NHVR

Strategic Local Government Asset Assessment Project

Asset Assessment Guide

Phase 2 (Version 01 - 2022)

Contents

1 Project Background

The Australian Government provided the National Heavy Vehicle Regulator (NHVR) with $7.96 million under the Strategic Local Government Asset Assessment Project (SLGAAP) to assist road managers with the assessment of bridges and culverts, on key local government heavy vehicle routes. Phase 1 of the project was administered between November 2019 and June 2021. Subsequently, the Australian Government announced the commitment of an additional $12 million in May 2021 for Phase 2 of the project to enable the continuation of project activities to be conducted from January 2022 to 31 October 2024.

Overall, the SLGAAP Phase 2 program is focused on four key areas:

Understand

- Understanding what assessment and data collection activities are required to make suitable determinations of bridge capability for the purposes of making heavy vehicle access decisions and how to undertake these activities in a cost effective, accurate and reliable way.

Prioritise

- Determining how to consider road networks from a strategic viewpoint to maximise value for money assessment activities in order to achieve the best access outcomes, as well as feeding into strategic development activities that support desired service levels.

Enable

- Enable business systems capability and processes to streamline assessment activities in order to reduce the burden associated with administering heavy vehicle access applications to allow road managers to focus on the critical aspects of determining bridge capability. Fundamentally, developing guidelines to assist road managers with these activities is an important part of the program.

Educate

- Developing educational resources to assist road managers and suppliers to understand the processes, tool and methodologies needed to accurately and fairly assess heavy vehicle access in the most cost effective and reliable way.

2 Purpose of this Document

The intent of this document is to provide a methodology for Phase 2 of the SLGAAP program such that the appointed suppliers can undertake various forms of assessment that will help inform local government road managers of the capability of their assets.

3 Spirit of the Program

To be involved in this program, suppliers need to acknowledge that this program is more than conducting individual assessments using conservative processes leading to conservative outcomes. The program is targeting optimised outcomes that could build a portfolio of assessment approaches, frameworks and methodologies that support future endeavors in this area. The program is about engineering judgment, cooperation, and collaboration with road managers and the NHVR to optimise heavy vehicle access on the road network.

Importantly, all assessments must be commensurate with the level of detail and certainty of the investigation, and the observed performance and distress a structure is showing. Also, assessments should represent actual use patterns and not consider conservative assumptions typically used in the appropriate design of structures. Critically, recommendations should be carefully discussed with the road manager before placing them in writing. This discussion should cover the extent of analysis undertaken, risks, risk control options and use of current performance to assist in setting reasonable access levels (if required). Theoretical rating should not be the sole parameter used to rationalise access determinations.

As can be seen from the above descriptions, the program is intent on engaging closely and regularly with local government road managers in order to bring about a much needed shift in terms of capability and understanding within this crucial cohort who are responsible for managing the vast majority of the Australian road network. At the same time, this work will contribute to the development of systems and processes which better support the stakeholder 'day to day' activities and strategic intent at a time when the heavy vehicle task, and therefore demand for access, will continue to grow.

4 Scope of Supplier Works and Services

To be read in conjunction with the tender documentation.

Suppliers will be asked to undertake bridge/culvert assessments as specified and agreed between both the NHVR and the specific road manager. This document, along with relevant reporting templates (e.g., Assessment Results templates), provides the scope for each tier of assessment. These documents are intended to guide suppliers in this phase but are evolving as the program progresses. Given this, there is the likelihood, existing documents will be updated and new ones may be produced. In the event they become available, they may supersede this document along with the relevant templates.

The development of asset assessments to facilitate productive and safe heavy vehicle access should include the assessment of the structural assets (i.e., bridges and culverts) against nominated heavy vehicle combinations; as well as the minimum tasks of:

1. Assisting the NHVR and the Local Government(s) with the collection of any required inputs to undertake an asset assessment, noting that wherever possible the program will, in partnership with the participating councils, endeavour to collect the required data. This should result in most assessments being undertaken as a 'desktop' exercise.
2. Completing an assessment of the identified Local Government road assets (i.e., bridges and culverts) against nominated heavy vehicle combinations with careful considerations of the intent of the program to improve access outcomes considering priority routes, and prudent use of judgement and risk based thinking to reach appropriate and manageable outcomes.
3. Advising on the outcome of the assessment and the use of risk controls (such as conditions of travel) to promote access for nominated heavy vehicles.
4. All information related to the production of assessments and analysis conducted (including, but not limited to, modelling information, capacity calculations, additionally sourced drawings and quality assurance documentation) under this project will be provided to the NHVR and relevant Local Government for **unconditional "use"** by both the NHVR and the relevant local government road authority. "Use" may include providing such information to other parties for the purpose of, but not limited to, verification of results, extending analysis activities, research into bridge families etc. Refer to the Contract for further details on I.P, copyright and licensing.
5. This document and associated templates are used to guide and define supplier outputs in this phase. The provided templates must be used as part of the reporting processes and be filled in comprehensively. New guides and templates may be produced during this phase based on new developments and changing needs. In the event they become available, they will supersede this guide and the relevant results templates. Any change to the template shall be agreed by the supplier in writing with the NHVR.

Note: The tier of assessment to be conducted by the supplier will be clearly defined in the contract or in writing from the NHVR. Any change to this shall be agreed in writing with the NHVR and the relevant road manager.

4.1 Assessment Methodologies

The methodologies used in the various Tiers of assessment for the SLGAAP shall be consistent with:

- Tier 1 and Tier 1-2D
  - The assessment method presented in this document
- Tier 2 (Capacity assessment)
  - AS5100.7 and AS5100.2; and
  - AS5100.5; AS5100.6; AS5100.9; AS1720.1 (2010 or 1988); AS1597.2; AS/NZS 1041.1
  - As modified/clarified in this document
- Tier 3 (Methods over and above AS5100)
  - E.g., AS/ISO 13822; and other codes as relevant
  - As modified/clarified in this document

Note: These methodologies should be used as a guide for conducting the asset assessments along with the supplied templates and supporting documents. Suppliers may utilise their own processes and procedures in order to ensure that professional obligations are met. Alternatives or variations used by suppliers are to be documented, justified and agreed with the NHVR and the relevant road manager before proceeding with assessments. All variations in approach must be comprehensively recorded and justified.

4.1.1 Tier 1: Heavy Vehicle Access Assessment

Tier 1 heavy vehicle access assessments are performed by comparing the bridge capability (as defined through a set of % reference vehicle/s or maximum allowable line moments, shears, and reactions), to the worst load action effects of an application vehicle on a given structure. The objective is to identify if the application vehicle's effects are more adverse than the bridge capability (reference vehicle/s).

A line model (comparison) is used for this tier of assessment and is thus referred to as a heavy vehicle access assessment (as distinct from a bridge assessment, refer to Appendix C). The configuration of the bridge under consideration is used to create the line model and includes modelling the actual spans and articulation of the superstructure. As with any tier of assessment, engineering judgement would generally be required to take into consideration the current condition of the structure. Key inputs into the assessment are:

- Number and length of all spans
- Continuity at each support including any pin locations (i.e., cantilevers with drop in spans)
- Bridge capability (as defined by a set of reference vehicles or line moments, shears, and reactions)
  - Maximum line model moments, shears, reactions
  - Any number of % reference vehicle/s
  - Design vehicles; or
  - Currently approved heavy vehicles
- Bridge Geometry as defined by
  - Vehicle envelope restrictions (both height and width)
  - Number of lanes in each direction
- Historic bridge information including
  - Design year
  - Construction year
  - Design standard (as constructed)
  - Design vehicle/s (as constructed)
- Information on Bridge Condition
  - Date and result of last condition inspection
  - Whether condition is currently restricting access
  - Extent that condition is restricting access as a percentage of reference vehicle/s line model loading actions (sometimes this assessment will need to be made by the Tier 1 assessor but should routinely have already been considered in the appropriateness of the reference vehicle)
- Current approved heavy vehicle gazettes, networks, permits etc.

Comparison between the bridge capability and the application vehicle considers the following line model load action effects:

- Structure articulation (simple support, continuous, pins, cantilevers etc.)
- Maximum negative moment (continuous structures)
- Maximum positive moment
- Maximum shear
- Maximum support/pier reaction

The assessment ratio for each load action effect is given by:

$$\text{Tier 1 assessment ratio} = \frac{\text{peak reference vehicle effect} * \text{LLF}_{\text{RV}} * \text{DLA}_{\text{RV}}}{\text{peak application vehicle effect} * \text{LLF}_{\text{AV}} * \text{DLA}_{\text{AV}}}$$

Where: Vehicle effect should include line model bending moment, shear force and support/pier reactions, and each assessment ratio for each effect shall be separately reported.
In order to define these maximums, it is necessary to place the vehicle/s in locations along the line model that maximise the load action effect under consideration. While this can be done theoretically with a single case for each action effect, it is typically more practical when using modern computers, to step the vehicle across a model of the structure in small increments calculating actions for each position and taking the maximum and/or envelope. The increments need to be sufficiently small to capture the true maximums. Stepping the vehicles at 0.1m increments generally provides the necessary granularity to capture the necessary accuracy in any comparison. The line model granularity should match this spacing at minimum.

In order to undertake a Tier 1 assessment, suitable reference vehicles are needed to ensure appropriate and accurate outcomes are estimated. Tier 1 assessments should not be undertaken in situations where appropriate reference vehicles are not available i.e., reference vehicles must be located in similar lateral locations and configuration to the application vehicle. 'In lane' design vehicles are generally suitable for in lane Tier 1 assessments, but comparison of in lane design vehicles to straddling vehicles, such as OSOM vehicles, is not appropriate for most bridge types. In this case, a HLP load or other suitable reference vehicle should be known either though the original design, Tier 2 assessment, or other proven vehicles. Any reference vehicles used in Tier 1 assessment as the comparison point must have been developed giving adequate consideration to multiple presence of vehicles (associated vehicle). If this is done appropriately there is no need to give further consideration to multiple presence of vehicles in Tier 1 assessment.

Reference vehicle/s shall be considered at the start of the assessment process and discussed and agreed with the relevant road manager and the NHVR.

4.1.1.1 Special Considerations for Culverts

In a Tier 1 assessment of a culvert, a line model can still be used as the assessment is a vehicle comparison rather than a structure assessment. Due consideration of appropriate reference vehicles must be made. For smaller culverts, the wheel load will be the controlling case and so comparison of wheel and/or axle loads can be made directly. As the span length increases, the axle groups may govern. Reference vehicles therefore must also consider both wheel loads, axle loads and axle group loads.

4.1.1.2 Consideration of Condition

Tier 1 assessments must consider the condition of bridges along the proposed route. If the reference vehicle/s used in the Tier 1 comparison have been developed considering existing condition, then further reductions to account for condition are unnecessary. In this situation, any variation between the assumed condition used to develop reference vehicles should be compared and considered against current condition.

It is generally considered sufficient to use Level 2 condition assessment documentation to assess condition as long as the assessments are not older than the typical inspection cycle adopted by the relevant road manager.

4.1.1.3 Optimising Tier 1 Access using Risk Assessment

Where the Tier 1 assessment result for a specific vehicle is favorable for the applicant, no further assessment needs to be undertaken. Where the assessment ratio result (rating factor) is less than 1, further consideration needs to be applied in order to see whether the vehicle can travel under certain circumstances. These considerations are as follows:

- *Has the specific application vehicle been given access in the past and there has been no issue as a result of the vehicle travelling over the structure?*
- *Is the LLF used in the assessment appropriate and representative of the actual magnitude and likelihood of overloading? Can overloading be managed in a suitable way that facilitates access to the structure?;*
- *Can a reduction in speed support access?* If reducing speed facilitates access, then this should be tabled for discussion with the road manager;
- *Can alignment of travel support access?* If 'centralising' facilitates access, then this should be tabled for discussion with the road manager;
- *Can a reduced mass or modification to the configuration support access?* This should also be tabled with the road manager and potentially discussed with the applicant;
- *Is the assessment reflective of the true capability of the asset or is there a plausibility gap?*

When considering the scenarios above, the effectiveness of any control measures necessary to manage the risks needs to be carefully considered.

4.1.2 Tier 1-2D assessments

Tier 1-2D assessments are similar to Tier 1 assessments but the analytical model used to compare vehicles is extended to a two-dimensional model (usually a grillage model) which allows the reference load actions to be determined and compared to the application vehicle at the element level.

Due to the cost, this assessment type is typically only used in situation when an "in lane" reference vehicle is known and there is a need to develop an equivalent straddling lane reference vehicle for use in typical one-dimensional Tier 1 assessment.

4.1.3 Tier 2: Bridge Capacity Assessment

Tier 2 assessments are focused on using structural engineering principles to identify the theoretical maximum load action effects the structure can withstand as governed by the material and configuration (capacity assessment). Two-dimensional analysis techniques, such as grillage analysis, are typically used to determine the theoretical member load action effects from the vehicle load case. A deterministic analysis approach is used with load factors and appropriate associated lane factors consistent with AS 5100.7 being applied, considering multiple vehicles on the structure during a loading event. The results of the loading analysis are then compared to a theoretical estimate of the structural capacity of each member of the bridge through the rating equation specified in AS5100.7.

A Tier 2 assessment requires the supplier to review the configuration and construction arrangement of the structure. As with any tier of assessment conducted by a supplier, a Tier 2 assessment would usually require engineering judgement to consider the current condition of the structure. The outcome of a typical Tier 2 bridge assessment generally considers all appropriate load effects.

Key inputs to the assessment are:

- Design drawings or As-Built Drawings
- Component Geometries and Material Properties to construct analytical models (including any structure modifications)
- Assessment Vehicles
- Level 2 Structure Condition (Latest inspection should have been conducted at a date not longer than the standard inspection cycle i.e., 2-3 years typically).
- Site Measurements (if necessary, to confirm drawings, typically the Level 2 inspection report will guide, if this is necessary)

In AS5100.7, the bridge capability is equal to the load rating factor (Cl 14.1;14.2):

$$\text{Tier 2 assessment ratio (RF)} = \frac{\text{Available bridge capacity for traffic effects}}{\text{Traffic load effects of nominated assessment vehicle/s}}$$

Where: Ratio must be calculated and reported for all relevant load effects.

In many cases, the Tier 2 assessment is undertaken to understand the "bridge capability" as defined by a suitable set of reference vehicle/s for future Tier 1 assessments (which is one of the key focuses of the SLGAAP program). In this case, the output of the Tier 2 assessment is the maximum % of the assessment vehicle that can be accommodated on the structure using the requirements of AS5100.7 (or as otherwise specified).

In AS5100.7, the maximum % of the assessment vehicle is known as the rated load (L_R) (Cl 14.4) which is the:

$$L_R = Assessment\ vehicle\ (L_{RV}) \times RF$$

A rated load is calculated for all assessment vehicles and can form the basis for future reference vehicles in Tier 1 assessments.

Some important points:

- This percentage can be less than or greater than 100% and needs to be specified accurately.
- No additional safety factors over and above the requirements of AS5100.7 are to be considered unless specified or agreed with the NHVR and the relevant road manager.
- Where factors are considered to be overly conservative, or there is ambiguity in the specification of such parameters in the code, they are to be discussed and agreed with the NHVR and the relevant road manager.
- The final result will be governed by a certain bridge component and load effect. To assist with road manager decision making in the future, it is important to understand the capability of different elements of the structure. At a minimum the following % of reference vehicles should be provided for:
  - The deck
  - Main girders
  - Headstock
  - Remaining substructure

  For each of these cases, each load action effect and location must be reported. Other elements should be quantified if relevant.
- **Associated vehicles are to be identical to the main assessment vehicle and associated vehicles need to be scaled in the same proportion as the main assessment vehicle when determining the % of assessment vehicle result.**

For the purposes of the SLGAAP program, additional assessment assumptions and code clarifications are provided in Appendix B.

4.1.3.1 Special Considerations for Culverts

In a Tier 2 assessment of a culvert, due consideration of distribution of loads through both the fill and the culvert itself must be made. For smaller culverts, the wheel load will be the controlling case and so the load footprint must be considered when assessing loading widths. As the span length increases, the axle groups may govern, however loading footprints must still be considered.

In all situations, geometry from the site should be used to undertake a Tier 2 assessment.

4.1.3.2 Optimising Tier 2 Access using Risk Assessment

When assessing vehicle/s to become reference vehicle/s for Tier 1 assessments, due consideration should be given to ensuring appropriate vehicles are assessed that will allow a range of risk-based measures to be investigated in a Tier 1 assessment, particularly regarding various access scenarios like lane straddling positioning etc. Importantly, assessment vehicles should cover both in lane and straddling OSOM vehicle types. This will ensure maximum value can be extracted from Tier 2 assessments by making sure enough scenarios are considered to allow the development of reliable reference vehicles that can be fed back into rapid Tier 1 assessments.

4.1.4 Tier 2 Assessment of Complex Bridges

This assessment categorisation is effectively the same as Tier 2 assessment but has been included in the procurement document in acknowledgement of the additional complexity and cost of undertaking Tier 2 assessment on more complex bridges. Modelling approaches may be more complicated and may include finite element analysis for bridge types when the additional complexity is warranted and will result in more appropriate and accurate outcomes. Achieving this may also require site visit/inspection by the supplier.

Some examples may include: box girder bridges, truss bridges, bridges with more than 6 lanes, structures that require finite element analysis modelling due to complexity of the design, structures that have a very long span i.e., > 50m.

The Tier 2 assessment template shall be used to report results but may require modification in some circumstances to cater for the different component types and relevant components and load action effects.

4.1.5 Tier 3: Special Bridge Assessment

Tier 3 assessments cover a wide range of activities but typically refers to assessment or testing activities that employ methodologies other than typically accommodated in the Australian Standards. Tier 3 assessments can be either deterministic or probabilistic in nature, and they can consider singular or combinations of parameters. Tier 3 assessments also typically focus on:

- Aspects of the Loading Model,
- Aspects of the Resistance Model, and
- Advanced Analytical Modelling Techniques.

Tier 3 assessments are usually costly and careful consideration of the value and usefulness of the evaluation is required. It is important to consider that gains often diminish as progressively more advanced techniques are employed.

Tier 3 assessments may include but not limited to:

- Higher-level advanced analyses including non-linear and plastic methods
- Assessment methods based on overseas standards, other Australian Standards, and other recognised methods, including but not limited to:
  - AS/ISO 13822: provides a site-specific approach framework that considers safety, business and asset integrity objectives and other criteria useful for assessment.
  - Canadian Highway Bridge Design Code CSA-S6-06: utilises modified compression field theory for determining the shear strength of concrete and strut-tie provisions.
  - Fib Model Code: provides a range of more sophisticated methods for determining the structural capacity of concrete members.
  - AS/ISO 13822: provides a generic approach and other criteria useful for assessment.
  - Dutch NEN 8700 and Swiss SIA 269 codes: defines short-term higher risk criteria until the design and remedial work can be completed to restore the bridge to a higher Reliability Index.
- Field and laboratory testing to understand the in-service performance of bridges and the loads applied.
- Collection and/or the analysis of reliable weigh-in-motion (WIM) data.

It is essential that Tier 3 assessments are robust and based on good engineering principles. Generally, a peer review process would be undertaken to confirm that Tier 3 methodology is technically sound.

4.1.5.1 Optimising Access using a Tier 3 Assessment

Tier 3 assessments often focus on some site-specific element or risk, to gain confidence and more accurate estimates of how a structure may behave under load. In turn, this should provide more certainty and provide a solid basis to apply the findings to Tier 2 or Tier 1 assessments. Due consideration of the effectiveness of controlling the risk/s needs to be made and improvements in analytical ratings need to have a rational basis. Assessments must provide confidence that the investigation has yielded dependable results that are applicable to the specific structure, structure family and/or network of assets as applicable.

4.1.6 Level 3 inspections

Level 3 inspections are undertaken when site-specific elements are investigated to reduce uncertainty in assessment.
Level 3 inspections may include:

- Invasive and/or non-invasive inspections of components to confirm design details, deterioration and/or material characteristics.
- Exploration of internal details e.g., reinforcing details
- Check for structural integrity

Generally, Level 3 inspections are used to make Tier 2 assessments more site-specific.

4.1.7 Asset Improvement Reports (AIRs)

In situations where previous inspections or assessments have revealed bridges to be significantly substandard, in very poor condition and/or significantly limiting the freight task, an improvement assessment for the structure may be prudent to determine the best treatment options to understand and deal with such issues in the safest and/or most cost-effective way. An asset improvement report is focused on examining a range of courses of action that may be implemented to improve the safe functionality of the structure. This shall include, but not limited to:

- Rehabilitating the existing bridge capability
- Strengthening the structure
- Partial or full replacement
- Strategically assigning the freight task to alternative routes

Asset Improvement Reports (AIRs) shall include, but not be limited to:

Current Context

- Current freight task
- Current condition
- Assessment outcomes/ current bridge capability
- Risks

Strategic assessment of the route

(With significant consultation with the relevant road manager)

- Current route capability
- Current route freight task
- Planned future route capability
- Other bottleneck/issues on the route
- Alternative routes

Options Study

For each option:

- Concept details of the option
- Calculated new bridge capability of the option
- How the option meets the strategic need of the route/network
- Direct cost of the option
- Expected life of the option
- Whole of life cost of the option

Estimate & Evaluation

- Probabilistic strategic cost estimate for each bridge asset including P50, P90 and out-turn costs.
- Quantitative strategic economic evaluation for each bridge asset including NPV, BCR, IRR, & FYRR
- Qualitative benefits including journey reliability improvements

Recommendations

5 Related Resources

Standards Australia

AS 5100:2017, *Bridge design.*

AS 5100.1:2017, *Bridge design: Part 1: Scope and general principles.*

AS 5100.2:2017, *Bridge design: Part 2: Design loads.*

AS 5100.7:2017, *Bridge design: Part 7: Bridge assessment.*

AS ISO 13822-2005 (R2016), *Basis for design of structures - Assessment of existing structures.*

6 Definitions & Abbreviations

The following terms are specific to this framework:

Term	Definition / Abbreviation
AS5100	Australian Standard 5100
Application Vehicle	A heavy vehicle proposed by an operator to access the network
Assessment Vehicle	A vehicle that is being assessed in a Tier 2 or Tier 3 bridge assessment
Australian Government	The Australian Federal Government and all its affiliations (i.e., Commonwealth, Federal Government, Federal Government Departments, etc.).
Austroads	Association of Australian and New Zealand Road Transport and Traffic Authorities
Bridge Capability	A measure of bridge performance that is defined in terms of a set of % reference vehicle/s which translate to a set of maximum factored line model load action effects that the bridge can withstand as defined by a Road Manager. For the purposes of this project, the bridge capability includes the LLF and DLA caused by the unfactored primary vehicle only.
Culverts	A tunnel carrying a stream or open drain under a road or railway.
DLA	Dynamic load allowance
EOI	Expression of Interest
Freight	Goods transported in bulk specifically in reference to this project by heavy vehicles.
GIS	Geographical Information System
HVNL	Heavy Vehicle National law
IAP	Intelligent Access Program
Jurisdiction	Reference to any State or Territory government.
LLF	Live load factor
Local Government	Reference to any ‘council’ level of government, the third tier of government after federal and state governments.
NHVR	National Heavy Vehicle Regulator
OSOM	Oversize Overmass
Reference Vehicle	A vehicle representative of the bridge capability used in a Tier 1 heavy vehicle access assessment to compare to the application vehicle
Road Asset	Includes any structures (bridges and culverts) or amenities that include earthworks, drainage, safety barriers, lighting, signs, lines, and the soft estate (grassland, trees, and shrubs).
Road Manger	Means a road manager for a road in the area for which an entity has authority/responsibility over (can be a state or local government department).
Route	A way or course taken in getting from a starting point to a destination (i.e., roads).
SLGAAP	Strategic Local Government Asset Assessment Project
SOA	Standing Offer Arrangement
SPV	Special Purpose Vehicle

7 Appendix A: Tier 1 Heavy Vehicle Access Assessment Example

Note: this is not a bridge assessment; it is a heavy vehicle access assessment.

Bridge Details:

Number spans:	3
Continuity:	Simply supported
Bridge span:	12m
No Lanes:	2 lanes
Superstructure Type:	Reinforced concrete beam
Substructure Type:	Concrete blade wall piers with bored concrete piles below
Year of Construction:	1966

Bridge Condition:

A Level 2 inspection was undertaken 1 year ago and there are no issues that are currently thought to affect the load carrying capacity of the structure.

Bridge Capability:

100% MS18 design loading (design)

LLF = 2.0 (AS5100.7)

DLA = 1.3 (From original design code)

105% 48t; 4-axle all terrain crane single lane travel (From previous Tier 2 assessment)

12t per axle; 1.65m, 1.9m 1.65m axle spacings

LLF = 1.6 (AS5100.7)

DLA =1.4 (AS5100.7)

Individual capability percentage for moment, shear and pier reaction are not available (only the governing percentage)

No straddling lane position reference vehicles have been previously calculated

Application vehicle:

9-axle HML B-double:

LLF = 2.0 (AS5100.7)

DLA =1.4 (AS5100.7)

Mass (t) 6t 17t 22.5t 22.5t

Spacing (m)	3.0	1.2	5.2	1.2	1.2	5.2	1.2	1.2

Figure 1 shows the line model action effect estimates for a range of bridge spans considering the nominal reference vehicles and application vehicle (Note: in this plot, no specific bridge capability is plotted. i.e., no % of bridge capability is plotted for any specific bridge). These plots are for discussion purposes only and are not required for a Tier 1 assessment, only the actual span ranges and resulting line model action effects need to be considered for bridges that are included in the proposed route).

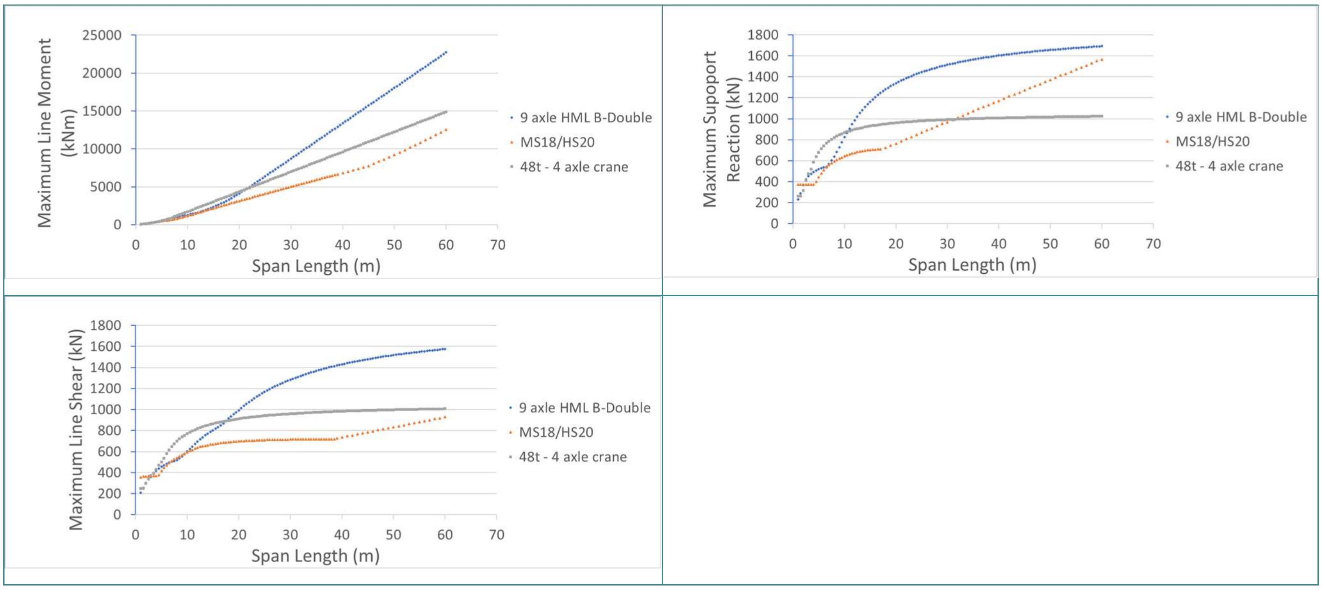


Figure 1: Factored line action effects

Some points to note in the figure:

- The upturn in the MS18 distribution; this is because at longer span ranges, the design lane loading associated with the MS18 load set is higher than the MS18 vehicle loading alone, and so governs the MS18 reference vehicle capability in these span ranges. Similar situations exist for most historic design vehicles and in some cases the lane loading is additive to the main vehicle (e.g., SM1600).
- The 9-axle B-Double becomes more onerous as the span length increases compared to the reference vehicles because the B-Double is much heavier. This affects span ranges where the whole vehicle can sit on the span.

For this particular assessment, the one bridge on the route is a 3-span, 12m per span bridge:

Bridge capability is defined as the maximum envelope of % of reference vehicle/s

Bridge Capability (for 12m span)	100% MS18 Design Load (Factored)	105% × 48 T; 4-axle crane (Factored)	**Maximum Bridge Capability** (Factored)	Governed* by	**Application Vehicle Loading Action Effects** (Factored)
Moment	601 * 2.0 * 1.3 * 100% = 1563 kNm	1003 * 1.6 * 1.4 * 105% = 2359 kNm	2359 kNm	105% of 48 T crane	1607 kNm
Shear	245 * 2.0 * 1.3 * 100% = 637 kN	365* 1.6 * 1.4 * 105% = 858 kN	858 kN	105% of 48 T crane	695 kN
Support reaction (in this case the pier)	260 * 2.0 * 1.3 * 100% = 676 kN	401 * 1.6 * 1.4 * 105% = 943 kN	943 kN	105% of 48 T crane	986 kN

*Note: the maximum value of the various reference vehicles must be taken, or assessments will be inappropriately conservative.

Assessment Ratios (for 12m span)	
Moment	2359/1607 = 1.47
Shear	858/695 = 1.23
Support reaction (in this case the pier)	943 / 986 = 0.96

Discussion of assessment results:

The proposed B-Double vehicle produces lower effects in both bending and shear than the reference vehicle set (bridge capability), however the B-Double produces higher load action effects in terms of pier reaction.

Nominally the application is not ideal, however consideration should be given to the limits of the current reference vehicle set and the characteristics of the structures on the route. The use of engineering judgment becomes critical to reaching logical outcomes. Some points:

- The current reference vehicle set does not include any longer and/or heavier vehicles that are similar to the application vehicle, so the representation of pier reaction bridge capability may not be accurate.
- The crane reference vehicle is defined using the governing load action effect (and we do not know what it is), therefore assessments considering the non-governing load actions of the crane would be conservative. This highlights the need to always report bridge capability in terms of all of the major load action effects and not just the governing effect.
- Considering the structure in question, the substructure has a blade wall construction. The substructure design is therefore likely to be nominal in nature and have a significantly higher capacity to resist support reaction loads.

Considering that the support reaction assessment was close and that the blade pier is likely to be able to carry significantly higher loads. If there is any concern, then risk control measures may be put in place if deemed necessary. In this case the difference is minor and given the configuration of the pier, no additional measures are warranted.

If the result was similar (pier reaction governed) but with a wider gap in the assessment ratio, then consideration may be given along the following lines:

- *How would the structure fail?* Failure of the blade wall would be highly unlikely; settlement of the piers could become a concern, but this would be very noticeable before there was any risk of collapse of the structure and is not likely to happen rapidly.
- *How could the risk of settlement be controlled?* The primary purpose of the control would be to ensure any settlement does not progress to the point that collapse could occur. An additional inspection protocol could be added to Level 1 inspections to investigate this over time.

Considering the B-Double itself:

- If IAP and on-board mass weighing was implemented in a way suitable to the road manager, the live load factor used in the assessment may be reduced.
- The B-Double could run at slightly reduced masses or modified load distribution (make spacing between tri-axle groups longer).

All of the above considerations are hypothetical in nature but provide some insight into the ways of using engineering judgment and risk-based thinking to promote access. All situations should be based on merit and the specific context, with careful attention placed on the likely effectiveness of any risk-based controls proposed. Importantly, access decisions should not be made on assessment ratios alone.

What if the application vehicle was an OSOM?

In this case, there are no straddling lane reference vehicles currently determined for the structure. Assessment comparing to a single lane reference vehicle can be made in most situations but is likely to be very conservative and not worth pursuing.

Comparing multiple single lane reference vehicles to a straddling lane OSOM vehicle is generally not appropriate. This would only be appropriate in situations where the bridge has a very high ability to spread loads transversely across the structure. Typically, in this situation, a Tier 2 assessment would be required to develop suitable reference vehicles. In time, experience with Tier 2 assessments of particular bridge families will hopefully yield adjustment factors to allow Tier 1 assessments in situations where there are no straddling lane reference vehicles.

8 Appendix B: Tier 2 Bridge Capacity Assessment Criteria

8.1 Overview

This section sets out the guide for undertaking a Tier 2 assessment as part of the Strategic Local Government Asset Assessment Project. A Tier 2 assessment is a theoretical assessment undertaken using typical bridge capacity estimates using as-built or design drawings, appropriate 2-dimensional modelling techniques and capacity assessment of individual members. The objective of a Tier 2 assessment is to set a theoretical benchmark for bridge capability. If additional Level 3 inspections are undertaken, site-specific modification of factors in Tier 2 analysis may be employed.

The key outcome from a Tier 2 assessment, as defined in this project, is a measure of bridge capability which is defined as the set of nominated % reference vehicles that can theoretically be carried using AS5100.7 to assess the capacity of the structure. Additional undue conservatism in approach over and above the code, be it in modelling, loading assumption, material parameters etc. will not assist in achieving optimised outcomes from the project. The cost of such conservatism cannot be accommodated in the evaluation of existing infrastructure. Some aspects from a typical design approach as defined in AS5100 are modified to account for how structures are typically used and how we understand structures behave. These modifications are set out in this appendix.

Assessment shall be caried out on the premise that assessment of existing structures is fundamentally different to design of new structure because the bridge and operating conditions are able to be better defined. Due consideration of operating context should be made, with fair consideration of the intent of AS5100.1, Cl 8.3.1 which states that ultimate design/load actions should be consistent with a 5% chance of occurrence in 100 years (consistent with a 1 in 2000 year recurrence interval). This means that just because an extreme contextual condition could exist, does not mean that it is appropriate for assessment when combined with other extreme factors.

Modelling and analysis shall be comprehensive but focus on key elements that are critical in preventing global failures with the appropriate use of engineering judgement to ensure cost effective assessments.

8.2 Loading Assumptions

8.2.1 Loading Cases

Applied loading shall be primarily focused on vehicle live loads. Loads associated with flooding, earthquake, collision/impact etc. shall generally not be considered unless they contribute to standard everyday operation.

8.2.2 Standard Vehicle Loading

Twenty-one (21) standard assessment vehicles have been specified for Tier 2 assessments. These are to be evaluated in all situations, no matter what the typical operating parameters are of an individual structure, unless the vehicle cannot physically fit on a structure. Another assessment vehicle may be substituted if the vehicle/s are too wide for the asset. Configurations, masses, and lane positioning are provided in the '*SLGAAP - Phase 2 - Assessment Results Template - v1.0'*. Some vehicles are to be assessed in both in lane and straddling lane positions.

8.2.3 Vehicle Positioning

Assessments should be based on typical operation rather than extremes, and so marked lanes should be considered in all situations unless it is clear that the structure may be used in a non-standard way on an "as usual basis".

Example: If a bridge has a width suitable for three lanes, however the third lane is typically taken up by parked cars, then the bridge shall be assessed considering the two loaded lanes only in their marked position. Some consideration for passenger car parking loads may be made for the third lane but shall not consider truck loading.

Example: If a bridge has enough width for three lanes but only two lanes are marked with wide shoulders, then the two marked lanes shall be loaded, and the vehicle positioning shall be constant with the lane line marking (not shuffled against the edge of the bridge).

The '*SLGAAP - Phase 2 - Assessment Results Template - v1.0'*, specifies if a vehicle shall be considered "in lane" or "straddling".

"In lane" vehicles shall be positioned in marked lanes.

"Straddling" vehicles shall be positioned according to AS5100.2 Cl 7.3 but centered (and offset) around any two marked lanes.

All vehicle positioning assumptions shall be recorded accurately and specifically through visual representation in the assessment template. Generic positioning templates are not acceptable.

8.2.4 Adjacent Associated Vehicles

Allowance for adjacent associated vehicles shall be in accordance with AS5100.7. Special reference is made to clauses 11.3.3 in the determination of appropriate specification of associated vehicles. Adjacent associated vehicles should be carefully considered on bridges with widths of 6.0m or less to determine if it is realistic that two vehicle would feasibly pass one another, particularly at significantly over loaded levels. There should be an intent to ensure the overall probability of occurrence is not significantly higher than intended by AS5100.1.

For any "in lane" vehicle, any associated vehicle shall be the same as the primary/nominated reference vehicle under consideration. When determining the rating factor or assessment ratio, the factor shall apply uniformly to all vehicles loading the structure.

For any "straddling lane" vehicle, there shall be no adjacent vehicles unless there are three or more lanes. In this case, the associated vehicle shall be a reference vehicle loaded to either GML or HML, as relevant to the route in question and approved by the NHVR and relevant road manager. No adjustment to % of the associated reference vehicle shall be made in this case. If the additional loaded lane creates a substandard assessment ratio of the straddling lane vehicle, then a separate case with just the straddling lane vehicle shall be included to provide suitable management options for the road manager.

8.3 Modelling

All modelling assumptions shall be accurately recorded using the provided template. A generic approach to assumptions with a copy-and-paste approach shall be avoided.

8.4 Load Factors

Load factors shall be considered based upon the likelihood of overloading. AS5100.7 provides some limited guidance on this; however, consideration of live load factors should be commensurate with the effectiveness of any controls put in place to manage risks.

Load factors shall generally be consistent with state practice and it is the supplier's responsibility to source this information.

All load factors shall be carefully considered and discussed with the relevant road manager and the NHVR prior to conducting the assessment process.

8.5 Accounting for Asset Condition

All assessments shall consider the condition of the asset. This will generally require a current Level 2 inspection in accordance with the relevant state road authority practice. The provision of a Level 2 inspection report is the responsibility of the relevant local road manager; however, it is the supplier's responsibility to engage with the council to gather this information. In situations where this information cannot be sourced, approval to commence an assessment without considering condition shall be sought from the NHVR.

Each assessment will consider two cases:

1. The structure is in good condition assuming all elements are functional and not affected by condition, and
2. The structure is in actual condition with an assessment which considers the reduced capacity.
   - All assumptions must be quantified clearly in the assessment template (*SLGAAP - Phase 2 - Assessment Results Template - v1.0*)

8.6 Documentation and Analysis Files

All results are to be recorded in the provided Excel templates (*SLGAAP - Phase 2 - Assessment Results Template - v1.0*). All assumptions need to be clearly defined and recorded such that analysis could be replicated. Several fields are implemented to allow future research and development. All fields must be comprehensively filled out, unless expressly agreed otherwise in writing with the NHVR and the relevant road manager.

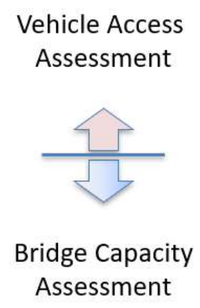
All calculations are to be undertaken by a suitably qualified engineer consistent with the requirements of state legislation where the asset is located and where the assessment is being conducted from. All calculations are to be verified by a qualified structural engineer with relevant qualifications for the state where the asset is located and where the assessment is being conducted from.

All analysis and modelling files must be provided as part of the reporting package. These shall be presented in such a way that the calculation can be interrogated directly and verified by an independent engineer.

9 Appendix C: Comparison of Tiers of Assessment used in Australia

The following maps the different terminology used throughout Australia regarding Tiers of Assessment. It is provided here for clarity and communication understanding. The framework used in the SLGAAP program is consistent with the Austroads definition of Bridge Asset Owners Tiers of Assessment.

PBS tiers of assessment	Bridge asset owner tiers of assessment
Tier 1 PBS Assessment 'Must meet the PBS Bridge Formula'	
Tier 2 PBS Assessment 'Must not cause more effects than existing commercial vehicles acceptable to bridge owner'	**Tier 1 (TMR Tier 0) Bridge Asset Owner Assessment (Access assessment)** Line model (comparison) comparing load effect of applicant vehicle and design vehicle or previously approved commercial vehicle. Must consider condition of structures.
Tier 3 PBS Assessment 'Detailed individual bridge assessment'	**Tier 2 (TMR Tier 1) Bridge Asset Owner Assessment (Structural assessment AS 5100.7)** 2D Grillage model/Line model (with distribution factors) analysis and structural capacity assessment. Must consider condition of structures.
	Tier 3 (TMR Tier 2) Bridge Asset Owner Assessment (Site specific and or higher order assessment) More advanced method, bridge specific analysis and use of international standards that are more sophisticated than AS 5100.7. Non-linear analysis, load testing to support either recalibration of computer models/determination of capacity.



Source: AP-R565-18 Implementation of a Nationally Consistent Framework for the Assessment of Bridges in Australia

Figure 2: Comparison of Tiers of Assessment used in Australia