Towards better bridge management – inspection data

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Abstract:
Level 2 bridge inspections form a key input into bridge management in Australia, and internationally. While technical aspects of bridge condition rating are described in bridge inspection manuals published by various road agencies, there is currently significant variability in the way that such inspections are undertaken. In this paper, accreditation of both bridge inspectors and agency business processes are proposed. The intention is that this paper form the basis for discussion, and if appropriate, the development of accreditation scheme to improve bridge management outcomes.

Keywords: Bridge Inspection, Accreditation

1. Introduction
Level 2 bridge inspections form an input into bridge maintenance management and bridge asset management decisions so improved consistency and alignment (of data with organisational needs) should facilitate improved agency decisions. This paper provides a discussion of current Level 2 bridge inspection issues, then proposes an accreditation scheme for Level 2 bridge inspection. The intention of this paper is to foster discussion with the objective of improving bridge management outcomes, based on better (Level 2) input data. Both road agencies and service providers should benefit from the proposed scheme, although details require further development.

2. Current bridge inspection issues
Overview
Bridge inspection is a key tool informing bridge management internationally (Scutaru, 2019), and in Australia (Lake, et al, 2012). Most jurisdictions in Australia have implemented an approach to bridge inspection that can be summarised as:

1. Level 1 – Regular (yearly) operational inspection
2. Level 2 – Periodic (2 to 7 year) systematic component condition rating
3. Level 3 – Event driven technical investigation targeted at specific concerns, often triggered by Level 2 or Level 1 inspections.
Current bridge inspection issues are discussed in this Section, including:

1. Research
2. The industry transition from maintenance management to asset management that affects the context in which bridge condition data is collected and interpreted
3. An overview of the Australian Level 2 bridge inspection commercial services market.

These issues form the basis for discussion of the proposed accreditation scheme.

Research
A key source of variability of bridge inspection data is that humans undertake visual inspection of bridges. In a major research project undertaken by the Federal Highways Administration (FHWA) at the turn of the last century, a range of bridge inspections were undertaken, involving 49 inspectors undertaking the same inspection tasks on the same bridges. Key outcomes of that research were (Phares et al, 2001):

1. Bridge inspection results are subjective but have an impact on safety and maintenance of a bridge
2. Bridge conditions rating differs between inspectors and from reference ratings
3. Rating consistency is better for major elements (girders etc) compared with secondary elements (barriers, joints etc)
4. Inspector attributes influencing inspection rating include:
   a. Fear of traffic/heights
   b. Eyesight limitations
   c. Extent of formal training
   d. Perception about maintenance, accessibility, complexity
5. Most inspectors reliably detect general defects (e.g. weathered paint), but there is much more variability associated with the detection of critical/local defects (e.g. fatigue cracks)
6. Inspection accuracy correlates with available site time, focus and comfort level (experience) of the inspector.

Based on this research it is evident that there are strong factors that drive inconsistency in bridge inspection data, and the hypothesis is that consistency could be improved though some relatively simple measures.

Maintenance Management to Asset Management Transition
Bridge managers are transitioning from a maintenance management focus to as asset management focus, as illustrated by the respective frameworks in Error! Reference source not found. and Figure 2. Decision making is central to both frameworks, and Level 2 bridge inspection is a key activity supporting bridge management in both frameworks, but the way in which data is used, and the organisational culture and expectations regarding data vary significantly as each organisation transitions.

The transition to data driven decision making, is still in its infancy (Johnson et al, 2018). The perceived and actual needs of organisations vary depending on the extent of progress with their transition, meaning that even though two organisations may reference the same (technical) bridge inspection manual as the basis for inspections, the way they utilise data, and their expectations of data may vary significantly. In addition, their expectations will vary through time as the organisation transitions. Typically, these expectations are not transparent to external service providers.
Consequently, two Requests for Proposal (RFP) may read similarly, but are underpinned by different expectation. Therefore, further to the comments above regarding research which highlighted inconsistency between inspectors, there is inconsistency in expectations by agencies, even though they may specify requests in a similar manner.

![Typical bridge maintenance management framework](Source: ARRB L1/L2 Bridge Inspection Workshop)

![Typical bridge asset management framework](Source: Institute of Asset Management)

Figure 1 Typical bridge maintenance management framework (Source: ARRB L1/L2 Bridge Inspection Workshop)

Figure 2 Typical bridge asset management framework
Overview of bridge management and Level 2 Bridge Inspection market

ARRB has been active for more than 10 years (most recently in collaboration with IPWEA) in delivering Level 1 and 2 training workshops throughout Australia including, Queensland, New South Wales, Victoria, Tasmania, and commercially deliver projects for many agencies at all 3 levels. In addition, ARRB regularly provides bridge management advisory services to bridge agencies.

ARRB’s perspective on the current state of bridge management in Australia is summarised in Table 1. Other publications (Heldt et al, 2019) deal with other decision framing improvement opportunities, but this paper explores opportunities for improvements in bridge condition data collection.

Condition data is a key decision input for both maintenance and asset management perspectives, so regardless of an organisation's progress in transitioning from maintenance management to asset management improvements in condition data collection are still beneficial. One of the key areas of improvement (Table 1) is decision inputs and consistency. Further to the above discussion on research and organisational transition, more consistent input data should lead to more consistent decisions.

Table 1. Bridge Management current state assessment

<table>
<thead>
<tr>
<th>What we do OK...</th>
<th>What we don’t do well...</th>
<th>What does it mean...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing use AM principles</td>
<td>Focus on decision inputs and consistency</td>
<td>Limited effectiveness and efficiency</td>
</tr>
<tr>
<td>Collect historical data</td>
<td>Document decisions</td>
<td>Increased liability</td>
</tr>
<tr>
<td>Collect condition data</td>
<td>Document basis for decisions</td>
<td>Limited continual improvement</td>
</tr>
<tr>
<td>Collect capacity data...?</td>
<td>Link decisions (line of site) to consistent data</td>
<td></td>
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</table>

Based on participants attending bridge inspection training provided by ARRB, attendees can typically be grouped as follows:

1. Agency staff who wish to gain a better understanding of the bridge inspection process
2. Consulting engineers (often junior), who attend the course on the basis that they might have to undertake bridge inspections in the future, particularly if other markets are quiet
3. Experienced construction or maintenance supervisors who undertake inspections or direct inspections to be undertaken.

It is clear from ARRB's workshops that even experienced inspectors further hone their skills by engaging in solution development with case study examples that combine inspection maintenance, and engineering principles. This engagement promotes a sharp focus on relevant issues and helps instil appropriate confidence in inspection decisions facilitating focus and comfort level which has been demonstrated to be beneficial (Phares et al, 2001). Further, it is ARRB's internal experience that the confidence of bridge inspectors is enhanced by a vibrant community of practice that can debate
observations and their impact on bridge management. This debate results in more confident and decisive inspection outcomes.

As a commercial provider in the Level 2 bridge inspection market, ARRB notes the following:

1. Market prices often varying significantly for the same scope (up to a factor of 3)
2. The scope of services requested by agencies is quite variable and does not adequately address extent of inspections and required methods to ensure safety e.g. Use of specialised access equipment such as underbridge inspection units
3. Issues with inspection data reliability & interpretation are relatively common
4. Business rules associated with incorporating bridge condition inspection data into the asset data base vary significantly between agencies
5. Benchmark Level 2 bridge inspection costs have halved over past 10 years (but so has the requirement to undertake at arms-length inspections resulting in increased risk that defects are not being recognised and reported)

Given that bridge condition data is a key input to bridge management, the above suggests that decisions upon which the data is based may also be quite variable, and this is consistent with ARRBs experience providing bridge management advisory services to agencies. Importantly, best value does not necessarily result from current decision processes, resulting in poorer outcomes for agencies.

Discussion and recommendations for improvement
Recent correspondence between ARRB and IPWEA suggests concern that Level 2 bridge inspection outcomes exhibit variability and inconsistency, creating difficulties when decisions are to be framed based on Level 2 inspection reports. This is consistent with ARRBs observations as both a bridge inspection training agency, and commercial service provider and is partly explained by both previous (FHWA) research, and the industry transition from maintenance to asset management discussed above.

The proposal is for IPWEA (in collaboration with ARRB) to develop accreditation processes for both individual inspectors and agencies as summaries in Table 2. The proposal for basic inspector accreditation is essentially intended as a response to address the issues (largely human factors) identified by the FHWA (Phares et al, 2001). The advanced inspector accreditation is intended to support the basic accreditation with both a community of practice and provide a sound basis for quality control and inclusive continual improvement.

The basic business process accreditation is intended to provide a common basis for data to be incorporated into an agency. Note that these items all need to be included in the inspection scope of services provided to the market when tenders are issued. It is ARRBs experience that organisations that routinely include these items into the scope of services seem to gain significantly more value for their investment in bridge condition inspection than those organisations that do not, and generally, the incremental cost of including these activities is minor.

The advanced business process accreditation is intended to support organisations that are pursuing alignment with ISO55001. This accreditation does not attempt to address ISO55001 accreditation, however it is intended to be supportive of same. It recognises that data collection and verification is central to ISO55001. It is proposed that the scope of advance business process accreditation is limited to data collection, verification and integration, and that this would complement other potential ISO55001 activities in an agency.
Table 2. Bridge Management current state assessment

<table>
<thead>
<tr>
<th>Inspector</th>
<th>Business Process</th>
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<tr>
<td><strong>Basic</strong></td>
<td></td>
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<tr>
<td>Competent Inspector – accreditation addresses human factors associated with inconsistent data</td>
<td>Competent data integration – accreditation primarily addresses organisational alignment and context setting for inspectors</td>
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<tr>
<td>-Current medical certificate – eyes and ears</td>
<td>-Alignment kick-off meeting</td>
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<tr>
<td>-Satisfactorily completed recognised training course</td>
<td>-Inspector accreditation prescription</td>
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<tr>
<td>-Linked into a community of practice</td>
<td>-Maintenance register generation</td>
</tr>
<tr>
<td>-Sample of work audited on an annual basis</td>
<td>-Exceptions reviewed and tracked</td>
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<tr>
<th>Advanced</th>
<th>ISO55001 data integration – accreditation promotes consistent alignment with broader management systems</th>
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<tbody>
<tr>
<td>Master Inspector – accreditation promotes continual improvement, excellence and community of practice</td>
<td>In addition to the above...</td>
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<tr>
<td>-Competent trainer of inspectors</td>
<td>-Inspection documentation consistent with ISO55001, particularly Sections 8 and 9.</td>
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<tr>
<td>-Industry leader in inspection</td>
<td>-Pilot inspections (alignment)</td>
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<tr>
<td>-Current experience in the management, interpretation and use of inspection data</td>
<td>-Data consistency, integrity and quality control</td>
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<tr>
<td>-Current experience in Level 3 investigations</td>
<td>-Data integration trial</td>
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<td></td>
<td>-Draft report (sample/pilot) &amp; final report</td>
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<td></td>
<td>-Asset group review workshop</td>
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3. Conclusions
The discussion in Section 2 highlights some of the current inconsistencies in Level 2 bridge data, and the underlying reasons that may contribute to this outcome. This paper proposes an accreditation scheme (summarised in Table 2) to improve the manner in which Level 2 bridge condition inspections are undertaken, providing more consistent and engaged agencies and service providers. It is proposed that IPWEA is the appropriate body oversee such an accreditation scheme, assuming there is broad support for such a scheme. The proposed approach would complement the inspection manuals that typically form the technical basis for Level 2 inspections. Feedback in relation to the proposed approach is sought, and can be made via the authors of the paper, or via IPWEA.

Assuming there is support for accreditation consistent with Table 2 (or similar), the scope and cost of the scheme will require further development. It is anticipated that the cost of implementing such a scheme would not substantially impact the bridge inspection pricing, but would add significant value for stakeholders.

Acknowledgements
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References
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