescence powder visible but no rust staining due to corrosion of the transverse rods. • The asphalt surface may exhibit fine longitudinal cracking along the lines of these units. There may be minor cracks and spalls but no exposure of the stressing strands.	Not available.
Condition state 3 – Description	**Photo**
• The units may have medium moisture staining and efflorescence powder in the joints, along with some rust staining due to corrosion of transverse tensioning rods. • The asphalt surface may have medium cracking due to differential movement between the units or loss of tensioning force in the transverse rods. • There may be medium cracking and spalling with minor loss of section of the stressing strands due to corrosion. • Non-prestressed reinforcement may be heavily corroded with up to 20% section loss.	Not available.
Condition state 4 – Description	**Photo**
• The units may have heavy moisture staining at the transverse tensioning rods. • The asphalt surface may be badly cracked or broken along the lines of the precast units. • There may be heavy cracking and spalling with substantial loss of section of the non-prestressed reinforcement. • Stressing strands may be broken or have lost up to 10% of section due to corrosion. Transverse tensioning may be loose.	Not available.

Component 8 C – Deck/Slabs – Cast-in-situ Concrete

Units of measurement: **Square Metres**

This component includes all reinforced concrete decks cast-in-situ, including overlays cast non-composite with precast units beneath. Cast-in-situ flat slab bridges built generally pre 1949 are also included in this component.

Condition state 1 – Description	**Photo**
• The deck shows little or no deterioration though there may be some dampness and efflorescence. • Minor cracking due to corroding reinforcement may be present. • The characteristic shrinkage crack down the centre of the flat slab is fine and dry.	 Cast-in-situ RC flat slab deck in good condition.
Condition state 2 – Description	**Photo**
• Minor cracking and spalling may be present with corroding reinforcement visible. • Dampness patches and efflorescence powder may be more prominent. • The characteristic shrinkage crack along the centre of flat slab bridges is fine and dry.	 Cracking and efflorescence powder in joints indicating dampness penetrating the deck.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be present with corrosion of the reinforcement causing loss of section up to 20% in areas. • Patches of dampness and efflorescence may be large with numerous stalactites and lime flows visible. • The characteristic shrinkage crack along the centre of flat slab bridges may be medium with some moisture and staining around the crack. • Deck has extensive crazed cracking but no differential movement between honeycomb sections.	 Cracking, spalling and delamination of areas of the deck.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling may be present with advanced corrosion of the reinforcement over large areas. • The characteristic shrinkage crack along the centre of flat slab bridges may be severe with excessive moisture penetration and heavy staining around the crack. • Deck has extensive honeycomb cracking with differential movement between sections of the deck, i.e. lateral load distribution has been greatly affected.	 Heavy map cracking on underside of deck with relative movement between cracked sections. Lateral load distribution across the deck has been affected along with composite action between RSJs

Component 8 T – Deck/Slabs – Timber

Units of measurement: **Square Metres**

This component includes all types of timber decks constructed using fully treated timber and acting as a plate deck. Included in this component are nailed laminated pine decks, stress laminated timber decks and glued laminated timber sheet decks either as a longdecking or crossdecking replacement or as a span replacement.

Condition state 1 – Description	**Photo**
• The timber may have minor cracks, splits or checks but is fully protected by the preservatives, with no untreated heartwood. • The decks are well bolted to the supports. • Tensioning rods have adequate stressing and there is no damage to the timber at the stressing plates.	 Transverse 'Bridgewood' glued laminated decking in good condition.

Condition state 2 – Description	**Photo**
• Preservative protection may be beginning to dissipate with minor leaching of preservative salts (white powder on underside of deck) and with minor weathering and rot of timber. • Bolting of the deck may be slightly loose with fine reflective cracks through the asphalt on top. • Tensioning rods should still have adequate stressing and there should be no damage to the timber at the stressing plates.	 Nailed laminated pine decking showing signs of weathering and end decay.

Condition state 3 – Description	**Photo**
• Further leaching of the preservative is occurring with the timber looking well weathered and rot pockets forming. • Bolting of the decks may be loose and minor corrosion, with medium reflective cracking through the asphalt on top. • With transverse sheeting, reflective cracking may also be occurring due to differential movement between the slabs under loading, or due to inadequate bolting. • Tensioning rods may be losing stress with minor movement or separation of the laminations beginning to occur.	 Nailed laminated pine decking showing signs of separation of the laminations and some loss of preservation salts due to moisture ingress.
Condition state 4 – Description	**Photo**
• Deterioration of the timber may be well advanced with substantial loss of the preservative protection. • Weathering and rot of the timber is severe with some laminations almost rotted out. Bolting of the decks is very poor with excessive movement of the decking. • If small washers were used, the bolts may have punched through the decking which lead to loose panels. • Tensioning rods may be loose with movement and separation of the laminations. • Longitudinal cracking in the asphalt above the laminations will be seen if this is occurring. • The decking will also deflect excessively under load as the lateral distribution has been severely affected.	 'Bridgewood' decking sheets showing edge damage to top ply layers. Bolting is loose with one sheet having lost all intermediate hold down bolts.

Component 9 S – Crossbeams/Floorbeams – Steel

Units of measurement: **Each**

This component includes all steel crossbeams or truss floor beams whether painted or galvanised.

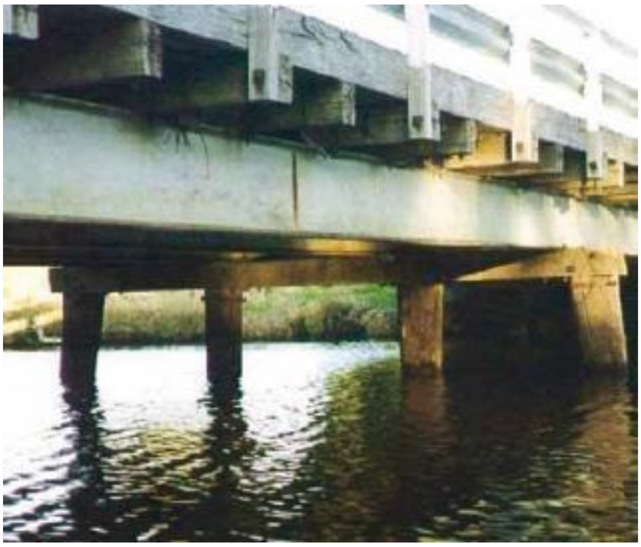
Condition state 1 – Description	**Photo**
• The paint system is generally sound with only minor chalking, peeling or curling with no exposure of the metal. • All welds or bolts are in good condition.	 Steel floorbeams in good condition with no rusting through the paintwork.
Condition state 2 – Description	**Photo**
• Rust spotting is occurring to 5% of the surface area and the paint system is no longer effective, though corrosion has not yet commenced. • All welds or bolts are in good condition, though a few of the bolts may be slightly loose.	 Steel floorbeams with spotting of the paintwork.

Condition state 3 – Description	Photo
• The paint system has broken down with rust spotting up to 10% of the surface area and some pitting is occurring, but no loss of area is occurring to affect the strength of the member as a whole. • Nuts and bolts may be corroded and may be loose. Welds to RSJ's are in good condition.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced with significant loss of section, which may affect member strength. • Nuts and bolts may be heavily corroded and no longer functioning properly. • Bolts may also be very loose or welds may be cracked. • The paint system has completely broken down.	Not available.

Component 9 T – Crossbeams/Floorbeams – Timber

Units of measurement: **Each**

This component includes all crossbeams or floor beams constructed using sawn timber sections which do not include the centre of the original log (i.e. no pipe rot).

<table>
<tr><th>Condition state 1 – Description</th><th>Photo</th></tr>
<tr><td>The timber is in good condition with only minor splits or checks having no effect on strength.
All bolted connections are tight and in good condition.</td><td>
Crossbeams in good condition with only minor weathering of the ends of the members.</td></tr>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>The timber shows signs of minor decay, splitting and checks but does not affect the strength of the members.
The tops of the member may have some moisture ingress and be wet and slightly spongy.
Bolted connections may be slightly loose.</td><td>
Crossbeam in minor decay and splitting at ends and damp from moisture ingress.</td></tr>
</table>

Condition state 3 – Description	Photo
• Medium decay, splitting and checking may be present. Moisture ingress into the top of the member has caused softness with indentations and slight bulging from the deck planks. • The strength of the member has been affected to a minor extent. • Bolted connections may be loose allowing the member to move excessively when loaded. • Member may have cracked due to overloading, ineffective support, or supports being too far apart or crossbeams being non-continuous, i.e. only two supports.	 Crossbeams badly rotting at the top due to moisture ingress.
Condition state 4 – Description	**Photo**
• The member is heavily decayed, split or rotted, with large indentations at the top along with excessive bulging due to the top being very wet and spongy. • Bolted connections are very loose and the member is moving excessively when loaded causing deterioration of the member. • The member may be cracked through due to overloading, ineffective support or crossbeams being non-continuous.	 Crossbeam completely rotted out due to moisture and white ant attack.

Component 10 T – Longdecking/Crossdecking – Timber

Units of measurement: **Square Metres**

This component includes all timber planked decking systems whether the system is longdecking or crossdecking with or without thin longitudinal running planks, though the latter system is generally to be found on lower classified roads. If timber spiking planks are used with the crossdecking, then their condition should also be considered as part of this component.

Condition state 1 – Description	Photo
• The timber is in good condition with only minor checks, splits or weathering having no effect on strength. The longdecking is tightly bolted at the ends and each alternate crossbeam. • Longdecking is continuous over at least 3 crossbeams. Crossdecking is firmly held at each stringer or spiking plank and running planks are firmly held to the crossdecking. • Crossdecking should also span across 3 supports.	 Longdecking in good condition.
Condition state 2 – Description	**Photo**
• The timber shows only minor signs of decay, weathering, splitting or checks but does not affect the strength of the members. • Bolted connections may be slightly loose or longdecking is only held down at the ends of the planks. • Crossdecking may be slightly loose or not bolted at each support. • Running planks may be slightly loose or held down at the ends only. Spiking planks are in good condition.	 Longdecking with minor signs of weathering, some splitting, checking, and a few planks slightly loose.

Condition state 3 – Description	Photo
• Medium decay, weathering, splitting or checks may be present, affecting the strength of the member to a minor extent. • Bolted connections may be loose or the longdecking may only have two supports. • Crossdecking may be rotting beneath the running planks, or may only have 2 supports, or may be allowing the member to move excessively under load. • Running planks may be split with sections broken away or the planks split in half. • The spiking planks may have minor rot, splits or are loose but still serviceable.	 Timber crossdecking in poor condition with edge rot and pipe rot.
Condition state 4 – Description	**Photo**
• The member is heavily damaged, weathered, split or rotted which affects the strength of the member. • Ends of the longdecking may be in poor condition and bolting may be completely loose allowing the member to flap up and down when loaded. • Crossdecking may be severely rotted under the longdecking or may be completely loose. • Running planks are split, broken or completely loose. • The spiking planks may be split in two and no longer effective or they may have fallen out completely.	 Timber longdeck plank almost rotted out at end.

Component 11 S – Thin Plated Deck Support – Steel

Units of measurement: **Square Metres**

This component includes a number of deck support plates made of steel or wrought iron. Included are buckle plates, usually held to the beams and braces by riveted connections, with a weak concrete and asphalt seal placed on top; heavy gauge steel corrugated decking units spanning over crossbeams with weak concrete, fill or asphalt infill material; or light gauge steel trough decking generally with asphalt infill. Not included in this component is corrugated iron sheets which are only used as formwork support and not as a structural component.

The infill or decking material should be included with this component as it greatly influences the action of the steel decking.

Condition state 1 – Description	**Photo**
• The steel is in good condition with only minor rusting at the joints. The surfacing or infill is in good condition with no cracking, rutting or potholes. • The decking units are well bolted to the support, or all rivets are good and tight. • Connections between the units are in good condition with no separation.	 Corrugated steel trough decking supporting deck material in sound condition.
Condition state 2 – Description	**Photo**
• There is rusting and minor corrosion at the joints but all bolting, tapscrew connections, welds or rivets are good and tight. • There may be minor cracking and rutting of the asphalt surface.	Not available.

Condition state 3 – Description	Photo
• Medium corrosion is occurring at the joints. • Buckle plates show moderate leakage at the joints with small stalactites forming. • With trough decking the welds between the units may have minor cracking or some tapscrews may be loose or sheared off with minor separation of the units. • The hold down of the units may be slightly loose allowing too much flexing of the sections. • Asphalt surface may have medium cracking, rutting, small broken up areas or small potholes. • Concrete infill may be breaking up allowing excessive moisture penetration.	Not available.
Condition state 4 – Description	**Photo**
• Heavy corrosion is occurring with holes appearing in the rough decking and concrete or asphalt fill above. • Trough decking units may be separating with many joining tapscrews broken or missing. • Hold down bolts may be completely loose and the sections are flexing up and down under load. • The asphalt surfacing is severely cracked, rutted, or has large badly broken areas and potholes. Rivets holding the buckle plates in position may have sheared or the edge material of the buckle plates may have sheared. • The buckle plates may have severely corroded with holes appearing. • Large stalactite growths indicate excessive moisture penetration of the severely cracked weak concrete above.	Not available.

Component 12 S – Diaphragms/Bracing – Steel

Units of measurement: **Each**

This component includes all stiffening devices for the ends of the deck and between steel girders and includes wind bracing of large girder bridges. The diaphragms may have stud connectors into the deck to support and stiffen the ends of the deck. Bracing may be simple steel rods, straps or small angles crossing between the girders, or be heavy channel connectors between the beam webs. Wind bracing may be by steel angles or steel rods.

Condition state 1 – Description	Photo
• The paintwork is generally sound with only minor chalking, peeling or curling, but no exposure of the metal. • All welds, bolts and rivets are in good condition. • Distance between adequate bracing is no more than 5 or 6 metres unless the RSJs have a composite reinforced concrete deck.	 New heavy steel connections between beams at min span.

Condition state 2 – Description	Photo
• Spot rusting of the paint system is occurring to 5% of the surface area and the system is no longer effective. • No corrosion with section loss has occurred. • No cracking of welds has occurred, but there may be some minor rusting of nuts or bolts. • Bracing may be too far apart to adequately stiffen girders, or bracing may be too light if deck is not solid.	 Rust spotting of very light steel channel and rod bracing.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- The paint system has broken down with surface rusting to 10% of the area and minor corrosion and pitting in some areas.
- Nuts and bolts may be corroded with minor loss of tension in bolt.
- Welds may be cracked with minor loss of effectiveness.
- On structures without a composite concrete deck, inadequate or lack of effective bracing between girders is affecting the lateral distribution of heavy loads between girders.
- Girders should be well braced with heavy channel connectors at approximately 5 to 6 metre centres, or if older girders, they may have angle or plate cross bracing or wind bracing to prevent lateral buckling or bowing under load.

</td><td>

Cross bracing is very rusty, connecting rivet is loose and bracing is much to light to be effective.

</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

- Corrosion is well advanced having a definite detrimental effect on the strength of the component.
- Braces have broken loose or bolts and rivets are missing.
- No bracing was supplied and girders are behaving independently with no lateral load distribution.
- The paint system has completely broken down.

</td><td>Not available.</td></tr>
</table>

Component 12 C – Diaphragms/Bracing – Cast-in-situ Concrete

Units of measurement: **Each**

This component includes cast-in-situ reinforced concrete end of deck stiffening and deep diaphragms between "I" and "T" beams. In monolithic cast-in-situ flat slab bridges this component includes the deck thickening beam at the pier supports.

Condition state 1 – Description	Photo
• The components are in good condition with only very minor fine cracking visible. • There may be minor dampness or efflorescence powder visible in a few locations.	 Deep diaphragm at mid span and small diaphragm at end of span in good condition.
Condition state 2 – Description	**Photo**
• There may be a few minor cracks or spalls due to corroding reinforcement. • End of deck stiffener may be damp and stained due to excessive moisture penetration of the deck joints, and efflorescence powder may be visible in numerous areas. • In monolithic structures there may be cracking of the tops of the columns or at the bearing areas of expansion type piers.	 Minor spall in diaphragm at pier.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Moderate cracking and spalling may be present along with possible delaminated areas due to corroding reinforcement.
Exposed reinforcement may have section loss up to 20% in isolated areas, in monolithic structures there may be medium cracking or spalling in the bearing areas of expansion type piers, or at the column/diaphragm joint of fixed type piers.</td><td>
Moderate spalling in pier diaphragm with heavy moisture penetration of diaphragm / deck join and formation of stalactites due to leaching of concrete.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Severe cracking, spalling or large delaminated areas exist with heavily corroded steel visible.
Monolithic structures may have heavy spalling in the bearing areas with loss of bearing area greater than 40%.</td><td>
Severely cracked and spalled diaphragm over column support with loss of bearing area in diaphragm.</td></tr>
</table>

Component 13 S – Load Bearing Diaphragms – Steel

Units of measurement: **Each**

This component defines those load bearing diaphragms constructed using steel which are integral with the superstructure and visible to the inspector. These diaphragms are used as a means of joining the steel girders or boxes to provide continuity over the pier supports, and the diaphragm is used to support and distribute the loads to the pier or columns below. If the load bearing diaphragm is built-in to the steel box and is not externally visible to the inspector, it should be considered as part of the superstructure and not included in this component.

Condition state 1 – Description	Photo
• The load bearing diaphragm is in good condition with no deterioration of the welds or bolts. • The paint system is in good condition with only minor chalking, peeling or curling, but with no exposure of the metal.	 Steel diaphragms in good condition.
Condition state 2 – Description	**Photo**
• Spot rusting of the paint system is occurring to 5% of the surface area. • No corrosion with section loss has occurred. • No cracking of welds has occurred, but there may be some minor rusting of nuts or bolts.	 Minor corrosion on diaphragms.

Condition state 3 – Description	Photo
• The paint system has broken down with surface rusting to 10% of the area and minor corrosion and pitting in areas. • Nuts and bolts may be corroded with minor loss of tension in the bolt. • Welds may be cracked with minor loss of effectiveness.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced having a detrimental effect on the strength of the component. • The paint system has completely broken down with corrosion and pitting in areas.	Not available.

Component 13 C – Load Bearing Diaphragms – Cast-in-situ Concrete

Units of measurement: **Each**

This component defines the load bearing diaphragms constructed using reinforced or prestressed concrete which are integral with the superstructure beams and visible to the inspector. These diaphragms are used as a means of joining precast beams to provide continuity over the pier supports, and the diaphragm is used to support the beams on the pier or columns below. Those load bearing diaphragms built-in to box girders or voided slab bridges and are not visible should be considered as part of the superstructure and are not to be included in this component.

Condition state 1 – Description	Photo
• The load bearing diaphragm is in good condition with only minor cracking due to corroding reinforcement. • The crossheads should have no flexural or shear cracking.	 I girder joined by load bearing diaphragms for continuity over the piers.

Condition state 2 – Description	Photo
• The load bearing diaphragms may have minor cracking and spalling due to corroding reinforcement. • There may be some very fine flexural or shear cracks. No stressing strands should be exposed.	 Cracking between precast girder (left) and cast-in-situ diaphragm (right), with separation of the girder from the common steel bearing plate.
Condition state 3 – Description	**Photo**
• Moderate cracks, spalls and possible delaminations may be present with exposed reinforcement being heavily corroded with up to 20% section loss. • Stressing strands may be exposed with only minor corrosion. • Flexural cracking may be medium sized but shear cracks should only be fine.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking, spalling or large delaminations may exist with heavily corroded reinforcement. • Flexural cracking may be heavy but shear cracks should only be medium sized. • Exposed stressing strands may have up to 10% section loss.	Not available.

Component 14 O – Fill/Wearing Surface – Other

Units of measurement: **Square Metres**

This component includes those structures with a fill, gravel, asphalt or spray seal over the deck. This component includes asphalt overlays which have been reinforced with fibreglass mesh or polypropylene geogrid mesh. Also included is the pavement on masonry arch bridges in which the fill forms the road surface.

This component should not be used in conjunction with culverts. Generally, the road pavement is not directly supported on the culvert rather a layer of fill. If the road pavement is in poor condition over the culvert or stock underpass, describe the problem in the Information Sheet with a component number 52 O. Do not rate the problem as 52 O.

Condition state 1 – Description	**Photo**
• The asphalt surface is in good condition with no cracking, potholes, rutting, bumps or depressions. • The surface has adequate crossfall or gradeline to efficiently drain surface water from it.	 Road pavement in good condition though gravel fill on sides has grass growth.
Condition state 2 – Description	**Photo**
• There may be minor cracking, rutting, small bumps or depressions. These irregularities cause a minor hindrance to drainage of the deck. • Potholes may be beginning to form in cracked areas. • Ride qualities are beginning to be affected.	 Minor cracking and rutting on pavement.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- Potholes, cracking, rutting, bumps or depressions are-holding moisture on the deck and allowing it to penetrate the fill.
- Ride qualities have been affected to a moderate extent.
- Deck drainage systems may be poor or inadequate.

</td><td>

Cracking, bulging, rutting and large potholes in the wearing surface.

</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

- Potholing, cracking, rutting, bumps or depressions are having a marked effect on the drainage and rideability of the asphalt surface.
- The asphalt surface may not extend full width of the bridge and may have excessive weed or grass growth, or no deck drainage has been catered for.

</td><td>

Heavy rutting along lines of the units below, heavy cracking and potholes.

</td></tr>
</table>

Component 15 – Fauna Bridge

Units of measurement: **Each**

Typical fauna bridge shown below.

Components comprise of:

- 15S steel components
- 15T timber poles
- 15C for all concrete items including anchor blocks
- 15O for ropes and netting and etc

Description	**Photo**
• Typical fauna bridge shown. Condition state guidelines and photos to be included in future updates of the manual.	 Typical fauna bridge over freeway.

Component 20 S – Crossheads – Steel (non integral with superstructure)

Units of measurement: **Each**

This component includes all crossheads, which are constructed of steel and are separate from the superstructure above. The steel may be painted or galvanised.

Condition state 1 – Description	Photo
• The crosshead has sufficient size to adequately carry the load of the superstructure and distribute it to the supporting piles or columns. • Painted surfaces should be generally sound with only minor chalking, peeling or curling, but no exposure of metal. • All welds, bolts or rivets are in good condition.	 Steel crossheads in good condition with no rusting visible.

Condition state 2 – Description	Photo
• Spot rusting is occurring to 5% of the surface area and the paint system is no longer effective. • No corrosion with section loss has occurred. • Welds are in good condition but there may be minor rusting of nuts or bolts.	 Steel crosshead with rust spotted paint system but no corrosion of the steel.

Condition state 3 – Description	Photo
• The paint system has broken down, and surface rusting to 10% of the area and minor pitting corrosion is occurring. • Nut and bolts may be corroded with only minor loss of tension in the bolt. • Welds may have faint cracking with only minor loss of effectiveness. • Crossheads may be too light to carry the loads imposed on them and may have minor bows or buckles in them.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced having a definite detrimental effect on the strength of the component. • Connecting bolts or nuts may have corroded severely, broken loose or are missing. • Crosshead size may be inadequate with large bows or buckling occurring. • The paint system has completely broken down.	Not available.

Component 20 P – Crossheads – Precast Concrete (non integral with superstructure)

Units of measurement: **Each**

This component includes all precast reinforced or prestressed concrete crossheads which are independent of the superstructure. The crossheads will have blockouts above the columns to allow for cast-in-situ full connections for transfer of load and moment to the columns or piles beneath.

Condition state 1 – Description	Photo
• There is no deterioration of the components except for possible very minor fine cracks around the situ connections.	 Precast concrete crossheads in good condition.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>

The crossheads may have a few minor fine cracks or minor spalls due to corroding reinforcement.
No stressing strands should be exposed in any spall.
There should be no moment cracking in the stressed crossheads. Reinforced crossheads may have fine moment cracking.

</td><td>

Precast concrete crossheads with minor cracking beneath beam.
</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

Moderate cracking or spalling may exist and there may be some rust staining in the cracks.
Exposed reinforcement may have up to 20% section loss in isolated areas. Exposed stressing strands may have only minor corrosion.
Stressed crossheads may have fine flexural cracking but not shear cracking.
Reinforced crossheads may have moderate flexural cracks and/or fine shear cracks

</td><td>

Moderate cracking in precast concrete crossheads with rust staining also visible in some of the cracks.
</td></tr>
</table>

Condition state 4 – Description	Photo
• Severe cracking or spalling may have occurred with large delaminated areas visible. • Loss of section of reinforcement may be greater than 20% but stressing strands should only have up to 10% loss of section. • Flexural cracking in reinforced crossheads may be severe but in stressed crossheads the flexural cracking should only be moderate. • Shear cracks may be of medium size in reinforced crossheads, or fine in stressed crossheads.	Not available.

Component 20 C – Crossheads – Cast-in-situ Concrete (non integral with superstructure)

Units of measurement: **Each**

This component defines those crossheads constructed of cast-in-situ concrete and includes the concrete capping on top of bluestone, grouted rubble or brick walls at both piers and abutments.

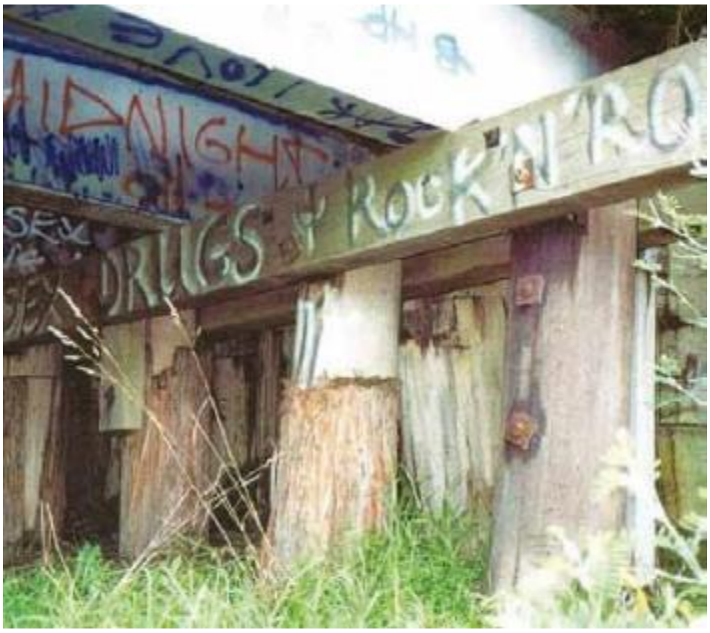
Condition state 1 – Description	Photo
• The crossheads are in good condition with only minor fine cracking due to reinforcement corrosion. • The crossheads should have no moment or shear cracking.	 Crosshead in good condition minor staining due to leaking deck joint.
Condition state 2 – Description	**Photo**
• The crossheads may have minor spalling due to corroding reinforcement or due to beam friction and bearing directly on the crosshead edges. • Some minor fine cracks due to moment or shear may exist.	 Cracking in pier crosshead due to corroding reinforcement.

Condition state 3 – Description	Photo
• Moderate sized cracks, spalls and possible delaminations may exist with exposed corroding reinforcement having up to 20% loss of section. • Flexural cracking may be medium sized but any shear cracks should only be fine.	 Severe cracking and rust staining in crosshead.
Condition state 4 – Description	**Photo**
• Severe cracking, spalling or large delaminations may exist with heavily corroded steel reinforcement. • Moment cracking may be severe whilst shear cracks may be moderate sized.	 Heavy shear cracking in crosshead.

Component 20 T – Crossheads – Timber (non integral with superstructure)

Units of measurement: **Each**

This component includes those crossheads constructed of sawn timber sections which do not include the centre pipe rot affected area of the original log. Timber crossheads at the abutments should also be included in this component due to their importance and susceptibility to deterioration.

Condition state 1 – Description	Photo
• The crossheads are in good condition with only minor weathering, splits or checks having no effect on strength. • All bolted connections are tight and in good condition with at least half the crosshead having good bearing support on the piles.	 Crosshead in good condition.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>The crossheads show signs of minor decay, weathering, splits and checks not affecting member strength. There may be minor sags in the crossheads beneath loaded RSJs.
Bolted connections may be slightly loose or the crosshead may have less than half width bearing on the piles.</td><td>
Weathering and edge rotting of crossheads. Right hand side crosshead is slightly pulling away from top of pile due to looseness of bolts.</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>The crosshead may have moderate decay, weathering, crushing at supports or splitting which may have a minor effect on member strength.
The crossheads may be sagged beneath the RSJs with minor moment cracks.
Bolted connections may be loose or crossheads may have no bearing support at the piles.
The top of the piles may be severely rotted offering little bearing support to the crosshead bolted connections, and the crossheads may be pulling off piles.
Crossheads may be spliced and the splice is in poor condition and pulling apart.</td><td>
White ant damage to rear crosshead with loss of section and strength of member.</td></tr>
</table>

Condition state 4 – Description	Photo
• The crossheads may be heavily decayed, weathered, severely split or cracked, and may have crushing at the supports. • Large sagging may be evident under RSJs and the crosshead may have moment cracking. • Bolted connections may be completely loose and the crossheads may have pulled off or almost pulled off the supporting piles. • Crosshead splices may have broken apart with loading on the unsupported cantilever crosshead section.	 End of crosshead rotten and stringer now basically supported on pile only.

Component 21 C – Crossheads – Cast-in-situ Concrete (integral with superstructure)

Units of measurement: **Each**

This component defines those crossheads using reinforced concrete cast-in-situ which is integral with both the superstructure beams and with the substructure walls or columns, especially in old monolithic "T" beam bridges.

Condition state 1 – Description	**Photo**
• The component is in good condition with only very minor fine cracking visible. • There may be minor dampness or efflorescence powder visible in a few locations.	 Integral crosshead in good condition with no cracking or staining, though beam and deck are cracked and spalled. Construction joint at underside of beam is beginning to enlarge.
Condition state 2 – Description	**Photo**
• There may be a few minor cracks or spalls due to corroding reinforcement but no structural cracking is visible. • There may be fine cracks at the construction joints at the undersides of the beams.	 Moisture and staining of crosshead due to crack at deck / crosshead joint.

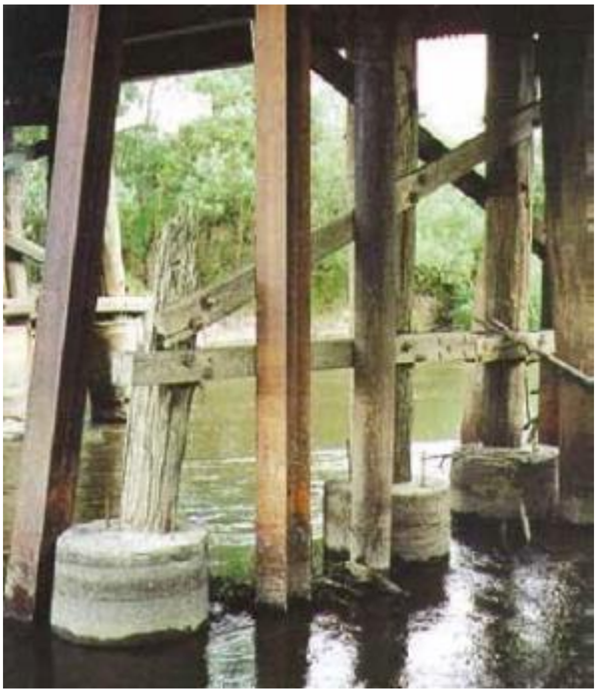
Condition state 3 – Description	Photo
• Medium cracking and spalling may exist due to corroding reinforcement and there may be fine cracking beneath supported beams. • Minor cracking may exist at the crosshead/deck joint with moisture, staining and/or efflorescence visible.	 Heavy staining, cracking and spalling at deck / crosshead joint.
Condition state 4 – Description	**Photo**
• Heavy cracking and spalling or large delaminated areas may exist with heavily corroded reinforcement visible. • Medium sized cracking may exist beneath supported beams. • Medium or heavy cracks may exist at the deck/crosshead joint due to lack of moment steel, and heavy moisture staining and efflorescence may be visible.	Not available.

Component 22 S – Column or Pile Extensions – Steel

Units of measurement: **Each**

This component includes all columns or protruding piles manufactured from steel at either abutments or piers. The steel may be painted or unpainted and should encompass footings, ties and braces which may be used to stiffen the columns or piles and to distribute loads.

Condition state 1 – Description	Photo
• The paintwork is generally in good condition with only minor chalking, curling or peeling, but no metal exposure. • The piles are adequately braced and all connections are in good condition.	 Steel columns in good order with no rust spotting of the paintwork.
Condition state 2 – Description	**Photo**
• Painted steelwork has spot rusting to 5% of the surface area and the protective coating is no longer effective. • The piles or columns may not be effectively braced or the connections may be slightly loose or corroded. • The footings, if visible, may have fine cracking or spalling. • Unpainted steel piles may be rusted.	 Rusting of steel shell piles but no corrosion.

Condition state 3 – Description	**Photo**
• Steelwork has medium corrosion and the paint system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. Bracing may be ineffective or non-existent and connections may be heavily corroded or loose. • If footings are visible they may have medium cracking and spalling or some loss of support.	 Heavy corrosion of steel H piles at water level with minor loss of section. Piles are also unbraced.
Condition state 4 – Description	**Photo**
• Steelwork is heavily corroded with up to 20% loss of section. • Footings may be heavily cracked and spalled or may have substantial loss of bearing support. • Connections may be very loose or bracing may be missing or totally ineffective. • The paint system has completely failed.	 Heavy pitting corrosion at ground level of column. Painted over but rust stains beginning to show again.

Component 22 P – Column or Pile Extensions – Precast Concrete

Units of measurement: **Each**

This component includes all columns or protruding piles manufactured from precast concrete at either abutments or piers. The precast units may be stressed or reinforced concrete and the component should encompass footings, ties or braces which may be used to stiffen the columns or piles and to distribute the load.

Condition state 1 – Description	Photo
• The piles or columns are in good condition with only minor fine cracking due to reinforcement corrosion. • There should be no moment cracking in the piles or columns. The piles are adequately braced with unsupported height less than 3.5 metres. • Footings, if visible, are in good condition.	 RC pile in good condition.

Condition state 2 – Description	Photo
• The piles or columns have fine cracking or spalling due to corroding reinforcement. • Fine moment cracking may be visible. • Stressing strands should not be exposed. • The piles or columns may not be effectively braced, or the footings, if visible, may have fine cracking or spalling.	 Minor crack in precast RC pile and in top small cast-in-place pile extension.
Condition state 3 – Description	**Photo**
• Moderate cracking and spalling due to corroding reinforcement may be visible with up to 20% loss of section of the bars. • Exposed stressing strands should only have minor corrosion. • Flexural cracking may be moderate sized especially if bracing or ties are ineffective or non-existent. • The footings, if visible, may have medium cracking or spalling.	 Moderate crack in precast pile and top area of pile close to spalling out.

Condition state 4 – Description	Photo
• Severe cracking and spalling due to corroding reinforcement may be visible with advanced corrosion of the reinforcement. • Any exposed stressing strands may have up to 10% section loss. • Flexural cracking may be severe, with bracing or ties totally ineffective or missing. • Footings, if visible, may have heavy cracking and spalling.	Not available.

Component 22 C – Column or Pile Extensions – Cast-in-situ Concrete

Units of measurement: **Each**

This component includes all cast-in-situ columns or cast-in-situ extensions on top of driven piles. This component should also encompass footings, ties or braces, which may be used to stiffen the columns or piles and to distribute loads.

<table>
<tr><th>Condition state 1 – Description</th><th>Photo</th></tr>
<tr><td>

The piles or columns show only minor fine cracking due to reinforcement corrosion.
There should be no flexural cracking in the piles or columns.
The piles are adequately braced with unsupported height less than 3.5 metres.
Footings, if visible, are in good condition.

</td><td>

Reinforced concrete columns in good condition.
</td></tr>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>

The piles or columns have fine cracking or spalling due to corroding reinforcement.
Fine flexural cracking may be visible.
The piles or columns may not be effectively braced, or the footings, if visible, may have fine cracking or spalling.

</td><td>

Minor cracking and spall of small reinforced concrete column.
</td></tr>
</table>

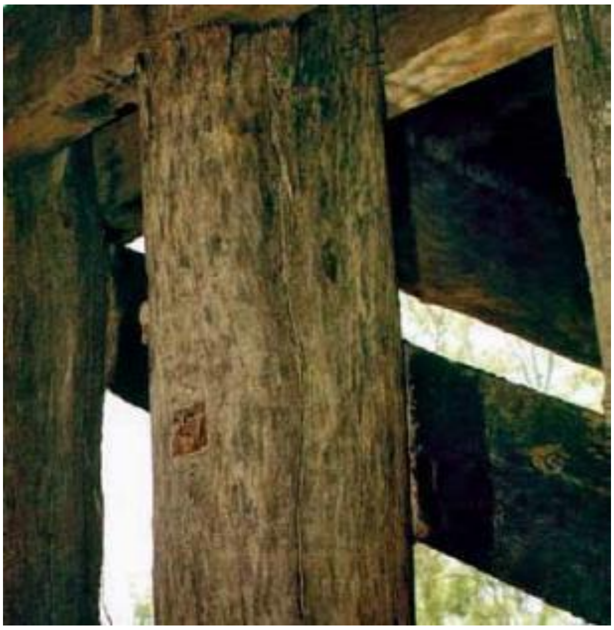
Condition state 3 – Description	Photo
• The piles or columns have moderate cracking or spalling due to corroding reinforcement with up to 20% loss of section in the steel bars. • Flexural cracking may be moderate sized, especially if the bracing or ties are ineffective or non-existent. • Footings, if visible, may have medium cracking or spalling.	 Large column with moderate cracking of a repaired delamination, extended cracking with some rust staining.
Condition state 4 – Description	**Photo**
• Severe cracking or spalling due to corroding reinforcement may be visible with advanced corrosion of the steel bars. • Flexural cracking may be severe with bracing or ties totally ineffective or missing. • Footing, if visible, may have severe cracking or spalling.	 Small column with very heavy cracking full height and rust staining in cracks.

Component 22 T – Column or Pile Extensions – Timber

Units of measurement: **Each**

This component includes all potted timber piles or columns as well as driven timber piles at both piers and abutments. Abutment wing piles however are not included in this component and should be considered in the timber abutment component. If the abutment piles have been relieved by props or potted piles then these supports should be rated rather than the original piles.

Condition state 1 – Description	**Photo**
• The piles or props are in good condition with little or no pipe rot or decay, though they may have minor cracks, splits or checks having no effect on the strength of the component. • Relieving props are well braced and have fox wedges or other systems of adjustment to account for any settlement of the bedding or footing. • This is required, especially on soft ground, to provide full support to the superstructure. • Pier piles over 3 m high are to be well braced and all connections in good condition.	 Timber piles in good condition.

Condition state 2 – Description	**Photo**
• Piles or props are in good condition though they may have up to 20% pipe rot of the diameter. • They may also have medium decay, splitting or checking but not of sufficient magnitude to affect the strength of the member. • Relieving props may be in good condition but are poorly braced or have settled slightly from beneath the beams. • Pier piles may be in good condition but may have ineffective braces or the connections may be slightly loose.	 Pile is split under the load bearing area.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Piles or props have a reasonable amount of pipe rot up to 35% of the diameter. They may also have large splits, especially under load bearing areas, heavy decay or checks, which may have a reduction in strength of the member.
Relieving props may be completely unbraced and subject to being knocked out easily, or they may have settled well away from the beam they are supposed to be supporting with load being still carried by the original pile or crosshead until very heavily loaded.
Bracing connections may be heavily corroded or be reasonably loose having little effectiveness.</td><td>
Pile has a very severe split which extends to a knot hole.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Piles or props have heavy pipe rot up to 50% of the diameter.
Splitting or decay may be severe with a definite reduction in the strength of the member.
Relieving props may be completely ineffective and offer no resistance even under heavy load.
Bracing may be missing or totally ineffective due to very loose connections.</td><td>
Pile is severely split and bulging above the walings. Only a thin shell of pile remains.</td></tr>
</table>

Component 23 C – Pier Wall – Cast-in-situ Concrete

Units of measurement: **Square Metres**

This component describes pier walls constructed using cast-in-situ concrete and includes any visible footings and any thickening at the top of the wall to accommodate the superstructure bearings. If, however, this thickening cantilevers out from the walls, it must be considered under the item for crossheads. If the pier is of a hammerhead type with large overhangs, the wall must be considered as a column and included under that item.

Piers, which have thin infill panels between columns, are not considered under this item. These piers must be considered as crosshead and column as the infill panels serve no structural purpose.

Condition state 1 – Description	Photo
• The wall is in good condition with only fine cracking due to corroding reinforcement. • Footings, if visible, are in good condition with only fine cracking. • There is no cracking due to differential settlement of the foundations.	 Pier wall in good condition.

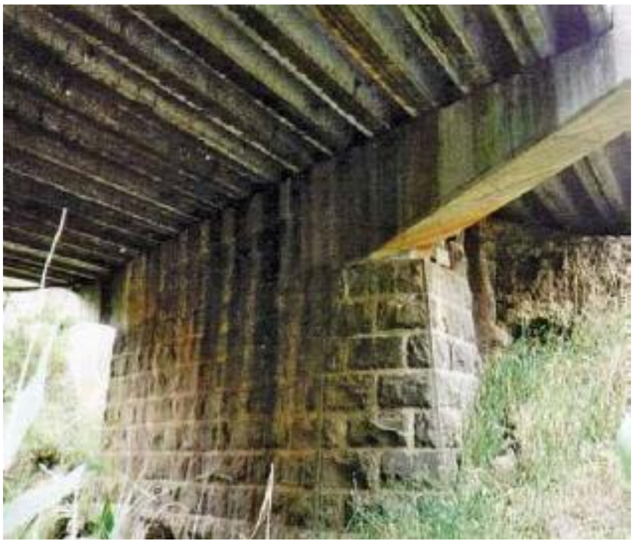
Condition state 2 – Description	Photo
• The wall may have fine cracking and spalling due to corroding reinforcement. • Footings, if visible, may have fine cracking or spalling due to corroding reinforcement or differential settlement of foundations. • Tops of the walls may have fine cracking due to friction or edge loading of beams.	 Very boney and water washed lower section of column and infill wall.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be visible with loss of reinforcement section up to 20%. • Footings, if visible, may have moderate cracking or spalling due to reinforcement corrosion or differential settlement of foundations. • Top of walls may have moderate cracking or spalling due to friction or edge loading of beams.	 Moderate cracking and spalling of pier wall columns, infill wall panels also cracked.
Condition state 4 – Description	**Photo**
• Severe cracking or spalling may be visible with advanced corrosion of the reinforcement. • Footings, if visible, may have severe cracking or spalling due to reinforcement corrosion or differential settlement of the foundations, tops of walls may have severe cracking and spalling due to friction or edge loading of the beams.	Not available.

Component 23 O – Pier Wall – Other

Units of measurement: **Square Metres**

This component describes all wall types other than concrete and includes stone masonry walls, red brick walls or grouted rubble walls. The component does not include any reinforced concrete cap on top of the walls. If bluestone blocks are used to cap the walls, those blocks could be considered in this component. Foundations, if visible, should be included in this component.

Condition state 1 – Description	Photo
• The wall is in good condition with only a few very minor fine cracks in the mortar between the bricks, stones or blocks. • There is no cracking due to differential settlement of the foundations. There should be no loss of mortar between the blocks.	 Bluestone wall with reinforced concrete cap and overhang, all in good condition.
Condition state 2 – Description	**Photo**
• The wall may have a number of fine cracks in the mortar between brick or blocks, but no cracking of the masonry. • There may be minor loss of mortar of no concern. • There may be fine cracking due to differential settlement of the foundations.	 Slight loss of mortar under bluestone sill caps and minor cracking in wall.

Condition state 3 – Description	Photo
• Moderate cracking of the mortar between the blocks may be occurring or moderate mortar loss may be occurring due to water wash. • There should be, however, be only minor mortar loss beneath any masonry capping blocks. • Medium cracking may exist due to differential settlement of the foundations.	 Brick pier cracked at the end due to edge loading, loss of mortar under bluestone sill cap and general loss of mortar between bricks.
Condition state 4 – Description	**Photo**
• The mortar and blocks may have severe cracking through them. • Mortar loss may be severe requiring pressure repointing. • Loss of mortar below masonry capping blocks may be moderate. • Differential settlement of the foundations may have caused severe cracking.	 End of pier wall lost all mortar.

Component 24 P – Abutments – Precast Concrete

Units of measurement: **Square Metres**

This component describes all precast concrete abutments or precast concrete components used in abutments. Included in this component are precast RC sheeting planks, precast RC earth retaining slabs, precast RC facing panels for reinforced soil walls (including cast-in-situ sill or ground beam on top), precast RC crib walls (including sill or ground beam on top), and precast RC crossheads where the crossheads are at ground or top of batter level. Where the crossheads are well above the ground level (height exceeding 1.0 m) with embankment supporting walls below, the crossheads must be considered under Component 20.

Condition state 1 – Description	Photo
• The units are in good condition with only minor fine cracking of no consequence. • There should be no settlement of units or gaps between units allowing loss of embankment fill to occur. • Where units form retaining walls, they must be securely positioned and have no bulging due to earth pressure.	 Precast reinforced earth panels in good condition with no cracking, spalling, settlement or bulging.

Condition state 2 – Description	Photo
• There may be fine cracking or minor spalling of the units due to corroding reinforcement or earth pressure. • There may be minor bulging or settlement of units but allowing only minor loss of embankment fill from behind.	 Precast retaining slabs with minor cracking and edge spalling.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>There may be moderate cracking or spalling of the units due to corroding reinforcement or earth pressures, moderate bulging, settlement or separation of units may be allowing medium loss of the embankment fill.</td><td>
Levelling concrete strip holding the base of the precast retaining strips has become exposed and undermined.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Severe cracking and spalling of the units may be occurring due to reinforcement corrosion or earth pressure.
Excessive bulging, settlement or separation of the units may be allowing heavy loss of embankment fill.</td><td>
Severely cracked and heavily bulged precast retaining slab.</td></tr>
</table>

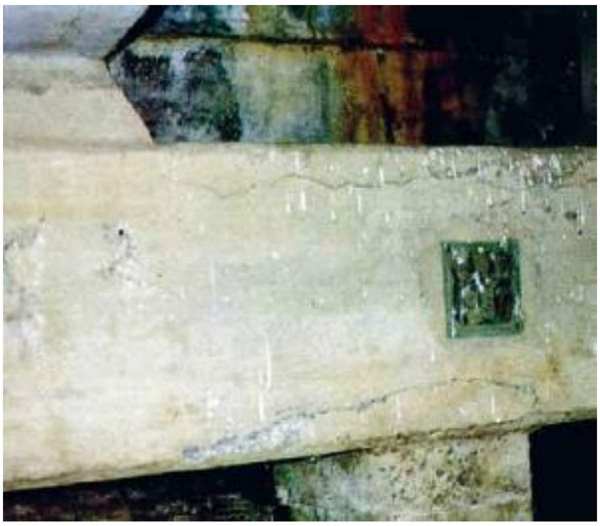
Component 24 C – Abutments – Cast-in-situ Concrete

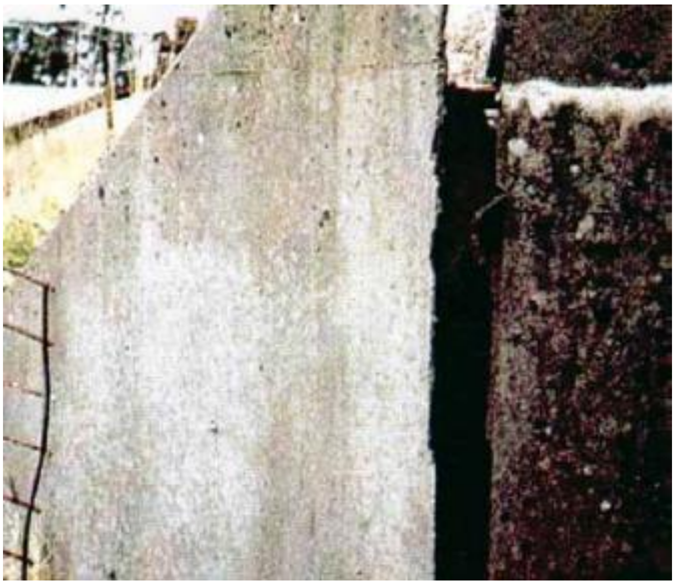
Units of measurement: **Square Metres**

This component includes all abutments constructed of cast-in-situ concrete and includes wingwalls whether attached or independent.

Where the crossheads are well above the ground level or batter level (height exceeding 1.0m) the crossheads should be considered under Component 20, and the embankment retaining wall material under Component 24.

Condition state 1 – Description	Photo
• The crossheads show only a few minor fine cracks due to corroding reinforcement. • Independent wingwalls are hard up against the abutment walls. • No flexural cracking due to earth pressures are to be found in the crossheads. The crossheads should be reasonably dry and clean.	 Reinforced concrete wall in good condition though stained due to leaking deck joint.

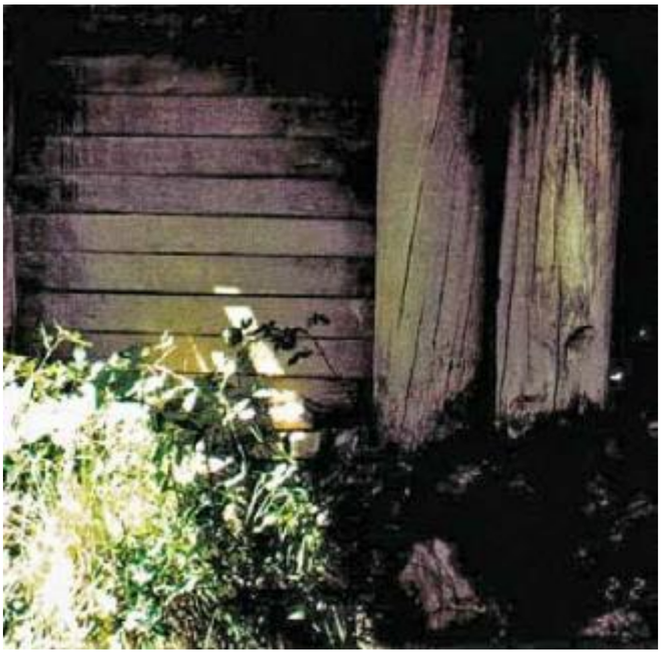
Condition state 2 – Description	Photo
• The crossheads may have fine cracking and spalling due to corroding reinforcement, or due to earth pressure, beam friction or differential movements. Crossheads should be reasonably dry and clean. • Independent wingwalls may have slight movement away from the abutments (up to 30 mm) but not enough to cause loss of embankment fill material. • Crossheads may also have fine moment or shear cracking.	 Crosshead has cracked and minor spalling due to corroding reinforcement.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be visible due to corroding reinforcement, earth pressure or frictional beam movements. • Crossheads may be damp but no heavy staining or puddles of water being retained on the crosshead. • Crossheads may have moderate moment cracks or fine shear cracks. Corroding reinforcement may have up to 20% loss of section. • Independent wingwalls may have moderate movement away from the abutments (up to 75 mm) with some loss of fill material evident.	 Cast-in-situ wingwall moved well away from abutment wall with loss of embankment fill from behind.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling may be visible due to corroding reinforcement, earth pressure or frictional beam movements. • Corrosion of the reinforcement is well advanced. • Crossheads may be very wet, heavily stained or have excessive water resting on top. • Severe moment cracking or medium shear cracks may be evident. • Independent wingwalls may have severe movement away from the abutments (over 75 mm) causing excessive loss of fill material from behind.	 Severely cracked, spalled and crumbling abutment wall.

Component 24 T – Abutments – Timber

Units of measurement: **Square Metres**

This component includes abutments where the main embankment support material consists of timber sheeting or high timber piles. Timber piles and crossheads at abutments will be considered under other substructure components because of their uniqueness. Timber sill beams resting on a concrete footing may be considered in this component as well as timber bedlogs embedded in the embankment.

Condition state 1 – Description	Photo
• The timber may have minor decay, splits or checks but is generally in good condition. • Timber wing piles are in good condition as are the wingwalls. • Concrete fender walls are in good condition with no cracking or spalling.	 Timber sheeting in good condition.

Condition state 2 – Description	Photo
• Timber units may have moderate decay, splits or checks, but are generally in good condition. • Timber wing piles may have pipe rot, top rot or medium sized splits but are still operating normally in supporting the wingwalls. • Concrete fender walls may be cracked and spalled where RSJs bear against them or have their ends cast into the fender wall, but are still retaining the embankment with no loss of fill material.	 Timber sheeting showing signs of minor rot and weathering but still in good condition.
Condition state 3 – Description	**Photo**
• Timber units may be severely decayed with sheeting planks rotted out or attacked by white ants. • Timber wing piles may have extensive pipe rot, top rot and splitting. They may have taken on a slight lean due to earth pressure on them. • Concrete fender walls may be heavily cracked and spalled with loss of embankment filling occurring. • Settlement of sheeting units may be occurring or embankment and wingwall loss of fill may be occurring due to water wash beneath the sheeting or due to sheeting rotting out.	 Fender wall with expensive pipe rot and splitting.

Condition state 4 – Description	Photo
• Timber units may be severely decayed and whole areas may have rotted out or been eaten out by white ants. • Loss of embankment fill or wingwall fill is occurring due to earth pressure or the material is being lost due to water wash at the base of the abutment or wingwalls. • Wingwalls may be in a state of collapse due to rotted supporting piles. • Concrete fender walls may be severely cracked and broken allowing heavy loss of embankment fill material.	 Rotted out timber sheeting, collapsed sheeting and washout of embankment filling behind the abutment.

Component 24 O – Abutments – Other

Units of measurement: **Square Metres**

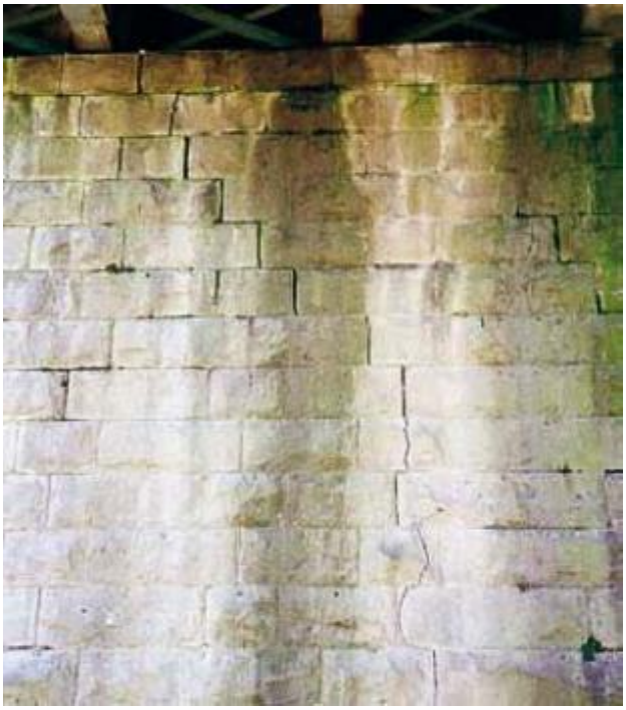
This component describes all abutment types other than concrete or timber, and includes stone masonry walls, red brick walls or grouted rubble walls. The component does not include any reinforced concrete cap on top of the walls. If bluestone blocks are used to cap the walls, the bluestone sill cap should be considered as part of this component. Foundations, if visible, should be considered as part of this component.

Condition state 1 – Description	Photo
• The wall is in good condition with only minor fine cracks in the mortar between bricks, stones or masonry blocks. • There should be no cracking due to differential settlement of the foundations, or bulging due to earth pressures on the walls. • There should be no loss of mortar between the blocks. The wall and sill cap should be reasonably dry with no staining.	 Bluestone walls in good condition.

Condition state 2 – Description	Photo
• The wall may have a number of fine cracks in the mortar but no cracking of the blocks. There may be minor loss of mortar of no concern. • Fine cracks may exist due to differential settlement of the foundations or minor bulging due to earth pressures. • The wall and sill cap should be reasonably dry. • The wingwalls may have slight movement away from the abutment but not sufficient to cause loss of embankment fill material.	 Minor loss of mortar in brick walls, especially near the water level.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

Moderate cracking of the mortar or moderate mortar loss may be occurring due to water wash.
There should be only minor mortar loss beneath any masonry sill caps. Medium cracking may exist due to differential settlement of the foundations.
Wingwalls may have moderate movement away from the abutments causing some loss of fill material.
Abutment walls may have moderate bulging due to earth pressure.

</td><td>
Heavy cracking in wall with crack through a number of stones.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

Severe cracking of the mortar or heavy loss of mortar may be occurring in the wall.
There may be medium loss of mortar beneath the masonry sill caps.
Heavy cracking may exist due to differential settlement of the foundations or bulging of the walls due to earth pressures.
Wingwalls may have severe movement away from the abutments causing excessive loss of fill material from behind.

</td><td>
Heavily cracked, dislodged, wet and crumbling stonework in the abutment wall.</td></tr>
</table>

Component 30 O – Pourable Joint Seals – Other

Units of measurement: **Linear Metres**

This component defines those joints filled with pourable joint sealant or asphalts. Materials used in pourable joints are bitumen, bitumen/cork filler in tin or copper trays, polyurethanes, 2 part pack polyester polyurethanes, rubberised bitumen, megaprene and polymer modified bitumen. Asphalt joints encompass normal asphalt, rubberised asphalts and polymer modified asphalts.

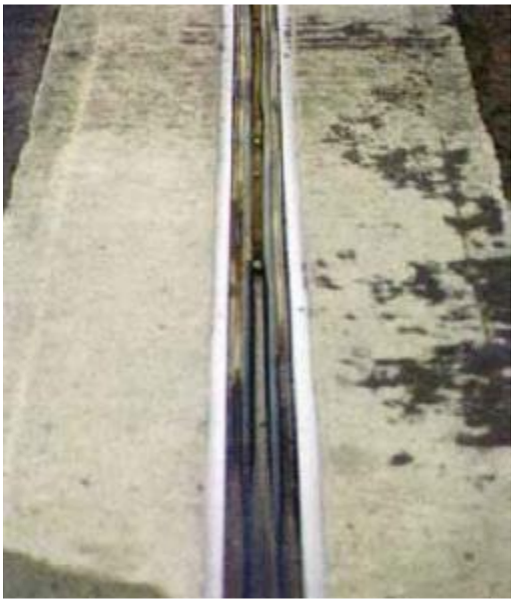
Condition state 1 – Description	**Photo**
• The seal shows little or no deterioration and completely seals the joint against moisture penetration. • There are no adhesion cracks along the sides of the joint, or any cohesion cracks due to elongation of the sealant.	 Polymer modified asphalt joint in good condition.
Condition state 2 – Description	**Photo**
• There may be minor fine adhesion and/or cohesion cracks allowing minor leakage of the joint. • The deck or asphalt adjacent to the joint may have minor spalling. • Overfilled sealer may be flowing out of the joint or may be impacted by traffic. Thin asphalt surfacing over the joint may be cracked.	 Asphalt joint repaired with rubberized bitumen in the cracks.

Condition state 3 – Description	Photo
• Adhesion and/or cohesion cracking may be moderate allowing reasonable leakage of moisture through the joint. • The adjacent deck or asphalt may have medium spalling. • Overfilled sealer may be heavily impacted by traffic and tending to rip the sealer out. • Thin asphalt surface over the joint may be breaking up with minor areas lost.	 Adhesion failure at the edge of joint, and cohesion cracking in the centre are allowing moisture to penetrate the joint.
Condition state 4 – Description	**Photo**
• The joints have completely failed allowing extensive moisture penetration. • Pourable joint sealant may be almost completely lost. • Bitumen/cork filler may be broken up and being ripped out in chunks by traffic.	 Badly cracked asphalt joint with adhesion and cohesion cracking.

Component 31 O – Compression Joint Seals – Other

Units of measurement: **Linear Metres**

This component describes all joints using preformed compression type seals such as plastic foam strips, rubber based hose joints, Wabo seals or Hercules/Honel seals.

Condition state 1 – Description	Photo
• The joint seal and its armouring (if any) are in good condition with no movement of the armouring visible, and no adhesion or sealing problems with the compression seal.	 Hercules joint seal and concrete nosings in good condition.
Condition state 2 – Description	**Photo**
• The joint may have lost adhesion with the deck or armouring in small areas allowing minor leakage of moisture. • The adjacent deck may have minor spalls or the armouring may be moving slightly with cracks developing between the asphalt surface and the steel.	 Wabo at the top of the steel angles and being impacted by traffic.

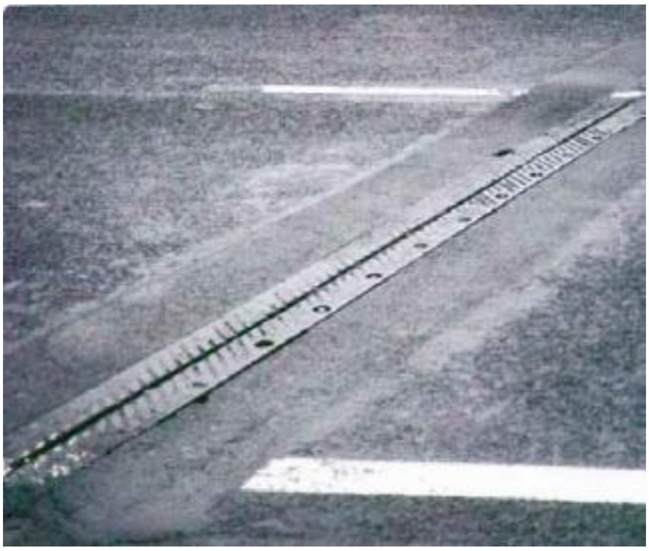
Condition state 3 – Description	Photo
• The joint may have lost adhesion over a long length allowing excessive moisture penetration. • The seal may have worked to the road surface and may be suffering damage due to traffic impact. • The adjacent deck may have moderate spalling or the armouring may be moving with the asphalt surface breaking away from the steel.	 Steel angles are moving, breaking up asphalt around them, Wabo seal is at the top of the plates and beginning to be impacted by traffic.
Condition state 4 – Description	**Photo**
• The joint may have completely lost adhesion and is no longer operative or may be lost. • Steel armouring may be moving considerably and breaking free. • The joint seal may be impacted by traffic to the extent that the seal has suffered extensive damage.	 Joint movement has far exceeded the range of the Wabo seal with subsequent complete adhesion failure. Steel armouring broken and missing.

Component 32 O – Assembly Joint Seal – Other

Units of measurement: **Linear Metres**

This component defines those joints, which have an assembly mechanism consisting of end dams bolted down to the deck with a gland or gland type seal between. Common joints, which are included in this component, are products such as Transflex, Felspan, Wabo Maurer gland seals, Cipec and Firmsec (small) joints.

Condition state 1 – Description	Photo
• The seal and anchorages are in good condition and there is no cracking of the surrounding deck, concrete nosings or asphalt.	 Seal and nosing in good condition.

Condition state 2 – Description	Photo
• There may be minor splits of the seal or gland. Some rubber may be peeling from the end dams. • Anchorages may be slightly loose and surrounding deck or concrete nosings may be cracked. • Asphalt nosings may be breaking away from the end dams, which may also be slightly higher than the approach asphalt due to slight rutting in the wheel lines. • Glands may be pulling out of their housing due to traffic impacting or poor installation.	 Asphalt nosing breaking away from Felspan seal and one bolt has failed at the end of the nearest unit.

Condition state 3 – Description	Photo
• The glands may be severely split or pulled out of their housings allowing moisture and road grit to penetrate. • Rubber may have peeled from the end dams exposing steel shims, which may be damaged by traffic. • Some anchorages may be quite loose allowing excessive movement of the end dams. • Surrounding concrete or concrete nosings may be badly cracked. Asphalt nosings may be badly rutted or cracked.	 Localized failure of Transflex joint seal with steel shim plate protruding from the rubber. The rubber is also stripping off the rear edge and there is minor fretting of the asphalt away from the expansion joint.
Condition state 4 – Description	**Photo**
• Glands may be severely damaged or completely out of their housings. • End dams may be severely damaged by traffic, or have broken loose due to anchorage failure. • Concrete nosings may be completely broken up or asphalt nosings are potholing next to the joint.	 Reinforced concrete nosing completely broken up and impact loads are occurring directly on the Felspan.

Component 33 S – Open Expansion Joint – Steel

Units of measurement: **Linear Metres**

This component defines those open expansion joints constructed with steel edge armouring and designed to allow moisture and grit to penetrate the deck, to be removed by specially designed substructure components. This component does not include those expansion joints where the expansion seals have been completely lost. Those joints should be considered under their original component with the seal in place.

Condition state 1 – Description	**Photo**
• The component shows no deterioration with the steel armouring firmly in place. • There is no cracking of the concrete block around the steel armouring. • The joint width is sufficiently wide to pass any road grit without it jamming in the joint.	 Armoured joint in good condition.
Condition state 2 – Description	**Photo**
• The steel armouring may have rust staining and/or minor corrosion but it is firmly in place. • The deck may have very fine cracking in the vicinity of the joint. Width of the joint is sufficient.	Not available.

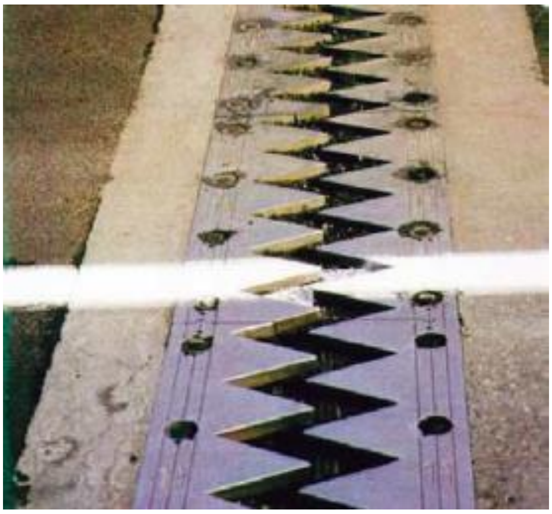
Condition state 3 – Description	Photo
• The steel armouring is showing advanced corrosion and there may be medium cracking in the deck around the joint indicating the armouring is loose due to traffic impact. • Width of joint may be small allowing road grit to jam in the joint, or joint width may be excessive allowing high traffic impact forces onto the armouring.	Not available.
Condition state 4 – Description	**Photo**
• The steel armouring may be loose due to excessive traffic impact. The deck may be heavily cracked and spalled due to the loose or broken anchorages of the armouring. • The deck joint may have closed up allowing dirt and grit to be trapped in the joint.	Not available.

Component 34 S – Sliding Joint – Steel

Units of measurement: **Linear Metres**

This component describes those joints constructed mainly of steel which move or slide over or within a mating component on the other side. The joints may have a compression seal, gland, membrane or catch drain beneath, which should be considered as part of the joint component.

Joints included in this component are steel sliding plates, steel finger joints, PSC FT joints, CIPEC and FIRMSEC (large) joints.

Condition state 1 – Description	Photo
• The component is in good condition with only minor rusting. • All hold down bolts are in good condition with no movement of the anchorages. • The joint shows no moisture penetration.	 Cipec joint in good condition with only minor faint cracking in the concrete nosing.

Condition state 2 – Description	Photo
• Minor corrosion may be showing on the steel and there may be some slight loosening of the anchorage bolts. • The adjacent asphalt may have minor cracking at the joint. • The joint may show signs of medium moisture penetration.	 Steel fingers are well raised but in good condition and meshing well.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- Heavy corrosion of the steel plates may be present, and some bolts may have failed allowing the anchorages to move.
- Cracking and minor broken up asphalt may be occurring.
- The joint may show signs of heavy moisture penetration.
- Catch drains may be full of grit etc. and may not be functioning or catch membranes may have badly deteriorated.
- Steel fingers may be rubbing due to side movement or fingers may be raised well above the mating fingers, or widening of the gap may only have the ends of the fingers in line.

</td><td>

Sliding plate joint with plate a little loose causing breakup of surrounding asphalt.

</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

- Advanced corrosion of the steel may be present and a number of bolts may have failed allowing excessive movement of the anchorages.
- The asphalt around the joint may be badly cracked and pieces breaking out.
- Steel fingers may be broken or completely apart due to excessive movement, or rotations.
- Catch drains or membranes may have completely failed or are missing.

</td><td>

Plates are loose despite additional bolts used to hold plates down. The fingers are raised well above the other meshing fingers, and the joint is raised well above the surrounding.

</td></tr>
</table>

Component 35 O – Fixed Joint – Other

Units of measurement: **Linear Metres**

This component describes those joints, which are basically fixed but may allow very small movement of 1 or 2 mm. Transversely tensioned prestressed slabs are separated at the piers by malthoid strips and a cast-in-situ concrete infill and this joint can be considered in this component.

Longitudinal deck joints, with or without a sprayed seal on top, where the decks are cast against each other or with a thin separator such as cork, bitumen impregnated fibreboard, styrene sheets or malthoid sheets are included in this component. If fill has been placed over the longitudinal joints, any defect in the road surface resulting from the joint should be considered under the item for Fill.

Moisture leakage through the joint should be considered as a defect of the joint.

Condition state 1 – Description	Photo
• The component shows no deterioration and the joint material is held firmly in place by the surrounding concrete. • There is no moisture penetration of the joint.	 Fine crack along fixed joint, crack could be sealed by hot poured bitumen or megaprene.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>Minor deterioration of the material may have occurred or the units have moved slightly allowing minor moisture leakage of the joint through the fine crack.</td><td>
Cracking at end of deck due to settlement of approach material. Cracking is allowing moisture to penetrate the joint.</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Moderate deterioration of the material has occurred due to weathering, pressure or movement of the surrounding concrete.
Moderate leakage is occurring as the joint material pulls away from the surrounding concrete.</td><td>
Poured bitumen is being lost from the joint.</td></tr>
</table>

<table>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Severe deterioration has occurred and the joint material has pulled well apart from the surrounding concrete, or the joint material has badly weathered or been lost.
Heavy leakage is occurring through the joint and may be affecting the surrounding concrete or the mortar bearings below.</td><td>
Asphalt cracking and breaking away allowing excessive moisture penetration.</td></tr>
</table>

Component 40 O – Fixed Bearings – Other

Units of measurement: **Each**

This component defines those bearings that may provide for deflection or rotation and includes steel plates bearing on concrete with or without locating pins or lugs, concrete bearing on malthoid, lead sheet or a bond breaking layer of colourless grease.

Condition state 1 – Description	Photo
• The component shows minimal deterioration with the paint system in good condition protecting the steel plates and any material allowing minor movements is in good condition and functioning properly.	 Fixed steel bearing in good condition.
Condition state 2 – Description	**Photo**
• Minor movement may have caused faint cracking in the ends of the beams due to pressure on the locating dowels. Protective paint systems may be failing allowing rusting of the metal plates. • Malthoid or lead sheets may be deteriorating or beginning to be squeezed out from beneath the beams. • Bearing support may be cracked but still basically sound.	 Lead sheet bearing is rotating and being squeezed out from beneath beams.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- Moderate movement may have caused medium cracking or minor spalling of the ends of the beams.
- Protective paint systems may have failed causing medium corrosion of the metal plates.
- Malthoid or lead sheets may well be deteriorated or up to 50% extruded from beneath the beams.
- Bearing supports may show heavy cracking, crumbling of mortar or have sizeable spalling with some reduction of bearing support area.

</td><td>

Heavy cracking at end of beam and crosshead due to excessive movement on anchor dowel.

</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

- Large movements may have caused heavy spalling of the ends of the beams.
- Steel plates may be heavily corroded due to complete loss of protective paint.
- Malthoid or lead sheets may be totally deteriorated or almost completely extruded beneath the beams.
- Bearing supports may have badly crumbled mortar or heavily spalled concrete with extensive reduction in bearing support area with possible cracking having occurred.

</td><td>

Heavily corroded fixed bearing on right and sliding plate slipping out of left expansion bearing.

</td></tr>
</table>

Component 41 O – Sliding Bearings – Other

Units of measurement: **Each**

This component defines those bearings that provide for movement by the use of a sliding mechanism. They also may have thin elastomer strips which will allow for some deflection and rotation, but the main mechanism is to allow for sliding of one surface over another with the use of copper or phosphor bronze plates, Teflon (PTFE) discs or coated sliding plates. The bearing may simply be greased surfaces with the sliding plate moving between guides in a steel base plate.

Condition state 1 – Description	Photo
• The component is in good condition with minimal deterioration. • The paint system is in good condition and sliding components are in their correct positions and appear to be working as normal. • There is minimal debris in the bearing. • Bearing support is sound with mortar or concrete uncracked and in good condition.	 Sliding plate in good condition between steel plates.

Condition state 2 – Description	Photo
• Protective paint systems may be failing, allowing rusting of the metal plates. • Sliding components may have moved excessively but the joint is still moving correctly. • Debris in the bearing or corrosion may be having a minor effect on the movement capabilities of the bearing. • Bearing support may be cracked but still basically sound.	 Thin sliding Teflon coated plate buckled, rotated and beginning to be extruded.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

Protective paint systems may have failed causing medium corrosion of the metal plates.
Sliding components may have moved excessively and are being extruded between the steel plates.
The PTFE coating is delaminating from its base plate and is buckled and being destroyed. The lubricating system may have failed and the joint is failing to operate normally.
Bearing support may show heavy cracking, crumbling of mortar or sizeable spalling with some reduction of bearing support area.

</td><td>

Phosphor bronze sliding bearing plates being extruded between bearing and sole plate.
</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

Steel plates may be heavily corroded due to complete loss of protective paint.
Sliding components may have slipped out and are no longer functional or the PTFE coating has completely delaminated, buckled and destroyed.
The lubricating system may have failed and the joint has seized and is no longer functional.
Bearing support may have badly crumbled mortar or heavily spalled concrete with extensive reduction in bearing support area, with possible crushing having occurred.

</td><td>

Sliding plate with Teflon disks completely slipped out of bearing arrangement.
</td></tr>
</table>

Component 42 O – Elastomeric/Pot Bearings – Other

Units of measurement: **Each**

This component defines those bridge bearings constructed primarily of elastomers, with or without metal shims reinforcing the elastomer. The bearings may be free to move or have anti-sliding containment or be fully contained in pot bearings.

Condition state 1 – Description	**Photo**
• The bearing shows minimal deterioration. • Shear deformations are correct for the temperatures and structural movements. • Bearing support surfaces are flat and sound with no cracking of the mortar or concrete.	 Neoprene bearings in good condition with only slight shearing.

Condition state 2 – Description	**Photo**
• The bearing may have faint cracking, splitting or signs of weathering. • Shear deformations may be large but not excessive, and the bearing is functioning normally. • Bearing support surfaces may not be flat with only partial support to the bearings, or the bearing support may be cracked but still basically sound.	 Moderate shear on bearing.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

The bearing may have slight bulges between the shims and the elastomer may have fine cracking or splitting.
Rotation or shear deformations may be excessive with rollover of the edges of the bearing.
Bearing is still functioning but is being overstressed.
Bearing support may have sizeable irregularities or spalling with loss of bearing support area.
Pot bearing may have faint cracking of the container.
Bearing may have large rotation or sliding components are showing large movements. Elastomer may be beginning to be extruded from the top of the container.

</td><td>

Twisting, shearing and faint cracking in elastomeric bearing.
</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

The bearing may have large bulging with cracking or splitting at the shims which have delaminated from the elastomer.
Shear or rotation deformations may be excessive with a sizeable reduction in the bearing area in contact with the surfaces and transferring load.
Bearing support may have heavily spalled concrete with some crushing possible.
Pot bearing container may be cracked with elastomer being extruded from the crack or through the top of the container.
Bearing may show excessive rotation or sliding components may have excessive movement and no longer functioning correctly.

</td><td>

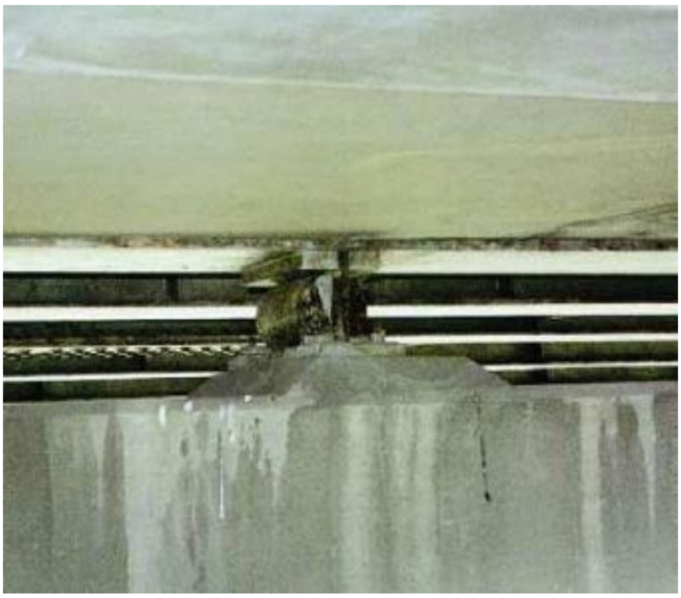
Twisting and large shear on bearing resulting in rollover of front top edge of bearing and lift off from the pedestal at the rear.
</td></tr>
</table>

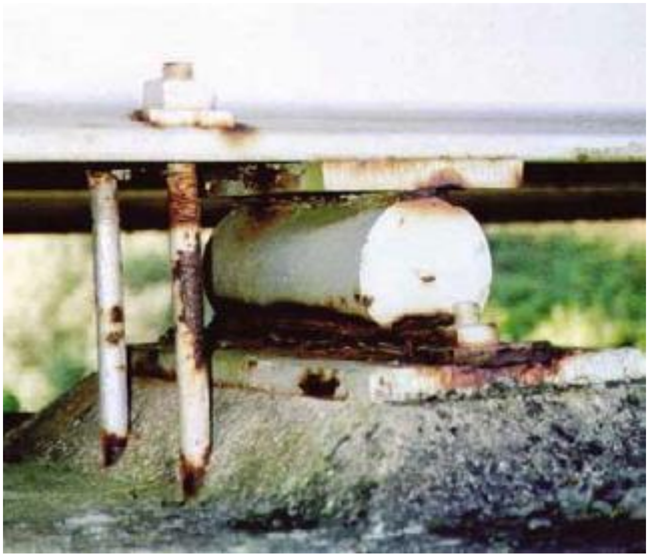
Component 43 S – Rockers/rollers – Steel

Units of measurement: **Each**

This component defines those bearings that may provide for rotation and movement by means of steel rollers or rocker mechanisms.

Condition state 1 – Description	Photo
• The component shows minimal deterioration. • The paint system is in good condition with the bearing well lubricated and functioning correctly. • Bearing support is sound with no cracking of the mortar or concrete.	 Roller bearings in good condition and well maintained.

Condition state 2 – Description	Photo
• Protective paint systems may be failing allowing rusting to 5% of the surface area of the metal. • Debris has lodged in the bearing hampering the movement or rotation of the bearing. • Rocker has rotated correctly, but not excessively, for the temperature and movements of the bridge. • Bearing support may be cracked but still basically sound.	 Roller bearings with only minor rusting.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Protective paint systems may have failed causing surface rust to 10% of the area and medium corrosion of the metal.
Debris is preventing the movement of the bearing and its correct operation. Rockers may have rotated to their tolerance limits. Bearing support may show heavy cracking, crumbling of mortar or sizeable spalling with some reduction of the bearing support area.</td><td>
Pitting corrosion and heavy rusting of rocker bearing.
Roller bearings with only minor rusting.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>The steel may be heavily corroded due to complete loss of protective paint.
Lubrication systems have completely failed and excessive debris has seized the bearing.
Rockers may have rotated to their tolerance limit and the shear key may have cracked off.
Bearing support may show badly crumbled or heavily spalled concrete with extensive rotation in bearing support areas with possible crushing having occurred.</td><td>
Corroded roller bearings completely inoperable.</td></tr>
</table>

Component 44 C – Mortar Pads/High Bearing Pedestals – Cast-in-situ Concrete

Units of measurement: Each

This component defines those bearings consisting entirely of dry pack or wet boxed mortar, or high concrete pedestals greater than the nominal 50 mm thickness, unreinforced or reinforced with distribution steel. This section does not cover the packing mortar placed under a steel bearing base plate. That mortar is covered under the relevant bearing on top of the base plate.

Condition state 1 – Description	Photo
• The component is in good condition with minimal deterioration and no cracking.	 Mortar pad bearings beneath prestressed slabs in good condition though moist and stained.

Condition state 2 – Description	Photo
• The mortar pads may show signs of minor dampness and leaching. • The pedestals may have some fine cracking due to bearing movement or edge loading, but the strength of the bearing has not been affected.	 High bearing pedestal with cracking in front face due to edge loading from bearing plate overhanging the pedestal.

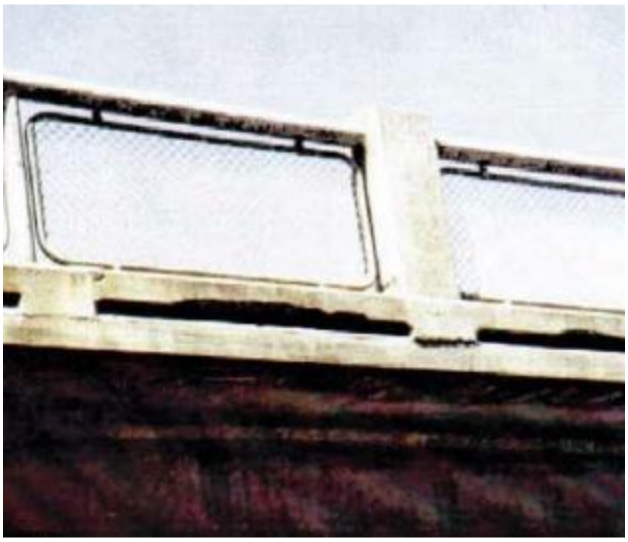
Condition state 3 – Description	**Photo**
• Heavy leaching due to excessive dampness is exhibited by the mortar pads. • The pads may also show cracking, crumbling or minor crushing of the mortar, with minor loss of bearing area.	 Mortar bearing pad breaking up beneath beam.
Condition state 4 – Description	**Photo**
• The mortar is crushing or has been lost with large subsequent loss of bearing area. • The high concrete pedestals may have heavy cracking with large spalls and subsequent loss of bearing area.	 Mortar pad lost and edge pad cracked.

Component 50 P – Kerbs/Footways – Precast Concrete

Units of measurement: **Linear Metres**

This component describes those kerbs constructed using precast concrete RC kerb units connected by small cast-in-situ infills, or footways which are constructed using precast RC slabs spanning between cast-in-situ road and outer kerbs. The kerbs or footways must consider all components making up the component as part of that component. Stepping between adjacent footing slabs is considered a problem when the height difference exceeds 10 mm.

Condition state 1 – Description	Photo
• The precast kerbs and their cast-in-situ connections are in good condition with no cracking or spalling. • Footway slabs are in good condition with only minor superficial cracking, and all units are at the same level.	 Precast RC kerb units in good condition.

Condition state 2 – Description	Photo
• Precast kerb units may have minor cracking or spalling at the joints or in the face of kerb due to corroding reinforcement. • Minor cracking and/or stepping between footway units may exist but presenting no danger to pedestrians.	 Minor spalling of rear underside of precast RC units.

Condition state 3 – Description	Photo
• Medium cracking and spalling at the kerb joints may exist. • Moderate stepping between footway slabs may present some danger to pedestrians. • Some precast slabs may be badly cracked or broken.	 Severe spalling of ends of precast kerb units and spalling of cast-in-place infill sections.
Condition state 4 – Description	**Photo**
• Kerb joints are heavily cracked and spalled affecting their operation. • Large stepping between footway slabs with numerous broken slabs presents a danger to pedestrians.	Not available.

Component 50 C – Kerbs/Footways – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component defines those kerbs or footways which are fully constructed from cast-in-situ concrete.

Condition state 1 – Description	Photo
• The slabs are in good condition with no cracking or spalling. • Footway slabs may have minor superficial cracks of no importance.	 Cast-in-place reinforced concrete kerb in good condition with no cracking or spalling.
Condition state 2 – Description	**Photo**
• Kerbs may have minor cracking or spalling due to movements or corrosion of steel reinforcement. • Footway slabs may also have minor cracks or spalls due to shrinkage, temperature, relative movement or corroding reinforcement. • Differential vertical movement between footway slabs should be less than 10 mm to present minimal danger to pedestrians tripping over.	 Minor spalling due to movement and corroding bars close to the surface

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Kerbs and footings may have moderate cracking and spalling due to movement or steel reinforcement corrosion.
Differential movement between footway slabs may have caused broken edges and vertical displacements greater than 10 mm, presenting a danger of tripping to pedestrians.</td><td>
Heavily spalled kerbs with exposed reinforcement.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Kerbs and footways may have severe cracking and spalling.
Footway slabs may be badly broken and uneven in areas or have large vertical displacements causing major danger to pedestrians.</td><td>
Posts and surrounding kerb severely cracked due to heavy vehicle impact.</td></tr>
</table>

Component 50 T – Kerbs/Footways – Timber

Units of measurement: **Linear Metres**

This component defines those kerbs or footways constructed of timber.

Condition state 1 – Description	Photo
• The timber is in good condition and firmly bolted, nailed or screwed in place. • There are no large gaps between footway timbers and ends of timbers are at a similar level.	 Timber kerbs and footways in good condition.
Condition state 2 – Description	**Photo**
• Minor decay, splitting or cracking may be present but not affecting the strength or serviceability of the timber. • A few planks may be loose but do not cause a danger to pedestrians. • Gaps or uneven timbers are small enough not to be a danger to pedestrians.	 Kerbing split and rotting at top.

Condition state 3 – Description	Photo
• Moderate decay, splitting or crushing may be present affecting the components serviceability. • Planks are generally loose and along with gaps and uneven ends of timbers present a danger of tripping to pedestrians.	 Kerb badly weathered and split
Condition state 4 – Description	**Photo**
• Severe decay, splitting or crushing may be present affecting the serviceability of the component. • Planks may be broken, missing or very loose presenting a major danger to pedestrians.	 Timber kerb severely eaten out by termites.

Component 50 O – Kerbs/Footways – Other

Units of measurement: **Linear Metres**

This component defines those kerbs or footways constructed with a gravel or asphalt or sprayed seal surface, brick or masonry blocks. Kerbs may also be in a steel plate with gravel or asphalt behind, or simply be a built up mound of asphalt.

Condition state 1 – Description	**Photo**
• The component is in good condition with only minor superficial cracking of the surface, minor rusting of the steel kerb face plate or broken masonry blocks.	 Asphalt surfacing generally in good condition and new kerb.
Condition state 2 – Description	**Photo**
• The asphalt surface may have some minor cracking, but no broken-up areas. Steel kerb face plate may be rusty but no corrosion pitting. • Masonry kerb blocks may be cracked or have minor edge spalls but still basically in fair condition.	Not available.

Condition state 3 – Description	Photo
• The kerb face plate may have moderate corrosion but still be effectively holding the footway material in place. • Masonry kerb blocks may be severely cracked and broken up but still be effectively holding the footway material in place. • Asphalt surfacing may have moderate cracking or small broken up areas.	 Kerb RSJ heavily corroded in the web and asphalt broken away at edge.
Condition state 4 – Description	**Photo**
• Asphalt surface may be severely cracked and broken up in large areas. • Steel kerb face plate may be severely corroded with holes or loss of edges. • Masonry kerb blocks may be completely broken with sections missing.	Not available.

Component 51 S – Bridge Railing/Barriers – Steel

Units of measurement: **Linear Metres**

This component defines all types of steel barrier / railing and includes rails formed from tubes, rolled hollow sections, rolled shapes or beams for road traffic, pedestrian and cyclist including the protection screens for objects falling or being thrown from bridges. It includes steel girders on railway bridges used to support the edge of the deck, and steel shields to protect against contact with electrified wires. Also included in this component are the post and endposts, which support the railing and any pedestrian grilles attached to the component.

This component does not include pedestrian mesh fencing with GWI posts and rails, nor does it include steel pedestrian grill fencing on pedestrian bridges. These should be assigned a component number 51 O.

Condition state 1 – Description	Photo
• The paint or galvanising is generally in good condition with no rusting or corrosion. • The posts supporting the rails are in good condition with no splitting of timber, corrosion of steel or cracking of concrete. • No accident damage is visible. Post spacing for guardrail are less than 2 metres.	 New steel posts and guardrail independent of steel tube rails.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>Spot rusting has formed to 5% of the surface area and the paint system is no longer effective.
Posts may have spot rusting, minor splitting of the timber or fine cracking in the concrete, but bolting or joint support is tight.
Any accident damage or vandalism is minor and of no consequence.
Post spacings for guardrail are 2½ metres or less.</td><td>
Railing is showing spot rust throughout.</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>The paint system has failed with up to 10% surface spot rusting but any minor corrosion is having minimal effect on the strength or serviceability.
Posts may also have corroding areas, loose hold down bolts, split timber or medium concrete cracking with some spalling.
Bolts holding down rails or rail joint support may be a little loose.
Accident damage has only a minor effect on strength or serviceability of the railing.
Post spacings for guardrail are greater than 2½ metres, but less than 4 metres.</td><td>
Steel railing showing moderate section loss and corrosion in areas.</td></tr>
</table>

Condition state 4 – Description	Photo
• Corrosion is advanced with loss of section affecting both strength and serviceability. • Posts may be badly corroded, become quite loose in their grouted anchorage or bolting, or heavily cracked and spalled concrete. • Rails may have broken away at their joints. • Accident damage is severe with loss of railing. • Small bridges and culverts having no railing but kerbs or endwalls at the outer edge of the pavement shoulder (or closer to the road seal) should be classified in this condition state, as steel guardrail should have been supplied Post spacings for guardrail are 4 metres or greater.	 Severe accident damage with loss of railing.

Component 51 P – Bridge Railing/Barriers – Precast Concrete

Units of measurement: **Linear Metres**

This component defines all types and shapes of railing or barriers where the main component consists of precast concrete. This item also includes any cast-in-situ concrete posts and endposts used to support the railing, cast-in-situ concrete used to join precast parapets to the deck, and any steel post and tube rails on top of the precast parapets.

Condition state 1 – Description	Photo
• The component shows only minor deterioration and the end connections or anchorage to the deck are in good condition. • Concrete posts are in good condition with no cracking or spalling. • Railings on top of the parapets are in good condition with no rusting and the bolting connections are good. • No accident damage should be visible.	 Precast concrete railing in good condition with no cracking or spalling.

<table>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>

- The rails may have minor flexural cracks or minor cracking and spalling due to corroding reinforcement.
- Rail connections and anchorages should be in good condition.
- Minor cracking and spalling of posts or joining concrete may be visible.
- Steel railing on top of the parapets may have rust spotting but connections should still be tight.
- Accident damage should be minor and of no consequence.

</td><td>

Minor cracking and spalling of posts and rails. Step in height of posts indicate a bearing problem beneath the beams.

</td></tr>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- The rails may have moderate flexural cracks or moderate cracking and spalling due to corroding reinforcement.
- Posts and parapets may have moderate cracking and spalling due to corroding reinforcement.
- Rail connections may be slightly loose and post or parapet anchorages may have minor fine cracking due to vehicle impact.
- Accident damage has only a minor effect on strength or serviceability. Steel railing on top of parapets may be corroded or have loose bolting.

</td><td>

Posts have moderate spalls which have been broken out for grit blasting and repair.

</td></tr>
</table>

Condition state 4 – Description	Photo
• The rails may have severe cracking and spalling affecting their strength and serviceability. • Posts may also have severe cracking and spalling, especially at their base, which affects their strength and serviceability. • Rails may be loose or have broken away at their connections. Severe cracking or spalling of the parapets or their anchorages may affect their strength and serviceability. • Accident damage may be severe with loss of railing, or parapets may have been knocked out of line. • Steel posts and railing on top of parapets may have been demolished.	 Severe damage to post and heavy cracking and spalling of precast concrete rails.

Component 51 C – Bridge Railing/Barriers – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component defines those bridge rails constructed using cast-in-situ concrete, and includes those rails with a concrete top rail and infill wire mesh cast into the concrete. Posts are included as part of this component.

Condition state 1 – Description	**Photo**
• The component shows only minor deterioration and the wire mesh has no rusting or corrosion. • Posts are in good condition with no cracking or spalling, and there is no accident damage visible.	 Original railing is in good condition with steel guardrail bolted to the posts as strengthening and rubbing rail.
Condition state 2 – Description	**Photo**
• The posts and rail may have minor fine cracking or spalling due to corrosion of reinforcement. • The wire mesh may be rusty but still intact. • Accident damage is minor and of no consequence.	 Minor spalling of posts and rails.

Condition state 3 – Description	Photo
• The posts and rails may have moderate cracking and spalling due to corrosion of reinforcement. • The wire mesh may be heavily rusted or corroding with small breaks in the wire. • Accident damage has only a minor effect on strength or serviceability.	 Moderate spalling and cracking due to corrosion of reinforcement.
Condition state 4 – Description	**Photo**
• The posts and rails have severe cracking and spalling affecting their strength and serviceability. • The wire mesh has severely corroded with large holes through it. • Accident damage is severe with part of the railing missing or demolished.	 Barrier severely damaged by traffic impact.

Component 51 T – Bridge Railing/Barriers – Timber

Units of measurement: **Linear Metres**

This component defines those rails constructed using timber either from a sawn section or glued laminated sections. This component also includes the supporting posts.

Condition state 1 – Description	Photo
• The component shows only minor deterioration and all the bolting is tight. No accident damage is visible.	 Timber railing in good condition with steel rubbing rail in front.

Condition state 2 – Description	Photo
• The component shows signs of minor decay, splitting or cracking but does not affect the strength or serviceability. • Bolting of the posts and rails is generally tight. • Accident damage is only minor with no effect on strength or serviceability.	 Some posts have splits and some straps holding the top rail are loose.

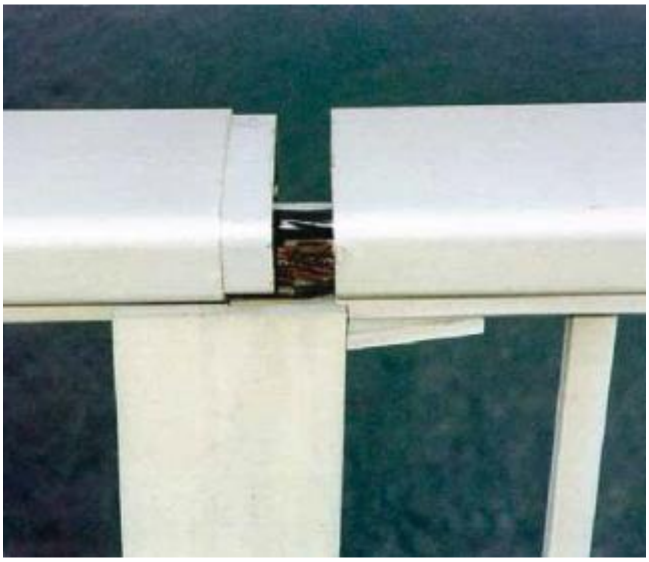
Condition state 3 – Description	Photo
• Moderate decay, splitting cracking or crushing may be present affecting the strength and serviceability of the railing to a minor extent. • Bolting may be loose in a number of areas. • Accident damage may have a minor effect on the strength or serviceability of the railing.	 Moderate decay of timber around connecting bolts and railing becoming loose.
Condition state 4 – Description	**Photo**
• Severe decay splitting cracking or crushing may be present affecting the strength and serviceability of the railing. • Bolting may be quite loose affecting the strength of the railing. • Accident damage is major affecting the serviceability of the railing.	 Top rail rotted out at connection.

Component 51 O – Bridge Railing/Barriers – Other

Units of measurement: **Linear Metres**

This component defines all types of shapes and materials other than those already covered. Included in this component are masonry parapets, aluminium rails with steel tensioning cables inside, G.W.I. pipe, post and rails, wire mesh fencing panels, wire or chain cables. The component covers any posts required to support the railing system or cables.

Condition state 1 – Description	Photo
• The component shows only minor signs of deterioration with minor cracking between masonry blocks or rusting of steelwork. • No accident damage is visible.	 GWI pipe and fence mesh in good condition though offer no protection to an errant vehicle.
Condition state 2 – Description	**Photo**
• Minor cracking, spalling, loss of mortar between masonry blocks, surface or spot rusting has occurred but having little or no effect on strength or serviceability. • Accident damage is very minor with no effect on strength or serviceability.	 Pipe and mesh fence with mesh broken in areas

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Moderate cracking, spalling, loss of mortar between masonry block, or corrosion of metal is occurring but having a minor effect on strength or serviceability.
Accident damage may have a minor effect on the strength or serviceability of the railing.</td><td>
Light aluminium railing with expanded and corroding steel tensioning cable inside top rail.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Severe cracking, spalling, loss of mortar or corrosion has a large effect on rail strength or serviceability.
Accident damage is major affecting the strength or serviceability of the railing.</td><td>
Heavy spalling of posts and two intermediate posts completely missing.</td></tr>
</table>

Component 52 O – Bridge Approaches – Other

Units of measurement: **Each**

This component defines the carriageway immediately behind the abutments, and includes such items as the wearing surface on the pavement and approach slabs if any.

Each approach must be given a single rating, and this rating will report the worst condition state applicable to that approach.

Condition state 1 – Description	Photo
• The transition between the road and bridge is smooth with no level difference, rutting, bumps, depressions cracking or potholes. • Approach slabs are in good condition and have not settled.	 Smooth, constant approach to bridge.

Condition state 2 – Description	Photo
• The approaches may have settled slightly (< 15 mm) but the transition is generally smooth with minor rutting, bumps, depressions, potholes or some minor cracking due to embankment movement. • Settling approach slabs have caused a small height difference and opened up the abutment expansion joint slightly.	 Slight rutting in wheel lines only minor settlement of approximately 5 mm.

Condition state 3 – Description	Photo
• Settlement of approaches is advancing with level difference up to 25 mm. • Rutting, bumps, depressions or potholes are affecting the rideability and transition onto the bridge. • Approach slabs may have settled substantially and rotated causing an opening of the abutment expansion joints but without failure of the joint.	 Settlement of approach 10 mm with heavy cracking and potholes beginning to occur.
Condition state 4 – Description	**Photo**
• Settlement of the approaches is pronounced with a drop in level greater than 25 mm. • The approaches may also have rutting, bumps, depressions or potholes affecting the rideability and transition onto the bridge. • Approach slabs may have settled dramatically causing rotation at the abutment expansion joint sufficient to cause total failure of the joint.	 Severe drop, rutting in the wheel path, and cracking of added on asphalt on bridge approach. Road ramps up to bridge rather than a smooth level approach.

Component 53 P – Batter Protection – Precast Concrete

Units of measurement: **Square Metres**

This component defines those bridge abutment batters protected by precast concrete units placed either separately or locked together to prevent loss of embankment fill. Small walls at the toe of the batter may be included in this item even if constructed of a different material, but high vertical or near vertical walls with an abutment on top or behind should be included under the item for abutments

Condition state 1 – Description	Photo
• The precast concrete units are in good condition with no damage, differential settlement between units or scour beneath the toe of the units.	 Precast concrete units in good condition.

Condition state 2 – Description	Photo
• There may be local minor damage to units or minor differential movement between units. • Minor local scour may be beginning to uncover the toe of the batter beaching.	 Minor local damage and settlement of precast unit.

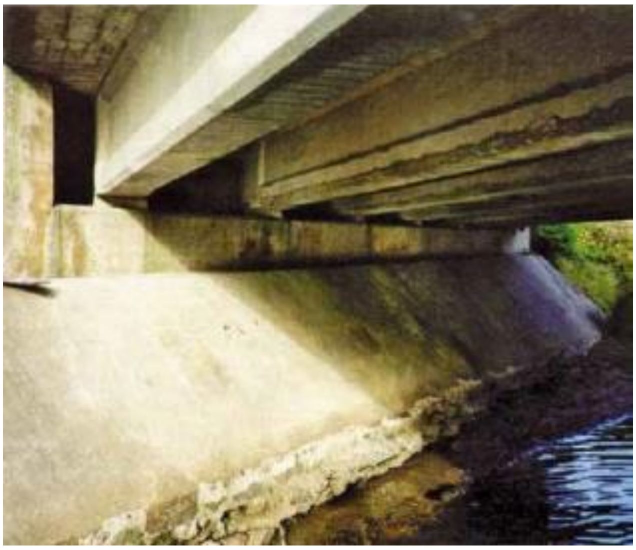
Condition state 3 – Description	Photo
• Local damage is beginning to be more pronounced and spreading to larger areas. • Differential settlement between units is more pronounced with possible loss of batter fill material from between the units. • Scouring is beginning to become a problem with the toe of the batter being eroded over reasonable length and with some possible loss of batter material from beneath the batter units. • A few units may have been lost or severely damaged.	Not available.
Condition state 4 – Description	**Photo**
• Failure of the units, extensive differential movement between units or scour of the toe of the batter has resulted in loss of whole areas of the beaching. • Severe scour has undermined the toe of the beaching and batter fill has eroded away from beneath the units.	Not available.

Component 53 C – Batter Protection – Cast-in-situ Concrete

Units of measurement: **Square Metres**

This component defines those bridge abutment batters protected by cast-in-situ concrete. Concrete may be cast in forms, pumped into a nylon fabric mattress, or sprayed on the batter with or without anchorage rods into the fill material. Small retaining walls may be used at the toe of the batter and these should be considered as part of the batter protection.

Condition state 1 – Description	**Photo**
• The batter is in good condition with no cracking or spalling noticed. • The embedded toe of the batter is in good condition with no scouring.	 Concrete batter slope in good condition.

Condition state 2 – Description	**Photo**
• Minor local cracking or spalling may have occurred or separation or movement at casting joints. • Minor local scour may be beginning to occur, uncovering part of the toe of the beaching.	 Concrete batter in good condition but minor undermining of toe of beaching.

Condition state 3 – Description	**Photo**
• Local cracking and spalling is more pronounced with small areas broken and possibly missing. • Movement at casting joints is more pronounced with possible loss of batter material from beneath the concrete. • Scouring is becoming a problem with the toe of the batter eroded over a reasonable length and possible erosion of batter material beneath the toe.	 Concrete batter has some cracking but of no concern. Toe of beaching being heavily undermined and requires repairs before loss of beaching begins to occur.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling with large broken areas or areas of missing concrete are providing erosion of batter arterial from beneath the concrete batter. • Movements at the casting joints are excessive and batter material has been eroded away. • Severe erosion has undermined the toe of the batter with loss of batter material below the concrete.	Not Available.

Component 53 O – Batter Protection – Other

Units of measurement: **Square Metres**

This component includes those batters either unprotected, grassed, protected with stone or rocks (grouted or ungrouted), stone filled cages or mattresses, stone with reinforcing mesh tied down on top, or placed fabric tied down by light wire mesh. Small retaining walls may be used at the toe of the batter and these should be included as part of the batter protection.

Condition state 1 – Description	Photo
• The unprotected batters or protected batters are generally in good condition with no scour evident. • Some of the rock beaching may have been lost from the batter and is now in the stream, but there is no scour of the unprotected areas or toe of beaching.	 Rock beaching in good condition.

Condition state 2 – Description	Photo
• There may be local damage to the protective system or minor differential settlement or movement of cages or mattresses. • Some wires may be damaged or broken with minor loss of the stone filling. • Minor local erosion or scour of the batters may be occurring or the toe of the beaching may be beginning to be uncovered.	 Minor settlement of rock mattress exposing underside of abutment crosshead.

Condition state 3 – Description	Photo
• Damage to the beaching is more pronounced and spreading to larger areas. • Wire cages are broken and heavy loss of stone filling is occurring. • The batter material is being eroded from beneath the protective system or unprotected banks are beginning to be eroded away. • The toe of the protective beaching is exposed over a sizeable length and some possible loss of the batter material is occurring.	 Scouring has removed fill in front of the abutment, just beginning to expose the foundations.
Condition state 4 – Description	**Photo**
• Failure of the beaching has allowed erosion and scouring of the banks to occur. • Severe scour has undermined the toe of the beaching and batter fill material is being eroded away. • Settlement or movement of the beaching has exposed the underside of the abutments with loss of fill material in the road embankment.	 Scour has completely removed stone beaching and fill beneath and in front of abutment.

Component 54 C – Waterway Invert Protection – Cast-in-situ Concrete

Units of measurement: **Each**

This component defines the condition of stream or channel banks and/or bed in the vicinity of the structure which have been lined with cast-in-situ reinforced concrete or mortar pumped into a nylon mattress. The component must be given a single rating only, and this rating should report the worst condition state applicable to the site.

This component does not include cast-in-situ base slabs within culverts and arches.

Condition state 1 – Description	**Photo**
• There is little or no change in channel shape or bed level at the site. • The reinforced concrete channel or aprons are undamaged with no differential settlement between slabs.	 Concrete lined channel in good condition.
Condition state 2 – Description	**Photo**
• Channel shape and bed level is unchanged but there may be cracking of the concrete or minor differential movement between the slabs.	 Large amount of movement and settlement of concrete channel at culvert entrance.

Condition state 3 – Description	**Photo**
• Differential settlement or movements have caused concrete edges to break away allowing water behind the concrete. • Some loss of fill material may have occurred.	 Differential settlement has caused concrete to crack and breakaway in channel lining
Condition state 4 – Description	**Photo**
• Large settlements or movements have severely damaged the concrete allowing large washouts beneath the concrete banks or bed.	Not available.

Component 54 O – Waterway Invert Protection – Other

Units of measurement: **Each**

This component defines the condition of unprotected or protected stream banks and bed in the vicinity of the structure. Protected banks and bed may be constructed of brick, masonry, stone filled cages or mattresses, a geotextile layer with grass, or rocks held down by wire mesh.

The component should be given a single rating only, and this rating should report the worst condition state applicable to the site.

Condition state 1 – Description	Photo
• There is little or no change in the stream shape or bed level at the site. • Protective works (if any) are in good condition with no damage visible.	 Bluestone channel in good condition.

Condition state 2 – Description	Photo
• Minor scour has only a minor effect on the stream shape and bed level at the site. • Minor settlement may have occurred or there may be minor cracking of the mortar between stones. • Rock gabions or mattresses may have lost their shape slightly but only minor loss of rock fill may have occurred. Silting from ¼ to ½ depth in culverts.	 Local scour of stream bed at pier exposing piles beneath pile cap.

Condition state 3 – Description	Photo
• Scour of the banks has altered the stream shape or the bed beneath the bridge is scouring due to inadequate waterway. • Settlement may have badly cracked mortar between blocks and a few blocks may be missing with possible loss of fill material. • Gabions or mattresses may be badly distorted with some wires broken and a moderate loss of rock filling may have occurred. • Heavy silting in the stream and overgrowth of vegetation (blackberries, rushes, reeds and etc.), such that the culvert is silted to ½ depth.	 Severe erosion of unprotected stream bed downstream of structure requiring drop structure with energy dissipaters.
Condition state 4 – Description	**Photo**
• Large settlements or movements may have severely damaged the beaching with loss of large areas of rocks, and possible large cavities due to washout of fill material. • Gabions or mattresses may be completely broken with almost total loss of rock filling. • Unprotected banks and beds may be severely scoured with loss of approach embankment occurring. • Excessive silting and overgrowth of vegetation (blackberries, rushes, reeds and etc.) have severely restricted the waterway with more than 2/3 of the culvert depth silted.	 Severe erosion of creek bed beneath abutment footing after flooding. Erosion caused by complete blockage of adjacent span with debris.

Component 55 S – Bridge Approach Barriers – Steel

Units of measurement: **Linear Metres**

This component defines the approach guardrail leading up to the bridge endposts and/or bridge railing.

Condition state 1 – Description	**Photo**
• The approach railing is in good condition with no accident damage, and is well connected to the endpost or bridge railing.	 Approach guardrail in good condition and well attached to strengthening railing on bridge
Condition state 2 – Description	**Photo**
• The approach guardrail is generally in good condition with only minor rusting and/or minor accident damage. • The railing is well connected to the endposts or bridge railing and has sufficient strength, i.e. posts closer than 2½m centres.	 Steel approach guardrail hit but still functioning.

Condition state 3 – Description	Photo
• The approach guardrail may be moderately damaged due to vehicular impact or the guardrail is poorly or not connected to the endposts but have sufficient strength with posts not greater than 2½ m spacings. • The guardrail may be heavily rusted or may be connected to the endposts but have insufficient strength with post spacings greater than 2½ m centres.	 Badly weathered timber posts and blockouts on bridge approach
Condition state 4 – Description	**Photo**
• The approach guardrail has been severely damaged, demolished, not connected to the endposts as well as having insufficient strength, or is non-existent, too low in height to be effective, has corroded through or has lost support due to rot of the timber posts.	 No approach guardrail to protect errant vehicles from hitting bridge endposts

Component 55 P – Bridge Approach Barriers – Precast Concrete

Units of measurements: **Linear Metres**

This component defines the approach barrier constructed using Precast Concrete units leading up to the bridge and / or bridge railing.

Condition state 1 – Description	**Photo**
• The approach barrier is in good condition with no accident damage, and is well connected to the bridge endpost or railing.	 Precast concrete parapets in good condition on the bridge approaches
Condition state 2 – Description	**Photo**
• The approach barrier is generally in good condition with only minor cracking, spalling or minor accident damage having no effect on the serviceability of the railing or connections to the endpost or bridge railing.	Not available.

Condition state 3 – Description	Photo
• The approach barrier may have moderate accident damage or has medium cracking or spalling which may have a minor effect on its serviceability or connection to the endpost or bridge railing. • The approach barrier may be in good condition but is not connected to the endposts and is a potential hazard.	Not available.

Condition state 4 – Description	Photo
• The approach barrier has heavy cracking or spalling, severe accident damage, has lost the connections or is unconnected to the endpost, or has moved relative to the endpost and is a hazard to any errant vehicle.	Not available.

Component 55 C – Bridge Approach Barriers – Cast-in-situ Concrete

Units of measurements: **Linear Metres**

This component defines the approach guardrail using cast-in-situ concrete leading up to the bridge endposts and/or bridge railing.

Condition state 1 – Description	**Photo**
• The approach barrier is in good condition with no accident damage and is well connected to the bridge endpost or railing.	 Appraoch barier is in good condition.
Condition state 2 – Description	**Photo**
• The approach barrier is generally in good condition with only minor cracking, spalling or minor accident damage having no effect on the serviceability of the railing or connections to the endpost or bridge railing.	Not available.

Condition state 3 – Description	Photo
• The approach barrier may have moderate accident damage or has medium cracking or spalling which may have a minor effect on its serviceability or connection to the endpost or bridge railing. • The approach barrier may be in good condition but is not connected to the endposts and is a potential hazard.	Not available.
Condition state 4 – Description	**Photo**
• The approach barrier has severe cracking or spalling, severe accident damage, has lost the connections or is unconnected to the endpost, or has moved relative to the endpost and is a hazard to any errant vehicle.	Not available.

Component 57 S – Bonded Strengthening Systems – Steel

Units of measurement: **Linear Metres**

This component includes bonded steel plates applied to prestressed concrete or reinforced concrete components.

Strengthening relies entirely on the anchorage and bond of the material to the base component and the following areas should be inspected during a site inspection:

- The ends of the strengthened area for signs of the plates debonding from the epoxy resin or the resin debonding from the concrete base.
- The concrete base at the strengthening boundary for signs of any cracking or spalling which could affect the bonding of the steel plate to the member.
- Signs of distress in mechanical anchorage systems or in parent concrete around anchorages
- General corrosion or deterioration of the parent concrete component
- Corrosion or cracking of the bonded steel plate

If any area is classified as being in condition state of 3 or 4 then a Level 3 Inspection should be conducted in the surrounding locations to determine the full extent of the problem.

Condition state 1 – Description	Photo
• The bonded steel plate system appears in good condition with no signs of distress (as indicated above) in either the base concrete, the bonding resin or in the steel plate or anchors.	 Bonded steel plate and anchors in good condition.

Condition state 2 – Description	Photo
• Small delaminations of less than 50mm in length may be evident and there may be a fine crack across the end of the plate or fine cracks in the resin or concrete base material, i.e. there is a minor initial breakdown of the system.	Not available.
Condition state 3 – Description	**Photo**
• A delamination of approximately 300 mm in length, or a series of delaminations totalling 1m should be reported as being in condition state 3. • The end of the plate has begun to debond or the plate and epoxy have begun to separate from the base concrete. • Cracking is more pronounced along the base concrete/ epoxy resin interface, or along the plate/ epoxy resin interface.	Not available.
Condition state 4 – Description	**Photo**
• Larger delaminations (i.e. more than 300 mm in length, or a series of delaminations totalling more than 1 m) will affect structure capacity. • Cracking along the interfaces between plate, resin and/or the base concrete is severe and some cracking may be occurring in the base concrete in the vicinity of the plate or anchors.	Not available.

Component 57 O – Bonded Strengthening Systems – Other

Units of measurement: **Linear Metres for FRP Strips /m2 for Fabric**

This component includes all bonded Fibre-reinforced Polymer (FRP) strip and fabric strengthening systems applied to prestressed or reinforced concrete components. The use of FRP by DoT has almost always been limited to Carbon Fibre-reinforced Polymer (CFRP) materials.

Strengthening relies entirely on the anchorage and bond of the material to the base component and the following areas should be inspected during a site inspection:

- The ends of the strengthened area for signs of the strips peeling from the epoxy resin or the resin debonding from the concrete base.
- The concrete base at the strengthening boundary for signs of any cracking or spalling which could affect the bonding of the FRP to the member.
- Delamination of the strengthening from the base concrete in other areas, or kinks in the material, air bubbles, bulging or waviness.
- Tears, cuts or crazing of the FRP material.

If any area is classified as being in condition state of 3 or 4 then a Level 3 Inspection should be conducted in the surrounding locations to determine the full extent of the problem.

Condition state 1 – Description	Photo
• The CFRP appears in good condition with no signs of distress (as indicated above) in either the base concrete, the bonding resin or in the FRP material.	 Bonded CFRP fabric strengthening on soffits of reinforced concrete beams in sound condition with no evidence of bubbles or peeling at ends of along edges

Condition state 2 – Description	Photo
• Small delaminations of 150 square mm are acceptable provided they form less than 5% of the laminate area. • There may be a fine crack across the end of the laminate or fine cracks in the resin or concrete base material, i.e. there is a minor initial breakdown of the system.	Not available.
Condition state 3 – Description	**Photo**
• A delamination of approximately 2,500 square mm, or a series of delaminations totalling 10,000 square mm should be considered as being in condition state 3. • The end of the laminate has begun to peel, or the laminate and epoxy has begun to tear from the base concrete. • Cracking is more pronounced along the base concrete/ epoxy resin interface, or along the laminate/ epoxy resin interface.	Not available.
Condition state 4 – Description	**Photo**
• Larger delaminations (i.e. more than 2,500 square mm, or a series of delaminations totalling more than 10,000 square mm) will affect structure capacity. • Cracking along the interfaces between laminate, resin and/or the base concrete is severe and some cracking may be occurring in the base concrete in the vicinity of the FRP.	Not available.

Component 58 S – Protective Coatings for Open Girders/Stringers Steel

Units of measurement: **Each**

This component includes protective coatings on all girders constructed of wrought iron or steel. The girders may be rolled sections, welded plate girders, riveted girders constructed of plates and angles, or lattice girders using flat sections crossing each other to form the vertical web/webs.

Condition state 1 – Description	**Photo**
• The paint system is generally sound with only minor chalking, peeling or curling, but with no exposure of metal.	 Painting system has recently been replaced and in an excellent condition.
Condition state 2 – Description	**Photo**
• Spot rusting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion of the section has occurred.	Not available.

Condition state 3 – Description	Photo
• Some surface pitting may be present with active corrosion occurring in isolated areas. • The paint system has broken down with rust spotting to 10% and surface pitting. • Nuts and bolts may be corroded.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced. Rivets or bolts may be severely corroded. • The paint system has completely broken down.	Not available.

Component 59 C – Deflection Walls – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all deflection walls for railway overpass bridges and constructed using cast-in-situ reinforced concrete.

Condition state 1 – Description	Photo
• The components are in good condition with no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • There is no settlement, sliding, bulging or tilting of wall facing systems.	 Concrete deflection walls in good condition.

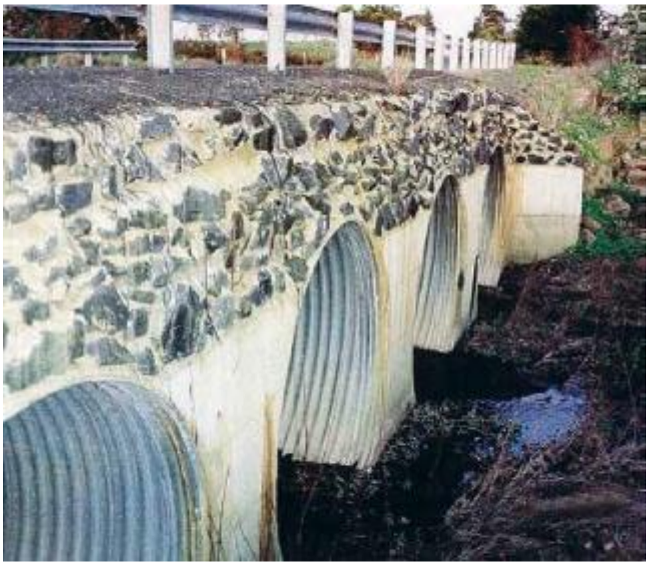
Condition state 2 – Description	Photo
• The components have fine cracking or spalling due to corroding reinforcement. • Minor sections of wall are showing dampness or efflorescence. • There is no settlement, sliding, bulging or tilting of wall facing systems.	Not available. .

Condition state 3 – Description	Photo
• The components have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Moderate sections of wall are showing dampness or efflorescence. • There is up to 20 mm settlement, sliding, bulging or tilting of wall facing systems.	Not available.
Condition state 4 – Description	**Photo**
• The wall facing system have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is more than 20 mm settlement, sliding, bulging or tilting of wall facing systems.	Not available.

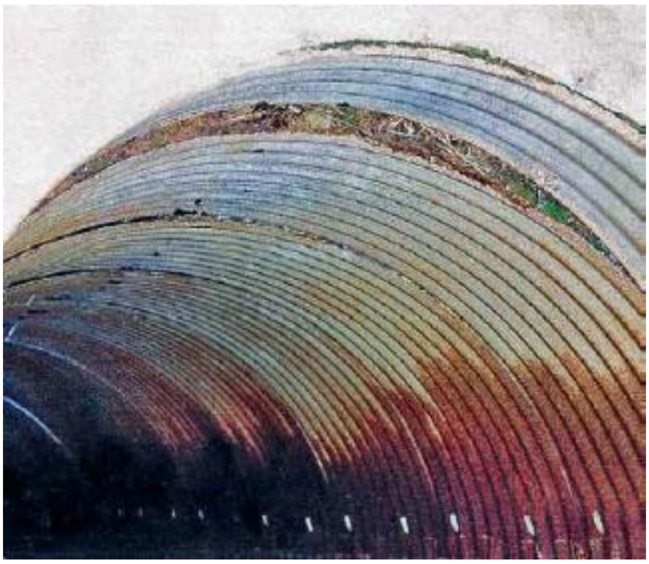
Component 60 S – Pipe Culverts – Steel

Units of measurement: **Linear Metres**

This component includes all steel pipes, painted or galvanised, circular, elongated or elliptical.

Condition state 1 – Description	Photo
• There is no evidence of rust or corrosion and the paintwork or galvanising is in good condition. • The line and invert of the pipe is straight with no water being retained in the pipe.	 Steel pipes in good condition.

Condition state 2 – Description	Photo
• Surface or spot rusting may be evident and the paint system is no longer effective. • No corrosion with section loss has occurred. • The line of the pipe is straight, but minor settlement may be allowing some water to be retained in the pipe.	 Rusting of steel pipe especially at water level.

Condition state 3 – Description	Photo
• The paint system has failed and pitting corrosion is prominent especially at normal water level. • Loss of section has occurred but there is still adequate section left to not affect serviceability of the pipe. • There may be some deviation of the line of the pipes due to local buckling, or moderate settlement of the pipe may be allowing a significant amount of water to be retained in the pipe.	 Rusting of steel pipe with broken concrete in invert. Pipe has sagging under roadway and holds silt and water in it.
Condition state 4 – Description	**Photo**
• Heavy corrosion is occurring and the invert of the pipe may have corroded out in areas. • There may be large deviation of line of the pipe due to buckling of plates or plates may have crinkled at the bolt line in large diameter pipes. • An excessive amount of water may be retained in the pipe. • Bolts may have torn through the plates or split the plate edges allowing differential movement and buckling of plates.	 Pipe has heavy rusting and corrosion in invert. Pipe sections are separating allowing embankment fill to be lost.

Component 60 P – Pipe Culverts – Precast Concrete

Units of measurement: **Linear Metres**

This component includes all precast concrete pipes and includes the jointing arrangements between them.

Condition state 1 – Description	**Photo**
• The component may show only minor superficial cracking of no consequence. • The line and invert of the pipe is straight with no water being retained within the pipe.	 Precast concrete pipes in good condition and functioning well.
Condition state 2 – Description	**Photo**
• The component may show minor cracking or spalling due to corroding reinforcement in isolated areas. • The line of the pipe is straight but minor settlement of some units may be allowing a minor pool of water to be retained in the pipe.	 Fine cracking and rust stains.

Condition state 3 – Description	Photo
- Moderate cracking, spalling or delaminated areas may be present in areas, having a minor effect on strength and serviceability of the pipe. - Deviation of the line of the pipes may be occurring or moderate separation and settlement of units may be allowing a significant amount of water to be retained in the pipe or to leak out at the separated joints.	Not available.
Condition state 4 – Description	**Photo**
- Severe cracking, spalling or delaminated areas may be present having a pronounced effect on the strength and serviceability of the pipe. - Pipe line deviation, separation or settlement may be excessive allowing a significant amount of water to be retained in the pipe, or to leak out at separated joints.	Not available.

Component 60 O – Pipe Culverts – Other

Units of measurement: **Linear Metres**

This component includes all pipes of circular or elliptical construction consisting of masonry, red bricks or plastic.

Condition state 1 – Description	**Photo**
• The component shows little or no deterioration with only minor areas of dampness or efflorescence. • There is no cracking or loss of mortar between the blocks. • Pipe shape, line and invert level is good and straight. No water is retained in the pipe.	 Brick pipe culvert in good condition. (Cracking in endwalls reported in Component 63 O).
Condition state 2 – Description	**Photo**
• There may be minor cracking or loss of mortar between blocks but not sufficient to affect the strength of the pipe. • The plastic may have a few superficial splits of no importance. Shape of the pipe is good and the line of the pipe is straight. • Minor settlement of the pipe may be allowing a small pool of water to be retained in the pipe.	 Minor cracking and mortar loss.

Condition state 3 – Description	Photo
• Moderate cracking or loss of mortar between the blocks may have occurred, Minor loss of pipe shape or bulging of the walls may have occurred, with splitting of the plastic. • The line of the pipe may have minor deviations, or moderate settling may be allowing a significant amount of water to be retained in the pipe.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking or loss of mortar has occurred between blocks and some blocks may have slipped. • Loss of shape, bulging of walls, splitting of plastic, deviation of pipeline or settlement of the invert is excessive and is affecting the strength and serviceability of the pipe. • An excessive amount of water is retained in the pipe or is leaking out through the joints.	Not available.

Component 61 P – Box Culverts – Precast Concrete

Units of measurement: **Linear Metres**

This component includes all box culverts constructed using precast concrete. Included in this component are the small precast U shaped culverts with precast lids on top, crown units, link slabs between crown units, precast and cast-in-situ base slabs.

Condition state 1 – Description	**Photo**
• The component shows little or no deterioration with only a few minor fine superficial cracks of no importance. • There may be minor efflorescence especially on the underside of the culvert roof or near the unit joints.	 Precast concrete crown units with alternate link slabs between the units. Units are in good condition.
Condition state 2 – Description	**Photo**
• Minor cracking and spalling may be evident along with moderate efflorescence. • The crown units or U shaped culverts may have edge spalling due to the presence of excess moisture. • The U-shaped culverts may have minor spalling of the base or there may be minor level differentials of up to 5 mm in the inverts.	 Small inverted crown units with precast concrete lids. Minor spalling of culvert legs due to lack of concrete cover.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be evident along with small delaminated areas, especially in the precast lids on U-shaped culverts. • Edge spalling of units may be more prominent and level differential may be up to 10 mm in the inverts.	 Spalling in base of small precast culverts along with differential settlement and movements between units under traffic.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling may be evident along with possible large delaminated areas. • Edge spalling of units may be severe as well as large differential settlements between U shaped units, especially under heavy loaded wheel lines on major highways.	 Delamination of cover concrete and severe corrosion of reinforcement in precast concrete culvert lid

Component 61 C – Box culverts – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all monolithic cast-in-situ reinforced concrete box culverts usually built pre 1950.

Condition state 1 – Description	Photo
• The component shows little or no deterioration with a few minor fine superficial cracks and minor efflorescence.	 Cast-in-situ box culvert in good condition.
Condition state 2 – Description	**Photo**
• Minor cracking and spalling may be evident along with a moderate amount of efflorescence in areas. • Construction joints at the top of the walls may be opening up slightly or weathering at the joint.	 Minor cracking on cast-in-situ box culvert wall extending to roof.
Condition state 3 – Description	**Photo**

• Moderate cracking and spalling may be evident. • Excessive efflorescence may be noticed with areas of delamination of the concrete cover in the underside of roof or outer walls especially. • Corroded steel may have up to 20% section loss in areas.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling may be evident with large areas of delamination. • If cut off walls are not constructed at each end of the base slab then erosion of the sub base material may have occurred with some flow beneath the base slab. • In this case the base slab may sound hollow when struck with a hammer or piece of timber.	Not available.

Component 61 O – Box Culverts – Masonry

Units of measurement: **Linear Metres**

This component describes all culvert types other than concrete and includes stone masonry walls, red brick walls or grouted rubble walls. The component does not include any reinforced concrete cap on top of the walls. If bluestone blocks are used for the obvert, the bluestone blocks should be considered as part of this component. Foundations, if visible, should be considered as part of this component.

Condition state 1 – Description	**Photo**
• The wall is in good condition with only minor fine cracks in the mortar between bricks, stones or masonry blocks. • There should be no cracking due to differential settlement of the foundations, or bulging due to earth pressures on the walls. There should be no loss of mortar between the blocks. • The wall and sill cap should be reasonably dry with no staining.	 Culvert is in good condition after mortar repairs.
Condition state 2 – Description	**Photo**
• The wall may have a number of fine cracks in the mortar but no cracking of the blocks. There may be minor loss of mortar of no concern. • Fine cracks may exist due to differential settlement of the foundations or minor bulging due to earth pressures. • The wall and sill cap should be reasonably dry. • The wingwalls may have slight movement away from the abutment but not sufficient to cause loss of embankment fill material.	Not available.

Condition state 3 – Description	Photo
• Moderate cracking of the mortar or moderate mortar loss may be occurring due to water wash. • There should be only minor mortar loss beneath any masonry sill caps. • Medium cracking may exist due to differential settlement of the foundations. • Wingwalls may have moderate movement away from the abutments causing some loss of fill material. • Abutment walls may have moderate bulging due to earth pressure.	 Moderate mortar loss and wall bulging due to earth pressures.

Condition state 4 – Description	Photo
• Severe cracking of the mortar or heavy loss of mortar may be occurring in the wall. • There may be medium loss of mortar beneath the masonry sill caps. Heavy cracking may exist due to differential settlement of the foundations or bulging of the walls due to earth pressures. • Wingwalls may have severe movement away from the abutments causing excessive loss of fill material from behind.	Not available.

Component 62 S – Arch Culverts – Steel

Units of measurement: **Linear Metres**

This component includes all arches used for stream flow or cattle underpasses and constructed of galvanised steel with concrete strip footings. If a cast-in-situ concrete floor has been constructed, it should be considered as part of this clement.

Condition state 1 – Description	**Photo**
• The component shows no sign of deterioration of the metal or galvanising. • Bolts connecting the multiplates are tight and in good condition. • The concrete at the base of the arch is in good condition with no cracking or spalling. Shape, line and level of the arch are good.	 Steel arch subway culvert in good condition with no corrosion visible
Condition state 2 – Description	**Photo**
• Spot rust may be occurring but all connecting bolts are tight and in good condition. • Concrete footing may have minor cracking or spalling of no concern, though there should be no cracking to differential settlement of the footing. • Shape, line and level of the arch are good.	 Corrosion at the base of the corrugated metal arch due to water and debris collecting in the concrete ledge

Condition state 3 – Description	Photo
• Rusting and minor corrosion may be occurring in areas having only a minor effect on the strength or serviceability of the member. • The plate around some bolts may be damaged or torn allowing some looseness in the bolts. • The arch may have developed a small fiat spot due to movement or differential settlement of the foundations. • Foundations may have moderate cracking and spalling due to corroding reinforcement or have cracking due to movement or settlement of the footing.	Not available.

Condition state 4 – Description	Photo
• Severe rusting and corrosion may be occurring to the extent that they are having an effect on the strength or serviceability of the arch, especially at the joint to the foundations. • Plates may have moved and bolts may have torn or pulled through the plates. Plates may have crinkled at the bolt line or badly bulged due to earth pressure, with the shape of the arch badly distorted. • The concrete footings may have severe cracking and spalling due to corroding reinforcement or may have moderate cracking due to movement or differential settlement.	Not available.

Component 62 P – Arch Culverts – Precast Concrete

Units of measurement: **Linear Metres**

This component includes precast concrete arches such as Bebo arches, Techspan and other 3 hinged arches. If cast-in-situ concrete floors have been constructed, they should be considered as part of this component.

Condition state 1 – Description	Photo
• The component shows little or no deterioration with only minor efflorescence or minor fine superficial cracking of no consequence. • Shape, line and level of the arch units is good and straight. The concrete footing and base slab are in good condition with no cracking or spalling.	 Three hinged precast concrete arch in good condition

Condition state 2 – Description	Photo
• Minor fine cracking and spalling may be evident due to corroding reinforcement in isolated areas. • There may be fine cracking or moisture penetration around the hinge areas with moderate efflorescence powder visible. • Shape, line and level of the arch units should be good and straight. • The footing may have fine cracking and spalling due to corroding reinforcement, but no cracking due to movement or differential settlement.	Not available.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be evident with up to 20% loss of section of exposed reinforcement. • The shape and line of the arch may show some deviation due to movement or differential settlement, with minor spalling at the hinge points. • The footing may show fine cracking due to movement pressures or differential settlement.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling may be evident with large delaminated areas. • The shape and line of the arch may show a dip due to movements and differential settlements with medium to heavy spalling around the hinge points. • The footing may have moderate cracking due to movement pressures or differential settlement.	Not available.

Component 62 C – Arch Culverts – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all cast-in-situ concrete arches and includes the footings and any concrete floor in the culvert.

Condition state 1 – Description	**Photo**
• The component shows little or no deterioration with only minor fine superficial cracks and minor areas of efflorescence. • Shape, line and level of the arch units is good and straight. • The concrete footing and base slab have no cracking or spalling.	 Cast-in-situ concrete arch culvert in good condition
Condition state 2 – Description	**Photo**
• Minor fine cracking and spalling may be evident due to corroding reinforcement along with moderate efflorescence due to moisture penetration of the concrete. • Shape, line and level of the arch should be good and straight. • The footing should have no cracking due to movement or differential settlement.	 Cast-in-situ arch culvert with fine cracks and slight shape loss.

Condition state 3 – Description	Photo
• Moderate cracking and spalling may be evident due to corroding reinforcement with up to 20% loss of steel section in isolated areas. • Efflorescence and scaling of the concrete surface may be prevalent along with small delaminated areas. • The shape and line of the arch may show some deviation due to movement or differential settlement. • The footing may have fine cracking due to movement or differential settlement.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling is evident with large delaminated areas. • Severe scaling of the concrete surface and efflorescence may be noticed. • The shape and line of the arch may show a dip due to movements and differential settlement of the medium cracked foundations.	Not available.

Component 62 O – Arch Culverts – Other

Units of measurement: **Linear Metres**

This component includes those arch culverts constructed using brick or masonry, with or without a base slab, which should be considered as part of the component.

Condition state 1 – Description	Photo
• The component shows little or no deterioration with no cracking or loss of mortar. • There may be small areas of dampness or efflorescence. • The shape, line and invert of the arch are good and straight.	 Masonry arch culvert in good condition.
Condition state 2 – Description	**Photo**
• There may be minor loss of mortar or cracking of the mortar between the blocks. • The shape, line and invert of the arch should be in good condition. Large areas of dampness and efflorescence may be present. • There should be no differential settlement of the arch footings.	 Crack and minor loss of mortar between stones in roof of masonry arch culvert.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>There may be moderate loss of mortar or cracking of the mortar between the blocks.
There may also be cracking due to minor differential settlement of the foundations and some blocks may have slipped slightly due to the movement and loss of mortar.
There may be some minor loss of arch shape, line or level, but not of sufficient magnitude to cause concern for the strength or serviceability of the culvert.</td><td>
Heavy cracking in roof of brick arch culvert and excessive white efflorescence powder visible due to dampness penetration.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>There may be severe loss of mortar and/or cracking between and through the blocks, with some blocks having slipped significantly.
There may be moderate cracking due to differential settlement of the foundations, with significant loss of shape, line and level of the arch, causing some concern as to the strength or serviceability of the culvert.</td><td>
Complete loss of mortar has caused stone to drop in masonry arch culvert roof. Stone is also cracked through its centre at birds nest location.</td></tr>
</table>

Component 63 P – Endwalls/Wingwalls – Precast Concrete

Units of measurement: **Linear Metres**

This component includes all culvert endwalls, wingwalls and concrete aprons associated with culverts and constructed using precast reinforced concrete.

Condition state 1 – Description	**Photo**
• The components are in good condition with no cracking or spalling noticed. • There should be no movement or movement cracking in the endwalls or wingwalls.	 Precast wingwalls in good condition.
Condition state 2 – Description	**Photo**
• There may be minor cracking and spalling due to corroding reinforcement or due to earth pressures. • The endwalls or wingwalls may show minor movements of up to 30 mm which are of no consequence.	Not available.

Condition state 3 – Description	Photo
• There may be moderate cracking and spalling due to corroding reinforcement or due to earth pressures. • The endwalls or wingwalls may show moderate movements of up to 75 mm but having little effect on serviceability.	Not available.
Condition state 4 – Description	**Photo**
• There may be severe cracking or spalling due to corroding reinforcement or due to earth pressures. • The endwalls or wingwalls may show large movements over 75 mm, or the wingwalls may be leaning due to earth pressure on them, with possible loss of embankment fill behind.	Not available.

Component 63 C – Endwalls/Wingwalls – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all culvert wingwalls, endwalls and concrete aprons associated with the culverts and constructed using cast-in-situ reinforced or mass concrete.

Condition state 1 – Description	Photo
• The components are in good condition with no cracking, spalling, movement or movement cracking in the endwalls or wingwalls.	 Concrete culvert endwall and wingwall in good condition.

Condition state 2 – Description	Photo
• There may be minor cracking and spalling due to corroding reinforcement or due to earth pressures. • The endwalls or wingwalls may show cracking or movements up to 30 mm which are of no consequence.	 Cast-in-situ concrete endwall breaking away around precast culvert units and culvert lids.

Condition state 3 – Description	Photo
• There may be moderate cracking and spalling due to corroding reinforcement or due to earth pressures. • The endwalls or wingwalls may show moderate movements of up to 75 mm but having little effect on serviceability.	 Severe differential settlement crack through concrete endwall and around pipes. Concrete apron has cracked and broken away from endwall and wingwalls.
Condition state 4 – Description	**Photo**
• There may be severe cracking and spalling due to corroding reinforcement or due to earth pressures. • The endwall or wingwall may show large movements over 75 mm, or may be leaning over due to earth pressure on them, resulting in loss of embankment fill from behind.	 Cast-in-situ concrete endwall has severely cracked and been pushed outwards from the precast culvert units. Endwall is in danger of being pushed over due to lateral pressures.

Component 63 O – Endwalls/Wingwalls – Other

Units of measurement: **Linear Metres**

This component includes all culvert wingwalls, endwalls and concreted aprons associated with the culverts and constructed using masonry, rubble, brick, or rock filled cages.

Condition state 1 – Description	Photo
• The components are in good condition with little or no deterioration. • There is no movement of the endwall or wingwalls.	 Cemented rubble endwall in good condition.
Condition state 2 – Description	**Photo**
• There may be minor cracking of the mortar between blocks due to slight movements of up to 10 mm, or earth pressure. • Ungrouted masonry or rubble should be well stacked and quite stable with only minor movements of the stones. • Rock filled cages may have minor settlement or loss of stone or a few broken wires.	 Cemented rubble endwall has lost grout between stones and has extensive weed growth.

Condition state 3 – Description	Photo
• There may be moderate cracking of the mortar due to movement of up to 40 mm or due to earth pressure. • Ungrouted masonry or rubble may have moved with loss of some stones and minor loss of embankment fill. • Rock filled cages may have distorted with moderate loss of stone and broken or corroded wires.	 Masonry endwall severely cracked around masonry arch ring with minor lateral movement of endwall due to earth pressure and tree growth above.
Condition state 4 – Description	**Photo**
• There may be severe cracking of the mortar due to excessive movements or earth pressure, with loss of embankment fill. • Ungrouted masonry or rubble walls may have moved appreciably, lost numerous rocks or generally be in a very poor condition. • Rock filled cages may be badly corroded, lost substantial filling or have numerous broken wires.	 Stone rubble around ends of pipe collapsing and being lost. Timber plank over top of pipes rotting out. Endwall requires rebuilding to prevent erosion and to hold embankment fill.

Component 64 S – Cladding Facing/Panels – Steel

Units of measurement: **Square Metres**

This component includes the steel cladding facing/panels as well as the fixing bolts, clips or welds within this cladding facing. Steelwork may be painted or galvanised for protection. The cladding may be made from flat steel, steel troughing or other pressed method.

Condition state 1 – Description	Photo
• The paint system is generally sound with only minor chalking, peeling or curling, but with no exposure of metal. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	 Steel cladding panels in sound condition.

Condition state 2 – Description	Photo
• Spot rusting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	Not available. .

Condition state 3 – Description	Photo
• Some surface pitting may be present with active corrosion occurring in isolated areas, but no loss of area is occurring to affect the strength of the member as a whole. • The paint system has broken down with rust spotting to 10% and surface pitting. • Nuts and bolts may be corroded but are still tight and no cracking of welds has occurred. • Riveted plates may have very minor movements of 1 to 2 mm but rivets are generally sound.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and loss of section has occurred having a detrimental effect on the strength of the member, i.e. a flange may be badly corroded over a sizeable length. • There may be some cracking of the welds between the plates. • Rivets or bolts may be severely corroded and no longer carrying full load or functioning as intended. • Rivets may be broken or missing allowing excessive movement of plates. • The paint system has completely broken down.	Not available.

Component 64 P – Cladding Facing/Panels – Precast Concrete

Units of measurement: **Square Metres**

This component includes all precast concrete wall units used for cladding.

Condition state 1 – Description	Photo
• The components are in good condition with no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • There is no settlement, sliding, bulging or tilting of cladding systems.	 Concrete cladding in good condition.

Condition state 2 – Description	Photo
• The components have fine cracking or spalling due to corroding reinforcement. • Minor sections of wall are showing dampness or efflorescence. • There is no settlement, sliding, bulging or tilting of cladding systems.	Not available. .

Condition state 3 – Description	Photo
• The components have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Moderate sections of wall are showing dampness or efflorescence. • There is up to 20 mm settlement, sliding, bulging or tilting of cladding systems.	Not available.
Condition state 4 – Description	**Photo**
• The cladding systems have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is more than 20 mm settlement, sliding, bulging or tilting of wall facing systems.	Not available.

Component 64 C – Cladding Facing/Panels – Cast-in-situ Concrete

Units of measurement: **Square Metres**

This component includes all cast-in-situ concrete wall units used for cladding.

Condition state 1 – Description	**Photo**
• The components are in good condition with no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • There is no settlement, sliding, bulging or tilting of wall facing systems. • Wall slopes are true to line with no separation of the cast sections.	Not available.

Condition state 2 – Description	**Photo**
• The components have fine cracking or spalling due to corroding reinforcement. • Minor sections of wall are showing dampness or efflorescence. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	Not available. .

Condition state 3 – Description	Photo
• The components have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Moderate sections of wall are showing dampness or efflorescence. • There is up to 20 mm settlement, sliding, bulging or tilting of wall facing systems or wall panels.	Not available.
Condition state 4 – Description	**Photo**
• The wall facing system or wall panels have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is more than 20 mm settlement, sliding, bulging or tilting of wall facing systems.	Not available.

Component 64 T – Cladding Facing/Panels – Timber

Units of measurement: **Square Metres**

This component includes all timber panels used for cladding system.

Condition state 1 – Description	Photo
• The timber panels are in good condition with no or only minor weathering at the edges or minor damage elsewhere. • Connections to the posts are tight.	Not available.

Condition state 2 – Description	Photo
• The timber panels are in good condition with moderate weathering at the edges but away from the connections, or moderate damage elsewhere. • There is no slope change, sliding, bulging shrinkage or tilting of the timber panels. • Minor sections of facing are showing dampness, mould, moss and fungi growth. • Connections may be slightly loose but having little or no effect of the panel support.	Not available.

Condition state 3 – Description	Photo
• The timber panels may have moderate weathering at the edges beginning to affect the connections, or have moderate damage elsewhere. • There is only minor slope change, sliding, bulging, shrinkage or tilting of timber panels. • Connections may be loose allowing movement of the panels away from the supports.	Not available.
Condition state 4 – Description	**Photo**
• The timber panels have severe weathering affecting the connections, or have severe damage elsewhere. • There is substantial slope change, sliding, bulging, shrinkage or tilting of wall facing systems or wall panels. • Rot, moss and fungi growth on timber is quite prevalent. • Connections may be lost or completely loose allowing excessive movement of the panels away from the supports.	Not available.

Component 64 O – Cladding Facing/Panels – Other

Units of measurement: **Square Metres**

This component includes all other materials used for cladding systems.

Condition state 1 – Description	Photo
• The cladding systems are in good condition with no cracking, no loss of mortar, bricks or stones, and has maintained its slope and level. • The Perspex, fibre glass or light pressed metal section screens are in good condition and well held in place.	 Transparent cladding no visible damage.
Condition state 2 – Description	**Photo**
• The cladding systems are in good condition but have minor cracking or loss of mortar. • Minor settlement or slope changes may be present. • The Perspex, fibre glass or light pressed metal section screens may have lost some of the flexible filler at the connections, or the connections may be slightly loose or have minor cracking at the corners. • There may be minor accident damage of no concern.	Not available.

Condition state 3 – Description	Photo
• The cladding systems are in fair condition with moderate cracking or loss of mortar. • Medium settlement or slope changes may be present. • Minor loss of bricks or stones may have occurred which are of no consequence. • The Perspex, fibre glass or light pressed metal panels may have lost flexible filler at the connections, or the connections may be loose. • The Perspex may have minor splits of no great concern. The panels may be bent or buckled but not serious enough to require replacement. • Panels may have moved or suffered moderate accident damage and may be only have partial supported at one of the ends.	Not available.

Condition state 4 – Description	Photo
• The cladding systems are in poor condition with severe cracking or loss of mortar. • Extensive settlement or slope changes may be present. • Loss of bricks or stones may have occurred which accentuate the other damage. • The Perspex, fibre glass or light pressed metal panel connections may be completely loose. • The panels may have large splits, cracks or have torn away. • There may be no physical support at one end of the panel.	Not available.

Component 65 S – Piles & Columns – Steel

Units of measurement: **Each**

This component includes all steel piles or columns, driven or bolted in place, to support the cladding panels. Steelwork may be painted or galvanised for protection.

Condition state 1 – Description	**Photo**
• The steel columns are in good condition with no loss of paintwork or corrosion evident. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	Not available.
Condition state 2 – Description	**Photo**
• The steel piles/columns are in good condition with only minor loss of paintwork up to 5% rust spotting of the surface area. • Minor corrosion may be visible on the flanges. • There is no change in the slope of the columns due to differential movement, and the panels are securely held in place.	Not available.
Condition state 3 – Description	**Photo**
• The steel columns are in fair condition with loss of paintwork up to 10% rust spotting of the surface area. • Moderate corrosion may be visible on the flanges. • There is only minor change in the slope of the piles/columns due to differential movement, and the panels are securely held in place.	Not available.

Condition state 4 – Description	Photo
• The steel columns are in poor condition with loss of paintwork greater than 10% of the surface area. • Severe corrosion may be visible on the flanges. • There are substantial changes in the slope of the columns due to differential movement, and the panels may be slipping out from the piles/columns.	Not available.

Component 65 C – Piles & Columns – Precast Concrete

Units of measurement: **Each**

This component includes all precast reinforced concrete piles or columns, driven or bolted in place, to support the panels.

Condition state 1 – Description	Photo
• The columns are in good condition with no cracking or spalling. • There is no change in the slope of the columns due to differential movement, and the panels are securely held in place.	Not available.

Condition state 2 – Description	Photo
• The columns are in good condition with only minor cracking or spalling of no consequence. • There is no change in the slope of the columns due to differential movement, and the panels are securely held in place.	Not available.

Condition state 3 – Description	Photo
• The columns are in fair condition with moderate cracking and spalling due to corroding reinforcement. • Exposed reinforcement may have section loss up to 20% in isolated areas. • There is only minor change in the slope of the columns due to differential movement, and the panels are securely held in place.	Not available.

Condition state 4 – Description	**Photo**
• The columns are in poor condition with severe cracking or spalling present due to corroding reinforcement. • Exposed reinforcement may have section loss greater than 20% in isolated areas. • There may be substantial changes in the slope of the columns due to differential movement, and the wall panels may be slipping out from the columns.	Not available.

Component 66 S – Connections & Supports – Steel

Units of measurement: **Each**

This component includes all steel hold down bolts and arrangements, including base and connecting plates, all steel horizontal, vertical or diagonal struts, braces, stiffeners and walers attached to piles/columns, all connections, and all exposed tiebacks and anchor heads. Steelwork may be painted or galvanised for protection.

Condition state 1 – Description	**Photo**
• The connections and supports paint system or galvanising is not affected by rusting or corrosion. • Bolted connections are tight and in good condition. • Welds are sound.	 Connections in good condition.
Condition state 2 – Description	**Photo**
• The connections and supports have spot rusting to up to 5% of the surface area. • Bolted connections may be slightly loose. • Welds are sound.	Not available.

Condition state 3 – Description	Photo
• Steelworks have moderate corrosion and some surface pitting may be evident but section loss is minimal. • The connections and supports paint system or galvanising have failed with spot rusting to up to 10% of the surface area but any minor corrosion is having minimal effect on strength or serviceability. • Bolted connections are loose. • Welds have cracked with minor loss of effectiveness.	Not available.
Condition state 4 – Description	**Photo**
• Steelworks are severely corroded with significant section loss and the paint system has completely failed. • The connections and supports have advanced corrosion with loss of section affecting both strength and serviceability. • Bolted connections have failed or are missing. • Welds have failed.	Not available.

1.2 Roadside Structures

1.2.1 Major Sign Structures and High-mast Lighting Structures

Component 70 S – Footings/Support – Steel

Units of measurement: **Each**

This component defines the condition of steel support systems in the immediate vicinity of the baseplate. The component must be given a single rating only, and this rating should report the worst condition state applicable to the steel support area.

Condition state 1 – Description	Photo
• The support system is in good condition with minimal corrosion or loss of coating and no visible cracks in the vicinity of the baseplate and hold down bolts.	Not available.

Condition state 2 – Description	Photo
• The support system may have some minor surface corrosion to 5% of the area and loss of coating in the baseplate area. • There are no visible cracks in the vicinity of the baseplate and hold down bolts.	Not available.

Condition state 3 – Description	Photo
• The surface coating system may have broken down and some active corrosion may be present with rust spotting to 10% of the area and surface pitting. • There are no visible cracks in the vicinity of the baseplate and hold down bolts.	Not available.
Condition state 4 – Description	**Photo**
• The coating system may have completely broken down. • There may be well advanced corrosion. • Any visible signs of cracking of the parent metal or welds must be recorded and reported immediately. • Engineering inspection may be required to determine whether visible signs of cracks are confined to the coating system or are within the metal supporting component or welds.	Not available.

Component 70 P – Footings/Support – Precast Concrete

Units of measurement: **Each**

This component defines the condition of precast concrete parapet barrier or other precast concrete support systems. The component must be given a single rating only, and this rating should report the worst condition state applicable to the parapet or other support component.

Condition state 1 – Description	**Photo**
• The parapet is in good condition with possibly only a few fine cracks away from the hold down bolts and has not been damaged or displaced by vehicle impact.	Not available.

Condition state 2 – Description	**Photo**
• The footing / parapet may have some minor spalling due to corrosion of reinforcement close to the surface. • There may be some fine cracking around the hold down bolts due to forces transferred through the bolts. • The parapet may have some minor damage or be displaced by less than 50mm as a result of vehicle impact.	Not available.

Condition state 3 – Description	**Photo**
• There may be moderate cracking or spalling due to corroding reinforcement. Small delaminations may exist with corroding steel having up to 20% section loss. • Structural cracking around the hold down bolts is fine but there may also be some minor spalling associated with the bolt forces. • There may be some minor loss of bearing support. • The parapet may have vehicle impact damage around the hold down baseplate or have a protruding edge that could snag vehicles	Not available.

Condition state 4 – Description	Photo
• There may be severe cracking or spalling due to corroding reinforcement. • Medium size delaminations may exist with corroding steel having greater than 20% section loss. • Structural cracking and spalling around the hold down bolts, associated with the transferred bolt forces, is medium. • There may be substantial loss of bearing support. • The parapet may have suffered severe impact damage, particularly near the hold down baseplate or displacement that could cause snagging of the parapet or mast arm by traffic.	Not available.

Component 70 C – Footings/Support – Cast-in-situ Concrete

Units of measurement: **Each**

This component defines the condition of the footings and should be included only if the top is visible. This component also includes cast-in-situ concrete parapet barrier support systems. The component must be given a single rating only, and this rating should report the worst condition state applicable to the footing or support.

Condition state 1 – Description	**Photo**
• The footing / parapet is in good condition with possibly only a few fine cracks away from the hold down bolts.	 The footing is in good condition with possibly only a few fine cracks away from the hold down bolts.
Condition state 2 – Description	**Photo**
• The footing / parapet may have some minor spalling due to corrosion of reinforcement close to the surface. • There may be some fine cracking around the hold down bolts due to forces transferred through the bolts.	 Concrete footing has minor cracks.

Condition state 3 – Description	Photo
• There may be moderate cracking or spalling due to corroding reinforcement. • Small delaminations may exist with corroding steel having up to 20% section loss. • Structural cracking around the hold down bolts is fine but there may also be some minor spalling associated with the bolt forces. • There may be some minor loss of bearing support.	 The concrete footing is severely cracked.
Condition state 4 – Description	**Photo**
• There may be severe cracking or spalling due to corroding reinforcement. • Moderate size delaminations may exist with corroding steel having greater than 20% section loss. • Structural cracking and spalling around the hold down bolts, associated with the transferred bolt forces, is medium. • There may be substantial loss of bearing support.	 The concrete footing is severely cracked and crushed.

Component 71 S – Columns – Steel

Units of measurement: **Each**

This component includes all columns and masts manufactured from steel plates, tubes or sections. The steel may be painted or galvanised and include any bracing or stiffeners between the columns.

Condition state 1 – Description	**Photo**
• The paintwork is generally in good condition with only minor chalking, curling or peeling, but no metal exposure. • If dual columns, they are adequately braced or stiffened, and all connections are in good condition.	 Column is in good condition.
Condition state 2 – Description	**Photo**
• Painted steelwork may have rust spotting to 5% of the surface area and the protective coating is no longer effective. • The columns may not be effectively braced or the connections may be slightly loose or corroded.	 Column has minor corrosion.

Condition state 3 – Description	Photo
• Steelwork has moderate corrosion and the paint system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. • Bracing may be ineffective or non-existent and connections may be heavily corroded or loose.	 Steel mast has no visible damage but surface corrosion and peeling of coating is evident.
Condition state 4 – Description	**Photo**
• Steelwork is severely corroded with up to 20% loss of section. • The paint system has completely failed requiring cleaning back to bright metal and repainting. • Connections may be very loose or bracing may be missing or totally ineffective. • There may be visible evidence of cracking in the parent metal or welds. This should be recorded and reported immediately.	 Column wall was corroded through.

Component 71 P – Mast – Precast Concrete

Units of measurement: **Each**

This component includes all precast concrete high lighting masts.

Condition state 1 – Description	**Photo**
• The mast is in good condition with only minor fine cracking due to reinforcement corrosion. • There should be no flexural cracking in the mast.	Not available.

Condition state 2 – Description	**Photo**
• The mast may have fine cracking or spalling due to corroding reinforcement. • Fine flexural cracking may be visible.	Not available.

Condition state 3 – Description	Photo
• Moderate cracking and minor spalling due to corroding reinforcement may be visible. • Fine to moderate flexural cracking may be present.	Not available.
Condition state 4 – Description	**Photo**
• Severe cracking and spalling due to corroding reinforcement may be visible with advanced corrosion of the reinforcement. • Flexural cracking may be heavy. This should be recorded and reported immediately.	Not available.

Component 72 S – Cantilever Arms or Gantry Beams (incl. connections) or Light Head Supports (incl. bracing) – Steel

Units of measurement: **Each**

This component includes all the structural steelwork to support the large signs and light heads. The members could be constructed using plates, tubes or sections and include all bracing and stiffeners. The connections to the columns and the connections of the sign supports to the gantry members should also be considered as part of this component. The steelwork may be painted or galvanised for protection.

Condition state 1 – Description	**Photo**
• The paintwork is generally in good condition with only minor chalking, curling or peeling, but no metal exposure. • If dual arms, they are adequately braced or stiffened, and all connections are in good condition.	 Gantry arm is in a good condition.

Condition state 2 – Description	**Photo**
• Painted steelwork may have rust spotting to 5% of the surface area and the protective coating is no longer effective. • The arms may not be effectively braced or the connections may be slightly loose or corroded. • Connection bolts may be tight but too short and not fully threaded.	Not available.

Condition state 3 – Description	Photo
• Steelwork has moderate corrosion and the paint system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. • Bracing may be ineffective or non-existent and connections may be heavily corroded, loose or only half threaded.	 Moderate corrosion on the cantilever arm.
Condition state 4 – Description	**Photo**
• Steelwork is severely corroded with up to 20% loss of section. • The paint system has completely failed requiring cleaning back to bright metal and repainting. • Connections may be very loose, missing or the bracing may be missing or totally ineffective. • There may be visible evidence of cracking in the parent metal or welds. This should be recorded and reported immediately.	Not available.

Component 73 S – Gantry Truss – Steel

Units of measurement: **Linear Metres**

This component describes all steel trusses and includes all truss chords, verticals, diagonals, crossbraces and windbracing. The component will also include the metal floor grillage for personnel to access the signs. The steelwork may be painted or galvanised for protection.

Condition state 1 – Description	Photo
• The paintwork is generally in good condition with only minor chalking, curling or peeling, but no metal exposure. • The truss should be adequately braced or stiffened, and all connections should be in good condition.	 Paintwork in generally good condition.
Condition state 2 – Description	**Photo**
• Painted steelwork may have rust spotting to 5% of the surface area and the protective coating is no longer effective. • The truss may not be effectively braced or the connections may be slightly loose or corroded. • Connection bolts may be tight but too short and not fully threaded.	 Moderate corrosion on gantry truss.

Condition state 3 – Description	Photo
• Steelwork has moderate corrosion and the paint system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. • Bracing may be ineffective or non-existent and connections may be heavily corroded, loose or only half threaded.	Not available.

Condition state 4 – Description	Photo
• Steelwork is severely corroded with up to 20% loss of section. • The paint system has completely failed requiring cleaning back to bright metal and repainting. • Connections may be very loose, missing or the bracing may be missing or totally ineffective. • There may be visible evidence of cracking in the parent metal or welds. • This should be recorded and reported immediately.	Not available.

Component 74 S – Hold Down Bolts & Fittings – Steel

Units of measurement: **Each**

This component describes the connections of the columns and masts to the reinforced concrete footings and includes all hold down bolts and arrangements. In some cases, the levelling nuts if used can be observed below the baseplate. Steelwork may be painted or galvanised for protection.

Condition state 1 – Description	**Photo**
• The hold-down bolts and nuts are generally in good condition with no surface rust. • All connections are tight and in good condition, with full thread engagement by nuts. • Nuts and washers are present on all bolts.	 Hold down bolts and nuts in good condition.
Condition state 2 – Description	**Photo**
• Hold-down bolts and nuts may have rust spotting to 5% of the surface area. Minor pitting less than 5% may occur. • The connections may be slightly loose. • Connection bolts may be tight but too short and not fully threaded. Nuts may be loose, and washers may be absent.	 Hold down bolts and nuts have considerable corrosion.

Condition state 3 – Description	Photo
• Hold-down bolts and nuts have moderate corrosion and the protective coating system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. • The connections may be moderately corroded, loose or only half threaded. One nut may be missing.	 Nut on hold down bolt is not engaged over full thread length.
Condition state 4 – Description	**Photo**
• Hold-down bolts and nuts are severely corroded with up to 10% loss of section. • The paint system has completely failed. Bolts may be fractured and there may be visible evidence of cracking of bolts. • Multiple nuts may be missing or loose. • Fractured or cracked bolts must be recorded and reported immediately.	 Severe section loss on hold down bolt and nut.

Component 75 S – Base Plates & Gussets – Steel

Units of measurement: **Each**

This component describes base plates, gusset plates and welds at the connection of column to the foundations. Steelwork may be painted or galvanised for protection. Assessment is for steel up to 100 mm above the top of any gussets.

Condition state 1 – Description	**Photo**
• The steelwork and protective coating is generally in good condition with only minor chalking, curling or peeling, but no metal exposure or rusting. • All welds have no visible defects.	 Base plate and gusset are in good condition and no visible defects.
Condition state 2 – Description	**Photo**
• Steelwork may have rust spotting to 5% of the surface area. Minor pitting less than 5% may occur. • All welds have no visible defects.	 Base plate and gusset have minor corrosion.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>Steelwork has moderate corrosion and the paint system has failed with up to 10% surface area rusted.
Surface pitting may be evident but section loss is less than 10%.
Base plates may be buried in soil, debris or vegetation.
Paint cracking of paint coatings may occur on weld lines.</td><td>
Base plate is buried.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>Steelwork is severely corroded with up to 10% loss of section by pitting.
Base plates are buried in soil, debris or vegetation.
There may be visible evidence of cracking in the parent metal or welds, particularly at top of gussets.
This should be recorded and reported immediately.</td><td>
Base plate and gusset is severely corroded and there is a loss of cross section.</td></tr>
</table>

Component 75 C – Grout or Mortar Pad Beneath Baseplate – Cast-in-situ Concrete

Units of measurement: **Each**

This component describes any grout or mortar pad beneath the steel baseplate, because it is a critical part of the performance the baseplate and holding down system. A 45° mitre around the baseplate perimeter may be present. In some cases, support blocks are used to provide for initial clamping before clamping against hardened grout. Where levelling nuts are provided under the baseplate, the grout or mortar pad may not be present nor required. This detail should be reported for an engineering review.

Condition state 1 – Description	Photo
• The pad completely fills the area beneath the baseplate, with no shrinkage. • The pad is sound with no cracking, spalling or other signs of deterioration. • When no pad is present beneath the steel base plate, there is no debris under the base plate.	 The grout bed and mitre are in a good condition.

Condition state 2 – Description	Photo
• The pad may have fine cracks or small gaps, but is generally sound and fills the area beneath the baseplate. • The 45° mitre around the baseplate perimeter may show cracking. • When no pad is present, there may be some debris under the base plate.	 Grout pad has fine cracks.

Condition state 3 – Description	Photo
• The pad may be severely cracked or contain large gaps, of width of more than 0.5 mm, over of more than 20% of the baseplate area, where it has spalled or not been installed thoroughly. • The 45° mitre around the baseplate perimeter may be detached for more than 20% of perimeter length. • When no pad is present, the base plate may be covered with debris or vegetation.	 The grout pad is severely cracked.
Condition state 4 – Description	**Photo**
• The pad may be completely fractured or not present.	 Mortar pad cracked and spalled around perimeter and incomplete filling of area beneath baseplate.

Component 78 S – Miscellaneous (including access ladder, platform, etc.) – Steel

Units of measurement: **Each**

This component describes all steel miscellaneous components and includes access ladder, platform, handrails, etc. for accessible gantry. The steelwork may be painted or galvanised for protection.

Condition state 1 – Description	Photo
• The paintwork is generally in good condition with only minor chalking, curling or peeling, but no metal exposure. • All connections should be in good condition.	Not available.

Condition state 2 – Description	Photo
• Painted steelwork may have rust spotting to 5% of the surface area and the protective coating is no longer effective. • The connections may be slightly loose or corroded.	Not available.

Condition state 3 – Description	Photo
• Steelwork has moderate corrosion and the paint system has failed with up to 10% surface area rusted. • Surface pitting may be evident but section loss is less than 10%. • Connections may be heavily corroded, loose or only half threaded.	Not available.

Condition state 4 – Description	Photo
• Steelwork is severely corroded with up to 20% loss of section. • The paint system has completely failed requiring cleaning back to bright metal and repainting. • Connections may be very loose, missing. • There may be visible evidence of cracking in the parent metal or welds. • This should be recorded and reported immediately.	Not available.

1.2.2 Noise Attenuation Walls and Visual Screen Walls

Component 80 S – Wall Facing/Panels – Steel

Units of measurement: **Square Metres**

This component describes the cladding on the wall and includes the cladding as well as the fixing bolts, clips or welds within this cladding. Steelwork may be painted or galvanised for protection. The cladding may be made from flat steel, steel troughing or other pressed design.

Condition state 1 – Description	Photo
• The paint system is generally sound with only minor chalking, peeling or curling, but with no exposure of metal. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	 Steel visual screen wall in sound condition.
Condition state 2 – Description	**Photo**
• Spot rusting of the paint system to 5% surface area is occurring and the paint system is no longer effective. • No corrosion with section loss has occurred. • All welds, bolts or rivets are in good condition with no movement of plates or sections in the component.	Not available.

Condition state 3 – Description	Photo
• Some surface pitting may be present with active corrosion occurring in isolated areas, but no loss of area is occurring to affect the strength of the member as a whole . • The paint system has broken down with rust spotting to 10% and surface pitting. • Nuts and bolts may be corroded but are still tight and no cracking of welds has occurred. • Riveted plates may have very minor movements of 1 to 2 mm but rivets are generally sound.	Not available.
Condition state 4 – Description	**Photo**
• Corrosion is well advanced and loss of section has occurred having a detrimental effect on the strength of the member, i.e. a flange may be badly corroded over a sizeable length. • There may be some cracking of the welds between the plates. • Rivets or bolts may be severely corroded and no longer carrying full load or functioning as intended. • Rivets may be broken or missing allowing excessive movement of plates. • The paint system has completely broken down.	 Surface pitting and section loss around connections has resulted in loss of support for corrugated steel.

Component 80 P – Wall Facing/Panels – Precast Concrete

Units of measurement: **Square Metres**

This component includes all precast concrete wall units used for noise attenuation and visual screen walls.

Condition state 1 – Description	Photo
• The components are in good condition with no damage visible. • There may be minor dampness or efflorescence powder visible in a few locations. • No separation or relative movement between units is apparent.	 Precast panels in good condition.

Condition state 2 – Description	Photo
• There may be a few minor cracks or spalls due to corroding reinforcement. • Dampness or efflorescence may be a little more prevalent. • There is no separation or relative movement between units.	 Precast panel minor spalling and staining.

Condition state 3 – Description	Photo
• Moderate cracking or spalling may be present due to corroding reinforcement or pressure on the units at the support corners. • Exposed reinforcement may have section loss up to 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is only minor separation or relative movement between units up to 20 mm. • Connections may be slightly loose or there may be partial separation from the supporting column.	
Condition state 4 – Description	**Photo**
• Severe cracking or spalling may be present due to corroding reinforcement or pressure on the units at the support corners. • Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is moderate separation or relative movement between units of greater than 20 mm. • Connections may be completely loose with separation from the supporting column.	 Severe cracking and spalling of precast panel.

Component 80 C – Wall Facing/Panels – Cast-in-situ Concrete **Units of measurement:** **Square Metres** This component includes all cast-in-situ concrete walls used for noise attenuation and visual screen walls.	
Condition state 1 – Description	**Photo**
• The components are in good condition with no damage visible. • There may be minor dampness or efflorescence powder visible in a few locations. • Wall slopes are true to line with no separation of the cast sections.	 Cast-in-situ concrete no visible damage.
Condition state 2 – Description	**Photo**
• There may be a few minor cracks or spalls due to corroding reinforcement. • Dampness or efflorescence may be a little more prevalent. • There is no separation or relative movement between cast sections.	 Minor crack in noise attenuation wall with no movement observed.

Condition state 3 – Description	Photo
• Moderate cracking or spalling may be present due to corroding reinforcement. • Exposed reinforcement may have section loss up to 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is only minor separation or relative movement between cast sections up to 20 mm.	Not available.

Condition state 4 – Description	Photo
• Severe cracking or spalling may be present due to corroding reinforcement. • Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is moderate separation or relative movement between cast sections of greater than 20 mm.	Not available.

Component 80 T – Wall Facing/Panels – Timber

Units of measurement: **Square Metres**

This component includes all timber panel walls used for noise attenuation and visual screen walls.

Condition state 1 – Description	**Photo**
• The timber panels are in good condition with no or only minor weathering at the edges or minor damage elsewhere. • Connections to the columns are tight and adequate to transfer all loads due to wind.	 Timber panels in good condition.
Condition state 2 – Description	**Photo**
• The walls are in good condition with only minor weathering at the edges but away from the connections, or minor damage elsewhere. • Minor settlement or slope changes may be present. • Connections may be slightly loose but having little or no effect on the panel support.	 Weathering of timber panels at the edges and connections slightly loose.

Condition state 3 – Description	Photo
• The walls are in fair condition with moderate settlement or slope changes present. • The timber panels may have moderate weathering at the edges beginning to affect the connections, or have moderate damage elsewhere. • Connections may be loose allowing movement of the panels away from the supports.	 Minor weathering of timber at edges. Connections are loose allowing panels to move.

Condition state 4 – Description	Photo
• The walls are in poor condition with extensive settlement or slope changes present. • The timber panels may have extensive weathering at the edges affecting the connections, or have significant damage elsewhere. • Connections may be lost or completely loose allowing excessive movement of the panels away from the supports or the panels to be free at one end.	 Connections are completely lost allowing excessive movement of panel.

Component 80 O – Wall Facing/Panels – Other

Units of measurement: **Square Metres**

This component includes all other materials used for noise attenuation and visual screen walls.

Condition state 1 – Description	Photo
• The walls are in good condition with no cracking, no loss of mortar, bricks or stones, and has maintained its slope and level. • The Perspex, fibre glass or light pressed metal section screens are in good condition and well held in place.	 Walls in good condition.
Condition state 2 – Description	**Photo**
• The walls are in good condition but have minor cracking or loss of mortar. • Minor settlement or slope changes may be present. • The Perspex, fibre glass or light pressed metal section screens may have lost some of the flexible filler at the connections, or the connections may be slightly loose or have minor cracking at the corners. • There may be minor accident damage of no concern.	Not available.

Condition state 3 – Description	Photo
• The walls are in fair condition with moderate cracking or loss of mortar. Medium settlement or slope changes may be present. • Minor loss of bricks or stones may have occurred which are of no consequence. • The Perspex, fibre glass or light pressed metal panels may have lost flexible filler at the connections, or the connections may be loose. • The Perspex may have minor splits of no great concern. The panels may be bent or buckled but not serious enough to require replacement. • Panels may have moved or suffered moderate accident damage and may be only have partial supported at one of the ends.	 Moderate cracking in acrylic panel.
Condition state 4 – Description	**Photo**
• The walls are in poor condition with severe cracking or loss of mortar. • Extensive settlement or slope changes may be present. • Loss of bricks or stones may have occurred which accentuate the other damage. • The Perspex, fibre glass or light pressed metal panel connections may be completely loose. • The panels may have large splits, cracks or have torn away. • There may be no physical support at one end of the panel.	 Perspex panel has large split and will eventually break away.

Component 81 S – Column & Horizontal Supports – Steel

Units of measurement: **Each**

This component includes all steel piles or columns, driven or bolted in place, to support the wall panels. Steelwork may be painted or galvanised for protection.

Condition state 1 – Description	Photo
• The steel columns are in good condition with no loss of paintwork or corrosion evident. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	 Steel columns in good condition.

Condition state 2 – Description	Photo
• The steel columns are in good condition with only minor loss of paintwork up to 5% rust spotting of the surface area. • Minor corrosion may be visible on the flanges. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	Not available.

Condition state 3 – Description	Photo
• The steel columns are in fair condition with loss of paintwork up to 10% rust spotting of the surface area. • Moderate corrosion may be visible on the flanges. • There is only minor change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	Not available.
Condition state 4 – Description	**Photo**
• The steel columns are in poor condition with loss of paintwork greater than 10% of the surface area. • Severe corrosion may be visible on the flanges. • There are substantial changes in the slope of the columns due to differential movement, and the wall panels may be slipping out from the columns.	Not available.

Component 81 P – Column & Horizontal Supports – Precast Concrete

Units of measurement: **Each**

This component includes all precast reinforced concrete piles or columns, driven or bolted in place, to support the wall panels.

Condition state 1 – Description	**Photo**
• The columns are in good condition with no cracking or spalling. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	 The foundations or barrier walls are in good condition with no cracking or spalling. There are no indications of settlement of the foundations.
Condition state 2 – Description	**Photo**
• The columns are in good condition with only minor cracking or spalling of no consequence. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	Not available.

Condition state 3 – Description	Photo
• The columns are in fair condition with moderate cracking and spalling due to corroding reinforcement. • Exposed reinforcement may have section loss up to 20% in isolated areas. • There is only minor change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	Not available.
Condition state 4 – Description	**Photo**
• The columns are in poor condition with severe cracking or spalling present due to corroding reinforcement. • Exposed reinforcement may have section loss greater than 20% in isolated areas. • There may be substantial changes in the slope of the columns due to differential movement, and the wall panels may be slipping out from the columns.	Not available.

Component 81 T – Column & Horizontal Supports – Timber

Units of measurement: **Each**

This component includes all timber piles or columns, driven or bolted in place, to support the wall panels.

Condition state 1 – Description	**Photo**
• The columns are in good condition with no splitting or edge rot. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	 Columns in good condition.
Condition state 2 – Description	**Photo**
• The columns are in good condition with only minor splitting or edge rot, but the columns are sound with no pipe rot. • There is no change in the slope of the columns due to differential movement, and the wall panels are securely held in place.	 Timber column has minor splitting.

Condition state 3 – Description	Photo
• The columns are in fair condition with moderate splitting and edge rot. • They may have some minor pipe rot up to 35% but the strength of the member is unduly affected. • There may be minor slope difference between columns but the wall panels are securely held in place.	Not available.
Condition state 4 – Description	**Photo**
• The columns are in poor condition with extensive splitting, pipe rot and edge rot significantly affecting the strength of the member. • There may be substantial changes in the slope of the columns due to differential movement, and the wall panels may be slipping out from the columns.	 Timber column has split and no longer provides any structural support to noise attenuation wall.

Component 82 S – Foundation/Foundation Support – Steel

Units of measurement: **Linear Metres**

This component defines all types of steel vehicle barrier used to support noise attenuation and visual screen walls.

Condition state 1 – Description	Photo
• The paint or galvanising is generally in good condition with no rusting or corrosion. • The posts supporting the rails are in good condition. • The connections joining the noise attenuation or visual screen wall to the steel vehicle barrier are also in sound condition. No accident damage is visible.	Not available.
Condition state 2 – Description	**Photo**
• Spot rusting has formed to 5% of the surface area and the paint system is no longer effective. • Posts may have spot rusting but bolting or joint support is tight. • The connections joining the noise attenuation or visual screen wall to the steel vehicle barrier are also in sound condition. • Any accident damage or vandalism is minor and of no consequence.	Not available.
Condition state 3 – Description	**Photo**
• The paint system has failed with up to 10% surface spot rusting but any minor corrosion is having minimal effect on the strength or serviceability. • Posts may also have corroding areas and loose hold down bolts. • Bolts holding down rails or rail joint support or the connection of the noise attenuation or visual screen wall to the vehicle barrier may be a little loose. • Accident damage has only had a minor effect on strength or serviceability of the railing.	Not available.

Condition state 4 – Description	**Photo**
• Corrosion is advanced with loss of section affecting both strength and serviceability. • Posts may be badly corroded, become quite loose in their grouted anchorage or bolting, or heavily cracked and spalled concrete. • Rails may have broken away at their joints. • The connections joining the noise attenuation or visual screen wall to the steel vehicle barrier may have become loose, corroded, fractured or missing. • Accident damage is severe with loss of railing.	Not available.

Component 82 P – Foundation/Foundation Support – Precast Concrete

Units of measurement: **Linear Metres**

This component defines the condition of precast concrete parapet barrier or other precast concrete support systems for the noise attenuation or visual screen walls. The component must be given a single rating only, and this rating should report the worst condition state applicable to the parapet or other support component.

Condition state 1 – Description	Photo
• The parapet is in good condition with possibly only a few fine cracks away from the hold down bolts and has not been damaged or displaced by vehicle impact.	Not available.

Condition state 2 – Description	Photo
• The footing / parapet may have some minor spalling due to corrosion of reinforcement close to the surface. • There may be some fine cracking around the hold down bolts due to forces transferred through the bolts. • The parapet may have some minor damage or be displaced by less than 50 mm as a result of vehicle impact.	Not available.

Condition state 3 – Description	Photo
• There may be moderate cracking or spalling due to corroding reinforcement. Small delaminations may exist with corroding steel having up to 20% section loss. • Structural cracking around the hold down bolts is fine but there may also be some minor spalling associated with the bolt forces. • There may be some minor loss of bearing support. • The parapet may have vehicle impact damage around the hold down baseplate or have a protruding edge that could snag vehicles	Not available.

Condition state 4 – Description	Photo
• There may be severe cracking or spalling due to corroding reinforcement. • Medium size delaminations may exist with corroding steel having greater than 20% section loss. • Structural cracking and spalling around the hold down bolts, associated with the transferred bolt forces, is medium. • There may be substantial loss of bearing support. • The parapet may have suffered severe impact damage, particularly near the hold down baseplate or displacement that could cause snagging of the parapet or mast arm by traffic.	Not available.

Component 82 C – Foundation/Foundation Support – Cast-in-situ Concrete

Units of measurement: **Linear Metres**

This component includes all cast-in-situ reinforced concrete foundations or barrier walls which support the noise attenuation or visual screen walls. If the foundation is hidden below fill then this component should not be used.

Condition state 1 – Description	**Photo**
• The foundations or barrier walls are in good condition with no cracking or spalling. • There are no indications of settlement of the foundations.	 Foundations or barrier walls in good condition.
Condition state 2 – Description	**Photo**
• The foundations or barrier walls are in good condition with only minor cracking or spalling of no consequence. • There are no indications of settlement of the foundations.	Not available.
Condition state 3 – Description	**Photo**
• The foundations or barrier walls are in fair condition with moderate cracking and spalling due to corroding reinforcement. • Exposed reinforcement may have section loss up to 20% in isolated areas. • There may be signs of minor settlement of the foundations.	Not available.

Condition state 4 – Description	**Photo**
• The foundations or barrier walls are in poor condition with severe cracking or spalling present due to corroding reinforcement. • Exposed reinforcement may have section loss greater than 20% in isolated areas. • There may be significant settlement of the foundations.	 Severe cracking and minor spalling on concrete barrier supporting precast noise attenuation wall panels.

Component 83 S – Hold-down Bolts, Base Plates and Fittings – Steel

Units of measurement: **Each**

This component describes the connections of the noise attenuation or visual screen walls or columns to the foundations and includes all hold down bolts and arrangements, including base and connecting plates. Steelwork may be painted or galvanised for protection.

Condition state 1 – Description	**Photo**
• The paintwork is in good condition with no metal exposure. • All connections are tight and in good condition.	 Steel base plates, nuts and bolts connections in sound condition
Condition state 2 – Description	**Photo**
• Painted steelwork may have rust spotting to 5% of the surface area and the protective coating is no longer effective. • The connections may be slightly loose or beginning to corrode.	Not available.

Condition state 3 – Description	**Photo**
• Steelwork has moderate corrosion and the paintwork has failed with up to 10% surface area rusted. • Some surface pitting may be evident but section loss is minimal. • Connections may be moderately corroded or loose.	Not available.
Condition state 4 – Description	**Photo**
• Steelwork is severely corroded with significant section loss and the paint system has completely failed. • Connections may be very loose or heavily corroded.	Not available.

Component 83 C – Grout or Mortar Pad Beneath Baseplate – Cast-in-situ Concrete

Units of measurement: **Each**

This component describes any grout or mortar pad beneath the steel baseplate, because it is a critical part of the performance the baseplate and holding down system. Where levelling nuts are provided under the baseplate, the grout or mortar may not be present nor required. This detail should be reported for an engineering review.

Condition state 1 – Description	Photo
• The mortar pad completely fills the area beneath the baseplate, is sound with no drummy sound, cracking, spalling or other signs of deterioration.	 Mortar pad in good condition.
Condition state 2 – Description	**Photo**
• The mortar pad may have fine cracks or small gaps, but is generally sound and fills the area beneath the baseplate.	 Minor cracks and small gaps in mortar pad beneath baseplate.

Condition state 3 – Description	Photo
• The mortar pad may be severely cracked or only contain large gaps, of more than 25% of the baseplate area, where it has spalled or not been installed thoroughly.	Not available.
Condition state 4 – Description	**Photo**
• The mortar pad may be completely fractured or not present.	Not available.

1.2.3 Retaining Walls

Component 85 S – Wall Facing/Panels – Steel

Units of measurement: **Square Metres**

This element includes all wall facing systems and wall panels between columns manufactured from steel including rolled sections, plates, hexagonal mesh wire netting gabions, square welded mesh gabions, welded mesh and similar. The steel may be painted, galvanised, PVC coated or uncoated, and may be used as a facade for aesthetic purposes with the true retaining wall hidden behind the facade.

Condition state 1 – Description	Photo
• No corrosion or deterioration on paint system or galvanising of wall facing system or wall panels. • Connections are tight. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Plate facade with paint system not affected by rusting or corrosion.

Condition state 2 – Description	Photo
• The wall facing system or wall panels have spot rusting to up to 5% of the surface area and the paint system or galvanising is no longer effective. • Connections are tight. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Rolled sections with spot rusting to up to 5% of the surface area and the galvanising is no longer effective.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>The wall facing system or wall panels paint system or galvanising has failed with spot rusting to up to 10% of the surface area but any minor corrosion is having minimal effect on strength or serviceability.
Connections are loose.
There is only minor settlement, sliding, bulging or tilting of wall facing systems or wall panels.</td><td>
Hexagonal mesh wire netting gabions with minor bulging.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>The wall facing system or wall panels has advanced corrosion with loss of section affecting both strength and serviceability.
Connections have failed or are missing.
There is substantial settlement, sliding, bulging or tilting of wall facing systems or wall panels.</td><td>
Plates with advanced corrosion with loss of section affecting strength and substantial bulging between columns.</td></tr>
</table>

Component 85 P – Wall Facing/Panels – Precast Concrete

Units of measurement: **Square Metres**

This element includes all wall facing systems and wall panels between columns consisting of precast concrete units, including crib headers, stretchers and blocks, keystones and other small interlocking block systems, large hollow and solid interlocking block systems, L and inverted T sections, facing panels and infills. The precast concrete units may be coloured and textured for aesthetic purposes, and may be used as a facade for aesthetic purposes with the true retaining wall hidden behind the facade.

Condition state 1 – Description	**Photo**
• The wall facing system or wall panels have no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • Connections are tight. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Keystones with no cracking or spalling.
Condition state 2 – Description	**Photo**
• The wall facing system or wall panels have fine cracking or spalling of no consequence. • Small sections of wall are showing dampness or efflorescence. • Connections are tight wall facing or wall panels are securely held in place. • There is no settlement, sliding, bulging or tilting of wall facing system or wall panels.	 Infills with fine cracking of no consequence.

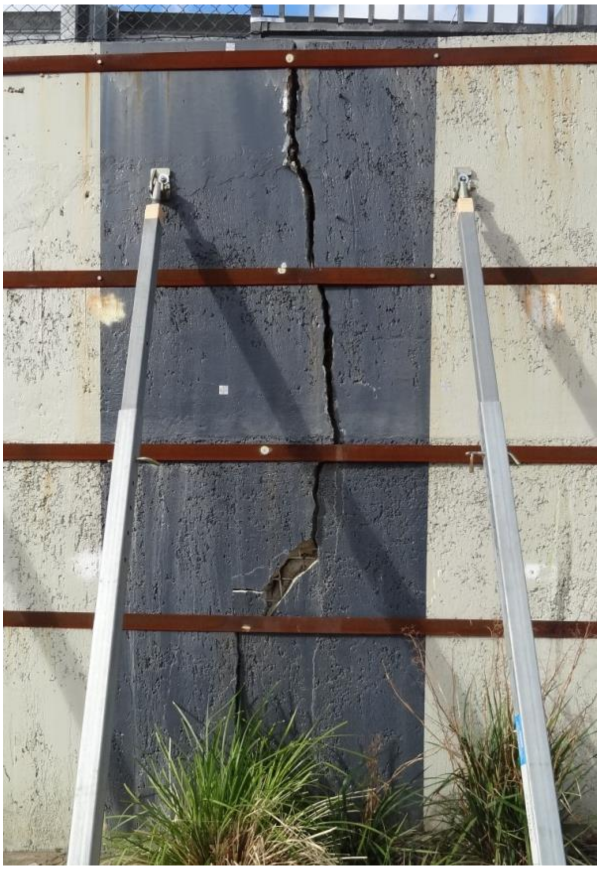
Condition state 3 – Description	Photo
• The wall facing system or wall panels have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Moderate sections of the wall have dampness or efflorescence. • Connections are loose. • There is up to 20 mm settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Facing panels with 20 mm bulging between columns.
Condition state 4 – Description	**Photo**
• The wall facing system or wall panels have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • Connections have failed or are missing. • There is more than 20 mm settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Crib headers, stretchers and blocks with heavy cracking and spalling due to corroding reinforcement affecting both strength and serviceability.

Component 85 C – Wall Facing/Panels – Cast-in-situ Concrete

Units of measurement: **Square Metres**

This element includes all wall facing systems and wall panels between columns consisting of cast-in-situ concrete, including mass concrete, L and inverted T sections, sprayed concrete and infills. The cast – in-situ concrete may be coloured and textured for aesthetic purposes.

Condition state 1 – Description	Photo
• The wall facing system or wall panels have no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 L section with no cracking or spalling.
Condition state 2 – Description	**Photo**
• The wall facing system or wall panels have fine cracking or spalling of no consequence. • Minor sections of wall are showing dampness or efflorescence. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Sprayed concrete with fine cracking of no consequence and evidence of dampness.

Condition state 3 – Description	Photo
• The wall facing system or wall panels have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Moderate sections of wall are showing dampness or efflorescence. • There is up to 20 mm settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Infills with moderate cracking and spalling due to corroding reinforcement.
Condition state 4 – Description	**Photo**
• The wall facing system or wall panels have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is more than 20 mm settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Sprayed concrete with more than 20 mm bulging.

Component 85 T – Wall Facing/Panels – Timber

Units of measurement: **Square Metres**

This element includes all wall facing systems and wall panels between columns manufactured from timber including timber crib headers, stretchers and blocks, sleepers, sawn logs and similar. The timber may be treated or untreated.

Condition state 1 – Description	**Photo**
• The wall facing system or wall panels have only minor weathering at the edges or minor damage elsewhere. • There is no settlement, sliding, bulging, shrinking or tilting of wall facing systems or wall panels.	 Sleepers with minor weathering at the edges.

Condition state 2 – Description	**Photo**
• The wall facing system or wall panels have moderate weathering at the edges but away from the connections, or moderate damage elsewhere. • There is no settlement, sliding, bulging shrinkage or tilting of wall facing systems or wall panels. • Minor sections of wall are showing dampness, mould, moss and fungi growth.	 Timber crib headers, stretchers and blocks with moderate weathering at the edges but away from the connections between components.

Condition state 3 – Description	Photo
• The facing system or wall panels have moderate weathering affecting the connections. • There is only minor settlement, sliding, bulging, shrinkage or tilting of wall facing systems or wall panels. • Moderate sections of wall are showing rot, moss and fungi growth.	 Sawn logs with moderate weathering affecting the connections to the columns.
Condition state 4 – Description	**Photo**
• The facing system or wall panels have severe weathering affecting the connections, or have severe damage elsewhere. • There is substantial settlement, sliding, bulging, shrinkage or tilting of wall facing systems or wall panels. • Rot, moss and fungi growth on timber is quite prevalent.	 Sleepers with substantial shrinkage, with wall panels not securely held in place by the columns (too short).

Component 85 O – Wall Facing/Panels – Other

Units of measurement: **Square Metres**

This element includes all wall facing systems and wall panels between columns consisting of granular fill between crib wall headers, gabion fill, masonry (brick or natural stone with mortar) and geotextile (where observable). These may be used as a facade for aesthetic purposes with the true retaining wall hidden behind the facade.

It must include any buttresses and brick columns which protrude out from the face of retaining wall.

Condition state 1 – Description	Photo
• The crib retaining wall granular fill is not affected by volume loss. • The gabion fill material is not affected by weathering or volume loss. • The masonry is not affected by cracking or loss of mortar, or weathering or loss of brick or natural stone. • The geotextile is not affected by weathering. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Geotextile not affected by weathering.

Condition state 2 – Description	Photo
• The crib retaining wall granular fill is affected by up to 5% volume loss. • The gabion fill material is affected by up to 5% volume loss. • The masonry has minor weathering, cracking or loss of mortar or stones, . • The geotextile has only minor weathering. • There is no settlement, sliding, bulging or tilting of wall facing systems or wall panels.	 Stones affected by weathering.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

The crib retaining wall granular fill is affected by up to 10% volume loss.
The gabion fill material is affected by up to 10% volume loss or moderate weathering.
The masonry has moderate weathering, cracking or loss of mortar or stones, or minor loss of bricks.
The geotextile has moderate weathering.
There is only minor settlement, sliding, bulging or tilting of wall facing systems or wall panels.

</td><td>

Brick facade with minor loss of bricks which is of no consequence.
</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

The crib retaining wall granular fill is affected by severe volume loss.
The gabion fill material is affected by severe volume loss or weathering.
The masonry has severe weathering, cracking or loss of mortar. Significant loss of bricks and stones may have occurred which accentuate other damage.
The geotextile has severe weathering.
There is substantial settlement, sliding, bulging or tilting of wall facing systems or wall panels.

</td><td>

Crib retaining wall granular fill with severe volume loss.
</td></tr>
</table>

Component 86 S – Columns – Steel

Units of measurement: **Each**

This element includes all steel sheet piling and steel columns, driven or bolted in place, to support the wall panel system. The steel may be painted, galvanised or uncoated, and may be used a facade for aesthetic purposes with the true retaining wall hidden behind the facade.

Condition state 1 – Description	**Photo**
• The uncoated sheet piles have surface minor surface rust to the entire surface area but no loss of section. • The column paint system or galvanising is good condition and not affected by rusting or corrosion. • There is no tilting of columns. • There is no differential movement between columns, and the wall panels are securely held in place by the columns.	 Columns with galvanising not affected by rusting or corrosion and with no tilting or differential movement.
Condition state 2 – Description	**Photo**
• The uncoated sheet piles have surface rusting to the entire surface area but any corrosion is minor and of no consequence. • The columns have spot rusting to up to 5% of the surface area and the paint system or galvanising. Corrosion may be visible on the flanges but is minor and of no consequence. • There is no tilting of columns. • There is no differential movement between columns, and the wall panels are securely held in place by the columns.	 Sheet piles with spot rusting to the entire surface area.

Condition state 3 – Description	Photo
• The uncoated sheet piles have surface rusting to the entire surface area but is having minimal effect on strength and serviceability. • The column paint system or galvanising has failed with spot rusting to up to 10% of the surface area. Moderate corrosion may be visible on the flanges but is having minimal effect on strength or serviceability. • There is only minor tilting of columns. • There is only minor differential movement between columns, and the wall panels are securely held in place by the columns.	 Columns with paint system that has failed with spot rusting to 10% of the surface area and moderate corrosion on flanges.
Condition state 4 – Description	**Photo**
• The sheet piles have surface rusting to the entire surface area and corrosion is advanced with loss of section affecting both strength and serviceability. • The columns have advanced corrosion with loss of section affecting both strength and serviceability. • There is substantial tilting of columns. • There is substantial differential movement between columns, and the wall panels may not be securely held in place by the columns.	 Sheet piles with advanced corrosion with loss of section affecting both strength and serviceability.

Component 86 C – Columns – Cast-in-situ Concrete

Units of measurement: **Each**

This element includes all bored piles, continuous flight auger (CFA) piles and similar used to form a retaining wall or to support the wall panel system. These piles are installed and then exposed by excavation.

Condition state 1 – Description	**Photo**
• The columns have no cracking or spalling. • There may be minor dampness or efflorescence powder visible in a few locations. • There is no tilting of columns. • There is no differential movement between columns, and the wall panels are securely held in place by the columns. (May require design drawings for verification).	 Columns with no cracking or spalling.
Condition state 2 – Description	**Photo**
• The columns have fine cracking or spalling of no consequence. • Minor sections of the wall showing dampness or efflorescence. • There is no tilting of columns. • There is no differential movement between columns, and the wall panels are securely held in place by the columns.	 Columns with fine cracking of no consequence.

Condition state 3 – Description	Photo
• The columns have moderate cracking and spalling due to corroding reinforcement. Exposed reinforcement may have section loss up to 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is only minor tilting of columns. • There is only minor differential movement between columns, and the wall panels are securely held in place by the columns.	Not available.
Condition state 4 – Description	**Photo**
• The columns have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability. Exposed reinforcement may have section loss greater than 20% in isolated areas. • Dampness or efflorescence may be quite prevalent. • There is substantial tilting of columns. • There is substantial differential movement between columns, and the wall panels may not be securely held in place by the columns.	Not available.

<table>
<tr><td colspan="2">

Component 86 T – Columns – Timber

Units of measurement: **Each**

This element includes all timber piles or columns, driven or bolted in place, to support the wall panel system. The timber may be treated or untreated.
</td></tr>
<tr><th>Condition state 1 – Description</th><th>Photo</th></tr>
<tr><td>

- The columns have only minor splitting with no edge rot or pipe rot.
- There is no tilting of columns.
- There is no differential movement between columns, and the wall panels are securely held in place by the columns.
</td><td>

Columns with minor splitting.
</td></tr>
<tr><th>Condition state 2 – Description</th><th>Photo</th></tr>
<tr><td>

- The columns have minor splitting or edge rot with no pipe rot.
- There is no tilting of columns.
- There is no differential movement between columns, and the wall panels are securely held in place by the columns.
</td><td>

Columns with minor splitting and edge rot.
</td></tr>
</table>

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>

- The columns have moderate splitting and edge rot and may have minor pipe rot up to 35% but any deterioration is having minimal effect on strength or serviceability.
- There is only minor tilting of columns.
- There is only minor differential movement between columns, and the wall panels are securely held in place by the columns.

</td><td>

Column with minor pipe rot up to 35%.

</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>

- The columns have extensive splitting, edge rot and pipe rot severely affecting both strength and serviceability.
- There is substantial tilting of columns.
- There is substantial differential movement between columns, and the wall panels may not be securely held in place by the columns.

</td><td>

Columns with substantial tilting.

</td></tr>
</table>

Component 87 S – Barriers – Steel

Units of measurement: **Linear Metres**

This element includes all steel barriers fixed to the retaining wall.

Condition state 1 – Description	**Photo**
• The barrier paint system or galvanising is not affected by rusting or corrosion. • Bolting or joint support is tight. • No accident damage is visible.	 Traffic safety barrier with galvanising not affected by rusting or corrosion and no accident damage visible.

Condition state 2 – Description	**Photo**
• The barrier has spot rusting to up to 5% of the surface area and the paint system or galvanising. • Bolting or joint support is tight. • Accident damage or vandalism is minor and has no impact on performance of barrier.	 Traffic safety barrier with spot rusting to 5% of the surface area and the paint system is no longer effective.

Condition state 3 – Description	Photo
• The barrier paint system or galvanising has failed with spot rusting to up to 10% of the surface area but any minor corrosion is having minimal effect on strength or serviceability. • Bolting or joint support is loose. • Accident damage has only a minor effect on strength or serviceability.	 Pedestrian barrier with accident damage with only a minor effect on both strength and serviceability.
Condition state 4 – Description	**Photo**
• The barrier has advanced corrosion with loss of section affecting both strength and serviceability. • Bolting or joint support has failed or is missing. • Severe accident damage affecting the strength and serviceability. • Retaining walls within the clear zone but with no traffic safety barrier, or a substandard traffic safety barrier, should be classified in this condition state. • Retaining walls within 3 m of a footpath and below footpath level but with no pedestrian barrier should be classified in this condition state.	 Traffic safety barrier with advanced corrosion with loss of section affecting both strength and serviceability. Bolting has failed. The traffic safety barrier also has substandard timber block outs.

Component 87 P – Barriers – Precast Concrete

Units of measurement: **Linear Metres**

This element includes all precast reinforced concrete barriers fixed to the retaining wall.

Condition state 1 – Description	**Photo**
• The barriers have no cracking or spalling. • No accident damage is visible.	 Traffic safety barrier with no deterioration or accident damage.
Condition state 2 – Description	**Photo**
• The barriers have fine cracking or minor spalling of no consequence. • Accident damage is minor and of no consequence.	 Traffic safety barrier with minor accident damage.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>The barriers have moderate cracking and spalling due to corroding reinforcement.
Accident damage has only a minor effect on strength or serviceability.</td><td>
Traffic safety barrier with moderate cracking and spalling due to corroding reinforcement.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>The barriers have heavy cracking or spalling due to corroding reinforcement affecting both strength and serviceability.
Accident damage has a severe effect on strength and serviceability.
Retaining walls within the clear zone but with no traffic safety barrier, or a substandard traffic safety barrier, should be classified in this condition state.
Retaining walls within 3 m of a footpath and below footpath level but with no pedestrian barrier should be classified in this condition state.</td><td>
Pedestrian barrier dismantled due to heavy cracking and spalling affecting both strength and serviceability.</td></tr>
</table>

Component 88 S – Connections and Supports – Steel

Units of measurement: **Each**

This element includes all steel hold down bolts and arrangements, including base and connecting plates, all steel horizontal, vertical or diagonal struts, braces, stiffeners and walers attached to columns, all connections, and all exposed tiebacks and anchor heads. The steel may be painted, galvanised or uncoated.

Condition state 1 – Description	Photo
• The connections and supports paint system or galvanising is not affected by rusting or corrosion. • Bolted connections are tight. • Welds are sound.	 Stiffeners with galvanising not affected by rusting or corrosion.

Condition state 2 – Description	Photo
• The connections and supports have spot rusting to up to 5% of the surface area. • Bolted connections are tight. • Welds are sound.	 Hold own bolts and connecting plates with spot rusting to up to 5% of the surface area and the galvanising is no longer effective.

Condition state 3 – Description	Photo
• The connections and supports paint system or galvanising have failed with spot rusting to up to 10% of the surface area but any minor corrosion is having minimal effect on strength or serviceability. • Bolted connections are loose. • Welds have cracked with minor loss of effectiveness.	 Exposed anchor heads with spot rusting to 10% of the surface area with minimal effect on strength or serviceability.
Condition state 4 – Description	**Photo**
• The connections and supports have advanced corrosion with loss of section affecting both strength and serviceability. • Bolted connections have failed or are missing. • Welds have failed.	 Waler with advanced corrosion with loss of section affecting both strength and serviceability. Welds to columns have failed.

Component 88 T – Connections and Supports – Timber

Units of measurement: **Each**

This element includes all timber horizontal, vertical or diagonal struts, braces, stiffeners and walers attached to columns. The timber may be treated or untreated.

Condition state 1 – Description	Photo
• The connections and supports have only minor splitting with no edge rot or pipe rot. • Bolted connections are tight.	 Walers and struts with no splitting, edge rot or pipe rot.

Condition state 2 – Description	Photo
• The connections and support have minor splitting or edge rot with no pipe rot. • Bolted connections are tight.	 Stiffeners with minor splitting.

<table>
<tr><th>Condition state 3 – Description</th><th>Photo</th></tr>
<tr><td>The connections and supports have moderate splitting and edge rot and may have minor pipe rot up to 35% but any deterioration is having minimal effect on strength or serviceability.
Bolted connections are loose.</td><td>
Brace with moderate edge rot and minor pipe rot.</td></tr>
<tr><th>Condition state 4 – Description</th><th>Photo</th></tr>
<tr><td>The connections and supports have extensive splitting, edge rot and pipe rot severely affecting both strength and serviceability.
Bolted connections have failed or are missing.</td><td>
Struts with extensive pipe rot. Timber strut block bolted connections have failed.</td></tr>
</table>

Component 89 O – Drainage System – Other

Units of measurement: **Each**

This element includes all surface and subsurface drainage above, through and below the retaining wall including kerb, channel, pits, drainage pipes, wingwalls, endwalls, energy dissipators, weep holes, subsurface drain flush-out risers, subsurface drainage pipes, subsurface drainage outlets, and waterways.

Condition state 1 – Description	Photo
• The drainage system is not affected by blockages. • The drainage system is not affected by structural failure. • The drainage system is not affected by vertical settlement or horizontal displacement. • No erosion or scour is evident.	 Weep holes with no blockages, no structural failure, and no erosion evident.

Condition state 2 – Description	**Photo**
• The drainage system has blockages causing up to 10% loss of capacity. • Concrete components have fine cracking or spalling of no consequence, steel components have spot rusting to up to 5% of the surface area. • Vertical settlement and horizontal displacement of drainage system components is minor and of no consequence. • Erosion or scour is minor and of no consequence.	 Channel with blockages causing 10% loss of capacity.
Condition state 3 – Description	**Photo**
• The drainage system has blockages causing up to 25% loss of capacity. • Concrete components have moderate cracking and spalling due to corroding reinforcement, steel components have spot rusting to up to 10% of the surface area and minor corrosion. • Vertical settlement and horizontal displacement of drainage system components is moderate and water is leaking from the drainage system. • Erosion or scour has only a minor effect on strength or serviceability.	 Channel with blockages causing 25% loss of capacity. Channel has moderate cracking allowing water to leak into fill behind retaining wall.

Condition state 4 – Description	**Photo**
• The drainage system has severe blockages causing a loss of drainage system effectiveness. • Concrete components have heavy cracking or spalling affecting both strength and serviceability, steel components have advanced corrosion with loss of section affecting both strength and serviceability. • Vertical settlement and horizontal displacement between drainage system components is severe causing a loss of drainage system effectiveness. • Erosion or scour has a severe effect on strength and serviceability.	 Channel with vertical settlement between components causing loss of drainage system effectiveness. Erosion has exposed reinforcement in reinforced soil block and is severely affecting the strength and serviceability of the retaining wall.

APPENDIX

Appendix A – Datasheets for Level 2 Inspection

1.1 General

It is essential that uniformity be developed for the inspection of the DoT assets so results from different inspectors are based on the same set of standards. The field sheets shown in this section of the manual aim to achieve such a uniform approach.

1.2 Datasheets for Bridges and Culverts

- Inventory and photographic record sheet for SN – bridge or culvert.
- Bridge inspector's sheet.
- Condition rating sheet.
- Structure defect and treatment sheet.
- Defect mapping sheet.
- Structure information sheet.
- Sketch sheet.

1.3 Datasheets for Roadside Structures

The relevant inventory and photographic record sheet must be used for the following roadside structures.

- SS – Major sign structures.
- SL – High mast lighting structures.
- SZ – Noise attenuation walls.
- SR – Retaining walls.
- SV – Visual screen walls.
- SB – Emergency boom gates.
- SG – Emergency median barrier access gates.

Then the same sheets as for bridges and culverts must be used for recording component condition and other general information:

- Bridge inspector's sheet.
- Condition rating sheet.
- Structure defect and treatment sheet.
- Defect mapping sheet.
- Structure information sheet.
- Sketch sheet.

DoT Level 2 Structure Condition Inspection

Bridge Inspector's Sheet

Structure ID No.: S		Location (Km): (Fwd/Rev)
Road name:		Road number:
Crossing/General Location:		
Region:	Map reference: (Melways/VicRoads)	
Inspector:		Date:

Site conditions

Climatic	Limitations	Hazards
Weather		
Temperature ºC		

Equipment and tool required for inspection

Inspection access	Tools	
Under-bridge inspection Unit	Hammer	Torch
Scissor Lift	Probe	Binoculars
Boom lift	GPS unit	Measuring tapes
Ladder	Electronic Camera	Crack Gauge
Boat	Measuring Wheel	Traffic control
Other _		

Note: Personal safety and protective equipment is mandatory for inspections.

General comments (incl. inspection summary and intention)

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Condition Rating Sheet

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

Component			**Widening**		**% of component in each condition**											
	No.		**L/R**	**1/2**		**1**			**2**			**3**			**4**	

Notes

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Structure Defect and Treatment Sheet

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

Note: examples provided within the table for information only

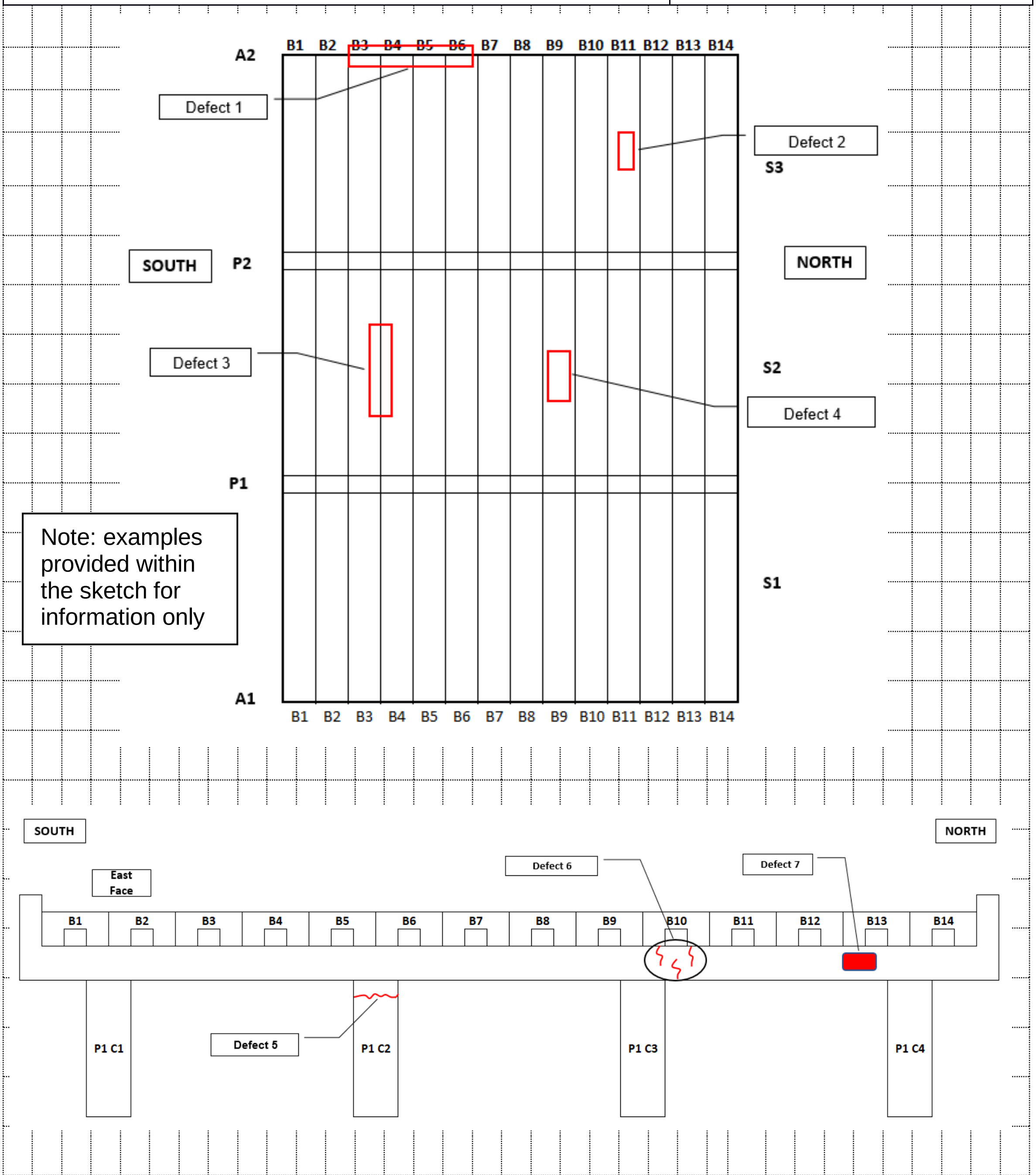
Defect No.	Component No.	Component name	Location	Quantity	Photo Nos. (key photo if relevant)	Photo Nos. (full list)	Defect description (including related condition state, approximate size and extent)	Treatment for Condition State 3 and 4	Timeframe	Treatment Code
e.g. Defect 1	52O	Bridge approaches	A2 over B3-B6	2.4 m^2	126	126-127	Condition State 3 Settlement of approach, drop in level 20 mm	Repair the member	Work completed within 2 Year	M13-Raising bridge approaches
Defect 4	8P	Precast U Slab	S2B9 Approx. 1.5 m from P1 crosshead	0.6 m^2	123	122-125	Condition state 4 Heavy spalling with corroded reinforcement in the U slab leg	Repair the member	Work completed within 1 Year	RPM10-Repair of large spalled areas
Defect 5	22C	Pier Column	P1C2 Approx. 0.1m below P1 crosshead	0.7 m	132	132-133	Condition State 3 Medium cracking (0.5mm width) over the width of column	Repair the member	Work completed within 1 Year	RPM02-Repair of inactive cracks
Defect 6	20C	Pier Crosshead	P1 under B10 Approx.. 0.2 m from P1C3	1 m	129	128-131	Condition State 2 Cracking (0.2-0.3mm width) at 200mm (E) spacings			

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Defect Mapping Sheet

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:



Sheet __ of __

DoT Level 2 Structure Condition Inspection

Structure Information Sheet

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

Component No.	**Information or comment (Including: Load, Height, speed limits; hydraulic performance or similar; and location of any material testing & sampling)**

The presence (or the likelihood) of asbestos (Including a detail description and location of the components):												
Existing posted load limit (if any):							Existing posted clearance height (if any):					
Existing posted speed limit (if any):												
Min. vertical clearance for overpass bridges (m)	Forward carriageway						Reverse carriageway					
	F1	F2	F3	F4	F5		R1	R2	R3	R4	R5	

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Sketch Sheet

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Inventory and Photographic Record Sheet ☐ **Bridge (SN)** ☐ **Culvert (SN)**

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

GPS (GDA2020)

Latitude South:	Longitude East:
Location:	

Bridge or Culvert Measurements and Quantities (1 = 1st widening on one side; 2 = 2nd widening on one side)

B = Bridge, C = Culvert (select one & cross the other)	Original structure	Widening left		Widening right		Whole structure
		1	2	1	2	
B: Length (m) C: Cell length/dia (m)						
B: O/All width (m) C: Cell width along invert (m)						
B: No. spans C: Cell height						Width between kerbs (m):
B: No. beams/slabs C: No. of cells						

Span No.	1	2	3	4	5	6	7	8	9	10	11	12
B: Span Length (m) C: Cell Size (m)												

Structure Photographic Record

Photo identification number	Description (Including: location, view, relevant defect number, etc.)

Notes

Sheet __ of ___

Note: insert additional sheet if required

DoT Level 2 Structure Condition Inspection

Inventory and Photographic Record Sheet

☐ **Major sign structure (SS)** ☐ **High mast lighting (SL)**

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

GPS (GDA2020)

Latitude South:	Longitude East:
Location:	

Side of road: (left or right)	Clearance from carriageway: m
Min. vertical clearance (LHS): m	Min. vertical clearance (RHS): m

ONLY FOR MAJOR SIGN STRUCTURE

Type of Sign:	Cantilever	Butterfly	Gantry	Pedestal	Other
VMS:	**Yes**	**No**	**Other**		
Base	Located on concrete pad		Yes	No	
	Levelling nuts exist		Yes	No	

Photos

No.	Location	Description	Comment

General comments (incl. inspection summary and intention)

Sheet __ of ___

DoT Level 2 Structure Condition Inspection

Inventory and Photographic Record Sheet

☐ Visual Screen Walls (SV) ☐ Noise Attenuation Walls (SZ)

☐ Retaining Walls (SR)

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	Municipality:
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

GPS (GDA2020) start of wall (lowest chainage)

Latitude South:	Longitude East:
Overall length (if applicable):	

For Visual Screen or Noise Attenuation Wall	Type of wall: (freestanding, on parapet or retaining wall, other)	
	Material: (steel, concrete, timber, masonry, other)	
For Retaining Wall	Materials: Facing, Supports	
Side of road: (left or right)		Clearance from carriageway: m

Photos

No.	Location	Description	Comment

General comments (incl. inspection summary and intention)

Sheet __ of ___

For retaining walls a sketch must be provided showing each segment with start chainage, length, end chainage using Sketch Sheet above.

DoT Level 2 Structure Condition Inspection

Inventory and Photographic Record Sheet

☐ Emergency Boom Gates (SB) ☐ Emergency Median Barrier Access Gates (SG)

☐ Other Roadside Structures

Structure ID No.: S	Location (Km): (Fwd/Rev)
Road name:	Road number:
Crossing/General Location:	Municipality:
Region:	Map reference: (Melways/VicRoads)
Inspector:	Date:

GPS (GDA2020) start of wall (lowest chainage)

Latitude South:	Longitude East:
Overall length (if applicable):	

Photos

No.	Location	Description	Comment

General comments (incl. inspection summary and intention)

Sheet __ of ___

Appendix B – Deterioration of Road Structures

1.1 Material Defects

1.1.1 General

This section describes the defects that are normally found in concrete, steel, timber, masonry and coatings. Each defect is briefly described and the causes producing it are identified.

1.1.2 Concrete

Concrete elements may be unreinforced mass concrete, reinforced concrete or prestressed concrete. This section is based on concrete defects described in *Ontario Ministry of Transportation, Ontario Structure Inspection Manual.*

Defects in concrete are commonly linked with poor durability resulting from the composition of the concrete, poor workmanship and quality control during construction and/or the aggressive environment surrounding and in contact with the structure.

The following defects commonly occur in concrete:

- Scaling.
- Disintegration.
- Water wash.
- Corrosion of reinforcement.
- Delamination.
- Spalling.
- Cracking.
- Alkali Aggregate Reaction.
- Surface Defects.
- Carbonation.
- Chloride ingress.

1.1.2.1 Scaling

Scaling is the local flaking or loss of the surface portion of concrete or mortar. Scaling is common in non air-entrained concrete but can also occur in air-entrained concrete in the fully saturated condition. Scaling occurs in poorly finished or overworked concrete where too many fines and not enough entrained air is found near the surface. Scaling of concrete is shown in Figure 1.1.2.1.

Figure 1.1.2.1. Scaling of Concrete

1.1.2.2 Disintegration

Disintegration is the physical deterioration or breaking down of the concrete into small fragments or particles. The deterioration usually starts in the form of scaling and, if allowed to progress beyond the level of very severe scaling, is considered as disintegration. Disintegration of concrete is illustrated in Figure 1.1.2.2.

Figure 1.1.2.2. Disintegration of concrete

1.1.2.3 Water wash

Water wash is caused by water borne sand and gravel particles eroding the concrete surface.

Water wash of a concrete column is shown in Figure 1.1.2.3.

Figure 1.1.2.3. Waterwash

1.1.2.4 Corrosion of reinforcement

Corrosion is the deterioration of reinforcement by the process of oxidation. Corrosion can also occur in the presence of high Chloride ion concentration such as when the concrete is immersed in sea-water or exposed to salt-spray. Corrosion may appear as a rust stain on the concrete surface initially. In the advanced stages, the surface concrete above the reinforcement can crack, delaminate and spall-off exposing the underlying reinforcement. This process is illustrated in Figure 1.1.2.4 (a) & (b)

Figure 1.1.2.4 (a) Corrosion of reinforcement in concrete

Figure 1.1.2.4 (b) Corrosion of reinforcement in concrete

1.1.2.5 Delamination

Delamination is defined as a discontinuity in the surface concrete which is substantially separated but not completely detached from the main mass of concrete. Visibly, the concrete may appear to have a solid surface, however, the delamination can be identified by the hollow sound if the concrete is tapped with a hammer. Delamination commonly begins with the corrosion of reinforcement and subsequent cracking of the concrete and normally occurs in the plane of the reinforcement parallel to the exterior surface of the concrete. It can also result from impact and from crushing that occurs when two concrete components come into contact.

1.1.2.6 Spalling

A spall is a fragment, which has been detached from a larger concrete mass. Spalling is a continuation of the delamination process in which the pressure exerted by the corrosion of reinforcement results in complete separation of the delaminated concrete.

Vehicular or other impact can also result in spalling. Spalling may also be caused by overloading of the concrete in compression. Spalling may also occur in areas of localised high compressive load concentrations, such as at structure supports, or at anchorage zones in prestressed concrete. Concrete exposed to extreme temperatures such as in a fire may also spall.

The spalled area left behind is characterised by irregular edges.

Spalling of concrete is shown in Figure 1.1.2.6 (a) & (b).

Figure 1.1.2.6 (a) Spalling of concrete

Figure 1.1.2.6 (b) Spalling of concrete

1.1.2.7 Cracking

A crack is a fracture in the concrete which extends partly or completely through the member. Cracks in concrete are caused by tensile stresses induced in the concrete as result of volumetric changes or loads applied. Concrete is weak in tension. When the level of the tensile stress in concrete exceeds its tensile capacity, the concrete cracks. After this point the tensile force is transferred to the steel reinforcement. The purpose of reinforcement and prestressed strand is to control crack width and crack distribution.

Tensile stresses and cracks in concrete may be due to externally applied loads, external restraint forces, internal restraint forces, differential movement and settlements, or corrosion of the reinforcement. Externally applied loads generate compressive and tensile stresses in the members and components of the structure. Cracks resulting from externally applied loads initially appear as hairline cracks and are not significant. However, if the applied load increases, the stress in the reinforcement rises and the initial cracks widen and progressively spread.

Cracks may also be caused by:

- External restraint forces if the free movement of the concrete arising from temperature, creep and shrinkage is prevented.
- Internal restraint forces resulting from the differential expansion or contraction of the exterior surface of concrete relative to the interior mass of the concrete – e.g. plastic shrinkage cracking and early thermal cracking. The resulting surface cracks are normally shallow and appear as pattern cracks.
- Differential movements or settlements resulting in the redistribution of external reactions and internal forces in the structure. This may in turn result in the introduction of additional tensile

stresses and cracking in the concrete components of the structure. Movement cracks may be of any orientation and width, ranging from fine cracks above the reinforcement due to formwork settlement, to wide cracks due to foundation or support settlement.

The types and location of cracking that are the most likely to be observed are shown in Figure 1.1.2.7 (a).

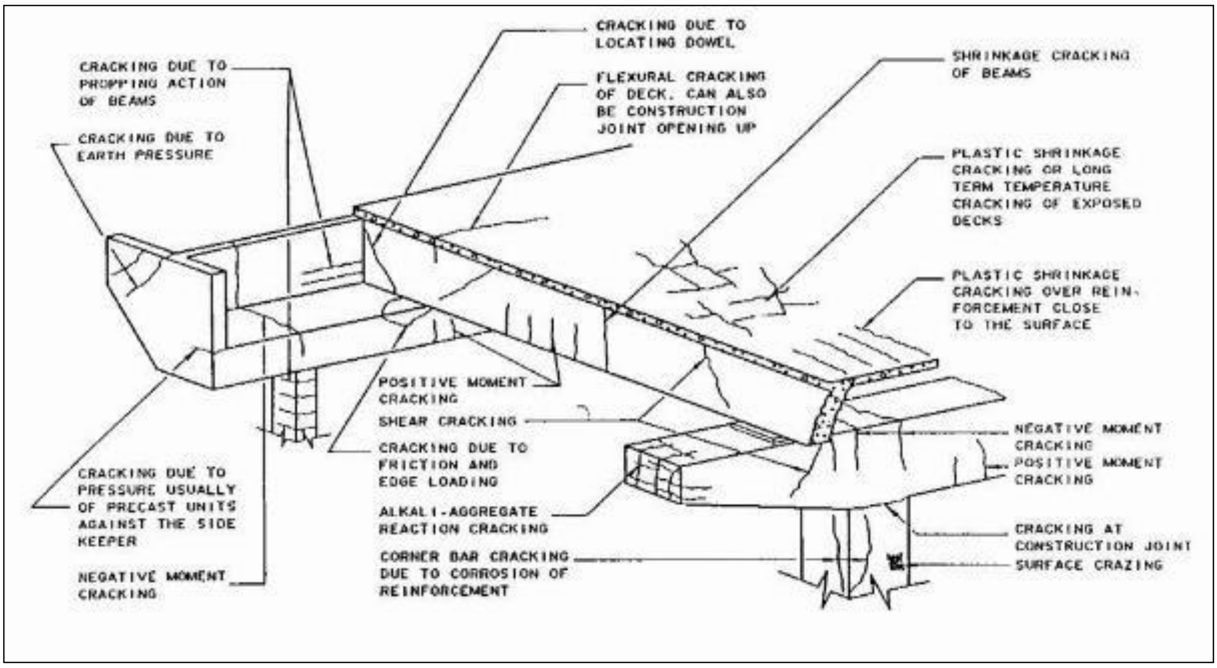


Figure 1.1.2.7 (a) Types and location of cracks in concrete structures

The severity of cracking is shown in Figure 1.1.2.7 (b) and is defined as:

- Hairline: up to 0.1 mm.
- Fine: > 0.1 mm and ≤ 0.3 mm.
- Medium: > 0.3 mm and ≤ 0.7 mm.
- Heavy: > 0.7 mm.

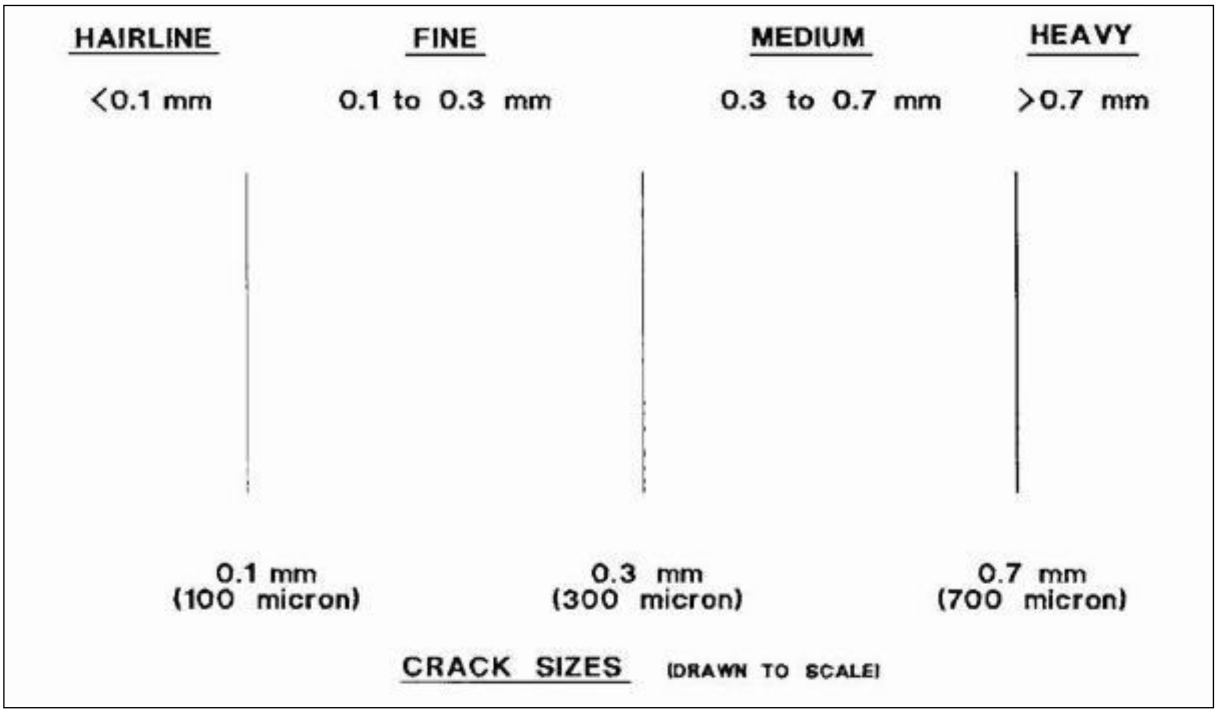


Figure 1.1.2.7 (b)

When the concrete surface around a crack has spalled, it is important to ensure that the actual crack width is measured rather than the spalled width as shown in Figure 1.1.2.7 (c).

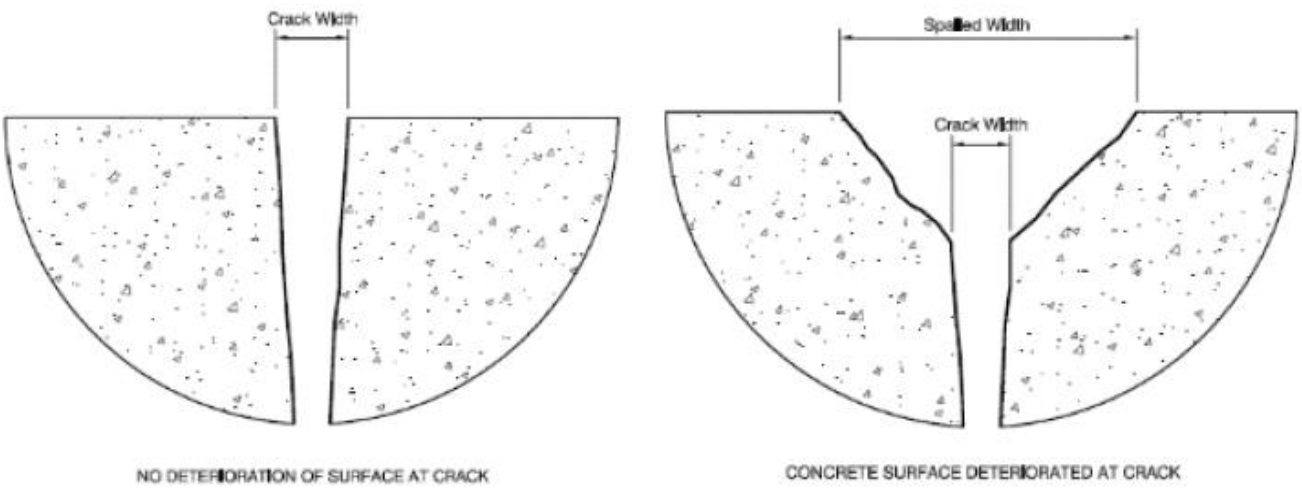


Figure 1.1.2.7 (c) Accurate measure of crack width

1.1.2.8 Alkali Aggregate Reaction (AAR)

Some aggregates react adversely with the alkalis in cement to produce a highly expansive alkali-silica gel. The expansion of the gel and aggregates under moist conditions leads to cracking and deterioration of the concrete. The cracking occurs through the entire mass of the concrete. AAR is generally slow by nature, and the results may not be apparent for many years. The appearance of concrete affected by alkali-aggregate reactions is shown in Figure 1.1.2.8.

Figure 1.1.2.8 Alkali aggregate reaction (AAR)

Figure 1.1.2.9 Efflorescence on the beam soffit

1.1.2.9 Surface defects

The following are examples of surface defects in concrete:

- Segregation.
- Cold Joints.
- Surface deposits – efflorescence, stalactite.
- Honeycombing.
- Abrasion and wear.

Surface defects are not necessarily serious. However, they can be indicative of a potential weakness in the concrete.

Segregation is the differential concentration of the components in fresh concrete resulting in variable composition. For example, when concrete is allowed to fall from a height of more than 2 m, the coarse aggregate may settle to the bottom of the fresh concrete mass leaving an excess of the fine particles at the upper part of the mass. Other causes of segregation are poor mix design or if closely spaced reinforcing bars prevent the uniform flow of concrete.

Cold Joints are produced if there is a delay between the placement of successive deliveries of concrete, and if an incomplete bond develops at the joint due to the partial setting of concrete in the first pour.

Deposits are often left behind where water percolates through the hardened concrete and dissolves or leaches chemicals from it and deposits them on the surface.

Deposits may appear as the following:

- Efflorescence – a deposit of salts (chemical components of the concrete), usually white and powdery refer to Figure 1.1.2.9.
- Exudation – a liquid or gel-like discharge through pores or cracks in the surface.
- Encrustation – a hard crust or coating formed on the concrete surface.
- Stalactite – a downward pointing formation hanging from the concrete surface, usually shaped like an icicle and made from salts in the concrete.

Honeycombing is caused by inadequate compaction of the concrete which results in voids where the cement matrix failed to completely fill the spaces between the coarse aggregate.

Abrasion damage is caused by contact with vehicles and results in the removal of the concrete surface. It can also be caused by friction of water-borne particles against submerged members. This phenomenon is also known as water wash.

Slippery surfaces – e.g. polished concrete deck – may be caused by the repetitive passage of vehicles.

1.1.2.10 Carbonation

Carbonation is a process through which the alkalinity of concrete slowly reduces over time due to the ingress of atmospheric carbon-dioxide. Reduction in alkalinity leads to corrosion of embedded steel reinforcement.

1.1.2.11 Chloride ingress

Sodium chloride in the atmosphere or in water can penetrate concrete through to the reinforcement. The sodium chloride separates into Sodium (Na) and Chloride (Cl) ions. When the chloride ions reach the reinforcing steel, corrosion of the embedded reinforcement occurs. Corroding steel increases in volume leading to the risk of delamination and spalling. The greatest risk of Chloride ion ingress occurs in coastal areas and in river estuaries where tidal flows can bring salt-laden (brackish) water inland. Salt spray may be blown inland by strong winds affecting structures several kilometres from the sea.

1.1.3 Steel

Based on Ontario Ministry of Transportation, Ontario Structure Inspection Manual.

The use of steel has progressed from cast iron, wrought iron, riveted steel and plain carbon steel to notch tough low temperature steel.

The following defects commonly occur in steel:

- Corrosion.
- Permanent Deformations.
- Cracking.
- Loose connections .

1.1.3.1 Corrosion

Corrosion (rust) is the oxidation of steel resulting from exposure to air, moisture, fumes, chemicals and contact with other metals. Corrosion can be prevented or minimised by the use of coatings but the effectiveness of these coatings is reduced or lost if the coating is damaged.

Rust on carbon steel is initially fine grained, but as rusting progresses it becomes flaky and delaminates, exposing a pitted surface leading to a progressive loss of section.

Light corrosion can be identified as small reddish brown spots and occurs on steelwork when the existing protective coating is loss.

Figure 1.1.3.1 (a) Light corrosion on steel work and loss of protective coating

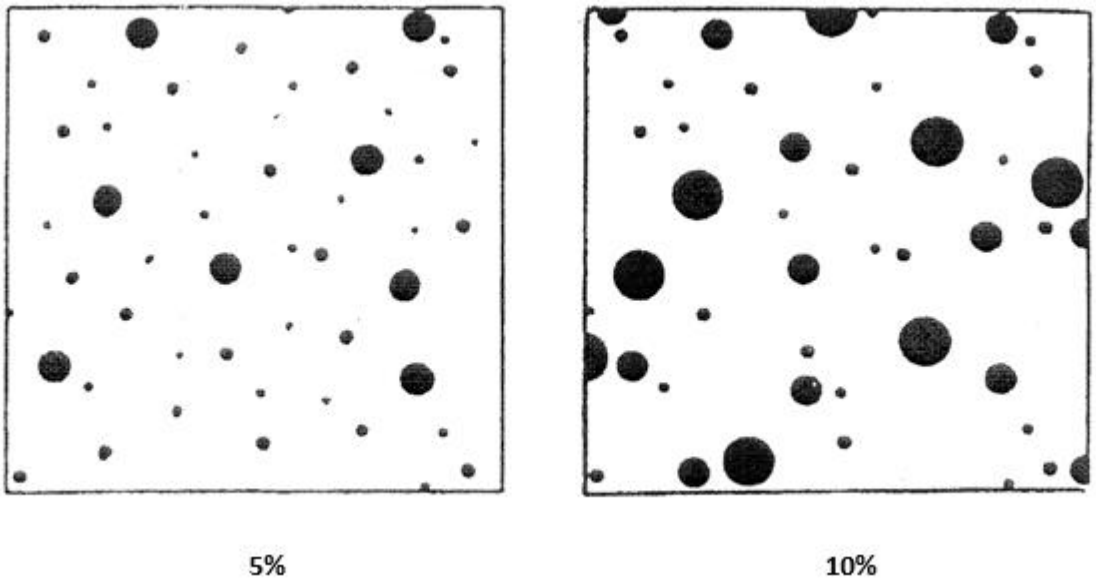


Figure 1.1.3.1 (b) Typical rust spotting as % of web surface area

Pitting corrosion can be identified as holes and cavities and is caused by localised corrosion. This generally progresses from light corrosion spots on steelwork or is due to localised water ponding or exposure.

Section loss can be identified as uniform area of steelwork with noticeable cross sectional loss. This may occur when the section of steel work has lost its protective coating exposing the steel surface area to environmental conditions.

Figure 1.1.3.1 (c) Section Loss and Pitting Through Steel

1.1.3.2 Permanent deformations

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

Permanent bending deformation generally occurs in flexural members in the direction of the applied loads. However, vehicular impact may produce permanent bending deformation in any member.

Permanent buckling deformation generally occurs in compression members in a direction perpendicular to the applied load. Buckling may also produce local permanent deformations of webs and flanges of beams, plate girders and box girders.

Permanent twisting is a rotation of the member about its longitudinal axis and usually results from eccentric transverse loads on the member.

Permanent axial deformation occurs along the length of the member and is normally associated with tensile loads.

1.1.3.3 Cracking

Cracking is a linear fracture of the steel and is normally caused by fatigue. It can lead to brittle fracture of the affected component and to more widespread structural failure.

Brittle fracture is a crack completely through the component that usually occurs without plastic deformation and with little or no warning. Brittle fracture may result at fatigue prone details after initial fatigue cracking.

The primary factors leading to fatigue cracking are:

- The number of applied stress cycles (influenced by volume of traffic and/or the wind loading and the effects of passing vehicles).
- The magnitude of the stress range which depends on the applied live load.
- The fatigue resistance of the connection detail (which is influenced by the strength, toughness and geometry of the components and the weld size and geometry.

Fatigue cracks normally occur at points of tensile stress concentrations, at welded attachments or at termination points of welds in components subject to cyclic loading. Cracks may also be caused or enlarged by overloading, vehicular collision or loss of section thickness due to corrosion. Poorly designed and fabricated details and the fracture toughness of the steel are also contributing factors. Fracture toughness determines the size of the crack that can be tolerated before fracture occurs.

Welded components are more susceptible to cracking than bolted or riveted components. If cracking occurs in a welded connection, it can extend into other components and possibly lead to a brittle fracture.

Bolted or riveted connections may also develop fatigue cracks, but a crack in one component will generally not pass through into the others. Bolted and riveted connections are also susceptible to cracking or tearing as a result of the force generated by expansive corrosion between connection components.

Common locations susceptible to cracking are illustrated in Figure 1.1.3.3 (a) & (b). As cracks may be concealed by rust, dirt or debris, the surfaces should be cleaned before inspection.

Cracks that are perpendicular to the direction of stress are potentially very serious; those parallel to the direction of stress less so. In either case, cracks in steel components should be treated with caution as parallel cracks may for a number of reasons turn into a perpendicular crack. Any crack should be carefully noted and recorded including its specific location in the member, and the member's location in the structure. The length, width and direction of crack should also be recorded.

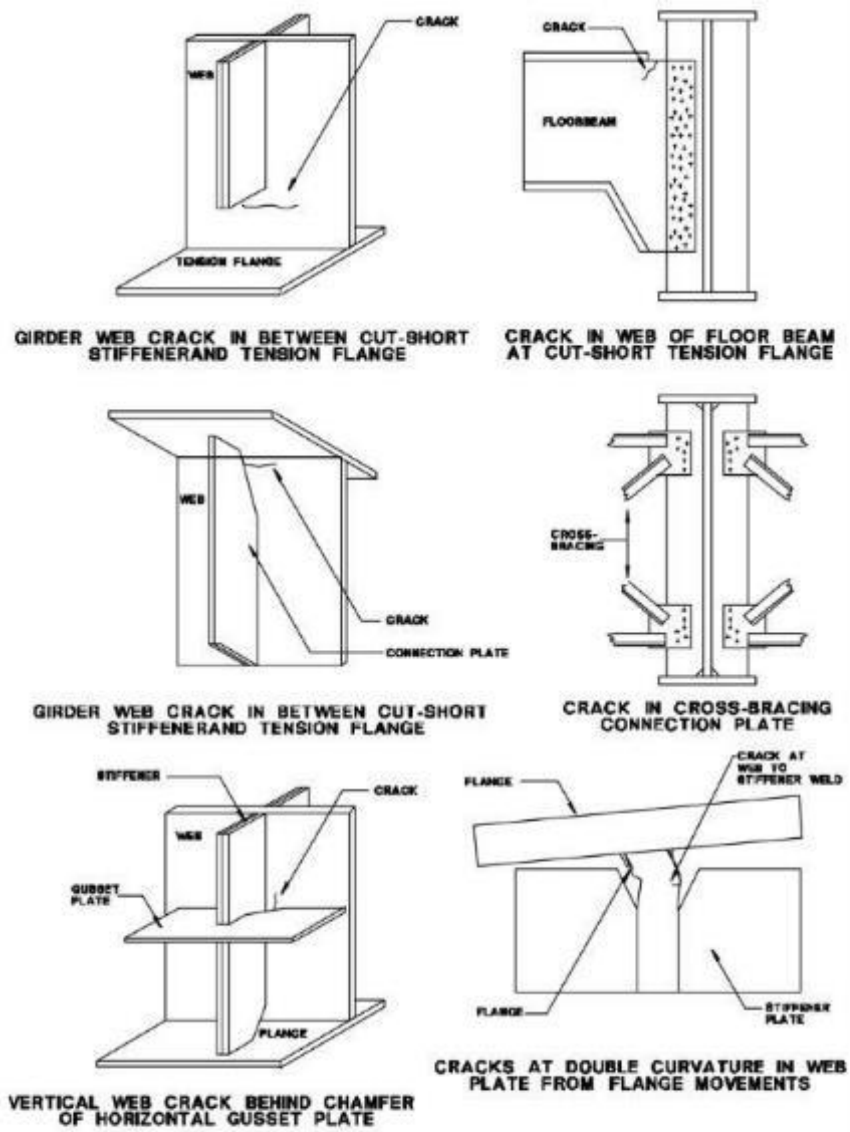


Figure 1.1.3.3 (a) Common locations susceptible to cracking

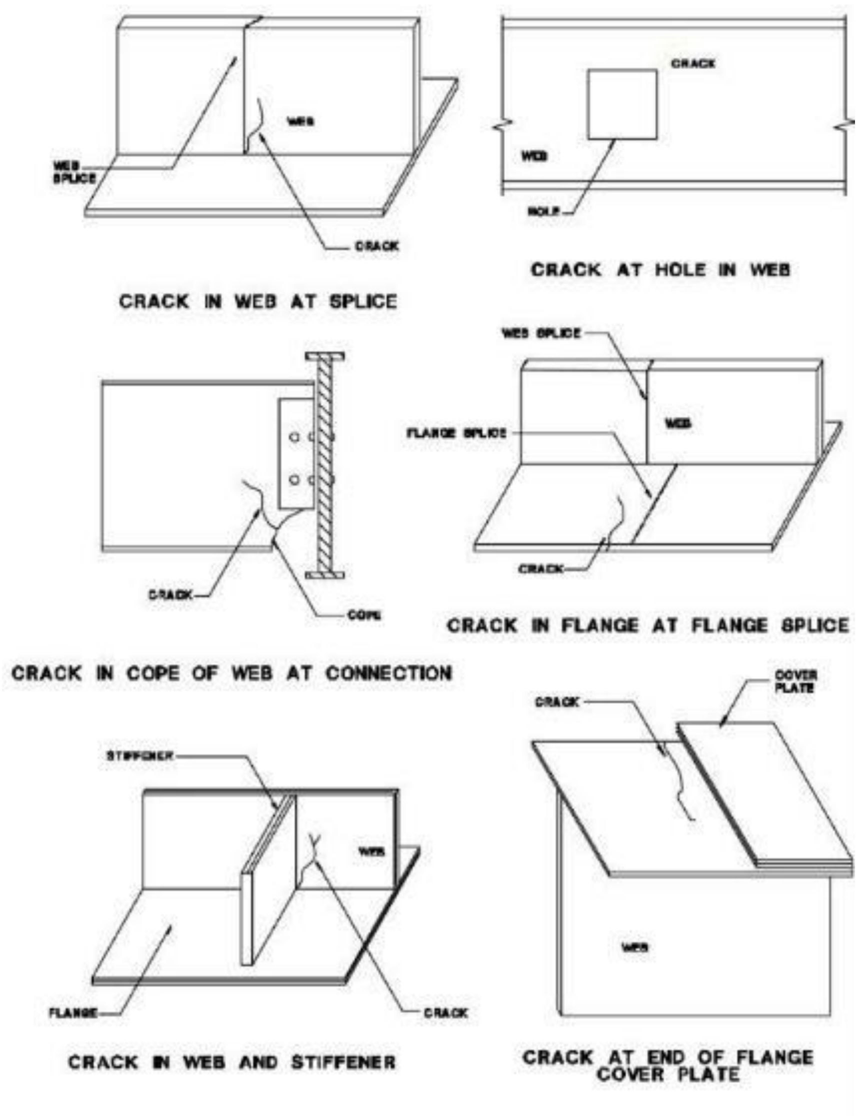


Figure 1.1.3.3 (b) Common locations susceptible to cracking

1.1.3.4 Loose connections

Bolted and riveted connections may become loose as a result of corrosion of the connector plates or fasteners, excessive vibration, overstressing, cracking, or the failure of individual fasteners. Loose connections may sometimes be undetectable by visual inspection. Cracking or excessive corrosion of the connector plates or fasteners, or permanent deformation of the connection or members framing into it, may be indications of a loose connection. Tapping the connection with a hammer is one method of determining if the connection is loose. If a connection is suspect but the status cannot be confirmed, its full details should be noted as required for cracks in welds and further monitoring/investigation should be arranged.

1.1.4 Timber

Timber bridges were extensively used on Victorian roads until the middle 1900s and now constitute only a small proportion of the structures on the state road network. The majority of timber bridges are on local roads controlled by municipalities. Some are on tourist roads and forest roads and may carry heavy loads.

The following defects commonly occur in timber bridge components:

- Fungal rot.

- Termites.
- Marine organisms.
- Corrosion of fasteners.
- Shrinkage and splitting.
- Fire damage.
- Flood damage.
- Weathering.

This section is based on *Austroads 1991 Bridge Management Practice.*

1.1.4.1 Fungal Rot

White rot or brown rot fungi causes severe internal decay of bridge timbers members. External surface decay, especially in ground contact areas, is caused by soft rot fungi. Other fungi such as mould and sap stain fungi may produce superficial discolouration on timbers but are not generally of structural significance.

Fungal growth does not occur unless there is a source of infection from which the fungus can grow.

Fungi procreate by producing vast numbers of microscopic spores which will not germinate and develop unless there is:

- An adequate supply of food (wood cells).
- An adequate supply of oxygen (air) – prolonged immersion in water saturates timber and inhibits fungal growth.
- A suitable range of temperatures – optimum temperatures are 20° - 25°C for soft rots, while their rate of growth declines above or below the optimum with a greater tolerance of lower temperatures apparent); and.
- A continuing supply of moisture (wood with a moisture content below 20% is safe from decay, and many fungi require a moisture content above 30%).

Once established and provided that favourable conditions prevail, the decay fungi continue to grow at an accelerating rate. Depriving the fungi of any one of the required conditions will effectively curtail the spread of decay. Wood that is kept dry or saturated will not rot. Moisture change can affect decay indirectly because drying often leads to surface checks, which may expose untreated parts of timber or create water trapping pockets. Proper preservative treatment effectively provides a toxic barrier to the fungi’s food supply, thus preventing decay.

Figure 1.1.4.1 Pile failure resulting from heartwood rot.

1.1.4.2 Termites

Australia has a large number of termite species which are widely distributed. Heavy termite attack is found in the northern tropical belt of Australia but the hazard is sufficient in southern Australia to constitute a significant problem. Practically all termite damage to timber bridges occurs through subterranean termites (especially *Coptotermes acinaciformis* and allied species) which require contact with the soil or some other constant source of moisture.

Termites live in colonies or nests which may be located below ground in the soil, or above ground in a tree stump, hollowed out bridge member or an earth mound. Each colony contains a queen, workers, soldiers and reproductive termites or alates. The workers, who usually constitute the highest portion of the population, are white-bodied blind insects some 3 mm in length which have well developed jaws for eating timber. Attack by subterranean termites originates from the nest, but may spread well above ground level, either inside the wood or via mud walled tubes called galleries which are constructed on the outside of bridge members. These galleries are essential for termites as they require an absence of light, a humid atmosphere and a source of moisture to survive. At least once a year the alates develop eyes and wings and leave the nest under favourable weather conditions to migrate up to 200 m from the original nest. After migration, their wings fall off and a few may pair to start new colonies.

Well-established termite attack usually degrades timber much more quickly than fungi, but it is rare for termite attack to occur in durable hardwoods normally used in bridge construction without some pre-existing fungal decay. This decay accelerates as the termites extend their galleries through the structure, moving fungal spores and moisture about with their bodies. Hence, although most of the material removed by termites has already lost its structural strength because of decay, the control of termites remains an important consideration.

Basically, there are two main strategies in termite control:

- Eradication of the nest (by either direct chemical treatment or by separation of the colony from its sustaining moisture).
- Installation of chemical and physical barriers to prevent termites from entering a bridge or attacking timber in contact with the ground.

In practice it may be difficult to eradicate the nest because of the problem of locating it.

Refer to Figure 1.1.4.2 showing termite attack.

Figure 1.1.4.2 Termite attack

1.1.4.3 Marine organisms

Damage to underwater timber in the sea or tidal inlets is usually caused by marine borers, and is more severe in tropical and sub-tropical waters than in colder waters.

The two main groups of animal involved are:

- Molluscs (teredinidae) – this group includes various species of Teredo, Nausitora and Bankia.
- Crustaceans – this group includes species of Sphaeroma (pill bugs), Limnoria (gribbles), and Chelura.

Teredinid molluscs are commonly known in Australia as Teredo or shipworm. They start life as minute, free-swimming organisms and after lodging on timber they quickly develop into a new form and commence tunnelling. A pair of boring shells on the head grow rapidly in size as the boring progresses, while the tail with its two water circulating siphons remains at the original entrance. The teredine borers destroy timber at all levels from the midline to high water level, but the greatest intensity of the attack occurs in the zone between 300 mm above and 600 mm below tide level. A serious feature of their attack is that while the interior of the pile may be eaten away, only a few small holes may be visible on the surface.

Refer to Figure 1.1.4.3 for signs of Teredinid marine borer.

Figure 1.1.4.3 Signs of teredinid marine borer.

Crustaceans attack the wood on its surface, making many narrower and shorter tunnels than those made by the teredines. The timber so affected is steadily eroded from the outside by wave action and the piles assume a wasted appearance or hourglass effect. Attack by Sphaeroma is limited to the zone between tidal limits, with the greatest damage close to half tide level. They cannot survive in water containing less than 1.0 - 1.5% salinity, but can grow at lower temperatures than the teredines.

Many strategies have been developed for the control of marine borers but, assuming that the piles have sufficient remaining strength, the most effective work by reducing the oxygen content of water around the borers.

1.1.4.4 Corrosion of fasteners

Corrosion of steel fasteners can cause serious strength reductions for two related reasons. Firstly, the steel fastener reduces in size and weakens, and secondly a chemical reaction involving iron salts from the rusting process can significantly reduce the strength of the surrounding wood (this is not fungal decay).

1.1.4.5 Shrinkage and splitting

Moisture can exist in wood as water or water vapour in the cell cavities and as chemically bound water within the cell walls. As green timber losses moisture to the surrounding atmosphere, a point is reached when the cell cavities no longer contain moisture, but the cell walls are still completely saturated with chemically bound water. This point is called the fibre saturation point. Wood is dimensionally stable while its moisture content remains above the fibre saturation point, which is typically around 30% for most timbers. Bridges are normally constructed from green timber which gradually dries below its fibre saturation point until it reaches equilibrium with the surrounding atmosphere. As it does so, the wood shrinks but because it is anisotropic, it does not shrink equally in all directions. Maximum shrinkage occurs parallel to the annular rings, about half as much occurs perpendicular to the annular rings and a small amount along the grain.

The relatively large cross section timbers used in bridges lose their moisture through their exterior surfaces so that the interior of the member remains above the fibre saturation point while the outer layers fall below and attempt to shrink. This sets up tensile stresses perpendicular to the grain and when these exceed the tensile strength of the wood, a check or split develops, which deepens as the moisture content continues to drop. As timber dries more rapidly through the ends of the member than through the sides, more serious splitting occurs at the ends. Deep checks provide a convenient site for the start of fungal decay.

Shrinkage also causes splitting where the timber is restrained by a bolted steel plate or other type of fastening. This splitting can be avoided by allowing the timber to shrink freely by using slotted holes. As timber shrinks, it tends to lose contact with steel washers or plates, so the connection is no longer tight. Checking the tightness of nuts in bolted connection is therefore a standard item of routine maintenance for timber bridges.

1.1.4.6 Fire damage

References include Bootle (1983)

Wood itself does not burn. The effect of heat is firstly to decompose the wood (a process known as ‘pyrolysis’) and it is some of the products of this decomposition that burn if conditions are suitable. This concept is important in discussions on the action of retardants.

In theory, wood decomposes even at temperatures as low as 20°C (at the rate of 1% per century). At 93°C the wood will become charred in about 5 years.

When wood is heated, several zones of pyrolysis occur which are well delineated due to the excellent insulating properties of wood (thermal conductivity roughly 1/300 that of steel). These zones can be described generally as follows:

- Zone A: 95°C - 200°C water vapour is given off and wood eventually becomes charred.
- Zone B: 200°C - 280°C water vapour, formic and acetic acids and glyoxal are given off, ignition is possible but difficult.
- Zone C: 280°C - 500°C combustible gases (carbon monoxide, methane, formaldehyde, formic and acetic acids, methanol, hydrogen) diluted with carbon dioxide and water vapour are given off. Residue is black fibrous char. Normally vigorous flaming occurs. If, however, the temperature is held below 500°C, a thick layer of char builds up and because the thermal conductivity of char is only 1/4 that of wood, it retards the penetration of heat and thus reduces the flaming.
- Zone D: 500°C - 1000°C in this zone the char develops the crystalline structure of graphite, glowing occurs and the char is gradually consumed.
- Zone E: above 1000°C at these temperatures the char is consumed as fast as it is formed.

As the temperature of the wood is lowered, the above mentioned behaviour still holds, e.g. combustion normally ceases below 280°C.

1.1.4.7 Flood damage

Floods can have a disastrous affect particularly on timber structures. This is due to:

- Extra pressure from the flood waters and debris.
- Log impact on the substructure. If the flood is high enough, the super-structure can also be damaged by the flood waters.

A prime example of flood damage was the 1946 floods in the Western District when approximately 13 major timber structures were washed away.

A special inspection of all structures is required following a major flood event.

1.1.4.8 Weathering

Weathering is the gradual deterioration of sawn or log timber due to its exposure to sun, wind and rain. Weathering can be a serious problem especially to the exposed end grain of untreated or unprotected wood, where severe rotting can occur around the connections and end splitting occurs.

1.1.5 Masonry

Based on *Ontario Ministry of Transportation, Ontario Structure Inspection Manual.*

Masonry is made of natural stone blocks or clay bricks usually bonded together by mortar. Although not a common construction material today, masonry was used in retaining walls, abutments, piers or arches, primarily in the 19th century while brick masonry was only rarely used in highway structures. Types of masonry construction are Ashlar masonry, squared stones masonry and rubble masonry.

The following defects commonly occur in masonry:

- Cracking.
- Splitting, spalling and disintegration.
- Loss of mortar and stones.
- Arch stones dropping.
- Deformation.
- Separation of arch rings.

1.1.5.1 Cracking

Cracks develop in masonry as a result of differential settlement of the structure, loss of mortar, thermal restraint and overloading leading to crushing and splitting of blocks.

Cracks develop either at the interface between the stone and mortar, following a zigzag pattern, when the bond between them is weak; or, go through the joint and stone, in a straight line, when the mortar is stronger than the stone, as shown in Figure 1.1.5.1.

Figure 1.1.5.1 Cracking through masonry

1.1.5.2 Splitting, spalling and disintegration

Splitting is the opening of seams or cracks in the stone leading to the breaking of the stone into large fragments.

Spalling is the breaking or chipping away of pieces of the stone from a larger stone.

Disintegration is the gradual breakdown of the stone into small fragments, pieces or particles.

The splitting, spalling and disintegration of masonry is caused by the actions of weathering and abrasion or by the actions of acids, sulphates or chlorides, which cause deterioration in certain types of stones, such as limestone. Splitting, spalling and disintegration may also occur if adjacent blocks touch as a result of deformation of the arch ring.

1.1.5.3 Loss of mortar and stones

Loss of mortar is the result of water wash, plant growth or softening by water containing dissolved sulphates or chlorides. Partial disintegration of mortar may lead to loss of stone blocks.

Figure 1.1.5.3 shows evidence of loss of mortar.

Figure 1.1.5.3 Loss of mortar.

1.1.5.4 Arch stones dropping

Ground or foundation movement or severe vibration can cause stone blocks to displace and drop relative to other stones in an arch. This can also be exacerbated if the quality of the stones or mortar is poor and failing as shown in Figure 1.1.5.4.

Figure 1.1.5.4 Dropping arch masonry block

1.1.5.5 Side wall movement at masonry arch

Excessive pressure normally due to heavy loads or vibration can cause the side walls of a masonry arch to move outwards away from the arch. This is a serious problem and will probably require a higher level inspection.

1.1.5.6 Deformation

Arches are either semi-circular, segmental (i.e. part of a semi-circle) or elliptical in shape. The regular curvature may become deformed if the arch is overloaded or if there is differential settlement of the foundations. Deformation may be accompanied by cracking and dropped stones. The position and degree of deformation should be recorded.

1.1.5.7 Separation of arch rings

Arches may comprise multiple rings or layers of bricks which combine in practice to form a single arch. The rings may delaminate if the mortar fails or if overloading or settlement occurs. The position and degree of separation should be recorded.

1.1.6 Protective Coatings

Coating defects are not necessarily serious but they are indicative of potential weaknesses in the coating system and eventual loss of protection to the coated surface.

Protective coatings generally have a shorter life than the life of the structure. Hot-dipped galvanising may be totally lost in less than 30 years: even less in aggressive or abrasive conditions.

Breakdown of paint or loss of galvanising is inevitable and should be anticipated. The rate of breakdown is dependent on a number of interrelated factors with the duration of continuous exposure to water being a significant factor. In addition to rainfall, exposure to water arises from immersion and from condensation and the effect may be increased if the moisture contains windborne salt and the salt is not removed by rain. Accumulation of debris, bird droppings, flaking paint, for example, will retain moisture and promote corrosion.

In addition to eventual failure of a coating system by weathering, premature failure may result from:

- Poor adhesion due to incorrect specification, preparation or application of the coating.
- Incompatibility of successive coats.
- Rusting due to inadequate surface preparation and/or priming paint.
- Localised failure due to mechanical damage.
- Inadequate paint film thickness on sharp edges, welds and paint shadow areas.

Expert advice may be required to establish the cause of failure and recommend suitable remedial action.

1.1.7 Fibre-reinforced Polymer Strengthening

Fibre-reinforced Polymer (FRP) composites are used to strengthen reinforced and prestressed concrete members which are deficient in moment, shear or bursting capacity. The fibres can be Carbon, Aramid or Glass. The FRP material can be used in the form of flexible sheets to wrap around the member or in the form of plates. Plates comprise one of the three fibre types, typically in a resin or epoxy matrix. The system relies on the high tensile capacity of FRP and the bond between the FRP and the steel or concrete beam.

FRP strengthening can be detrimentally affected by overloading of the structures, extreme temperature, moisture absorption and high UV exposure. The effects are exacerbated by defects introduced in the materials during manufacture, handling and installation. The strengthening method relies entirely on the anchorage and bond of the FRP material to the base component.

The following areas should be inspected and recorded:

- The ends of the strengthened area for signs of the FRP strips debonding from the epoxy resin or the resin debonding from the concrete base.
- The visible concrete surface at the edge of the strengthening for signs of cracking or spalling which could affect bonding between the FRP and the member.
- The whole of FRP surface for signs of delamination from the concrete or any irregularities in the material such as blistering or folding.
- Tears, cuts or crazing of the FRP material.

If any area is classified as being in condition state of 3 or 4, pull-off testing should be conducted in the surrounding FRP to ensure the full extent of the problem is identified. Repair should not be instigated until the whole area of the defect has been identified.

1.2 Common Causes of bridge Deterioration

1.2.1 Concrete Bridges

The following section lists the various types of reinforced and prestressed concrete bridges and lists the main problems associated with each type.

1.2.1.1 Monolithic and simply supported T-beams

The majority of monolithic structures are T-beam bridges with the whole structure cast-in-situ. Spans are generally small but bridges of this type may have up to 5 spans. This can cause significant strains at piers, columns and abutments due to temperature-related movements possibly leading to cracking and other relative displacement or distortion of the beam/wall joint at the abutment. Cracking may also occur at the column faces of the furthest pier from the centre of the bridge due to temperature-related movement. This type of structure may also exhibit cracking and staining of the underside of the deck in negative moment areas (near to the junction of the deck with pier/column and abutments).

T-beam bridges often have insufficient shear reinforcement near supports and diagonal shear cracking may be observed at 1/3rd of the span from the support. The abutments and wingwalls were frequently cast monolithically. Heavy cracking, spalling and movements may be observed at the wingwall joints especially in the case of higher abutment walls.

Gravel fills were often placed over the deck of these structures with a sprayed seal which did not cover the full width of deck. Deck drainage was often poor allowing water ponding on the road surface which could then penetrate the concrete leading to efflorescence and spalling of the underside of deck.

Simply supported T-beam structures are generally a later design that features increased shear resistance in the beams and reduces risk of shear cracking. Some flexural cracking of the beams might be seen at mid-span especially on structures which carry frequent heavy loads. The beams were sometimes fixed at one end using a locating dowel with the other end free to move. The free end frequently locks with the consequence that the beam may crack and spall at both ends. The crosshead/bearing concrete at the beam supports can also spall due to frictional forces as the original debonding layer of grease or malthoid at the bearing surface deteriorates.

1.2.1.2 Precast I beams

The first precast I beams were made in 1949 and used on the Kiewa Valley Highway bridges. These beams were made from normal strength concrete and reinforcement. By the early 1960s, standard precast high strength reinforced and prestressed concrete beams were in use for spans of 9.1 to 18.3 metres (originally 30 to 60 feet). These beams have generally performed well over the years but some of the precast reinforced concrete beams have minor flexural cracking at mid-span.

NAASRA beam sections came into use in 1970 and were only adopted for long span structures in 1976. The NAASRA type 4 beams have been used for simply supported prestressed beams up to 33 metres, but also used for continuous prestressed beams of longer spans. This was accomplished by casting load bearing diaphragms at the piers which encased the ends of the beams.

The beams were also connected on the bottom bulb by heavy steel bars welded together. In recent years a new bulb tee section has been used in place of the type 4 NAASRA beam for spans up to 36.5 metres.

Prestressed beams can exhibit cracking at the ends in response to the prestressing forces in the strands. The cracks are normally horizontal and the result of inadequacies in reinforcement detailing in the end block. If the beam end is cast into a diaphragm these cracks are concealed and sealed against ingress of moisture. If cracking of this nature is discovered during an inspection, it must be reported. Skewed beam ends are vulnerable to spalling damage during production at the bottom surface and at the apex of the end. The damage occurs when stress is transferred into the beams. Exposed reinforcement is normally patched before delivery to site and the patches may be visible on inspection. Severely damaged beams may be rejected and are unlikely to be seen during inspections.

1.2.1.3 Precast prestressed inverted T beams

These beams were used during the 1970s to give a flat under-side to bridges crossing freeways. This was done for aesthetic reasons as the appearance is more appealing to the driver than the interrupted underside of a T beam bridge. Spans were usually in the range of 32 to 36 metres with the designs being continuous for live load. These beams were not an efficient section and lost favour with designers. No problems have been encountered with these types of structures.

1.2.1.4 Box-girder bridges

Box-girder bridges are generally cast-in-place and post-tensioned. A number of problems can occur during construction and at post-tensioning.

The major maintenance risk for this type of bridge is that the grout around the post tensioning tendons is incomplete and does not provide adequate protection against corrosion of the tendons.

Serious concerns have been identified in some overseas countries where de-icing salts are used on the road surface but to-date no evidence of tendon corrosion has been discovered in DoT bridges.

Some box-girders can be precast in segments and post-tensioned when erected in place. Bell Street Bridge over the Tullamarine Freeway and the West Gate Elevated Freeway being two structures of this type. Minor problems have occurred at Bell Street with slight moisture penetration of the joints between segments and cracking in the internal diaphragms due to high stress.

1.2.1.5 Prestressed voided flat slab bridges

Cast-in-place prestressed voided flat slab bridges provide an attractive shallow depth superstructure, ideal for very wide bridges and with spans in the range of 35 metres. Larger spans are relatively heavy and uneconomical although variable depth voided slabs of 40 metres have been built.

Problems with flotation and distortion of the void formers have been experienced during construction, but these structures are relatively cheap, aesthetically pleasing, and have performed well to-date.

1.2.1.6 Reinforced concrete flat slab bridges

This is a type of monolithic cast-in-place multi-span bridge, typically with 5 spans which have performed very well with the slab providing considerable lateral load distribution. Structures can be continuous over a number of spans, hence there is a possibility of cracking of the columns primarily due to thermally induced movements but also if the bridge is subject to the passage of large numbers of heavy vehicles.

The deck slab in this type of bridge often has a shrinkage crack which runs almost directly down the centreline of the slab. Provided this remains dry it is of no concern.

The final span is a short cantilever from the pier sometimes with a transverse beam stiffening the end of the deck. Vertical precast concrete wall units are placed against the stiffening beam at the end of the deck to retain the approach embankment fill. Spalling can occur due to friction between the wall units caused by vertical movement of the cantilever deck. Moisture may seep through the deck/wall joint. Movement of the wingwalls can occur in bridges with high abutments due to the correspondingly high fill pressures.

1.2.1.7 Rail in slab concrete bridges

These bridges comprise old railway lines spaced close together with a concrete deck cast on top with a layer of light mesh. Used on short spans with deck thickness of approximately 250 mm, these superstructures are generally strong with good shear capacity provided by the rail heads and effective lateral load distribution by the plate effect. Under the effect of repetitive heavy loads they can deflect considerably leading to cracking of the concrete deck and loss of the bond between the rails and concrete. The condition of the deck concrete is vital to the stiffness and lateral load distribution it provides. The concrete acts as a shear key between the rails. Deterioration of the deck concrete is the cause of significant loss of capacity.

The railway lines can corrode with significant loss of section which may require repair. The parapet at the back of footway is generally provided by deep I-beams which are often in direct contact with the footway soil backfill leading to the potential for severe corrosion to the hidden surface. Severe corrosion to this hidden surface may become evident on the external face of the beam web or the bottom flange.

Some bridges of this type have been successfully strengthened with the use of a reinforced concrete deck overlay. Use of an overlay in this manner is subject to accommodation of the thickened deck in the vertical grade of the road and consideration of adjacent property usage.

1.2.1.8 Precast prestressed slabs

Introduced in 1958 for spans of 4.6 to 9.1 metres (originally 15 to 30 feet) these units are held together by transverse tensioning rods in cored holes through the beam webs.

Slabs are 620 mm wide, vary in depth between 160 mm and 315 mm and have a cast-in-situ shear key between units. Although the transverse tensioning rods hold the decking firmly together, the shear-key concrete can crack and fragment allowing moisture penetration. The slabs have two layers of malthoid at the bearing surfaces under the ends of spans with a cast-in-place infill over the piers and abutments. Movement of the beams may cause cracking at the beam ends allowing moisture to penetrate to the crosshead.

The transverse tensioning rods require periodical checking and tightening. If they become loose, this reduces transverse load distribution in the deck leading to higher live loads on individual beams and the potential for long-term failure.

In 1961 a 10.7 metres (originally 35 foot) long prestressed slab was introduced. This had two voids and did not include transverse tensioning rods. Units were independent of each other but a 100 mm thick composite reinforced deck was added to provide lateral load distribution between the units.

New South Wales (RTA) designed precast prestressed planks with spans of 7 to 15 metres were used in the late 1970s and 1980s with composite cast-in-place overlays ranging from 125 mm to 145 mm in thickness. These units had shear keys cast as part of the overlay. The overlay was made continuous over a maximum of three spans to reduce the number of expansion joints and improve the ride-quality over the structure. Some cracking problems have been experienced in the deck over the piers with this type of design. Examples of wide precast prestressed slab bridges have been built but these are now out of favour.

Early in 1993 a new prestressed slab, with a span of 17½ metres, was introduced from Queensland. The units are designed for T44 live loading and plate action is achieved via transverse tension rods through the deck slabs. The units have voids with solid diaphragms at each transverse tension rod location. A sprayed seal is laid over the top of the slabs for anti-skid purposes.

1.2.1.9 Precast U slabs

1.2.1.9.1 General

1951 saw the introduction of precast reinforced concrete inverted U slabs using normal strength concrete and reinforcement. These units were designed for half the axle load of the design vehicle and acted independently of each other. Fill was usually placed on top of the U-slabs to enhance the lateral load distribution between units.

These bridges suffer from moisture penetration between the U-slab legs and also through the expansion joints at the ends of the spans. The beams themselves appear to be strong and only minor flexural cracking at mid-span is normally observed. The kerb slabs are a solid section and the kerb is precast with the beam. If shoulders are unsealed, moisture-related problems are usually most severe under the edge of the seal.

High-strength inverted U-slabs with shear keys and bolts between the vertical legs of adjoining slabs were adopted in 1962. An amended 1965 design increased reinforcement sizes, added mesh in the top flange and altered bolt positions. These U-slabs were designed for 0.47 of axle load of the design vehicle, relying on the shear keys and bolts to provide adequate lateral load distribution. These units had a number of problems including cracking at the top of the legs from over tightening of the bolts by constructors trying to bring the legs of the slabs together. Placing of the high strength concrete in the small shear keys was also a major problem with the joint concrete either setting too quickly or with shrinkage cracking of the joint concrete.

When subjected to repeat heavy loading, the concrete in the joint tends to crack and fragment allowing moisture to leak through the deck. The bolts also get loose due to vibration and the nuts fall off leading to a significant reduction in lateral load distribution between slabs and a consequential loss of load capacity. The slabs become overstressed (the proportion of axle load can rise to 0.67) with heavy flexural cracking of the legs at mid-span. Many of these bridges have now been strengthened by the use of a 140 mm reinforced concrete overlay which extends over three spans.

In 1976, with the introduction of T44 loading, the shear keys and bolts between the legs were eliminated and all U-slab bridges had a 140 mm high strength reinforced concrete overlay added during construction. The U-slab sections were decreased in depth for the span but reinforcement, both flexural and shear, was substantially increased.

A small number of prestressed concrete U-slab bridges were built, including double width U-slabs, but these were not successful due to levelling problems at the legs after stressing. With the introduction of the prestressed voided T slabs, use of stressed U-slabs was abandoned.

1.2.1.9.2 Inspection of Precast U slabs

(a) 1951 Standard Units

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

Inspection and Monitoring: The legs of these units must be inspected for flexural cracking, particularly near mid-span and for shear cracking near the supports as shown in Figure 1.2.1.9.2, 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 must be recorded and photographed.

Some U-slabs are supported on mortar pads whilst others are supported on plain elastomeric bearing pads. There is a tendency for these mortar pads to crack and fail under repeated heavy loading. This in turn may lead to failure of the road pavement along the line of the interface between adjacent U-slabs and destroy any load transfer. Mortar pad and elastomeric bearing pad supports should be inspected and their condition recorded. Particular note should be made of situations where mortar pad failure has resulted in differential settlement of one or more U-slabs relative to adjacent slabs.

Evidence of water penetration such as efflorescence staining and stalactite growth along and between the soffits of the U-slab legs is an indicator of possible independent movement and loss of load sharing between adjacent slabs.

(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, under the action of repeated heavy loads which exceed the original design capacities, many of these bridges have suffered severe damage. This is particularly true of skew bridges where induced torsional loads in the units have not been explicitly designed 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 would be evident in the deck bituminous surfacing.

Inspection and Monitoring: Refer to Figure 1.2.1.9.2. These units must be inspected to determine whether any of the bolts are corroded, loose or broken. This must be recorded and reported for maintenance purpose.

U-slabs must also be inspected to determine whether there is any evidence of cracking of the shear keys. This must 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 interfaces of the precast units. An inspection must 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 shear key concrete failure.

A thorough inspection must also be carried out for 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 must be recorded in detail and photographed.

As with the 1950s U-slabs, some slabs are supported on mortar pads whilst others are supported on plain elastomeric bearing pads. There is a tendency for these mortar pads to crack and fail under repeated heavy loading. This in turn may lead to failure of the road pavement along the line of the interface between adjacent U-slabs and destroy any load transfer. Mortar pad and elastomeric bearing pad supports should be inspected and their condition recorded. Particular note should be made of situations where mortar pad failure has resulted in differential settlement of one or more U-slabs relative to adjacent slabs.

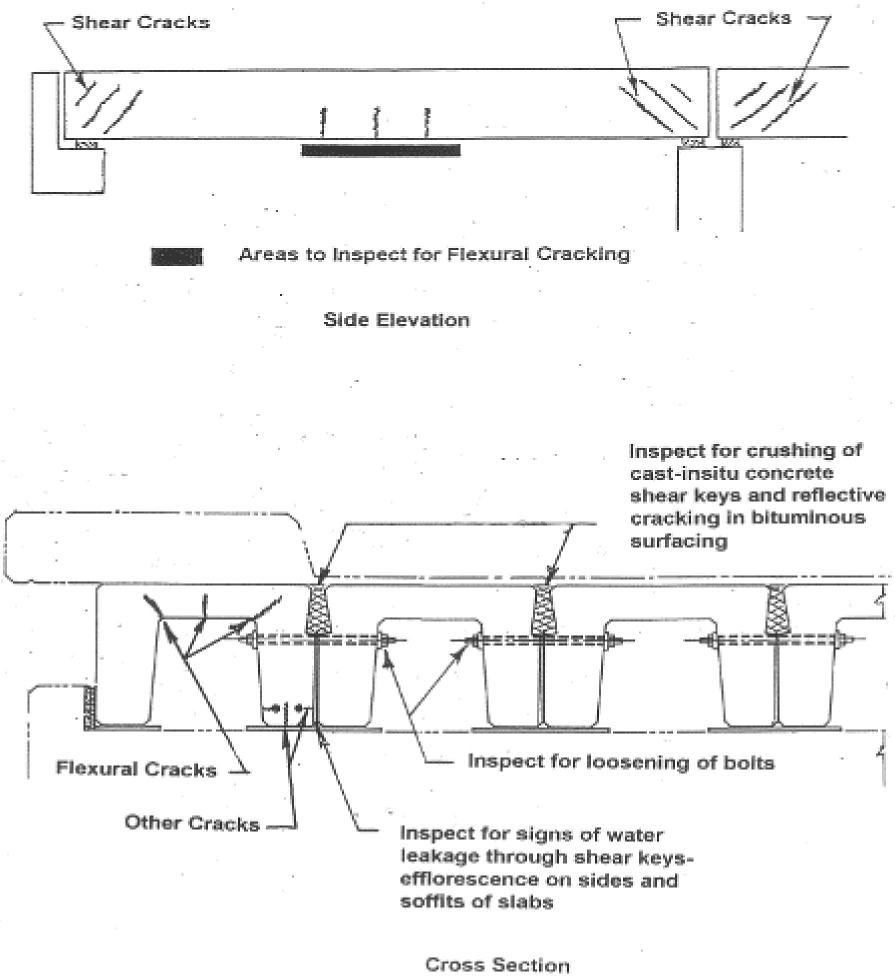


Figure 1.2.1.9.2 – 1962 Series U-slab bridges

1.2.1.9.3 Rating of U-Slabs

Condition Rating

Once the inspection of the structure has been conducted, the following matrix (Figure 1.2.1.9.3.1) may be used to establish a relative rating of the U-slabs. The matrix combinations can then be used as part of the bridge monitoring process to give an indication of the structure condition.

		Water Leakage/Staining #	Flexural Cracking	Shear Keys – Reflective cracking	
A	in one span only				
B	in more than one span	1	1	1	Nil
C	in all spans	2	2	2	Minor
D	in wheel path	3	3	3	Minor/Moderate
E	outer edge U-slabs	4	4	4	Moderate
F	in traffic lane	5	5	5	Moderate/Severe
G	shoulder of bridge	6	6	6	Severe

Figure 1.2.1.9.3.1 – Condition Rating Matrix

Water leakage through the longitudinal shear keys

Structures subjected to repeated heavy loading particularly those on significant skews tend to deteriorate more rapidly and the shear keys and bolts are no longer able to distribute wheel loads to adjacent U-slabs. This usually results in flexural cracking of the beams and ultimately failure if not attended to.

The first sign of shear key deterioration is water penetrating through the deck and between the legs of adjacent units leaving efflorescence and staining on the legs of the beams. This generally occurs, initially along the wheel paths and/or at the outer edge U-slabs particularly beneath where the kerb and pavement meet or under unsealed shoulders where water is more likely to pond.

Water seepage from the expansion joint above the abutments and piers is also common however this should not be confused with water seepage between the U-slabs. This leakage occurs as a result of damage to the seal material of the expansion joints. Although this should be addressed as part of maintenance, it is not a direct indication of structural deterioration. If not attended to, it could potentially lead to corrosion of substructure elements.

Reflective cracking in the road pavement occurs once the shear keys begin to deteriorate, U-slab bolts are loose and there is differential movement between the U-slabs.

The rating of the U-slabs can be determined with the use of the manual (photos) and the findings from the inspection to determine the condition of the slabs which can be used to assess the urgency of the maintenance, strengthening or possible replacement.

Refer to Figure 1.2.1.9.3.2 (a), (b) & (c) for examples of the different ratings for each category.

Figure 1.2.1.9.3.2 (a) Water leakage/Staining

Minor

Moderate

Severe

Figure 1.2.1.9.3.2 (b) Flexural cracking

Minor

Moderate

Severe

Figure 1.2.1.9.3.2 (c) Shear keys – reflective cracking

Minor

Moderate

Severe

Example:

A monitoring inspection was conducted on a bridge constructed in 1963 with bolted high strength reinforced concrete U-slabs with no reinforced concrete overlay. The columns, abutments and crossheads are all cast-in-situ reinforced concrete.

Generally the piers and abutments were in good condition with only minor water seepage. When the soffit of the structure was inspected it was noted that minor water seepage was evident between the outer two U-slabs on the up and down stream side of the structure and between U-slabs 7 and 8 from the east side of the structure. Efflorescence and stalactites were also evident between the outer U-slabs with minor water staining and silt build up on the soffit of most of the U-slab legs. Severe flexural cracking was evident throughout the legs of the U-slabs with spacing between the flexural cracks ranging from 50 to 200 mm. From the top of the structure slight depressions in the road pavement were evident however longitudinal cracking was difficult to identify due to a recent spray seal. Shear keys were exposed near the kerbs and the scuppers were blocked.

From these findings in the Monitoring Inspection Report the following U-slab Rating was given.

Water Leakage	Flexural Cracking	Shear Keys – Reflective cracking
2CE	6C	5CD

Bridge Details

The following bridge details may provide an indication of the likelihood of damage occurring and probable rates of deterioration. They should be included in the assessment.

- Bridge skew – 0°, 14°, 26° 30°, 36° 50°or 45°.
- Smooth or rough approach road profile.
- Operational speed of road for heavy vehicles – 40, 60, 80, 100 km/hr.
- Overall bridge width.
- Number of traffic lanes / width between kerbs.
- Single / multiple spans and span length.
- Mortar pads or neoprene strip bearing supports.

The greater the bridge skew, the higher the probability that the shear keys will crack and fracture under repeated loading.

Uneven approach road profiles increase the dynamic interaction between the bridge and heavy vehicles and potentially rapidly accelerating the structural degradation of the bridge.

The greater the speed of heavy vehicles, the greater the potential damage to the structure.

Greater overall bridge width for a given number of traffic lanes may lead to better load distribution and decrease in the probability of shear keys cracking and failing. This possible correlation between bridge width and damage requires further review based on the results of monitor inspections.

The relative effects of single versus multiple spans and span length on the probability of shear key cracking and rate of fracture are not known at this stage. Further review is required.

Elastomeric strip bearing supports tend to reduce the dynamic impact on the bridge superstructure and shear keys.

Other links between design detailing and structure performance may be established with further inspections and reviews.

Traffic Volume, Mix and Speed

The greater the AADT and number of trucks per day the greater the probability of damage to the shear keys and rapid rate of deterioration. The following table attempts to provide a measure of the relative risk associated with different traffic volumes.

Parameter	Value	Risk	Value	Risk	Value	Risk
AADT	< 1000	Minor	1000 - 5000	Moderate	> 5000	High
Trucks/day	< 50	Minor	50 - 200	Moderate	> 200	High
Speed km/hr	< 60	Minor	60 - 80	Moderate	> 80	High

1.2.1.10 Precast prestressed voided T slabs

These standard slabs span from 8 metres to 19 metres and were developed in 1986. The slabs vary in depth from 250 mm to 750 mm and have a 140 mm overlay. Width of the top flange of the T-slab varies from 900 mm to 1500 mm to suit the width of bridge. These slabs were used quite extensively and were then the cheapest and most popular type unit for spans up to 19 metres. Problems have occurred with high neoprene bearings placed on sloping crossheads beneath the T-slabs.

1.2.1.11 Decks and overlays

Reinforced concrete decks are usually cast-in-place over beams. The deck is then surfaced with either a sprayed seal or a 50 mm thick bituminous surfacing. Permanent or sacrificial formwork comprising thin precast concrete slabs is used to eliminate the need to remove the formwork after casting the deck particularly for bridges over highways and railway lines.

Concrete decks without surfacing were increased in depth by 12 mm to allow for wear by traffic. This practice was discontinued due to temperature cracking of the surface which allowed moisture to penetrate into the deck.

In order to provide composite action between beams and deck, longitudinal shear connectors (shear studs) or projecting bars are provided on the tops of beams which project into the deck. A bevelled concrete cap was cast between the deck and beams on many older bridges. Cracking of the cap can occur along the fillet line at the deck. Cracking coincident with the location of the stud or projecting bar connectors might also be visible. Unless severe, this cracking is not serious.

Many older concrete bridges had reinforced concrete decks with a gravel fill together with a sprayed seal of the whole or partial width of the deck. Deck drainage was often through the kerbs at the top of gravel level. This system did not drain the deck well and allowed a considerable amount of water into the deck fill. This acted as a reservoir allowing water to penetrate the concrete deck causing severe corrosion of reinforcement and spalling of the underneath of the deck.

Reinforced concrete overlays have been used extensively to strengthen U-slab bridges that are subject to repeated heavy loading. Overlays have also been used to simultaneously widen bridges and to seal old concrete decks against moisture ingress. By making the overlay continuous the number of expansion joints has also been considerably reduced. Bridge designs now include a concrete overlay over the precast units to achieve required design live load capacity.

1.2.1.12 Diaphragms

A diaphragm is a transverse beam at the end of the deck which connects the beams together and provides stiffness. In older structures this may be the full depth of the beams. In later structures it can be of the order of 200 mm to 250 mm in depth.

Diaphragms may also be found at mid-span or at the third points in the span to provide web stiffening and to assist with live load distribution between beams.

Precast I-beam bridges continuous for live load can feature a wide heavily reinforced load bearing diaphragm at the piers. This diaphragm is required to support the full superstructure loads and to transfer load back to the sub-structure.

All diaphragms should be checked for cracking and for separation from the embedded beam-ends.

1.2.1.13 Kerbs, footways, posts and railing

The majority of older concrete bridges have either narrow kerbs (sometimes tapered in cross section) or 810 mm wide kerbs tapered in plan at their ends. These wider kerbs had a barrier facing and were positioned in front of the railing leading to a dangerous situation such as errant vehicles could aviate and land on top of the barrier rather than be safely redirected. Some bridges used precast reinforced concrete kerb sections which dowelled into solid kerb sections at the intermediate posts. Spalling of the dowelled areas of these kerbs is common. The drainage path of the deck is designed to pass under these precast units and flow over the outside edge of deck. In practice, the moisture and road debris is trapped under the kerb units and the area remains wet and vegetation can grow there. Water flowing over the deck edge causes extensive staining of the concrete.

Where footways are constructed on bridges they should be inspected for pedestrian safety to ensure that footways are level and free from holes and trips. Moisture can penetrate footway slabs and adequate drainage of the area under the footway is required. If drainage is inadequate, dampness penetrates the deck; weed growth and efflorescence can then develop under bridge deck.

A number of different forms of posts and railings have been used on bridges ranging from guideposts, timber posts and rails, reinforced concrete posts with precast reinforced concrete rails, reinforced concrete posts with steel tube rails, steel channel posts with steel guardrails, rectangular rolled hollow steel posts and rails, and reinforced concrete New Jersey barriers and F-type barriers with steel posts with one or two steel rails on top.

Steel guardrail has been installed in front of the existing bridge railing on some bridges. Steel plate parapets have been installed on older rail overpasses to provide an impermeable barrier. These comprise flat steel plate shaped to a sloping profile over a steel post and rail framework.

Steel mesh is fixed to barriers on pedestrian bridges and should be inspected for damage and tightness of the attachment bolts.

In locations of possible salt spray, aluminium railing has been used with a steel tensioning cable under the top rail. This tensioning cable is wrapped in plastic but if incorrectly installed or exposed to the weather because of missing rail sleeves, the plastic will disintegrate exposing the steel cable and heavy corrosion will occur in a short time span.

Steel guardrail on bridge-approaches must be attached to and overlap the bridge endposts and possibly continue over the bridge. This will prevent vehicles from hitting the bridge approach rail and being redirected into the endposts. Current standards require that there is a smooth transition in stiffness between the bridge approach barriers and the bridge barrier and that the entire length of barrier is free from snagging points.

For some time it has been the practice on highly trafficked, high-speed roads to provide rigid reinforced concrete bridge approach barriers. These are also designed to give a smooth transition in stiffness.

1.2.1.14 Abutments

Abutments will generally be of the following type:

- Spill-through abutments using a reinforced concrete crosshead supported on driven precast concrete piles or a frame type with reinforced concrete columns supported by a footing below ground.
- Wall type abutments either reinforced or mass concrete.
- Wall type comprising columns and a crosshead with infill wall panels between the columns.
- Masonry walls comprising stone blocks.
- Sill beams on piles (to support the bridge loads) with a reinforced earth wall.
- Bed logs or logs installed in pig-pen style to support the cross heads.

Spill-through abutments are a common type and usually have little or no cracking of the crosshead other than possibly shrinkage cracks. Frame type crossheads are more highly stressed and some flexural cracking may be found at mid-span between the columns or over the columns. Loss of retaining fill in front, beneath and behind the crossheads is also a common problem which requires attention.

Cracking of piles has been reported in bridges where large movements of the embankment fill have occurred as the abutment fails and is prevented from rotating or sliding forwards by the superstructure. Severe cracking and distress may occur in beams and bearing pedestals. Movement joints can lock and the bridge beams become overstressed particularly during periods of high temperature. The fender walls will often crack if beams bear hard against them or if the deck puts pressure on the top of the wall. Keeper walls on the ends of crossheads can crack particularly on bridges on a steep cross fall where beams bear against them.

On many older bridges the ends of the steel RSJs were cast into the fender walls for a short distance. This invariably causes heavy cracking and spalling of the fender walls due to differential movement or rotation of the abutment crosshead. The spalling can become quite severe with complete loss of the fender wall in some instances.

All instances of cracking where movement of the abutment is suspected must be investigated to identify the cause and the appropriate remediation measures.

Wall abutments are generally more resistant to differential movement and less likely to exhibit cracking. Abutment walls may exhibit full depth cracks as a result of early-thermal cracking. Mass concrete walls are generally small in height. They may suffer from rotation or sliding instability or in some instances loss of fill from around their foundations due to scour. Wall abutments comprising columns with crossheads and thin infill panels might crack from the effects of earth pressure and shrinkage.

The wingwalls on the high abutment walls can fail and move relative to the abutment walls due to earth pressure. The wingwalls are not normally self-supporting and rely on a concrete key or a few bars of light reinforcement to hold them in place. Cracking and differential movement between the wingwall and the abutment wall is common and may be severe.

Bridges may have reinforced concrete approach slabs which rest on top of the fender walls. These are installed to reduce live load earth pressures behind the abutments and to maintain a smooth transition onto and off the bridge for fast moving and heavy traffic thus reducing the potential for impact loads on the structure.

Bridges comprising timber superstructures on stone masonry abutment walls were once common. A number of them had the original timber superstructure replaced by a concrete superstructure. These walls must be inspected for cracking, a sign of settlement, especially in heavily loaded areas such as directly under beams. Bridges of this type may feature a reinforced concrete capping beam on top of the masonry wall to distribute concentrated loads from beams.

1.2.1.15 Piers

There are several types of bridge pier:

- Piles (pile bents) or columns supporting a crosshead (single or multiple columns).
- Wall piers of constant or variable thickness (some of which consist of columns with a crosshead with infill panels between the columns).
- Mass concrete.
- Masonry.

Concrete piers can be cast in stages with horizontal construction joints between the stages. Horizontal cracking may occur around the construction joints.

All pier types may have deficiencies in reinforcement and may suffer from cracking.

Older structures may have poor quality concrete which can be eroded by the action of flowing water, sand, pebbles and grit. This can significantly reduce the amount of cover to the steel reinforcement. Shotcreting (sprayed concrete) may have been used to reinstate the concrete surface and this in itself may be eroded over time.

1.2.2 Steel bridges

There are several forms of steel bridge:

- Rolled Steel Joist (RSJ) and Universal Beam (UB) – pre-fabricated I-sections.

- Plate girder (I-section welded or built-up from plate steel).
- Trough girder (open trough with sloping webs built-up from plate steel).
- Box girder (closed section possibly with two or more cells – e.g. West Gate Bridge steel span).
- Truss.

Some timber bridges have been strengthened by incorporating rolled I-sections while preserving the timber members for aesthetic reasons.

Modern steel bridges normally comprise one of the above steel beam types with a composite reinforced concrete deck. Composite action with the deck slab significantly enhances the strength of the steel beam.

Steel beam bridges with composite reinforced concrete decks are used for longer span structures. Fabricated steel plate girders are more expensive than prestressed concrete beams and will require repainting several times during their life.

Steel superstructures may deflect substantially under load and vibrate leading to the risk of cracking of the reinforced concrete deck particularly in old structure. Moisture, corrosion and efflorescence will normally be seen at the cracks. Cyclic loading and vibration is a cause of fatigue in steel components and affects steel plates (including gusset plates in truss bridges), welds and bolts.

Steel beams may be galvanised or painted or painted over galvanising. Galvanising and painting are temporary coatings and may deteriorate or suffer from mechanical damage. All steel components must be checked for condition of the paintwork and corrosion. If no action is taken, severe corrosion may result in loss of section and perforation of plates.

Steel beam bridges have steel bracing frames at the supports and at intervals throughout the length of the bridge to provide stability in the temporary state and to prevent lateral buckling in permanent conditions. These components and their connections must be inspected in the same way as the main members.

Splice plates are used to connect beam webs and flanges. These may be riveted, bolted or welded. All welded connections, splices and stiffeners should be closely inspected for any signs of cracking of the weld or metal immediately adjacent to it. Progressive increase in crack length and width is a symptom of fatigue and is caused by cyclic loading. Position and size of cracks must be accurately recorded and reported.

Bolted and riveted connections require inspection to check whether all connections are intact and tight. Missing bolts and nuts may arise as a result of fatigue failure of the bolt shank. Loose bolts can be detected by cracks in the coating system, by permanent displacement or by relative movement of the connected components as vehicles cross the deck.

Signs of excessive wear at pinned joints in trusses or other movement joints should be recorded.

Surfaces at member connections should be clean and free from debris, dirt and moisture as these are cause for corrosion of connections and connecting members. Uncontrolled drainage through leaking deck joints will discharge onto the ends of beams, cross bracing and bearings leading to corrosion. Signs of this should be recorded and rectified. Similarly, accumulation of water within closed units (e.g. box girders), such as leakage or condensation will lead to deterioration of the protective coating and eventually corrosion.

Longitudinal girders and truss members should be inspected for signs of deformation. This may be evidence of buckling of the member caused by overloading or sign of inadequate bracing and must be reported.

Steel members (particularly those made with lightweight steel sections as in truss bridges) are susceptible to damage by vehicle impact which, if severe, can significantly reduce the load carrying capacity of the structure. Impact from a high vehicle may cause damage to truss members in through-girders and trusses. Truss bridges are particularly vulnerable to impact damage as the failure of a single member or connection can lead to collapse of the structure. Impact damage to steel bridge components must be reported as a matter of priority.

1.2.3 Timber Bridges

1.2.3.1 Timber stringers

Timber stringers (beams/main members) may be either round (stripped of bark but otherwise in the natural state), hewn (cut to size with an axe or sharp blade) or sawn. Hewn or sawn stringers will not have any outer sapwood.

Pipe rot is the deterioration and loss of the central soft core of the timber leaving a hollow section and proportionally loss of strength. Calculations may be required to verify if the stringer still has adequate reserves of strength. Timber stringers should be inspected for pipe rot. This is normally done by drilling or coring at critical locations such as at mid-span and measuring the thickness of the remaining timber. Inspection should be done at points along the span if severe pipe rot is suspected.

The stringers should also be checked at their ends for splitting (many timber stringers have anti-split bolts at their ends to control splitting). Stringers should have full bearing on either corbels or corbel blocks. Stringers should be checked for end rot especially at abutments where moisture or water leakage may be present.

Splitting of timber stringers can affect their performance and working life considerably. Splitting generally occurs along the grain and, unless severe, is not significant unless moisture is penetrating into the splits. Spiking of the decking into the timber stringers can cause splitting at the top and, with the presence of moisture and vibration of the spikes under traffic, this leads to spike rot.

If the stringer is severely split in the vertical plane, heavy loads might widen the split causing premature failure. Fractures due to overloading and splits that start from the bearing area and travel diagonally across the timber grains towards the top of the stringer are the most dangerous splits. In both cases the stringers will require relieving or replacing, although steel banding may be used to control the diagonal splitting. In this case, it is possible to consider a load limit on the structure.

Other problems which may occur with timber stringers are the presence of rotting knot holes (particularly at mid-span) and sagging or excessive deflection of the stringer under live load due to poor lateral distribution of loading via the decking.

Termite infestation of stringers, together with the associated loss of section, can seriously affect the performance of timber stringers. Careful inspection is required to identify if there is evidence of their presence.

1.2.3.2 Corbels and corbel blocks

Corbels should be checked for splitting and pipe rot at their ends. If pipe rot or splitting is severe then crushing of the corbel can occur with subsequent excessive vertical movement of the timber stringer at the end. Many corbels have bolts through their ends in an attempt to prevent crushing.

1.2.3.3 Decking

Timber decking can be of two types: cross-beams with longitudinal decking, or cross-decking with thin longitudinal running planks. The cross beams are generally used on more heavily trafficked roads and the planks are usually used on minor roads.

Timber cross-beams are usually spaced at 1.2 metre centres to support the long-decking and legal axle loads. These should be inspected for end rot, top rot, bulging at the top due to ingress of moisture, sagging at mid-span due to excessive span length, fracture and severe splitting. Severe splitting and top rot can often be caused by spiking of the decking. The effect of termite damage on small sections can be severe. Careful inspection is required to identify if there is evidence of termite.

Timber cross-beams (normally 225 mm x 175 mm @ 1.2 m centres) normally extend across a minimum of three beams unless designed specifically for simple spans. They should be firmly bolted to the beams and all bolts should be regularly checked to ensure tightness.

Long-decking should be laid in long continuous lengths and span at least three cross-beams unless designed specifically for simple spans. It should be securely bolted to the cross-beams at each end and at alternate intermediate cross-beams. This is done to stop flexing of the long-decking under load and to reduce the risk that the bolts will pull through the ends of the long-decking planks. Mild steel angle cleats are commonly used to bolt the long-decking to the cross-beams. These offer a rigid point against which the bolts can be tightened. Mild steel plates can bend on tightening and the bolts can work loose.

Long-decking should be laid with the heartwood down to prevent it rotting and splitting at the centre or curling up at the edges.

As the timber shrinks and dries, gaps will form between the planks and action may be required to close up the gaps by inserting additional thin sections of plank. This is especially important on bridges used by cyclists.

Timber cross-decking is often used on low volume unclassified roads, and is not as rigid as the long decking described above. In many cases the cross-decking is only spiked to the spiking plank or timber stringer below. This type of decking generally becomes loose and requires continual tightening of bolts if they are used. Longer spikes are often used but this only compounds the splitting and spike rot. Timber running planks are usually supplied with cross-decked bridges. These planks aid load distribution to the cross-decking. The running planks are usually of a thin section being only 40 mm to 50 mm thick. They are usually only spiked and easily become loose. These planks tend to split easily requiring constant replacement and also form a moisture trap which hastens rot of the cross-decking below. Some bridges have fill or asphalt over the cross-decking, although it does offer improved load distribution, this is not generally successful as the surface becomes uneven and cracked due to cross-decking movement. Surfacing also tends to trap a reservoir of moisture which accelerates timber rot.

Steel trough decking has been used to replace timber long-decking on a number of timber bridges. The troughs are usually sprayed with tar on the inside then filled with premixed asphalt to a level of approximately 50 mm above the top of the trough sections which is then compacted by the action of traffic loads. The infill should be resurfaced every 2 to 5 years approximately after opening (depending on traffic volumes and loads) to re-establish the longitudinal grade and cross-falls. It is vital with this type of decking to maintain a crack-free surface with good drainage to remove all surface water from the deck so that it will not seep through the infill and cause corrosion in the steel trough. Some trough sections were tack welded along their joints whilst others have been bolted or screwed together. A check should be made of the joining arrangements in case the trough sections are spreading under load.

If this problem occurs, it will normally be reflected in the road surface above as irregularities or pot-holes in the infill or areas of severe cracking. These are signs that the trough sections are deflecting excessively under load or are not effectively held down to the cross-beams. A few early trough decking bridges used concrete in place of the premixed asphalt but this was unsuccessful due to the large relative movements of the steel trough sections and the concrete infill. Cracking of the thin concrete section above the trough allowed moisture to penetrate and corrode the trough sections.

The most popular timber deck replacement has been the use of Waldren precast reinforced concrete deck units. The units are 1.99 m long and are cast to the width of bridge required. Ferrules are cast into the ribs of the units to allow for attachment to the RSJs with a thin neoprene strip separating the concrete and the steel to dampen the traffic loading. Steel guardrail is attached to the outsides of the units to provide an improved safety barrier compared to the old timber post and rail. Solid end units are installed at the ends of the bridge for live load impacts onto the bridge. Cracking problems have been encountered with this deck replacement option particularly if the neoprene strip between the slab and the supporting steel beam is missing. Other problems include rotation of the clips that are used to hold the slab in position.

Other deck replacement options include Transfloor reinforced concrete deck formwork slabs with a reinforced concrete overlay cast on top. The advantage of this deck replacement is that the deck is made composite with the RSJs via shear stud converters to greatly improve superstructure capacity.

Nail laminated pine decks have been used in the past and have generally performed well, treated timber without heartwood was used and the laminates are butted over a cross beam. Heartwood components are highly susceptible to rotting, requiring early replacement. A poorly drained deck allows moisture to penetrate the laminates which dissolves the timber preservative accelerating the rate of rotting. Heavily trafficked decks tend to cause separation of the laminates allowing moisture between them, corroding the nails that join the laminates.

Bridgewood laminated veneer sheets (a proprietary material) have been used in a small number of examples. The sheets must be firmly anchored to the beams and the joints and edges treated with a bituminous paint to prevent deterioration of the laminates.

Stress laminated decks have been used in a small number of bridges. Restressing of the transverse steel rods or strands is required from time to time together with further monitoring of the tendon force depending on the dimensional stability of the timber.

1.2.3.4 Kerbs, posts and railing

Visual inspection of the kerb condition and bolted connections is required. The kerbs must be firmly held in place to ensure the strength of the barrier support.

Endposts are usually round timbers and suffer from settlement, splitting, sap rot, base rot, piping, and top rot due to weathering.

Intermediate posts are normally timber but can be mild steel channel or angle sections or occasionally old railway lines.

Visual inspection should include bolting, paintwork and impact damage from vehicles.

Timber rails were originally used on timber bridges but steel guardrail is now a common addition. Connections must be inspected for rigidity. Painting is provided for traffic safety reasons and must be inspected. Rotting and split timber rails will require replacement.

On short bridges that are occasionally over topped by floodwater guideposts may only be used without rails, or if the bridge is long and traffic speed high, then posts with a steel wire cable may be used. The steel wire cable should be taut and well anchored at its ends to retain any errant vehicle. The wire cable should also be on the trafficked side of the post to give lateral support to the wire in retaining an errant vehicle. The wire should pass either through the post or through a steel eyelet attached to the post, and not simply rest upon a steel support bracket. The wire cable should also be checked for corrosion.

1.2.3.5 Piles

Piles for timber bridges can be of two functional types, those used to take vertical loads and support crossheads and those which take moments such as wingwall piles or stream fender piles.

Rot is most likely to occur at or just below ground level, at normal water level (usually 300 mm to 600 mm below walings) or around areas where there are large numbers of bolt holes such as walings and cross-bracing.

Piles which take moments are particularly susceptible at ground or normal water level where the maximum stress and maximum risk of rot coincide. If pipe rot has been detected in these critical areas the extent of the rotting must be investigated to determine the length of repair or replacement.

Care must also be taken to determine the natural ground level as scour, filling or siltation may have occurred. If filling or siltation has occurred, the pile may have substantial pipe rot well below the current ground level. If the pile has rotted below ground and is moving under load, a void will be seen around the pile and the pile will move as load is applied. If this occurs in water, ripples will be seen to emanate from the moving pile. In scoured areas the pile must be inspected higher up at the original ground level.

The loaded areas at piles tops must be visually checked for rot or splitting; especially splits originating from below the crossheads.

Timber piles may be infested by termites in many parts of the state. Termites can enter the piles to a depth of 300 mm below ground but usually enter via splits in the timber above ground. Their presence can be detected by the presence of small covered runways in the splits or along the outside of the pile. They may also stick to the probe when testing the pile for rot. Termites create runways in the timber which can be detected when probing the test hole as if the scraper is passing through a series of thin timber sections.

Piles can wear away at ground level or at bed level due to the action of abrasive gravels or sands. The abrasive gravels occur in the mountainous regions and the wear can usually be seen. Abrasion by sands usually occurs at or near rivers estuaries and is due to sand movement with the tides. Pile diameters of structures in these locations should be checked by divers for loss of section.

Timber piles in marine situations can also suffer attack from Teredo although this is rare in cooler sea-water. This attack can occur anywhere between bed level and mean low tide level. Presence of Teredo can be detected by either sacrificial timber attached to the pile group or by smooth runways along the hardwood timber in the mean low tide area (they may often only attack the softwood) or by small 5 mm to 10 mm diameter holes in the piles below water. Teredo will bore networks of tunnels in the timber and the damage may go completely unnoticed until the pile fails below water level. Early detection is vital. The use of Old Growth turpentine piles will deter Teredo attack.

1.2.3.6 Walings and crossbraces

Walings and cross-bracing should be visually checked to ensure that the piles are adequately stiffened and to provide a rigid structure to resist the action of the stream and possible debris and log impact. Walings are usually positioned 300 mm to 600 mm above normal water level and give a good indication of the relative water level at the time of inspection. If the water level is higher than the walings then the timber piles should be reinspected when the level returns to normal. Walings can also be a good indication of whether scour or silting is occurring at the pier. The inspector must report the components below water level that could not be inspected.

1.2.3.7 Crossheads

Crossheads on timber bridges are usually comprise sawn timbers approximately 300 mm x 150 mm in section which should be visually inspected. However, some bridges comprise hewn timbers which must be checked for pipe rot. Inspection of crossheads should check for the following:

- Presence of termites.
- Top rot due to the presence of wet fill.
- Weathering or end rot.
- Splitting.
- Rot or separation of crossheads that are spliced at the centre pile.
- Sagging (i.e. that the crossheads are not overloaded) where beams are not directly over the piles.
- Settlement of piles leading to sagging of the crossheads.
- Condition of loaded timber cantilevers.
- That the crossheads are fully supported on the piles and are not reliant on bolting to transfer loads.
- Bolting to ensure tightness.

1.2.3.8 Abutments

a) Bedlogs and props

Timber bridge abutments may comprise stacks of bedlogs; others may have props resting on a bedlog to form a relieving abutment in front of the original abutment.

Items to check and record if present:

- Pipe rot in load bearing areas.
- Load bearing of the timber stringers or props on the bedlogs.
- Severe crushing of the bedlogs under load.
- Excessive splitting or end rot of the bedlogs.
- Leaning of the bedlogs.

A bedlog may be placed in front of the other bedlogs to support the fill on which the bedlogs bear. These bedlogs do not support the stringers but are still important in retaining the fill and preventing scour beneath the bearing bedlogs.

Suspect piles and abutments might be propped to supplement their vertical load capacity. These props usually bear on bedlogs or heavy sawn timbers. The props should be inspected for rot if they consist of round or hewn timber which still contains the heartwood. If the prop is a sawn timber, pipe rot will not occur. However, the condition of the end bearing support, connections to bedlogs, splitting etc. should be examined and noted. The prop must be securely attached to the stringer or relieving crosshead, and capable of taking the direct load. Props must be stable; if a prop is mis-aligned or leaning, this must be recorded and the prop must be re-positioned.

b) Abutment sheeting, fender walls, wing caps and wing planks

Abutment sheeting and fender walls are main structural elements; wing planks and wing caps are primarily aesthetic elements.

Abutment sheeting can consist of timber planks or precast reinforced concrete units placed behind the piles to hold the embankment fill in place. These members should be checked for rotting, cracking, bulging and undermining by the stream.

Fender walls can consist of timber sheeting or precast reinforced concrete units. RSJs can also be used, in which case cast-in-situ concrete is placed around the ends of the RSJs. These members should be checked for rotting, cracking, bulging or cracking/loss of concrete around the RSJs.

1.2.4 Deck Joints

1.2.4.1 General

Purpose of deck joints is to seal the gap between the end of a bridge deck and the fender wall against the ingress of water and debris. Joints are designed to accommodate thermal and rotational movements in the bridge deck, normally by the use of a flexible seal in the gap. A number of different types of expansion joint have been used in the past.

Early bridges featured short spans and simple supports for which the required movement capacity of the joint was small. Materials with a small movement capacity such as cork, bituminous impregnated fibreboard, butyl impregnated polyurethane foam, styrene and foam strips were used. Asphalt, rubberised bitumen or polyurethane was often poured on top of the joint to seal it from moisture penetration. Many of these joints failed due to the joint material debonding or being inelastic. Sealant placed too high in the joint gap tended to crack and was lost.

As spans increased, so did the width of expansion joint, and compression seals were required to cater for the movements expected. Neoprene tube was the earliest recorded type of seal but proved to be inelastic and often fell through the joint leaving it completely open. Compression seals were then developed. These can be placed between concrete surfaces, steel angles, steel plates and proprietary 'concrete' headers/nosings. Compression seals may debond and gradually move upwards to the top of the joint where traffic damages the seal or, in some cases, completely removes it. Steel angles are susceptible to impact loading from wheels, especially if dry packed mortar has been used beneath the angle. The mortar breaks up and the ensuing loss of support breaks the anchor bars holding the angle into the deck. The angles can then vibrate and move under load which cracks the bitumen at the edge of the angle.

A further type of expansion joint comprises a cellular neoprene seal attached to aluminium strips which in turn are bolted to the deck and abutment. These strips or rails may lift and break if the holding-down bolts are not properly secured into the underlying concrete. Holding-down bolts in cored holes are more vulnerable than bolts cast into the concrete although the latter type is at-risk if the concrete around the cast-in anchorage is not compacted correctly or if the holding-down bolts are not tensioned correctly. The seal and aluminium strips/rails may then be damaged possibly leading to a hazard for vehicles.

Steel finger plates and steel sliding plate joints have been used on larger span bridges. These joints may not incorporate a seal to prevent moisture penetration. Sliding plate joints can also vibrate loose causing a danger to traffic. These joint types were superseded by heavy duty rubber joints of the Transflex type comprising steel plates in an elastomeric plank. Debonding of the metal and rubber sections can occur in this type of joint and must be reported. Reinforced concrete nosings were used to support the joints but these can crack and fragment under repeated impact loads.

Asphaltic plug joints are used on bridge decks with small movements and sufficient asphalt cover. This joint consists of a 50 mm thick (minimum) hot mix of selected aggregate and an elastomer modified bitumen binder and has the appearance of a strip (approximately 500 mm wide) of dark asphalt. Defects may include fretting and loss of asphalt and movement of the steel cover plate (situated at the bottom of the joint under the asphaltic plug) where this has been used.

Cold-poured sealant joints are used mainly as replacement joints for bridges with a small range of movement. There have been examples of the use of this type of joint in new bridges in Victoria. This class of joint comprises a cold-poured sealant over a circular backing strip between proprietary concrete nosings/headers. The thickness of sealant is generally half the installation width of the joint. Joints of this type may fail by tearing or by debonding from the nosing leading to loss of the seal. Defects of this nature must be reported.

1.2.4.2 Inspection of deck joints

1.2.4.2.1 Procedure

Inspection of deck joints should be carried out as follows:

STEP 1 From the bridge construction drawings, determine the size, type, end treatment and any other relevant details of the deck joint(s). It should be noted that DoT practice is for the design drawings to show design criteria and 3 types of suitable joint for each bridge. That is, drawings show the type and size of joint, but the product details will appear on 'as built' drawings, when produced.

STEP 2 Prepare suitable summary sheets of data to be confirmed on site. The sheet should include an area for noting of any faults. Typical service faults are discussed below and a suitable data sheet is shown.

STEP 3 Carry out site inspection and record findings on the attached check list.

STEP 4 Recommend any necessary corrective action based on the results of inspection(s).

1.2.4.2.2 Joint defects

Most joint defects occur because installation has not been carried out in accordance with the manufacturer's or Code requirements. For example, anchor bolts become loose because they were not installed and tightened correctly, or joints leak because the treatment at kerbs, medians or parapets is not in accordance with the design details.

Some common service faults are listed below: –

Loose or missing anchor bolts

This is the most common service fault, and is generally due to inadequate initial load in the bolt. Re-tightening of all bolts after a period of service is recommended. However, loose or missing bolts may be due to failure of the bolt or ferrule.

Use of unsuitable anchor bolts

All anchor bolts should be hexagon headed – use of socket head bolts such as "Unbrako' is unsuitable because of the difficulties of re-tightening and replacement.

Excessive water leakage

It is likely that there will be some water leakage through most deck joints. It is important that leakage is minimised because it results in staining of the substructure, and deterioration of steelwork and concrete. All deck joints should be inspected from below the joint to assess the extent of leakage, and if possible to locate the cause of seal failure.

Loose, damaged or missing seals

Deck joint seals may be damaged or worn by vehicles or sharp objects such as stones, or may be poorly installed or of unsuitable material. Inspection should include examination along the seal in order to detect defects including loss of bond between lengths of seal.

Excessive debris in joint

Joints such as strip seal type should be designed to expel debris by the passage of vehicle tyres.

Joints having a deep recess such as strip seals with excessive 'drape' may be filled with debris especially adjacent to kerbs. Regular routine maintenance may consist of cleaning with compressed air or water, but the seals may need to be replaced to provide a long term solution.

Joint width outside design movement range

For good vehicle riding characteristics, the maximum width of expansion joint gap should be 70 mm (measured square to the joint).

Variation in joint width

Deck joints should have uniform gap width, and variation in width along the joint may be due to poor initial installation, loose fittings or plan rotation of the bridge.

Excessive noise

Most deck joints cause some tyre noise, but loose components of joints such as sliding plate type can cause excessive noise. For this reason sliding plate joints are not recommended by the current Australian Bridge Design Code for vehicular traffic, but are used on footways to provide a smooth surface.

Damage of joint nosing

Where a concrete strip or 'nosing' is used adjacent to deck joints, inadequate reinforcement or compaction of the concrete may cause cracking or spalling of the nosing. These faults can result in unsafe driving conditions and should be repaired as soon as possible.

1.2.5 Step (Half) joints

Step joint or half joint is a type of articulation in which a suspended beam or deck slab (the drop-in span) is supported on a short cantilever or corbel as shown in Figure 1.2.5. Step joints can be found on both concrete and steel structures on existing structures.

Step joints are normally positioned several metres away from the pier or abutment and often over live traffic or wide waterways. Traffic management, extensive scaffolding, machinery or custom designed suspended platforms are required to provide a safe access for personnel to inspect and maintain the joints.

This type of construction detail inherently leads to leakage through the joint. This causes debris and moisture to accumulate at the beam seats and eventual deterioration of the concrete and steel surfaces. Due to the difficulty in inspection and maintenance of step joints, DoT no longer permits the use of this type of construction detail.

Level 2 Inspections must identify the presence of step joints on the comments sheet. The inspector must inspect step joints using binoculars unless the step joint is readily accessible. The inspection must make comment and take photos on any staining, build up of debris, or cracking within 300 mm of the stepped profile. Photos of the elevation of each side of the step joint and underside must be taken.

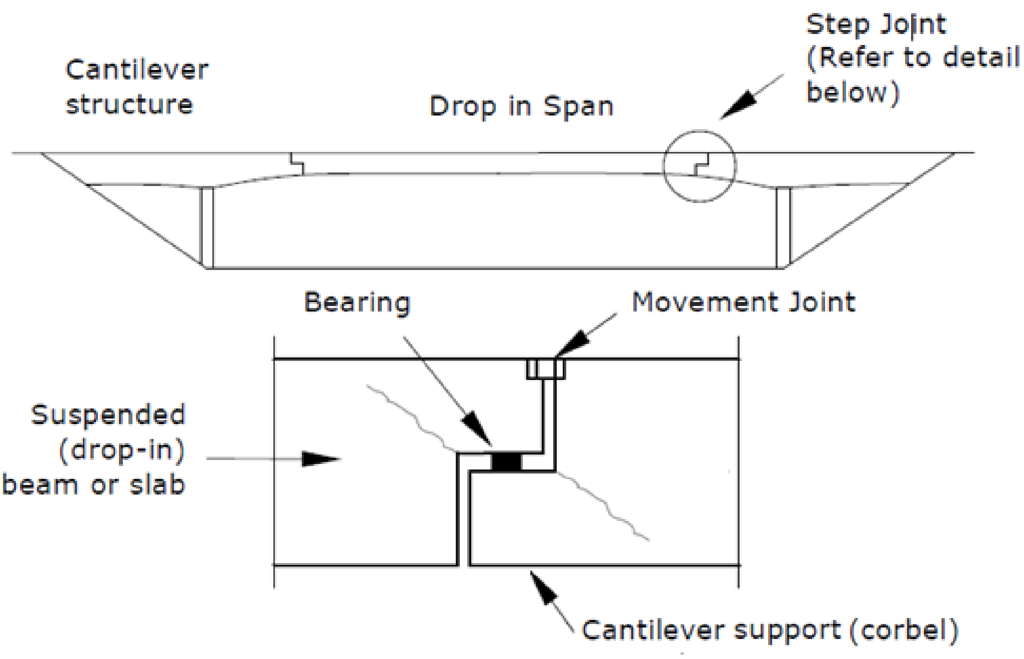


Figure 1.2.5 Step joint

1.2.6 Bearings

The following covers only the common types of bearing in past and present use. The first precast and cast-in-situ beam bridges sat on a layer of clear grease, a sheet of malthoid or in some cases a sheet of lead placed on the crosshead. Dowels projecting from the crosshead were used to locate beams but these have tended to break free from the ends of the concrete beams or, in some instances, the dowels have broken the top of the crosshead under the beam as a result of deck movement and edge loading.

Mortar pads were frequently used in the past and may sometimes be found in good condition although some mortar pads made by hand-ramming mortar into the gap under the beam have tended to crack and the mortar has spalled.

Steel base plates in conjunction with small steel bearing plates on the underside of beams have been used on a number of bridges. A phosphor bronze sliding plate was sometimes inserted between the steel plates to reduce friction.

Cast iron bearing blocks with sliding plates or pins, mild steel rollers and rocker bearings have also been used in conjunction with longer span steel beams. The performance of roller and rocker bearings can be adversely affected by grit and corrosion; bearings sometimes seize completely as a result of corrosion.

Large span, heavy concrete bridges such as box girders can be supported on pot or spherical bearings (bearings with a P.T.F.E. (Teflon) sliding disc). The P.T.F.E. strip can be squeezed out by vibration and its position should be recorded. Excessive rotation of the bearings should also be noted. On freeway bridges the pot bearings at the piers may be hidden by stainless steel skirts.

Elastomeric bearing are now in common use; either as a thin strip or pad usually 20 mm thick, or in a rectangular form incorporating metal plates between the layers of elastomer. The thinner bearing strips/pads are normally used to support small span beams. However, if the bearing pedestals are poorly constructed then some parts of a pad may not carry load.

If poorly designed or manufactured, elastomeric bearings with steel plates can suffer from irregular bulging and shearing at the elastomer/metal plate interfaces. Elastomeric bearings rotate and deform in shear as the bridge moves and, in extreme cases, this can cause lift-off of the bearings at the edge, leading to over-stress of the opposite edge of the bearing. Irregular and uneven pedestal construction is a common problem associated with large bearings and can also lead to uneven development of stress in the bearings – overstress in some locations and little or no stress in others.

Creep, shrinkage and elastic shortening due to post-tensioning can cause excessive shear stress on the bearings in box-girder bridges. Bearings may require resetting in this circumstance. This will require the beam to be jacked-up – rarely done unless deformation is excessive. Actual deformation should be measured and reported if it is thought to be excessive.

Slippage (walking) of elastomeric bearings can occur, particularly in older structures where bearings retainers were not used. More recent designs (since the 1980s) incorporate bearing retainers that prevent slippage.

1.2.7 Culverts

1.2.7.1 Concrete box culverts

Early box-culverts were cast-in-place and many of these early examples suffer from corrosion of reinforcement, cracking and spalling due to lack of concrete cover, porous concrete and/or ingress of moisture. Once corrosion, cracking and spalling has commenced, progressive deterioration generally ensues.

Small precast inverted U culverts with precast concrete lids may exhibit significant cracking and spalling due to inadequate cover to reinforcement.

Larger precast concrete crown units have also been extensively used. Link slabs have been used between units in multi cell culverts to reduce construction costs and time.

The link slabs may be either precast in a casting yard, or cast on top of the culvert base slab and then lifted into position.

Box culverts are more susceptible to concrete problems under the edge of the seal if the shoulders are unsealed.

1.2.7.2 Concrete pipe culverts

Large pipe culverts have been used for many years. The pipes are susceptible to many defects that may arise from inadequacies in manufacture, handling, stacking, transportation and installation

Large pipes may have a lifting hole. It is important that the hole be accurately positioned at the pipe obvert as elliptical reinforcement is used.

Pipe culverts should be inspected for the presence of cracks, spalls, line and level and stability of headwalls and wingwalls

1.2.7.3 Masonry arch culverts

Refer to Section 1.1.5 Masonry.

1.2.7.4 Buried Corrugated Metal Structures (BCMS) – pipes and arch culverts

1.2.7.4.1 General

Large corrugated steel pipe and arch culverts have been used in Victoria for many years. A very limited number of corrugated aluminium culverts have also been used.

Unequal lateral soil pressure applied during construction, long term settlement or scour may lead to permanent deformations and instability of corrugated metal structures. These issues may also develop as a result of lack of thickness specified in the design process, loose, corroded or missing bolts, corrosion and loss of section of metal plates.

Significant deformations are potentially a high risk to the structural integrity and those who inspect and maintain them. Inspectors should not enter a corrugated metal pipe that has significant corrosion or deformation. A Level 3 Inspection should be initiated as a matter of urgency.

Corrosion of steel culvert panels commences when the galvanised or other protective coating is damaged by impact or by abrasion resulting from the action of soil-particles in the flowing water or if the coating is lost through the normal sacrificial process. Contact with aggressive water or soils (natural ground or in the backfill) or other materials such as cattle droppings may also contribute to corrosion.

It may only be possible to assess the loss of metal in the water-side (open side) surface of the BCMS walls around the invert and within the splash-zone above water-level. There may be significant loss of metal thickness to the buried (soil-side) faces of the BCMS and, unless the metal becomes visibly perforated or so thin that it can be pierced with a hand pick or chisel point, it will not be possible to fully assess the degree of corrosion on the soil-side. If a detailed assessment of soil-side corrosion is required, this can be achieved by cutting samples from the wall-panels or by excavation to expose the BCMS. The extent and method of cutting or excavation must be agreed with the Principal Engineer – Structures in order to prevent the risk of de-stabilising the BCMS. It may also be possible to use non-destructive methods of testing such as ultra-sound to measure the thickness of the metal.

Issues that may require action to enable detailed inspection:

- The invert of the BCMS may be obscured by debris and or submerged below water-level.
- If the BCMS is being used as a cattle underpass, the invert may be obscured by gravel and cattle-droppings.
- If the BCMS is being used as a pedestrian underpass, the invert may be paved.

Features of a potentially unstable BCMS:

- The walls may be deformed.
- The soffit may be propped.
- The invert may be severely corroded and there may be significant loss of metal.
- The backfill may be eroded or softened.

1.2.7.4.2 Inspection of Buried Corrugated Metal Structures (BCMS)

Confined Spaces Regulations

In all cases entry into BCMS must be managed in accordance with Confined Spaces Regulations together with DoT confined spaces procedures.

Unaccompanied Inspection

Unaccompanied inspection should not be attempted whatever the anticipated condition of the BCMS. The inspector should be accompanied by an assistant who is equipped with a mobile phone or some other means of summoning help in the event of an incident or emergency.

Level 1 Inspection Requirements

A severely corroded/damaged BCMS may be discovered for the first time during a Level 1 Inspection. In this event before the undertaking the inspection a risk assessment should be undertaken to determine whether it is safe to enter. A BCMS showing signs of corrosion damage (section loss/delamination), deformation or if it has been propped (tommed) can be considered unsafe and should be referred to L2 bridge inspector or DoT Structural Asset Performance Team for further inspection advice.

Further advice is provided in 1.2.7.4.3 on the procedure to be followed during inspections when there is debris obscuring the invert.

Risk Assessment

The inspector is advised to make a preliminary visit to the BCMS in order to assess the need for special means of access such as a ladder or the clearance of dense vegetation and to enable the preparation of a site-specific risk-assessment / Job-Safety Analysis. If a two-stage visit is impractical – due to the remoteness of the location for example – the inspector is advised to conduct a preliminary inspection and risk assessment on arrival at the BCMS and to continue with a detailed inspection only in the event that safe access is possible.

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. Risk assessments must be in writing and must be recorded for future reference in RAS and in the PBE Bridge Records structure file.

1.2.7.4.3 Recommended procedure for inspection

Access to Records

Before the inspection of BCMS, the inspector or the manager responsible for the inspection is advised to review the most recent inspection reports and inform the inspection team of the last known condition of the BCMS together with any previously identified hazards.

In the normal course of events a Level 3 Inspection will be arranged on the basis of a previously reported condition state of 3 or 4 rating and there will be a known history of deteriorating condition. Where a BCMS is already known to be severely corroded with significant loss of metal to the invert, or it is deformed or propped, a Safety Inspection (as described below) must be arranged. In these circumstances the possibility of instability must be assumed. However, a corrosion-damaged BCMS may be discovered for the first time during a Level 1, 2 or 3 Inspection. With this in mind the procedure described below is to be adopted in accordance with the level of the inspection.

General Guidance Applicable to all Levels of Inspection

- Adequate lighting must be available throughout the inspection.
- In all cases an initial inspection should be conducted from outside of the BCMS to check for the presence of propping, visible severe corrosion, deformation and erosion of the surrounding soil.
- If the planned inspection is at Level 1, 2 or 3 and any of these defects are present, the inspection must be aborted and a safety inspection, as described below, must be arranged.
- Hand-tools (hammer, pick and chisel) must be available to take soundings and to probe the condition of the metal surfaces.
- Under no circumstances whatsoever must propping be removed during an inspection unless there is an alternative temporary works support system in place.

Note:

- The inspection must be aborted if, at any stage, the inspector becomes concerned about safety.
- Those managing inspections must ensure that if a potentially unstable BCMS is identified:
  - Warning signs are erected promptly.
  - A Safety Inspection is arranged at the earliest opportunity.
  - The need for temporary closure is addressed promptly.

Level 1 Inspection

The fundamental principle is that an inspection at this level must only be attempted if the BCMS is in condition state of 1 or 2 and there is no propping or deformation.

- The BCMS is to be inspected from outside and, if the metal is rusting and has holes or there are missing sections or the BCMS is propped or there is visible deformation, the inspection must be terminated immediately and a report made to the appropriate manager.
- If there is debris or other material obscuring the invert, the first 0.3 to 1 m of the metal surface should be exposed <u>without entering the BCMS</u> (i.e. use a shovel standing outside BCMS) and its condition assessed as before.
- If metal in the exposed area is badly rusted and there are holes or metal is missing, the inspection must be terminated and a report made to the appropriate manager as before.
- If the Level 1 inspection team considers the BCMS to be unsafe, they must place signs warning the public and other workers of the potential hazard at both ends of the BCMS.
- If invert metal is clearly visible and is sound and in good condition, clearing of debris may continue in 0.3 to 0.5 m steps unless the condition of the corrugated metal deteriorates and holes or missing

areas become visible – in which case the inspection must be terminated immediately and a report made to the appropriate manager.

Level 2 Inspection

The Level 2 Inspection must be as the Level 1 Inspection described above with the following additions:

- Provided that it is safe to do so the Level 2 inspector may probe the exposed metal surface from outside the BCMS and take soundings with a hammer and / or probe the metal with a pick or chisel point to assess the condition rating.
- If the visible part of the BCMS is in condition state of 1 or 2 the Level 2 inspector may enter the BCMS and continue to assess its condition.
- If the BCMS deteriorates to condition state of 3 or 4, the inspection must be aborted and a report must be made to the appropriate manager. It is recommended that a Safety Inspection is then arranged.

Level 3 Inspection

The Level 3 Inspection must be as the Level 2 Inspection above with the following additions:

- The inspector must firstly assess the stability of the BCMS. Then and, only if it is safe to do so, the inspector may continue to inspect and quantify the condition of the BCMS and authorise removal of debris and other works to facilitate the completion of the inspection.

Safety Inspection

The Safety Inspection must be as the Level 3 Inspection above with the following additions:

- The inspector may recommend further and more detailed investigation.
- Where the BCMS is used by the public (pedestrian and agricultural use for example), the inspector may recommend its temporary closure in the interests of safety.
- The inspector may if they consider that it is safe to do so, authorise access for maintenance and repair work and determine the requirement for propping.
- The propping system must be designed by an engineer who is experienced in the design of temporary works and who must either be:
  - qualified to Proof Engineer level in accordance with the DoT/VicRoads Prequalification Scheme; or
  - an engineer who meets the approval of the Principal Engineer – Structures.

1.2.7.4.4 Actions

Warning Signs

In the event that a serious defect is discovered and it is considered to be too dangerous for the inspection to continue, warning signs should be erected immediately at both ends of the BCMS in order to inform both the public and other DoT personnel of the hazard.

Stability of the Highway

In the event that the inspector considers the BCMS to be unstable and that there is a potential risk to users of the highway over the BCMS, the inspector must advise the Asset Manager and Regional Director immediately.

Barricading of Unstable BCMS

If the inspector considers that a pedestrian underpass or a stock crossing (or any BCMS that is used for these purposes whether formally or informally) is considered to be unsafe for entry, this must be reported to the Asset Manager and Regional Director immediately with the recommendation that the underpass is closed pending further investigation and repair. The following should be considered before closure:

- Consultation with users of the underpass and other affected parties (Police, catchment management authority and landowners for example).
- The route and signing of safe temporary diversions.
- The choice of barricade particularly where the BCMS carries water.

Register of Occurrences and Actions

In order to ensure that information is properly recorded for future reference, the structure record in RAS and in the PBE Bridge Records structure file should be updated with details of propping and any serious defect that is discovered such as deformation or severe corrosion damage together with details of any preventative action that is taken such as signing and barricading.

1.2.8 Causes of Deterioration Not Related to Bridge Materials

The following items (which are not caused by defective materials) must be inspected and maintained in order to avoid structural deterioration:

1.2.8.1 Damage due to accidents

Vehicular impact damage is usually self-evident and may be widespread, affecting all parts of a structure. In extreme cases the impacted item may be displaced or even dislodged. Concrete beam and slab bridges have been partially severed following impact from high loads.

Steel beams are particularly susceptible to impact from over-height vehicles which can cause severe deformation to the bottom flange and web of the beam and severely reduce its capacity. A technique for straightening and restoring impact-damaged steel beams using controlled application of heat is available.

Concrete components may crack, spall and fracture following impact, requiring extensive repair or replacement.

Pier columns and pile caps of bridges over navigable waterways may also be damaged as a result of impact by water vessels.

Structural damage or and/or displacement of the affected members will require a Level 3 Inspection to assess the safety, structural stability and capacity of the bridge.

Other minor damage may occur such as abrasion and spalling of concrete which can result in eventual corrosion of reinforcement.

1.2.8.2 Drainage

Inadequate or impaired drainage may affect a bridge in several ways:

- Flooding of the bridge deck which may create a serious traffic hazard.
- Water flowing over concrete, steel surfaces or bearings may result in corrosion or impaired performance of bearings.
- Build-up of debris retains moisture and promotes corrosion.
- Uncontrolled discharge from the deck can cause erosion of approaches, batters and possibly undermine foundations.
- Leakage from the bridge deck through joints and cracks can cause unsightly staining of beams, piers and abutments.

Inadequate road-surface drainage from the bridge approaches can also cause erosion, piping and washout or scour of the approach embankment and batter slopes, particularly in areas where flows are concentrated at the ends of bridges, near the end post and at ends of kerbs or service ducts. These areas should be inspected particularly after heavy rain or flooding.

1.2.8.3 Debris

Build up of debris on the upstream side and on the deck of a bridge can cause the following adverse effects:

- Very high imposed loads on the bridge possibly exceeding the design load.
- Impact loads particularly on slender piles leading to breakage of pile bents and/or total loss of piles.
- Blockage (partial or total) of the waterway which can cause flooding upstream, exacerbate problems of scour, undermine foundations and in extreme cases result in diversion of the watercourse.

Build up of debris is usually most severe in bridges with small openings or low freeboard.

1.2.8.4 Vegetation

Uncontrolled and excessive growth of vegetation under or adjacent to bridges does not necessarily cause damage to the bridge. However, penetration of roots into the joints in a masonry or brick structure can cause damage and deterioration. Vegetation can result in a fire hazard, blockage of the waterway together with the build-up of debris and moisture around abutments and bearings. Presence of vegetation should be reported.

1.2.8.5 Scouring of foundations

Scour of river-bed material under and around foundations caused by stream flows or changes in the alignment of the stream channel can result in progressive settlement or movement of abutments and piers, which if not rectified may ultimately cause total failure of the bridge. In extreme cases, scour can completely remove the sedimentary material surrounding piles and has caused the failure of bridge superstructures leading to the need for replacement. Bridges on pile bents where the pile to crosshead connection is pinned are most vulnerable.

Aggradation is the process of deposition of river-bed materials that have been eroded upstream. Materials can be fine-graded silts and clays or coarser gravels and rocks depending on the nature of the upstream river-bed. Accumulation of material against or under a bridge has the following possible effects:

- High imposed loads on the bridge sub-structure and superstructure leading to damage or failure.
- Loss of waterway area leading to the risk of upstream flooding.

Where evidence of scour or aggradation of the stream bed is observed during an inspection, this must be noted by the inspector for comparison with past and future inspections.

Beaching may be damaged and removed by scour action.

Adequacy of batter protection to abutments and the stream bed adjacent to pier foundations must be noted together with changes in stream-bed condition upstream and downstream of the bridge.

1.2.8.6 Movement of the structure

Settlement and horizontal displacement of piers and abutments can be caused by:

- Scour.
- Land slips around or under the bridge .
- Earth pressure resulting from long-term settlement or movement of the embankment fill and underlying ground.
- Collisions with vehicles and vessels.
- Locking of bearings or expansion joints.

Visual indicators of settlement and horizontal displacement:

- Closure or excessive opening of expansion joints.

- Contact between the superstructure and abutment fender wall with associated cracking and spalling.
- Steps in horizontal and vertical alignment of the road surface and bridge barriers, particularly at movement joints.
- Cracking of abutments and columns or piers.
- Cracking or excessive settlement of the approach embankments and in beaching or heave at the embankment toe.
- Scour causing undermining of the foundations.
- Out of verticality of adjacent roadside columns, poles and fences etc.

Observations of these indicators are an important aid in determining whether movement is continuing, seasonal or has ceased. Movements of this nature can continue over a long period of time and the ability to make comparisons with past inspections is useful in understanding the cause(s) of the movement and the appropriate response.

1.2.8.7 Condition of approach embankments

Embankments provide a smooth and navigable transition between the road level on approaches and the road level over the bridge. Embankments may also provide horizontal and vertical support to bridge abutments.

If excessive settlement of the approach embankments occurs immediately adjacent to a bridge abutment, this can cause poor ride-quality, possible damage to bridge joints, and high dynamic loads on the bridge deck.

Settlement of approach embankments is caused by inadequately compacted embankment fill and/or longer-term consolidation settlement of the underlying natural ground.

Other embankment defects commonly encountered are erosion, piping, washout and scour, particularly after heavy rain or flooding or a result of inadequate or blocked drainage.

1.2.9 Deterioration of Roadside Structures

Cantilever sign and high-mast lighting structures share some common features and vulnerabilities:

- Fatigue-related failure of holding down bolts and to a lesser degree fatigue-related failure of the column and welds above the base-plate.
- Cracked, incomplete or missing mortar or grout under base-plates.
- Foundation-related failure leading to tilting of the structure.

Fatigue failure is the result of rhythmic, wind-induced oscillation of the structure that occurs at relatively low wind speeds.

Truck-induced gusts also cause oscillation of sign and light structures and contribute to fatigue. Structural steels and other metals are susceptible to fatigue failure when subjected to cyclic loading. The degree of susceptibility depends on the ductility of the metal and its fracture toughness. Higher strength steels are generally more brittle than low strength steels and more prone to develop fatigue failure. Fatigue failure results in the development of cracking of components and eventually to their failure if the crack penetrates the full depth of the section.

1.2.9.1 Major sign structures

Large cantilever signs, butterfly signs and sign gantries must be inspected in order to detect fatigue-related failure (particularly in holding-down bolts) which could lead to collapse of the structure onto trafficked lanes.

Columns of cantilever structures can progressively tilt over as a result of poor ground conditions and/or inadequate foundations.

These structures must be inspected for missing nuts, cracked bolts, loose connections, gaps between plates, cracked welds, heavy corrosion or small cracks and splits or ruptures of the columns and stiffeners, tilting columns. The concrete footings should also be inspected for cracking or spalling around the bolts or base plate, including signs of crushed or missing mortar below the base plate which could indicate that movement has occurred.

Nuts on holding-down bolts are normally checked at installation for tension and marked. The inspector should check the marks and note if there has been any movement or loosening of the nuts.

1.2.9.2 High mast lighting

Hight-mast lighting structures are structures that support luminaires at ≥ 15 m height. The height is measured from the highest part of the luminaire to the ground level directly under the luminaire. High mast lighting must be inspected in order to detect fatigue-related failure (particularly in holding-down bolts) which could lead to collapse of the structure onto trafficked lanes.

These structures must be inspected for missing nuts, cracked bolts, loose connections, gaps between plates, cracked welds, heavy corrosion or small cracks and splits or ruptures of the columns and stiffeners, tilting columns. The concrete footings should also be inspected for cracking or spalling around the bolts or base plate, including signs of crushed or missing mortar below the base plate which could indicate that movement has occurred.

Nuts on holding-down bolts are normally checked at installation for tension and marked. The inspector should check the marks and note if there has been any movement or loosening of the nuts.

1.2.9.3 Noise attenuation and visual screen walls

Noise attenuation and visual screen walls are normally located along major roads where there are residential or light commercial developments at the right of way boundary. They are commonly made from a range of materials including timber (plywood), concrete, steel, aluminium, acrylic and polycarbonate materials.

Some noise attenuation walls have built-in lighting powered by solar panels. These are subject to electrical problems and to vandalism.

Visual screen walls are similar to noise attenuation walls but are normally used to shield unattractive commercial or industrial development along important roads or shared use pedestrians routes.

Noise attenuation and visual screen walls must be inspected in order to prevent collapse onto trafficked carriageways or pedestrian ways.

Problems can occur due to:

- Rot and termites in timber particularly at or just below ground level.
- Corrosion in steel and cracked welds.
- Reinforcement corrosion.
- Cracking and spalling concrete.
- Collapse of panels due to failure of fixings including self-tapping screws.
- Cracking of concrete and plastic panels.
- Graffiti.

The inspector should also observe and record problems associated with ground movement that may cause columns to move and allow panels to fall out. The footings should be inspected for cracking or spalling around the cast-in-situ or bolted connections.

1.2.9.4 Retaining walls

Retaining walls are generally made from timber, concrete, masonry and steel materials.

Problems can occur with the foundations of the wall due to:

- Rot and termites in timber particularly at or just below ground level.

- Corrosion in steel and cracked welds.
- Reinforcement corrosion.
- Cracking and spalling concrete.
- Cracking of mortar or stone degradation in masonry walls.
- Settlement, sliding or overturning of the wall.
- Insufficient or ineffective weep holes to relieve pore pressure behind the wall.

The inspector should also observe and record problems associated with ground movement that may be exerting unusual pressure on the walls.

1.2.9.5 Emergency median barrier access gates

Emergency median barrier access gates are generally made of galvanised steel.

There are currently two approved products for new installations which include ArmorGuard Gate System and BarrierGuard 800 Steel Gate. There are also legacy installations IronMan Median Gate which is no longer approved for new installations.

Problems with legacy installations include:

- Difficulty removing locking pins.
- Difficulty manually moving gates and hinge side plates.
- Debris build up under rubber skirt (can be permanently removed).

Figure 1.2.9.5: Typical Ironman Gate System (legacy installation)

Given the location of emergency median barrier access gates, it is more convenient and efficient that these structures are inspected, maintained, and tested at the same time under appropriate traffic management.

Regular maintenance of these structures in accordance with the supplier's requirements is vital to ensure they perform in the event of an emergency. Maintenance may include cleaning debris, lubricating movable parts, and treating rust which may make their operation difficult when needed.

Appendix C – Examples of Briefs and Scopes for Level 3 Inspections and 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 Inspection.

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 to the Superintendent for approval before 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 DoT).
- 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.

1.2 Examples of Level 3 Inspections and 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 Inspection 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 Inspection.

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 to the Superintendent for approval before 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.
- 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:
  - 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.
- 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 Inspection.

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 before commencement. The plan should include, as a minimum:

- The extent of investigation, preferably defined by reference to a drawing of the structure.
  - Identification of the unique characteristics and features of the structure that is to be investigated.
  - 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.
  - 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 Level 2 Inspection.
- Report the results of the inspections in the agreed format and within the specified time period.

1.2.3 Programmed Level 3 Inspections

1.2.3.1 Introduction

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

A range of Level 3 Inspections 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 Structure Risk Management Plan (SRMP). SRMPs include ongoing inspection and maintenance requirements. This may form or be part of a Conservation Management Plan for Heritage and Historic Structures.

The SRMP may be required to specify:

- Specialist equipment for access or monitoring the performance and condition of the following components:
  - Beams and other components at height or over water that cannot be accessed by normal means.
  - Interiors of box girders.
  - Piles and other components underwater.
  - Welded and bolted connections in steel structures using non-destructive methods such as ultrasonic testing.
  - The requirements for periodic inspection of the structures as part of the Monitor program*.

*Based on 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.

SRMPs 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 SRMP does not exist, a Level 3 Inspection may be required to develop the scope for the programmed Level 3 Inspections 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 Inspections.

The following examples are provided for each of these categories.

1.2.3.2 Monitor structures inspections

As described in Part 2 Section 5.1, DoT 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-in-situ 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 Structures status. DoT has developed deep understanding of these forms 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 categorised as having Monitor Structures status. The technical aspects of Level 3 Inspections 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 wingwalls have not settled or rotated significantly or that arches have not flattened. Significant cracks through the mortar and/or masonry must be recorded and mapped, and areas of water penetration and efflorescence must also be recorded. These details must 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 Inspections and Investigations may be implemented following the above initial inspections, that might include the use of Demountable Mechanical (DEMEC) Strain 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 Appendix B 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. DoT/VicRoads Bridge Technical Note (BTN) 015 – 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 Inspections 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 Inspections 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.

Major 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. DoT/VicRoads BTN 014 – Sign Gantries and lighting masts – provides guidance on the design of new structures and gives some insight into potential problem areas of existing structures. DoT Construction Materials experts in Standards and Transport Engineering Branch must be consulted when developing Level 3 Inspections 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 Inspections and 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 Inspections and 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, etc.), wind loading from adjacent large high vehicles or similar parameters. The Brief and Scope of such investigations may be part of a DoT 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 Structures 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:

- Structures require special knowledge to conduct an inspection of a specific component.
- 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 Inspections or development of a Structure Risk Management Plan (SRMP) 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 Inspection.

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 before commencement. The plan should include, as a minimum:
  - The extent of inspection, preferably defined by reference to a drawing of the structure.
  - Identification of any unique characteristics and features of the structure that must be investigated.
  - 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:
  - The specific areas to be monitored.
  - The method of monitoring including specific recommendations on what to observe and/or measure.
  - The frequency of monitoring.
  - An explanation as to how the monitoring will keep an eye on the known or suspected deficiency.
- Summarise the SRMP 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 structures inspections

The DoT Structural Asset Performance Team is responsible for classifying a structure as a Complex Structure. Principal Engineer – Structure is to be consulted where additional assistance is required. 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 require special knowledge to conduct an inspection of a specific component.

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, especially the components that are not covered in Part 3.
- 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 Inspection.

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

- Identify the discernible difference between the actual structure and details in drawings provided through site measuring. Detail differences observed on site as hand sketches where necessary.
- Report the results of the investigations in the agreed format and within a specified time period.
- Provide a Structure Risk Management Plan (SRMP) for inspection of the structure (refer to Appendix I for the SRMP template), including as a minimum:
  - High level description of
    - defects;
    - deficiencies;
    - potential failure;
    - consequence of failure;
    - key benefits of mitigating the risk; and
    - major implications of not receiving funding for mitigation measures.
  - Commentary around failure mechanisms and modes.
  - Commentary around vulnerable zones.
  - An inspection plan for all aspects of the structure, including those within and outside the scope of a Level 2 Inspection.
  - A definition of condition states 1 to 4 for components that are not included in this manual
  - Specific recommendations on what to observe and/or measure.
  - Details of deliverability of the SRMP.
  - Details of interim response and stepwise improvement response.
  - Collation of evidence to support SRMP.
- Summarise the SRMP 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 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 Inspection.

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 Inspection.

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 before commencement. The plan should include, as a minimum:
  - The extent of inspection, preferably defined by reference to a drawing of the structure.
  - Identification of any unique characteristics and features of the structure that must be inspected.
  - 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 currently responsible for the structure should normally arrange the handover inspection, however the party accepting 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 Inspection.

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 before commencement. The plan should include, as a minimum:
  - The extent of inspection, preferably defined by reference to a drawing of the structure.
  - Method for recording the results of the inspection.
- Report the results of the investigations in the agreed format and within a specified time period.
- Undertake the inspections in accordance with the approved plan.

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 rating 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 Inspection.

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 before commencement of any activity. The plan should include, as a minimum:
    - the extent of investigations, preferably defined by reference to a drawing of the structure.
    - method for recording the results of the inspection.
- Report the results of the investigations in the agreed format and within a specified time period.
- Undertake the investigations per the approved plan.

1.2.5 Load Rating 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:
    - Site specific load factors.
    - Site specific requirements for multiple presence of vehicles.
    - Structure specific fatigue assessment requirements.
    - Specific design or marked lane requirements to be used in the assessment.
- Whether the structural assessment is to:
    - Be based on a desk-top analytical structural assessment only, using design drawings.
    - 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:
    - current or future freight vehicles;
    - a specific permit vehicle; or
    - 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:
    - Structure geometry, such as span lengths, beam spacing, skew, asphalt thickness and similar.
    - 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 Inspection.

The **Scope** might include:

- Provide recommendations on the method to be used for the load rating including:
    - Analytical methods and assumptions to be used for desk-top structural assessment.
    - Whether field and laboratory investigations are to be used for determining component dimensions, properties or condition.

    - 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 Inspections and Investigations before commencement of any field activity. The plan should include, as a minimum:
    - The extent of investigations, preferably defined by reference to drawings of the structure.
    - The type of visual inspection that will be undertaken.
    - The extent and nature of any destructive or non-destructive testing.
    - Identification of any unique characteristics and features of the structure that must be inspected.
    - 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:
    - Drawings of the structure that were used for the structural assessment calculations.
    - Condition information on the structure that was used for the structural assessment calculations.
    - Details of the loads for which the structure was load rated.
    - Reference standards that were used.
    - The design methodology and assumptions that was employed.
    - The results of the load rating calculations and associated information that explains how the load-rating factors and the location of the critical sections were determined including the corresponding loading details for all load effects (permanent effects, transient effects, etc.) and all supporting calculations for loadings and capacities.
    - A strengthening concept for the deficient components, material quantities estimate, and the load-rating factors after strengthening if required.

Appendix D – Management of Heritage and Historic Structures

Statement of Policy

Heritage and Historic Structures must 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, DoT must maintain a record of heritage bridges of significance to DoT 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 DoT's 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.

Department of Transport:

DoT must 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 must be maintained to the same functional standards as equivalent non-heritage bridges.

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

Heritage and Historic Structures must 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 DoT road reserve but no longer serve a major traffic function must 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 DoT's Roads 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 must 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 must apply to all heritage bridges whether trafficable or not.

Data Recording

The Bridge Inventory within the Road Asset System (RAS) must 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 must also be recorded.

Key Responsibilities

Director Strategic Asset Management (Road)

- Prioritise works of a purely heritage nature and apply for funding under all appropriate government heritage programs.
- Ensure that level 2 Inspections are undertaken on all heritage-listed bridges.

Regional Directors

- Ensure that the heritage classification is maintained in RAS.
- Ensure that level 1 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/Earthquake/Fire Bridge Inspection Report

Road Name: ____________________ Road Number: ______________

Bridge: _____________________

Structure Number: SN______________

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

Inspector: ____

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

Appendix F – Disused or Other Hazardous Structure Checklist

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

DISUSED BRIDGES	
Site Conditions	**Action Taken if Relevant**
Level of use by the public	
Proximity to population centres and schools	
Public access to areas under the bridge	
Agricultural use (Cattle underpass/ storage)	
Condition Report – Extent of structural defects	
Holes in deck	
Weak and rotten deck timbers / decking	
Missing or damaged handrail	
Weak and rotten supports	
Sharp or splintered timber	
Unguarded drops	
Tripping points	
Heritage status – Is it on the Victorian Heritage Database, Council Heritage Overlay, National Trust Register?	
Cost and practicality of demolition if not Heritage	
Cost and practicality of running repairs	
Other (please specify)	
Other (please specify)	
Other (please specify)	

OTHER HAZARDOUS STRUCTURES	
Site Conditions	**Action Taken if Relevant**
Size, geometry and location of structure	
Depth of flowing water	
Flow capacity (effects of any grill or gate)	
Level of public use	
Proximity to population centres and schools	
Risk of flooding	
Consultation with catchment management authority	
Agricultural use	
Condition Report – Extent of structural defects	
Other (please specify)	
Other (please specify)	

Appendix G – Deck Joint Inspection Checklist

DECK JOINT INSPECTION
CHECK LIST

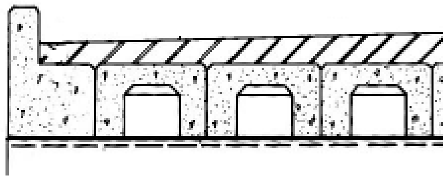
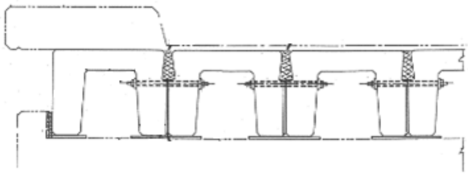
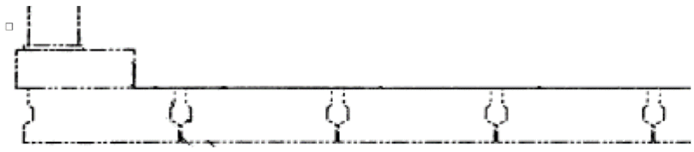
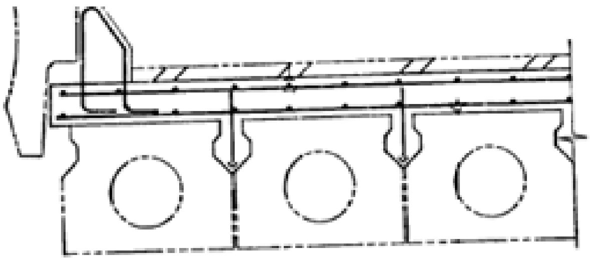
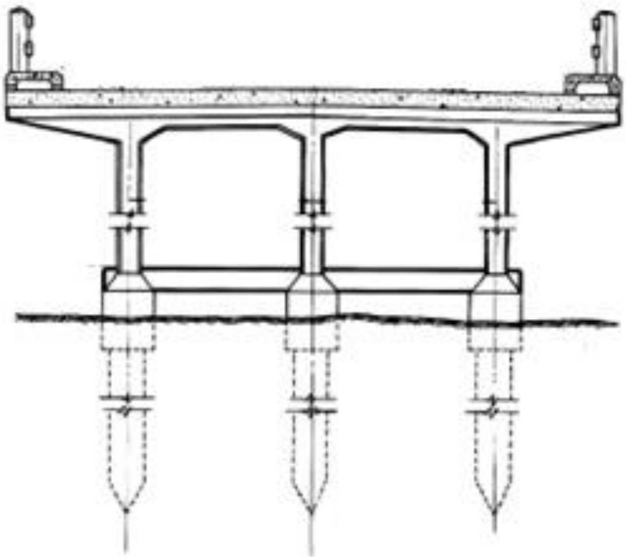
Road Name : …………………………….. **Date:** …………
Crossing : ……………………………..
SN : ……
Location on bridge: ……………………..

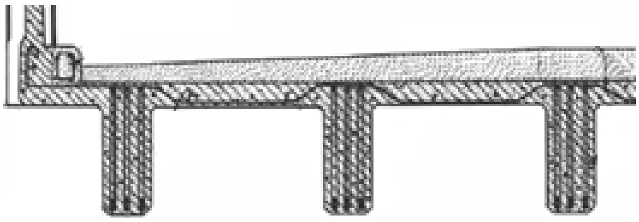
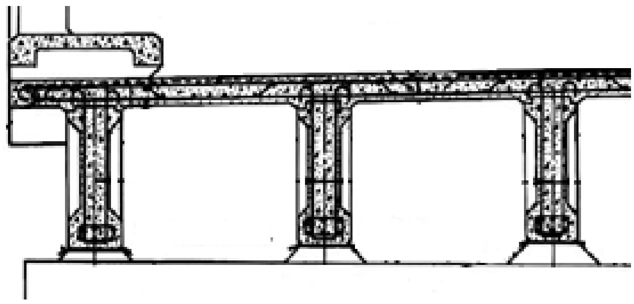
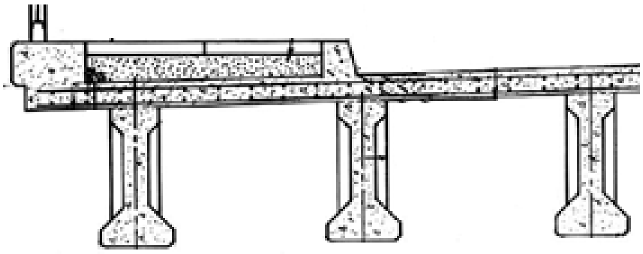
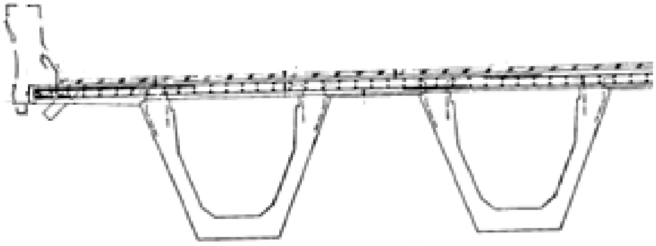
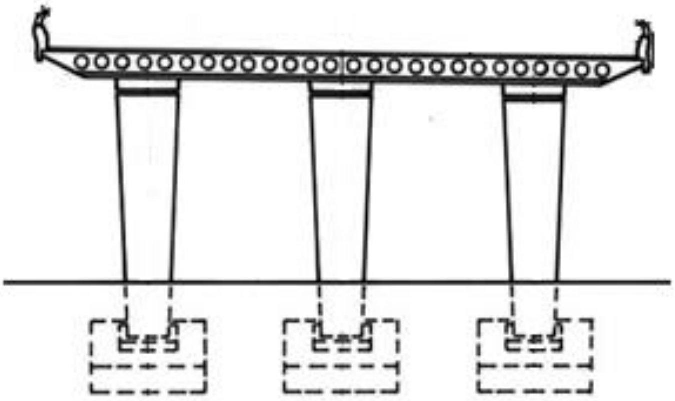
JOINT TYPE	Compression seal Strip seal Finger plate Asphaltic plug joint Modular Other (give type) …………………………….
MANUFACTURER	…………………………………………………..
MODEL & SIZE	…………………………………………………..
ANCHOR BOLTS **Yes** **No**	Type, size & spacing (e.g. 20 mm HS hex @ 300 mm) ………………………………………. Loose bolts (give details) ……………………… Missing bolts (give details) …………………….
WATER LEAKAGE **None** **Some** **Excessive**	Give details ………………………………………….. ………………………………………………………..
JOINT SEAL	Type N/A
JOINT SEAL CONDITION	Give details, including comments on debris content ………………………………………………. ……………………………………………….
JOINT WIDTH	At …….. end …………. mm At mid length …………. mm At …….. end …………. mm Approximate Temperature ….. °C
JOINT NOSING	Type ………………… N/A
JOINT NOSING CONDITION	Give details ………………………………….. ………………………………………………

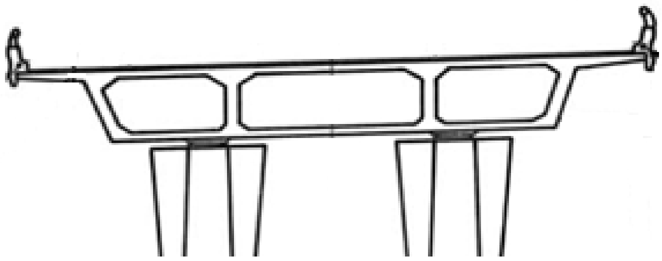
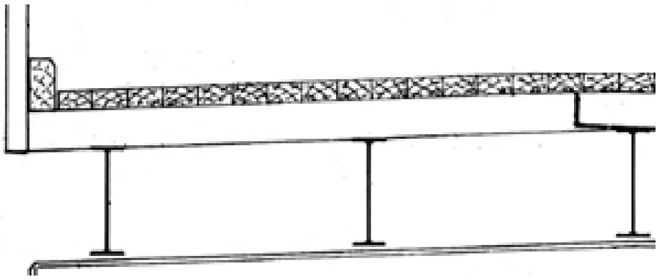
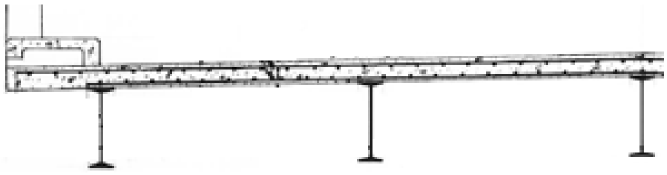
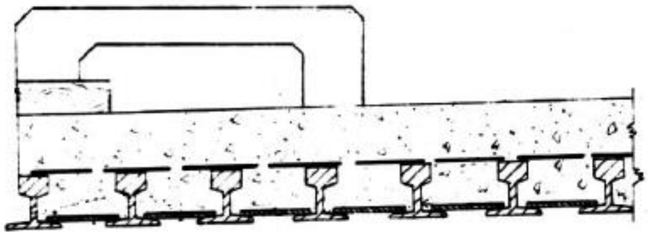
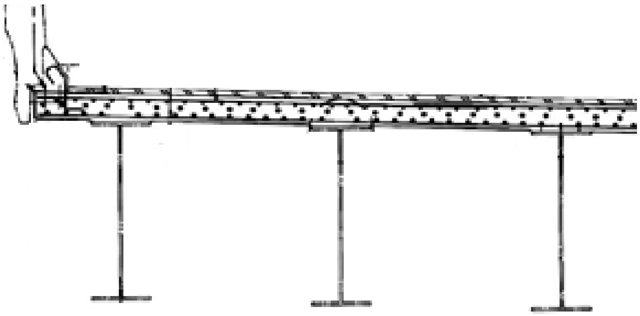
OTHER COMMENTS **e.g. Noise** **Riding quality – level** **Wear/cracking of asphaltic plug**	Give details …………………………………… …………………………………………………

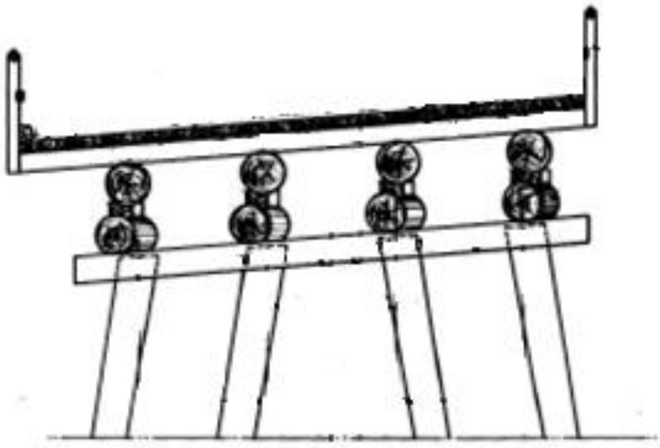
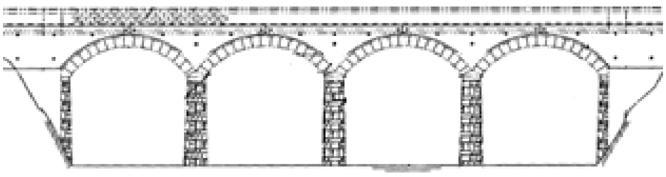
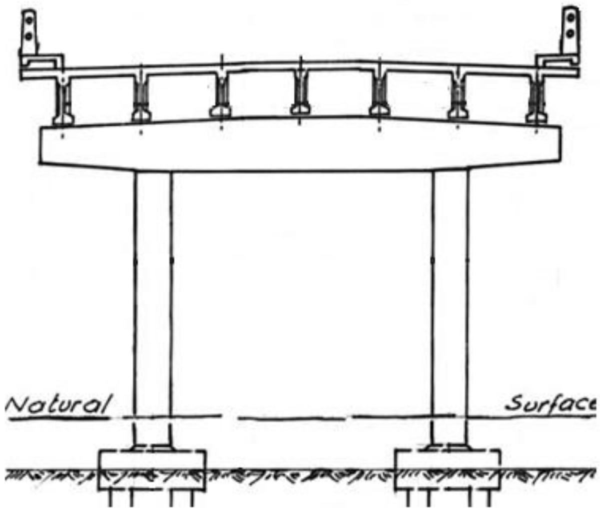
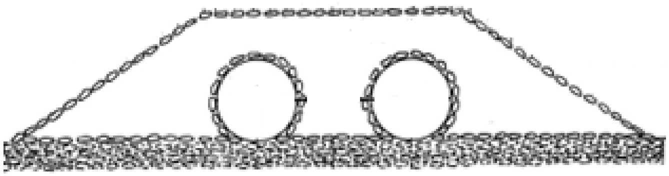
Appendix H – Monitor Structures

The following guidelines relate to individual types of bridges and culverts that have been identified as requiring inspection and monitoring. The typical section of different types of structures are shown below.

Number	Structure Type	Typical Section	
1.1	**U-Slab Bridges without Reinforced Concrete Overlays**	**1951 Standard Units**	
		1962 Standard Units	
1.2	**Precast Prestressed Concrete Deck Units (Rectangular Beams) without Reinforced Concrete Overlays**		
1.3	**Precast Prestressed DMR Plank Bridges**		
1.4	**Cast-in-place Reinforced Concrete Flat Slab Bridges**		

1.5	**Cast-in-place Reinforced Concrete Tee Beam Bridges**	
1.6	**Precast RC 'I' Beam Bridges with Cast in Place Decks**	
1.7	**Precast Prestressed Concrete NAASRA 'I' Beam Bridges with Cast** **in Place Decks**	
1.8	**Precast Prestressed Concrete Trough Girder Bridges with Cast in** **Place Decks**	
1.9	**Cast-in-place Post-tensioned Concrete Voided Slab Bridges**	

1.10	**Cast-in-place Post-tensioned Concrete Box Girder Bridges**	
1.11	**Rolled Steel Girders with Timber Deck Bridges**	
1.12	**Rolled Steel Girders with Cast in Place RC Deck Bridges**	
1.13	**Concrete Encased Steel Rail Girder Bridges**	
1.14	**Fabricated Metal Girder Bridges**	

1.15	**Timber Stringers with Timber Deck Bridges**	
1.16	**Reinforced Concrete, Stone Masonry and Brick Arch Bridges**	
1.17	**Bridge Substructures**	
1.18	**Buried Corrugated Metal Structures**	

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 must be inspected for flexural cracking, particularly near mid-span and for inclined shear cracking near the supports as shown in Figure 1.1.1.

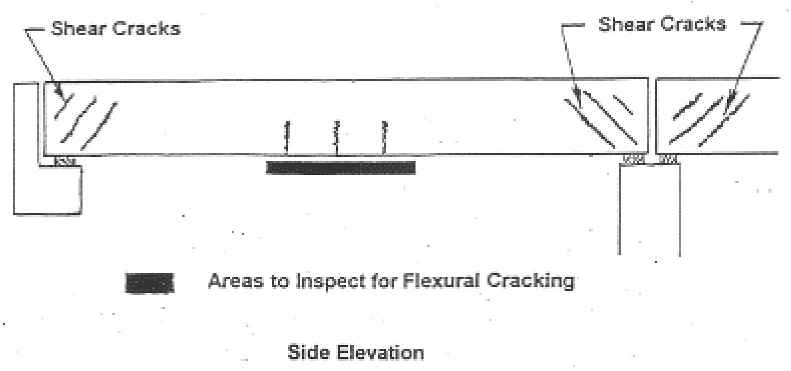


Figure 1.1.1 U-Slab side elevation

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 must be recorded and photographed.

(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 must be inspected to determine whether any of the bolts have corroded, worked loose or broken. This must be recorded and reported so that consideration may be given to the rehabilitation method to be used.

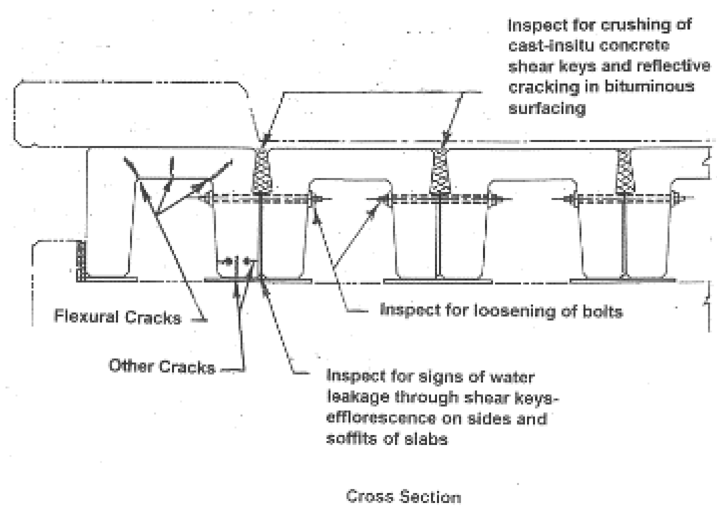


Figure 1.1.2 U-Slab inspection areas

They must also be inspected to determine whether there is any evidence of cracking of the shear keys. This must 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 must 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 must 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 must be recorded in detail and photographed.

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

Both DoT (formerly VicRoads) 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 DoT 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 must 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 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 must be recorded. An alternative date must 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.

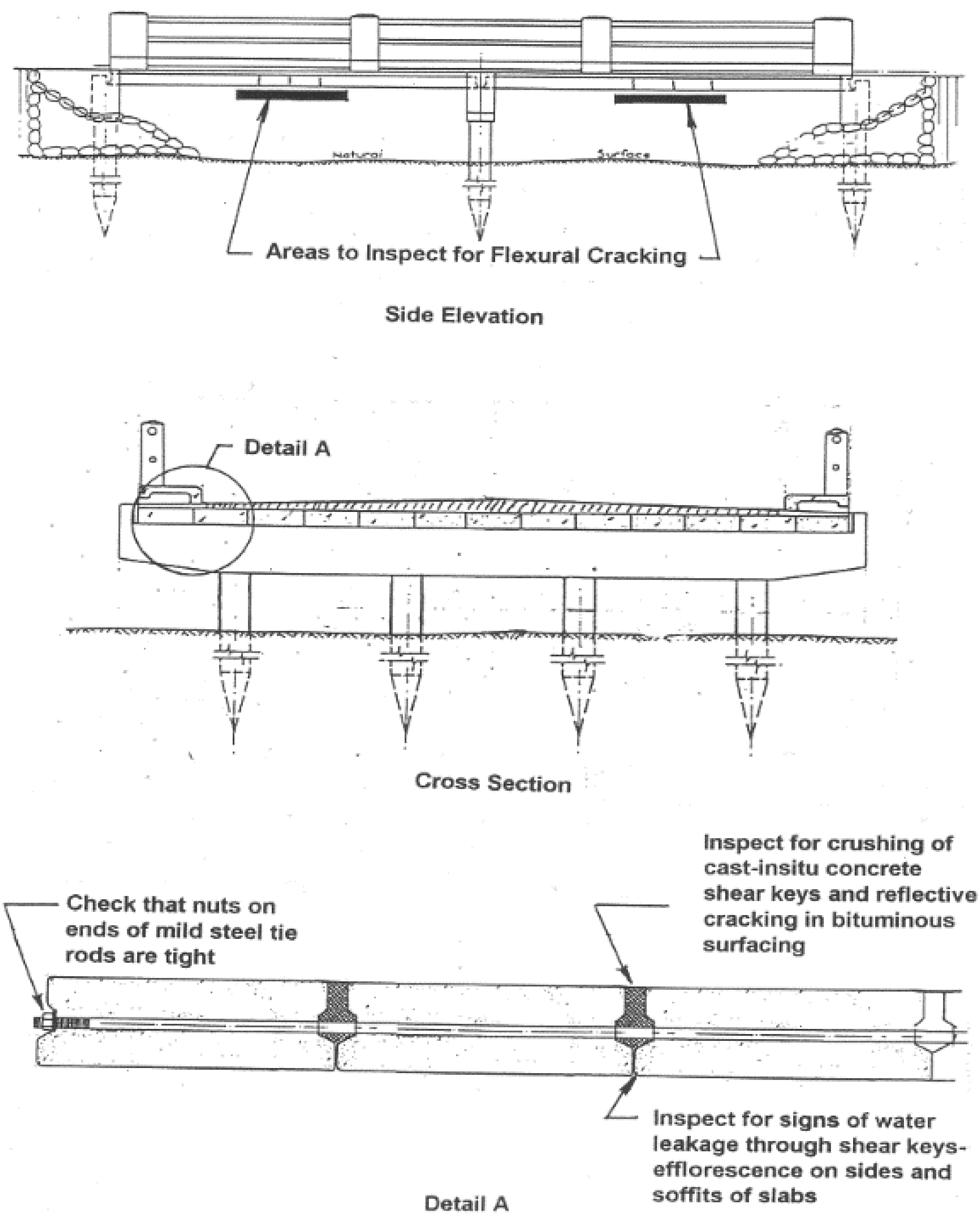


Figure 1.2 PSC Unit without concrete overlay

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. DoT 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 must 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 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 1.5 m, 3.6 m, one or more 4.57 m, 3.6 m and 1.5 m. 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 must 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 must 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 must 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 3.6 m, one or more 4.57 m and 3.6 m 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 1.5 m, 5.5 m, one or more 7.0 m, 5.5 m, and 1.5 m.

They should be inspected at the same locations as the above Type 1a bridges.

Type 3

The span arrangements are 2.1 m, 7.0 m, one or more 9.14 m, 7.0 m and 2.1 m. 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 must be made on the outside vertical faces of the flat slab in the regions of these piers.

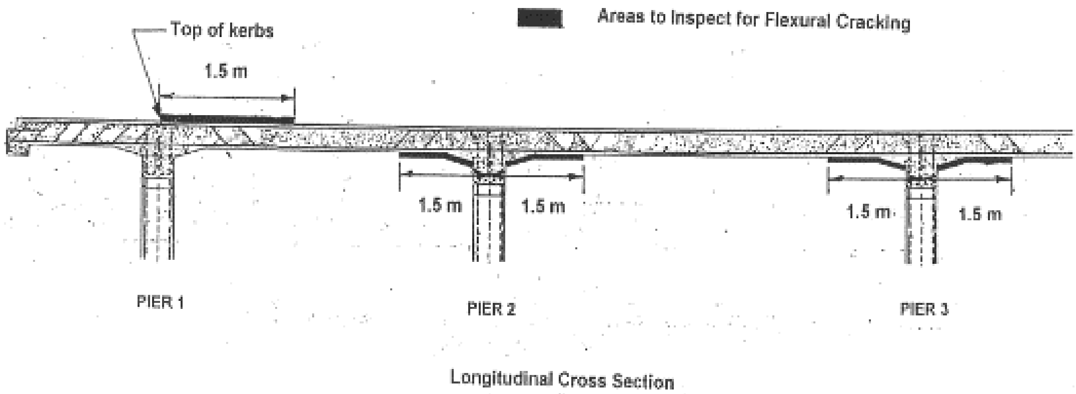


Figure 1.4 Flat Slab Bridge inspection areas

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 must 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 must 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 must 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 must 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 must be given to inspection for inclined shear cracks in the beams near the piers of older bridges without transverse diaphragms.

1.6 Precast Reinforced Concrete '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 Post-tensioned 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 Post-tensioned 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 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 Reinforced Concrete 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 DoT 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 assess performance more accurately, 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 per AS5100.8 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, DoT (operating as 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.

The traditional two column piers designed for MS18 loading also need a thorough inspection for flexural cracking in the crosshead between columns and shear cracking in the crosshead near the columns.

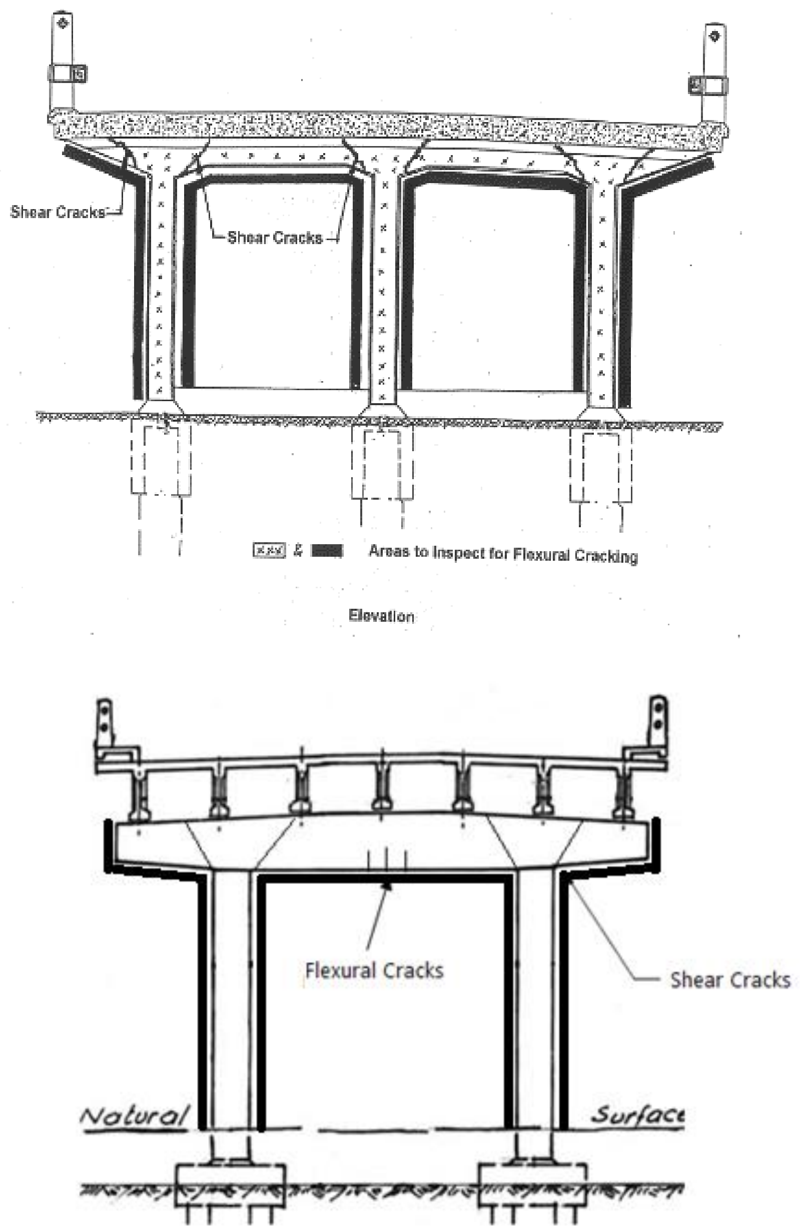


Figure 1.17 Bridge substructure inspection areas

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 before 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 Part 2 Section 4.2; or

3. is authorised to make an inspection by the Principal Engineer – Structures 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.

Item	Feature	Hazard	Risk	Possible Controls
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 per Occupational Health and Safety (Confined Spaces) Regulations together with DoT 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

5	Corroded / missing areas of metal	Sharp metal edges	Laceration	*Assess individual circumstances* Personal Protective Equipment (Gloves, boots, helmet) Provide lighting
6	- Voids in and behind BCMS walls caused by corrosion and erosion - Surrounding area	Venomous creatures	Snake or insect bites	*Assess individual circumstances* No lone-working Provide lighting Avoid probing by hand into hidden voids / dark areas
7	Debris or water in invert (invert condition obscured)	Hidden corrosion-damaged metal surfaces	As items 1 and 5	*Assess individual circumstances* Clear debris and enter in stages only if safe to proceed

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 – Structure Risk Management Plan Template

Monday, 12 December 2022

<Structure ID>
<Road Name>
<Location, Suburb>
<Brief Description of Structure>

Highest Risk Rating: Choose an item.	**Region:** **<Region Name>**
Total Cost $: **<######>**	**Map Ref:** **<Mel ways/VRCD>**
SRMP Duration: **< ###### >**	**GPS Coordinates:** Lat: **< ##### >** Long: **< ##### >**
Author: **< Insert Authors name>**	

Estimated tot. Cost:
$<insert total cost of Interim + Stepwise> million

Interim response Cost:
$<insert amount> million

Stepwise improvement Cost:
$<insert amount> million

Cash flow
<Insert all years you are seeking funding for
20xx-xx
20xx-xx>

High level description of the defects/deficiency & why it's a risk (current State of the structure)
< Provide a summary of the current issues / state of the structure >

Generic description of potential failure (Describe Failure)
< Provide a summary of how the structure will fail if left untreated, e.g. will it be just one component or a complete collapse? >

Consequence of most critical failure (Safety related)
<Describe the consequences of structural failure. >

Key benefits <Results of mitigating the Risk:>

- <####>
- <####>
- <####>

Major implications <Consequences of not receiving funding for mitigation measures>

- <####>
- <####>
- <####>

Stakeholder Summary <List Key Stakeholders Involved>

- <####>
- <####>
- <####>
- <####>
- <####>
- <####>

Deliverability of the Structures Risk Management Plan (SRMP)
Proposed <Interim / Stepwise> commencement date:

- <Expected to commence delivery in xx>

SRMP duration:

- <X years >

<Duration is defined for stepwise treatments (should not exceed 3 years), otherwise for ongoing interim risk management, duration defines interval for review of the plan (should be less than 2-year interval)>
Key SRMP dates and timelines:

	Interim Risk Mitigation	Stepwise Risk Mitigation
Year – 1		
Year – 2		
Year – 3		

<<## Contents of page -1 should not exceed more than 1 page## "PAGE 1 only">>

Failure mechanisms and modes			
<Describe the failure mechanisms occurring on the structure and the failure mode that these will lead to, e.g. ductile or brittle failure. This section should include technical descriptions of the defects and deficiencies, why they are occurring and how they are currently affecting the performance of the structure.> All of these are expected to reduce structural capacity or have significant serviceability issues leading to Public Safety concerns			
Defect/Deficiency	**Location of defect / deficiency**	**Observations/Contributing Factors/Failure type**	**how they impact the performance of the structure and potential consequences**
1.			
2.			
3.			
4.			

RISK (major risks that may impact the SRMP at any stage) (Safety Related)				
Failure Mode	**Consequence type**	**Likelihood - Rating**	**Consequence - Rating**	**Risk Rating**
	Choose an item.	Choose an item.	Choose an item.	Choose an item.
	Choose an item.	Choose an item.	Choose an item.	Choose an item.
	Choose an item.	Choose an item.	Choose an item.	Choose an item.
	Choose an item.	Choose an item.	Choose an item.	Choose an item.
	Choose an item.	Choose an item.	Choose an item.	Choose an item.
	Choose an item.	Choose an item.	Choose an item.	Choose an item.

Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	High
	Consequence				

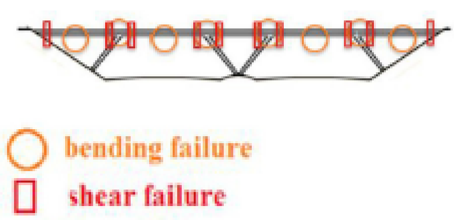
Rating	Likelihood	Frequency Single Events	Frequency Recurring Events
Almost Certain (5)	76-100%	More than likely to happen	Several times a year
Likely (4)	51-75%	As likely as not to happen (50/50)	Once or twice a year
Possible (3)	31-50%	Likelihood less than 50/50	Once in two years
Unlikely (2)	11-30%	Likelihood low but not negligible	Once in five years
Rare (1)	0-10%	Negligible likelihood	Once in 10 years or unlikely for the event to occur

Fig1: DoT Risk Management Framework

Vulnerable zones

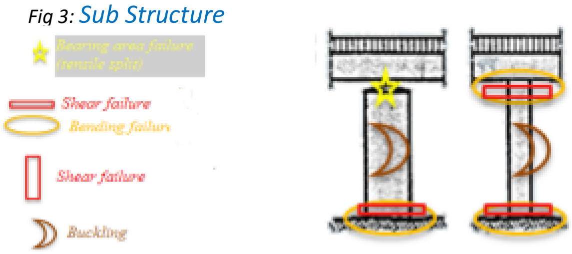
<Provide details or drawings outlining the areas of the structure that are vulnerable zones due to all the failure mechanisms mentioned above>

Fig 2: Super Structure



WG3 Technical Report Sep 2018

Fig 3: Sub Structure



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Defect monitoring requirement
< Describe how the defects/deficiencies will be monitored going forward in conjunction with the management plan, and any failure warning signs to look out for and limits to monitor. Attach in the appendices any previous defect monitoring reports, inspections reports, monitoring data etc. >

Structure Risk Management Plan

Describe the details and timeline of how the structure will be managed for the duration of the plan. This section should be separated into two categories;

- Interim response: manages the immediate risk to public safety which is achievable in the short term without much cost where the defect is known. Plan to investigate structure to develop stepwise improvement.

- Stepwise improvement Response (Rehabs) rectification plan which will involve significant funding to overcome the issues. This plan will only discuss and document stepwise improvement where the solution is routine and is achievable through rehabilitation of the structure.

Include specific details of the risk mitigation measures that will be part of the Risk Management Plan.
Consider a flow chart of the Risk Management Plan for visualisation and clarity as well as assisting with messaging and communication.

Evidence
<Photos / MIbs / Monitor Inspection Report / Level 3 Inspection Report. Additional information & supporting documents must be attached as an appendix to this document>

Endorsement

[1] (ENGINEERING) ENDORSED	[2] TRANSPORT ASSETS BAM APPROVED
Name: ______________________________	Name: ______________________________
Title: ______________________________	Title: ______________________________
Signature: ______________________________	Signature: ______________________________
Date: / /	Date: / /

Appendix A:

Appendix B:

Appendix C:

Appendix J – Affixing Location for ID Plates and Date Plates

Structure	Type	Number of Plates	Plate Location
Bridges (including pedestrian bridges)	SN	2	Plate 1 – inner face of the end post on the left-hand side when approaching from the start of the road, 300 mm below the top of the end post. Or Plate 1 – where no end post, centre of the Abutment 1 of the bridge, located approximately 300 mm below the top of the crosshead. Plate 2 – centre of the Abutment 2 of the bridge, located approximately 300 mm below the top of the crosshead.
Culverts (including underpasses)	SN	1	Plate 1 – centre of the outer face of the endwall on the left-hand side of the road when approaching from the start of the road, 300 mm below the top of the wall. For Reinforced Concrete Pipes (RCPs) with rock beaching headwalls the plate shall be attached centrally on the vertical face of the end/rim of the RCP provided that the pipe wall is thick enough. If this is not possible, the plate shall be attached to the curving outer surface of the pipe and failing this, to the inner surface – in both cases within 300 mm of the end of the pipe. For Buried Corrugated Metal Structures with no headwall, the plate is to be attached in a vertical position on a corrugation half way up the pipe barrel and within 300 mm of the end of the pipe. If this is not possible, the plate shall be attached to the outside of the pipe at the top central position.
Noise attenuation walls and visual screen walls	SZ and SV	2 or 3	The structure number plate for a noise attenuation wall shall be located at the start and end of noise attenuation walls in the direction of travel at a height of 1.5 m height from the bottom edge of the noise wall. A repeater structure ID plate or painted structure ID number can be considered at a gate joining two sections of noise attenuation walls (discontinuities/gaps are treated below). The structure ID plate shall be attached to the first post and last post of the noise attenuation wall and be positioned in the line of sight of drivers. If posts are concealed, the plates shall be placed on the panel in the same position.

			A new structure number shall be given to each section of noise attenuation wall on the same road: • If there is a clear break in the noise attenuation wall (discontinuity or gap) e.g. a gap for maintenance access. • If the materials used in the wall's construction changes significantly e.g. when a timber noise attenuation wall transitions to a steel noise wall. • If the design of the wall changes. If a noise attenuation wall is continuous for a long distance, the Asset Manager may consider providing additional way-finding information for inspection and maintenance purposes. A stencil painted structure number followed by length could be incorporated e.g. SZXXXX-2km at a height of 1.5 m from the bottom edge of the noise wall. This minimises the need for additional structure numbers for the same wall. For the purpose of Level 2 Inspection, a noise attenuation wall panel comprising different materials shall use a combination of component number and material classifications (P, C, S, T or O) as outlined in Part 4 of RSIM.
Retaining walls	SR	2 or 3	For retaining structures above road level, plates shall be placed on the vertical face 1.5 m above road level where there is sufficient height. For retaining structures below road level, plates shall be placed on vertical face at the top of retaining structure. Plate 1 – inner face of wall 300 mm from the start of the wall on the left-hand side when approaching from the start of the road. Plate 2 – 300 mm from the end of the wall. Plate 3 – If the wall is 200 m or more in length, an intermediate plate is to be provided at the mid-point of the wall.
Major signs structures	SS	1 or 2	Plate 1 – on the side of the column facing traffic approaching from the start of the road and at 1.5 m above shoulder/ adjacent surface level. Plate 2 – if the structure passes over both carriageways of a divided highway, a second plate is to be attached in a similar position facing approaching traffic on the opposing carriageway. Or

			Plate 2 – if the structure passes over one carriageway of a divided highway, a second plate is to be provided on the median post, orientated for vehicles on the fast lane travelling in the forward direction of the road, 1.5 m above the adjacent surface level.
High-mast lighting structures	SL	1 or 2	Plate 1 – on the side of the column facing traffic approaching from the start of the road and at 1.5 m above adjacent surface level. Plate 2 – for structures in the median only – both sides of the column orientated for vehicles on the fast lane travelling in the forward direction of the road and at 1.5 m above adjacent surface level.
Architectural and historical features	SA	1 or 2	Plate 1 – attach to a surface on the left side of road facing traffic approaching the structure from the start of the road, 1.5 m above the adjacent surface level. Plate 2 – if the feature passes over a divided highway, a second plate is to be attached in a similar position facing approaching traffic on the opposing carriageway.
Concrete pavement on piles	SP	1 (minimum)	Number and location to be advised by DoT Transport Assets.
Emergency median barrier access gates	SG	1	Plate 1 – in the middle of the top of the gate.
Emergency boom gates	SB	1	Plate 1 – on the emergency boom gate control box.
Emergency bridging systems		-	Not applicable.
Weigh-bridges	SW	1 (minimum)	Number and location to be advised by DoT Transport Assets.

Appendix K – Examples of Structure Types

Structure Type	Structure Subtype	Example Photos
Bridge (SN)	**Concrete Bridge**	
	Steel Bridge	
	Timber Bridge	
	Masonry Bridge	

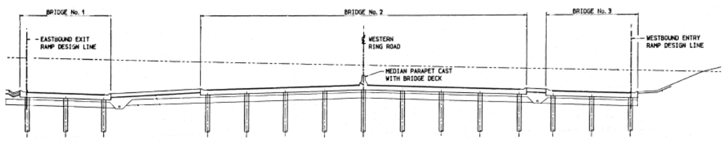
	Pedestrian Bridge	 
	Fauna Bridge	
Major Culvert (SN)	**Concrete Culvert**	 
	Concrete Pipe	

	Buried Corrugated Metal Structure	
	Masonry Arch Culvert	
	Underpass	
Noise Attenuation Wall (SZ)	**Concrete Noise Wall**	
	Metal Noise Wall	

	Timber Noise Wall	
	Plastic Noise Wall	
Visual Screen Wall (SV)	**Plastic Visual Screen Wall**	
Retaining Wall (SR)	**Precast Concrete Panel Wall**	

	Cast-in-site Concrete Retaining Wall	
	Reinforced Soil Structure	
	Sheet Pile Wall	
	Crib Retaining Wall	
	Sleeper Retaining Wall	

	Gabion Wall	
Major Signs Structure (SS)	**Cantilever Sign, Pedestal Sign and Butterfly Sign Structure**	 
	Portal (gantry) Sign Structure	 
	ITS Sign Structure	

High-mast Lighting Structure (SL)	**N/A**	
Architectural and Historic Feature Structure (SA)	**Public Art**	
Concrete Pavements on Piles (SP)	**N/A**	 
Emergency Median Barrier Access Gate (SG)	**N/A**	
Emergency Boom gate (SB)	**N/A**	

Emergency Bridging System (SE)	**N/A**	
Weigh-bridge (SW)	**N/A**	

image source: Google Maps

Appendix L – References

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