Criteria

Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges

May 2014

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Amendment Register

Issue / Rev no.	Reference section	Description of revision	Authorised by	Date
1.00		Original	BCM&AM	3-Jul-13
1.01		Editorial	Review Structures	17-Sep-13
1.02		Definition of significant crack	Structures	20-Sep-13
1.03		Title changed, associated amendments and editorial changes	Structures	10-Oct-13
1.04		Amendments following feedback	Structures	1-Nov-13
1.05		Integration with Level 2 inspections	Structures	3-Feb-14
1.06		Updated for revised Bridge Inspection Manual	Structures	20-May-14

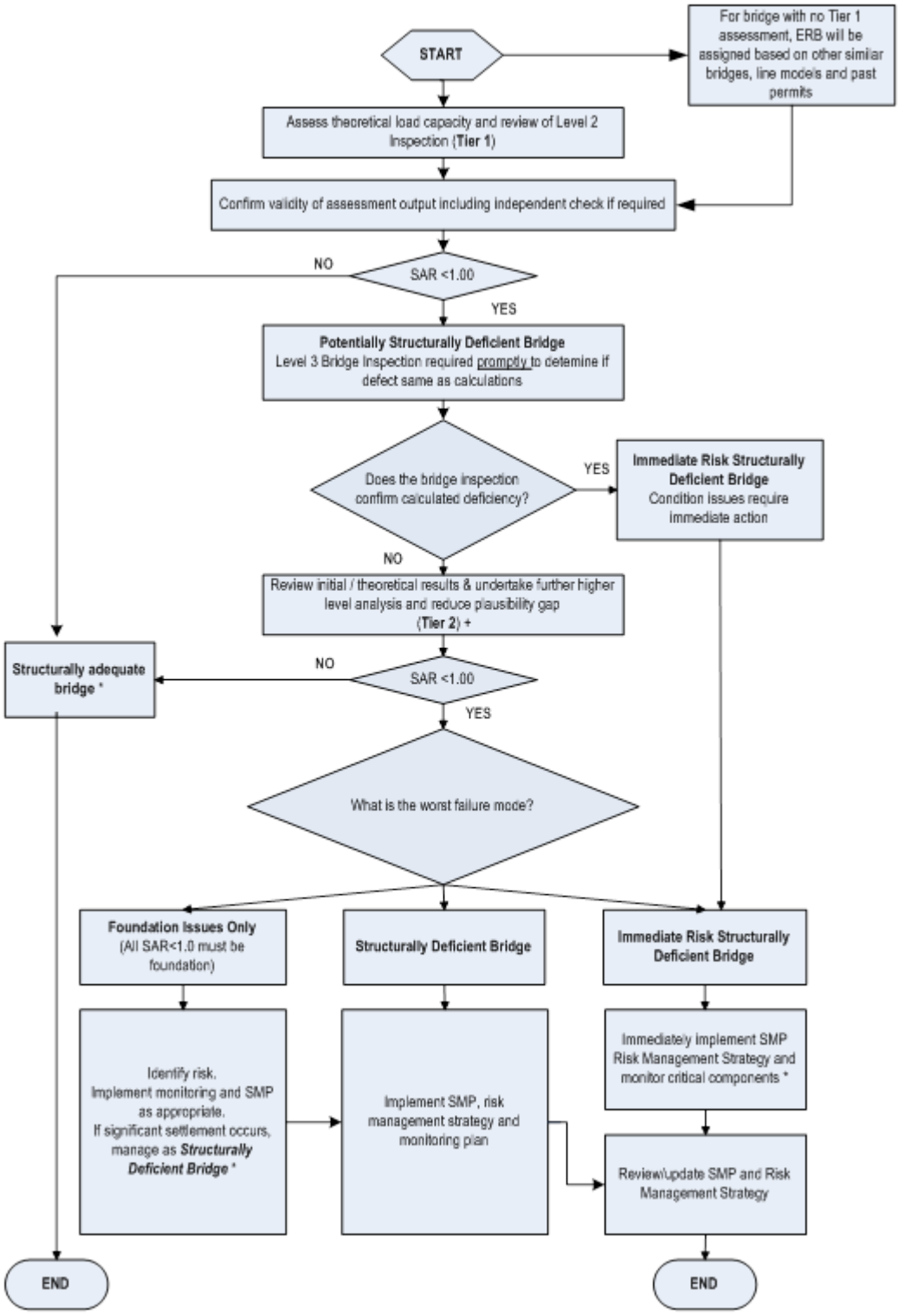
Contents

1 Introduction

Transport and Main Roads (TMR) is committed to providing structurally safe, sustainable access to all bridges on the road network. TMR assesses bridges based on Australian and international practice to manage risk. This risk is managed through the process depicted in Figure 1 and the Bridge Inspection Manual. This process consists of:

- an initial assessment (Tier 1) based on Australian Standard AS 5100 bridge assessment criteria as described in the Tier 1 Bridge Heavy Load Assessment Brief
- a "Level 3 Inspection" when the Tier 1 Assessment identifies a Potentially Structurally Deficient Bridge (PSDB) for freight vehicles (as-of-right MCVs). The focus of this Level 3 Inspection is to determine if the defect is the same as the potential structural deficiency identified in the calculations. The Level 3 Inspection may be either (refer Bridge Inspection Manual):
    - A structural engineering investigation or
    - A structural engineering inspection
- actions based on the findings of the Level 3 Inspection will vary with the intensity of the observed distress:
    - if the Level 3 Inspection identifies defects consistent with a calculated deficiency and are severe enough (refer Section 8) to require immediate action, then the bridge is classified and managed as an Immediate Risk Structurally Deficient Bridge (IRSDB) and the risks controlled via the immediate preparation and implementation of a Structure Management Plan (SMP).
    - if the Level 3 Inspection identifies defects that are consistent with a calculated deficiency but not severe enough (refer Section 8) to require immediate action, then the bridge is managed as a Potentially Structurally Deficient Bridge (PSDB) while additional higher-level assessment (Tier 2) is undertaken to further investigate/resolve the risk. Alternatively, the risk may be managed through a Structure Management Plan. If the deficiency is confirmed by Tier 2 assessment, the risks will be controlled via the preparation and implementation of a SMP.
    - if a Tier 1 calculated deficiency is not confirmed by a Level 3 Inspection, then the bridge may remain as a Potentially Structurally Deficient Bridge while additional higher-level assessment (Tier 2) may be undertaken or the risk controlled through a Structure Management Plan. If the deficiency is confirmed by Tier 2 assessment, the risks will be controlled via the preparation and implementation of a SMP.

Figure 1: Flowchart for Structural Assessment of Existing Bridges for MCV



* If the ERB for permit vehicle (e.g. crane or HLP) causes route load capacity problem, then a Tier 2 assessment may be requested by Dir (BCM&AM) or DCE.

+ If a Tier 2 assessment does not immediately follow Tier 1 assessment, a SMP should be implemented. Previous Tier 2 results of a similar issue may be adopted on another bridge.

2 TMR Documents related to Bridge Assessment

The following is a list of documents prepared by the Department of Transport and Main Roads in relation to the assessment of existing road bridges.

Policy documents:

- *Structural Assessment of Existing Road Bridges Organisational Policy*
- *Vehicle Limits Manual* (Version 2 Feb 2011) (Not publically available)
- *Bridge Inspection Manual*

Project criteria:

- *Level 3 Inspection Criteria for Potentially Structurally Deficient Bridges – this document*
- *Tier 1 Bridge Heavy Load Assessment Criteria*
    - *Annexure S01: Frame Models of Complete Bridge Structures for Tier 1 Assessments*
    - *Annexure S02: Modelling Deck Unit Superstructures for Tier 1 Assessments*
    - *Annexure S03: Tier 1 Assessment of Shear in Concrete Short Span Bridges to AS 5100 & AS 3600*
    - *Annexure S04: Tier 2 Assessment of Shear in Concrete Short Span Bridges*

3 Purpose

A Level 3 Inspection is targeted at elements of bridges identified as Potentially Structurally Deficient as a result of Tier 1 or Tier 2 Bridge Heavy Load Assessments. Level 3 Inspections are to:

- determine if the elements or groups of elements are exhibiting distress consistent with the assessed deficiency (i.e., the bridge is considered an Immediate Risk Structurally Deficient Bridge as per Figure 1)
- provide immediate advice (e.g., while on site during a Level 3 Inspection, if possible) to TMRs' Director (Bridge Construction Materials & Asset Management) of any bridge identified as an Immediate Risk Structurally Deficient Bridge
- determine if the elements or groups of elements are exhibiting signs of possible distress consistent with the assessed deficiency (i.e., the bridge not considered an Immediate Risk Structurally Deficient Bridge as per Figure 1 but there is possible distress that may warrant further investigation)
- confirm or otherwise that the drawings used for the Tier 1 or Tier 2 assessment are broadly consistent with the as constructed bridge (e.g., an alternate design for the superstructure may have been constructed but the assessment was for the original drawings)
- identify other deficiencies observed during the assessment that are considered significant in terms of the assessment and/or management of the bridge
- provide input for the ongoing assessment and management of the bridge.

4 Investigator and Inspector Qualifications

The lead Engineering Investigator and Inspector shall be a Registered Professional Engineer of Queensland (RPEQ) with extensive and current bridge design and assessment experience (minimum

of 10 years) shall conduct the engineering investigations inspections. The report shall contain a signature block including date, name, RPEQ number and signature of the RPEQ responsible for the inspection.

5 Scope

5.1 In-Scope

5.1.1 Structural Engineering Investigation:

- Identification from the Assessment Report of all the elements identified as Potentially Structurally Deficient (i.e. Assessment Ratios < 1.0 for freight vehicles (as-of-right MCVs)) and the reasons / magnitude of each potential deficiency.
- The collation of the available information relating to the Potentially Structurally Deficient elements, including:
    - The Assessment report/s for the bridge
    - Level 2 Inspection Reports
    - Drawings
    - Photographs
    - Other information such as previous reports, TMR files
- A review of the available information to confirm that the drawings used for the assessment are broadly consistent with the as constructed bridge.
- A desktop review of the available information to identify if the potential deficiencies observed during the assessment is considered significant in terms of the assessment and/or management of the bridge. The inspection shall also take note if significant deterioration of structural elements is evident.
    - When the engineer believes there is adequate and sufficient information to determine that the calculated deficiency is not confirmed by the condition of the bridge, a Structural Engineering Investigation report is prepared.
    - When there is insufficient information to determine if the calculated deficiency is confirmed by the condition of the bridge, a targeted supplementary Level 2 inspection report is to be prepared and reviewed as part of the Structural Engineering Investigation or a Structural Engineering Inspection is to be conducted.
    - When there is a concern that the condition of the bridge confirms the calculated deficiency, a Structural Engineering Inspection is to be conducted.
    - When the condition of the bridge confirms the calculated deficiency, a Structural Engineering Inspection report is prepared, the Director (Bridge Construction Materials & Asset Management) advised, and the risk managed via a Structure Management Plan.
- The immediate reporting to the Director (Bridge Construction Materials & Asset Management) of elements where the visual inspection confirms the calculated deficiency.
- Preparation and submission of a report for each bridge.

5.1.2 Structural Engineering Inspections:

- Identification from the Assessment Report of all the elements identified as Potentially Structurally Deficient (i.e. Assessment Ratios < 1.0 for freight vehicles (as-of-right heavy MCVs)) and the reasons / magnitude of each potential deficiency.
- Review of the provided information relating to the Potentially Structurally Deficient elements, including:
    - The Assessment report/s for the bridge
    - Level 2 Inspection Reports
    - Drawings
    - Other provided information
- Determination and programming of equipment and resources required for the inspection (in conjunction with the TMR Region) including preparation of a safety plan. In general, Structural Engineering Inspections are to be conducted “at arm’s length” and specialist access and traffic control is a likely requirement. Arrangements are to be agreed with TMR regarding the provision of site clearance, provision of access and access equipment, traffic management, site management (refer Annexure).
- Confirmation or otherwise that the drawings used for the assessment are broadly consistent with the as constructed bridge.
- A Structural Engineering Inspection is to identify deficiencies observed during the assessment considered significant in terms of the assessment and/or management of the bridge. The inspection shall also take note if significant deterioration of structural elements is evident.
- A photographic record of the inspection with a particular focus on elements identified as Potentially Structurally Deficient from the Assessment report.
- The immediate reporting to the Director (Bridge Construction Materials & Asset Management) of elements where the visual inspection confirms the calculated deficiency.
- Preparation and submission of a report for each bridge.

5.2 Out-of-Scope

- Underwater inspections (unless specified otherwise in job specific brief)
- Inspections of elements that are underground
- A Level 2 inspection of the bridge
- Preparation of a Structure Management Plan (SMP)

5.3 Limitations of this Document

5.3.1 Within the Limits of the Document

This document is applicable to:

- Any TMR bridge or culvert that has been identified as a Potentially Structurally Deficient Bridge as a result of a Tier 1 assessment.
- the portion of substructures that are above ground/water level

- the portion of substructures below ground (if specified).

5.3.2 Beyond the Limits of the Document

This document is not applicable to:

- The portion of substructures that are below ground level.
- The portion of substructures that are below water level (unless specified otherwise in job specific brief).
- Level 3 inspections triggered by other purposes such as poor condition.

6 Definitions & Abbreviations

Term	Description
As-of-right vehicles	Vehicles that can operate on a route without a permit
Assessment Ratios	Ratios used in bridge assessment (refer ERB, ERT and SAR)
Assessment Vehicles	Reference Vehicles and Accompanying Vehicles (refer Tier 1 Heavy Load Assessment Criteria)
B-Double route (BD)	A highway designated as acceptable for utilisation by B-Doubles (i.e., excludes road trains)
BIS ID	A unique bridge identification number assigned to each bridge – the BIS ID is essential for all naming and filing systems
Critical Element	The critical element is the element with the minimum SAR for the loading scenario and component grouping under consideration
Defect	A noticeable departure from the expected in-service performance (rather than as a consequence of construction)
Distress	Structure exhibiting signs consistent with it having operated beyond its expected modes of operation (i.e. requires immediate assistance to protect the bridge and the public)
ERB	Equivalence Ratio Bridge (refer Tier 1 Heavy Load Assessment Criteria)
ERT	Equivalence Ratio Traffic (refer Tier 1 Heavy Load Assessment Criteria)
General Access route (GA)	A highway designated as acceptable for General Access Traffic (i.e., excludes B-Doubles and Road Trains)
Grouping	A code used to identify if the component is part of an abutment, pier or span
High redundancy bridges	Bridges where the failure of an element does not lead to total collapse.
HLP	Heavy load platform
Longitudinal direction	The direction on a bridge generally parallel with the road centre line
Low redundancy bridges	Bridges where the failure of an element leads to total collapse (e.g., a bridge with two girders).
MCV	Multi-combination vehicle including Road Trains, B-Doubles, and BAB-quads (refer TMR “Guideline for Multi-combination Vehicles in Queensland”).
Reference Vehicle (RV)	The Assessment Vehicle the bridge was assessed for

Term	Description
Road Train route	A highway designated as acceptable for Road Trains (i.e., includes General Access vehicles, B-Doubles and Type 1 or Type 2 Road Trains)
RPEQ	Registered Professional Engineer of Queensland
SAR	Strength Assessment Ratio (refer Tier 1 Heavy Load Assessment Criteria)
SLS	Serviceability limit state
SMP	Structure Management Plan
Transverse direction	The direction on a bridge generally perpendicular to the road centre line.
ULS	Ultimate limit state

7 Principal Supplied Material

TMR will provide:

- project drawings for each bridge (unless previously supplied)
- relevant standard drawings (unless previously supplied)
- Level 2 bridge inspection reports including photographs (unless previously supplied)
- inventory photographs (unless previously supplied)
- Tier 1 and/or Tier 2 Assessment Reports
- Bridge Parameters for the Level 3 Inspection of Potentially Structurally Deficient Bridges (refer Appendix B)f

7.1 Interpretation of Drawings

Drawings shall be interpreted in conjunction with the particular Standard Drawing identified on the Drawing itself. The relevance of the Standard Drawing shall be further confirmed by comparing the year of issue of both the Drawing and the Standard Drawing.

7.2 Interpretation of Inspection Reports

The Bridge Inspection Reports are to be read in accordance with the Bridge Inspection Manual (2nd Edition, June 2004), found at the following link:

http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Bridge-Inspection-Manual.aspx

Particular attention shall be paid to:

i. Part 3: Procedures
    a. Figure 1.0 Standard Component Matrix
    b. Table 1.3 Standard Component Schedule
    c. Figure 1.3 Bridge Component Designation
    d. Figure 1.5 General Terminology for Bridges

ii. Appendix D: Standard Component Condition State Guidelines

8 Bridge Inspection

8.1 Introduction

The identification of an Immediate Risk Structurally Deficient Bridge requires some judgement and will be dependent upon specific circumstances. In assessing immediate risk to public safety, relevant factors such as the consequence of failure, nature of the structural weakness, any corresponding signs of distress, the possibility of hidden distress, condition data, the sensitivity of the structure to the applied loading, the recent load history of the structure and the level of assessment completed should be taken into account. The past performance of the structure under unrestricted loading can often provide valuable evidence in assessing whether an immediate risk is posed.[1]

The inspection is to be focused on components identified as Potentially Structurally Deficient. Where there are multiple similar elements with the same potential structural deficiency (e.g., shear in an internal prestressed concrete girder), then a close inspection of a sample of these elements and an overview inspection of the balance will generally be sufficient.

8.2 Data Recording

Care is required to ensure that the reporting of the inspected elements conform with standard descriptions of the bridge, with a particular emphasis on the correct identification of abutments and pier numbers (from Abutment A to Abutment B) and deck members (numbered from left to right looking in the direction of increasing chainage from Abutment A to Abutment B) (refer Section 7.2 for more information).

8.3 Photography

Photographs become a historic record of the inspection and should provide sufficient evidence to enable an independent engineer to verify the observations and conclusions.

Clear, sharp photographic images are essential.

Photographs are to include:

- The sign identifying the bridge (if it exists)
- Overall pictures of the bridge including:
    - Side view of the left hand side of the bridge
    - Side view of the right hand side of the bridge
    - A view along the bridge from Abutment A to Abutment B
    - A view along the bridge from Abutment B to Abutment A
- Overall pictures of the underside of the bridge including:
    - Each abutment
    - Each pier type

[1] Slightly modified extract from BD79/06 The management of Sub-standard Highway Structures, Design manual for Roads and Bridges, Volume 3 Highway Structures: Inspection and maintenance Section 4 Assessment, part 18, UK Highways Agency

    - Each typical span arrangement
- Photographs of each or representative samples of elements identified as Potentially Structurally Deficient. Elements are generally to be photographed 3 times (preferably in sequence):
    - photo/s to set the element in context of the bridge and to allow its location to be identified
    - photo/s to set the element in the context of its component
    - photo/s to show the defects (or the lack thereof), preferably including an identifying label and an object of known scale

8.4 Identifying Structurally Deficient Components

The inspections are to target the components identified as Potentially Structurally Deficient. Engineering experience is to be used to ascertain the type of distress to be expected based on the calculated deficiency. Examples include:

- excessive deformations – vertical / horizontal / rotational
- excessive cracking
- buckling
- excessive distortion
- variations in performance between elements within or between spans
- excessive travel in bearings / deck joints.

Where possible, the cracks are to be measured and marked with a permanent marker pen. The extent of the cracks should be marked with a line across the end of the crack and the date. At locations where crack widths are measured, mark the crack with a line across the crack, the crack width and date so as to facilitate repeat crack width measurements. The marked up cracks, including crack widths, are to be photographed and reported.

Wetting concrete assists the visual identification of cracks. Large water pistols / “super soakers” can be used to dampen the surface of concrete from a distance such as during a Type A inspection.

It is important to determine if the distress is a consequence of traffic loads as opposed to other causes. For example, the cracking in concrete structures may be a result of shrinkage and creep and not be related to heavy vehicle loading.

Definitions of the categorisation of cracking in concrete members are contained in Appendix A. Particular care needs to be taken with thick concrete members that are lightly reinforced in shear, identified as potentially structurally deficient in shear, and the shear cracking may not be visible on the surface (e.g., thick slabs / deck units and possibly footings).

8.5 Reporting

The reporting is to be sufficient to report the current situation and to allow the distress or lack thereof to be monitored over time.

Cracking / distress is to be reported for each element or representative element identified as potentially structurally deficient during the theoretical assessment. Cracks in elements considered

consistent with or possibly consistent with the theoretically deficiency are to be documented. Finer cracking or the absence of cracks is to be noted.

8.6 Reporting Immediate Risk Structurally Deficient Bridges

If the Structural Engineering Investigation or Inspection identifies distress consistent with a calculated deficiency, then the bridge is classified as an Immediate Risk Structurally Deficient Bridge (IRSDB) and there will be an immediate preparation and implementation of a Structure Management Plan (SMP). In this scenario, the engineering investigator/inspector is to immediately report (preferably while on site for an inspection) the revised classification to the Director (Bridge Construction Materials & Asset Management).

8.7 Other Observations

8.7.1 Traffic

Observe and report the volume and type of traffic crossing the bridge while at the site. The volume need only be a vehicle every 5 minutes etc for example. The type of vehicles should be recorded as road trains (no of trailers), rigid trucks (no axles) cranes etc.

8.7.2 Road Conditions

Record any observations that may prove helpful should lane restrictions prove necessary for the bridge. This includes the approximate available sight and stopping distances for heavy vehicles.

8.7.3 Construction Access

Record any observations that may prove helpful should it prove necessary to strengthen the potentially structurally deficient components of the bridge. This includes the approximate available sight and stopping distances for heavy vehicles.

9 Deliverables

The following deliverables are required to be delivered to the project manager at the completion of the works:

- a covering letter summarising the works completed
- a succinct bound hard copy of each report in A4 portrait format for every bridge inspected (i.e. one bridge per report) and shall include:
    - the front cover should include the BIS ID, Bridge Name, Road No and Road Name
    - a signature block is to be incorporated at the front of each bridge report. The signature block is to include date, name, RPEQ number and signature of the RPEQ responsible for the inspection
    - a brief description of the bridge (at the front of the report)
    - a copy of the general arrangement drawing/s for the bridge
    - a summary of Potentially Structurally Deficient Components for unrestricted travel by MCVs identified during the Tier 1 Theoretical Assessment
    - a summary of the inspection, including:
        - Observations Relating to Potential Structural Deficiencies

        - Other Observations
        - Discussion
    - Conclusions & Recommendations
        - A determination regarding the likelihood of the bridge being a Immediate Risk Structurally Deficient Bridge
        - Other observations
    - An Appendix of representative photographs appropriately labelled
- a CD or USB containing electronic copies of:
    - each report in PDF file format
    - All photographs taken during the inspection (including information on the date and time taken)
    - The Assessment Report used as the basis for the inspection
    - Level 2 Inspection reports used
    - drawings used
    - other information provided

The CD or USB shall have the following folders with the relevant information stored in each folder:

- BIS ID Bridge Name
    - Dwgs
    - L2 Insp Report
    - Assess Reports
    - PSDB L3 Insp Report
    - Photos yy_mm_dd

Please note that the BIS ID is a unique numeric identified for each bridge and it is the primary means of identification of a bridge and thus all filing should be BIS ID centric. Filenames are to be short.

10 Additional Work

As a consequence of this inspection, additional work that is outside the scope of the inspection may be requested.

11 Communication

All communication with TMR shall be via the TMR Structures Project Manager.

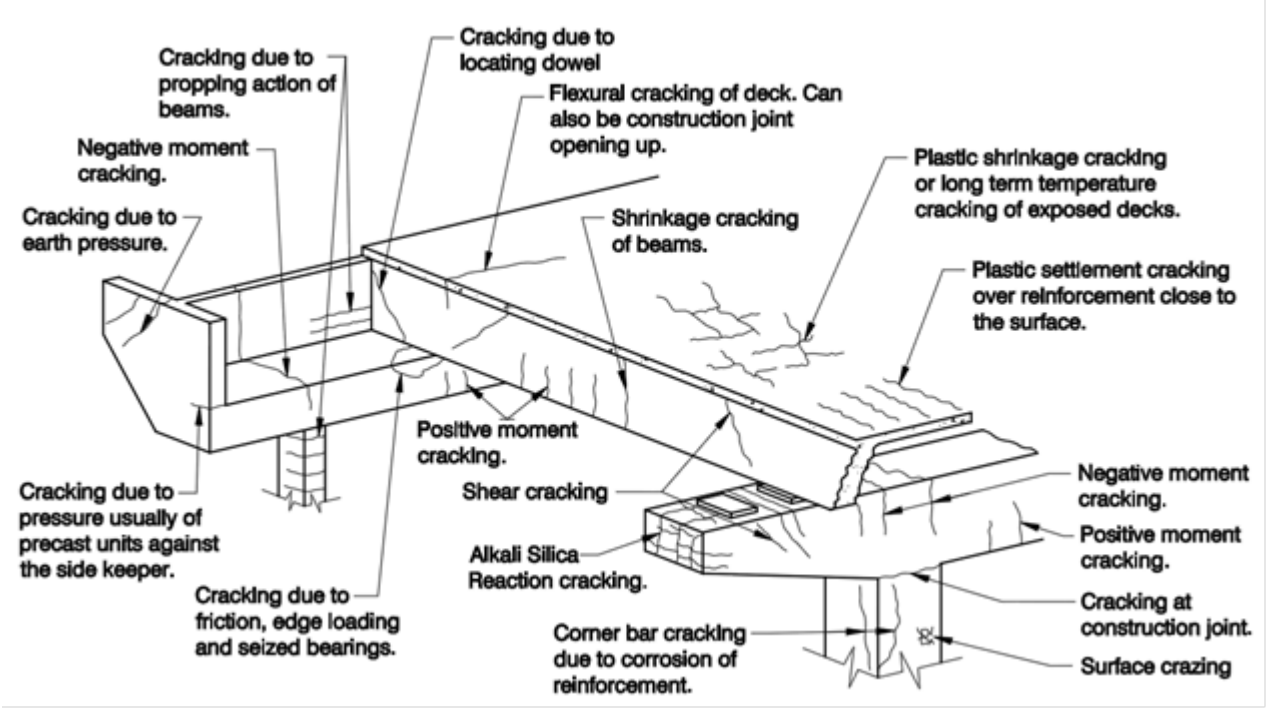
12 Timing

The assessment deliverables are required to be delivered to TMR Structures within 28 days of the receipt of the commission unless specified otherwise in the invitation for offer.

Appendix A Definition of Cracking in Potentially Structurally Deficient Concrete Components

It is not uncommon for cracks to be observed in concrete structures (refer Figure 2). Cracks are more common in reinforced concrete, especially older structures where the side face and shear reinforcement was minimal and restraints to shrinkage substantial. Cracks are less common in prestressed concrete elements due to the effect of the prestress and the isolation from the effects of restraint.

Figure 2 Cracking of Structures (Figure 1.2.4(a) from Bridge Inspection Manual, part 2 – Deterioration Mechanisms)



The Bridge Inspection Manual adopts the definitions of cracks based on their widths as summarised in Table 1.

Table 1 Definition of terms to describe crack widths

Definition of crack	Crack width
Hairline	≤ 0.1mm
Minor	0.1mm to 0.3mm
Moderate	0.3mm to 0.6mm
Severe	> 0.6mm

Cracks are can be assigned to two groups: cracks induced by structural actions; and cracks induced by non-structural actions such as deterioration mechanisms. This PSDB Level 3 Inspection targets the cracks induced by structural actions and seeks to categorise the bridge as:

- Immediate Risk Structurally Deficient Bridge requiring the immediate implementation of a SMP Risk Management Strategy and monitoring of critical components

- Potentially Structurally Deficient Bridge requiring SMP monitoring
- Potentially Structurally Deficient Bridge requiring further investigation of the crack

Table 2 provides some information to assist assign cracking in concrete members to these categorisations of structural cracking. It is intended that all of the criteria (compatible with theoretical defect, maximum crack width, and extent of cracking / depth of component) are satisfied for the same crack in order for that crack to satisfy the criteria for the category. This listing is not complete and other factors may need to be considered when determining the category of cracking.

Table 2 Categorisation of cracking in structural concrete

Category of structural cracking	**Reinforced concrete elements: Area of reinforcement associated with theoretical deficiency ≤ 1.2 x AS5100.5 minimum area of reinforcement** **Pre and post-tensioned members**			**Area of reinforcement associated with theoretical deficiency** **> 1.2 xAS5100.5 minimum area of reinforcement**		
	Compatible with theoretical defect	**Maximum cracks width (mm)**	**Extent of cracking / depth of component**	**Compatible with theoretical defect**	**Maximum cracks width (mm)**	**Extent of cracking / depth of component**
Immediate Risk Structurally Deficient Bridge	Yes	>0.3 (moderate)	>50%	Yes	>0.6 (severe)	>50%
Potentially Structurally Deficient Bridge requiring SMP monitoring	Yes	0.1 to 0.3 (minor)	10% to 50%	Yes or No	0.3 to 0.6 (moderate)	10% to 50%
Potentially Structurally Deficient Bridge requiring further investigation of the crack	No1	>0.3 (moderate)	>25%	No[1]	>0.6 (severe)	>25%

Notes:

1. The structural crack may have been caused by other effects such as settlement, differential temperature vehicle impact.

Appendix B Bridge Parameters for the Level 3 Inspection of Potentially Structurally Deficient Bridges

BIS ID	
Bridge Name	
Road No	
Road Name	
Road Section Name	
Tdist (km)	
Heavy Vehicle Route Type [Road-train, B-Double, or General Access]	
Loading Level [GML or HML]	
Potentially Structurally Deficient Components [Specify]	
Type of Level 3 Inspection [Investigation or Inspection]	
Requirements regarding site clearance, provision of access and access equipment, traffic management, site management [Specify].	
Other [Specify]	