Manual

Structures Inspection Manual

Part 3 - Appendix F: Guidelines for the Management of Sub-Standard and Defective Bridges

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Queensland Government

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1 Introduction

1.1 General

The corporate bridge inspection programme that commenced in 1997 has identified large numbers of defective bridges; amounting to some 260 in December 2003. These structures have been classified as being defective as a consequence of severe material degradation in principal load bearing members, overstressing, deficient design, construction or maintenance works or the substitution of undersized timber components in lieu of the specified member sizes when the bridge was constructed or in subsequent maintenance.

Additionally, almost two thirds of the department's bridges have been designed to now obsolete bridge loading design standards that are grossly inferior to contemporary standards and represent some 33 - 75% of the T44 design loading. As a point of reference, the T44 design vehicle produces a design load effect some 25% greater than the general access 42.5t semi-trailer. It should be noted that the department is already designing new structures to the proposed SM1600 loading standard that produces a design load effect approximately 200% greater than the 42.5t semi-trailer. Theoretical load capacity assessments, conducted in accordance with current Australian Standards, have found that the department's timber bridge stock, with the exception of A-Class bridges in good condition, are overstressed when crossed by the general access 42.5t semi-trailer. Accordingly, these sub-standard timber bridges represent a significant risk to road users when principal load bearing members are allowed to deteriorate. Conversely, many non-timber structures that have been designed to obsolete standard have been assessed and found to have significant reserves of strength and are able to carry current loadings without undue distress.

These defective and sub-standard bridges are vulnerable due to their sensitivity to increasing axle loads, numbers of freight vehicles, changing vehicle configurations and vehicle dynamics. These increasing demands tend to accelerate deterioration of the structural condition and load carrying capacity with a corresponding increase in risk to road users and maintenance expenditure. The safety of the public is paramount and, while the costs and risks to the public must be assessed along with other network priorities, these defective and sub-standard structures must be actively managed.

1.2 Purpose

The purpose of this document is to detail the corporate procedures to manage defective and sub-standard bridges safely through a corporate approval and certification mechanism. This will ensure that thorough operational and structural assessments are conducted and a detailed management plan is developed and approved for all sub-standard and defective structures that are identified. This management plan will consider the need for one or more "Interim Management Measures" from structural engineering inspection and material investigation, load testing, load, lane, speed or vehicle restrictions, propping of defective load bearing members, temporary closure or emergency repairs pending replacement or rehabilitation.

Although these guidelines are primarily intended for use within Transport and Main Roads, the advice provided herein is transferable to LGA and private bridge owners.

1.3 Scope

These guidelines cover the safe management of bridges, or structural groups such as abutments, piers and spans comprising a bridge, that are found to be defective or sub-standard during or pursuant

to an inspection or load capacity assessment. In particular, guidance is provided on the following topics:

- Definitions of defective and sub-standard bridges or structural groups.
- Structures Management Plans - Interim management measures pending rehabilitation, strengthening or replacement.
- Immediate Risk Structures
- Low risk defective bridges
- Monitoring
- Approvals and certification process
- Departures
- Prioritisation of rehabilitation, strengthening or replacement.

1.4 Implementation

These guidelines shall be used for any structures that are found to be defective or sub-standard.

1.5 Definitions

The following definitions apply to terms used in this document:

Condition State – The assessed rating of a component based on a whole number scale of 1 - 4 made by an accredited inspector in accordance with the condition state guidelines stated in the department's *Structures Inspection Manual*. Condition State 1 represents the "as new" condition while Condition State 4 denotes a component with severe defects that compromise its structural integrity.

Significance Rating – A whole number rating on a scale of 1 - 4, determined by Bridge Construction Maintenance and Asset Management, which reflects the structural criticality of an individual component type. A ranking of 4 represents a critical load bearing member such as a girder or a pile while a kerb has a rating of 1. The ratings for all standard components are detailed in Appendix B of the *Structures Inspection Manual*.

Principal Components – Standard structural components that have a "Significance Rating" of 3 or 4.

Risk - The department's "WhichBridge" risk assessment methodology/software generates a numerical score, which can be used to rate and rank the risk exposure of structures. It should be noted that the risk scores generated represent a relative ranking of risk rather than an absolute quantification of risk. The value is specific to a set of criteria applied at a specific point in time and is defined by the following relationship.

Risk = Probability (of failure) x Consequence (of failure)

STANDARDS AUSTRALIA and STANDARDS NEW ZEALAND (1999)

It is currently considered that a risk score between 750 and 1500 should represent the threshold for intervention.

Defective Structures – One or more of the following criteria may define a defective structure.

1. Structures where more than 25% of the principal components have been rated in Condition State 4 within a single abutment, pier or span group by an accredited bridge inspector. For example, two girders out of five in a span meet this criterion.

2. Timber structures where more than 25% of the principal components are undersized in a single abutment, pier or span group when compared with the relevant specified member sizes for that class of bridge.
3. Structures with a risk rating in excess of 1500.
4. Structures with an overall condition rating of 4 or 5.

Sub-Standard Structures – One or more of the following criteria may define a sub-standard structure.

1. Timber bridges other than A class. (A-modified, B and B-modified class structures are theoretically overstressed under legally loaded semi-trailers.)
2. Bridges of unknown design class.
3. Bridges that have been assessed by Structures Section and found to be deficient in load carrying capacity. Typically, a structural engineer, pending rehabilitation or replacement of a structure, will have recommended formal interim measures.

Low Risk Sub-Standard Structures- Any structure, not covered in the previous definition, that has been designed to a standard inferior to the T44 design class and has not been assessed by a structural engineer.

Immediate Risk Structures- Structures which are considered to represent an immediate and unacceptable risk to the public.

Structures Management Plan- Formal interim measures that have been certified by the department to manage a defective or sub-standard structure pending its rehabilitation or replacement. This requires the submission of Form SMP1 to Structures Division (Appendix F) and the relevant Regional Director for certification and approval.

Departures (Other Interim Measures) - Measures short of or different from the "Structures Management Plan" These must be in the form of monitoring alone or monitoring in conjunction with other measures.

Monitoring-suitable Structures - Structures which are considered to be suitable for monitoring as an interim measure by virtue of their predictable and gradual mode of failure.

2 Inspection and assessment

The processes of inspection, assessment and the preparation and implementation of appropriate management plans are of crucial importance for ensuring that all highway structures remain in a safe and serviceable state. The department's policies, methodologies and guidelines must be applied rigorously and in a consistent manner. If inspection ratings and assessments are unduly conservative, then structures will be unnecessarily strengthened or maintenance conducted prematurely. This consumes scarce resources and causes traffic, social and economic disruptions. Conversely, if these processes are not regulated effectively then some structures may be operating with an unacceptable margin of safety.

The required bridge management processes are illustrated in the Management Actions Flow Chart in Appendix F Figure F1. Form SMP1- Structures Management Plan (Appendix F) shall be used to document the inspection and assessment findings and the required interim management measures.

3 Structures management plan

Whenever a "defective structure", as defined in Paragraph 1.4, is detected then a Structures Management Plan, Appendix F Form SMP1 detailing the proposed interim measures should be prepared and submitted for certification and approval. Operational managers may elect to seek advice about the management of "sub-standard bridges" from Structures Section. In this event, a Structures Management Plan will be developed for these bridges. Districts will normally agree interim management measures with Structures Section pending the development of the formal Structures Management Plan. Interim measures may consist of one or more of the following:

1. Close the structure and establish a side track.
2. Close the structure, advertise the fact, and direct traffic to an alternative crossing.
3. Deny access to Excess Mass Vehicles.
4. Impose one or more of mass, width, lane or speed restrictions and advertise the fact.
5. Install height bars on each approach and advertise the fact to reinforce restrictions to vehicle height.
6. Raise an "Issues Alert" to the DDG when an Immediate Risk Structure is detected.
7. Install temporary propping or other strengthening.
8. Carry out partial or full rehabilitation of the structure, and
9. Initiate a bridge replacement scheme.
10. Increasing the frequency of Level 1/2 inspections.

4 Immediate risk structures

Districts are required to quickly inform Structures Section and the relevant Regional Director pursuant to an inspection or assessment finding that a structure poses an immediate and unacceptable risk to public safety. In assessing the immediate risk to public safety, relevant factors such as the nature of structural weakness, any corresponding signs of distress, the recent load history of the structure and the level of inspection and assessment completed to date should be taken into account.

Once emergency interim measures are agreed and confirmed with Structures Section, a Structures Management Plan detailing the formal interim measures should be prepared, certified and implemented as soon as is practically possible. These structures are to be termed "Immediate Risk Structures".

In the event that the structural integrity is considered to be severely compromised, a temporary emergency closure should be ordered until a bridge engineer from Structures Section has inspected the structure and/or reviewed available reports and recommended the necessary interim measures for the Structures Management Plan. This shall only be effected where there is likely to be a delay in developing and implementing the Structures Management Plan and the risk of keeping the structure in service in the interim period is considered to be unacceptable.

5 Low risk defective bridges

Certain structures that meet the defective or sub-standard bridge criteria may be considered to be of low risk and do not warrant interim measures other than monitoring while further investigations are carried out. These structures must be performing normally under traffic with no signs of significant

distress (no excessive deflections of components or progressive development of observed defects under traffic loading) and the consequences of failure must be extremely low. Additionally, managers must be certain that the potential failure mechanism will be gradual over time and capable of detection through the monitoring regime. For example, increases in crack width severity, extent and length. Individual cases shall be discussed with Structures Section to confirm whether monitoring is an appropriate management mechanism. Monitoring in its self will not prevent damage from occurring and the probability of damage will generally increase with the duration of monitoring. For example, increased loading cycles and/or increased probability of an overloaded vehicle crossing the structure and/or further material deterioration. For these reasons, it is recommended that a detailed assessment of the monitoring strategy be undertaken every twelve months. Ensuring the safety of a structure through monitoring is a complex process and requires in-depth knowledge of the techniques, potential problems structural behaviour and material properties. This should not be undertaken in a casual manner and must be controlled by professional engineers.

6 Approvals and certification process

1. District to discuss interim management measures with Structures Section immediately following the detection of a defective structure. (This may include the commissioning of a Level 3 Detailed Engineering Inspection and structural analysis of the structure).
2. Emergency interim measures to be agreed pending development of the Structures Management Plan.
3. Structures Section completes Structures Management Plan with recommended interim management measures pending rehabilitation or replacement and forwards copy signed by Deputy Chief Engineer (Structures) to the district.
4. District Director accepts and signs the Structures Management plan and forwards it to the Regional Director for information and approval.
5. If the District Director disagrees with or cannot comply with the recommended interim measures then a departure as described below may be sought.
6. Regional Director forwards certified copies of the Structures Management Plan or Departure to the District Director, Deputy Chief Engineer (Structures) and the Deputy Director General.
7. The interim management measures detailed in the Structures Management Plan are implemented.

7 Departures

It is a general principle of these guidelines that Structures Management Plans shall be developed for all defective structures and the interim measures certified by the relevant District Director, Regional Director and the Deputy Chief Engineer (Structures). However, it is acknowledged that on occasion, the operational areas may elect to adopt measures that fall short of or are different from those specified by Structures Section. In this event, the Regional Director and the District Director must detail the reasons for the departure, complete and certify an amended Structures Management Plan and forward a copy to the Deputy Chief Engineer (Structures) and the Deputy Director General. The minimum interim measures stated therein shall be a monitoring regime that has been approved by Structures Section, generally in conjunction with one or more of the other previously stated interim measures.

8 Prioritisation for rehabilitation and replacement

In most cases, the rehabilitation or replacement of defective and sub-standard bridges will take a number of years to effect. These works will have to be prioritised along with other network demands, while ensuring the safety of the structures in service by maintaining the appropriate Structures Management Plans. Prioritisation should take account of the following factors:

1. The relative risks of the structures to which the management plans apply as calculated by the "WhichBridge" methodology.
2. The effectiveness of the interim measures detailed in the Structures Management Plan in controlling these risks. As stated previously, monitoring is a passive measure and does not positively control risk.
3. The reserves of strength, traffic loading, probability of overloading, failure mode and consequences of failure.
4. Traffic delays and associated costs caused by the implementation of the Structures Management Plan.
5. Other social, environmental and economic consequences to business and the community associated with the Structures Management Plan.
6. The availability of alternative routes or feasibility of constructing a side track including wet season considerations, excess mass and dimension restrictions and other route related considerations.
7. The cost-effectiveness of the rehabilitation or strengthening compared with the replacement structure costs taking account of the ratio of costs and benefits.
8. Other benefits that will result from the work such as improvements to parapet and guardrail containment, scour resistance, pedestrian access and bridge geometry.

To ensure the currency and effectiveness of the interim measures adopted, the Structures Management Plan shall be reviewed every twelve months until the structure is rehabilitated or replaced.

Figure F1 - Management Actions Flow Chart