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Civil Engineering

MN C 10301

Structures Examination

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Transport Sydney Trains

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Replaced Professional Head, Civil Engineering responsibilities with content from TN 068	5.1.7
Replaced Competencies with content from TN 068	6
Added text on mandatory activities from EI C 17-04	7.1
Replaced Detailed Examinations section with content from TN 068	8.5.1
Added Engineering Assessments section from TN 068	8.7
Added content on rust damage and section loss from EI C 17-04	9.1.2.1
Added content on measuring concrete cracks from EI C 17-04	9.2.4.8
Added content on measuring masonry cracks from EI C 17-04	9.3.3.2
Added Deterioration Modes in Crib Wall Structures section from TN 068	9.5
Added Examination of Hidden Structures section from TN 072	11
Added Crib Walls content to Defect Comments table	12.6.2.2
Added Crib Walls content to Action Required table	12.6.2.3
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Added E. Underbridges – Concrete > Abutments and Wing walls from TN 068	21
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Replaced Structurally Critical Members appendix with content from TN 068	22
Changed text to list to improve readability	23.3.2
Added Miscellaneous Structures (Crib Wall) report from TN 068	23.7
Added Steel and Concrete Underbridges table from TN 065	25

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1 Introduction

This Manual outlines procedures to be followed for the examination of structures on the rail network maintained by Sydney Trains.

2 Scope

Structures include underbridges, overbridges, footbridges, culverts, overhead wiring structures, signal gantries, steel transmission poles (particular attention to those with underwater footings), tunnels, retaining walls, platforms, airspace developments, track slabs, lighting towers, aerial service crossings, noise abatement walls, loading banks and stages, turntables, fixed cranes, weighbridges, buffer stops, stop blocks, overhead water tanks, sedimentation basins, stormwater flow controls and similar structures, rock fall shelters, structures over and adjacent to tunnels.

The Manual is not applicable to buildings, communication towers, advertising hoardings and signs. For facilities buildings refer to *MN C 10701 Facilities Buildings Maintenance Manual*.

Also excluded from this manual are geotechnical inspections for cuttings and embankments.

The examination process includes the inspection of the structures and the recording and assessment of their condition.

This Manual outlines methods and procedures for structures examination. It covers standard terminology, examination personnel, standard types of examinations, categories of exceedents, standard inspection equipment associated with the examination of structures and specific procedures the examination of bridges and other structures.

2.1 The structure of this manual

The Manual covers the requirements for examination of structures. It includes:

- general requirements including defect categories and levels of repair priorities associated with the examination of structures
- the hierarchy of examination personnel and their respective responsibilities
- standard procedures for the examination of bridges
- standard procedures for the examination of other structures including overhead wiring structures, tunnels, retaining walls, platforms, and drainage
- standard report forms
- registration of reports and defects in EAM|SAP.

2.2 Application

This Manual should be used by Sydney Trains personnel programming and undertaking examination of structures, and responding to examination results.

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3 Reference documents

ST C 10100 Civil Technical Maintenance Plan

MN C 10110 Civil and Structures Service Schedules

MN T 20203 Track Inspection

MN C 10302 Structures Repair

MN C 10303 Underwater Examination of Structures (formerly T HR CI 12005 ST)

MN C 10305 Structures Assessment

Special Civil Technical Maintenance Plans (TMP):

- MN A 00100 Civil and Track Technical Maintenance
- MN A 00119 Maintenance Plan – Tunnels
- MN C 10111 Maintenance Plan – Stanwell Park Viaduct
- MN C 10112 Maintenance Plan – Georges River Bridge Como
- MN C 10113 Maintenance Plan – Hawkesbury River Bridge
- MN C 10114 Maintenance Plan – Knapsack Gully Viaduct
- MN C 10115 Maintenance Plan – Nepean River Bridge
- MN C 10116 Maintenance Plan – Wolloomooloo Viaduct
- MN C 10117 Maintenance Plan – Georges River Viaduct East Hills
- MN C 10118 Maintenance Plan – Rushcutters Bay Viaduct
- MN C 10119 Maintenance Plan – West Terrace Underbridge Bankstown
- MN C 10121 Maintenance Plan – Wombarra Drainage Tunnel
- MN C 10131 Maintenance Plan – Chatswood Rail Enclosure Structure
- MN C 10132 Maintenance Plan – Epping To Chatswood Rail Line Structures
- *MN C 10133 Maintenance Pla*n – Chatswood Transport Interchange Structures

Sydney Trains Bridge Management System (BMS-EAM/SAP)

Sydney Trains Safety Management System (SMS).

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4 Terms and definitions

The following definitions apply in this document:

Standard terminology to describe structures and conventions for numbering of components are provided in this section.

These conventions are to be followed when describing and reporting on examination results.

Terms used to describe individual members of bridges and structures are listed in section *18 APPENDIX 1: Terms used in reference to Bridges and Structures*.

Sketches of typical bridge spans and members are shown in Section 19.

The following terminology is also used in this Manual:

Track Patroller	Person responsible for the examination and maintenance of a track length.
Bridge Examiner	Person responsible for the examination of bridges and other civil structures.
Structures Co-ordinator	Person with relevant technical competency in the structures discipline. The manager of structures discipline personnel in a Territory or District.
Territory Civil Engineer	Civil Engineer of the Territory with relevant technical competency in the Track and Civil discipline.
Senior Manager Civil & Structures Engineering **Bridges and Structures Engineers**	Network Maintenance civil engineering manager responsible for bridges & structures with reporting Territory Civil Engineers Engineers from the ESI Civil Engineering team, or person from an external service provider with relevant qualifications and experience in the detailed design of bridges and structures.
Examination	The process of inspection of a structure and the recording and assessment of its condition.
Defect	Deterioration of a component from its original condition.
Defect Category	Classification of a defect into a category that indicates the severity of the defect and response time recommended for continuing train operations and engineering assessment.
Exceedent/ Exceedence	Any defect in the asset that requires remedial action within two years or less.
Non-compliant	Component not build in accordance with design or standards
Non-exceedent/ Non-exceedence	A defect in an asset that requires recording for future reference, monitoring and possible remedial action outside two years.
Paint Index	A qualitative index reflecting the condition of the surface coating of steel structures.
Repair Priority	Time frame for the repair of a defect.

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4.1 Length of bridge spans

The length of bridge spans is measured and described as follows:

- Timber bridges: distance between centres of headstocks
- Steel bridges: distance between centres of bearings
- Concrete bridges: distance between centres of bearings
- Brick and Stone bridges: distance between faces of piers.

For bridges with an integral deck, walls, and invert (e.g. box culverts, arch culverts, box drains and pipes), the span length is measured between faces of walls.

Skew spans are measured generally parallel to the supported track or road.

4.2 Numbering of bridge members

Numbering of bridge members follows the same pattern for underbridges, overbridges, and footbridges.

For underbridges, the Sydney end abutment is the datum for numbering, being the No. 1 Abutment. For overbridges and footbridges, the Down side Abutment is the datum for numbering, i.e. the No. 1 Abutment, and other members then are numbered as for an underbridge.

Members are numbered as follows:

- Girders, Stringers, Corbels: From the Down side of each span. For compound girders, add “top”, “intermediate”, or “bottom”.
- Other Longitudinal Members: as for Girders.
- Transverse Decking/ Cross Girders: from the Sydney end of each span.
- Abutments: No. 1 closest to Sydney, No. 2 other end of bridge.

  (Typically the Sydney end of the bridge is shown in drawings is located on the left hand side – both in plan and in elevation).
- Piers: No. 1 closest to No. 1 Abutment, others in sequence.
- Trestles and Sills: As for Piers.
- Piles: From the Down side of each Abutment/Trestle/Pier.
- Wing Piles: From the track end of each Wing.
- Abutment Wings: No. 1 (Down) and No. 2 (Up) for No. 1 Abutment. No. 3 (Down) and No. 4 (Up) for No. 2 Abutment.
- Intermediate Supports: Numbered as for the span they support.
- Walings/Bracing: No. 1 on Sydney side of support.

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4.3 Location of bridges and structures

All bridges and structures shall have a kilometrage (correct to 3 decimal places) stencilled in 75mm high black figures on a white background, or engraved on a plaque.

The kilometrage value is generally the value at the face of the structure on the Sydney end. For bridges and culverts, the kilometrage value is as follows:

- Underbridges: the km value at the face of the Sydney end abutment under the centreline of the furthest Down track.
- Culverts: the km value at the centreline of the culvert or the Sydney side centreline of a group of culverts.
- Overbridges and Footbridges: the km value where the Sydney side of the bridge crosses the track.

The stencilled kilometrage shall be located as shown:

Underbridges	On the Up side of the No. 1 abutment and on the Down side of the No. 2 abutment. Underbridges less than 10 metres long are to be stencilled on the No. 1 abutment only. Bridges without defined abutments, e.g. some culvert structures, are to be stencilled on the face of the Down side headwall.
Overbridges and Footbridges	On the abutment or pier adjacent to the furthest Down track and at the Sydney end.
Tunnels	On the Down side of the No. 1 portal, and on the Up side of the No. 2 portal.
Platforms	On the face of the coping at each end of No. 1 platform.
Overhead Wiring and Signal Structures	In accordance with conventions implemented by electrical and signalling disciplines.
Other Structures	On the Down side of the track and at the Sydney end.

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4.4 Bridge identification

Every bridge on the rail network has its own unique identification, based on the line, distance from Central Station and the tracks on or under the bridge.

A bridge location can be further identified by reference to the nearest railway station. An overbridge can also be identified by the name of the road that it carries and an underbridge by the name of the road or waterway that it traverses.

A footbridge can be identified by the railway station it services or the nearest public road.

4.4.1 Total Bridge

The following conventions shall be followed for the high-level description of bridges:

Material of main deck members

- Bridge category
- Structural type.

Examples: Concrete Overbridge, Steel Footbridge, Steel Underbridge, Through Deck Truss.

4.4.2 Individual Spans

- Span length (to nearest 0.1 metre)
- Material of main deck members
- Span type.

Examples: 6.0m steel plate web girder transom top, 1.5m concrete box culvert.

4.5 Structure identification

Overhead wiring structures and signal gantries have a unique number as marked on the structure.

Other structures on the network are identified by the line and distance from Central Station.

A structure location can be further identified by reference to the nearest railway station.

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4.6 Track identification

Each track on any given line also has a form of identification. Tracks that carry trains away from Sydney are called Down tracks. Trains that run towards Sydney are called Up tracks. Tracks that carry Interurban or Country trains, or where there are only two tracks, are known as Main Lines (refer to *ESC 200 Track System* for definition of Main Line).

Where there are multiple lines (i.e. more than two tracks), there is a further breakdown. The tracks operating trains out to the far suburbs are known as Suburban Lines and those that service the nearby suburbs are known as the Local Lines. Further identification of tracks is used for Sidings and for Goods Lines. The following list of typical abbreviations are used for individual track identification:

UM	Up Main
DM	Down Main
US	Up Suburban
DS	Down Suburban
UL	Up Local
DL	Down Local
UG	Up Goods
DG	Down Goods
S	Siding

4.7 Acronyms

Acronyms to be used when describing bridge components are detailed in Sydney Trains Bridge Management System (BMS) documentation.

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5 Management Requirements

5.1 Examination responsibilities

Network Maintenance Territory management is responsible for ensuring that all structures within the railway corridor are examined.

The examinations shall be carried out by persons with the relevant competencies as specified in this manual.

The examinations shall be carried out in accordance with the procedures in this Manual and the requirements of relevant Technical Maintenance Plans and Service Schedules.

The respective responsibilities of personnel assigned to the examination of structures are detailed below:

5.1.1 Track Patroller

The Track Patroller (TP) is required to undertake cursory examinations of structures during their track patrols in accordance with *MN T 20203 Track Inspection*.

5.1.2 Bridge Examiner

The Bridge Examiner is responsible for the following:

- Detailed examination of all structures within his/her allocated area.
- Monthly examination of broad flange beam (BFB) underbridges over roads.
- Special examination of other structures.
- Identification and quantification of exceedents and non-exceedents.
- Taking appropriate action in accordance with the defect categories.
- Assignment of repair priorities (optional).
- Assignment of paint indices except for underbridges, overbridges and footbridges (optional).
- Preparation and submission of weekly summary of exceedent reports.
- Preparation of written examination reports.
- Ensuring defects and examination reports are recorded in the Bridge Management System (EAM/SAP).

The BE is required to have a copy of the previous examination results when examining each structure. The BMS (SAP) shall be used to generate the previous examination reports for bridges, culverts and other structures covered by the system.

The BE should take photographs where appropriate to visually illustrate degraded components, etc., for inclusion in the written reports.

For underbridges, the BE is required to paint where applicable the level and date of the highest flood level. This is to be located on the Down side of the No. 1 abutment.

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5.1.3 Bridge Examiner Steel (Experience steel)

This role has been taken over by the Bridge Examiner (BES), experienced in steel structures and is responsible for the following:

- Detailed examination of all steel and wrought iron underbridges, overbridges and footbridges.
- Identification and quantification of exceedents and non-exceedents.
- Taking appropriate action in accordance with the defect categories.
- Assignment of repair priorities.
- Assignment of paint indices.
- Preparation and submission of weekly summary of exceedent reports.
- Preparation of written examination reports.

The BES is required to have a copy of the previous examination results when inspecting each structure. Photographs should be taken where appropriate to visually illustrate degraded components etc., for inclusion in the written reports.

The BES's responsibility lies solely with the steelwork component of bridges. The non-steel components (such as masonry and concrete substructures, etc.) can be examined and separately reported on by the BE as prescribed above.

5.1.4 Structures Co-ordinator (SC)

The SC is responsible for the following:

- Mid-Cycle examinations of bridges, overhead wiring structures (OHWS) and signal gantries.
- Assessment of exceedents detected and reported by the BE in the weekly summary and detailed examination reports.
- Referral of exceedents where necessary to the Territory Civil Engineer for higher level assessment.
- Confirmation of defect categories and repair priorities where assigned by the BE, checking the performance of the BE and their reporting.
- Special examinations where there are doubts concerning the condition and safety of a structure.
- Ensuring defects and examination reports are recorded in the EAM/SAP.
- Preparation and implementation of repair programmes, including scoping of work and estimating.
- Certification of new structures before formal handover to maintenance.

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5.1.5 Network Maintenance Territory Civil Engineer

The Network Maintenance Territory Civil Engineer (NMTCE) is responsible for the following:

- Ensuring that all structures within the railway reserve are examined by competent persons in accordance with the procedures prescribed in this Manual.
- Arranging the attendance of the Experience BE for the examination of steel and wrought iron bridges.
- Arranging special examinations and underwater examinations by specialist consultants and contractors.
- Confirming the condition of structures following inspections and initial assessment by the SC.
- Responding as appropriate to the defect categories and repair priorities assigned by examination staff and as referred by the SC.
- Visual examinations on a sampling basis or in response to a particular report or condition and preparation of written inspection notes.
- Signing-off of repairs.
- Checking the performance of the SC.
- Ensuring defects and examination reports are recorded in the SAP.
- Arranging the periodic engineering assessments of bridges.

The NMTCE is also responsible for ensuring the progressive acquirement of load rating and fatigue damage rating values for the structures under their control.

5.1.6 Senior Manager Civil & Structures Engineering

The Senior Manager Civil & Structures Engineering (SMC&SE) is responsible for the following:

- Scheduling with ESI – System Integrity assignment of the Asset Assurance Inspector Civil/Structural or Structures Co-ordinator to conduct visual examinations on a sampling basis for assurance purposes.
- Endorsement or approval of REVCOM (non safety critical) requests from the Bridge Examiner or Territory Engineers.

5.1.7 Professional Head, Civil Engineering

The Professional Head, Civil Engineering (PHCE) is responsible for the following:

- Allocation of bridges and structures engineers to perform load and fatigue damage ratings and engineering assessments of bridges.
- Allocation of bridges and structures engineers to respond to special requests (e.g. Category B defects repairs) from field staff (for example, Bridge Examiner, Structures Co-ordinator or Territory Civil Engineer) for design/technical assistance.

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5.2 Recording and reporting of defect detection and removal

All structures defects that are detected shall be recorded in an identifiable Defect Management System. Multiple systems are not precluded.

An auditable trail shall exist for all actionable defects from detection/notification to investigation, assessment, repair programming, repair action and certification.

The 'System' shall include, as a minimum, the following details:

- Defect
- Type
- Size
- Location
- Date found
- Source of information
- Action required (includes investigation, assessment, repair)
- Programmed action date (includes investigation, assessment, repair)
- Repair action
- Repair date
- Repair agency
- Review of performance.

S&CME shall:

1. Ensure that the Defect Management System is satisfactorily managed by the Team Manager.
2. Monitor the level of structures defects, assess the impact on structures performance and take appropriate action.
3. Review records and defects for trend identification at least annually. The outcomes must be considered in the development of regional maintenance strategies and Asset Management Plans.
4. At any time the Structures & Corridor Engineering Manager must be able to demonstrate, through the Defect Management System, current status of all defects recordable on the system.

5.2.1 Use of Electronic Systems

Electronic systems may be used to record and manage defects. Electronic systems shall be used for bridges and culverts.

Sydney Trains EAM/SAP asset management system shall be used to record and manage all defects.

Superseded by MN C 10301 v3.0, 18/10/2021

5.2.2 Source of Information

Defect Management Systems shall contain defects from the following formal examination and reporting systems:

- Structures Examination System
- Track Patrol
- Other Examinations (actionable defects)
- Reports form train drivers
- Field Inspections by Supervising Officers.

Superseded by MN C 10301 v3.0, 18/10/2021

6 Competencies

Detailed examination of structures shall be carried out by persons with:

- TDT B3701A “Conduct Detailed Structures Examination”. Mid-cycle examination of structures shall be carried out by persons with:
- TDT B3701A “Conduct Detailed Structures Examination” and
- *TBA “Structures Assessment.*

Cursory examination of structures shall be carried out by persons with:

- TDT B41 “Visually Inspect and Monitor Track”.

Special examination of structures shall be carried out by persons with:

- TDT B3701A “Conduct Detailed Structures Examination”.

Underwater examination of structures shall be carried out by persons with the qualifications and experience as detailed in *MN C 10303 Underwater Examination of Structures*.

Assessment of structures shall be carried out by persons with:

- TBA “Structures Assessment".

Engineering Assessment (Underwater Inspection) of bridges shall be carried out by bridges and structures engineers under the Professional Head, Civil Engineering.

Superseded by MN C 10301 v3.0, 18/10/2021

7 Defect Limits and Responses

7.1 Defect categories, repair priorities and paint indices

Defect categories have been created to establish standard and consistent response times to various levels of exceedences found during the examination of bridges.

A standard system for the assignment of repair priorities commensurate with the defect category has also been created.

The standard defect categories, responses and repair priorities are listed in Section 20.

RECORDING EXCEEDENT RATINGS IS A MANDATORY ACTIVITY FOR STRUCTURES DEFECTS.

- Where a defect does not fit under any of the defined defect categories, a photograph and description shall be sent to ESI Civil Engineering for clarification or assistance.

A specific list of defect limits has been established for structures. This list is included in Section 21.

A standard approach to the description of paint condition on steel bridges has also been developed, by the assignment of paint indices. Details are included in Section 20.3.

For bridges, some nominated defect types have a mandatory repair priority and those defects shall be repaired within the mandatory timeframe.

The nominated defect types are:

- Loose rivets and bolts in steel bridge members
- Missing or broken holding down bolts in bearing and bed plates
- Loose transom bolts
- Cracks and spalling in main members and decks in concrete bridges
- Blocked culverts.

The nominated defect types with a mandatory repair priority are detailed in Section 21.

Superseded by MN C 10301 v3.0, 18/10/2021

7.2 Transoms

Definition of condition:

Failed / missing transoms	Are those that are broken, missing or do not give vertical support to the rails – evidence of major dry rot and missing or loose rail plate fastenings.
Effective transoms	Transom/fastener system where the required fastenings are in place and which provides vertical support and lateral restraint. Restraint must allow no lateral movement of the fastenings relative to the transom. The transom must provide gauge restraint and must be one piece that will not separate along its length or transversely. Transoms must have a flat rail plate seat. Transoms shall not have more than 20% loss from any part. A transom that can be re-drilled will become effective again. It shall have sufficient material between the rail fastenings (in the "four foot") to distribute the load adequately.
Ineffective transoms	Transom that is ineffective. Transoms with rot or holes through which "daylight" can be seen are unsatisfactory.

For the purposes of assessment ineffective transoms include those that are missing or failed. **Where three or more consecutive transoms are deemed to be have failed or are defective, such defect must be entered in the defect management system for urgent replacement.**

Superseded by MN C 10301 v3.0, 18/10/2021

8 Examination Process

8.1 General

The condition of structures on the network is managed by examination (inspection, recording and assessment), audit and repair processes. The objective of these processes is to ensure that the structures are maintained in an acceptable and safe condition.

Structures on the network deteriorate over time from their 'as-new' condition, owing to loading cycles from trains and climatic conditions such as the sun, rain and salt air. Defects that develop include corrosion of steel members, cracking and spalling of concrete and pipes in timber members.

Examination of structures is a necessary part of effective and preventative maintenance. It is an important indicator of condition and is the basis for maintenance and replacement programs. The types and frequencies of these examinations are laid down in the respective Technical Maintenance Plans.

Defect categories and limits have been set to guide examination staff in the appropriate level of action to be taken when examining and measuring defects in structural members.

Written reports together with photographs shall be compiled from each detailed examination in accordance with the standard formats included in this Manual.

Reports and defects for bridges shall be recorded in the Bridge Management System (EAM/SAP).

A standard approach to the inspection, recording and assessment of structures will ensure consistent reporting of defects together with their implications and required responses. The same approach shall be applied irrespective of material type (steel, concrete or timber).

This chapter provides an introduction to the examination of structures (e.g. including associated fixtures such as protection screen or traffic barriers for overbridges):

- underbridges and culverts
- overbridges and footbridges
- overhead wiring structures and signal gantries
- tunnels
- subways
- retaining walls and platforms
- rockfall shelters
- structures over and adjacent to tunnels
- airspace developments
- lighting and communications towers
- aerial service crossings
- noise abatement barriers
- track slab
- other miscellaneous structures, including track drainage and subways.

Superseded by MN C 10301 v3.0, 18/10/2021

8.2 Objectives of structures examination

The regular examination of structures serves the following purposes:

- To ensure the safety of users and the general public including rail traffic, road traffic, pedestrians, maintenance staff and marine traffic passing under a bridge.
- To record the current condition of a structure that can be used in maintenance planning. The information is also used for rating the load carrying capacity of structures as well as for monitoring long term performance of structural and material types.
- To build-up a history of performance and degradation of a structure. This can be used in the planning and management of the rail network.
- To ensure that a structure continues to perform its required function in a safe and cost-effective manner.

To be successful, the examination process requires:

- objectives that are clearly defined
- properly planned examination programmes
- effective inspection and reporting procedures
- assessment of the examination results in order to assure the continuing integrity of each structure
- appropriately trained personnel to carry out the examinations and assessments.

8.3 Examination procedures

The examination of structures shall be carried out in a manner that is:

- organised
- systematic
- efficient
- thorough
- factual and measurable.

The examination procedure should ensure that all components are inspected and noted, all defects are found and recorded, problems relating to safety are identified and appropriate action initiated.

The use of general terms like ‘large’ should be avoided. Where exact measurements of a defect cannot be made, the ‘estimated loss of section’, etc., should be made and reported.

8.4 Examination personnel

Sydney Trains has a layered approach to the examination of its structures, utilising qualified personnel at various levels of detail and expertise. The use of appropriately trained personnel ensures consistency and objectivity in the inspection, reporting and assessment processes.

The layered approach is provided by the use of Track Patrollers, Bridge Examiners, Structures Co-ordinators, Territory Civil Engineers and the Asset Assurance Auditors/Inspectors.

Superseded by MN C 10301 v3.0, 18/10/2021

8.5 Examination types

Examination of structures is an important part of an effective management system and forms the basis for maintenance and replacement programs. Several different and complementary types of examinations may be required to ensure that a structure continues to perform its function under acceptable conditions of safety and with minimum maintenance.

Examination types are:

- Detailed examinations
- Mid-cycle examinations
- Cursory examinations
- Special examinations
- Underwater examinations.

8.5.1 Detailed examinations

8.5.1.1 General

Detailed examinations shall be conducted by the Bridge Examiner, Structures Co-ordinator or a qualified structural engineers.

These examinations are a detailed investigation of all aspects of the condition of a structure.

They involve close-up visual examination of all members of the structure.

The underlying requirement is that the examiner must be able to identify whether there is a defect with defect category A to E is present in the member being examined and be able to measure any identified defects.

The examination shall be at a level of detail sufficient to record the condition of the structure for the purposes of:

- determining required repairs or remedial actions
- load rating a bridge.

It is recognised that close-up access to all parts of some structures may be difficult and expensive, requiring major track possessions or road closures and extensive scaffolding.

On the TfNSW rail network, some structures are more critical than others and, within structures, some members are more critical than others.

To ensure that examination resources are effectively utilised, the following requirements for close-up examination apply:

- for structures and members as detailed in Section 8.5.1.2, close-up means examination from within one metre of the member
- for other structures and members as detailed in Section 8.5.1.3, close-up means examination from as close as reasonably practicable and using, where necessary, binoculars or other suitable equipment*.

  *Use of GoPro or drone inspection permitted and subjected to targeted inspection for verification of major defects

Superseded by MN C 10301 v3.0, 18/10/2021

8.5.1.2 Examination from within one metre

8.5.1.2.1 General

Close-up examination from within one metre is required for:

- readily accessible members of all structures
- members of bridges and OHWS as detailed in Table 1, whether readily accessible or not
- culverts, using mobile CCTV cameras where necessary.

Refer to Table 1 for the definition of readily accessible and for further details for examination within one metre of these structures and members.

8.5.1.2.2 Management requirements

Any nominated members that are not examined from within one metre within the nominated cycle time shall be:

- reported on the Weekly Summary of Exceedents form as a Category D exceedent
- managed as an overdue examination in accordance with the management and reporting requirements in Section 8 of *MN A 00100 Civil and Track Technical Maintenance*.

It is not permissible to miss examining structurally critical members from within 1 metre. Risk mitigation actions determined in accordance with MN A 00100 shall be implemented until the examination from within one metre can be carried out. Refer to Section 22.

For non-structurally critical members, it is not permissible to miss examination from within one metre on two consecutive cycles. Risk mitigation actions determined in accordance with MN A 00100 shall be implemented until the examination from within one metre can be carried out.

All risk mitigation assessments and actions shall be documented as part of the RECOM process and in the ‘comments’ field of the examination report.

8.5.1.3 Examination from more than one metre

Close-up examination from more than one metre applies to:

- all members of structures that do not comply with the definition of readily accessible
- Bridges - concrete substructures and masonry substructures
- OHWS - all structures and members of structures not specified for examination from within one metre.

Refer to the Table 1 for additional details for examination from more than one metre of these structures and members.

8.5.1.4 Incomplete Bridges & Structures Inspections

Refer to EI C 18-05.

Superseded by MN C 10301 v3.0, 18/10/2021

8.5.1.5 Defects

The underlying requirement is that the examiner must be able to determine at every cycle whether there is a defect present or not in the member being examined.

If a defect is detected by inspection from more than one metre (including by using binoculars or camera/drone), then a determination shall be made, at that time, as to whether a close-up examination from within one metre is required in the short term to confirm the defect extent and severity. The determination, including the timing of close-up examination, would be based on a judgement by the Territory Civil Engineer of the potential severity and consequences of the defect(s). If so, close-up examination is to be programmed and carried out as soon as practicable. It is not acceptable to wait until the next examination cycle. Determination details are to be recorded in the 'comments' field of the examination report.

Once a defect has been identified and measured, further measurements are to be made and recorded on every cycle until the defect is repaired.

Superseded by MN C 10301 v3.0, 18/10/2021

Service Description	Safety Importance	Applicability	Frequency	Comments
Structures				
Detailed structures examination from within one metre	S	Readily accessible members of all structures	Every cycle	Readily accessible means members of structures that can be readily reached/ viewed within one metre without the need for special access equipment from: • The bridge deck • The ground • A boat • Access gantries already attached to the bridge • An access walkway attached to a structure, e.g. signal gantries. Note that track possession may be required to provide accessibility
	S	Structurally critical members of bridges	Every cycle	Refer to Section 22 for a list of structurally critical members
	S	The following members of underbridges, overbridges and footbridges (except structurally critical members): • Trusses • Steel superstructures • Concrete superstructures • Bearings • Steel substructures • Fastenings and welds of steel truss, superstructure and substructure members.	Every cycle for readily accessible members	Refer to definition of readily accessible above
			Every second cycle for non-readily accessible members	Where the members are not readily accessible to within one metre, mobile access equipment (e.g. elevated work platforms, inspection units), scaffolding or abseiling equipment shall be used on every 2nd cycle. On the alternate cycle, close-up inspection is from as close as reasonably practicable and using, where necessary, binoculars and cameras Where possession time is limited – use of GoPro or Drone is to be considered and data attached as part of REVCOM for any “incomplete inspection “ TMP service schedule non-compliance

Superseded by MN C 10301 v3.0, 18/10/2021

Service Description	Safety Importance	Applicability	Frequency	Comments
	S	The following members of OHWS: • Support areas at footings and where attached to cuttings, tunnels and bridges. • All members of old structures i.e. non-galvanised structures or structures pre mid-1980's, including fastenings and welds of steel members, (except single mast structures).	Every cycle for readily accessible members	Refer to definition of readily accessible above
			Every second cycle for non-readily accessible members	Where the members are not readily accessible to within one metre, mobile access equipment (e.g. elevated work platforms, inspection units), scaffolding or abseiling equipment shall be used on every 2nd cycle. On the alternate cycle, close-up inspection is from as close as reasonably practicable and using, where necessary, binoculars and cameras (GoPro or Drone).
	S	Culverts	Every cycle	Where culverts are not readily accessible for examination within one metre, mobile CCTV cameras shall be used

Superseded by MN C 10301 v3.0, 18/10/2021

Service Description	Safety Importance	Applicability	Frequency	Comments
Detailed Structures Examination **from more than one metre**	S	All members of structures that do not comply with the definition of readily accessible and are not specified for examination from within one metre in previous sections	Every cycle	Readily accessible means members of structures that can be readily reached/ viewed within one metre without the need for special access equipment from: • the bridge deck • the ground • a boat • access gantries already attached to the bridge • an access walkway attached to a structure, e.g. signal gantries. For the applicable members close-up inspection is from as close as reasonably practicable and using, where necessary, binoculars and cameras (GoPro or Drone)
	S	Bridges: • Concrete substructures • Masonry substructures.	Every cycle	For these members close-up inspection is from as close as reasonably practicable and using, where necessary, binoculars and cameras(GoPro or Drone)
	S	OHWS: • All structures and members of structures not specified for examination from within one metre.	Every cycle	For these members close-up inspection is from as close as reasonably practicable and using, where necessary, binoculars and cameras (GoPro or Drone)

Superseded by MN C 10301 v3.0, 18/10/2021

Service Description	Safety Importance	Applicability	Frequency	Comments
	S	Minimum 1 in 20 sample of OHWS: • Horizontal members • Connection points between horizontal and vertical members • Splices and angle bracing including connections.	Every cycle	This inspection does not need to be from within one metre, but access equipment or inspection technology such as CCTV shall be used to ensure inspection from the top of the structure. When selecting the sample, priority should be given to older type structures and other structures based on condition. The same structures are not to be inspected on the following cycle(s). Different structures are to be included in the sample on subsequent cycles. The sample should be distributed across the District. Where a sample structure has significant defects i.e. category C or higher, the structures on either side shall also be inspected using access equipment. This sampling process is to continue until no significant defects are detected.

Table 1: Examination details for examinations within one metre

Superseded by MN C 10301 v3.0, 18/10/2021

8.5.2 Mid-cycle examinations

Mid-cycle examinations are visual examinations, normally conducted by the Structures Co-ordinator at least once between detailed examination cycles. Mid-cycle examinations are carried out for bridges, overhead wiring structures and signal gantries.

In addition to visual examination, scaffolding or other access equipment may be necessary in order to be able to measure existing defects in structurally critical members during mid-cycle examinations.

The mid-cycle examination also serves as an audit to check that regular and programmed maintenance is being satisfactorily carried out.

8.5.3 Cursory examinations

Cursory examinations are conducted during track patrols. The Track Patroller makes visual inspections of the general condition of structures including such matters as the track geometry over underbridges and any build-up of silt, rubbish, and plant growth around the structures.

8.5.4 Special examinations

Special examinations are conducted by persons with structures examination competency using self-initiative where necessary, or as directed by the Structures Co-ordinator or the Territory Civil Engineer or the person responsible for the area. These examinations shall include known or anticipated hazards, especially during periods of heavy rain, or following damage to structures by road or rail vehicles, fire or earthquakes. Special examinations may also be required to certify the structural or functional integrity of new structures.

8.5.5 Underwater examinations

Underwater examinations are conducted by persons with diving qualifications and competency in the inspection of underwater structures and supports. Underwater examinations would normally apply to piling and caissons supporting underbridges. Requirements are documented in *MN C 10303 Underwater Examination of Structures*.

8.5.6 Other

Visual examinations of structures may also be undertaken by the Territory Civil Engineer on a sampling basis or in response to a particular report or condition, and by Asset ESI Assurance Inspectors or Auditors on a sampling basis for assurance purposes.

Superseded by MN C 10301 v3.0, 18/10/2021

8.6 Inspection equipment

8.6.1 Detailed examinations

For detailed examinations, the following additional equipment may be required in order to measure exceedents and to determine their extent and severity:

8.6.1.1 Technical equipment

- Vernier calipers
- Wire brush
- Ultrasonic thickness meter (for steel sections) – training required
- Cover meter (concrete cover over reinforcing) – training required
- Dry film thickness gauge
- Brace and bit or electric drill
- Shovel and broom
- Spirit level with straight edge
- Carbonation test kit
- Dye penetrant or Magnetic Particle testing equipment
- Demec gauge, points and adhesive (for measuring long term movement across cracks)
- Spanners, screwdrivers and other miscellaneous tools
- Plumb bob
- Camera
- GoPro Camera (for difficult access and within 1 metre)
- Drone – generally for truss type bridges. Mapping of defects and identification of “targeted inspection”.

8.6.1.2 Access equipment

- Extension ladder (must be all timber/ fibreglass)
- Scaffolding, elevated work platforms
- Boat or barge.

8.6.1.3 Specialised equipment

Specialised equipment may be required for the testing of material properties, strain gauging and deflection testing, etc. This equipment is normally provided and operated by specialist operators.

Superseded by MN C 10301 v3.0, 18/10/2021

8.6.2 Visual inspections

The following equipment is typically required for a visual inspection of structures:

Technical equipment

- High powered torch
- Hand mirror for viewing behind bearings etc.
- Geologists hammer
- 30 metre tape (must be fibreglass)
- Binoculars
- Crayon for marking concrete or masonry
- Camera/Drone
- Examination report forms
- Writing/sketch paper
- Copy of previous examination report/drawing
- Probe (for timber structures).

8.7 Engineering assessments

Every steel underbridge or concrete underbridge listed in Section 25 shall undergo an engineering assessment review at regular intervals (generally 30 year cycle) by a suitably qualified professional engineer. The purpose of this review is to evaluate the safety, stability and functionality of the bridge, the conformity of its design and construction with good practice and safety standards and to determine appropriate remedial measures. The review shall be conducted no later than 30 years after the commissioning of the new bridge and updated at least every 30 years.

Note: This engineering assessment is separate to the underwater inspection report.

8.7.1 Steps involved in engineering assessment

a. Collect background information on the bridge. (This shall include all relevant historical investigation, design, construction, remedial, operation and maintenance, monitoring and inspection data).

b. Carry out a detailed examination of the bridge to assess all relevant condition parameters including detailed measurements of section loss to permit accurate assessment of ‘as is’ load rating.

c. Carry out sufficient sampling and testing of materials for all major elements of the bridge to determine remaining life and associated relevant maintenance activities (for example, testing of depth of chloride penetration for estimating time to onset of corrosion).

d. Compare the performance of the bridge with original design and assess the theoretical performance of the bridge against current standard and guidelines.

e. In case of incomplete documentation, further investigation may be required for the first engineering assessment. Typical investigation activities include:

   - Survey to establish lines and dimensions
   - Testing of foundation material if required
   - Geological drilling and mapping if required

Superseded by MN C 10301 v3.0, 18/10/2021

- Research or calculate recent flood estimates
- Updating of earthquake forces.

f. Particular attention shall be given to changes in operation of a bridge that may have occurred since construction. Check as to whether it can withstand appropriate loadings (including seismic) in accordance with current engineering practice.

g. Recommendations shall be made for the following:

- Live load 'as new' and 'as is' load rating.
- Remaining fatigue life.
- Necessary repairs including preliminary sketches and cost estimates.
- Time frames for implementation of repairs.
- Any restrictions on operations required (for example load restriction).
- Any changes to the examination program.
- The adequacy of the bridge examination, operation and maintenance activities to date and any identified areas for improvement.

h. Engineering assessment is generally based on the age of the bridge and a maximum 30 year cycle but may also be initiated in response to issues such as:

- An absence of design and construction documentation.
- A regulatory requirement.
- Detection of abnormal behaviour.
- Proposal to modify a bridge.
- Changes in loading condition.

8.8 Planning of examination programmes

Careful planning is required for the smooth running of an examination programme, to ensure that all structures are examined at the required frequency and that individual structures are examined to the appropriate level of detail and in a cost-effective manner.

The first step in planning an examination programme is to list all of the structures to be inspected and the time period in which the programme is to be completed. From there, personnel and equipment requirements can be determined.

When developing a programme, careful consideration shall be paid to other factors that may affect the execution of the work. These include:

- Access difficulties, e.g. at waterways or through private property where locked gates may need opening.
- Track possessions and power offs.
- Specialised equipment or personnel such as divers that may need to be called upon.
- Seasonal or tidal restrictions.
- Possibility of co-ordinating with scheduled maintenance activities and sharing of site protection, access equipment and scaffolding, etc.

Superseded by MN C 10301 v3.0, 18/10/2021

Prior to the inspection, information on the type of structure, its maintenance history and previous examination reports shall be assembled. Most of this information including photographs should be on the structure file or in the EAM/SAP. Structures records should be methodically registered and kept in kilometrage order, to facilitate retrieval and access for audit purposes. The file should be checked for any other information that may be relevant to the examination. It may be necessary to search further for bridge plans, maintenance histories, consultant's reports, etc.

This information should be reviewed prior to the inspection, so that the examiner is aware of critical areas, previous problems or unusual features.

A copy of the previous inspection report and any other relevant information shall be taken to site for the examination.

In order to perform an accurate and efficient inspection, the correct equipment and personnel should be readily at hand. An indicative list of the likely equipment required is included in Section 8.6 and this should be carefully considered prior to each inspection. It may also be necessary to arrange equipment such as scaffolding, "cherry pickers", boats or specialised testing equipment. The appropriate level of personnel resources should be arranged and consideration given to specialised personnel who may be required (e.g. divers for inspecting piles in rivers, mechanical, electrical or hydraulic specialists, testing experts or access equipment operators).

8.9 Liaison between examination personnel

The previous RailCorp Structures Officer is provided to assist the Civil Maintenance Engineer in the examination of steel bridges. This role has now been included as part of the experienced Bridge Examiner (BE) responsibilities. The Territory Civil Engineer sets the programme for the Bridge Examiner. Wherever possible, steel bridge examinations by the BE should be programmed on a face within a Territory. The programme shall include the arrangements for road closures and provision of access equipment.

The Territory Civil Engineer shall ensure that the Structures Co-ordinator and local Bridge Examiner are notified of the nominated Bridge Examiner's proposed attendance and inspection programme.

The Bridge Examiner and Structures Co-ordinator shall confer on the outcome of the latter's bridge examinations. It is highly desirable that the Regional Bridge Examiner visits each site while the Structures Co-ordinator is in attendance.

8.10 Frequency of examinations

The frequency of examinations is specified in *ST C 10100 Civil Technical Maintenance Plan*.

Detailed examinations by the Bridge Examiner and Structures Co-ordinator shall be undertaken in accordance with the cycles prescribed in the relevant Technical Maintenance Plans.

Mid-cycle examinations are normally conducted mid-cycle between the detailed examinations. Their frequency is also prescribed in the Technical Maintenance Plans.

Special examinations shall be performed as prescribed in the Technical Maintenance Plans. Where a structure is reported as being struck by a vehicle or damaged by fire etc., it is to be examined immediately.

Underwater examinations shall be undertaken in accordance with the cycles prescribed in the relevant Technical Maintenance Plans.

Superseded by MN C 10301 v3.0, 18/10/2021

8.11 Service schedules

Service Schedules detail the scope of work to be undertaken by examination staff at each type of examination and for structures assessment. They are detailed in Engineering Manual *MN C 10110 Civil and Structures Service Schedules*.

8.12 Structure types

Structures constructed of different materials require different examination techniques. This Manual provides examination procedures for structures variously constructed in steel, concrete, masonry and timber.

The principal causes of deterioration in each of the above material types are summarised in Section 9. It is essential that the person examining a structure is familiar with these causes, in order to accurately identify the types and consequences of deterioration in components of structures.

8.13 Structures Assessment

An assessment of the detailed examination results in order to assure the continuing integrity of each structure is a fundamental requirement of the examination process.

The structures assessment shall be carried out by the Structures Co-ordinator.

The Territory Civil Engineer shall conduct random sampling structures assessment of the detailed examination results.

Superseded by MN C 10301 v3.0, 18/10/2021

9 Deterioration Modes

9.1 Deterioration modes in steel structures

9.1.1 General

The main indicators of deterioration of steel or iron structures are section loss, cracking, loss of protective coating, deformation of members and loose or missing fasteners in connections (e.g. Nuts and bolts).

Other factors that shall be taken into consideration include the age of the structure, vulnerability to impact, location of the defect and importance of affected member(s).

The main modes of deterioration in steel, cast iron and wrought iron members include:

- breakdown of the corrosion protection system
- corrosion of exposed surfaces or at interfaces with concrete or steel
- loose or missing fasteners
- impact damage
- buckling of members
- fatigue cracking
- cracking of welds
- delamination (wrought iron).

Of the above modes, corrosion is the most prevalent factor affecting steel structures. In assessing the significance of the corrosion it is necessary to determine its extent, severity and location. This significance may vary from superficial surface corrosion only through to an exceedent condition resulting in a loss of load carrying capacity and even possible failure.

Cracking of welds or members, buckling and impact damage are other defects that can lead to sudden collapse or a reduction of load carrying capacity. Cracks in tension flanges must always be regarded as serious and requiring urgent action.

9.1.2 Corrosion

The majority of steel and iron deterioration results from the breakdown or loss of the protective system. Without adequate protection, steel and iron are vulnerable to corrosion resulting in loss of section.

Corrosion may be prevented by any of the following systems:

- Durable protective barriers such as painting, encasing in concrete or galvanising to prevent oxygen and moisture reaching the steel.
- Inhibitive primers which hold off attack on the steel substrate.
- Provision of sacrificial anodes such as zinc rich paints or galvanising.
- Provision of cathodic protection by use of an external current to suppress the anodic reaction. This process is also used for concrete bridges for arresting corrosion in reinforcement.

Superseded by MN C 10301 v3.0, 18/10/2021

The protective system usually adopted for bridges is painting or galvanising, however the loss or partial loss of either of these systems will see the onset of deterioration. The accumulation of debris around bearings, on flanges or the base of the substructure will further hasten the corrosion process by providing a moist environment. It is therefore important for these areas in particular to be regularly examined and cleaned.

9.1.2.1 Rust damage and section loss

Provide high resolution photos and if possible measurements of section thickness. If unsure on section loss estimates consult Territory Civil Engineer.

9.1.3 Impact damage

The next most common cause of deterioration of steel and iron members results as a consequence of impact loading. Steel trestles are particularly vulnerable to major deformation or even failure from train or vehicle impacts. The bottom flange of girders, bracings and cross girders are also exposed to risk of impact from high vehicles or protruding loads. Damage can include scraping, shearing of bolts or rivets, buckling of members, loss of protective barrier and notching (which can lead to crack propagation).

9.1.4 Fatigue cracking

Repetitive loading cycles and or overstressing of steel and iron members can eventually lead to fatigue cracking. A continuation of the loading cycle can result in the propagation of cracks and finally failure. Fatigue cracking is usually initiated at high stress concentration points such as bolt and rivet holes, welds, re-entrant corners, change of sections or areas of restraint.

As part of the engineering assessment the report will include bridge members with fatigue life expire. The details will be marked up in the drawings and included as part of the inspection data, so that the fatigue life expire members/connections will be targeted for “special” inspection or monitoring.

9.1.5 Loose or missing fasteners in connections

Loose or missing connections are another common cause of deterioration of steel or iron members. These may result from vehicle impacts, severe corrosion, incorrect initial installation, vibration and tensile sheer failure of the fastener.

9.1.6 Welds

9.1.6.1 Cracking

Any crack in a weld, regardless of length and location, shall be reported.

9.1.6.2 Appearance and finish

Exposed faces of welds shall be reasonably smooth and regular.

The surface of fillet welds shall junction as smoothly as practicable with the parent metal.

Butt welds shall be finished smooth and flush with abutting surfaces.

The ends of welds shall be finished smooth and flush with the faces of the abutting parts.

All weld splatter shall be removed from the surface of the weld and the parent material.

Superseded by MN C 10301 v3.0, 18/10/2021

9.2 Deterioration modes in concrete structures

9.2.1 General

The main indicators of deterioration of concrete and masonry structures are corrosion of the steel reinforcement, spalling, cracking, fretting and loss of mortar at joints.

Other factors that shall be taken into consideration include the age of the structure, vulnerability to chemical attack, vulnerability to impact and foundation movements.

Concrete members deteriorate in service in the following ways:

- Weathering or spalling at exposed faces, resulting from erosion, poor quality concrete, chemical action, water action, corrosion of reinforcement, insufficient cover to rebars, crushing at bearing surfaces and drumminess.
- Cracking from loading changes, including settlement.
- Mechanical damage, especially from road or rail vehicles.

Common defects that occur in concrete structures that require checking during examination are as follows:

- Corrosion of reinforcement, with subsequent cracking and spalling – water seepage will provide an indication for area to look for “loose” concrete
- Scaling - cement render breaking away
- Delamination
- Leaching and water penetration
- Rust stains
- Honeycombing or other construction deficiencies
- Fire damage
- Dampness
- Leaking joints
- Breaking up of existing repairs
- Shattering and crushing of bearing pads.

9.2.2 Corrosion

The major failure mode in concrete structures is corrosion of the reinforcement. The product of this corrosion has a volume many times larger than the parent metal. This results in a build-up of internal pressure that leads to de-bonding, cracking and eventual spalling. When a crack develops the rate of deterioration accelerates and this can lead to defects such as leaching, water penetration and rust staining.

Corrosion can be caused by many means ranging from construction deficiencies to mechanical weathering or chemical action. All of these threaten the protective barrier the concrete provides for the reinforcement. Once this process has been initiated and the reinforcement protection is lost, the rate of deterioration is accelerated dramatically. The physical properties of the concrete, environmental conditions, concrete cover and other design or construction practices will all influence the rate of deterioration.

Superseded by MN C 10301 v3.0, 18/10/2021

9.2.3 Other factors

Other factors that cause concrete structures to deteriorate include:

- Impact loading
- Overload
- Foundation movements
- Seizure of bearings
- Differential thermal strains
- Freeze/thaw cycles
- General wear and abrasion
- Leaching
- Chemical attack (carbonation, chloride contamination, sulphate attack and alkali aggregate reactivity).

9.2.4 Cracks in concrete

Refer also to EA C 18-03.

Cracking can be an important indicator of deterioration taking place in concrete and possible corrosion of reinforcement steel depending on the size, extent and location of the cracks. Because the significance of each type of crack is different, it is important to distinguish between them. Seven types of cracks can generally occur.

Note: It is also important that cracks are identified and mapped for any new structure as part of the “as built” handover documentation.

9.2.4.1 Longitudinal cracks (formed in hardened concrete)

These cracks run directly under or over and parallel to reinforcing bars and are caused by build-up of rust on the reinforcement. Eventually they will lead to spalling and complete loss of concrete cover. Longitudinal cracks cannot be treated without removal of the deteriorated concrete and renewing the cover.

9.2.4.2 Transverse cracks (formed in hardened concrete)

Cracks transverse to the reinforcement are caused by concrete shrinkage, thermal contraction or structural loading. The width and distribution of these cracks is controlled by the amount and disposition of the reinforcement.

Where there is no secondary reinforcement (as in beams), these cracks will only be transverse to the main reinforcement and are harmless unless they are very wide or the environment is exceptionally aggressive.

Where reinforcement runs in two directions at right angles (as in slabs), cracks that are transverse to secondary bars will tend to coincide with the main bars because reinforcement of the larger size tends to act as a crack inducer. Unless these cracks are treated soon after they appear they could cause rusting of reinforcement and further deterioration.

Superseded by MN C 10301 v3.0, 18/10/2021

9.2.4.3 Shear cracks (formed in hardened concrete)

Shear cracks are caused by structural loading or movement of supports (e.g. due to foundation settlement) or lateral displacement of frames and columns. Occurrence of shear cracks will result in reduced strength of a member. They may also cause rusting if left untreated.

9.2.4.4 Plastic shrinkage cracks (formed in unhardened concrete)

In the construction of concrete surfaces such as floor slabs or decks, loss of moisture from the surface due to rapid evaporation causes cracks on the surface. These cracks are harmless unless the concrete slab will later be exposed to salt or other contamination that would result in deterioration.

9.2.4.5 Plastic settlement cracks (formed in unhardened concrete)

These cracks develop during construction when high slump concrete is used, resulting in settlement of the solids and bleeding of water to the top especially in deep sections. Settlement cracks form at the top where the reinforcement has supported the aggregate and stopped it from settling, while water collects under the reinforcement displacing the cement grout and leaves the steel unprotected. The cracks form longitudinally over the reinforcement and are a common cause of serious corrosion.

9.2.4.6 Map cracks

Map cracking is caused by alkali-aggregate reaction over an extended period of time. The cracks are internal in origin and result in breaking up of the concrete and loss of strength.

9.2.4.7 Surface crazing

Craze cracks are fine, random cracks or fissures that develop on concrete surfaces. They result from shrinkage of the concrete surface during or after hardening and are caused by insufficient curing, excessive finishing or casting against formwork. Their significance is mainly aesthetic.

9.2.4.8 Measuring cracks

When carrying out a revised compliance inspection or a detailed inspection, use a gauge to record the crack width at the thickness point. Also use either a photo or measurements to indicate the length/extent of the crack. The extent of the crack is to be marked at each end point.

9.2.5 Spalling

Spalling is defined as a depression resulting from detachment of a fragment of concrete from the larger mass by impact, action of weather, overstress or expansion within the larger mass. The major cause of spalling is expansion resulting from corrosion of reinforcement. Spalling caused by impact can weaken the structure locally and expose the reinforcement to corrosion.

Superseded by MN C 10301 v3.0, 18/10/2021

9.2.6 Scaling

Scaling of concrete surfaces is defined as local flaking or peeling away of portions of concrete or mortar near the surface. As the deterioration continues, coarse aggregate particles are exposed and eventually become loose and are dislodged.

Scaling occurs where the surface finish of concrete is dense and homogenous. Poor finishing practices result in a weak layer of grout at the top of concrete surface that easily peels away by weathering or abrasion.

Light scaling refers to the loss of surface mortar only without exposing coarse aggregate. Medium and severe scaling involves loss of mortar with increasing exposure of aggregate. Very severe scaling refers to loss of coarse aggregate together with the mortar.

9.2.7 Delamination

Delamination refers to separation of layers of concrete from bridge decks, beams or walls at or near the level of the top or outermost layer of reinforcing steel and generally parallel to the surface of the concrete member. Delamination is not possible to identify visually as the concrete surface appears intact on the outside. It can, however, be detected by tapping the surface with a heavy rod or hammer when a hollow or drumming sound is given off indicating the separation of concrete from the reinforcement.

With practice, this sound can be identified accurately enough to mark the affected area on the surface of the concrete.

The major cause of delamination is the expansion resulting from the corrosion of reinforcing steel. As soon as delamination is detected steps should be taken to ascertain the cause of corrosion, including laboratory testing of concrete samples and appropriate repair action initiated. If a successful repair is not made, concrete above the delamination interface will eventually become dislodged and a spall will result.

9.2.8 Leaching

Leaching or efflorescence is the white deposit of salts or lime powder formed commonly on the underside of deck slabs or vertical faces of abutments, piers and wing walls. It is caused by surface or subsoil water leaching through the cracks and pores in the concrete. The water dissolves the lime and other salts in concrete (or, may already be contaminated with salts from the subsoil). The dissolved substances are deposited as white powder on concrete surface after the evaporation of water.

9.2.9 Rust stains

Brown or rust coloured stains on concrete surfaces indicate corrosion of steel reinforcement.

9.2.10 Honeycombing

Honeycombing is lack of mortar in the spaces between coarse aggregate particles. It is caused by insufficient compaction or vibration during placement of concrete and results in porous and weak concrete. The voids also provide channels for ingress of water, oxygen and corrosive agents such as carbon dioxide, chlorides and sulphates that will eventually cause corrosion of steel reinforcement.

Superseded by MN C 10301 v3.0, 18/10/2021

9.2.11 Dampness

Moderately wet or moist areas of concrete indicate penetration of moisture and will eventually lead to corrosion of reinforcement and deterioration of concrete. The source of moisture is often from ponding or improper drainage over or in the vicinity of the structure. This should be investigated and remedial measures taken as appropriate.

9.2.12 Leaking joints

Deterioration or loss of sealants and jointing materials from the joints and/or deterioration or lack of waterproofing membranes results in penetration of water through joints. Apart from being a nuisance, it causes ugly stains and growth of algae around the joints. The penetrating water along with dissolved contaminants will also find a way into porous or weak concrete leading to deterioration of the structure.

9.2.13 Breaking up of repairs

Past repairs are indicative of problems in the structure. The repairs should be monitored during inspections. The condition of the repair or patch will usually indicate whether the underlying problem has been solved or is still continuing. Cracking, delamination, spalling or rust stains in or around the repair indicate that the problem still exists and further investigation and repair are needed.

9.3 Deterioration modes in masonry structures

9.3.1 General

Masonry or stone is rarely used as a construction material for modern structures, except for facing or ornamentation. However, many structures on the network were built from masonry construction and are still in service, owing to the general longevity of the material. Most deterioration can be attributed to weathering, migration of water, impact damage and foundation movements.

Common defects that occur in masonry structures and therefore require checking during examination are as follows:

- loose, drummy or missing blocks
- fretting of blocks and mortar joints
- splitting or cracking of blocks and or mortar
- cracking due to subsidence or relative movements
- mortar loss
- scrapes and spalls from impact
- water penetration and leaching.

Superseded by MN C 10301 v3.0, 18/10/2021

9.3.2 Causes of deterioration

Many different factors lead to the deterioration and development of defects in masonry structures. Most of these are very slow acting and require repeated occurrence.

Seasonal expansion and contraction causes repeated volume changes that lead to the development of seams and fine cracks. These may grow over time to a size that allows other factors to contribute to further deterioration. Frost and freezing in these cracks, seams or even in pores can split or spall blocks. Plant stems and roots growing in cracks or crevices can exert a wedging force and further split open blocks or mortar.

Plants such as lichen and ivy will chemically attack masonry surfaces in the process of attaching themselves.

Abrasion also leads to deterioration of masonry and this may be due to water or wind borne particles.

Fretting of bricks, blocks and mortar can be caused by the loss of the connecting or binding agents via leaching through the structure. The water can either be drawn up from the footings and backfill by capillary action or leak down through the fill.

Gases or solids dissolved in water can chemically attack the masonry. Some of these may dissolve the cementing material between the blocks and lead to mortar loss.

9.3.3 Cracking

Cracking is the most common form of defect in masonry. It may occur due to several reasons, such as differential settlement of foundations or relative movement in members of the structure, thermal movements, growth of brickwork, corrosion of embedded iron or steel, impact damage and growth of vegetation in or around brickwork.

Differential settlement of parts of the structure or subsidence of foundations can lead to extensive and sometimes severe cracking. It is important to distinguish those cracks that relate to the stability and load carrying capacity of the structure from those that do not.

Cracking is especially significant if it is recent in origin and should be immediately investigated. In particular, it must be ascertained if the cracks are live, i.e. continuing to move and if they pose any threat to the strength and stability of the structure.

If the cracks are known to have existed for a long time and have not caused instability or distortion, they need not be a cause of concern, though steps should be taken to repair them.

Cracks that have formed due to overload will tend to close and be very fine after the overload is removed, and may not need any treatment.

9.3.3.1 Cracks in masonry arches

Masonry arch bridges are particularly sensitive to movements.

The major factors affecting the stability of a masonry arch bridge are summarised below:

- **Differential settlement across an abutment or pier**. This may cause longitudinal cracks along an arch ring, indicating that the arch has broken up into separate rings.
- **Movement or settlement of the foundations of an abutment or pier**. This may cause lateral cracks across an arch ring and settlement in the deck, indicating that the arch has broken up into separate segments.

Superseded by MN C 10301 v3.0, 18/10/2021

- **Settlement at the sides of an abutment or pier**. This may cause diagonal cracks starting near the side of the arch at the springing and extending to the centre of the arch at the crown.
- **Flexibility of the arch ring**. This may cause cracks in the spandrel walls near the quarter points.
- **Outward movement of the spandrel walls due to the lateral pressure of the fill**, particularly if the live loads can travel close to the parapet. This may cause longitudinal cracking near the edge of the arch.
- **Movement of the wingwalls**. This may cause cracking and if adjacent to the deck, loss of the surface material.

9.3.3.2 Measuring cracks

When carrying out a revised compliance inspection or a detailed inspection, use a gauge to record the crack width at the thickness point. Also use either a photo or measurements to indicate the length/extent of the crack.

9.3.4 Fretting

Fretting is surface damage caused by leaching of dissolved salts through the masonry, and cycles of wetting or drying. It disintegrates the lime mortar in the joints and can cause spalling of the masonry units.

9.3.5 Spalling

Spalling of masonry is generally caused by accidental impact. It may be accompanied by dislodgement of masonry units as well as cracking and depending upon the extent of damage, may cause loss of strength and stability in the structure.

Spalling due to other causes such as fretting, sulphate attack and unsound materials can generally be recognised by inspection and repaired accordingly.

9.4 Deterioration modes in timber structures

9.4.1 General

The main indicator of deterioration of timber members is the section loss caused by one or more outside agents including biological attack (fungi, termites and borers), weathering, fire and impact damage.

Timber generally does not deteriorate significantly in service without being attacked by some outside agent. This can take the form of a biological attack or non-biological deterioration.

In general, timber deteriorates in one of five ways:

- Fungi and insect attack (termites or borers)
- Weathering at exposed surfaces
- Decay or rot
- Fire
- Mechanical damage from impact.

Superseded by MN C 10301 v3.0, 18/10/2021

Of the above categories, decay and insect attack usually cause deterioration inside a member and are therefore the most difficult to accurately measure.

The most common defects that occur in timber structures and therefore require checking during examination are as follows:

- Decay
- Troughing or bulging (indicates internal decay)
- Insect infestation
- Weathering - abrasion, cracks, shakes, checks and splits
- Loss of section due to fire
- Vehicle impact damage
- Crushing
- Loose or missing bolts/connections
- Corroded connections.

The main indicator of deterioration of timber members is the section loss caused by one or more of the outside agents.

9.4.2 Biological attack

Timber structures and their individual components are vulnerable to biological attack from fungi, termites and marine borers.

Fungal attack is the main cause of deterioration in timber bridges, however certain conditions are necessary for the development of fungi. These include:

- a temperature range suitable to their life cycle
- a moisture content suitable for their development
- an adequate oxygen supply
- a food supply on which they can grow (i.e. timber).

Fungi attacks both sapwood and heartwood (under favourable conditions) causing breakdown of the wood substance and this is known as decay.

There are several types of insects in Australia that attack timber. However the termite is the only one that attacks seasoned heartwood. Termites work along the grain eating out large runways. In the early stages much sound wood is left between the runways, however in the long term only the thin outer layer of wood may remain.

Marine borers are of several types and the danger from these is dependent upon geography and water salinity. Although borers attack different sections of piles (depending on the type of borer), the simple rule is to protect from below mud line to above high water level. Borers may make only a few small holes on the surface and yet the pile interior may be practically eaten away.

Superseded by MN C 10301 v3.0, 18/10/2021

9.4.3 Non-biological deterioration

Timber is also vulnerable to non-biological deterioration from weathering, abrasion, fire, impact and overload.

Weathering is the most common form of non-biological deterioration. Exposure to the elements can lead to continual dimensional changes in the wood from repeated wetting/drying, or it may result in drying and shrinkage. These processes can lead to cracks, shakes, checks, splits (particularly at member ends or at bolted connections) or warping and loose connections.

Impact and overloading may result in damage to members such as shattered or injured timber, sagging or buckled members, crushing or longitudinal cracking. The action of vehicles passing over decking can cause abrasion and subsequent loss of section.

9.5 Deterioration modes in crib wall structures

9.5.1 General

The main indicators of deterioration in crib wall retaining structures are loss of infill; local deformation; cracking of crib members; and corrosion of steel reinforcement.

Other factors to be taken into consideration may include the age of the structure; frequency and magnitude of rainstorms; effectiveness of sub-soil drainage and capping; differential settlement in wall members; and vegetation management.

In general, crib wall structures deteriorate in the following ways:

- crushing of crib members
- development of voids between headers
- corrosion of steel reinforcement
- ineffective drainage system
- differential settlement between rows of stretchers
- settlement of embankment
- bulging of wall, or sliding of crib members
- vegetation growth
- concrete spalling.

9.5.2 Crushing of crib members

Crushing or cracking of crib members (headers, false headers and stretchers) is caused by high vertical loads and can be identified by visual inspection. The most obvious location to check this mode of deterioration is near the bottom of the crib wall. Crushed crib members usually exhibit a vertical straight crack. Usually the initial crushing of a crib member would lead to crushing of adjacent members following load redistribution.

9.5.3 Loss of infill and backfill material

Infill and backfill loss occurs due to insufficient compaction, leading to erosion. The loss of infill material reduces the soil support under the crib members, which means they are more prone to bend and crack. Moreover, the loss of infill also decreases the weight of the wall which reduces the overall stability.

Superseded by MN C 10301 v3.0, 18/10/2021

9.5.4 Corrosion of steel reinforcement

As for concrete structures, corrosion can be caused by many factors, including weathering or chemical action. Signs of corrosion should be evident during inspection, such as rust staining. Corrosion of reinforcement will reduce concrete capacity and accelerate the rate of deterioration after initial concrete cracking.

9.5.5 Ineffective drainage system

This mode of deterioration is characterised by blockage in the back of the wall drainage system. The crib wall is usually designed and constructed using free draining gravels as infill and backfill material to relieve hydrostatic pressure build up. However, if the drainage system is not functioning as intended, the wall will experience additional unforeseen forces during every rainstorm when high hydrostatic pressure may build up. The permeability of compacted sand is likely to be reduced with time due to deposition of fine particles within the pores. Draining materials have to be clearly defined with grading. This mode of deterioration may lead to sudden failure of the crib wall.

9.5.6 Differential settlement and movement

Differential settlement, as reflected by vertical cracks through the wall, can be caused by many factors including an uneven foundation settlement or misalignment of headers during construction.

The horizontal movement of the wall, as characterised by localised bulging, can be caused by vegetation growth or increased lateral load. Measurements may be needed to ascertain the magnitude of the movement.

9.5.7 Vegetation growth

Vegetation growth is a natural occurrence and appears in many crib walls. Large trees tend to undermine the structural integrity of the wall by cracking crib members (through protrusion) or locally bulging the wall, particularly at the top.

9.5.8 Settlement of embankment

The settlement of the embankment resulting from the outward movement of the crib wall is usually characterised by cracks forming at the top of the embankment parallel to the wall. This observation is a good tell-tale that the wall is moving and requires further assessment by an engineer.

Superseded by MN C 10301 v3.0, 18/10/2021

10 Examination Methods

10.1 Examination methods for steel structures

The principal methods for examining steel and wrought iron structures are:

- visual examination
- hammer test
- magnetic or electronic gauges for testing steel or coating thickness.

Specialist examination methods include:

- x-rays
- ultrasonic testing
- dye penetration
- magnetic particle testing
- acoustic emission
- laboratory analysis of steel samples
- thermal Imaging.

10.1.1 Visual examination

Visual examination as detailed below will detect most defects in steel bridges:

- Members are to be observed under load where possible, and any excessive movement in members or fastenings is to be noted.
- Examine for water build-up, especially in areas where build-up could cause corrosion.
- Examine for notches caused by impact from vehicles or equipment and note for grinding out as soon as possible (note that grinding will result in section loss). Check for cracks around the notch area.

Visual examination will detect most defects in steel structures: Particular note should be taken of the following:

- Any distortion and misalignment of structures or individual members
- Paint condition
- Water, dirt or other debris lying on steel surfaces that could lead to corrosion.

10.1.2 Hammer test

Hammer testing, where members are tapped lightly with an Examiner's hammer, will indicate loose plates and fastenings, extent of corrosion, and effectiveness of corrosion protection. Care must be taken that hammering does not cause unnecessary destruction of the protection systems.

Superseded by MN C 10301 v3.0, 18/10/2021

10.1.3 Magnetic or electronic gauges

Where protective coatings are showing signs of deterioration or where remote faces of steel members preclude surface examination, a dry film thickness gauge or ultrasonic flaw detection device can be used to determine the thickness of the coating or steel section.

Dye penetrant testing or magnetic particle testing will detect suspected cracking that is not clearly visible.

10.2 Examination methods for concrete and masonry structures

The principal methods for examining concrete and masonry structures are:

- visual examination
- hammer test.

Specialist examination methods include:

- x-ray
- ultrasonic testing
- acoustic emission
- core sampling
- carbonation tests
- alkali–aggregate reaction (AAR)
- thermal imaging.

10.2.1 Visual examination

Visual examination will detect most defects in concrete, brick, and stone structures.

The examiner is to look for signs of:

- weathering or spalling of surfaces or mortar joints
- cracking within members or at joints
- stains on surfaces indicating reinforcement corrosion
- crushing, especially at bearings or at prestressing anchorage points
- changed alignment of members whether vertically (e.g. abutments), horizontally (e.g. deck camber), or laterally (e.g. footings and culverts)
- changed alignment of structure whether vertically, horizontally or laterally.

Examine all members for the unplanned ingress of water. Scuppers, weepholes, and other outlets are to be cleared of rubbish. Any water build-up or seepage into undesirable areas is to be reported.

10.2.2 Hammer test

Hammer testing, where surfaces are tapped lightly with a hammer, can indicate drumminess, potential spalling areas, loose brickwork or stonework.

Superseded by MN C 10301 v3.0, 18/10/2021

10.2.3 Specialist examination

Where cracking or bulging of a member cannot be explained by visual examination, specialist testing can be used to examine the internal condition of structures. The Bridge Examiner is to note such concerns for follow up by the Structures Co-ordinator or Territory Civil Engineer.

10.3 Examination methods for timber structures

The principal methods for examining timber bridges are:

- visual examination
- hammer test
- bore and probe
- deflection test.

Specialist examination methods include:

- shigometer
- ultrasonics
- x-rays.

10.3.1 Visual examination

All bridge members are to be inspected for indications of deterioration or damage such as:

- weathering, cracks, shanks, checks, splits
- surface decay where members join or where members project behind abutments
- damp sides of members, especially timber decking
- indicators of internal decay such as troughing, sides bulging, brooming out of fibres, body bolts hanging out or loose in their holes
- termite or fungus attack
- crushing of members, especially headstocks at seatings and joints
- spike killing of transoms
- loose or missing bolts, including transom bolts
- general top and line of the track
- pumping of piles, piers or abutments
- scouring of piles, piers or abutments.

10.3.2 Hammer test

Hammering a timber member gives an indication of internal deterioration. The presence of rot or termite attack may cause a hollow sound when struck by the hammer, indicating boring is required. The hammer should weigh about 1kg, with one face flat and the other face spiked.

Superseded by MN C 10301 v3.0, 18/10/2021

10.3.3 Bore and probe

Test boring is carried out with a 10mm auger in order to locate internal defects such as pipes, rot or termites. Holes are bored square to the face of girders, corbels, headstocks, piles, sills and other members as necessary. Boring must not be overdone and holes are to be preservative treated and plugged, leaving the plug 20mm proud so that they can be easily found by the Structures Co-ordinator at the mid-cycle examination and at the next detailed examination. Unused holes are to be plugged flush.

The extent of an internal pipe or other defect is found and measured with a feeler gauge made from 4mm steel wire with one end flattened and about 4mm bent over at right angles. By probing down the bore hole, the extent of a defect can be felt, measured and recorded.

It is very important to note when boring holes to check the shavings for indications and determination of extent of dry rot.

10.3.4 Deflection test

For spans four metres and longer, a deflection test gives an indication of girder condition and riding quality. Tests are usually ordered by the Structures Co-ordinator but may be initiated by the Bridge Examiner after the detailed examination.

The span under test is to be “screwed up” before loading. Any movement that cannot be curtailed such as pumping piles, is to be estimated and noted. The heaviest permitted locomotives and wagons for the line are to be used and successive runs made between 20km/h and the permitted track speed. All results are to be recorded on the bridge file, including locomotive and wagon details and train speed.

Deflections are to be measured at the mid-point of all girders in the span being tested. Spring-loaded deflectometers with pencil traces are used to record the deflection and rebound.

Defect category limits for deflections and mandatory responses are set in Section 20.

10.3.5 Shigometer

This is an instrument used to indicate both actual and potential decay in timber. A probe is inserted into a bored 3mm hole, then the electrical resistance is measured by a meter. Test methods are to be advised by an experienced specialist or completed by an experienced specialist or consultant.

10.3.6 Ultrasonic

This is a non-destructive test method in which a pulse is transmitted through a member and recorded by a remote receiver. The system is claimed to give better results than the hammer test, especially with an experienced operator. Commercial testers are available but the method is not recommended for general use.

10.3.7 X-rays

This method has been used to identify decayed areas not readily discernible by manual methods. It is specialised work and costly, and of most value for members such as trusses. Experienced specialists should be consulted for advice on possible applications.

Superseded by MN C 10301 v3.0, 18/10/2021

11 Examination of hidden structures

11.1 General

Hidden structures are defined as structures or components of a structure that are obscured in such a way that they are not readily visible. They are generally obscured by non-structural panels such as architectural linings, false ceilings and advertising panels. The examination of hidden structures is important to assure ongoing structural integrity.

Listed below are examples of hidden structures:

- superstructure beams hidden by false ceilings
- columns hidden by architectural coverings
- bridge piers, parapets or abutment walls obscured by advertising panels.

Many hidden structures occur at pedestrian subways. Refer to Table 2 for a list of pedestrian subways.

Superseded by MN C 10301 v3.0, 18/10/2021

Maintenance responsibility area	Central	Illawarra	North	West	Infrastructure Facilities	Delivery Support Unit
Location	• Ashfield (x 3) • Burwood • Central (x 2) • Central Devonshire St • Edgecliff • Eveleigh • Lavender Bay • Leichhardt (x 2) • Lewisham • Macdonaldtown • Milsons Point • Newtown Trafalgar St • Petersham • Stanmore • Summer Hill • Sydenham • Sydney Yard (x 2) • Wynyard Argyle St • Yagoona	• Banksia • Como (x 2) • Cronulla • East Hills • Engadine • Kogarah • Minnamurra (x 2) • Miranda • Narwee • North Wollongong • Port Kembla North • Stanwell Park • Sutherland • Wolli Creek • Wollongong	• Artarmon (x 2) • Beecroft • Broadmeadow • Chatswood • Concord West (x 2) • Eastwood (x 2) • Gordon • Lindfield • Mt Kuring-gai • Point Clare (x 2) • Waitara • West Ryde • Wollstonecraft	• Auburn (x 2) • Berala • Carramar • Dundas • Fairfield • Flemington • Guildford • Katoomba • Lawson • Lidcombe • Merrylands • Parramatta (x 4) • Springwood • Strathfield (x 2) • Wentworthville • Westmead • Woodford	• East Maitland • Harden	• Glebe

Table 2: List of pedestrian subways

Superseded by MN C 10301 v3.0, 18/10/2021

Other hidden structures are present at the following locations:

- Chatswood Transport Interchange
- Parramatta Transport Interchange
- Chatswood Rail Enclosure Structure (RES).

For the purposes of this technical note, footings and piles that are buried below ground or in permanent water are not considered to be hidden structures.

11.1.1 Other Hidden defects in structures (components or elements)

Indicative list in the Table 3 below.

Underbridge	Prestressed Concrete – Trough or box girder	• Ungrouted post tension tendons • Inside box – cracking (if inaccessible) • Girder to Deck cross tension ties	• Como (Also underwater piles) • Y-Link (bean to tie) • Lidcombe – Bridge St UB
	PSC Girders/Planks	• Cross ties (Ungrouted)	• Typical ballast top conversion • Prevent spreading of the planks • Look for sign of falling ballast or gaps between the planks
	Steel Box girder	• Defects inside box girder (if inaccessible)	• Meadowbank • Emu Plains
	Steel Transom Top	• Under transom Zinc strip	
	Steel & concrete infill span (filler beam)	• Steel girder cannot be inspected (corrosion – due to water seepage)	• Strathfield – Raw Square UB (may need to waterproof deck)
	Steel span	• Half Joint	• Tempe Cooks River – may need specific inspection instruction
	Masonry – Abutments & Piers	• Timber piles	
	Steel bridges	• Fatigue damage	• Specific instruction required
Overbridges	Jack Arch	• Tie rod • Bottom flange – under the brick arch • Under brick parapet/traffic bearers	
	PSC planks	• Cross tension ties	• Blackheath

Superseded by MN C 10301 v3.0, 18/10/2021

Subways	Concrete/Masonry	• Unregistered or close off – not inspected • Inspection access – prevented by partition walls (some by tiling)/ceilings	
General	Bearings	• Inaccessible	• Chatswood – Floating slab bearings • Ballast top – elastomeric strip • Knife Edge type

Table 3: Other Hidden defects in structures

11.2 Examination of hidden structures

For structures hidden behind removable panels, some panels shall be removed during **detailed examination** to allow examination of a sample of the hidden structure.

Examination shall be visual and, where necessary, with the aid of inspection technology such as closed circuit television equipment or cameras (CCTV) on a flexible fibre optic cable.

Examine structures as closely and in as much detail as possible within the access constraints. The underlying requirement is that the examiner must be able to tell whether there is a defect or not in the area being inspected.

The extent and location of removed panels shall be determined to provide a representative sample for assessment of the overall condition of the hidden structure. For subways, a reasonable sample would be approximately 5% to 10% of total surface area of hidden structure for a suburban subway such as at Stanmore station and 3% to 5% of total surface area for a major subway such as the Devonshire Street subway. These figures are indicative only and depend on the complexity of the structure being examined and practicality of obtaining access. For bridges, the sample should include 50% of structurally critical members.

Prior to carrying out the examination, a detailed plan identifying areas to be examined and arrangements for removing panels shall be prepared. Drawings of the structure shall be reviewed to identify the details of the hidden structural components and panel fixings. Where various forms of construction are present, the sample areas shall be selected to cover each of the different forms of construction.

Where the initial examination of hidden components indicates that significant deterioration is present, further examination and investigation shall be carried out to assess the extent of significant deterioration.

If there is significant deterioration of at least one Category D or higher defect, on every subsequent cycle inspect the zone of significant deterioration and new sample areas as described below.

If there is little or no deterioration, that is no defect or only a Category E defect, vary the sample areas inspected at each examination so that the extent of the hidden structure that has been examined is progressively increased.

Superseded by MN C 10301 v3.0, 18/10/2021

For structures hidden behind non-removable linings, look for evidence of deterioration and develop further inspection actions accordingly.

Evidence of deterioration includes the following:

- structure movement, cracking
- water seepage
- rust staining, spalling and cracking
- distortion or displacement of the cladding
- ballast degradation, track pumping at track level above the structure
- cracks in platform walls or other structures at track level above the structure.

For structures behind non-removable linings, obtain advice from the AEO technical representative on requirements for providing access to the hidden structure to allow detailed inspection and assessment of structure condition. The AEO technical representative shall be an appropriately qualified senior bridges and structures engineer.

11.3 Examination reports

Examination reports shall clearly identify and detail the extent of structure examined and the examination method. A diagram including key dimensions shall be prepared to clearly identify the structure, sample examination areas, components examined, and examination dates for the areas examined. Examination reports shall include a comprehensive photographic record, including identifying labels, of the hidden components that have been uncovered during the examination.

Superseded by MN C 10301 v3.0, 18/10/2021

12 Recording and Reporting Examination Results

12.1 Recording procedures

One of the main objectives of a structures examination is to record its current condition. This information is used for design, construction and maintenance purposes as well as establishing a history of performance of the structure.

To achieve this objective, the recording shall be in a consistent format, accurate and clearly presented. To this end, standard recording formats for detailed examinations have been developed for the various types of structure assets and materials.

All detailed examination records should include a photograph showing the general configuration of the structure, e.g. a side elevation of a bridge showing the spans and bridge type. Photographs should also be taken of any newly detected defects or any previously identified defects that have deteriorated. This, together with the written documentation, will assist with subsequent assessment of the structure's condition and planning of repairs.

For special examinations, a comprehensive written report shall be prepared addressing the specific event and any other relevant aspect of the structure's condition and behaviour. The report is to be supplemented by photographs and sketches/plans as appropriate.

12.2 Reporting forms

Standard formats have been established for the recording of the results of structures examinations by Bridge Examiners. Examples of the standard forms are provided in Section 23.3.

The examination forms are comprised of two sections, the top portion covering permanent data for the particular structure such as location, type etc. and the lower portion being the examination record covering any exceedents found, defect categories and repair priorities.

Provision is also made at the bottom of the form for the overall condition to be shown, e.g. the paint index if a steel structure.

All defects in structures that have been identified as defect categories A, B, C and D are to be reported on a Weekly Summary of Exceedents Form (see example in Section 24). This form is to be submitted to the Structures Manager for their authorised action and subsequent endorsement of completed work.

The results of visual inspections made by the Civil Maintenance Engineers shall be recorded in an Inspection Notebook or similar electronic record, detailing the inspection date, comments and recommendations for repair.

Superseded by MN C 10301 v3.0, 18/10/2021

12.3 Signatures on reporting forms

Reporting forms are to be signed to certify that examinations and assessments have been carried out in accordance with the requirements of this Manual. The forms are signed by the person conducting the examination and also by the person certifying the structure.

The standard reporting forms shall be signed as follows:

- Detailed Examination form is signed by the Bridge Examiner to certify the examination and by the Structures Co-ordinator to certify the assessment.
- Mid-Cycle Examination form is signed by the Structures Co-ordinator only to certify the examination.
- Both detailed examination & mid-cycle examination form – random sampling is signed off by the Territory Civil Engineer

12.4 Bridge management system/SAP

Examination reports for bridges and culverts shall be loaded into the Bridge Management System (BMS)/SAP.

Defects shall be entered into the system.

12.5 Bridges

12.5.1 General

The results of all bridge examinations shall be recorded in electronic format. Prescribed examination report forms are provided for the recording of relevant data and information on the structure, defect categories, repair priorities, paint index (where applicable) and load rating information. For bridges and culverts, the online BMS/SAP is to be used for the recording of examination results.

The examination results and comments shall be written up within one month of the detailed examination.

Typical Bridge and Culvert Examination Report forms are provided in Section 23. When using these forms, the key components of the bridge are to be reported on as follows:

Steel bridge	Timber bridge	Concrete bridge	Culvert
Main Girders	Decking	Girders	Roof
Bracing	Girders / Corbels	Kerbs	Internal Walls
Stools	Headstocks	Tie Rods	Culvert Invert
Bearings	Bracing / Sills	Ballast Walls	Apron Slabs
Paint	Trestles	Ballast Logs	Headwalls
Abutments	Abutments	Bearings	Tie Rods
Piers	Wings	Abutments	Wingwalls
Transoms	Transoms	Piers	Scour Protection
Ballast Logs	Ballast Logs	Wingwalls	General

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Walkways/ Refuges	Walkways/ Refuges	Walkways/ Refuges	
Guard Rails	Guard Rails	Guard Rails	
General	General	General	

For timber bridges, the detailed examination results shall be recorded in accordance with the procedures in Section 23.3 .

Examination report forms shall be certified by the designated personnel as detailed in Section 12.3.

All defects that have been identified as defect categories A, B, C and D are to be reported on a Weekly Summary of Exceedents Form (see Section 24). This form is to be submitted to the Structures Manager for their authorised action and subsequent endorsement of completed work.

The results of visual inspections made by the Civil Maintenance Engineer shall be recorded in an Inspection Notebook or similar electronic record, detailing the inspection date, comments and recommendations for repair.

12.5.2 Defect and action comments on examination forms

12.5.2.1 Introduction

Bridge Examiners and Structures Co-ordinator are required to fully complete the examination forms as part of the standard bridge examination procedure. These forms serve as a means of recording the examination results and also as a checklist.

All previously reported defects should be re-inspected. Areas of particular types of structures where certain defects commonly occur should also be inspected, e.g. corrosion of the bottom flange of steel girders adjacent to bearings. The importance of carefully documented defects cannot be overemphasized.

All defects, and in particular those that reduce the load carrying capacity or performance of an element, should be adequately documented for future reference. Any action necessary to rectify the defect should also be documented on the relevant examination form.

Sufficient details should be recorded to cover defect location, severity, extent of defect and any other relevant information. Comments on any necessary action should be kept in general terms without detailing maintenance procedures. Where no defect exists or no action is required, the comment recorded should be “NIL”.

Superseded by MN C 10301 v3.0, 18/10/2021

12.5.2.2 Defect comments

Comments on the defects observed/measured during an examination are a key part of reporting. The description should be sufficient (along with photographs) to enable bridge maintenance priorities to be established.

A variety of defects may exist and these vary according to material types and construction form. Examples of typical bridge defects and appropriate descriptions are:

(Attach a photo if appropriate or where a defect is not within the defect definition).

Examination form/item	Example defect comment
Substructure-masonry/concrete	
Cracking/Spalling	Diagonal cracking in Abutment 1, UM No 2 wingwall, up to 2 - 3mm width
Water penetration of leaching	Moderate leaching throughout tops of all piers and abutments
Substructure-steel/iron	
Corrosion at base plates	Heavy corrosion at base of Pier 1 columns with up to 20% section loss
Footings	Two footings at Pier 1 are cracked through pier column, up to 2mm. Some minor spalling of concrete off corners of footing
Substructure- timber	
Split/rotted piles	Trestle 2, 3 piles have split at the bolted connections. Splits are up to 75mm deep, 600mm long from bolts
Superstructure-masonry arch	
Arch cracking	Cracking in top layer of arch ring up to 3mm wide, in span 1 near Pier 1. Transverse minor cracking, up to 1mm on U/S of all arches near mid span
Mortar loss	Severe loss of mortar from joints at base of Abuts and Piers. Abut 1 loss is getting critical with some loose blocks
Superstructure-steel/iron girder	
Flange section loss to Main Girder	Light corrosion and pitting of top and bottom flanges at ends of girders, up to 5% loss of section. Nominal section loss elsewhere
Behaviour under live load	Up to 5mm vertical movement at most bearings due to pumping. Up to 10mm movement at Abut 2.
Superstructure-steel/iron truss	
Loose rivets or bolts	2 bolts missing from Span 3 bracing adjacent to Pier 2. Loose connection at Span 2 bracing at mid span

Superseded by MN C 10301 v3.0, 18/10/2021

Examination form/item	Example defect comment
Superstructure-steel/iron jack arch or concrete encased	
Flange section loss	Up to 20% loss of bottom flange of outer girders in Spans 1 and 2 at ½ span point (i.e. girder exposed due to electrification). No loss to internal girder flanges
Decking – transom top	
Transoms	Transoms are generally weathered, with 5 heavily weathered and splitting/decayed
Decking – ballast top timber	
Handrail	Base of all railing posts and anchorage bolts heavily corroded. Railing posts and rails are heavily surface corroded throughout
Decking – Overbridge	
Wearing surface	Wearing surface is moderately worn throughout and cracked along centreline of construction joints (up to 1mm)
Traffic barrier railing	Diagonal cracking up to 3mm in masonry walls near Abut 1 and on UM side of Abut 2
Decking – Footbridge	
Treads and risers	One loose tread in Span 2 near Pier 1. Up to 30% loss of tread supports at Spans 1 and 2. Leading edge of 2 treads in span 1 are badly spalled and reinforcement is exposed
Railing and balustrade	Railing post bolts are generally corroded. Post on landing has 1 missing bolt and others are loose. Hence post is loose and unsafe

Superseded by MN C 10301 v3.0, 18/10/2021

12.5.2.3 Action required

Actions required to rectify defects are also a vital part of examination reporting. These are to be restricted to a general description only, to give an indication of the form of work required to fix a defect. Methods and techniques of performing maintenance repairs are detailed in *MN C 10302 Structures Repair*.

The action required to repair a defect depends upon the type of material, the severity of a defect and its location (i.e. is it in a critical position?). It is often difficult to determine the severity of corrosion for example, without removing loose corroded material, or knowing if in fact these section losses are critical. Therefore, it may only be possible to identify the correct action once work has commenced, or after design calculations have been completed. In these cases, a note should be made that further investigation is required.

Examples of some typical action comments are:

Defect	Example description of action
Light to moderate corrosion	Strip back corroded material and repaint
Severe corrosion	Strip back corroded material, plate and repaint or Further investigation of extent of corrosion required
Breakdown of protective coating at connections and exposed locations	Spot paint where necessary
Bottom flange notched from vehicle impact	Grind out notch magnetic particle test and paint
Concrete cracked and spalled from underside of deck and reinforcement exposed and corroded	Check loss of reinforcement and design capacity (if significant additional reinforcement may be needed). Patch concrete spalls and inject cracks with epoxy mortar.
Water penetration and leaching through deck	Resurface deck wearing surface and asphalt and patch cracks in footway slabs Or Further investigation of deck surface under asphalt required
Bolts loose or missing and generally corroded	Tighten loose bolts and replace missing or heavily corroded bolts
Bearings pumping under live load	Replace existing bearing mortar pads
Road approaches to bridge have subsided and wearing surface badly worn	Build up approaches with asphalt. Resurface deck with asphalt or Further investigation of subsidence required
Minor defects such as cracking, breakdown of paint, etc.	Monitor at next inspection

Superseded by MN C 10301 v3.0, 18/10/2021

12.5.3 Overall condition

12.5.3.1 Paint Index

Provision is made at the bottom of the examination forms for steel bridges to show the overall paint condition of the structure. This is assessed in accordance with the guidelines detailed in Section 20.3.

Especially on major steel bridges and in compliance with necessary environmental safeguards, re-coating becomes an extremely expensive activity. The indices provide the asset manager with important management information.

12.5.3.2 Load Rating

Provision is also made at the bottom of the examination forms to show the “as new” and “as is” capacity of the bridge. This is calculated in terms of its load rating, which is established by a design engineer, either when the bridge is designed or during its service life. Any changes to the load rating are calculated by a design engineer using information from bridge examinations such as section loss, cracking, etc.

The load rating is an indicator of the strength of a bridge. The primary objective of establishing a load rating is to ensure that the bridge has adequate strength.

Overloading and other severe load histories, deterioration, rehabilitation and strengthening may cause changes in a bridge’s load carrying capacity with time. Therefore, the load carrying capacity calculated at a particular date may not be the same as the future or past capacity, or even the same as the original design capacity.

Two types of load rating are used - “As New” and “As Is”.

- **As New** load capacity looks at the bridge in as new condition and rates it in accordance with relevant bridge design standards.
- **As Is** load capacity of a bridge takes account of the current condition and allows for damaged or deteriorated members.

Load rating of underbridges is expressed as a proportion of the bridge’s capacity.

Load rating of overbridges is expressed as gross weight in tonnes and prefixed with R (example: R20).

Footbridges are rated using a uniform load throughout and the live load capacity is expressed in kilo Pascals (example: 5kPa).

12.5.4 Bridges managed by others

Configuration and defect data for overbridges and footbridges that are owned and managed by the Roads & Maritime Services (RMS), local councils and other authorities, shall be included in the BMS (SAP).

Transport for NSW requires data to be included in the BMS for information and to allow defects to be monitored.

Information to be recorded includes:

- configuration data to describe the structures
- defect data obtained from bridge examinations
- signed copies of bridge examination reports

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- as-constructed drawings
- load rating
- photographs and other reports.

Data shall be obtained from the RMS, local council or other authority as appropriate.

For multi-span overbridges data need only be recorded in the BMS for the span or spans that are located over rail network property, including the supports to these spans.

12.6 Structures

12.6.1 General

Standard formats have been established for the recording of the results of structures examinations by Bridge Examiners. Examples of the standard forms are provided in Section 23.

Examination results and comments shall be written up within one month of examination.

Exceedances are to be recorded on the Weekly Summary of Exceedents form in accordance with the procedures detailed in Section 12.

For overhead wiring structures and signal gantries, missing bolts, members rated “poor”, and structures requiring detailed examination are to be reported on the *Weekly Summary of Exceedents* form.

Each of the items listed on the reporting forms shall be checked on site and comments made if appropriate.

It may be the case that the item listed does not exist at this particular site and therefore a “Not Applicable” comment should be recorded.

Where no defect or action is necessary then a “NIL” comment should be lodged against the appropriate item.

Where a component is not visible or is not accessible, comments “Not Known” and “Not Inspected” should be used respectively.

Of course, in most cases a detailed description of a defect and action will be required for each particular item.

Where a Structures Co-ordinator is undertaking a mid- cycle examination, he is to take a copy of the previous examination report to site. Where any amendments or additions are necessary, the Structures Manager shall endorse the copy accordingly.

12.6.2 Defect and action comments on examination forms

12.6.2.1 Introduction

Examination staff shall fully complete the relevant examination forms. These forms serve as a means of recording the examination results and also as a checklist.

All previously reported defects should be re-inspected. Areas of particular types of structures where certain defects commonly occur should also be inspected. The importance of carefully documented defects cannot be overemphasized.

Superseded by MN C 10301 v3.0, 18/10/2021

All defects, and in particular those which reduce the load carrying capacity or performance of a structural member, should be adequately documented for future reference. Any action necessary to rectify the defect should also be documented on the relevant examination form.

Sufficient details should be recorded to cover defect location, severity, extent of defect and any other relevant information. Comments on any necessary action should be kept in general terms without detailing maintenance procedures. Where no defect exists or no action is required, the comment recorded should be “NIL”.

12.6.2.2 Defect comments

Comments on the defects observed/measured during an examination are a key part of reporting. The description should be sufficient (along with photographs) to enable maintenance priorities to be established.

A variety of defects may exist and these vary according to the type and form of structure and construction materials. Examples of typical defects in structures and appropriate descriptions are:

Examination form/item	Example defect comment
Overhead wiring structure-steel	
Corrosion at base	Heavy corrosion at base of mast with up to 20% section loss
Bridge	Web of main girder perforated over Up Main
Deflection	Masts off vertical and leaning towards Sydney
Tunnel	
Seepage	Significant leaking from roof above overhead wiring, 20 metres from Sydney portal.
Refuges	Three refuges obstructed by track materials
Retaining wall-masonry/concrete	
Cracking/Spalling	Diagonal cracking 2 metres from Sydney end, 1 metre long and up to 2 - 3mm width
Weep holes	90% ineffective (blocked with dirt and vegetation)
Crib Walls	
Header/stretcher	Crushing of 3 members at bottom of wall
Infill material (void)	Infill loss covering area of 1 m^2, 1 m long at ⅓ height from bottom
Vegetation	Tree trunk (100mm) observed to protrude through the wall

Superseded by MN C 10301 v3.0, 18/10/2021

12.6.2.3 Action required

Actions required to rectify defects are also a vital part of examination reporting. These are to be restricted to a general description only, to give an indication of the form of work required to fix a defect. Methods and techniques of performing maintenance repairs are detailed in the *MN C 10302 Structures Repair*.

The action required to repair a defect depends upon the type of material, the severity of a defect and its location (i.e. is it in a critical position?). It is often difficult to determine the severity of corrosion for example, without removing loose corroded material, or knowing if in fact these section losses are critical. Therefore, it may only be possible to identify the correct action once work has commenced, or after design calculations have been completed. In these cases, a note should be made that further investigation is required.

Examples of some typical action comments are:

Defect	Description of action
Light to moderate corrosion	Strip back corroded material and repaint
Severe corrosion	Strip back corroded material, plate and repaint or Further investigation of extent of corrosion required
Breakdown of protective coating at connections and exposed locations	Spot paint where necessary
Crib walls: Cracked headers	Provide stabilisation
Crib walls: Loss of infill material	Refill the void with approved material
Crib walls: Vegetation growth	Cut the trunk and poison its growth
Concrete cracked and spalled, reinforcement exposed and corroded	Check loss of reinforcement and design capacity (if significant additional reinforcement may be needed). Patch concrete spalls and inject cracks with epoxy mortar.
Water penetration and leaching through brickwork	Further investigation of cause and appropriate remedy required

12.6.3 Overall condition

12.6.3.1 Paint Index

Provision is made at the bottom of the examination forms for steel structures to show the overall paint condition of the structure. This is assessed in accordance with the guidelines detailed in Section 20.3.

Recoating may become an extremely expensive activity, particularly in view of track possessions that may be required and in compliance with necessary environmental safeguards. The indices provide the asset manager with important management information.

Superseded by MN C 10301 v3.0, 18/10/2021

12.7 Recording procedures - timber

Examination results should be recorded in the bridge examination book as follows:

12.7.1 Decking

Record size, number and location of pieces split or with section loss.

12.7.2 Girders/Corbels/Truss Spans

Record all pipes showing span number, girder/corbel number and location, and the location of boring (end, centre, 300mm from end, etc.).

Split corbels are to be noted, and whether they have been bolted.

Record deflection test results, including locomotive and wagon details and train speed.

Where packing is installed the location, size and type is to be noted.

For truss spans, the result of the examination is to be shown on a diagram.

12.7.3 Headstocks

Record results of any boring showing trestle number, location of headstock (top/bottom) and location of boring (which end).

12.7.4 Bracing/Sills

Record ineffective or unsound bracing, defining the location of each piece.

Diagonal bracing should be described stating whether single or double bolted.

Identify and record whether solid or double waling type sills. Record unsound pieces, identifying location.

12.7.5 Piles

Record pipes showing trestle number, location of timber pile in trestle (pile no), boring location (headstock, mid height, ground level, 500mm below ground).

Record, and carry forward, date of below ground examination.

Spliced and planted piles are to be specially noted. Depth of splice or of plant footing below bottom wailing shall be noted.

12.7.6 Abutment sheeting and wing capping

Record general condition and ability to retain fill.

12.7.7 Transoms

Record number that are split, spike-killed or have poor bearing, identifying if any are consecutive, whether sleeper plates are fitted, whether guard rails exist and the numbers of the spans where defective transoms occur.

Superseded by MN C 10301 v3.0, 18/10/2021

12.7.8 General

Note any comments on:

- ballast walls/legs
- runners
- refuges
- temporary supports
- termites
- screwing up
- other components
- services
- site condition.

Termite infestations found during examination are to be reported as an exceedent to the Structures Manager, who will arrange for a licensed contractor to treat the infestation. Dates of examination and treatment are to be recorded.

Condition, records of pipes and effectiveness of all temporary supports, together with dates of installation and modification, are to be recorded.

12.7.9 Marking Defects

After examination, all timbers with 50mm or more of pipe, dry rot etc. must be branded adjacent to the boring with 50mm high figures stencilled in white paint, showing the defect. Where dry rot or white ants are present, the letters “DR” or “W” are to be placed respectively after the figures to indicate these defects. Where a dry pipe only is present in the timber, no letter indication is required.

At each succeeding examination the previous figures are to be removed and only the latest figure shown.

12.8 Recording and reporting engineering assessments

Engineering assessments shall be recorded as engineering reports with the following primary sections, which are to be supplemented with appropriate subsections:

- executive summary
- introduction
- methodology
- assessment findings
- summary of results
- conclusions
- recommendations (include any short or long term action or monitoring)
- appendices (including relevant background data, bridge examination report, calculations, analysis outputs, sketches, and captioned photos).

The report shall be signed by the report's author, reviewer and approver.

Superseded by MN C 10301 v3.0, 18/10/2021

13 Assessment of Examination Results

13.1 General

The standard defect categories provide an initial response for the Bridge Examiner to ensure safety of the structure. The defect limits for the defect categories are conservative. Assessment of the defect may result in the allocation of a different defect category.

During the assessment process, the Structures Co-ordinator shall confer with the Bridge Examiner and consult with the Territory Civil Engineer as necessary.

The Structures Co-ordinator or Territory Civil Engineer may seek engineering advice from the Senior Manager Civil & Structures Engineering or ESI Professional Head Civil Engineering

The response to a repair priority may include a risk management action such as installation of temporary supports or imposition of a speed or load restriction, pending final repair. These actions may lead to the repair priority being redefined to a lower level, e.g. from Rm1 to Rm6, or from Rm6 to Mm3.

13.2 Initial assessment by bridge examiner

As part of the examination process, the bridge examiner shall assess measured defects by comparing them with the defect limits in Section 21.

The Bridge Examiner shall take the action specified in the defect category responses in Section 20 for each identified defect, i.e.:

- Stop trains.
- Impose 20km/h speed restriction.
- Report to the Structures Manager the same day.
- Report to the Structures Manager on the Weekly Summary of Exceedents Form.

The defect category is recorded on the examination form.

13.3 Assessment of weekly summary of exceedents

Upon receipt of the Weekly Summary of Exceedents form and within the assessment timeframe specified in Section 20, the Structures Manager shall assess the exceedents based on the size and location of the defect, their own knowledge of the structure and, where necessary, inspection of the defect.

The Structures Manager shall assess the defect category allocated by the bridge examiner. The defect category is either confirmed or altered.

Based on the assessed defect category, the Structures Co-ordinator shall allocate a repair priority.

The weekly summary of exceedents form is loaded into the BMS with details of repair actions and changes to defect categories.

In Teams 3, the defect category is updated where necessary and the repair priority is entered.

Superseded by MN C 10301 v3.0, 18/10/2021

13.4 Structures Assessment

Following the detailed examination, the Structures Co-ordinator shall make an assessment of each structure in accordance with *MN C 10305 Structures Assessment*.

The assessment shall be carried out within one month of the receipt by the Structures Co-ordinator of the examination report.

This assessment includes all the defects, both exceedents and non-exceedents, and an overall assessment of the structure.

The assessment is based on:

- the examination report
- the results of the mid-cycle examination, where applicable
- additional examination where considered necessary
- an assessment of all defects including effects of multiple defects in a component
- consultation with the bridge examiner and/or structures Co-ordinator
- engineering advice from the Territory Civil Engineer and/or Senior Manager Civil & Structures Engineering where necessary.

The assessment confirms the defect categories, repair priorities, and paint indices where applicable.

For detailed examinations, underwater examinations and monthly broad flange beam examinations:

- Carry out the structures assessment.
- Sign the detailed examination form as the certification of the structure as safe for the operation of trains.
- Load the detailed examination form into the BMS with final defect categories and repair priorities.
- Enter final defect categories and repair priorities into Teams 3.

For special examinations:

- Carry out the structures assessment in response to identified damage.
- Sign the examination form as the certification of the structure as safe for the operation of trains.
- Load the detailed examination form into the BMS with final defect categories and repair priorities.
- Enter final defect categories and repair priorities into Teams 3.

13.5 Structurally critical members

A list of structurally critical members in bridges has been prepared, to assist examination staff in identifying deteriorated components that may have a serious impact on the strength and safety of the bridge. For a list of structurally critical members, refer to Section 22.

Superseded by MN C 10301 v3.0, 18/10/2021

13.6 Engineering assessments

The Structures Co-ordinator shall arrange for Engineering Assessment reports to be reviewed by bridges and structures engineers under the Professional Head Civil Engineering to confirm the recommendations in the report.

The Structures Co-ordinator shall carry out an assessment of each bridge following receipt of the Engineering Assessment report in accordance with Section 12.4, including installing the report into the BMS/SAP with defect categories and repair priorities and entering final defect categories and repair priorities into SAP.

Superseded by MN C 10301 v3.0, 18/10/2021

14 Examination Of Bridges And Culverts

14.1 General

A thorough examination shall be undertaken of all components of a bridge during Detailed Examinations.

Examinations shall be carried out using methods that allow close inspection of all structural members.

Refer to *MN C 10110 Civil and Structures Service Schedules* for the relevant Service Schedules.

14.2 Substructures

14.2.1 General

The substructure includes the abutments, wingwalls, retaining walls, piers, trestles, columns and footings. These elements can be constructed from steel, concrete, masonry and timber.

Major components are summarised below:

- piles
- footings (pile caps, spread footings)
- abutments
- wingwalls /retaining walls
- piers, trestles and columns
- waterway scour protection.

Generally, the substructure can be adequately examined from the ground, however, in some cases this may not be sufficient. Where piers are submerged in water or are very high, then a boat, ladder, scaffold, “Cherry Picker” or “Snooper” may be required to allow closer inspection.

The key areas of concern in the condition of substructures include:

- deterioration of structural material
- corrosion/deterioration in tidal or splash zones
- scour or undercutting of piers and abutments
- excessive or abnormal movements in the foundations
- proper functioning of drains and weepholes
- accident/impact damage
- leaning or tilting of piers and abutments.

Superseded by MN C 10301 v3.0, 18/10/2021

14.2.2 Piles

14.2.2.1 Steel and Concrete

Piles on steel and concrete bridges are generally underground and cannot be examined, or under water.

For underwater examination, see Section 14.2.8.

14.2.2.2 Timber

Examine visually and hammer test for soundness. Bore and probe at headstock level and near ground level.

Piles shall be observed for signs of pumping or sinking under traffic and the result noted. All piles with 125mm pipe or over shall be bored at right angles in addition and shown in the bridge examination book as per the following example: 125 x 150.

Examine below ground using a backhoe where possible. Excavate to a depth of 500mm or more if found necessary, and bore at trench bottom. Where spliced piles show signs of vertical or sideways movement, the splice rails and pipe stumps are to be exposed and examined. All excavations are to be filled, compacted, and scour protection reinstated.

Spliced and planted piles shall be specially noted. Depth of splice or of plant footing below bottom waling is to be noted.

All spliced piles shall be stencilled with the letter “S” in white and planted piles with the letter “P” on the pile itself. A mark is to be made on an accessible part of the pile, together with the stencilled depth of the splice below the mark.

Where piles have a surrounding concrete collar or invert, the concrete shall not be cut away for examination unless extensive pile necking or piping is evident.

In measuring the diameter of a pile, the minimum effective diameter shall be taken. Where the sapwood is soft and dozy, it must be removed and the diameter measured accurately with callipers. If no callipers are available the girth should be measured and this amount multiplied by 7 and divided by 22 to find the equivalent diameter.

14.2.3 Footings

Examine structure footings for heaving of foundation material, erosion at footing, settlement, earth cracks.

Examine concrete or masonry footings visually and by hammer testing for flood or impact damage, weathering or spalling of surfaces or mortar joints, cracking within members or at joints and evidence of reinforcement corrosion.

Visually examine timber pile seatings and at the ends and hammer test for soundness. Identify solid and double waling types. Inspect for loose bolts, straps, decay of undersides on concrete bases and bearing of walings on pile shoulders. Solid timber sills should be inspected by bore and probe, the same as corbels.

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14.2.4 Abutments/Wingwalls

Examine concrete or masonry abutments and retaining walls for cracking, settlement, movement, drainage and weep holes, corrosion and degradation of material and components, impact damage, condition of piles and sheeting (where fitted), condition of masonry (where fitted), condition of fastenings.

Examine abutments and wingwalls for spill-through material (as applicable), condition of girder ends, condition of backfill, erosion or loss of toe support, vegetation and rubbish.

Abutments should be checked for movement or rotation. This can be done by checking: the abutment for plumb; the position of permanent marks on the abutment; or evidence of cracking in the abutment or wing walls. Where this problem is detected the details should be submitted to specialist bridge designers so that remedial measures can be included in any major upgrading work.

Examine timber abutment sheeting for general condition and for the ability to retain backfill. Examine tip end sheeting and clean out the cavity between girders. The use of the condemned mark (X within a circle) is not to be used except on sheeting to abutments.

14.2.5 Piers/Trestles

Examine concrete or masonry piers and columns visually and by hammer testing for alignment, crushing of bearing seating, settlement or movement, weathering or spalling of surfaces or mortar joints, cracking within members or at joints, evidence of reinforcement corrosion, proper functioning of drains and weepholes, failed mortar joints and lime weepage, loose brickwork, or loose stonework.

Examine steel trestles for alignment, bearing seating, settlement or movement, corrosion around baseplates, between angles in bracing, in rivet heads and holding down bolts, loose rivets or bolts in connections to girders or bracing or loose turnbuckles in bracing and condition of protective coating.

Examine steel piers for corrosion at crosshead connection at water or ground level, inside of filled cylinders, excessive movement of any member under load and cracks in cylinder walls.

Visually examine all horizontal and diagonal timber bracing and hammer test for soundness. Inspect for loose bolts and effectiveness of bracing in restraining side-sway. The ends are to be examined as well as at pile seatings.

14.2.6 Scour protection

Examine structure footings in waterways for scour and the condition of scour protection measures, vegetation growth, silt deposits and debris, ponding of water under the structure due to downstream obstructions, channel movements and adequacy of waterway and freeboard for debris during high water.

14.2.7 Foundation movement

Foundation movements are potentially one of the most serious causes of deterioration of a bridge. The most common form of foundation movement is forward rotation of an abutment. This is due to inadequate allowance for horizontal earth pressure in design and is common in designs prior to 1960. The movements can also be caused by instability of the underlying material or through consolidation. Differential movement may also occur resulting from variability of the underlying material properties or thickness.

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Movement of the foundation is first noticed by development of substructure cracking or through changes to the bridge geometry such as abutment tilting.

Instability can be caused by the occurrence of a range of different foundation characteristics. These may include the sliding of rock masses along fault or joint plains, mining subsidence, change of pore water pressure in the foundation strata due to a change of water table level or from a slip circle failure of an embankment slope.

Consolidation is generally caused by one of two events. The first possible cause could be from the additional loads at the time of bridge construction, consolidating any unconsolidated material. Another cause is track reconditioning – using compaction methods too close to abutments. Alternatively, the expansion or shrinkage of reactive clays that respond to changes of moisture content may also cause consolidation.

The effects of foundation movements can range from minor cracking through to the bridge becoming unserviceable or even collapsing.

14.2.8 Underwater examination

Examine piles in permanent water. The underwater examination shall be carried out by an accredited diver with the Bridge Examiner (or nominated representative) present. A signed report by the diver shall be retained and placed on the bridge file with these examination reports.

Detailed procedures for underwater examinations are given in Engineering Manual *MN C 10303 Underwater Examination of Structures*.

Examine for:

- serious corrosion of steel piles
- deterioration or splitting of concrete piles
- insect/borer infestation and deterioration of timber piles
- pile loss and remaining section
- scour development.

It is preferable to keep underwater inspection to a minimum. Therefore, all inspections should be completed at the time of lowest water where possible.

14.2.9 Bridge bolts and rivets

Bridges are designed to carry loads on the assumption that the separate members are held firmly together as a whole. For instance, the timber components of a compound girder are bolted together tightly to develop its full strength. If these bolts become loose, movement may occur between the separate parts or at joints and some of the designed strength is lost. To ensure that a bridge is well maintained, therefore, these bolts must be kept tight.

During the detailed examination, all bolts and rivets shall be examined. Any bolts which cannot be tightened during the examination shall be reported.

14.2.10 Services

Services such as water or gas pipes shall be examined for general condition, integrity of attachment, leakage and any impact on the bridge structure.

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14.2.11 Temporary supports

Visually examine for soundness and effective support. Packing and wedges shall be tightened and re-spiked where necessary.

Temporary supports should be treated as a trestle and examined in the same manner. Hammer test when new and bore and probe.

14.2.12 Site condition

All dry grass, flood debris and other foreign matter which may cause a fire hazard, is blocking more than 25% of a defined waterway or may accelerate timber decay, shallbe removed from the immediate vicinity of the bridge.

When water covers the footings, it is necessary to determine if any scour has occurred underneath. If the water cannot be drained or pumped out, a long rod or stick should be used as a probe.

All debris and earth shall be cleaned from sills, walings, braces, foundations etc. from both underbridges and overbridges, as this is a frequent cause of rot and decay in timber.

14.3 Superstructures

14.3.1 General

Superstructures are constructed from a variety of materials including steel, concrete, masonry and timber.

Inspection of a superstructure should be carried out from all possible angles from above, below and also in elevation. Access beyond that is available from the ground or via binoculars may be required. Therefore, the use of a ladder, safety harness, scaffolding “Cherry Picker” or “Snooper” or even a boat, may be required for a detailed examination. Ladders and other safety equipment shall be used in accordance with the Sydney Trains Safety Management System requirements.

The superstructure shall be inspected in a systematic way that prevents any members from being overlooked.

Major components are summarised below:

- girders, corbels, stringers, truss, arch and jack arches
- wind and sway bracing
- bearings
- decking (including ballast troughs and joints)
- transoms and attachments
- ballast logs
- guard rails
- barriers, safety screens and protection screens
- walkways, refuges and handrails
- stepways including landings, treads, risers and handrailing
- kerbs and parapets/balustrades
- footways

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- wearing surfaces
- drainage
- awnings
- service ducts
- overhead wiring brackets
- advertising brackets.

The key areas of concern in the condition of superstructures include:

- cracking
- heavy corrosion
- excess spalling
- loose connections
- excessive deformation and deflection under live load
- impact damage
- water penetration
- rotting
- splitting or weathering
- excessive vibration and noise.

14.3.2 Steel Superstructures

14.3.2.1 General

Members of steel and wrought iron bridges shall be examined for:

- corrosion and section loss
- buckled webs, web stiffeners, and flanges
- cracks in webs, flanges, welds and bracing
- loose bolts, rivets, plates and bars
- paintwork condition, distortion from corrosion products
- stain trails indicating hidden corrosion or working members
- polished surfaces indicating movement between members.

Examine steelwork hidden by flashings and other fascia for signs of corrosion.

14.3.2.2 Deflection

Deflection in steel members is normally small. Any clear movement under load shall be measured or closely estimated, and reported.

Any permanent sag in deck members shall be measured and reported.

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14.3.2.3 Main girders (plate web or rolled section)

Main girders may be plate web steel, rolled section steel, reinforced concrete, prestressed concrete or timber.

Particular defect areas to be examined are:

- Corrosion under transoms or decking at toes of bottom flange angles, between flange plates, around bearings, at abutments and piers, at bracing connections, in rivet and bolt heads.
- Loose rivets or bolts in top flange angles, bracing connections, web stiffeners and splices, bearing plates.
- Cracks in top and bottom flanges.
- Cracked welds in web stiffeners with diaphragm bracing, bottom of web stiffeners, web/flange fillets, flange/flange butt welds fillets and welded repairs.
- Notches in bottom flanges from road vehicle impact.
- Buckled webs of unstiffened girders.

14.3.2.4 Cross girders

Particular defect areas to be examined are:

- corrosion near abutments
- cracks in webs at ends of girders
- loose rivets or bolts in connections.

14.3.2.5 Stringer girders

Particular defect areas to be examined are:

- corrosion under transoms or decking
- cracks in top fillets and at ends of girders
- loose rivets or bolts in connections.

14.3.2.6 Truss girders

Particular defect areas to be examined are:

- Corrosion in top and bottom chords, batten plates and lacing bars, portal and wind bracing over tracks, gusset plates, rivet and bolt heads.
- Loose rivets or bolts in chords, bracing connections, bracing, loose turnbuckles in bracing.
- Damaged steelwork from equipment or loads travelling out-of-gauge.
- Ineffective sliding, roller or segmented expansion bearings.
- Misalignment or distortion in chords.

14.3.3 Concrete Superstructures

Members of concrete and masonry bridges shall be examined as follows:

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14.3.3.1 Crack examination

Cracking in concrete, brick and stone is an indicator of weakness in the member. Cracks must be examined for size and movement under load and details recorded. Shrinkage or hairline cracks need be noted only.

Cracking or crushing around prestressing anchorages must be noted.

The length, width, and location of cracks shall be measured. A short line scribed across the midpoint of a crack will give easy indication of further movement. Reference points scribed at each end of the line can be measured to indicate changes in the crack width.

Extensive new cracking, or cracks clearly working under load shall be reported and appropriate action taken in accordance with the defect category limits set in Section 21.

14.3.3.2 Deflection

Deflection in concrete, brick or stone members is normally small. Any clear movement under load is to be measured and reported as indicated above.

Camber of deck members shall be measured, or estimated, and noted. Any change greater than 10% from the installed camber shall be reported to the Structures Manager and given a safety rating.

14.3.4 Timber Superstructures

14.3.4.1 Girders

Every member shall be initially examined visually and tested with a hammer. If the sound indicates a defect, then a boring shall be made at that place. However, girders are usually bored at mid depth positions over the ends of the corbels and also at the centre of the span.

Examine compound girders individually.

Examine continuous girders on the basis of individual girders for each span. This includes girders made continuous by addition of intermediate/temporary supports. By way of example, a girder 4.7m long temporarily supported at the centre is bored and probed at six locations.

The top surface of girders, especially under the decking of ballast top spans, is to be examined for signs of decay.

Where a pipe is found that is 125mm or more wide, cross bore vertically at the location, note size and position of the pipe, and record reading in red.

Where visual examination raises any doubt or where termites appear active, additional boring is to be carried out as necessary.

14.3.4.2 Corbels

Examine in a similar manner to girders. Bore holes to be 300mm from ends and at the centre, but clear of the bolt holes. Where packing is installed, the location size and type is to be noted.

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14.3.4.3 Headstocks

Visually examine and hammer test for soundness. Identify solid and double waling types. Bore and probe ends of members if hammer test indicates internal decay. Give special attention to corbel seatings and to pile bearings. Inspect waling headstocks for loose bolts and for bearing on pile shoulders. Solid headstocks should be inspected by bore and probe, the same as corbels.

14.3.4.4 Deflection

Conduct deflection test as required in accordance with Section 10.3.4.

14.3.5 Decking

14.3.5.1 Underbridge decks

Underbridge decks are described as either ballast top, transom top or direct rail fixing.

For ballast top bridges, items to be examined include ballast walls, timber planks, steel decking, concrete ballast troughs, deck drainage and joints.

For transom top bridges, items to be examined include transoms, bolts, packers, clips and spikes.

For direct fixed decks, items to be examined include concrete deck, track fastening system supports, deck drainage, deck joints and ballast walls.

Other components to be examined on all bridges include the guard rails, refuges, walkways and handrails.

Any other miscellaneous components should be examined and reported under the “General” heading on the examination forms. This will include any obvious track defects such as low bridge ends.

14.3.5.2 Overbridge decks

Inspection of the wearing surface, parapets, footways, barriers, joints etc. is vital, even though in many cases an overbridge deck may be owned by another Authority. A defect on the deck for example, may be allowing water penetration to girders and substructure causing deterioration of these elements. Therefore, it is good practice for examiners to check all deck components and report any major defects to the Authority responsible for the deck. The Authority should also be requested to repair the deck.

The deck material type will determine the defects likely to exist and therefore, what an examiner should look for.

The wearing surface is the single most important deck item to be examined. It should be cleaned where obscured by debris or dirt, so that a full inspection can be made.

For timber decks, decay, splitting, loose planking and spikes are the most common defects. Observation of the deck under traffic will reveal looseness or excessive deflection in members. All defects and their effect on the remainder of the structure are to be noted. Determine the general condition of the timber decking. Note the number, size and location of pieces split or with section loss.

Concrete decks shall be checked for cracking, leaching, scaling, potholes, spalling and exposed reinforcement. Each of these items should be evaluated to gauge the effect on the structure and the work required to rectify the defect.

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Asphaltic or similar type wearing surfaces on a deck hide defects until they are well advanced. Therefore, the surface should be examined very carefully for signs of deterioration such as cracking, breaking up or excessive deterioration. Where deterioration of the deck is suspected, small areas of the wearing surface should be removed to examine the deck more closely.

All decks should be examined for slipperiness to determine if a hazard exists. Also, check drainage to see that the decks are well drained with no areas where water will pond and produce a traffic hazard or contribute to deterioration. Other items to be checked include deck joints, kerbs and parapets, footways, medians, traffic and pedestrian railings and safety screens. All these items need to be checked and reported on as they affect the overall bridge condition or the general safety.

14.3.5.3 Footbridge decks

The general points made about deterioration of overbridge decks also hold for footbridge decks. Therefore, all key components should be inspected and any defects reported. Deck material types should be examined according to the methods and procedures detailed in Section 10. Key components to be inspected include deck, landings, railings, balustrades, treads and risers, railing mesh and safety screens. Miscellaneous items such as lighting or roofing also need examination and details should be reported under the “General” heading on the examination form.

Pedestrian safety and aesthetics are the key areas of concern with footbridges. Close attention should therefore be paid to the following items during the examination:

- loose or corroded railings
- cracked and spalled treads or landings
- worn or uneven deck
- security and condition of balustrades
- adequate safety screening over OHW.

14.3.5.4 Deck joints

Deck joints are necessary to allow for deck movement and rotation, and therefore prevent large forces being transferred to the structure. It is necessary to inspect joints on overbridges and footbridges to ensure the required free movement is available and to check the general condition. Substantial damage to the structure could be caused by an obstructed or seized joint.

14.3.6 Stepways

Particular defect areas to be examined are:

- corrosion at base connection, stepway risers, stringer webs, tread cleats and clips
- loose bolts and clips to treads.

14.3.7 Barriers

The function of a barrier is to prevent pedestrians and errant vehicles from falling over the side of the bridge or stepway. A further function is to protect pedestrians from out of control vehicles.

Barriers can take many forms and may be made from brick, concrete, masonry, timber, steel, aluminium, galvanised iron, mesh or a combination of these materials. Regardless

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of the construction material, barriers are required to meet the appropriate loadings as outlined in the relevant current Australian design standards.

The major cause of barrier deterioration is due to impact damage from vehicles, protruding loads, flood debris, etc. Typical deterioration will occur according to the particular material.

14.4 Transoms

Examine for weathering (for timber – rotting), fastenings, splitting, spike killing, fire damage, condition at rail fastener and girder seating and condition at girder bearings for intermediate or butt transoms. For FFU general inspection for cracking.

14.5 Bearings

The function of a bearing is to transfer forces from the superstructure to the substructure, whilst allowing free movement and rotation. Many different types of bearings exist including:

- elastomeric bearing pads (plain or reinforced)
- confined elastomer or pot bearings
- steel roller bearings
- steel rocker bearings (optional polytetrafluoroethylene “PTFE” sliding surface)
- sliding plate with lead sheet insert
- cylindrical bearings with rotation about one axis (optional PTFE sliding surface)
- spherical bearings with rotation about three axis (optional PTFE sliding surface)
- confined concrete hinge bearings.

Typical examples of bearing defects include:

- corrosion of bearing plates, rollers or hold down bolts
- restriction to bearing movement due to build-up of debris or corrosion
- deterioration of the bearing materials such as PTFE sliding surfaces or the elastomer in elastomeric bearings
- drying out of the lubricant in roller bearings
- deformation of the elastomer in elastomeric or pot type bearings
- deterioration of bearing mortar pad from cracking or disintegration
- misalignment or incorrect positioning of bearing plates, with subsequent loss of bearing contact area
- incorrect setting of bearings in relation to temperature (at the time of inspection) and hence restricted bearing movements
- excessive pumping of bearings under live load
- loose or missing hold down bolts.

All bearing devices, regardless of their type, shall be closely inspected and checked to ensure that they are functioning properly. Small changes in other parts of the structure such as foundation settlements or displacements may be reflected in the bearings. Therefore, the geometry and condition of the bearings and bearing seals is often an indication of the general health of the structure.

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Close attention should be paid to the following during examination:

- Expansion bearings are clear of corrosion or foreign material and can move freely.
- Holding down bolts are secure and undamaged, and nuts are tightened and properly set to allow normal movement.
- Rollers and rockers bear evenly for their full length.
- Lubricated type bearings are being properly lubricated.
- Bearings and shear keys have not been damaged from binding and/or bridge movements.
- The positioning and alignment of the bearing should provide complete contact across the bearing surface. A gap may indicate uplift.
- The setting is correct in relation to the current temperature and therefore the required range of expansion and contraction is available.
- Elastomeric bearings should be examined for splitting, tearing or cracking of the outer casing and for bulging and distortion caused by excessive compressive and/or shear forces.
- Cracking, spalling or deterioration of bearing mortar pads or pedestals.
- Pumping or excessive movements under live load.

Bearings should also be carefully examined after unusual occurrences such as accidents, overloading, earthquake, flooding, etc.

Particular defect areas to be examined are:

- corrosion at flange plate connections
- cracks in bearing or bed plates
- cracked welds between flanges and bearing plates
- loose, broken or missing holding down bolts, studs and clips
- expansion bearings not working and segmented bearings lying over
- condition of grease pipes.

14.6 Other components

14.6.1 General

Other components include:

- bridge approaches
- waterways
- clearance signs and other signage
- protection beams.

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14.6.2 Bridge approaches

Deteriorated conditions in the approaches to both under and overbridges may lead to damage to a bridge.

The approach track or pavement should be checked for formation failure, settlement or unevenness. The existence of these defects may cause additional, undesirable impact loads on the structure and therefore stresses within the structure.

Any such defects should be reported on the relevant examination form. Where the approach track ballast has settled, the local track maintenance crew should be instructed to rectify the defect. Where an approach pavement owned by another Authority is defective, details are to be forwarded to the Authority, requesting repairs to be carried out.

14.6.3 Waterways

The condition of the waterway opening of a structure or culvert should be observed at time of inspection. Defects in relation to scour or the condition of the scour protection are to be recorded on the relevant substructure examination form. Any other defects observed can be recorded under the “Comments” heading on the examination form.

For underbridges, the examiner should paint onto the Down Side of No.1 abutment the level and date of highest flood level, as advised by the Track Manager.

Typical problems and items to be checked include:

- scour and the condition of scour protection measures
- vegetation growth
- silt deposits and debris which restrict the waterway area
- ponding of water under the structure due to downstream obstructions, which lead to accelerated deterioration of substructure
- condition and adequacy of fendering of navigation channels
- channel movements
- adequacy of waterway and freeboard for debris during high water.

14.6.4 Signage

Signposting is an important part of bridge management. Therefore, the presence and condition of warning/restriction signs is to be checked during bridge examination. If any defects are found, the details of the defect are to be recorded under the “Comments” heading on the examination form.

The inspection should include warning signs at or near the structure. This should check that all signs required to show restricted weight or speed limit, navigation channel, restricted clearances, etc., are in their proper place. The lettering of signs should be clear and legible and the sign should be in good condition. Any changes in local conditions such as raising or lowering track, resurfacing roadway, strengthening of bridge, etc., will necessitate recalculating and possible change of sign details.

Height signs are to be checked by measuring and any changes required are to be notified in writing to the relevant road authority.

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14.6.5 Protection beams

Examine protection beams visually for condition and serviceability, impact damage and security of fastenings.

14.7 Impact damage

14.7.1 General

Impact damage to a bridge structure can be caused when:

- vessels (ships, boats, barges, etc.) glance or impact against piers, abutments and fendering
- heavy floating debris carried by rapid flowing floodwaters strikes the bridge
- trains are derailed or motor vehicles are out of control and collide against piers, abutments or barriers
- overheight loads impact against the underside of bridge superstructures
- overwidth loads or projecting parts of trains or motor vehicles strike against piers, abutments or barriers
- air borne debris carried by very strong winds strike the structure.

Typical impact damage includes:

- spalling of concrete or masonry members, with or without exposure of reinforcement
- cracking of steel or concrete members
- shattering of timber members
- local buckling or bending of steel members
- permanent deformation of members
- rupture or fracture of members
- damage to parapets, balustrades, posts and railings
- collapse of bridge.

14.7.2 Inspection of Impact Damage

14.7.2.1 Initial inspection and action

Inspection of impact damage is performed as a special examination.

Carry out an initial inspection to ensure safety to the user and to reduce further damage to the bridge.

When damage is severe, a competent structural engineer should make the initial inspection and determine whether to restrict traffic or close the bridge.

Preliminary strengthening should be made immediately to prevent further damage. Preliminary strengthening may also be made to allow traffic on the bridge. These preliminary actions are normally based on judgment supplemented by brief calculations.

If a severely damaged member is fracture critical, immediate steps shall be taken to prevent bridge collapse.

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Fracture critical members are those tension members or tension components of members whose failure would be expected to result in collapse of the bridge or inability of the bridge to perform its design function.

Primary members in tension are fracture critical members, for example, tension flanges of girders and truss tension members.

Broad flange beam spans over roadways are subject to a significant risk of fatigue and/or brittle fracture if damaged by road vehicle impact and shall be considered fracture critical.

When a member is damaged beyond repair, the engineer may recommend at this time to partially or wholly replace the member. When safety of the user is in question, the bridge shall be closed until it is conclusively determined that traffic can be safely restored.

14.7.2.2 Inspection sequence and record

Commence inspection with the most critically damaged area first, followed by inspection of other damage in descending order of severity.

Inspect the main supporting members first.

Tension members shall be inspected for indication of cracking.

Compression members shall be inspected for indications of buckling.

When more than one member has been damaged a complete description of damage for each member shall be given.

Painted surfaces shall be visually inspected for cracks. Cracks in paint and rust staining are indications of cracking in the steel. Heavy coatings of ductile paint may bridge over cracks that are tight. When there is any doubt about ability to inspect for cracks, the paint shall be removed. Damaged fracture critical members shall be blast cleaned and magnetic particle inspected.

All areas inspected, including those areas inspected that did not suffer damage, shall be recorded. This procedure aids the decision-making process of what, if anything, should be done to repair a member.

14.7.2.3 Measurement of damage curvature

Accurate inspection information is required for assessing damage.

A sufficient number of measurements shall be made to fully define the extent of damage.

The best way to estimate curvature is by measuring versines of short chords. Straight edges (or spirit levels) 600mm or 1200mm long held against the inside of the curvature are more convenient than using string lines.

14.7.2.4 Cracks

Carry out detailed inspection to locate cracks and determine their length and width, including visual inspection supplemented with magnetic particle or dye penetrant testing. Impact cracks are usually surface connected and ultrasonic testing is not generally necessary. The stress and shock of impact will sometimes cause cracking well away from the area of principal damage.

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Look for spalling of paint or scale as an indication that some unusual strain has occurred at such locations and use as a guideline for areas of detailed inspection. Visual examination shall not be limited to these areas, however, since a crack may occur in areas that were shock loaded but were not strained enough to spall the paint or scale. Visual inspection shall be supplemented with magnetic particle inspection in suspect areas.

Particular attention should be given to the examination of the toes of butt and fillet welds in areas subjected to damage as this is an area where cracks often occur.

Field inspection for cracks is performed by magnetic particle, dye penetrant and occasionally ultrasonic inspection.

14.7.2.5 Nicks and Gouges

Nicks and gouges shall be carefully described and photographed.

Superficial nicks and gouges shall be repaired by grinding smooth. As a guide, superficial nicks and gouges can be taken as those resulting in less than 10% loss of section of the affected element.

14.7.2.6 Monitoring of repairs

Follow up inspection of repairs shall be made on a regular basis.

Members that have complete restoration should be inspected with the same frequency as the complete bridge.

Member repairs where there is some doubt regarding strength and durability should be inspected at more frequent intervals.

Repairs to fracture critical members should receive close consideration with respect to inspection frequency.

Check for growth of cracks where cover plates for repair are less than full section requirements.

14.8 Overloading

Overloaded trains or motor vehicles may cause damage to a bridge that includes:

- yielding of member
- loose rivets
- loose or slipped bolts
- fracture of members
- cracking of concrete members
- fatigue of steel members
- buckling of compression member
- collapse of the bridge.

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Other causes of overload to bridges include:

- the build-up of flood debris against the structure which can cause large lateral hydraulic forces
- excessive build-up of ballast or road asphalt on deck
- extremes of temperature causing excessive movement or high temperature differentials within the structure
- very high winds.

14.9 Stream forces

Stream forces and their effects can be one of the most serious causes of deterioration of bridge structures.

The flow of water in a stream generates lateral pressure on bridge elements submerged in the flow. In large floods, the entire bridge may be submerged and the lateral forces become considerable as the flow increases. In addition to the lateral forces, the submersion of the deck can generate significant buoyancy forces. These can become amplified if entrapment of air pockets is possible under the superstructure.

Vent holes should always be installed on bridges where submersion is possible, to minimise the volume of trapped air. It is possible for superstructures to be lifted off their bearings due to the combined effects of buoyancy and lateral forces.

Log impact and debris loading add to the lateral force on a submerged bridge. Accumulated flood debris caught on the bridge increases the cross sectional area presented to the streamflow and thereby increases the lateral force. Also, heavy flood borne debris that strikes the bridge at velocity will cause a substantial impact loading on the structure. The relative effects of this depend upon the type of structure and the location of the impact. Timber structures for example may suffer shattered or fractured members following a heavy impact load.

Scour of the waterway channel near foundations has the potential to put the bridge out of service or perhaps cause catastrophic failure. It has been reported that 80 percent of all bridge failures are due to scour. As a consequence of positioning piers and approach embankments in the waterway area, a constriction of the waterflow occurs. During major flooding the water velocity may therefore be increased from that naturally occurring. Hence, without adequate scour protection such as reno-mattressing, gabions or stone pitching, serious scouring may occur.

The effects of stream forces can range from simply contributing to abrasion of concrete or masonry, through to collapse of the bridge. Where scour protection has been provided, it is critical for its condition to be checked.

14.10 Examination of steel broad flange beams over roadways

14.10.1 General

Broad flange beam (BFB) girders are highly susceptible to crack propagation.

BFB spans over roadways are subject to a significant risk of fatigue and/or brittle fracture if damaged by road vehicle impact. To minimise this risk, all such structures shall be included in a special examination program as detailed below.

Superseded by MN C 10301 v3.0, 18/10/2021

14.10.2 Inspection frequency

BFB spans over roadways shall be examined monthly by the Bridge Examiner for new damage or deterioration and shall be inspected as soon as possible after being reported as struck by a vehicle.

14.10.3 Examination procedures

The Bridge Examiner shall keep a list of locations of BFBs over roadways. The register shall include records of examinations including a copy of the detailed and mid-cycle inspections for such underbridges in that area.

The detailed or mid-cycle examination report shall include a detailed sketch, with photographs where possible of any affected flange. Where notches are sharper than 25mm radius or deeper than 10mm, each notch is to be individually measured and recorded. Where the flange is bent laterally or vertically, an estimate of the distance is to be given. The report should indicate whether damage is in the BFB flange or the flange plate, or both.

The spans shall be examined for evidence of flange damage, (i.e. cracking, notching, bruising, distortion, scores and bends), as well as repairs such as grinding. Note that cracks can develop from previously ground or repaired areas.

Examination shall be carried out from close proximity to enable measurement of defects and to facilitate the detection of cracking on any surface of the flanges.

Where there are welded flange plates, special attention shall be given to the BFB flange in the proximity of the welds, as there is a possibility of crack initiation and propagation from welds.

Any notch shall be noted and ground out as detailed in *MN C 10302 Structures Repair*.

Where notches sharper than 25mm radius or deeper than 10mm are found, detailed examinations within 300mm of the defect shall be made until repairs have been completed.

Defects when found shall be managed in accordance with the defect category limits set in Section 21 and reported on the *Weekly Summary of Exceedents* form.

14.10.4 Site action to be taken when cracking or damage occurs

The appropriate action for severe defects may include temporary track closure, temporary speed restrictions or temporary supporting of the bridge, depending on the extent of the crack.

If the track is not closed the bridge shall be monitored very closely and a speed restriction imposed to suit. A significant risk of rapid crack growth exists with any unplated BFB showing any crack, or a plated span showing cracks in both the BFB and plate flanges. Plated flanges showing cracks in one element, but not in both, are less of a risk.

If a span is temporarily supported at a crack, trains may run indefinitely up to 50km/h depending on the quality of the supports.

14.11 Structures over Public Spaces with damaged concrete

Particular attention should be paid when examining damaged concrete structures which span over public spaces. Loose concrete falling into public spaces presents a public safety risk.

Superseded by MN C 10301 v3.0, 18/10/2021

Structures which exhibit tell-tale characteristics require detailed close-up inspection, and if necessary removal of defective concrete and structural repair. The characteristics to look for include:

- Known previous repair work, in particular where there are sign of poor quality work or unsuitable material.
- Soffit slabs exhibiting signs of water ingress. This is characterised by staining and light-coloured calcium deposits.
- Visible cracks in concrete, generally cracks with a width in excess of 2mm.
- Heavy corrosion on adjacent steel components.
- Spalled concrete around steel reinforcement and steel members.
- For bridges with brick work – look for signs of loose bricks.

14.12 Culverts

Prior to examination of a culvert, assess whether it is a confined space. Refer to the Safety Management System for requirements for working in confined spaces.

If it is a confined space, either examination from outside the culvert is required or closed-circuit television cameras can be used.

Examination of subsurface drains, normally less than 300mm in opening, is not the Bridge Examiner's responsibility.

Examine culverts in accordance with *SSC 204*.

Examine structure for continuity and alignment of components.

Examine structure barrels, headwalls and aprons for general condition including flood or impact damage, weathering or spalling of surfaces or mortar joints, cracking within members or at joints, evidence of reinforcement corrosion, proper functioning of drains and weepholes, failed mortar joints and lime weepage, loose brickwork, loose masonry.

Examine corrugated metal pipes for alignment, corrosion, loose fastenings. Particular defect areas to be examined are:

- corrosion in corrugations
- distortion in pipe profile
- breakdown of bitumen coating/galvanising
- change in invert alignment indicating bedding failure
- scour or erosion around pipe ends.

Examine timber box drains for degradation of timber components, structural condition of load bearing members and continuity and alignment of components. Note any indication of failure of roof or wall timbers.

Superseded by MN C 10301 v3.0, 18/10/2021

15 Examination Of Overhead Wiring Structures And Signal Gantries

15.1 General

Examination of overhead wiring structures and signal gantries shall be undertaken by qualified staff at the frequencies set out in the relevant Technical Maintenance Plan (refer to *ST C 10100 Civil Technical Maintenance Plan*). The examiner shall have a copy of the previous examination results when examining each structure.

The examination covers the primary structure, structural components of overhead wiring and signals, and attachments such as walkways, handrails, decking, ladders and cages.

The examination of electrical/signal fittings is undertaken by Electrical and Signals Maintenance staff. The electrical/signal inspection includes the following:

- insulators and their attachments
- signal lights and their attachments
- all attachments to drop verticals and masts
- cantilever arrangements including diagonal tubes and chains
- tension regulator weights and associated attachments
- anchor guy rods, plates and associated fasteners.

15.2 Overhead wiring system

The present overhead wiring is energised by 1500 Volts Direct Current (DC).

The earth wire on structures must not be removed during examinations, and must be reinstated if found detached.

15.3 Wiring supports

Overhead wiring is supported off single timber or steel masts, or off steel portal structures.

Numbering of overhead wiring structure masts, bridges, droppers, etc., is to be as for overbridges, i.e. No. 1 mast (if any) is on the Down Side.

15.4 Examination methods

Examination methods for steel structures are detailed in Section 10.1.

15.5 Examination procedures

Members of steel structures shall be examined for:

- corrosion and section loss
- buckled webs, web stiffeners, and flanges
- cracks in webs, flanges, welds and bracing
- loose bolts, rivets, plates and bars
- paintwork condition; distortion from corrosion products

Superseded by MN C 10301 v3.0, 18/10/2021

- stain trails indicating hidden corrosion or working members
- polished surfaces indicating movement between members.

Basic examination can be undertaken from ground level, by using binoculars where necessary, to identify footing conditions, corroded areas in masts and bridges, missing fastenings, and corrosion or deterioration in structural components and attachments.

Members identified as deteriorated during basic examination, but inaccessible from ground level, and structural components more than 20 years old are to be noted for subsequent close up examination under “power outage” conditions.

Poles, masts, bridges, structural components and attachments are to be examined for corrosion losses, loose or missing fastenings, cracked welds, distorted members, loose or missing batten plates, holding-down bolt condition, soundness of concrete footings, erosion of earth support around foundations and soundness of guy foundations.

All debris, spent ballast and track materials are to be cleared away from masts and foundations.

15.6 Site condition

General site condition is to be noted. If practicable, all foreign matter or debris is to be removed during the examination. If impracticable, the situation is to be reported as an exceedent.

Foundations are to be checked for any undermining and the findings recorded.

Superseded by MN C 10301 v3.0, 18/10/2021

16 Examination Of Tunnels

16.1 General

Examination of tunnels shall be undertaken by qualified staff at the frequencies set out in the relevant Technical Maintenance Plan (refer to *ST C 10100 Civil Technical Maintenance Plan*). The examiner is to have a copy of the previous examination results when examining each tunnel.

16.2 Examination procedures

Serious deterioration in the stability of a tunnel is evidenced by bulging, distortion, cracking, or changing geometry in the tunnel.

Examination requires a working platform and good lighting so that close examination of the periphery can be made.

Tunnel examination will highlight the following indicators:

- The general condition of the rock face in unlined tunnels, or of the lining in others.
- The condition of joints in concrete, brickwork and stonework.
- Cracks, spalling, hollows or bulges in tunnel linings.
- Ineffective drainage, especially through weepholes and track drains.
- Signs of water seepage remote from constructed drainage outlets.
- Condition of overhead wiring attachments.
- Track heave, subsidence, or alignment change.
- Condition of tunnel refuges and lighting.
- Condition of Portals and movement away from tunnel stem.

Cracks, bulges, and spalled areas are to be measured for length, position and displacement. Extensively cracked areas should be photographed for easy reference.

Cracks or displacement beyond 10mm should have reference pins, or non-shrink grout installed for check measurement.

Spalling through the tunnel lining, or of whole bricks, is to be followed up with a geotechnical engineer.

16.3 Site condition

General site condition shall be noted. If practicable, all foreign matter or debris shall be removed during the examination. If impracticable, the situation shall be reported as an exceedent.

Foundations shall be checked for any undermining and the findings recorded.

Superseded by MN C 10301 v3.0, 18/10/2021

17 Examination Of Miscellaneous Structures

17.1 General

Examination of other structures as listed below is to be undertaken by qualified staff at the frequencies set out in the relevant Technical Maintenance Plan (refer to *ST C 10100 Civil Technical Maintenance Plan*). The examiner is to have a copy of the previous examination results when examining each structure.

17.2 Retaining walls and platforms

Retaining walls and platforms shall be examined for general condition as for bridges of similar materials.

Particular note should be taken of the condition of supporting walls and copings. Any settlement, tilting or other alignment changes should be noted. Platform copings should be checked for correct clearances to the adjacent track.

In addition, the following shall be recorded for crib walls:

- Wall distortion/bulging, relative displacement, settlement.
- Visible concrete elements (stretchers and headers) – condition, particularly at the base.
- Fill material – type and estimated loss and compaction.
- Effectiveness of drainage system.
- Water saturation.
- Any vegetation.

17.3 Air space developments

Air space developments shall be examined for those parts within the railway corridor, but excluding any levels above the supporting floor over the tracks.

The general condition of the members shall be checked in accordance with the guidelines for steel, concrete and other materials as outlined in Section 10. Particular note should be made of the condition of girders, floor slabs, deflection walls, columns, footings, attachments, passenger access, loose steps, cladding, and services.

17.4 Fixed buffer stops and stop blocks

Examine for correct alignment, structural integrity, condition of components, security of fastenings, impact damage, condition and functionality of buffers/springs, functionality of stop lights.

17.5 Energy absorbing buffer stops

Examine for correct positioning, structural integrity, condition of components, security of fastenings, impact damage, condition and functionality of buffers/springs, functionality of stop lights.

Superseded by MN C 10301 v3.0, 18/10/2021

17.6 Track slabs

Examine for structural integrity, condition of components including joints, movement between top and base slabs, ponding of water, evidence of damage to slab or components, bearings, gaps around floating slabs for debris

17.7 Noise abatement walls

Noise abatement walls shall be examined as for retaining walls and platforms.

17.8 Aerial service crossings

Service crossings not attached to bridges shall be examined where possible for general condition, as for bridges of similar materials.

17.9 Lighting towers

Lighting towers are to be examined as for steel bridges.

17.10 Sedimentation basins, stormwater flow controls and similar structures

Examine for general condition of structural elements as for bridges of similar materials.

17.11 Loading banks and stages

Loading banks and stages shall be examined as for retaining walls and platforms.

17.12 Turntables, fixed cranes and weighbridges

Examine for general condition only and record date of safety certification by others.

17.13 Overhead water tanks

Examine for condition as for air space developments.

17.14 Site condition

General site condition shall be noted. If practicable, all foreign matter or debris shall be removed during the examination. If impracticable, the situation shall be reported as an exceedent.

Foundations shall be checked for any undermining and the findings recorded.

Superseded by MN C 10301 v3.0, 18/10/2021

18 APPENDIX 1: Terms used in reference to Bridges and Structures

A	
Abutment	The support at each end of a bridge.
Abutment sheeting	Timber planks used to retain the filling behind an abutment.
Approach slab	Slab (usually reinforced concrete) laid above the formation behind bridge abutments and designed to provide a transition zone for track stiffness onto the bridge.
B	
Ballast kerb	Longitudinal member at the outer edge of a ballast top span to prevent ballast spilling over the side.
Ballast log	Timber, masonry or steel member sitting on top of the abutment ballast wall to hold back track ballast.
Ballast retention wall	Longitudinal member at the bridge end to retain the ballast profile.
Ballast top	Underbridge with continuous deck supporting metal ballast.
Ballast wall	Top part of the abutment wall to hold back earthworks and track ballast.
Barrier	The fence or walls along the sides of overbridges and footbridges, installed to protect road vehicles, cyclists and pedestrians from falling over the edge of the bridge.
Bearing	Seating area of a load-carrying member; may be a separate fabricated member attached to the girder ends.
Body bolt	Vertical bolt in timber girders and corbels causing pairs of members to deflect together.
Bracing	Horizontal or diagonal member attached to main members to stiffen those members, or to minimise sidesway.
Bridge	A structure spanning a river, road, railway, or the like, and carrying vehicles, persons or services.
Broad flange beam	A steel girder designed in the 1920s with thicker and wider flanges and reduced height of web for use in locations where greater vertical clearance was required.
Buffer stop	Structure provided at the end of a rail line or siding to prevent rolling stock from running off the end of the track and/or colliding with an adjacent structure.
Butt transom	Intermediate transom linking the ends of girders from adjacent spans.
C	
Caisson	A cylinder or rectangular ring-wall for keeping water or soft ground from flowing into an excavation. It may later form part of the foundation.
Capping	Impermeable layer of fill located immediately above the main formation and designed to shed water to the sides of the track.
Catchment	Area of land from which water flows into an underbridge.
Check	A separation that runs parallel to the timber grain and usually on the surface. It results from stresses that develop as the surface layers of wood loose moisture.

Superseded by MN C 10301 v3.0, 18/10/2021

Compound girder	Timber girder made from two or more sections bolted firmly together on top of each other.
Compression flange	The face of a member that is in compression. For beams it is usually the upper face and in particular near mid-span. For a cantilever or a continuous member it is the lower face over the supports.
Coping	The longitudinal edge of a station platform.
Corbel	Short longitudinal member seated on a headstock providing a bearing for adjacent girders.
Corrosion	The gradual removal or weakening of metal from its surface by chemical attack. Generally, it requires the presence of water and oxygen, and is helped by carbon dioxide, sulphur dioxide and by other materials in small quantities in the air or water.
Crack	Open fissure on the surface of a member, but not necessarily right through the member.
Culvert	Arch, box-shaped or piped structure/drainage having integral walls, roof and floor.
D	
Damage	The sudden worsening of the condition of a structure, its elements and component materials due to the effect of a sudden event such as fire, flood, accident or vandalism.
Debris	Rubbish or other loose material lying near an underbridge and which impedes smooth water flow through the bridge opening, or collected against a structure.
Decay	Deterioration on or in a timber member causing loss of strength.
Deck	Part of bridge superstructure directly carrying the load.
Defect	Deterioration of a member of a structure from its original condition.
Deflection	Downwards displacement or sag of a bridge girder when loaded by vehicles or persons, or displacement of a structure from its design position under load.
Deflection wall	Structural wall installed to protect the supports of a structure adjacent to the track from collapse caused by a derailed train.
Deflectometer	Instrument for measuring deflection in girders - also referred to as “mousetrap”.
Deterioration	The gradual worsening of the condition of a structure, its elements and component materials due to the effects of traffic and other loadings, the action of the environment on the structure and/or the actions of the constituents of component materials over a period of time.
Dive	Form of tunnel where one rail track passes under another track that is located at ground level
Driving mark	Mark cut into (timber) pile indicating in roman numerals the distance to the pile tip.
E	
Enhancement	The improvement of the condition of a structure above its design or initially planned level of service. Forms of enhancement include strengthening, widening, lengthening, raising and improved safety such as better barriers.

Superseded by MN C 10301 v3.0, 18/10/2021

F	
Flood level	Mark stencilled on No.1 Abutment of underbridges indicating height and date of maximum previous flood.
Footbridge	Bridge over the track carrying pedestrian traffic only. May be freestanding or combined with an overhead booking office.
Footway	Pedestrian access attached to, or included in, an overbridge.
Formation	Ground immediately beneath the capping and track.
Flyover	Bridging structure where one rail track passes over another which is at ground level.
G	
Gantry	An overhead structure consisting of side masts or columns joined at the top by a horizontal bridging member.
Girder	Horizontal main load-bearing member of a structure supporting the remaining components of the superstructure.
Guard rail	Old rail or steel angle, placed in pairs, fixed to transoms or sleepers between the running rails to guide derailed wheels across an underbridge/vulnerable site.
H	
Handhold device	A system of handrails provided along a wall structure to provide support for personnel.
Headstock	Horizontal member(s) attached at or near the top of a trestle or pier, on which the superstructure bears.
I	
Intermediate Transom	Timber transverse member set between top and bottom girders in a ballast top span.
Invert	Base or floor of a structure.
J	
Jack Arch	Form of bridge decking in which small concrete or masonry arches infill run between main longitudinal steel girders.
M	
Maintenance	The actions necessary to preserve the serviceability, reliability and safety of a structure at or near its current level and to slow the rate of deterioration.
Mast	An independent vertical column located adjacent to the track for the support of overhead wiring etc.
Minor opening	Underbridge less than 10 metres in length.
O	
Obvert	Underside of bridge superstructure.
Overbridge	Bridge carrying road vehicles or livestock over a track.
P	
Packing	Piece of timber, steel, or other hard material, placed or driven between members to adjust their relative position.

Superseded by MN C 10301 v3.0, 18/10/2021

Parapet	A type of barrier comprising a solid wall or post and rail fence along the sides of overbridges and footbridges, installed to protect road vehicles, cyclists and pedestrians from falling over the edge of the bridge.
Pier	Intermediate support of bridge spans between abutments, built of solid construction and usually in concrete or masonry.
Pile	A vertical or inclined member driven or cast in the ground to support a trestle, pier, sill, abutment, wall or other superstructure. Includes: Batter pile – set at an angle to the vertical to resist sidesway Planted pile – set in excavated hole then backfilled and compacted Plumb pile – vertical pile Potted pile – set in concrete below ground level Pumping pile – a pile that is moving vertically in the ground under load Spliced pile – two or more pile sections joined end-to-end by plates Stump pile – pile section left in the ground after top removed.
Pipe	Hollow longitudinal void near the centre of a timber member where the heartwood is usually situated.
Pitting	An extremely localised form of corrosive attack that results in holes or hollows in metal. Pits can be isolated or so close together that they may look like a rough surface.
Portal	An overhead structure consisting of side masts or columns joined at the top by a horizontal girder.
Protection screen	Screen installed on overbridges and footbridges to prevent accessibility to a safety screen and to restrict objects from falling or being thrown onto the track below.
R	
Refuge	A 'safe area' provided along a bridge, retaining wall or in a tunnel.
Rockfall shelter	A structure installed over and beside a rail track to prevent loose material from adjacent cuttings falling on to the rail line.
Rot	Internal decay of a timber member caused by fungal attack.
Rehabilitation	The actions necessary to restore a structure to its originally intended level of service in order to retain it in service for as long as possible. It is characterised by major repairs that are remedial in nature, are more costly and less frequent than those undertaken for maintenance.
Repair	The actions necessary to increase the current level of serviceability, reliability and/or safety of a structure.
Runner	Longitudinal member bolted to girders and transoms to hold transoms to correct spacing.
S	
Safe area	A place where people and equipment will not be hit by a passing train.
Safety screen	Impenetrable barrier intended to prevent persons from contacting 1500 volt DC equipment and to protect the equipment from damage.
Safety walkway	An area along an underbridge where personnel can walk without falling through to the ground.
Scaling	The gradual and continuous loss of surface mortar and or aggregate over irregular areas of concrete. It most frequently affects horizontal surfaces exposed to the weather or traffic, but could also be an indication of frost or salt attack.

Superseded by MN C 10301 v3.0, 18/10/2021

Screwing up	Maintenance process of tightening up body and other bolts to improve the load capacity of a timber bridge.
Service crossing	Structure carrying commercial product or utilities over or under a track and across the railway corridor.
Shakes (in timber)	Complete or partial separation, usually across the timber grain and due to causes other than shrinkage. Possible causes of shakes are due to felling of the tree, impact loading, stream forces or wind force.
Shear zone	That area of a member near to a support, where a force acts through the member.
Sheeting	Timber planks or steel panels, restraining the fill behind a wall type structure.
Sill	Concrete or masonry footing supporting a trestle.
Soffit	The underside of a bridge superstructure.
Spalling	Drummy or loose concrete, masonry or stone surfaces, which may have been initiated by corrosion of reinforcement or by heavy impact.
Span	Deck of a bridge between adjacent substructure supports. Also the distance between girder supports.
Spandrel wall	A wall carried on the extrados (upper convex surface) of an arch, filling the space below the deck.
Split	Fissure in a timber member running parallel to the grain, from one face right through to the opposite face.
Station platform	Line-side structure built to provide public access to passenger trains.
Strain	The lengthening or shortening of a member under load.
Strengthening	The form of enhancement which increases the load carrying capacity of a structure above the original design level. It is characterised by major repairs which are more costly and less frequent than maintenance.
Stress	Internal “pressure” in a member under load.
Substructure	The supports for a bridge deck including trestles, piers, abutments and foundations.
Subway	Underbridge passing over a pedestrian pathway.
Superstructure	The deck or “top part” of a bridge spanning between supports.
T	
Tension face	The face of a member that is in tension. For beams it is usually the lower face and in particular near mid-span. For a cantilever or a continuous member it is the upper face over the supports.
Teredo	Marine borer which destroys timber in tidal areas.
Termite	Insect (incorrectly called white ants) which attacks timber by eating the cells, causing strength loss.
Through span	Span type where the main girders rise above track level.
Tip end sheeting	Sheeting behind extended timber girder ends of abutments.
Transom	Structural member (usually timber) laid across girders for attachment of rails on transom top spans.
Transom top	Underbridge where the track is directly fixed to the superstructure and metal ballast is not provided.

Superseded by MN C 10301 v3.0, 18/10/2021

Trestle	Intermediate support for bridge spans between abutments, usually constructed as a timber or steel frame.
Troughing	Pipe in timber member starting at the top face.
Truss	Girder made from two horizontal members (top and bottom chords), joined by vertical and diagonal members.
U	
Underbridge	A bridge supporting a track and passing over waterways, roadways, pathways and flood plains etc. Includes culverts.
V	
Viaduct	An underbridge consisting of multiple spans with total length over 100 metres.
W	
Waling	Headstock constructed from 2 pieces of timber bearing on pile
Waterway	Clear area under a bridge for water to run through.
Wing	Piles and sheeting or concrete or masonry wall restraining embankment on each side of an abutment.

Superseded by MN C 10301 v3.0, 18/10/2021

19 APPENDIX 2: Typical Bridge Spans and Members

The following figures are attached, illustrating a number of different types of bridge structures that exist on the network, together with their major components:

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- Figure 13 - Footbridge and stepway 117
- Figure 14 - Rolled steel sections 118

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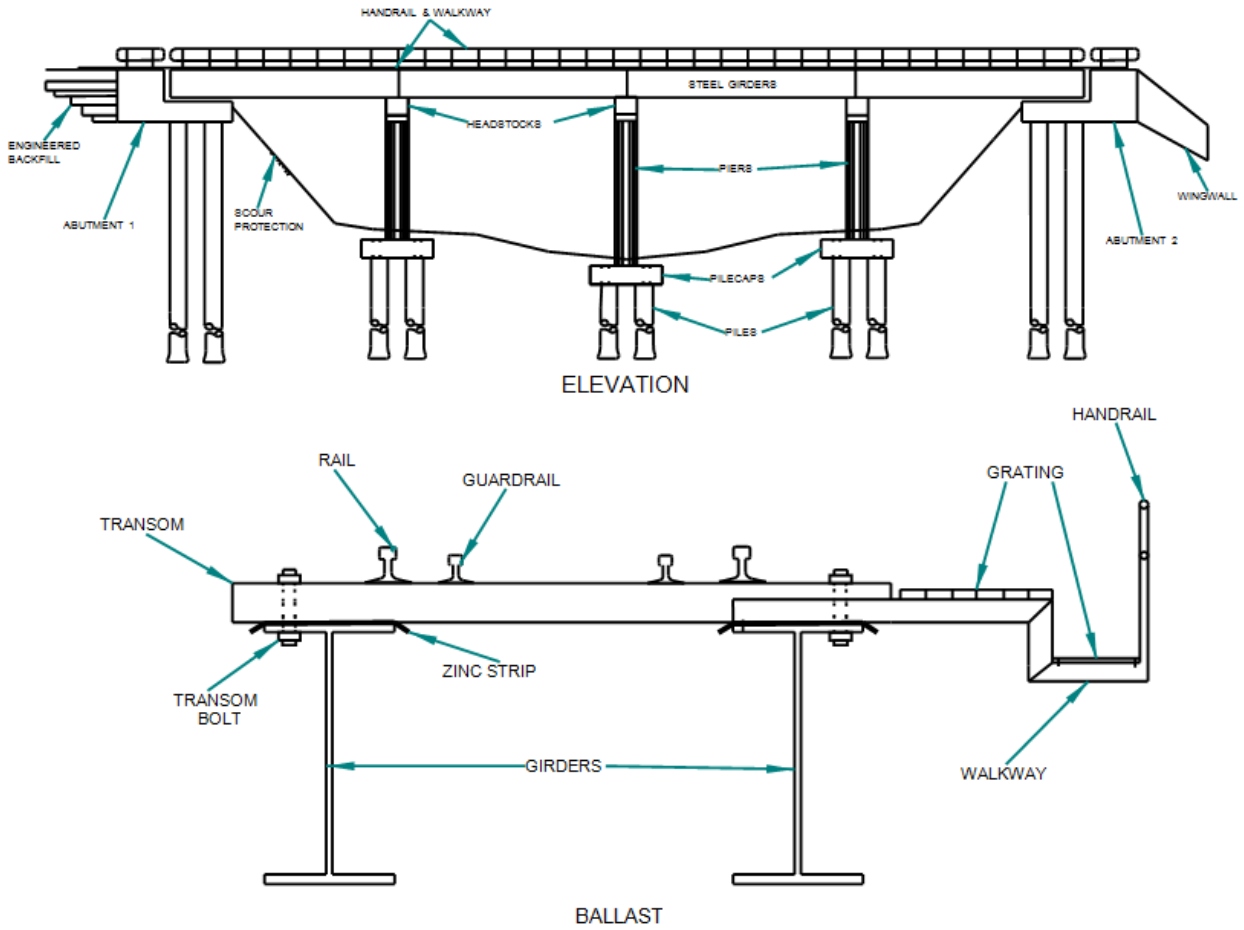

Figure 1: Transom top underbridge

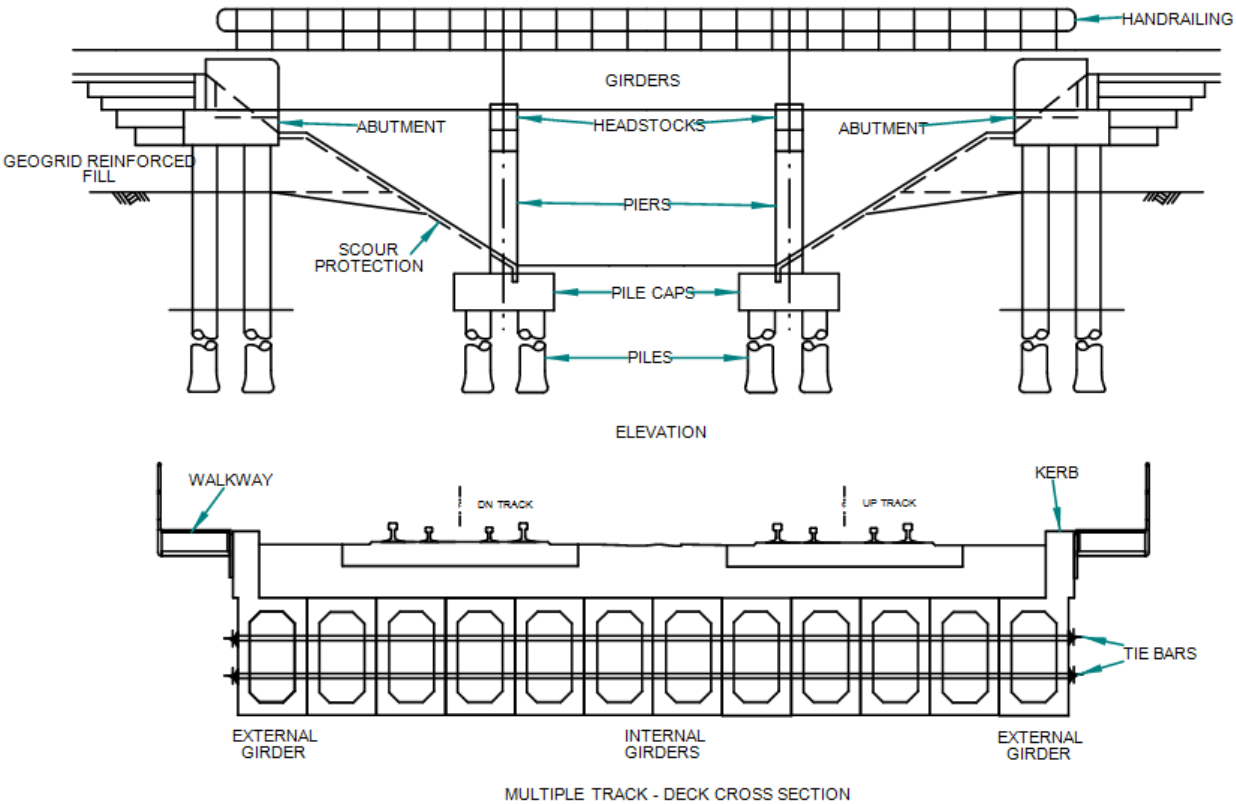

Figure 2: Ballast top underbridge

Superseded by MN C 10301 v3.0, 18/10/2021

Superseded by MN C 10301 v3.0, 18/10/2021

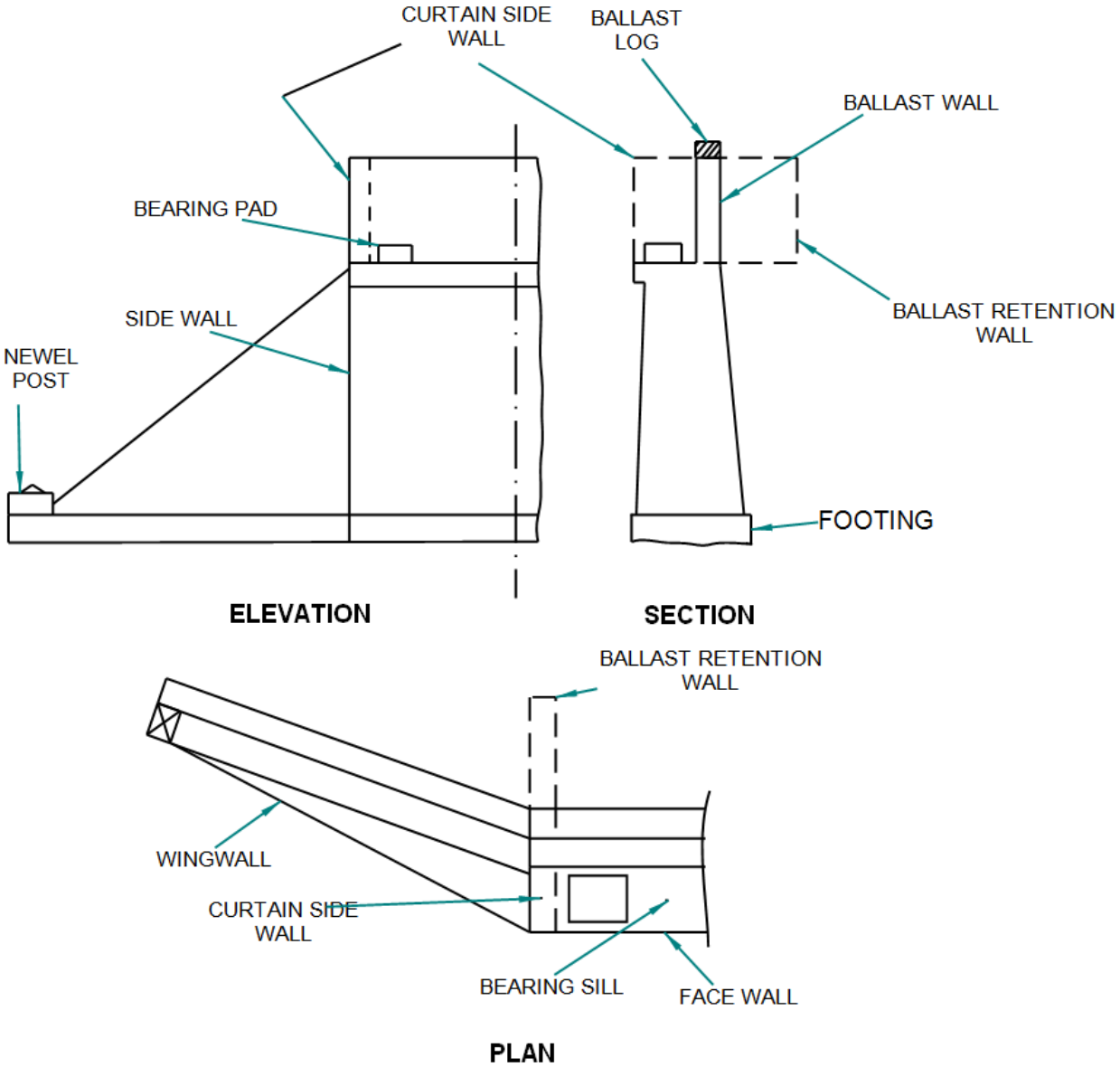

Figure 3: Bridge abutment – component terminology

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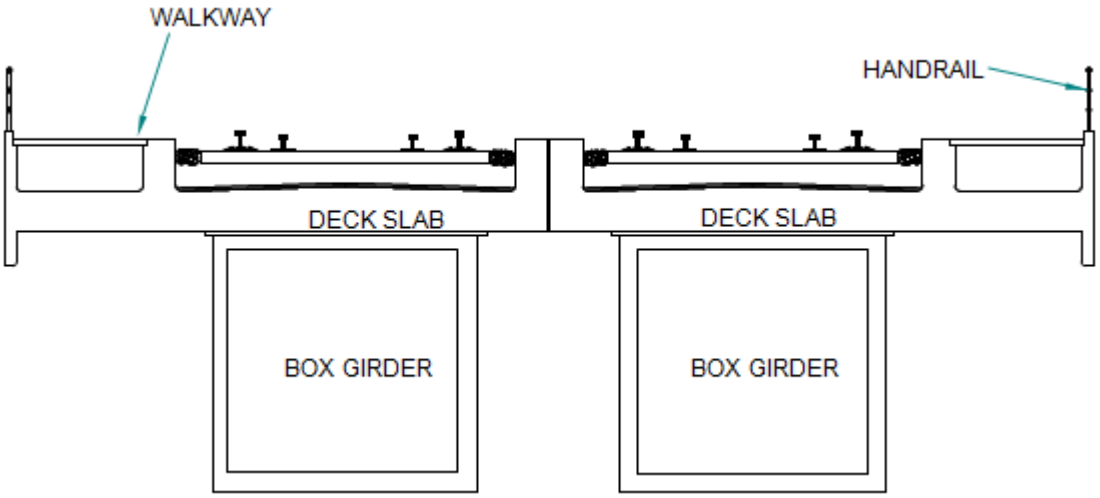

Figure 4: Concrete box girder multiple track

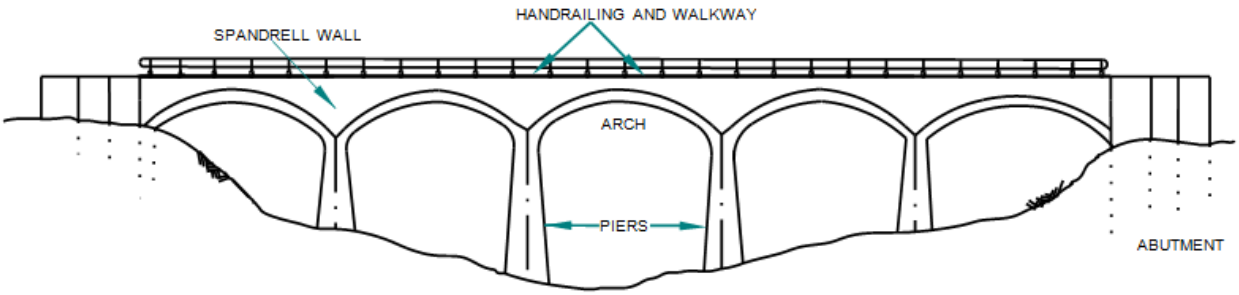

Figure 5: Masonry arch bridge

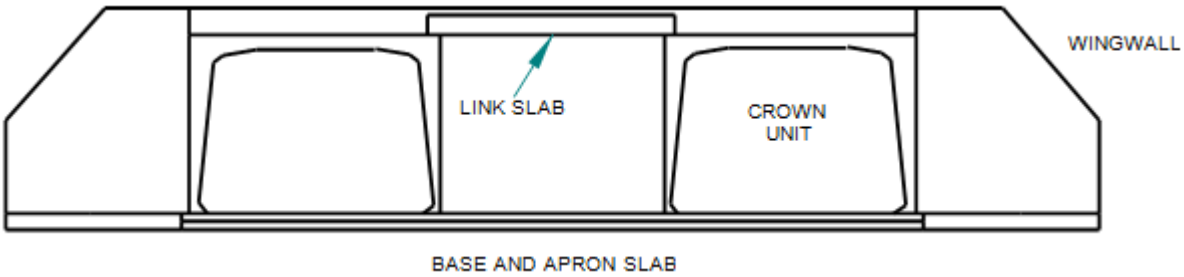

Figure 6: Concrete box culvert

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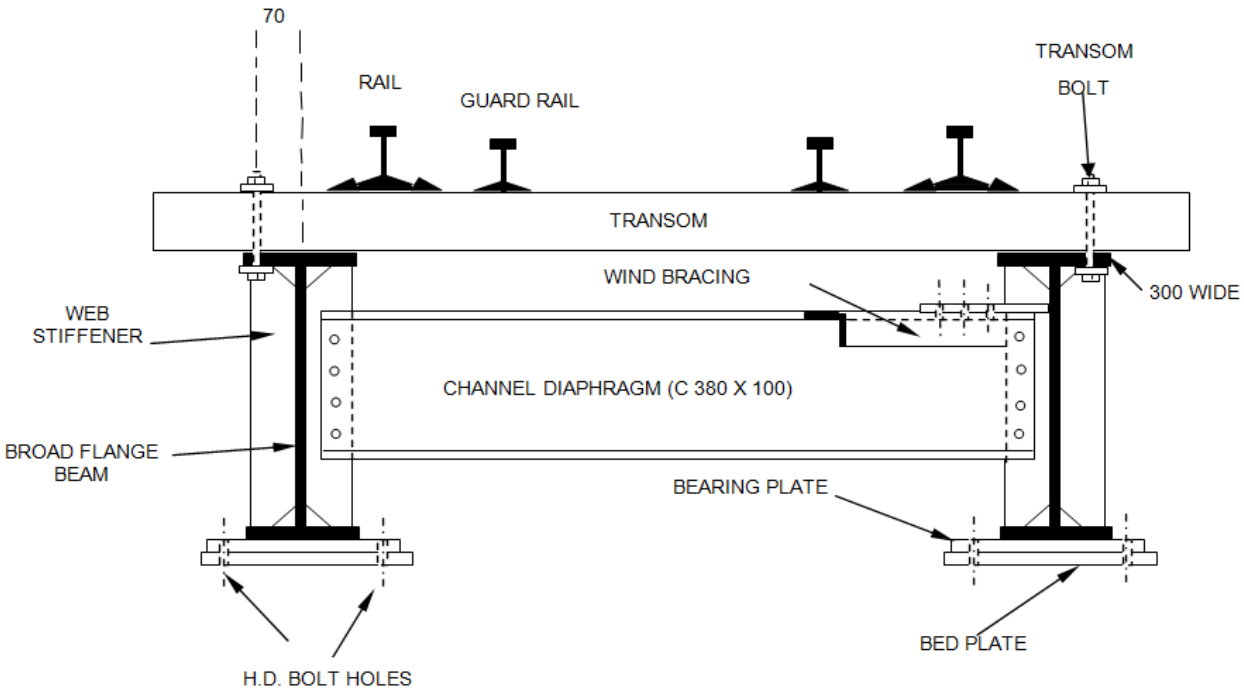
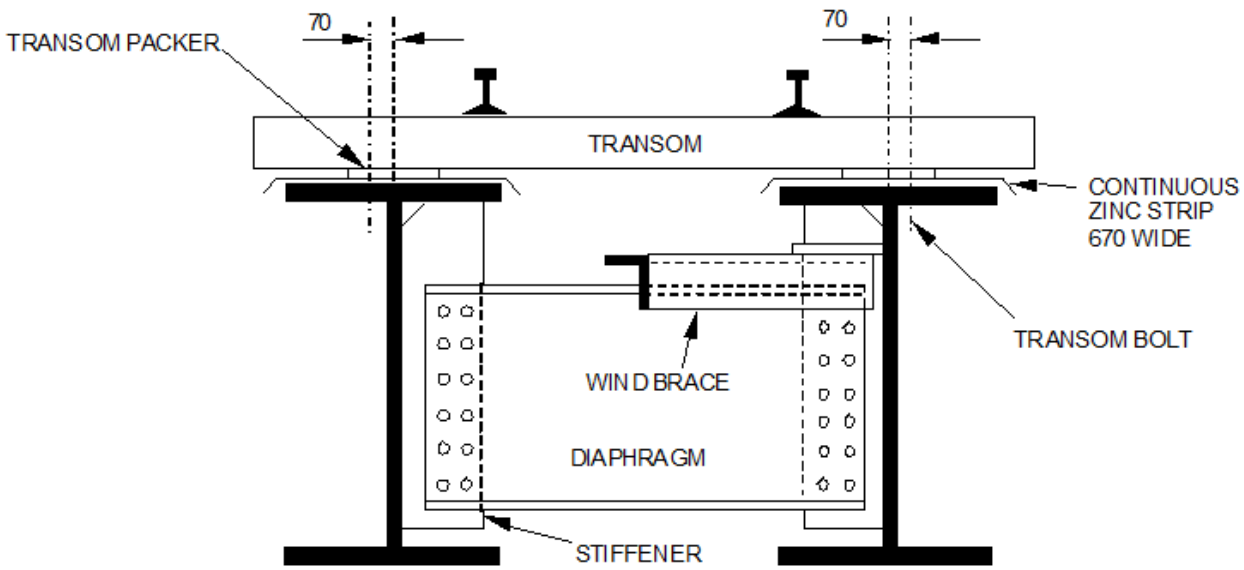
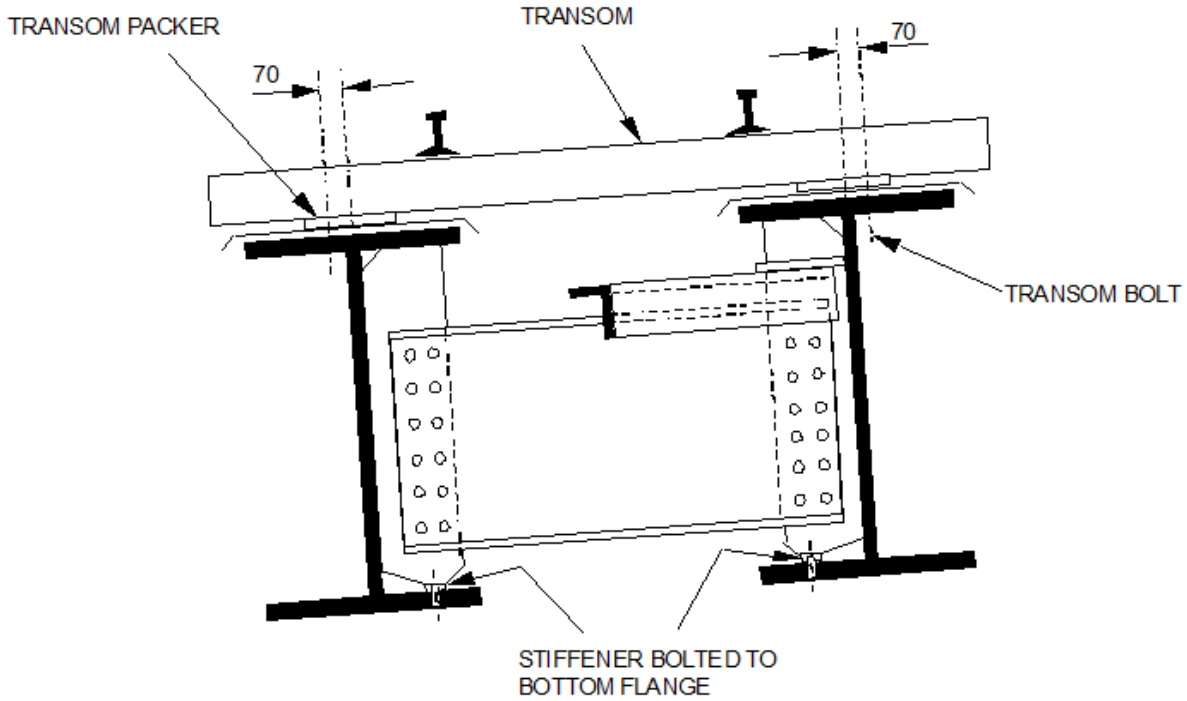


Figure 7: Broad flange beam (BFB) span

Superseded by MN C 10301 v3.0, 18/10/2021



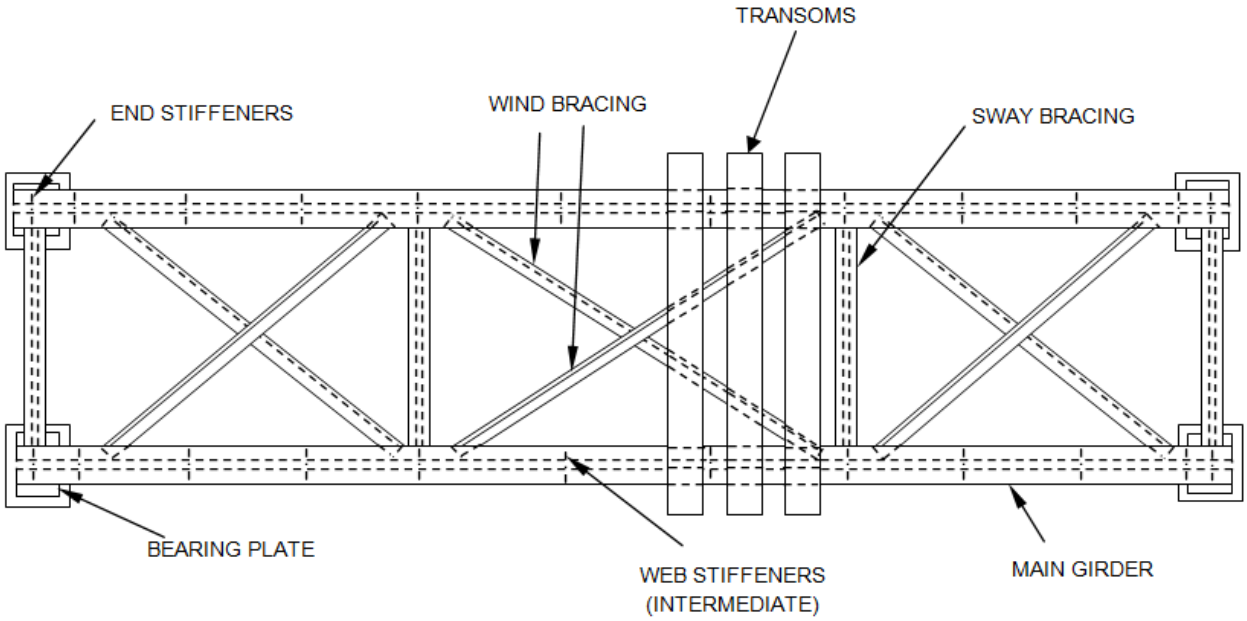
TYPICAL SECTION
ORIGINAL DESIGN



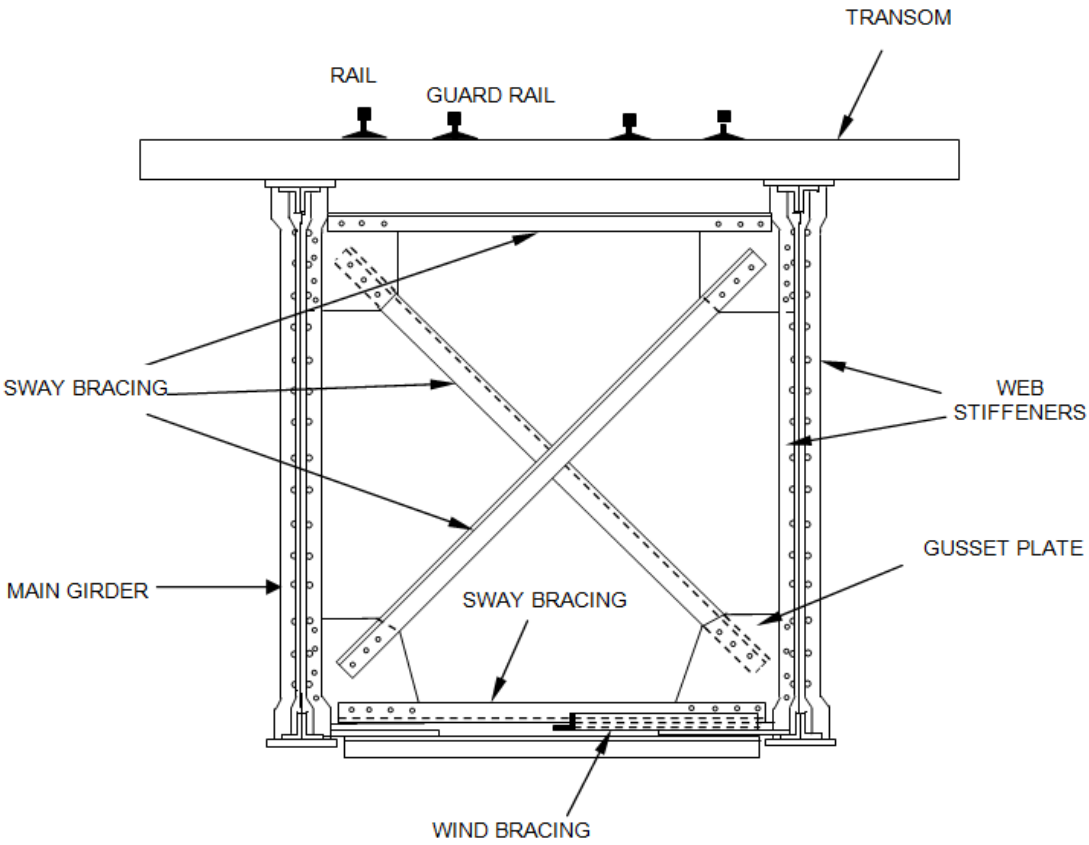
TYPICAL SECTION
MODIFIED DESIGN

Figure 8: Plate web girder (PWG) welded deck span

Superseded by MN C 10301 v3.0, 18/10/2021



PLAN



TYPICAL SECTION

Figure 9: Plate web girder (PWG) rivetted deck span

Superseded by MN C 10301 v3.0, 18/10/2021

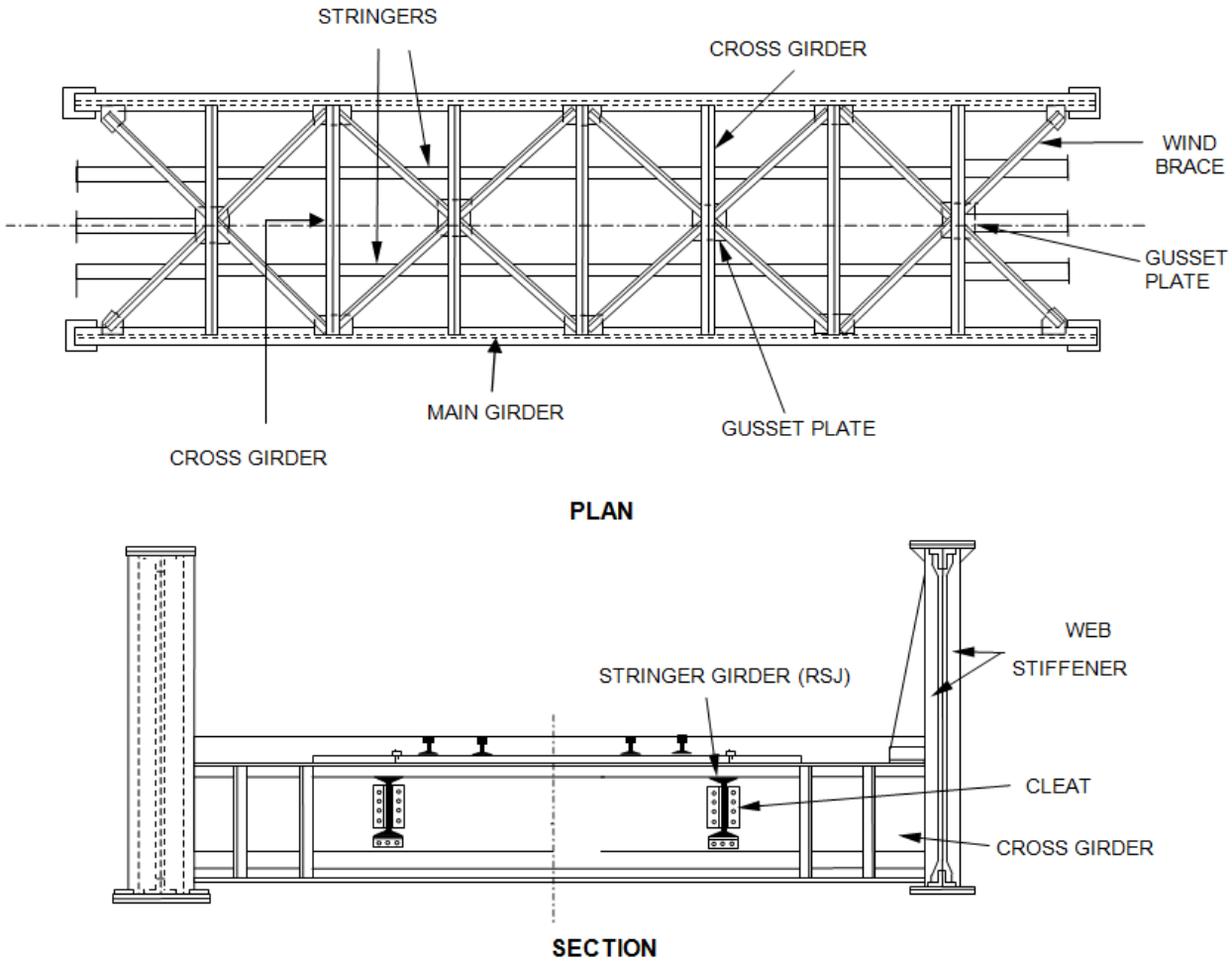


Figure 10: Plate web girder (PWG) rivetted through span

Superseded by MN C 10301 v3.0, 18/10/2021

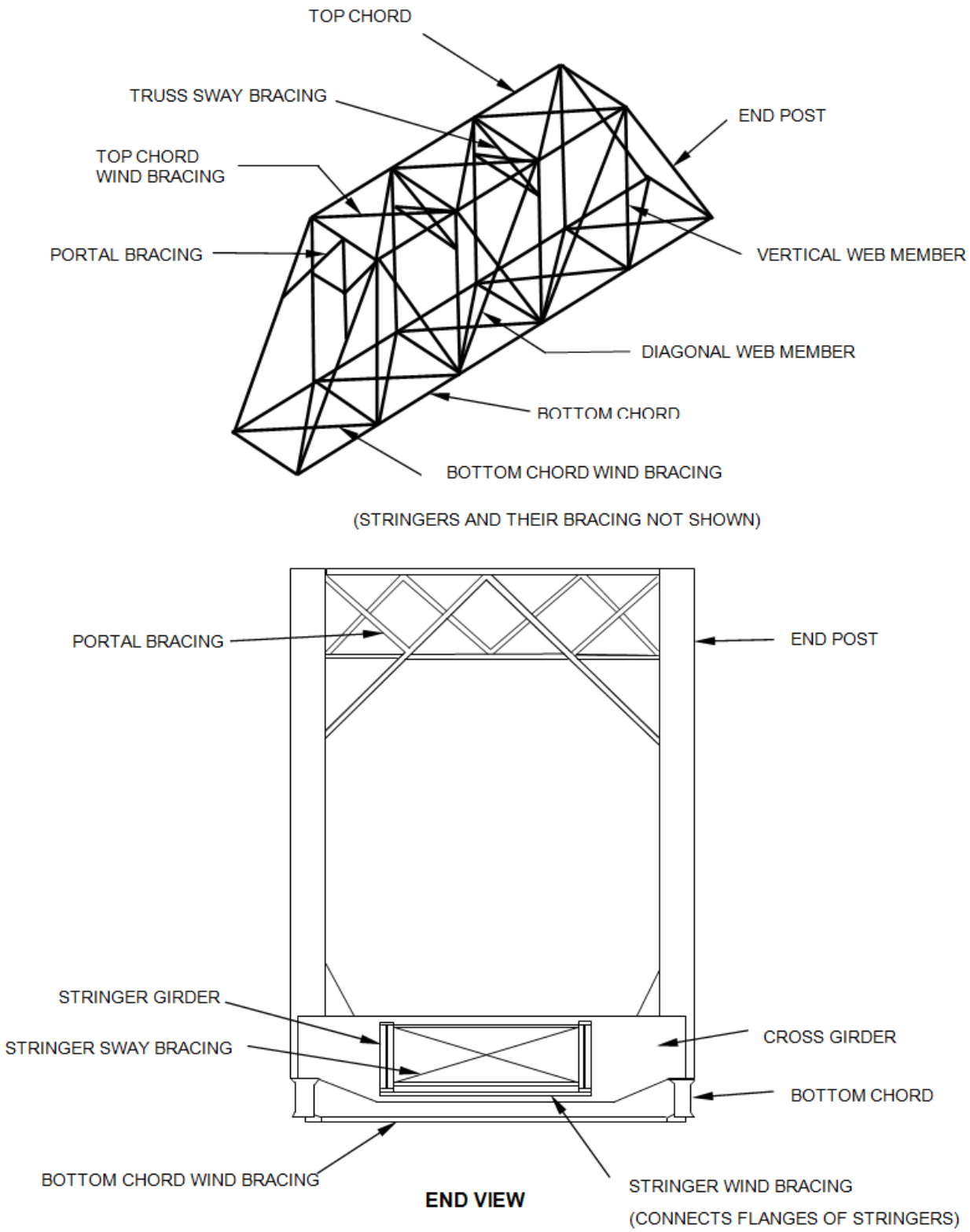


Figure 11: Truss girder through span

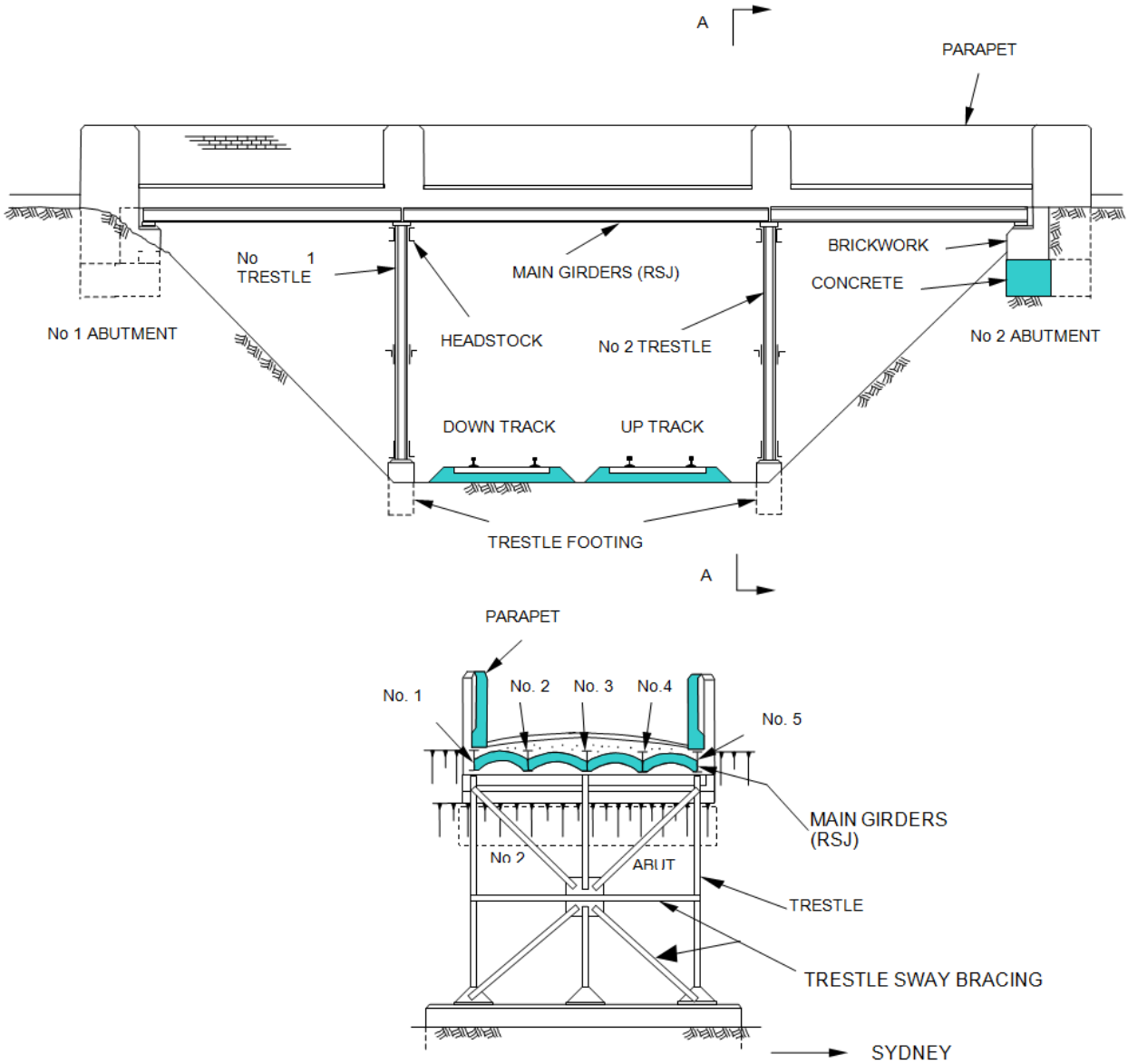


Figure 12: Steel overbridge jack arch span

Superseded by MN C 10301 v3.0, 18/10/2021

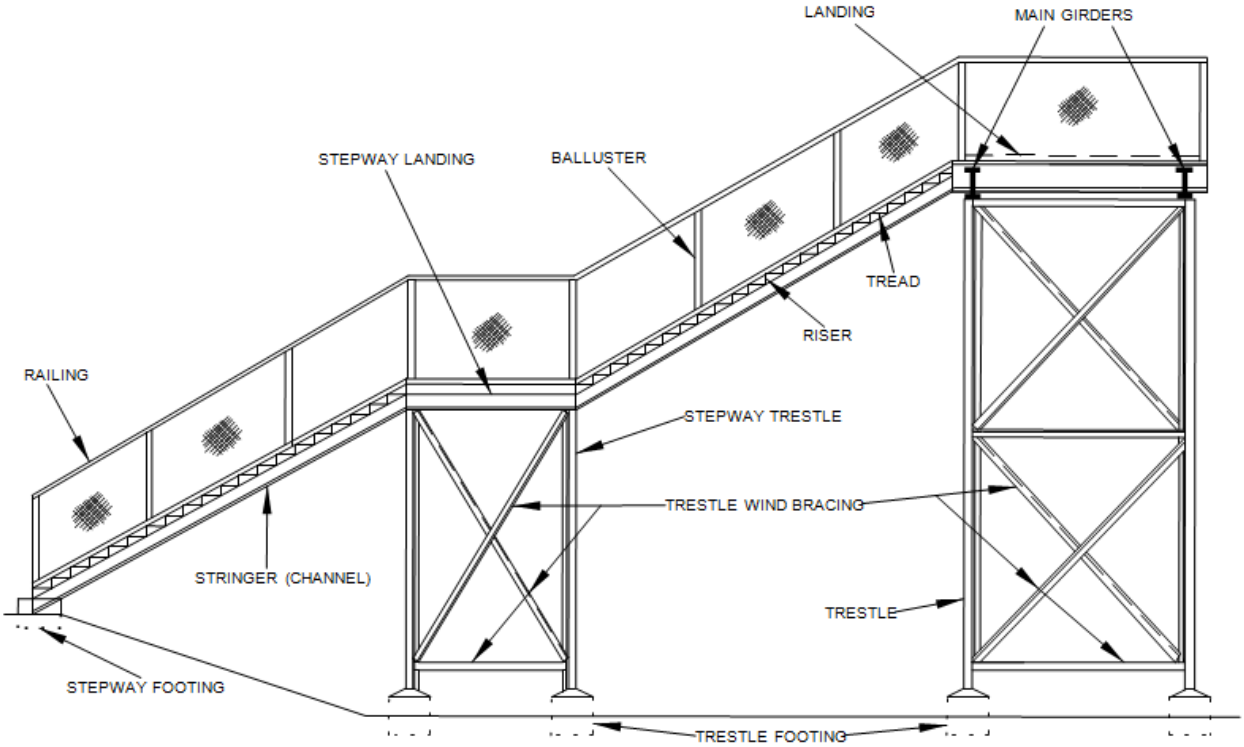


Figure 13: Footbridge and stepway

Superseded by MN C 10301 v3.0, 18/10/2021

Superseded by MN C 10301 v3.0, 18/10/2021

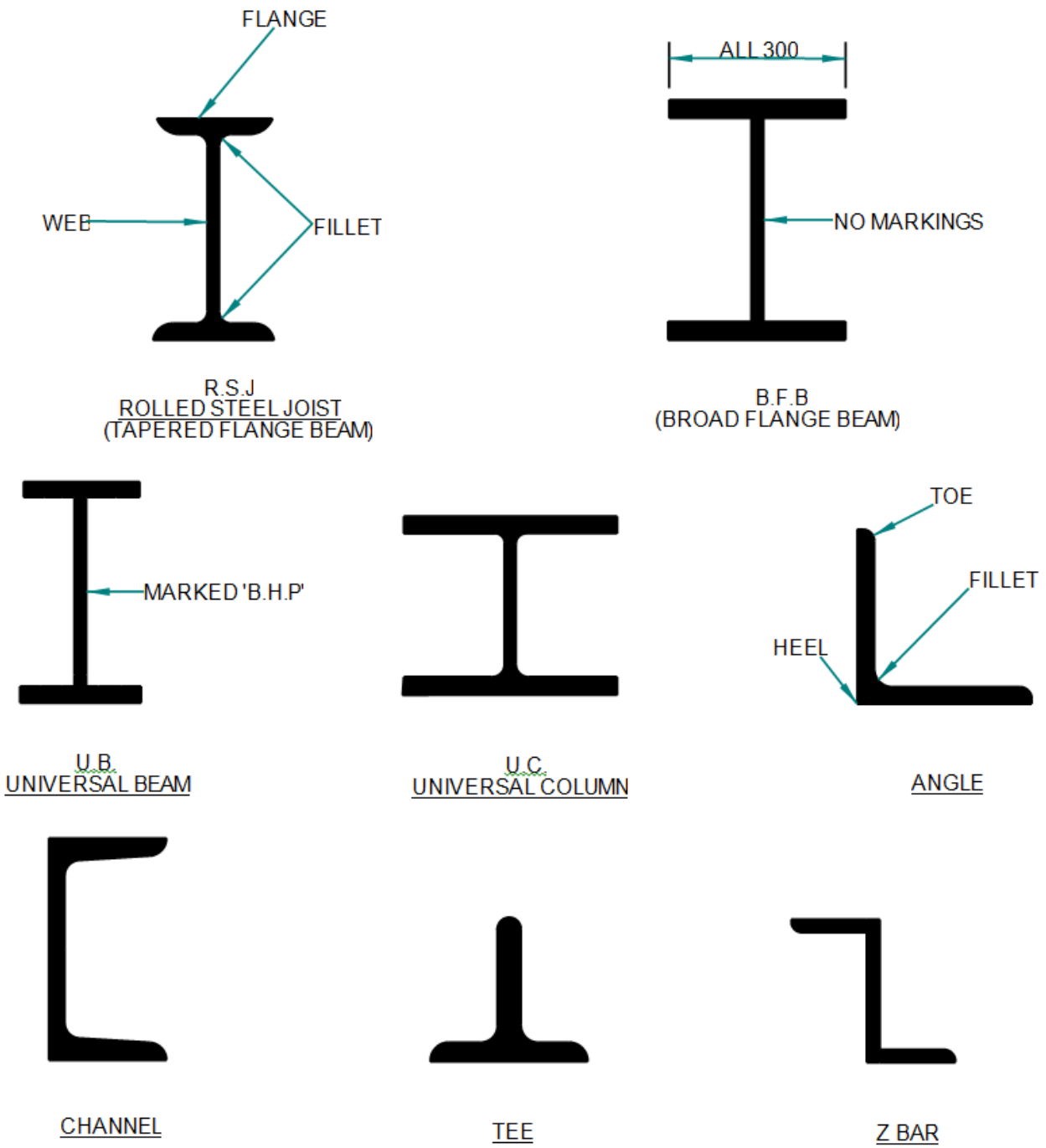


Figure 14: Rolled steel sections

Superseded by MN C 10301 v3.0, 18/10/2021

20 APPENDIX 3: Standard Defect Categories and Responses

20.1 Defect Categories and Responses

Defect Category	Bridge Examiner/ Structures Officer Response	Structures Manager Response
EXCEEDENTS		
A	Immediately stop trains in the case of an underbridge, or close if an overbridge or footbridge. Advise Structures Co-ordinator/Territory Civil Engineer immediately for further assessment.	Assess immediately.
B	Immediately impose a 20km/hr speed restriction in the case of an underbridge. Advise Structures Co-ordinator/Territory Civil Engineer immediately for further assessment. For footbridges and overbridges, the area is to be barricaded and a report provided to the Structures Co-ordinator/Territory Civil Engineer the same day.	Assess the same day for underbridges. Assess within 24 hours for footbridges and overbridges.
C	Report to Structures Co-ordinator/Territory Civil Engineer the same day for him to take appropriate action within 24 hours.	Assess within 24 hours.
D	Report to Structures Co-ordinator/Territory Civil Engineer on the Weekly Summary of Exceedents Form for the appropriate action.	Assess within 7 days.
NON-EXCEEDENTS		
E	Record in bridge examination report.	Assess as part of bridge management process.

Superseded by MN C 10301 v3.0, 18/10/2021

20.2 Repair Priorities

Rm1	Repair within 1 month	Applies to Defect Categories A to D
Rm6	Repair within 6 months	Applies to Defect Categories A to D
Ry1	Repair within 1 year	Could apply to any Defect Category
Ry2	Repair within 2 years	Could apply to any Defect Category
Ry5	Repair within 5 years	Applies to Defect Category E only
Ryxx	No repair for 5 years, reassess then	Applies to Defect Category E only
Mm1	Monitor monthly	Applies to Defect Categories A to D
Mm3	Monitor quarterly	Applies to Defect Categories A to D
Mm6	Monitor half yearly	Applies to Defect Categories A to D
My1	Monitor yearly	Applies to Defect Categories A to D
Axx	Assess/Inspect next inspection	Applies to Defect Category E only

20.3 Paint Indices

Paint Indices are to be assigned by the Bridge Examiner or Structures Officer for all steel structures that they examine. The indices reflect the condition of the surface coating, the order of the indices from worst to best being P1, P2 and P3.

They are defined as:

Paint Index P1	Paint broken down throughout Programme to paint within 5 years
Paint Index P2	Paint broken down locally Patch paint as required within 2 years
Paint Index P3	Paint in satisfactory condition

The paint index is to be recorded on the examination report.

Superseded by MN C 10301 v3.0, 18/10/2021

21 APPENDIX 4: Defect Limits

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
A. Underbridges – Steel and Wrought Iron				
For steel, wrought iron and broad flange beam underbridges items in the table are defined as follows: **Main structural members** are main girders, cross girders, stringers, truss chords, diagonals and verticals, columns, trestle legs and headstocks. **Secondary structural members** are bracing, bearing/bed plates, gusset plates, bearing and web stiffeners, tie bars etc. An **element** of a member is typically a flange or web and may consist of multiple plates and/or angles. For piers, abutments, wingwalls and reinforcement see Underbridges – Concrete				
Main member (excluding BFBs)	New crack or extension of previously assessed crack	More than 80mm long (total if old and new)	A – Stop trains	
		50 - 80mm long (total if old and new)	B – 20kph speed Observe under load	
		10 - 49mm long (total if old and new)	B – 20kph speed	
	New crack	0 - 9mm long	C – 24hr action	
	Missing	Any	A – Stop trains	
Main member	Crack at bearing zone	More than 300mm	B – 20 kph speed	
		Less than or equal to 300mm	C – 24hr action	
Main member	Corrosion loss	Perforation to any element	C – 24hr action	
		More than 30% section loss	C – 24hr action	
		10% to 30% section loss	D – Weekly exceedent	
		Less than 10% section loss	E – Record	
Secondary member	Crack	Any	D – Weekly exceedent	
	Missing	Any	B – 20kph speed	
	Corrosion loss	Perforations to any element	D – Weekly exceedent	
Main Member Fastenings (at connections)	Bolts / Rivets missing	More than 50%	A – Stop trains	
	Loose	More than 50%	B – 20kph speed	
	Loose / Missing	30% to 50%	B – 20kph speed	
		10% to 30%	C – 24hr action	
		Up to 10%	D – Weekly exceedent	Ry2
Main Rivets		More than 50% of rivet heads	C – 24hr action	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
	Corroded away in any 600mm length of girder	Less than or equal to 50% of rivet heads	D – Weekly exceedent	Ry2
Secondary Fastenings	Missing	More than 50%	B – 20kph speed	
	Loose	More than 50%	C – 24hr action	
	Loose / Missing	30% to 50%	D – Weekly exceedent	
		Up to 30%	E – Record	Ry2
Segmental Bearings	Locked over	-	D – Weekly exceedent. Reset but only after structural /geotechnical investigation into abutment stability	
Bed or Bearing Plate HD Bolts	Missing / Broken	More than 30%	D – Weekly exceedent	
		Up to 30%	E – Record	Ry2
Bed Plate	Broken	-	D – Weekly exceedent	
Bearing Pads	Broken / Missing mortar	More than 25%	D – Weekly exceedent	
		Up to 25%	E – Record	
Flaking paint	Any	D – Weekly exceedent		
Impact Damage				
Track	Out of alignment (bridge has moved)	More than 50mm	A – Stop trains	
		30mm – 50mm	B – 20kph speed	
		Less than 30mm	C – 24hr action	
Main member	Major structural damage	Structure likely to be unable to carry load	A – Stop trains	
Girder Flange	Flange outstand deformed vertically	More than 60% of outstand width	A – Stop trains	
		30% to 60% of outstand width	B – 20 kph speed	
		20% to 29% of outstand width	C – 24hr action	
		Up to 20% of flange outstand width	D – Weekly exceedent	
	Flange deformed horizontally within bracing bay	More than 60mm	B – 20kph speed	
		30mm – 60mm	C – 24hr action	
		20 - 29mm	D – Weekly exceedent	
		Up to 20mm	E – Record	
	Notched	More than 30mm	A – Stop trains	
		Up to 30mm	B – 20 kph speed	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
Trestle	Column deformed in any direction	More than 100mm	A – Stop trains	
		50 - 100mm	B – 20kph speed	
		25 - 49mm	D – Weekly exceedent	
		Up to 25mm	E – Record	
Main Rivets	Sheared off in any 600mm length of girder	More than 50% of rivets	C – 24hr action	
		Up to 50% of rivets	D – Weekly exceedent	
Any Joint Fastenings	Rendered ineffective	More than 50%	B – 20kph speed	
		Less than or equal to 50%	C – 24hr action	
B. Underbridges – Broad Flange Beams				
All the above limits for steel and wrought iron underbridges applies to B.F.B. underbridges except for the "Main Girder/Truss", "New Crack" items which are to be replaced with the following.				
Unplated B.F.B. spans				
BFB Flange	Crack	More than 25mm	A – Stop trains	
		10 - 25mm	B – 20kph speed and observe under load. Stop road traffic during passage of each train	
		5 - 9mm	B – 20kph speed	
		Less than 5mm	C – 24hr action	
Plated B.F.B. spans				
Both BFB Flange **and** Flange plate	Crack	More than 25mm	A – Stop trains	
		10 - 25mm	B – 20kph speed and observe under load. Stop road traffic during passage of each train	
		5 - 9mm	B – 20kph speed	
		Less than 5mm	C – 24hr action	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS								
Member	**Defect Type**	**Defect Size**					**Defect Category**	**Mandatory Repair Priority**
Either BFB Flange **or** Flange plate	Crack	More than 50mm					A – Stop trains	
		20 - 50mm					B – 20kph speed and observe under load. Stop road traffic during passage of each train	
		10 - 19mm					B – 20kph speed	
		Less than 10mm					C – 24hr action	
C. Underbridges – Timber								
The following maintenance limits are based on nominal 300mm x 300mm timber section								
Girder/Corbel	Pipe / Trough in any girder or corbel	More than 250mm					A – Stop trains	
		226 - 250mm					B – 20kph speed	
		200 - 225mm					C – 24hr action	
		151 - 199mm					D – Weekly exceedent	
		50 - 150mm					E – Record	
	Crushing						B – 20kph speed	
Solid Headstock	Pipe / Trough	More than 250mm					A – Stop trains	
		226 - 250mm					B – 20kph speed	
		200 - 225mm					C – 24hr action	
		151 - 199mm					D – Weekly exceedent	
		50 - 150mm					E – Record	
	Crushing	Any					B – 20kph speed	
Girder	Mid span deflection	Exceeds values tabulated below:					B – 20kph speed	
		Span (m)	4.27	4.57	7.32	7.92		
		De-flection (mm)	8	9	20	22		
Girder/Corbel small section 250x150mm	Rotted out						B – 20kph speed	
Waling Headstock	Rotted out						B – 20kph speed	
Waling Sill	Rotted out						C – 24hr action	
Body Bolts	Loose	More than 25%					D – Weekly exceedent	
		Less than or equal to 25%					E – Record	
Corbel bolts	Loose	More than 25%					D – Weekly exceedent	
		Less than or equal to 25%					E – Record	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
Trestle Bolts	Loose	More than 25%	D – Weekly exceedent	
		Less than or equal to 25%	E – Record	
Piles	Section loss in more than 50% of piles in any trestle or abutment	More than 75%	A – Stop trains	
	Section loss in more than 25% of piles in any trestle or abutment	More than 75%	B – 20kph speed	
	Section loss in any pile	More than 75%	C – 24hr action	
		50% to 75%	D – Weekly exceedent	
		40% to 49%	E – Record	
	Pumping	Any	D – Weekly exceedent	
Decking	Split or rotted out	More than 20%	E – Record	
Any Timber Section	Termite infestation	Any evidence of damage	C – 24hr action	
D. Underbridges – Timber Transoms (FFU Transom – Refer to Professional Head, Civil Engineering)				
Transoms	Ineffective	3 Adjacent	B – 20kph speed	
		2 Adjacent	C – 24hr action	
		2 in 3	D – Weekly exceedent	
		One isolated	E – Record	
Transom Bolts	Missing	3 Adjacent transoms	B – 20kph speed	
		2 Adjacent transoms	C – 24hr action	
		One transom (2 bolts) isolated	D – Weekly exceedent	
	Loose	Any	E – Record	Ry2

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
E. Underbridges – Concrete				
Main-P.S.C or R.C	Differential deflection between units under live load	Visible	C – 24hr action	
Main-P.S.C	Crack	Other than shrinkage (surface) crack more than 0.3mm	B – 20kph speed	
Main-R.C	Crack	More than 2mm wide	C – 24hr action	
		0.5 - 2mm wide	D – Weekly exceedent	Ry2
Main Reinforcing. Bar	Section loss in one bar	More than 30%	D – Weekly exceedent Undertake diagnostic testing	
Stirrup Reinforcing.	Section loss in one bar	More than 60%	D – Weekly exceedent Undertake diagnostic testing	
Prestressing Ducts/Tendons	Exposed	Any	C – 24hr action	
Piers/Abutments	Crack	More than 5mm wide and 1 metre long especially under bearings	C – 24hr action	
		2 - 5mm wide	D - Weekly exceedent	
Wingwall	Crack	More than 5mm wide and 2 metres long	C – 24hr action	
		2 - 5mm wide	D – Weekly exceedent	
	Lateral dislocation	More than 20mm	D – Weekly exceedent	
Abutments and wingwalls	Horizontal displacement	More than 50mm	C – 24hr action	Mm1
	Rotation	More than 1H:20V	C – 24hr action	Mm1
	Cracking at embankment/fill behind wall	More than 10mm wide crack parallel to wall and more than 2m long	C – 24hr action	Mm1
	Earth slump or slip at embankment/fill behind wall	Readily visible and more than 2m long	C – 24hr action	Mm1
Deck	Spalling	More than 1 square metre with exposed reinforcing	D – Weekly exceedent Undertake diagnostic testing	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
		300mm x 300mm and no reinforcing exposed	E – Record Undertake diagnostic testing	Ry2
Deck - joint between slabs	Fouling with ballast/debris	Any	D – Weekly exceedent	
Bearings		Any degradation	D – Weekly exceedent	
Impact Damage				
Main	Deformation	Any	A – Stop trains	
Main-P.S.C or R.C.	Crack	Other than shrinkage (surface) crack more than 0.3mm	A – Stop trains	
F. Underbridges – Masonry and Concrete Arch				
For piers, abutments, wingwalls and reinforcement see **Underbridges – Concrete**				
Arch Ring	Brickwork dislocation	More than 30% in any square metre missing or unbonded	B – 20kph speed	
		10% to 30% in any square metre missing or unbonded	D – Weekly exceedent	
	Longitudinal cracking (along arch barrel)	More than 3mm wide, through and across full arch width. Visible differential movement under live load	A – Stop trains	
		2 - 3mm and not through and across	C – 24hr action	
		Less than 2mm and not through and across	D – Weekly exceedent	
	Circumferential cracking (along arch profile)	More than 6mm wide and more than 2m long along arch	C – 24hr action	
		3 - 6mm wide, or more than 6mm wide and less than 2m long along arch	D – Weekly exceedent	
	Distortion of profile	More than 50mm - detectable by undulations in top line of spandrel walls / parapets or track	B – 20 kph speed	
		20 - 50mm	D – Weekly exceedent	
Other than Arch	Brickwork dislocation	More than 50% in any square metre missing or unbonded	C – 24hr action	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
		20% to 50% in any square metre missing or unbonded	D – Weekly exceedent	
Spandrel Wall	Displacement	Longitudinal more than 30mm, or more than 20mm longitudinal + 20mm tilt	C – 24hr action	
		15 - 30mm	D – Weekly exceedent	
Culvert floor	Heaving	More than 50mm	D – Weekly exceedent	
		25 - 50mm	E – Record	
Any other	Brickwork dislocation	Nil	D – Weekly exceedent	
Brickwork mortar	Missing or loose	More than 30% in any square metre missing or loose	D – Weekly exceedent	
		10 - 30% in any square metre missing or loose	E – Record	
G. Culverts and Pipes				
For undefined elements and reinforcement see **Underbridges – Concrete**				
Culvert	Collapse	Subsidence of formation/ballast	A – Stop trains	
		No subsidence of formation/ballast	B – 20kph speed	
	Blocked	50% to 100%	C – 24hr action	
		30% to 50%	D – Weekly exceedent	
		10% to 30%	E – Record	Ry2
Culvert	Cracked barrel	More than 30mm wide	B – 20kph speed	
		10 - 30mm	D – Weekly exceedent	
		Less than 10mm	E – Record	
Corrugated Metal Pipe	Joint Broken	-	D – Weekly exceedent	
	Out of round / distortion	More than 50mm	D – Weekly exceedent	
Headwall / Wingwall	Cracked	More than 50mm wide	B – 20kph speed	
		10 - 50mm wide	D – Weekly exceedent	
		Less than 10mm	E – Record	
Apron	Scouring under	More than 2m	C – 24hr action	
		Any	D – Weekly exceedent	
Floor	Heaving	More than 50mm	D – Weekly exceedent	
		25 - 49mm	E – Record	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
Adjacent Waterways	Blocked - Geotechnical risk site	More than 25%	C – 24hr action	
	Blocked	More than 25%	D – Weekly exceedent	
H. Footbridges and Overbridges				
In addition to the following, Underbridge Maintenance Standards for underbridges also apply where applicable				
Brick parapets	Horizontal crack	More than 3mm wide and more than ½ of parapet width and more than 2m long	D – Weekly exceedent	
Brick parapets	Vertical crack	Any crack full height and full width of parapet	D – Weekly exceedent	
Pedestrian Safety Aspects				
The bridge and stepway maintenance triggers described are of a structural nature and intentionally do not cover defects in walking surface finishes, i.e. tiles, etc. and associated anti-slip requirements				
Pedestrian Barriers	Missing / Broken	Any	B – Seal off area	
	Missing / Displaced chain wire infill	Any	B – Seal off area	
	Missing vertical balusters	Any	B – Seal off area	
	Missing displaced metal sheet	Any	B – Seal off area	
	Loose	Any	D – Weekly exceedent	
	Missing bolts	Any	D – Weekly exceedent	
Traffic Barriers	Missing / Broken / Loose	Any	C – 24hr action	
Deck	Walkway planks	Broken, decayed, missing or displaced	B – Seal off area	
	Cracks in AC/FC sheets	Any	B – Seal off area	
Deck-Nails, Screws	Protrusion above deck	More than 10mm	C – 24hr action	
		Less than or equal to 10mm	D – Weekly exceedent	
Safety Screens	Missing / Broken	Any	B – Seal off area	
Safety Screen Fixings	Defective	More than 50%	C – 24hr action	
		25% to 50%	D – Weekly exceedent	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
Timber Railing, Posts	Section loss	More than 25%	D – Weekly exceedent	
Protection Screens	Missing / Broken / Loose	Any	D – Weekly exceedent	
	Missing bolts	Any	D – Weekly exceedent	
Stepways (also includes balustrade and handrail references above)				
R.C. Stepway Tread	Broken front edges	More than 150mm long x 35mm deep	C – 24hr action	
		More than 50mm long x 15mm deep	D – Weekly exceedent	
	Cracked	More than 2mm wide	D – Weekly exceedent	
R.C. Stepway Landing	Cracked	More than 2mm wide	D – Weekly exceedent	
		Less than 2mm wide	E – Record	
Stepway Reinforcing	Protruding at toe	Any	C – 24hr action	
Stepway Tread	Rocking between heel and toe	More than 5mm	C – 24hr action	
		2 - 5mm	D – Weekly exceedent	
	Slope heel to toe	More than 15mm	D – Weekly exceedent	
		5 - 15mm	E – Record	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
I. Underbridge walkways and refuges				
Walkway and Refuge Handrails	Missing / Broken	Any	B – Seal off area	
Walkway and Refuge Planks	Broken, decayed, displaced or missing	Any	B – Seal off area	
Walkway fastenings	Loose or missing	Any	D – Weekly exceedent	
J. Underbridge guardrails				
Guardrail	Missing	-	D – Weekly exceedent	
	Undersize	-	D – Weekly exceedent	
Vee section	Missing / End not closed	-	D – Weekly exceedent	
Fastenings	Missing / Loose	-	D – Weekly exceedent	
K. Underbridge road/pedestrian safety aspects				
Clearance signs	Missing	-	D – Weekly exceedent	
	Not legible	-	D – Weekly exceedent	
Ballast	Falling	-	C – 24hr action	
L. Underbridge Ballast Logs/Walls				
Ballast Log	Missing / Rotted out	-	D – Weekly exceedent	
Ballast Wall	Decayed, displaced or missing	-	D – Weekly exceedent	
M. Overhead Wiring Structures and Signal Gantries				
Structural member	Corrosion loss	Perforation to any element	C - 24hr action	
		More than 20% section loss	*D – Weekly exceedent*	
	Loose / Missing bolts	*Any*	*D – Weekly exceedent*	
Masts or portal structure	Leaning off vertical	More than 50mm from design	D – Weekly exceedent	
Guy foundation	Dislodged	-	D – Weekly exceedent	
N. Tunnels				
Roof/Wall	Brickwork dislocation	More than 30% in any square metre missing or unbonded	C – 24hr action	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
		10% to 30% in any square metre missing or unbonded	*E – Record*	
	Longitudinal cracking *(along tunnel)*	*More than 5mm wide and more than 5m long*	*B – 20kph speed*	
		2 - 5mm and more than 5m long	*C - 24hr action*	
		Less than 2mm and more than 5m long	*D – Weekly exceedent*	
	Circumferential cracking *(along tunnel profile)*	*More than 5mm wide and more than 2m long along tunnel profile*	*D – Weekly exceedent*	
		More than 5mm wide and less than 2m long along tunnel profile	*E – Record*	
	Spalling	*Through the lining or of whole bricks*	*D – Weekly exceedent*	
	Seepage	*Causing corrosion of track fastenings*	*D – Weekly exceedent*	*Ry1*
		Any	*E – Record*	
Portal	Crack	More than 50mm wide	B – 20kph speed	
		10 - 50mm wide	D – Weekly exceedent	
		Less than 10mm	E – Record	
O. Retaining Walls and Platform Walls				
Mass concrete walls, reinforced concrete walls, masonry walls (excluding platform walls)	Crack	More than 10mm wide and more than 2m long	C – 24hr action	
		More than 10mm wide and less than 2m long	D – Weekly exceedent	
		5 - 10mm wide	E – Record	
Refer to 'All walls (movement)' for movement parameters	Lateral dislocation	More than 20mm	C – 24hr action	
		10 - 20mm	E – Record	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
Reinforced concrete panels at post and panel walls Refer to 'All walls (movement)' for movement parameters	Crack	More than 5mm wide and more than 1m long	C – 24hr action	
		More than 5mm wide and less than 1m long	D – Weekly exceedent	
		2 - 5mm wide	E – Record	
	Lateral dislocation (within panel)	More than 5mm	C – 24hr action	
		2 - 5mm	E – Record	
Reinforced concrete panels at reinforced soil wall Refer to 'All walls (movement)' for movement parameters * Inspection of ties where inspection sample provide	Crack	More than 5mm wide and more than 1m long	C – 24hr action	
		More than 5mm wide and less than 1m long	D – Weekly exceedent	
		2mm – 5mm wide	E – Record	
	Lateral dislocation (within panel)	More than 5mm	C – 24hr action	
		2 - 5mm	E – Record	
	Lateral dislocation between panels	More than 50mm	C – 24hr action	
Concrete crib walls Refer to 'All walls (movement)' for movement parameters	Loss of crib filling	Wall area with unfilled cribs more than 1m^2	C – 24hr action	Mm1
	Loss of fill behind wall	Wall area with fill loss more than 1m^2 (estimated from the face of the wall) or more than 1m length (estimated from the top of the embankment)	C – 24hr action	
	Local deformation	Deformed area more than 1 m^2 with misalignment greater than 75mm	C – 24hr action	
	Concrete interfaces – Crushing	Crushing at ≥ 3 adjacent interfaces	C – 24hr action	
	Concrete elements – Evidence of spalling, rust stains, etc.	Any	E – Record	
	Drainage system – Evidence of ineffective system	Any	D – Weekly exceedent	
	Vegetation Growth	Extent ≥ 5m^2	E – Record	

Superseded by MN C 10301 v3.0, 18/10/2021

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
	Tree stump	≥ 100mm diameter	D – Weekly exceedent	
Platform wall Refer to 'All walls (movement)' for movement parameters	Crack	More than 50mm wide	C – 24hr action	
		10 - 50mm wide	D – Weekly exceedent	
		Less than 10mm	E – Record	
Platform coping	Separation of coping from platform surface and/or wall (tension crack)	Visible	D – Weekly exceedent Check clearances for possible infringement	
	Broken edging	Any	D – Weekly exceedent	
All walls (movement)	Horizontal displacement	More than 50mm	C – 24hr action	Mm1
	Rotation	More than 1H:20V	C – 24hr action	Mm1
	Cracking at embankment/fill behind wall	More than 10mm wide crack parallel to wall and more than 2m long	C – 24hr action	Mm1
	Earth slump or slip at embankment/fill behind wall	Readily visible and more than 3m long	C – 24hr action	Mm1

Notes:

1. These defect limits apply to retaining walls that are not part of a bridge substructure. Refer to **E. Underbridges – Concrete** for defect limits for bridge abutments and wingwalls.
2. The location and extent of defects shall be measured carefully (for example, stringlines or survey) and recorded on the examination report.
3. Expert geotechnical advice shall be obtained within 7 days for all defects covered by **All walls (movement)**, in particular where tension cracks are found at the top.
4. The indicated mandatory repair priorities are the minimum response to the defect until it has been properly assessed and confirmed that a different response is appropriate.

APPENDIX 4: DEFECT CATEGORY LIMITS				
Member	**Defect Type**	**Defect Size**	**Defect Category**	**Mandatory Repair Priority**
P. Gabion Walls				
Gabion baskets - bridges	Damaged	Loss of tension/Rocks spilling out	D – Weekly exceedent	
	Lateral dislocation	More than 100mm	D – Weekly exceedent	

Superseded by MN C 10301 v3.0, 18/10/2021

22 APPENDIX 5: Structurally Critical Members

Span Type	Structurally Critical Member	Details of Critical Areas
A. Steel and wrought iron underbridges		
Plate web deck, RSJ and BFB	Main girders	Bottom flange: middle third of span and at any changes in flange plates
		Top flange: middle third of span and over intermediate piers
		Flange and web splices
		Web: at support
Plate web through	Main girders	Bottom flange: middle third of span and at any changes in flange plates
		Top flange: middle third of span and over intermediate piers
		Flange and web splices
		Web: at support
	Cross girders	Bottom flange and end connections
		Flange and web splices
		Web: at support
	Stringers	Bottom flange: middle half of span, at any changes in flange plates and end connections
		Web: at support
Trusses	Top chord	Whole member including connections
	Bottom chord	Whole member including connections
	Web verticals	Whole member including connections
	Web diagonals	Whole member including connections
	Portal frames	All frames including end connections
	Cross girders	Bottom flange and end connections
		Flange and web splices
		Web: at support
	Stringers	Middle half of span, at any changes in flange plates and end connections
		Flange and web splices
		Web: at support
B. Timber bridges		
All spans	Girders	Middle third (bending) and over corbels (shear)
	Corbels	Over headstocks (shear)
	Headstocks	Nil
	Piles	At ground level , and 500mm above and below ground level

Superseded by MN C 10301 v3.0, 18/10/2021

Span Type	Structurally Critical Member	Details of Critical Areas
C. Concrete bridges		
All spans	Pre-Stressed Concrete Girders	Middle third of span
		Over supports (shear)
	Reinforced Concrete Girders	Middle third of span
		Over supports (shear)

Superseded by MN C 10301 v3.0, 18/10/2021

23 APPENDIX 6: Structures Examination Report Forms

Superseded by MN C 10301 v3.0, 18/10/2021

23.1 Typical bridge examination report

(Check SAP for the current form)

Line and Km: ILLAWARRA 56.727KMS		**Report Date:** **Data as at Closing Business on:** **Examination Type:**	
Location: STANWELL PARK – STANWELL CK VIADUCT UndB		**Examination Date:**	
Region:	113 – Metro Illawarra	***File No.***	NK
Work Group:	NK	***Invert/Rail Level:***	NK
Equipment No:	15648	***Flood/Rail Level:***	NK
MIMS SPN:	I00UB10113MAIN_56.727	***Clearance Sign:***	N/A
Previous Station:	NK	***Bridge Clearance:***	N/A
Bridge Type:	Br Underbr XingWaterway/Land	***No of Crash Beams:***	NK
Span Configuration:	1/14.3 br + 6/15.7 br + 1/14.3 br	***Crash Beam Clearance:***	N/A
		No Tracks On/Under:	2 / -
Construction Date:	01/06/1921	***Track Alignment:***	R 240
Earliest/Latest Span:	1921 / 1985		
Strengthened Date:	NK	***Superelevation, Database:***	100 – 100mm
Repair Dates:	NK	***Superelevation Noted:***	NK
Painted dates:	NK	***Guard Rail on Track:***	NK
Drawing No:	9-136	***Signs:***	NK
SPANS REPORTED: Arch Span: 001DE, 002DE, 003DE, 004DE, 005DE, 007DE, 008DE. Deck Girder Span: 006DE, 006E.		**TRACKS OF BRIDGE:** D I00 DNMN 10113, E I00 UPMN 10119	

OVERALL CONDITION (DAD)					
Str Cond Index	**Worst Def Cat**	**Paint Index**	**Design capacity**	**As New Rating**	**As Is Rating**
	E		M 270	M 270	M 270

EQUIPMENT EXAMINATIONS (MIMS)						
Std Job No	Sched Desc	Work Group	Freq	Last Sch	Last Perf	Next Sch
P26002	Detailed Underbridge Inspection	ILL116	730	15/05/2004		15/05/2006
P26012	Mid Cycle Underbridge Examination	ILL116	730	15/05/2005		15/05/2007
P26036	Steel Bridge Exam – Underbridge	ILL116	720	15/05/2004		15/05/2006

COMMENTS (DAD)			
Action	Date	Comments/Observation	Originator

Examiner	Sign	Date
Structures Co-ordinator	Sign	Date

Line and Km: ILLAWARRA 56.727KMS		**Report Date:** **Data as at Closing Business on:** **Examination Type:**	
Location: STANWELL PARK – STANWELL CK VIADUCT UndB		**Examination Date:**	
Region:	113 – Metro Illawarra	***File No.***	NK
Work Group:	NK	***Invert/Rail Level:***	NK
Equipment No:	15648	***Flood/Rail Level:***	NK
MIMS SPN:	I00UB10113MAIN_56.727	***Clearance Sign:***	N/A
Previous Station:	NK	***Bridge Clearance:***	N/A
Bridge Type:	Br Underbr XingWaterway/Land	***No of Crash Beams:***	NK
Span Configuration:	1/14.3 br + 6/15.7 br + 1/14.3 br	***Crash Beam Clearance:***	N/A
		No Tracks On/Under:	2 / -
Construction Date:	01/06/1921	***Track Alignment:***	R 240
Earliest/Latest Span:	1921 / 1985		
Strengthened Date:	NK	***Superelevation, Database:***	100 – 100mm
Repair Dates:	NK	***Superelevation Noted:***	NK
Painted dates:	NK	***Guard Rail on Track:***	NK
Drawing No:	9-136	Signs:	NK
SPANS REPORTED: Arch Span: 001DE, 002DE, 003DE, 004DE, 005DE, 007DE, 008DE. Deck Girder Span: 006DE, 006E.		**TRACKS OF BRIDGE:** D I00 DNMN 10113, E I00 UPMN 10119	

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Components	Cat	Span/Supp	Defect Desc	Comments	Pri'ty	By	Date Removed
CURRENT DEFECTS IN TEAMS 3							
Paint/Prot Coating See Text Desc	P3	US 006DE		Paintwork stained especially on bottom flanges Defect Id 141611	My1	B Examiner	
Paint/Prot Coating See Text Desc	P3	US 006E		Paintwork stained especially on bottom flanges Defect Id 141610	My1	B Examiner	
See Text Desc	D	Parent		Cracking in both parapets have been monitored and inspected since 1978 by examiner and geotech Defect Id 141614	My1	B Examiner	

Superseded by MN C 10301 v3.0, 18/10/2021

23.2 Typical culvert examination report

(Check SAP for the current form)

Line and Km: ILLAWARRA 32.336KMS		**Report Date:**	26/02/2006
		Data as at Closing Business on:	25/02/2006
		Examination Type:	Detailed
Location: HEATHCOTE CULVERTS		**Examination Date:**	18/02/2006
Region:	113 – Metro Illawarra	***File No.***	NK
Work Group:	NK	***Invert/Rail Level:***	N/A
Equipment No:	111658	***Flood/Rail Level:***	N/A
MIMS SPN:	I00CU10113MAIN_32.336	***No Tracks On/Under:***	- / -
Previous Station:	NK	***Track Alignment:***	
Culvert Type:	Culvert Medium Arch Section	***Superelevation, Database:***	NK
Length (m):	1/14.3 br + 6/15.7 br + 1/14.3 br	***Superelevation Noted:***	NK
Section Width (m):	1.5	***Signs:***	NK
Section Height (m):	1.5	***Drawing No:***	
Construction Date:	09/03/1918		
Repair Dates:	NK		
TRACKS OF BRIDGE:			

OVERALL CONDITION (DAD)		
Design Capacity	As New Rating	As Is Rating
Str Cond Index:	*Worst Defect Category:*	

EQUIPMENT EXAMINATIONS (MIMS)							
Std Job No	Sched Desc	Ind	Work Group	Freq	Last Sch	Last Perf	Next Sch
P31002	MID CYCLE INSPECTION OF CULVERT	1	ILL116	720	15/02/2005	20/03/2005	15/02/2007
P31001	DETAILED EXMINATION OF CULVERT	1	ILL116	720	15/02/2006	18/02/2006	15/02/2008

COMMENTS (DAD)			
Action	Date	Comments/Observation	Originator

Examiner Sign Date

Structures Co-ordinator Sign Date

Superseded by MN C 10301 v3.0, 18/10/2021

Line and Km: ILLAWARRA 32.336KMS		**Report Date:**	26/02/2006
		Data as at Closing Business on:	25/02/2006
		Examination Type:	Detailed
Location: HEATHCOTE CULVERTS		**Examination Date:**	18/02/2006
Region:	113 – Metro Illawarra	***File No.***	NK
Work Group:	NK	***Invert/Rail Level:***	N/A
Equipment No:	111658	***Flood/Rail Level:***	N/A
MIMS SPN:	I00CU10113MAIN_32.336	***No Tracks On/Under:***	- / -
Previous Station:	NK	***Track Alignment:***	
Culvert Type:	Culvert Medium Arch Section	***Superelevation, Database:***	NK
Length (m):	1/14.3 br + 6/15.7 br + 1/14.3 br	***Superelevation Noted:***	NK
Section Width (m):	1.5	***Signs:***	NK
Section Height (m):	1.5	***Drawing No:***	
Construction Date:	09/03/1918		
Repair Dates:	NK		

TRACKS OF BRIDGE:

Components	Cat	Span/Supp	Defect Desc	Comments	pri'ty	Last Mod' By / Found By	Date Removed
CURRENT DEFECTS IN TEAMS 3							
Culvert Outlet	0	Parent	Blocked / Obstructed	CLEAN CULVERT U/S Defect Id 191198	Ry1	B Examiner	
End Structure MA Head Wall	0	Parent	See text	INSTALL HEADWALLS UP and DN Defect Id 191196	Ry2	B Examiner	

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23.3 Timber bridge examination books

23.3.1 Introduction

As indicated in Section 12.2, Bridge Examiners are required to record the results of their examination of timber bridges and report them on a standard report form as detailed in this Appendix.

The format of the report is in the form of an exception report, similar to the reporting format that is used for steel, concrete and masonry structures. For timber bridge examinations, a Bridge Examination Book is also kept. This book provides a complete, easily read record of the “bore and probe” examination of all members of timber structures, from which condition assessment can be more readily made.

To promote a common approach, the following guidelines are provided for the format and content of Timber Bridge Examination Books.

The information is based mainly on the contents of the Sub-Inspectors (Bridges and Buildings) Correspondence Course (1957). Changes have been made to the format to take advantage of current technology. This section will be updated in a future revision.

Attachments 1A – 1E in Section 23.3 provide an example of completed forms for a bridge.

23.3.2 Format of the Book

- Use an A4 folder with removable pages.
- The number of bridges in each folder will depend on personal choice, but each bridge examination folder must have the cover labelled with:
  - the Area
  - Line
  - kilometrage from and to between the bridges.

BRIDGE EXAMINATION
XXX REGION
SOUTH COAST LINE

- Bridges must be entered in kilometrage order.
- DO NOT split a bridge between two folders.
- For each bridge the following forms are required (a detailed explanation of these forms is provided below):
  - Page 1 – Summary Information as shown on Attachment 1A
  - Page 2 – Form 1A – Component details as shown on Attachment 1B
  - Page 3 – Form 1B – Examination details as shown on Attachment 1C
  - Page 4 (if needed) – the next Form 1A – Component details as shown on Attachment 1D
  - Page 5 (if needed) – the next Form 1B – Examination details as shown on Attachment 1E

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- Page 6, 7, 8, etc. (if needed) – You need to write up as many forms as is needed to give complete details of the bridge. For example, a 20 span bridge might need 4 Form 1A's and 4 Form 1B's.

- Always start a new bridge record by inserting the Summary Information sheet on the right hand page.
- Always put Form 1A on a left hand page with its matching form 1B on the opposite (right hand page).

23.3.3 Preparation

23.3.3.1 Summary Information

The heading for each bridge must clearly show the correct kilometrage, then the type and an accurate description giving dimensions of the spans or openings. The maximum height from rail level to ground level or invert is to be given thus: RL/GL 1750mm. The description is to be brief and accurate.

Where information concerning previous flood levels is obtainable, this should be given in the book with reference to rail level and also the underside of the girder as well as the date or month and year. The flood level mark should also be shown on the down side of No. 1 abutment with a suitable permanent mark.

The existing superelevation of the track when the bridge is on a curve, should be shown. This should be checked throughout the bridge at frequent intervals and an average measurement adopted. The correct superelevation should also be given. This can be obtained from the track monuments, where they exist, or from Office records.

Note: Sydney Trains currently does not have a timber underbridge in the network.

23.3.3.2 Form 1A – Description of the bridge or opening

- Provide Location information at the top of the form. Since the recommended format is loose leaf, it is possible for forms to be displaced.
- Put a consecutive form number on the form – you will probably need more than one Form 1A for most bridges.
- Each form has line numbers. Since the forms are loose leaf it is important that you be able to line up information on Forms 1A and 1B. Line numbers are an effective way to achieve this.
- All bridge members, whether defective or otherwise, must be shown in the order of sequence as follows:
  - Bridge supports such as piles, trestles, concrete or brick abutments or piers, must be grouped together in order, commencing with No. 1 abutment, then No. 1, 2, 3, etc., trestles or piers, then No. 2 abutment and finally the wings.
  - As abutment, trestles or piers are the main supports of the bridge, they are of first importance and are shown first, making it easier to locate the position of any pile and its condition.

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23.3.3.3 Piles

The following columns are provided for the examination of piles and the information is to be set out as follows:

- location of pile, viz, number of abutment or trestle
- the number of the pile
- effective diameter at top and at ground level (in mm)
- height of pile head above ground level (in mm)
- driving mark (D.M) (in feet).

The driving mark refers to a mark made on the pile at a measured distance from the point or toe before driving, as well as to the Roman numerals cut in the face of the pile to indicate that distance.

- Height of driving mark above ground level (DM/GL) (in mm)
- Remarks, and whether spliced or planted.

If planted piles have been replaced by concrete sills this must be noted in the remarks column. Concrete piers or trestles, or steel trestles, must also be shown.

Any value and height above ground level of foundation depth marks on concrete abutments, piers or sills must also be shown.

23.3.3.4 Girders, etc.

Next in order of importance are the girders and they should be grouped in sequence, followed by corbels, headstocks, etc. The following columns are provided:

- number of span, abutment or trestle
- the number of the member
- size
- length
- remarks.

23.3.3.5 Form 1B – Entering Examination details

- Provide Location information at the top of the form.
- Put a consecutive form number on the form – you will need as many Form 1Bs as you have Form 1As.
- Each form has line numbers which match the associated bridge member on Form 1A.
- The form has been ruled up for four (4) examination cycles, rather than the traditional 5 cycles. Since it is possible to create multiple forms without rewriting the information in Form 1A, the choice of number of cycles to display on one form is arbitrary. More or less can be shown but you need to make sure there is enough space to clearly display all examination results.
- The actual recording of the bridge examination must first be made into a rough book on the site and afterwards copied to the permanent bridge examination book.

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23.3.3.6 Date and Results of Examination

The date of examination is to be shown at the head of each column as well as the name of the bridge examiner who carried out the examination. In this column is to be shown the location of the boring, i.e.:

- for girders - end, centre, and end
- for piles - top, ground level and 600mm below ground level (GL/2).

23.3.3.7 Indicating Defects

The figure showing the extent of the defect or pipe in the timber is given in mm, nothing below 50mm need be shown. Where dry rot or activity by white ants is present, the distinguishing letters “DR” or “WA” are shown on the notation sheet. Where no letter is shown, it is understood that the defect is a dry pipe (see Note 1 in Section 23.3.6).

The term “O.K.” is to be used to indicate sound timber.

23.3.3.8 Renewal of Timber

If the examiner considers that a defective member requires renewal or where the defect shows 150mm or over, the figure must be shown in red ink or underlined in red (see Note 2 in Section 23.3.6).

Superseded by MN C 10301 v3.0, 18/10/2021

23.3.4 Attachment 1A

EXAMINATION REPORT:			TIMBER
Summary Information			
REGION	*North West*	**FILE No.**	
DISTRICT	*Tamworth*	**DRAWING**	*NK*
LINE	*Narrabri – Walgett*	**RAIL/FLOOD LEVEL**	
SECTION	*Burren Jct - Walgett*	**R.L/I.L.(S.L)**	
SECTOR CODE		**LOAD/CLEAR. SIGNS**	
PREV. STATION	*Burren Jct*	**No. TRACKS**	*Single*
KILOMETRAGE	*647.543*	**TRACK ALIGNMENT**	*Straight*
LOCATION	*Waterway*	**SUPERELEVATION**	*Nil*
BRIDGE TYPE	*Underbridge TT*	**ROAD/RIVER**	*Battle Ck*
SPANS	*2/7.32 m*	**GUARD RAILS**	*YES*

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23.3.5 Attachment 1B

1	Timber Bridge Examination						Location	Walgett Line
	Form 1A – 1							647.543 km
2	***Pile Examination***							
3	***Location***		***Diam***		***H.P G.L***	***D.M***	***D.M G.L***	***Remarks (in pencil)***
4			***T***	***GL***				
5	*No.1 Abut*	*No.1 Pile*	*400*	*325*	*1800*			*Spliced, 4 butt straps, stump OK 1200 below GL*
6		*No.2 “*	*375*	*350*	*1800*	XI	*900*	
7		*No.3 “*	*425*	*325*	*1800*	X	*750*	
8	*No. 1 Trestle*	*No.1 Pile*	*425*	*325*	*1950*			*Replaced by concrete sill*
9		*No.2 “*	*400*	*300*	*1950*			
10		*No.3 “*	*400*	*325*	*1950*			
11	*No.2 Abut*	*No.1 Pile*			*1800*			*Replaced by concrete abutment*
12		*No.2 “*						
13		*No.3 “*						
14	*No.1 Wing*	*No.1 Pile*	*350*	*275*	*1800*	VII	*450*	
15		*No. 2 “*	*325*	*200*	*900*	VII	*600*	
16	*No.2 Wing*	*No.1 Pile*	*350*	*275*	*1800*	VII	*450*	
17		*No.2 “*	*325*	*200*	*900*	VII	*600*	
18	*No.3 Wing*	*No.1 Pile*						*Replaced by concrete wing*
19		*No.2 “*						
20	*No.4 Wing*	*No.1 Pile*						*Replaced by concrete wing*
21		*No.2 “*						

22	***Girders***				
23	***Location***		***Size***	***Length***	***Remarks***
24	*No.1 Span*	*No.1 Girder Top*	*300 X 300*	*8 760*	
25		*No.1 Girder Bottom*	“	“	
26		*No.2 Girder Top*	“	“	
27		*No.2 Girder Bottom*	“	“	
28		*No.3 Girder Top*	“	“	
29		*No.3 Girder Bottom*	“	“	
30	*No.2 Span*	*No.1 Girder Top*	“	“	
31		*No.1 Girder Bottom*	“	“	
32		*No.2 Girder Top*	“	“	
33		*No.2 Girder Bottom*	“	“	
34		*No.3 Girder Top*	“	“	
35		*No.3 Girder Bottom*	“	“	

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36	**Corbels**				
37	**Location**		**Size**	**Length**	**Remarks**
38	No.1 Abut	No.1 Corbel	300 X 300	2 900	
39		No.2 “	“	“	50mm timber packing to girder
40		No.3 “	“	“	
41	No. 1 Trestle	No.1 Corbel	“	“	
42		No.2 “	“	“	Split on Country end bolted
43		No.3 “	“	“	
44	No.2 Abut	No.1 Corbel	“	“	
45		No.2 “	“	“	
46		No.3 “	“	“	

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23.3.6 Attachment 1C

1	Form 1B - 1			**Timber Bridge Examination**				Walgett Line			647.543 km	
	Ex	**M Smith**				**Ex**		**Ex**			**Ex**	
	Date	3/8/02				**Date**		**Date**			**Date**	
2	***Piles***											
3	**T**	**GL**	**GL**	**T**	**GL**	**GL**	**T**	**GL**	**GL**	**T**	**GL**	**GL**
4			**500**			**500**			**500**			**2**
5												
6	*OK*	*OK*										
7	*50*	*50*										
8	*50*	*50*										
9	*100*	*75*										
10	*OK*	*OK*										
11												
12												
13												
14	*100*	*50*	*OK*									
15	*OK*	*OK*	*OK*									
16	*50*	*OK*	*75*									
17	*OK*	*50*	*60*									
18												
19												
20												
21												
22	***Girders***											
23	**E**	**C**	**E**	**E**	**C**	**E**	**E**	**C**	**E**	**E**	**C**	**E**
24	*OK*	*50 DR*	*50 DR*									
25	*OK*	*OK*	*OK*									
26	*50 DR*	*OK*	*50*									
27	*50*	*75*										
28	*OK*	*OK*										
29	*50*	*75*										
30	*OK*	*60*										
31	*50*	*OK*	*OK*									
32	*70*	*90*	*100*									
33	*OK*	*OK*	*OK*									
34	*100*	*75*	*OK*									
35	*OK*	*OK*	*50*									
36	***Corbels***											
37	**E**	**C**	**E**	**E**	**C**	**E**	**E**	**C**	**E**	**E**	**C**	**E**
38	*70*	*90*	*100*									
39	*OK*	*OK*	*OK*									
40	*100*	*75*	*OK*									
41	*OK*	*OK*	*50*									
42	*OK*	*50 DR*	*50 DR*									
43	*OK*	*OK*	*OK*									
44	*OK*	*OK*	*OK*									
45	*OK*	*OK*	*OK*									
46	*OK*	*OK*	*OK*									

Note 2
Show cross boring like this.
If defect reaches 150mm show in **RED**

Note 1
Show DRY ROT (DR) or WHITE ANTS (WA) like this.
If defect is a PIPE show size only

Superseded by MN C 10301 v3.0, 18/10/2021

23.3.7 Attachment 1D

47	**Timber Bridge Examination**				Walgett Line
	Form 1A - 2				647.543 km
48	***Headstocks***				
49	***Location***	***Size***	***Length***	***Remarks***	
50	*No.1 Abut*	*300 X 300*	*3 500*		
51	*No. 1 Trestle*	*“*	*“*		
52	*No.2 Abut*			*Concrete abutment – no headstock*	
53	***Walings***				
54	***Location***		***Size***	***Length***	***Remarks***
55	*No.1Trestle*	*No.1 waling*	*300 X 200*	*4 110*	
56		*No.2 “*	*“*	*“*	
57	***Bracing***				
58	***Location***		***Size***	***Length***	***Remarks***
59	*No.1Trestle*	*No.1 Brace*	*225 X 125*	*4 570*	
60		*No.2 “*	*“*	*“*	
61	***Transoms***				
62	***Number***		***Size***	***Length***	***Remarks***
63	*15*		*250 X 150*	*2740*	
64	***Sheeting***				
65	***Location***			***Size***	***Remarks***
66	*No.1 Abutment*			*225 X 75*	
67			*No.1 Wing*	*“*	
68			*No.2 “*		
69	*No.2 Abutment*				*Concrete wings*
70			*No.3 Wing*		
71			*No.4 “*		
72	***Guard Rails***				
73					
74	***General***				
75	*Screwed Up*				
76	*Treated for White Ants*				
77	*Other*				
78					

Superseded by MN C 10301 v3.0, 18/10/2021

23.3.8 Attachment 1E

47	Form 1B - 2	**Timber Bridge Examination**					Walgett Line			647.543 km		
	Ex	**M Smith**		**Ex**			**Ex**			**Ex**		
	Date	3/8/02		**Date**			**Date**			**Date**		
48	***Headstocks***											
49												
50	*100 DR*	*OK*	*OK*									
51	*OK*	*50*	*OK*									
52												
53	***Walings***											
54												
55	*OK*	*OK*	*OK*									
56	*OK*	*OK*	*OK*									
57	***Bracing***											
58												
59	*OK*	*OK*	*OK*									
60	*OK*	*OK*	*OK*									
61	***Transoms***											
62												
63	*OK*											
64	***Sheeting***											
65												
66	*OK*											
67	*OK*											
68	*OK*											
69												
70												
71												
72	***Guard Rails***											
73	*OK*											
74	***General***											
75	*Screwed up*											
76	*Not required*											
77	*Slight scour in invert*											
78	*No.2 span*											

Superseded by MN C 10301 v3.0, 18/10/2021

23.4 Examination Report: Overhead Wiring Structures and Signal Gantries

(Check SAP for the current form)

District:		Structure Number:	
Line:		Examination Type:	Detailed: [ ] Mid-Cycle: [ ]
Tracks Spanned:			
Structure Type:	Simple Mast [ ] Cantilever Mast [ ] Portal [ ] Gantry structure [ ] Anchor structure (guyed) [ ] Anchor structure (free standing) [ ]		
Component Type:	I-Beam [ ] Channels [ ] Truss [ ] Hollow Section [ ]		
Examination Dates:	Basic:	Close:	
Condition:	G: Good F: Fair P: Poor		

DESCRIPTION	Condition		COMMENTS
	UP	**DOWN**	
Structure			
Bases			
Masts			
Knee braces			
Bridges			
Welds			
Bolts			
Attachments			
Droppers			
Pull off brackets			
Anchor plates			
Structure Footing			
Bolts			
Baseplates			
Grout			
Concrete pedestal			
Guy Footing			
Anchor lugs			
Concrete pedestal			
General Condition			
Paint/Galvanising			
Erosion of footings			

Gantry (Y/N)			
Walkway			
Handrails			
Ladders			
Cages			

Examiner: Date:

Structures Manager: Date:

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23.5 Examination Report: Tunnels

REGION		***FILE No.***	
DISTRICT		***DRAWING***	NK
LINE		***TUNNEL PROFILE***	
EQUIPMENT No		***MATERIAL***	Brick
MIMS SPN		***HEIGHT RAIL TO CROWN***	
PREVIOUS STATION		***WIDTH***	
KILOMETRAGE		***No. TRACKS***	1
LOCATION		***TRACK ALIGNMENT***	Straight
REPAIRED		***SUPERELEVATION***	0

COMPONENT	**Defect Category**	**COMMENTS**	**Repair Priority**	
			Examiner (optional)	Structures Manager
ROOF				
WALLS				
FLOOR				
PORTALS				
REFUGES				
REFUGE MARKERS				
DRAINS				
SIGNAGE				
GENERAL				

Examiner: Date:

Structures Manager: Date:

Superseded by MN C 10301 v3.0, 18/10/2021

23.6 Examination Report: Miscellaneous Structures

REGION		***FILE No.***	
DISTRICT		***DRAWING***	NK
LINE		***STRUCTURE TYPE***	
EQUIPMENT No		***MATERIALS***	
MIMS SPN		***No. TRACKS***	1
PREVIOUS STATION		***TRACK ALIGNMENT***	Straight
KILOMETRAGE		***SUPERELEVATION***	0
LOCATION		***GUARD RAILS (Y / N)***	
REPAIRED		***SPANS***	

MEMBER	**EXAMINATION REPORT**
Examiner:	Date:

COMMENTS	
Structures Manager:	Date:

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23.7 Examination Report: Miscellaneous Structures (Crib Wall)

REGION		***FILE No.***	
DISTRICT		***DRAWING***	
LINE		***STRUCTURE TYPE***	
EQUIPMENT No		***MATERIALS***	
MIMS SPN		***No. TRACKS***	
PREVIOUS STATION		***TRACK ALIGNMENT***	
KILOMETRAGE		***SUPERELEVATION***	
LOCATION		***GUARD RAILS (Y / N)***	
REPAIRED		***SPANS***	

ITEM	**EXAMINATION REPORT**
Concrete Element	Condition, movement
Fill	Type, loss
Drainage	Evidence of seepage, water flow, etc
Vegetation	Extent, tree trunk protrusion, etc
Capping	Type
Embankment / Fill behind wall	Condition, cracking, slump, etc

Examiner:	Date:
COMMENTS Height Alignment	
Structures Manager:	Date:

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24 APPENDIX 7: Weekly summary of exceedents form

WEEKLY STRUCTURES EXCEEDENT REPORT

Week Ending		Region		District		Line		Track Code		Examiner		Team Manager Signature		Date received in Area Office	

BRIDGE EXAMINER'S USE												STRUCTURES MANAGER'S USE			
Equipment No	Examination Date	Km	Member	Category	Defect	Size	UOM	Span	Maintenance response	Defect Description	ACTION REQUIRED	Date received Structures Manager	Action proposed	Target date	Date Completed

☐ If this box is ticked, my signature above as Examiner confirms that I have entered the exceedents into Teams 3

Superseded by MN C 10301 v3.0, 18/10/2021

25 APPENDIX 8: Steel and concrete underbridges

The table below lists the steel and concrete underbridges to which revised examination frequencies apply (needs to be validated against current SAP list)

DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1883	MAIN SUBURBAN (CEN-GRANV) 3.957KMS STANMORE - LIBERTY ST UndBr_HRTG_4803202	Central	M00	3.957
1885	MAIN SUBURBAN (CEN-GRANV) 6.377KMS L-SHAM – OLD C-BURY RD UnBr_HRTG_4801518	Central	M00	6.377
1891	ILLAWARRA 1.949KMS Eveleigh – Workmens PedSubWay	Central	I00	1.949
1892	MAIN SUBURBAN (CEN-GRANV) 2.575KMS M-donaldtwn-Burren St UndBr_HRTG_4803201	Central	M00	2.575
1892	MAIN SUBURBAN (CEN-GRANV) 10.716KMS BURWOOD ROAD UndBr_HRTG_4801085	Central	M00	10.716
1903	PYRMONT BRANCH 20.448KMS CENTRAL – WEST TRAMWAY MxRLRd	Del. Support Unit	M60	20.448
1903	NORTH SHORE 10.412KMS ARTARMON - STATION PedSWy	North	N30	10.412
1904	PYRMONT BRANCH 20.357KMS CENTRAL - TRAMWAY COLLONADE MxRLRd	Del. Support Unit	M60	20.357
1904	PYRMONT BRANCH 20.295KMS CENTRAL - EAST TRAMWAY MxRLRd	Del. Support Unit	M60	20.295
1906	0.210KMS Central-D-shire St PedSWay_HRTG_4801296	Central	M00	0.210
1907	MAIN WEST 56.371KMS EMU PLAINS-NEPEAN RVR UBr_HRTG_4801576	West	W00	56.371
1908	ILLAWARRA 20.310KMS COMO - SUBSTATION PedSWy	Illawarra	I00	20.310
1909	MAIN WEST 56.100KMS PENRITH - PEACH TREE CREEK Und	West	W00	56.100
1912	PETERSHAM PEDESTRIAN SUBWAY 5.580KMS PETERSHAM - ISOLATED PedSWy_HRTG_4801094	Central	M00	5.580
1913	MAIN NORTH 188.856KMS_EAST MAITLAND STATION Ped SubWay_HRTG_4806006	North	N00	188.856
1913	ALLT NORTH 26.995KMS BEECROFT - STN PedSWy_HRTG_4801062	North	N00	26.995
1915	MAIN NORTH 12.628KMS SN S-FIELD-PARRAMATTA Rd UndBr_HRTG_4800290	Central	N00	12.628
1915	BANKSTOWN LINE 6.160KMS MARRICKVILLE-M24&M50 ov M52 MEEKS RD Div	Central	M24	6.160
1915	ILLAWARRA 68.210KMS AUSTINMER - Wigham Rd UndBr	Illawarra	I00	68.210
1915	BOTANY LINE 15.360KMS: SYDENHAM S-HAM-M50-I00 & M24 FlyOv_HRTG_4805746	Central	M50	15.360
1915	ILLAWARRA 7.684KMS Wolli Creek - Guess Ave UnderBr	Illawarra	I00	7.684
1916	MARRICKVILLE LOOP - BOTANY 16.786 KMS MARRICKVILLE - CHARLOTTE Ave (M50) UndBr	Central	M50	16.786
1916	ROZELLE LINE 10.260KMS LEWISHAM - DOBROYD BRANCH SEWER UndBr	Central	M58	10.260
1916	ROZELLE LINE 10.489KMS LEICHHARDT - GREAT WESTERN H'Way UndBr	Central	M58	10.489

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1916	ROZELLE LINE 11.127KMS LEICHHARDT - MARION St UndBr	Central	M58	11.127
1916	ROZELLE LINE 12.405KMS LEICHHARDT - CHARLES St Und	Central	M58	12.405
1916	ILLAWARRA 1.187KMS R-fern -Eveleigh Eng Dive_HRTG_4801095	Central	I00	1.187
1916	ROZELLE LINE 9.838KMS LEWISHAM -near OLD CANTERBURY Rd UndBr	Central	M58	9.838
1917	MAIN SUBURBAN (CEN-GRANV) 8.430KMS ASHFIELD - Near DENGATE Ave PedSWy	Central	M00	8.430
1918	BANKSTOWN LINE 6.314KMS MARRICKVILLE - CHARLOTTE Ave (M24) UndBr	Central	M24	6.314
1918	BANKSTOWN LINE 6.182KMS MARRICKVILLE-CANAL1 UNDER M24&DIVE UndBr	Central	M24	6.182
1918	BANKSTOWN LINE 6.187KMS MARRICKVILLE-CANAL2 UNDER M24&M50 UndBr	Central	M24	6.187
1920	ILLAWARRA 112.468KMS MINNAMURRA - MINNAMURRA RIVER UndBr	Illawarra	I00	112.468
1922	PYRMONT BRANCH 14.328KMS ANNANDALE - RAILWAY Pde UndBr	Del. Support Unit	M60	14.328
1922	PYRMONT BRANCH 14.570KMS ANNANDALE - JOHNSTON St/The CRESCENT Un	Del. Support Unit	M60	14.570
1922	PYRMONT BRANCH 16.051KMS GLEBE - DARLING St UndBr	Del. Support Unit	M60	16.051
1922	PYRMONT BRANCH 16.211KMS GLEBE - BELLEVUE St UndBr	Del. Support Unit	M60	16.211
1922	PYRMONT BRANCH 16.244KMS GLEBE - WENTWORTH PARK Rd UndBr	Del. Support Unit	M60	16.244
1922	PYRMONT BRANCH 14.717KMS GLEBE - JUBILEE PARK VIADUCT UndBr	Del. Support Unit	M60	14.717
1922	ILLAWARRA 3.377KMS St Peters - Coulson St UnderBr	Central	I00	3.377
1922	MAIN SOUTH 26.161KMS CARRAMAR - PROSPT Crk UndBr_HRTG_4803254	West	S00	26.161
1923	MAIN SOUTH 17.815KMS LIDCOMBE - HASLAMS Crk UndBr	Central	S00	17.815
1923	ILLAWARRA 14.261KMS Hurstville - The Avenue UnderBr	Illawarra	I00	14.261
1923	MAIN SOUTH 17.336KMS LIDCOMBE - VAUGHAN St UndBr	Central	S00	17.336
1923	ILLAWARRA 7.006KMS Tempe - Cooks River UnderBr	Central	I00	7.006
1923	ILLAWARRA 9.570KMS BANKSIA - STATION PedSWy_HRTG_4801160	Illawarra	I00	9.570
1924	MAIN SOUTH 25.978KMS CARRAMAR - STATION PedSWy_HRTG_4800207	West	S00	25.978
1924	BANKSTOWN LINE 23.179KMS REGENTS PARK - (M24) WATERWAY UndBr	Central	M24	23.179
1925	ALLT SUBURBAN (CEN-GRANV) 6.218KMS LEWISHAM - STATION PedSWy	Central	M00	6.218
1925	NORTH SHORE 4.426KMS Milsons Pt-Stn PedSubWay_HRTG_4801026	Central	N30	4.426

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1926	ALLT SUBURBAN (CEN-GRANV) 7.111KMS SUMMER HILL STATION PedSWy_HRTG_4801099	Central	M00	7.111
1926	ALLT SUBURBAN (CEN-GRANV) 4.667KMS STANMORE - STATION PedSWy_HRTG_4801097	Central	M00	4.667
1926	CENTRAL 0.166KMS Central - Station PedSubWay_HRTG_4801296	Central	M00	0.166
1926	MAIN SUBURBAN (CEN-GRANV) 6.508KMS L-WHM-LNG CV Ck M00/M58 FOv_HRTG_4801584	Central	M00	6.508
1926	NORTH SHORE 0.310KMS Central - Hay St UnderBr _HRTG_4801296	Central	M01	0.310
1926	NORTH SHORE 0.370KMS Central-Campbell St UnderBr_HRTG_4801296	Central	M01	0.370
1926	NORTH SHORE 0.065KMS Central - Eddy Ave UnderBr _HRTG_4801296	Central	N30	0.065
1926	North Shore 1.000KMS Town Hall - North Shore Flyover	Central	N30	1.000
1927	NORTH SHORE 10.219KMS ARTARMON - HAMPDEN Rd PedSWy	North	N30	10.219
1927	MAIN SUBURBAN (CEN-GRANV) 2.565KMS M-donaldtwn-Burren St UndBr_HRTG_4803201	Central	M00	2.565
1927	MAIN SUBURBAN (CEN-GRANV) 12.974KMS HOMEBUSH - (M00 PART) SUBWAY LANE UndBr	Central	M00	12.974
1927	NORTH SHORE 17.727KMS GORDON - Mt. William St PedSWy	North	N30	17.727
1927	ILLAWARRA 1.719KMS Redfern-Illawarra Dive Dive_HRTG_4801095	Central	I00	1.719
1927	MAIN SUBURBAN (CEN-GRANV) 8.987KMS ASHFIELD - FREDERICK St UndBr	Central	M00	8.987
1927	MAIN SUBURBAN (CEN-GRANV) 11.987KMS STRATHFIELD - RAW SQUARE UndBr	Central	M00	11.987
1927	MAIN NORTH 12.172KMS S-FIELD-N00 over M00 FlyOv_HRTG_4801129	Central	N00	12.172
1927	MAIN SUBURBAN (CEN-GRANV) 11.734KMS STRATHFIELD - "ISOLATED" PedSWy	Central	M00	11.734
1927	ALLT SUBURBAN (CEN-GRANV) 11.809KMS STRATHFIELD-STATION PedSWy_HRTG_4801098	Central	M00	11.809
1927	ILLAWARRA 0.336KMS UP ILLA LOCAL CENTRAL-FLY JNCT #.2 FlyOvr _HRTG_4801296	Central	I00	0.336
1927	ILLAWARRA 0.337KMS UP ILLA MAIN CENTRAL-FLY JNCT #1 FlyOver _HRTG_4801296	Central	I00	0.337
1927	CENTRAL 0.010KMS Central - Station PedSubWay_HRTG_4801296	Central	M00	0.010
1927	MAIN SUBURBAN (CEN-GRANV) 0.335KMS CENTRAL-FLY JNCT#.3 FlyOver _HRTG_4801296	Central	M00	0.335
1927	MAIN SUBURBAN (CEN-GRANV) 0.338KMS CENTRAL-FLY JNCT #4 FlyOver _HRTG_4801296	Central	M00	0.338
1927	MAIN WEST 0.065KMS Syd Yd-Pasngr O-flw PedS-Wy_HRTG_4801296	Central	SYY	0.065
1927	MAIN WEST 0.135KMS Sydney Yard - PedSubWay_HRTG_4801296	Central	SYY	0.135
1928	MAIN WEST 21.863KMS GRANVILLE - PARRAMATTA ROAD UndBr	West	W00	21.863
1928	MAIN WEST 23.621KMS PARRAMATTA - MARSDEN STREET UndBr	West	W00	23.621
1928	BANKSTOWN LINE 19.202KMS BANKSTOWN - MARION St Und	Central	M24	19.202

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1928	BANKSTOWN LINE 19.601KMS YAGOONA COLEMAN Ave-WEIGAND AvePedSubWay	Central	M24	19.601
1928	MAIN WEST 23.427KMS PARRAMATTA - CHURCH STREET UndBr	West	W00	23.427
1928	MAIN WEST 23.800KMS PARRAMATTA - O'CONNELL STREET UndBr	West	W00	23.800
1928	MAIN WEST 23.984KMS PARRAMATTA - PITT STREET UndBr	West	W00	23.984
1929	MAIN SUBURBAN (CEN-GRANV) 18.680KMS AUBURN - UNDER WESTERN END OF STN PedSWy	Central	M00	18.680
1929	MAIN WEST 23.140KMS P-MTA -Unk Cross-PedSubWay_HRTG_4801031	West	W00	23.140
1929	TEMPE TO GLENFIELD JCT 15.689KMS NARWEE - STATION PedSWy_HRTG_4801924	Illawarra	M25	15.689
1929	TEMPE TO GLENFIELD JCT 9.573KMS BARDWELL PARK - Sewer Pipe UnderBr	Illawarra	M25	9.573
1931	TEMPE TO GLENFIELD JCT 18.316KMS RIVERWOOD - WEBB St (UP TRACKS) UndBr	Illawarra	M25	18.316
1931	NEW SOUTHERN RAILWAY - 10.067kms Wolli Ck - MAINS - SWOOS BRIDGE	Del. Support Unit	M26	10.067
1931	TEMPE TO GLENFIELD JCT 18.387KMS RIVERWOOD-SALT PAN Ck-UP TRACKS-UnderBr	Illawarra	M25	18.387
1932	NORTH SHORE 3.100KMS Harbr Brdg-Sth Approach UBr_HRTG_4801059	Central	N30	3.100
1932	NORTH SHORE 3.419KMS Harbour Bridge - UnderBr_HRTG_4801059	Central	N30	3.419
1932	NORTH SHORE 3.983KMS Harbr Brdg-Nth Approach UBr_HRTG_4801059	Central	N30	3.983
1932	NORTH SHORE 2.850KMS Wynyard-Argyle St PedSubWay_HRTG_4801059	Central	N30	2.850
1932	NORTH SHORE 2.857KMS Wynyard - Argyle St UnderBr_HRTG_4801821	Central	N30	2.857
1932	NORTH SHORE 3.394KMS Harbour Brdg-Sth Pylon UnBr_HRTG_4801059	Central	N30	3.394
1932	NORTH SHORE 3.958KMS Harbour Brdg-Nth Pylon UnBr_HRTG_4801059	Central	N30	3.958
1932	NORTH SHORE 4.250KMS Milsons Pt-Fitzroy St UnBr_HRTG_4801822	Central	N30	4.250
1932	NORTH SHORE 4.340KMS Milsons Pt-Burton St UndrBr_HRTG_4801026	Central	N30	4.340
1932	NORTH SHORE 4.737KMS Milsons Pt-Lavender St UnBr_HRTG_4801823	Central	N30	4.737
1932	NORTH SHORE 4.810KMS M-son Pt-L-vendr-Arthur UBr_HRTG_4801823	Central	N30	4.810
1932	NORTH SHORE 4.918KMS North Sydney-Arthur St UnBr_HRTG_4801824	Central	N30	4.918
1932	NORTH SHORE 5.740KMS Waverton - Euroka St UnderBr	Central	N30	5.740
1933	MAIN SOUTH 54.920KMS CAMPBELLTOWN - UndBr	Illawarra	S00	54.920
1935	ILLAWARRA 58.480KMS COALCLIFF - SUBWAY UndBr	Illawarra	I00	58.480
1936	MAIN NORTH 19.096KMS UM.DM WEST RYDE - VICTORIA Rd UndBr	North	N00	19.096
1938	SUTHERLAND-CRONULLA 34.665KMS: CRONULLA TONKIN St/PURLEY Pl. PedSWy_HRTG_4801157	Illawarra	I20	34.665

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1939	SUTHERLAND TO CRONULLA 28.542KMS GYMEA - SYLVANIA Rd UndBr	Illawarra	I20	28.542
1939	SUTHERLAND-CRONULLA 24.971KMS SUTHERLAND RAWSON Ave DNMN UndBr_HRTG_4801846	Illawarra	I20	24.971
1939	SUTHERLAND TO CRONULLA 25.425KMS KIRRAWEE - MERTON St UPMN UndBr	Illawarra	I20	25.425
1939	SUTHERLAND TO CRONULLA 25.794KMS KIRRAWEE - GLENCOE St UPMN UndBr	Illawarra	I20	25.794
1939	SUTHERLAND TO CRONULLA 30.480KMS MIRANDA - KAREENA Rd UndBr	Illawarra	I20	30.480
1939	SUTHERLAND TO CRONULLA 32.526KMS CARINGBAH - GANNONS Rd UPMN UndBr	Illawarra	I20	32.526
1939	SUTHERLAND-CRONULLA 34.421KMS: CRONULLA SEARL Rd/WILBAR Ave UndBr_HRTG_4804412	Illawarra	I20	34.421
1946	MAIN NORTH 150.423KMS COCKLE CREEK UndBr_HRTG_4800216	North	N00	150.423
1946	MAIN WEST 33.011KMS 7-HILLS-GRADE SEPARTN FlyOv_HRTG_4800175	West	W00	33.011
1946	MAIN NORTH 58.463KMS HAWKESBURY RIVER UndBr_HRTG_4800130	North	N00	58.463
1946	MAIN NORTH 150.397KMS COCKLE CREEK - RACECOURSE Rd UndBr	North	N00	150.397
1946	MAIN NORTH 150.540KMS COCKLE CREEK - UndBr	North	N00	150.540
1947	MAIN NORTH 73.524KMS WOY WOY - PARKS BAY UndBr	North	N00	73.524
1947	MAIN NORTH 110.320KMS WARNERVALE-WALARAH UndBr_HRTG_4801831	North	N00	110.320
1948	MAIN SUBURBAN (CEN-GRANV) 16.937KMS LIDCOMBE - OLYMPIC Dr UndBr_HRTG_4801842	Central	M00	16.937
1949	MAIN NORTH 96.802KMS TUGGERAH - OURIMBAH Crk UndBr	North	N00	96.802
1949	ALLT NORTH 21.267KMS EASTWOOD - PedSWy	North	N00	21.267
1950	ILLAWARRA 87.350KMS UNANDERRA - BHP SIDING over I00 FlyOv	Illawarra	I00	87.350
1950	MAIN SUBURBAN (CEN-GRANV) 20.474KMS CLYDE - DUCK RIVER UndBr	West	M00	20.474
1951	MAIN NORTH 21.398KMS EASTWOOD - STATION PedSWy	North	N00	21.398
1952	MAIN NORTH 40.597KMS MT KURING-GAI - PedSWy_HRTG_4801923	North	N00	40.597
1953	MAIN NORTH 100.480KMS WYONG - Creek/TACOMA Rd UndB	North	N00	100.480
1953	CONISTON TO PORT KEMBLA 87.191KMS CRINGILA - Bluescope over I10 FlyOv	Illawarra	I10	87.191
1954	MAIN SUBURBAN (CEN-GRANV) 18.605KMS AUBURN - STN ACCESS PedSWy	Central	M00	18.605
1956	CITY CIRCLE 2.743KMS Circular Qy-Rd Ped Stn UBr_HRTG_4801109	Central	M01	2.743
1958	MAIN WEST 55.796KMS PENRITH - CASTLEREAGH ROAD Und	West	W00	55.796
1958	MAIN NORTH 127.025KMS DORA CREEK - UndBr	North	N00	127.025
1960	MAIN NORTH 79.844KMS GOSFORD - BROADWATER UndBr_HRTG_4803389	North	N00	79.844
1960	MAIN NORTH 160.300KMS KOTARA - NORTHCOTT Drv UndBr	North	N00	160.300

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1962	ILLAWARRA 117.225KMS BOMBO - BEACH ACCESS UndBr	Illawarra	I00	117.225
1964	ILLAWARRA 93.161KMS KEMBLA GRANGE - MULLET CREEK UndBr	Illawarra	I00	93.161
1964	BANKSTOWN LINE 6.666KMS MARRICKVILLE-(M24 PART) SEWER LINE UndBr	Central	M24	6.666
1964	BANKSTOWN LINE 9.084KMS H-STONE PK M24 FOORD Av UBr_HRTG_4805737	Central	M24	9.084
1967	ILLAWARRA 91.964KMS KEMBLA GRANGE - TUBEMAKERS UndBr	Illawarra	I00	91.964
1967	MAIN SOUTH 53.807KMS CAMPBELLTOWN - WATERWAY UndBr	Illawarra	S00	53.807
1968	MAIN SOUTH (Lidcombe- Glenlee) 48.290KMS MINTO-VIADUCT (BOW BOWING Crk No2) UndBr	Illawarra	S00	48.290
1968	MAIN NORTH 139.185KMS AWABA - CREEK ONE UndBr	North	N00	139.185
1968	MAIN SOUTH 21.627KMS CHESTER HILL - HECTOR St UndB	West	S00	21.627
1970	ILLAWARRA 11.882KMS Kogarah - PedSubWay	Illawarra	I00	11.882
1970	MAIN NORTH 46.872KMS UM.DM COWAN - F3 FREEWAY Und	North	N00	46.872
1971	GRANVILLE TO CABRAMATTA 22.120KMS GRANVILLE-WOODVILLE Rd UBr_HRTG_4801833	West	M16	22.120
1971	ILLAWARRA 30.702KMS ENGADINE - STATION PedSWy	Illawarra	I00	30.702
1972	ILLAWARRA 19.929KMS COMO - GEORGES Rvr UndBr_HRTG_4801834	Illawarra	I00	19.929
1972	MAIN SOUTH 51.136KMS MINTO - WATERWAY UndBr	Illawarra	S00	51.136
1972	MAIN SOUTH 53.622KMS LEUMEAH - WATERWAY UndBr	Illawarra	S00	53.622
1972	MAIN SOUTH 57.009KMS MACARTHUR - WATERWAY UndBr	Illawarra	S00	57.009
1972	MAIN SOUTH 49.319KMS MINTO - WATERWAY UndBr	Illawarra	S00	49.319
1972	MAIN SOUTH (Lidcombe-Glenlee) 55.842KMS MACARTHUR - WATERWAY (Near O/B) UndBr	Illawarra	S00	55.842
1972	GRANVILLE TO CABRAMATTA 23.575KMS MERRYLANDS STATION PedSubWay	West	M16	23.575
1973	MAIN NORTH 163.020KMS BROADMEADOW - STA PedSWy_HRTG_4801899	North	N00	163.020
1974	BANKSTOWN LINE 21.697KMS BIRRONG - BRUNKER/FERRIER Rd UndBr	Central	M24	21.697
1975	GRANVILLE TO CABRAMATTA 25.669KMS GUILDFORD - STATION Ped Subway	West	M16	25.669
1976	ILLAWARRA 21.273KMS COMO - STATION PedSWy	Illawarra	I00	21.273
1976	OLYMPIC PARK LOOP 16.027KMS FLEMINGTON - M4 FREEWAY(EAST) UndBr	Central	M78	16.027
1976	MAIN WEST 45.349KMS ST MARYS - ROPES CREEK UndBr	West	W00	45.349
1976	MAIN SOUTH 27.866KMS CABRAMATTA - WATERWAY UndBr	West	S00	27.866
1976	MAIN NORTH 17.300KMS RHODES - LEEDS St UndBr	North	N00	17.300
1977	MAIN WEST 39.377KMS DOONSIDE - EASTERN CREEK UndBr	West	W00	39.377

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1977	NORTH SHORE 10.563KMS UM.DM ARTARMON - BRAND St UndBr	North	N30	10.563
1978	MAIN WEST 40.420KMS ROOTY HILL - ANGUS CREEK UndBr	West	W00	40.420
1978	PYRMONT BRANCH 16.530KMS GLEBE - WATTLE St UndBr	Del. Support Unit	M60	16.530
1978	ILLAWARRA 66.503KMS COLEDALE - UndBr	Illawarra	I00	66.503
1978	ILLAWARRA 72.300KMS BULLI - WHARTONS Crk UndBr	Illawarra	I00	72.300
1978	ILLAWARRA 74.761KMS WOONONA - UndBr (Unnamed Ck)	Illawarra	I00	74.761
1978	ILLAWARRA 54.085KMS OTFORD - UndBr (Unnamed Ck)	Illawarra	I00	54.085
1979	CLYDE TO CARLINGFORD 25.349KMS DUNDAS - LEAMINGTON Rd PedSWy	West	M13	25.349
1979	ESR 2.747KMS Woolloomooloo-V-duct UndrBr_HRTG_4801835	Central	M23	2.747
1979	ESR 4.024KMS R-cutters Bay-Vduct UnderBr_HRTG_4801125	Central	M23	4.024
1979	EASTERN SUBURBS 4.526KMS EDGECLIFF-GLENMORE Rd UndBr_HRTG_4801125	Central	M23	4.526
1979	MAIN NORTH 98.704KMS TUGGERAH - Crk UndBr	North	N00	98.704
1979	MAIN NORTH 99.780KMS TUGGERAH - STRAIGHT CK. UndBr	North	N00	99.780
1979	MAIN SOUTH 34.389KMS WARWICK FARM - WATERWAY UndBr	West	S00	34.389
1979	FLEMINGTON CAR SIDINGS 15.541KMS FLEMINGTON - CAR WASH SDG over M72 FlyOv	Central	FCS	15.541
1979	MAIN NORTH 99.640KMS TUGGERAH - CREEK UndBr	North	N00	99.640
1979	ILLAWARRA 121.611KMS KIAMA - UndBr (UNNAMED Ck)	Illawarra	I00	121.611
1980	MAIN NORTH 139.390KMS AWABA - CREEK TWO UndBr	North	N00	139.390
1980	MAIN NORTH 139.522KMS AWABA - CREEK THREE UndBr	North	N00	139.522
1980	MAIN NORTH 139.673KMS AWABA - CREEK FOUR UndBr	North	N00	139.673
1980	MAIN WEST 78.305KMS SPRINGWOOD - MACQUARIE RD. UNDRBR.	West	W00	78.305
1980	WAVERTON TO LAVENDER BAY 6.388KMS WAVERTON - JOHN St UndBr_HRTG_4801022	Infra. Fac.	M29	6.388
1980	MAIN NORTH 17.500KMS UM.DM M/DOWBANK-PARRA.RIVER UndBr_HRTG_4805744	North	N00	17.500
1980	MAIN NORTH 138.710KMS AWABA - STONY Crk UndBr	North	N00	138.710
1980	MAIN NORTH 86.643KMS LISAROW - NIAGRA PARK UndBr	North	N00	86.643
1980	MAIN NORTH 94.820KMS TUGGERAH - UndBr	North	N00	94.820
1980	MAIN NORTH 95.398KMS TUGGERAH - UndBr	North	N00	95.398
1980	MAIN NORTH 101.793KMS WYONG - CREEK No.3 UndBr	North	N00	101.793
1980	MAIN NORTH 103.532KMS WYONG - CREEK NORTH 1 UndBr	North	N00	103.532
1980	MAIN NORTH 103.767KMS WYONG - CREEK NORTH 2 UndBr	North	N00	103.767

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1980	MAIN NORTH 103.894KMS WYONG - CREEK NORTH 3 UndBr	North	N00	103.894
1980	MAIN NORTH 116.082KMS WYEE - SWAMP Crk UndBr	North	N00	116.082
1980	MAIN NORTH 130.404KMS AWABA-HAWK MOUNT - COAL CONVEYOR UndBr	North	N00	130.404
1980	MAIN WEST 24.739KMS WESTMEAD - DOMAIN CK PED SUBWY PedSWy	West	W00	24.739
1981	MAIN SOUTH 16.886KMS LIDCOMBE - OLYMPIC Dr/BRIDGE St UndBr	Central	S00	16.886
1981	WOODVILLE JCT TO NEWCASTLE 166.090KMS WICKHAM - COTTAGE CREEK UndBr	North	N33	166.090
1981	ILLAWARRA 7.003KMS Tempe - Cooks River UnderBr	Central	I00	7.003
1981	ILLAWARRA 73.461KMS WOONONA - UndBr (Unknown Crossing)	Illawarra	I00	73.461
1981	CONISTON TO PORT KEMBLA 86.807KMS LYSAGHTS - ALLENS Ck UndBr	Illawarra	I10	86.807
1981	INNER HARBOUR LINE 85.047KMS CONISTON - C11 ovr I10 FlyOv	Illawarra	C11	85.047
1981	ILLAWARRA 77.734KMS TOWRADGI - UndBr (Unknown Crossing)	Illawarra	I00	77.734
1981	ILLAWARRA 78.348KMS TOWRADGI - UndBr (Unnamed Ck)	Illawarra	I00	78.348
1981	ILLAWARRA 79.015KMS FAIRY MEADOW - UndBr (Unnamed Ck)	Illawarra	I00	79.015
1981	MAIN NORTH 92.297KMS OURIMBAH - BURNS ROAD UndBr	North	N00	92.297
1981	ILLAWARRA 71.869KMS BULLI - SLACKY Crk UndBr	Illawarra	I00	71.869
1981	SUTHERLAND TO CRONULLA 29.447KMS MIRANDA - KIORA Rd UndBr	Illawarra	I20	29.447
1981	SUTHERLAND TO CRONULLA 29.516KMS MIRANDA - STATION PedSWy_HRTG_4801922	Illawarra	I20	29.516
1982	MEEKS ROAD XPT DEPOT 5.650KMS SYDENHAM-(XPT RAIL ACCESS) CANAL UndBr	Central	M52	5.650
1982	MAIN NORTH 15.266KMS CONCORD WEST - PedSWy_HRTG_4801042	North	N00	15.266
1982	CLYDE TO CARLINGFORD 24.990KMS DUNDAS - KISSING POINT Rd UndBr	West	M13	24.990
1983	MAIN WEST 26.950KMS WENTWORTHVILLE - NEAR FREAME ST PedSWy	West	W00	26.950
1983	MAIN NORTH 78.050KMS POINT CLARE - STATION PedSWy	North	N00	78.050
1983	ILLAWARRA 75.257KMS BELLAMBI - UndBr	Illawarra	I00	75.257
1983	ILLAWARRA 75.769KMS BELLAMBI - UndBr (Unknown Crossing)	Illawarra	I00	75.769
1983	ILLAWARRA 76.442KMS CORRIMAL - OPEN DRAIN UndBr	Illawarra	I00	76.442
1983	MAIN WEST 22.072KMS HARRIS PARK - A'BECKETTS CREEK UndBr	West	W00	22.072
1983	ILLAWARRA 71.761KMS BULLI - BEACON Ave UndBr (Footpath)	Illawarra	I00	71.761
1983	ILLAWARRA 101.100KMS ALBION PARK - MACQUARIE RIVULET UndBr	Illawarra	I00	101.100
1984	ILLAWARRA 86.457KMS UNANDERRA - AMERICAN Crk UndBr	Illawarra	I00	86.457
1984	MAIN WEST 22.923KMS PARRAMATTA - PARKS STREET UndB	West	W00	22.923

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1984	MAIN WESTERN LINE 24.347KMS WESTMEAD - GRADE SEPARATION Dive	West	W00	24.347
1984	BLACKTOWN TO RICHMOND 53.250KMS MULGRAVE - SOUTH Ck UndBr	West	M17	53.250
1984	MAIN SUBURBAN (CEN-GRANV) 16.997KMS LIDCOMBE - OLYMPIC Dr PedSWy	Central	M00	16.997
1984	TEMPE TO GLENFIELDJCT 30.722KMS GLENFIELD - GEORGES RIVER WEST UndBr	Illawarra	M25	30.722
1985	TEMPE TO GLENFIELDJCT 27.004KMS HOLSWORTHY - HARRIS Crk UndBr	Illawarra	M25	27.004
1985	ILLAWARRA 81.559KMS NORTH WOLLONGONG - FAIRY Cr UndBr	Illawarra	I00	81.559
1985	TEMPE TO GLENFIELD JCT 24.127KMS EAST HILLS - Maclauren Ave UnderBr	Illawarra	M25	24.127
1985	UNANDERRA TO MOSS VALE 89.169KMS UNANDERRA - PRINCES Hwy UndBr	Illawarra	S34	89.169
1985	NORTH SHORE 18.020KMS UM.DM PYMBLE - MONA VALE Rd UndBr	North	N30	18.020
1985	MAIN WEST 23.280KMS P-MTA STN-PED S-WAY PedSWy_HRTG_4801031	West	W00	23.280
1985	TEMPE TO GLENFIELD JCT 20.750KMS REVESBY-THE RIVER Rd (UP TRACKS) UnderBr	Illawarra	M25	20.750
1985	MAIN WEST 59.166KMS EMU PLAINS - RUSSELL STREET Un	West	W00	59.166
1985	BLACKTOWN TO RICHMOND 37.570KMS MARAYONG - VARDYS Rd (UPMAIN) UndBr	West	M17	37.570
1985	TEMPE TO GLENFIELDJCT 25.638KMS HOLSWORTHY - WILLIAMS Ck UndBr	Illawarra	M25	25.638
1986	ILLAWARRA 119.940KMS KIAMA - FARMER St UndBr	Illawarra	I00	119.940
1986	CONISTON TO PORT KEMBLA 86.392KMS LYSAGHTS - UndB	Illawarra	I10	86.392
1986	NORTH SHORE 23.241KMS UM.DM WAHROONGA - F3 FREEWAY UndBr	North	N30	23.241
1986	ILLAWARRA 99.459KMS YALLAH - Unnamed Ck UndBr	Illawarra	I00	99.459
1986	CONISTON TO PORT KEMBLA 87.749KMS CRINGILA - UndBr	Illawarra	I10	87.749
1986	TEMPE TO GLENFIELD JCT 24.357KMS EAST HILLS - Georges River UnderBr	Illawarra	M25	24.357
1986	CONISTON TO PORT KEMBLA 88.171KMS PORT KEMBLA - NORTH UndBr	Illawarra	I10	88.171
1987	ILLAWARRA 80.988KMS NORTH WOLLONGONG - UndBr (Ck/Drain)	Illawarra	I00	80.988
1987	ILLAWARRA 118.830KMS KIAMA - SHOALHAVEN St UndBr	Illawarra	I00	118.830
1987	BLACKTOWN TO RICHMOND 55.755KMS WINDSOR - CHAIN OF PONDS UndBr	West	M17	55.755
1987	ILLAWARRA 83.700KMS WOLLONGONG - PedSWy	Illawarra	I00	83.700
1988	TEMPE TO GLENFIELD JCT 24.246KMS EAST HILLS - Cools Crescent UnderBr	Illawarra	M25	24.246
1988	TEMPE TO GLENFIELDJCT 31.080KMS GLENFIELD - QUARRY ACCESS Rd 1 UndBr	Illawarra	M25	31.080
1988	ILLAWARRA 144.570KMS BERRY - JASPER'S BRUSH UndBr	Illawarra	I00	144.570
1988	ILLAWARRA 144.706KMS BERRY - JASPER'S Ck. UndBr	Illawarra	I00	144.706

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1988	TEMPE TO GLENFIELD JCT 24.062KMS EAST HILLS - STATION PedSubWay	Illawarra	M25	24.062
1989	GRANVILLE TO CABRAMATTA 29.309KMS FAIRFIELD - PedSWy	West	M16	29.309
1989	MAIN WEST 57.550KMS EMU PLAINS-FLOODWAY UndBr-OLD BATHURST R	West	W00	57.550
1989	NORTH SHORE 9.535KMS UM.DM ARTARMON - F2 Fwy UndBr	North	N30	9.535
1990	ILLAWARRA 103.467KMS ALBION PARK - HORSLEY CREEK UndBr	Illawarra	I00	103.467
1990	ILLAWARRA 104.822KMS OAK FLATS CREEK - INDUSTRIAL Rd UndBr	Illawarra	I00	104.822
1990	ILLAWARRA 118.002KMS BOMBO - SPRING CREEK UndBr	Illawarra	I00	118.002
1990	ILLAWARRA 126.053KMS OMEGA - WEST ARM WERRI LAGOON UndBr	Illawarra	I00	126.053
1990	ILLAWARRA 126.259KMS OMEGA - FLAT FLOOD Plain UndBr	Illawarra	I00	126.259
1990	ILLAWARRA 126.463KMS OMEGA - OOAREE Creek UndBr	Illawarra	I00	126.463
1990	ILLAWARRA 140.220KMS BERRY - BROUGHTON MILL Creek UndBr	Illawarra	I00	140.220
1990	ILLAWARRA 140.636KMS BERRY - CAPEL Crk UndBr	Illawarra	I00	140.636
1990	ILLAWARRA 144.513KMS BERRY - JASPER'S Ck. UndBr	Illawarra	I00	144.513
1990	ILLAWARRA 148.688KMS BOMADERRY(NOWRA) - WILEY'S Ck Trib UndBr	Illawarra	I00	148.688
1990	ILLAWARRA 151.961KMS BOMADERRY(NOWRA) - MULGEN Creek UndBr	Illawarra	I00	151.961
1990	ILLAWARRA 139.688KMS BERRY - TANNERY Rd UndBr/BEACH RD.	Illawarra	I00	139.688
1990	ILLAWARRA 98.509KMS YALLAH - DUCK Ck UndBr	Illawarra	I00	98.509
1990	ILLAWARRA 113.880KMS MINNAMURRA - FEDERAL Ave UndBr	Illawarra	I00	113.880
1990	MAIN WEST 62.030KMS LAPSTONE - F4 FREEWAY UndBr	West	W00	62.030
1990	MAIN WEST 105.450KMS LEURA - GREAT WESTERN Hwy UndBr	West	W00	105.450
1990	MAIN WEST 56.253KMS PENRITH - BRUCE NEAL DRIVE Und	West	W00	56.253
1991	ALLT NORTH 19.114KMS WEST RYDE - VICTORIA Rd PedSWy	North	N00	19.114
1991	CHULLORA JCT-SEFTON JCT 21.551KMS SEFTON PARK JCT - WATERWAY UndBr	Central	M66	21.551
1991	MAIN SOUTH 20.275KMS REGENTS PARK - (S00) WATERWAY UndBr	Central	S00	20.275
1991	ILLAWARRA 139.338KMS BERRY - BROUGHTON Creek UndBr	Illawarra	I00	139.338
1991	ILLAWARRA 80.153KMS FAIRY MEADOW - UndBr (Unknown Crossing)	Illawarra	I00	80.153
1991	ILLAWARRA 80.733KMS NORTH WOLLONGONG - UndBr	Illawarra	I00	80.733
1991	MAIN NORTH 63.328KMS WONDABYNE - UndBr	North	N00	63.328
1991	CLYDE TO CARLINGFORD 23.915KMS CAMELLIA - VINEYARD Crk UndBr	West	M13	23.915
1991	ILLAWARRA 91.204KMS KEMBLA GRANGE - UNNAMED Ck Und	Illawarra	I00	91.204

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1991	ILLAWARRA 91.451KMS KEMBLA GRANGE - UNNAMED UndBr	Illawarra	I00	91.451
1991	BLACKTOWN TO RICHMOND 54.917KMS WINDSOR - GEORGE St UndBr	West	M17	54.917
1991	CLYDE TO CARLINGFORD 23.236KMS CAMELLIA - HARDIE'S UndBr	West	M13	23.236
1991	GRANVILLE TO CABRAMATTA 29.880KMS FAIRFIELD - Near AUSTRAL Pde UndBr	West	M16	29.880
1991	GRANVILLE TO CABRAMATTA 25.080KMS GUILDFORD - Near ELIZABETH St UndBr	West	M16	25.080
1991	WAVERTON TO LAVENDER BAY 6.091KMS W-VTON-W-COT Av/CAR St UnBr_HRTG_4801022	Infra. Fac.	M29	6.091
1992	BLACKTOWN TO RICHMOND 35.212KMS BLACKTOWN - Unkn Cross UndBr	West	M17	35.212
1992	MAIN SOUTH 20.745KMS SEFTON - WOODS Rd UndBr	Central	S00	20.745
1992	ILLAWARRA 92.558KMS KEMBLA GRANGE - MULLET CREEK OFlow UndB	Illawarra	I00	92.558
1992	ILLAWARRA 143.959KMS BERRY - FLYING FOX Creek UndBr	Illawarra	I00	143.959
1992	MAIN NORTH 126.117KMS MORRISET - MOIRA PARK Rd No2 UndBr	North	N00	126.117
1992	MAIN NORTH 127.490KMS DORA CREEK-MUDDY LAKE-No.1 CREEK UndBr	North	N00	127.490
1992	MAIN NORTH 127.608KMS DORA CREEK-MUDDY LAKE-No.2 CREEK UndBr	North	N00	127.608
1992	MAIN NORTH 127.769KMS DORA CREEK-MUDDY LAKE-No.3 CREEK UndBr	North	N00	127.769
1992	GRANVILLE TO CABRAMATTA 30.277KMS FAIRFIELD/C VALE - Nr CATHCART St UndBr	West	M16	30.277
1992	MAIN WEST 157.624KMS BOWENFELS - WATERWAY UndBr	West	W00	157.624
1992	ILLAWARRA 125.376KMS OMEGA - UNNAMED Ck. UndBr	Illawarra	I00	125.376
1992	MAIN SOUTH 44.246KMS MACQUARIE FIELDS - BUNBURY CURRAN Crk No	Illawarra	S00	44.246
1992	MAIN NORTH 70.165KMS WOY WOY - SHOALHAVEN Rd UndBr	North	N00	70.165
1992	MAIN NORTH 70.330KMS WOY WOY - WOY WOY Crk UndBr	North	N00	70.330
1992	MAIN NORTH 91.495KMS OURIMBAH - DOG TRAP GULLY UndBr	North	N00	91.495
1992	MAIN NORTH 120.462KMS MORISSET - POURMALONG Crk UndBr	North	N00	120.462
1992	MAIN NORTH 160.554KMS ADAMSTOWN - CYCLE-WAY UndBr	North	N00	160.554
1992	MAIN NORTH 124.315KMS MORISSET - MOIRA PARK Rd No1 UndBr	North	N00	124.315
1992	MAIN SUBURBAN (CEN-GRANV) 8.358KMS ASHFIELD - OLD STN ACCESS PedSWy	Central	M00	8.358
1993	ILLAWARRA 132.239KMS GERRINGONG - CROOKED CK Trib UndBr	Illawarra	I00	132.239
1993	MAIN NORTH 83.741KMS NARARA - NARARA Crk 2 UndBr	North	N00	83.741
1993	MAIN NORTH 153.931KMS SULPHIDE JCT - WINDING Crk UndBr	North	N00	153.931

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1993	MAIN WEST 48.410KMS WERRINGTON - SOUTH CREEK UndBr	West	W00	48.410
1993	MAIN WEST 48.758KMS WERRINGTON - CLAREMONT CREEK UndBr	West	W00	48.758
1993	ILLAWARRA 128.669KMS GERRINGONG - BELINDA St UndBr	Illawarra	I00	128.669
1993	MAIN NORTH 98.213KMS TUGGERAH - TUGGERAH CK. UndB	North	N00	98.213
1993	MAIN WEST 79.851KMS SPRINGWOOD - JERSEYWOLD AVENUE UndBr	West	W00	79.851
1994	WOODVILLE JCT TO NEWCASTLE 166.074KMS WICKHAM - COTTAGE Crk 1 UndBr	North	N33	166.074
1994	ILLAWARRA 148.004KMS BOMADERRY(NOWRA) - WILEY'S Creek UndBr	Illawarra	I00	148.004
1994	MAIN WEST 109.918KMS KATOOMBA - STATION PedSWy_HRTG_4801008	West	W00	109.918
1994	BANKSTOWN LINE 10.423KMS C-TRBY-C/Rvr-CHARLES St UBr_HRTG_4801568	Central	M24	10.423
1994	BANKSTOWN LINE 10.714KMS CAMPSIE - (M24 PART) WAIROA St UndBr	Central	M24	10.714
1994	ILLAWARRA 118.975KMS KIAMA - TERRALONG St UndBr_HRTG_4800158	Illawarra	I00	118.975
1994	ILLAWARRA 125.813KMS OMEGA - NTH WEST ARM WERRI LAGOON UndBr	Illawarra	I00	125.813
1994	ILLAWARRA 126.630KMS OMEGA-Ck.STH WEST ARM WERRI LAGOON UndBr	Illawarra	I00	126.630
1994	ILLAWARRA 135.771KMS GERRINGONG - WATERWAY UndBr	Illawarra	I00	135.771
1994	ILLAWARRA 142.667KMS BERRY - MULLER'S UndBr1-Nth MULLERS LANE	Illawarra	I00	142.667
1994	ILLAWARRA 142.723KMS BERRY - MULLER'S UndBr2-Nth MULLERS LANE	Illawarra	I00	142.723
1994	ILLAWARRA 151.334KMS BOMADERRY(NOWRA) - ABERNATHY'S Creek Und	Illawarra	I00	151.334
1994	BLACKTOWN TO RICHMOND 54.853KMS WINDSOR - MACQUARIE St UndBr	West	M17	54.853
1994	BANKSTOWN LINE 21.051KMS YAGOONA - FARNELL Rd UndB	Central	M24	21.051
1994	MAIN WEST 23.138KMS P-MTTA-SYD N STN ACES PdSWy_HRTG_4801031	West	W00	23.138
1994	FLEMINGTON GOODS 12.974KMS HOMEBUSH - (M72 PART) SUBWAY La UndBr	Central	M72	12.974
1994	MAIN WEST 90.391KMS WOODFORD - STATION PedSWy_HRTG_4801041	West	W00	90.391
1995	GRANVILLE TO CABRAMATTA 31.440KMS CANLEY VALE - Near BARTLEY St UndBr	West	M16	31.440
1995	MAIN WEST 35.174KMS BLACKTOWN - BALMORAL ST (RING RD) UndBr	West	W00	35.174
1995	CLYDE TO CARLINGFORD 23.365KMS RYDALMERE - P-MTA RVR UBr_HRTG_4800212	West	M13	23.365
1995	ILLAWARRA 73.775KMS WOONONA - COLLIN'S CREEK UndBr	Illawarra	I00	73.775
1995	MAIN NORTH 85.920KMS NIAGARA PARK - NARARA Crk UndBr	North	N00	85.920
1995	ILLAWARRA 70.552KMS THIRROUL - HEWITTS CREEK UndB	Illawarra	I00	70.552

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1995	ILLAWARRA 77.454KMS CORRIMAL - TOWRADGI Ck UndBr	Illawarra	I00	77.454
1995	ILLAWARRA 79.683KMS FAIRY MEADOW - CABBAGE TREE CREEK UndBr	Illawarra	I00	79.683
1995	MAIN NORTH 82.707KMS GOSFORD - BRADY'S GULLY UndBr	North	N00	82.707
1995	MAIN NORTH 83.220KMS GOSFORD - WINGELLO Crk UndBr	North	N00	83.220
1995	MAIN NORTH 83.347KMS NARARA - NARARA Crk1/WYOMING Crk UndBr	North	N00	83.347
1995	MAIN NORTH 89.792KMS OURIMBAH - CUT ROCrk Crk UndB	North	N00	89.792
1995	MAIN NORTH 93.099KMS OURIMBAH - BULLOCKS Rd UndBr	North	N00	93.099
1995	MAIN NORTH 154.143KMS CARDIFF - MAIN Rd UndBr	North	N00	154.143
1995	BLACKTOWN TO RICHMOND 59.773KMS EAST RICHMOND - UndBr	West	M17	59.773
1995	MAIN SOUTH 42.699KMS GLENFIELD - BUNBURY CURRAN Crk No.1 UndB	Illawarra	S00	42.699
1995	MAIN SOUTH 43.520KMS MACQUARIE FIELDS - BUNBURY CURRAN Crk No	Illawarra	S00	43.520
1995	MAIN SOUTH 44.263KMS MACQUARIE FIELDS - BUNBURY CURRAN Crk No	Illawarra	S00	44.263
1996	MAIN WEST 59.772KMS EMU PLAINS - ACCESS OFF BROMLER RD UndBr	West	W00	59.772
1996	MAIN NORTH 24.020KMS EPPING - M2 BUS SUBWAY UndBr	North	N00	24.020
1996	GRANVILLE TO CABRAMATTA 22.018KMS G-VLLE-Y-LNK M16 ov M42 Fov_HRTG_4800107	West	M16	22.018
1996	MAIN NORTH 24.400KMS EPPING - M2-Fwy UndBr	North	N00	24.400
1996	MAIN SUBURBAN (CEN-GRANV) 15.553KMS LIDCOMBE - ARTHUR St UndBr	Central	M00	15.553
1996	BANKSTOWN LINE 8.169KMS DULWICH HILL-(M24)NESS Av/TERR. Rd UndBr	Central	M24	8.169
1996	METROPOLITAN GOODS 9.084KMS H-STNE PK-M52 FOORD Av UnBr_HRTG_4805737	Central	M52	9.084
1996	ILLAWARRA 82.370KMS WOLLONGONG CITY - VICTORIA St UndBr	Illawarra	I00	82.370
1996	MAIN NORTH 92.071KMS OURIMBAH - BANGALOW Crk UndBr	North	N00	92.071
1996	MAIN NORTH 112.486KMS WYEE - SPRING Crk UndBr	North	N00	112.486
1996	MAIN NORTH 115.131KMS WYEE - MANNERING Crk UndBr	North	N00	115.131
1996	MAIN NORTH 116.221KMS WYEE - PALLAMANABA Crk UndBr	North	N00	116.221
1996	MERRYLANDS- HARRIS PARK 21.836KMS HARRIS PARK - PARRAMATTA ROAD UndBr	West	M42	21.836
1996	OLYMPIC PARK LOOP 16.214KMS HOMEBUSH BAY - EDWIN FLACK Ave UndBr	Central	M78	16.214
1997	METROPOLITAN GOODS 6.667KMS MARRICKVILLE-(M52 PART) SEWER LINE UndBr	Central	M52	6.667
1997	ILLAWARRA 7.324KMS Wolli Creek - Station PedSubWay	Illawarra	I00	7.324
1997	CLYDE TO CARLINGFORD 21.374KMS ROSEHILL - DUCK CREEK UndBr	West	M13	21.374

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
1997	CLYDE TO CARLINGFORD 21.641KMS ROSEHILL - ABECKETTS Ck UndBr	West	M13	21.641
1997	MAIN WEST 58.426KMS EMU PLAINS - UndBr	West	W00	58.426
1997	ILLAWARRA 7.360KMS WOLLI CREEK - I00 & M25 OVER M26 Dive	Illawarra	I00	7.360
1998	ILLAWARRA 112.843KMS MINNAMURRA - The Village PedSWy	Illawarra	I00	112.843
1998	OLYMPIC PARK LOOP 15.150KMS FLEMINGTON - M78 OVER M72 Dive	Central	M78	15.150
1998	OLYMPIC PARK LOOP 15.978 KMS FLEMINGTON - PARRA RD (EAST) UndBr	Central	M78	15.978
1998	MAIN NORTH 86.440KMS NIAGARA PARK - NORTH UndBr	North	N00	86.440
1998	OLYMPIC PARK LOOP 18.053KMS HOMEBUSH BAY - AUSTRALIA Ave UndBr	Central	M78	18.053
1998	MAIN WEST 156.041KMS LITHGOW - Unkn Crosg UndBr	West	W00	156.041
1999	MAIN WEST 79.700KMS SPRINGWOOD-STATION PedSWy_HRTG_4801035	West	W00	79.700
1999	MAIN WEST 74.985KMS WARRIMOO - SERVICE ROAD UndBr	West	W00	74.985
2000	NEW SOUTHERN RAILWAY - 0.390Kms PRINCE ALFRED SIDING - FLYOVER	Del. Support Unit	M26	0.390
2000	TEMPE TO GLENFIELD JCT 7.845KMS TURRELLA - Sewer Pipeline UnderBr	Illawarra	M25	7.845
2000	MAIN SOUTH 50.022KMS MINTO - WATERWAY UndBr	Illawarra	S00	50.022
2000	MAIN NORTH 78.880KMS POINT CLARE - CYCLEWAY UNDERPASS PedSWy	North	N00	78.880
2001	MAIN SOUTH 50.030KMS MINTO - WATERWAY UndBr	Illawarra	S00	50.030
2001	TEMPE TO GLENFIELD JCT 9.231KMS TURRELLA - Bardwell Creek UnderBr	Illawarra	M25	9.231
2001	BOTANY LINE 14.992 KMS SYDENHAM - PedSWy	Central	M50	14.992
2002	BLACKTOWN TO RICHMOND 37.570KMS MARAYONG - VARDYS Rd (DNMAIN) UndBr	West	M17	37.570
2003	ROZELLE LINE 7.944KMS DULWICH HILL-(M58)NESS Av/TERR. Rd UndBr	Central	M58	7.944
2003	TEMPE TO GLENFIELD JCT 14.199KMS BEVERLY HILLS -Stormwater Canal UnderBr	Illawarra	M25	14.199
2003	TEMPE TO GLENFIELD JCT 14.272KMS BEVERLY HILLS -Stormwater Canal UnderBr	Illawarra	M25	14.272
2003	NORTH SHORE 12.639KMS ROSEVILLE - WILLIAM St UndBr	North	N30	12.639
2004	FLEMINGTON CAR SIDINGS 15.527KMS FLEMINGTON - SHUNT NECK ovr M72 FlyOv	Central	FCS	15.527
2006	BANKSTOWN LINE 5.646KMS SYDENHAM - CANAL UnderBr	Central	M24	5.646
2006	MAIN WEST 93.903KMS HAZELBROOK - OAKLANDS Rd UndBr	West	W00	93.903
2006	MAIN WEST 23.086KMS PARRAMATTA - ARGYLE St No 2 Subs UndBr	West	W00	23.086
2006	MAIN WEST 23.090KMS PARRAMATTA - ARGYLE St No 1 Mains UndBr	West	W00	23.090
2007	TEMPE TO GLENFIELD JCT 15.577KMS NARWEE - BROADARROW Rd UndBr	Illawarra	M25	15.577

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
2007	ILLAWARRA 11.010KMS Rockdale - Harrow Rd UnderBr	Illawarra	I00	11.010
2007	NORTH SHORE 11.550KMS CHATSWOOD - ALBERT Ave UndBr	North	N30	11.550
2007	NORTH SHORE 11.896KMS CHATSWOOD - HELP St UndBr	North	N30	11.896
2007	MAIN WEST 57.755KMS EMU PLAINS - WATERWAY NEAR SCHOOL UndBr	West	W00	57.755
2008	WESTERN TRIANGLE LOOP 17.289KMS LIDCOMBE - BRIDGE St (On Loop) UndBr	Central	S00	17.289
2008	MAIN WEST 26.903KMS WENTWORTHVILLE-CUMB.Hwy/FREAME St UndBr	West	W00	26.903
2008	TEMPE TO GLENFIELD JCT 20.746KMS REVESBY-THE RIVER Rd (DN TRACKS) UnderBr	Illawarra	M25	20.746
2008	MAIN NORTH 112.078KMS WYEE-SOUTH BUSHELLS RIDGE Rd/CREEK UndBr	North	N00	112.078
2008	BANKSTOWN LINE 12.779KMS BELMORE - PED ACCESS TO OVAL UndBr	Central	M24	12.779
2008	MAIN SOUTH 17.865KMS BERALA - KERRS Rd UndBr	Central	S00	17.865
2008	MAIN SUBURBAN (CEN-GRANV) 12.227KMS S-FIELD-POWELLS CRK UndBr_HRTG_4801129	Central	M00	12.227
2008	METROP 49.360KMS METROP - Colliery Line C27 over I00 FlyO	Illawarra	C27	49.360
2008	TEMPE TO GLENFIELDJCT 31.330KMS GLENFIELD - QUARRY ACCESS Rd 2 UndBr	Illawarra	M25	31.330
2009	MAIN NORTH 93.921KMS OURIMBAH-CHITTAWAY Ck/TURPENTINE RdUndBr	North	N00	93.921
2009	TEMPE TO GLENFIELD JCT 16.792KMS RIVERWOOD - BONDS Rd UnderBr	Illawarra	M25	16.792
2009	ILLAWARRA 12.336KMS Kogarah - Prospect St UnderBr	Illawarra	I00	12.336
2009	TEMPE TO GLENFIELD JCT 18.313KMS RIVERWOOD - WEBB St (DOWN TRACKS) UndBr	Illawarra	M25	18.313
2009	MAIN SOUTH 37.171KMS CASULA - Nr CONGRESSIONAL Drv-1 UndBr	Illawarra	S00	37.171
2009	WAVERTON TO LAVENDER BAY 6.132KMS WAVERTON - COMMODORE CRES UndBr	Infra. Fac.	M29	6.132
2009	MAIN WEST 76.248KMS VALLEY HEIGHTS - GREEN PARADE #1 UndBr	West	W00	76.248
2010	MAIN SOUTH (Lidcombe-Glenlee) 36.290KMS LIVERPOOL-COLLINGWOOD VIADUCT UPMN UndBr	West	S00	36.290
2010	MAIN WEST 26.407KMS WENTWORTHVILLE - FINLAYSONS CK UndBr	West	W00	26.407
2010	SUTHERLAND TO CRONULLA 25.421KMS KIRRAWEE - MERTON St DNMN UndBr	Illawarra	I20	25.421
2010	MAIN SUBURBAN (CEN-GRANV) 15.521KMS FLEMINGTON - M00 OVER M52 GOODS FlyOv	Central	M00	15.521
2010	SUTHERLAND TO CRONULLA 24.987KMS SUTHERLAND-RAWSON Ave UPMN UndBr	Illawarra	I20	24.987
2010	SUTHERLAND TO CRONULLA 25.791KMS KIRRAWEE - GLENCOE St DNMN UndBr	Illawarra	I20	25.791
2010	SUTHERLAND TO CRONULLA 32.517KMS CARINGBAH - GANNONS Rd DNMN UndBr	Illawarra	I20	32.517
2010	TEMPE - GLENFIELD JUNCT 31.642KMS GLENFIELD-NORTHERN FLYOVER (M25overS00)	Illawarra	M25	31.642

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DATE	BRIDGE (BMS PARENT DESCRIPTION)	DISTRICT	ROUTE	KM
2011	BANKSTOWN LINE 18.438KMS BANKSTOWN - NORTH Tce to SOUTH Tce UndBr	Central	M24	18.438
2011	ILLAWARRA 9.471KMS Banksia - Subway Road UnderBr	Illawarra	I00	9.471
2011	BANKSTOWN LINE 22.665KMS BIRRONG - M24 OVER SSFL Dive	Central	M24	22.665
2011	TEMPE TO GLENFIELD JCT 18.370KMS RIVERWOOD-SALT PAN Ck-DN TRACKS-UnderBr	Illawarra	M25	18.370
2011	BLACKTOWN TO RICHMOND 40.910KMS QUAKER'S HILL - UndBr (Near SCO Sub)	West	M17	40.910
2011	BLACKTOWN TO RICHMOND 43.151KMS SCHOFIELDS - SCHOFIELDS RD UndBr	West	M17	43.151
2011	NORTH SHORE 12.836KMS ROSEVILLE - BOUNDARY St UndBr (NEW)	North	N30	12.836
2012	MAIN WEST 30.191KMS T-GABBIE - G-STANES CK UBr_HRTG_4800268	West	W00	30.191
2012	SOUTH WEST RAIL LINK 42.339KMS GLENFIELD-SOUTHERN FLYOVER-M28ovrS00&M25	Illawarra	M28	42.339
2013	SOUTH WEST RAIL LINK 42.661KMS GLENFIELD - SOUTHERN VIADUCT A UndBr	Illawarra	M28	42.661
2013	SOUTH WEST RAIL LINK 42.915KMS GLENFIELD - SOUTHERN VIADUCT B UndBr	Illawarra	M28	42.915

Table 4: Table of steel and concrete underbridges