This Manual is owned and controlled by the Senior Engineer Structures. The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

**Authorisation**

As head of Structures Engineering of Main Roads Western Australia, I authorise the issue and the use of this Manual.

**A. LIM**  
SENIOR ENGINEER STRUCTURES  
Date : 16/04/2018

Document No: 3912/02-1

This document is only controlled via the Main Roads website
# BRIDGE BRANCH DESIGN INFORMATION

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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 13/04/2018
1 INTRODUCTION, SCOPE AND PURPOSE

1.1 Introduction

The Bridge Branch Design Information Manual has been prepared to provide guidance and to set design criteria for the process of carrying out design and design related activities for bridges, culverts and other transport related structures. The Manual presents information and criteria for use in structural design to assist with the design process, clarify code ambiguities and to ensure uniformity, consistency and conformity of results.

The Manual has been prepared in good faith. However, Main Roads Western Australia (MRWA) does not guarantee or warrant the veracity of any information or referenced information contained within. The use of information and criteria contained within this Manual shall not relieve the user of their responsibilities for due diligence and checking of all results and outcomes.

1.2 Scope

The scope of the Manual includes, but is not limited to, the following:

- Design of new road and pedestrian bridges;
- Design of new culverts;
- Refurbishment design of existing bridges, including strengthening;
- Criteria for
  - Clearances
  - Bridge width
  - Bridge design loading
  - Serviceability stress limits
  - Construction forces and effects;
- Load rating of existing bridges, including historical design and load rating vehicles;
- Bearings and joints (including approach slabs);
- Railings and barriers; and
- Waterways investigation and flood estimation.

Unless specifically excluded by an authorised officer from Structures Engineering, all structural design undertaken within Main Roads Western Australia or by its authorised Agents shall incorporate the guidelines, methodologies, processes and criteria presented in this Manual.
1.3 Purpose

The principal purpose of this Manual is to:

- ensure uniformity of standards and details in the design of bridges, culverts and other transport related structures;
- record any variations from AS 5100 Bridge Design (CODE) approved for use in the design process;
- clarify any confusing or ambiguous areas of the CODE; and
- ensure that construction feedback receives widespread circulation.

Any person identifying a need for any of the above not already covered adequately elsewhere shall notify the Structures Design & Standards Engineer, who shall arrange the writing and issuing of any required revisions, if considered appropriate.

1.4 Use of this Manual

In using this Manual, references to other information Sections within the Manual are in the following format:

Design Information Manual / Document Number / Section Title

The above format is abbreviated to DIS 3912/02/xx “Section Title”, where DIS represents ‘Design Information Section’ and ‘xx’ represents the particular Section within the Manual.

1.5 Common Abbreviations

Common abbreviations used throughout this Manual are:

- DIS - Design Information Section
- BDC or CODE - Bridge Design Code, AS 5100
- MRWA - Main Roads Western Australia
- SES - Senior Engineer Structures
- SD&SE - Structures Design & Standards Engineer
- EBL - Engineer Bridge Loading
SECTION 2 – DESIGN OF NEW STRUCTURES

This information is Part 2 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

E R SMITH
A/SENIOR ENGINEER STRUCTURES

Date: : 30 / 3 /06

Document No: 3912/02-2

Controlled Copies shall be marked accordingly
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Revision Approval

E R SMITH
A/Senior Engineer Structures
Date: 30/3/06
2 DESIGN OF NEW STRUCTURES

2.1 INTRODUCTION
The design of new structures shall be carried out in accordance with generally accepted engineering principles in conjunction with the guidelines of the Bridge Branch Design Manual Document 3912/03, the requirements of AS 5100, Bridge Design (CODE), and this Manual. Reference shall also be made to the Structures Engineering Management System “Procedure for the Design of Structures” Document No. 3912/01/05.

2.2 PRELIMINARY DESIGN
Great importance is attached to the carrying out of an adequate Preliminary Design to ensure that all alternatives are considered, constraints identified and the most appropriate design selected. It is during this phase that decisions that influence the future course of the whole bridge design and construction process are made. The preliminary design phase usually has the greatest influence on the final cost of the structure - the potential for cost saving by appropriate selection of structure type and construction method, is much greater here than later in final design, where only marginal refinements are possible.

This "conceptualising" stage is vitally important and one where both experience and imagination are required. Sufficient time and effort MUST be put in at this stage, before beginning the final design to ensure the best option is selected in terms of form, function, aesthetics, site conditions and constraints, and ease and cost of construction.

During the preliminary design stage, it is important to consider all the constraints, as these will obviously have a considerable influence on the type of structure chosen. Information on the more common constraints and their influence on the preferred type of structure for specific sites are given in Chapter 2 of the Bridge Branch Design Manual (Document No. 3912/03), but amongst the more important would be: -

- clear spanning requirements;
- any staging requirements for future road or rail widening;
- environmental and/or ethnographical considerations;
- influence and importance to be placed on aesthetics;
- need to maintain traffic, rail or navigation clearances during construction; and
- choice of construction method (difficult site conditions, restricted access etc).

The choice of construction method is possibly the most important and often most neglected aspect of preliminary design. The correct choice of construction method can influence the rest of the design process and possibly lead to great savings later during construction. This is especially true for bridges over busy roads, railways and large bodies of water. Another important influence on the construction method is the need to make construction as easy and simple as possible.
Knowledge and experience are vitally important in the preliminary design phase. Chapter 2 of the Bridge Branch Design Manual is useful in this regard and should be referenced for further guidance. Also, consultation with other specialists, especially architects, at an early stage in the design can be very valuable.

The actual preliminary design process for a specific structure is only a simplification of final design, which is covered in the Bridge Branch Design Manual. The aim of preliminary design is to obtain an approximate idea of member sizes, reinforcement, foundations etc so that a reasonably accurate cost estimate can be prepared. The amount of effort put in at this stage will obviously depend on the size, importance and cost of the particular structure.

It is normal to produce at least a General Arrangement drawing of each bridge option or scheme investigated. Other drawings or sketches may also be necessary so that an approximate Bill of Quantities can be prepared to enable an estimate to be calculated.

On completion of the preliminary design, the Designer is required to produce a 15% review report and organise a meeting with MRWA to agree on the bridge option to be adopted, prior to proceeding with the detailed design.

A simplified flow chart of the Preliminary Design process is presented in Appendix A.

2.3 FINAL DESIGN

In general, final design shall be carried out in accordance with the guidelines provided in the Bridge Branch Design Manual Document No. 3912/03.

All bridge and structure design shall be carried out in accordance with the CODE, modified by this Manual, as detailed below.

The Clause numbers used below refer to the Clause numbers used in the CODE and are prefixed with BDC and a number to signify the part number of AS 5100, Bridge Design.

Part 1 – SCOPE AND GENERAL PRINCIPLES

BDC 1 - 9.1 General Geometric Requirements

To assist in safe future inspection and maintenance, bridge clear headroom shall not be less than 1.0m.

BDC 1 - 9.6 Horizontal Clearance to Substructure Components of Bridges over Roadways

The face of any support, apart from columns located in the median, must be set back from the ultimate edge of the nearest traffic lane by no less than 10.0m for bridges over Highways/Main Roads and 7.0m for bridges over other roads.

BDC 1 - 10 Road Traffic Barriers

The CODE shall be used for the design of all road bridge traffic barriers or Main Roads’ standard barriers that are deemed to comply with the respective CODE Performance Levels may be used.
BDC 1 - 11.3 Collision from Railway Traffic

Where possible, bridges over rail shall comprise a single clear span.

Collision loads as defined in the CODE shall be applied to all support elements (piers and abutments) in accordance with CODE requirements.

Abutment walls shall not be box type but near linear (parallel to railway alignment in plan) to remove the danger to the train from a head-on collision with the abutment sidewall. Where only box type abutments are possible (i.e. with a return angle of > 20 degrees), protection must be provided against a head-on impact through the provision of a deflection wall.

Reinforced soil abutments are acceptable provided that the superstructure is supported in a manner that is independent of the MSE wall and its retained backfill. However, MSE walls cannot be considered as contributing to the impact resistance unless the backfill is cement stabilised for a minimum width of 1.2m and for the full height of the wall.

MSE walls may be designed and used as abutment wingwalls.

Simply supported multi-span structures over railways must satisfy the following conditions:

(i) bridge supports (piers including any infill walls and abutments) must be designed to resist railway impact loads in accordance with CODE requirements; and

(ii) following a detailed risk analysis carried out in accordance with AS/NZ 4360 and AS/NZ 3931, the risk acceptance criteria for the structure must be tolerable or negligible (as defined in Figure 2.1).

Acceptable Risk for Bridges over Railways

![Acceptable Risk for Bridges over Railways](image)

Figure 2.1: Risk Acceptance Criteria
BDC 1 - 12  Pedestrian and Bicycle-Path Barriers

Where a structure, such as a retaining wall, head wall or wingwall, presents a vertical or near vertical face 1.5 m or more in height and it would be likely that a person could gain access to the upper edge of the structure, a pedestrian restraint system such as a monowills 2-rail barrier shall be installed close to, or on top of the structure.

A risk assessment shall be carried out for the protection screen requirements for objects falling or being thrown from bridges in accordance with Main Roads’ assessment procedure outlined in the report titled “Risk Management of Hazards on Pedestrian Overpasses”.

Protection screens adjacent to traffic lanes, emergency breakdown lanes or parking lanes, shall have a minimum setback derived using Table 4.5 of Road and Traffic Engineering Branch’s Document No. D06#26105, Assessment of Roadside Hazards. The values in the table can be extrapolated for lower speeds but not for a smaller vehicle or hazard height.

BDC 1 - 14  Drainage

The drainage system must be designed so that a minimal amount of water flows across Deck joints.

All bridge drainage pipes whether external or internal must be of durable material, must be corrosion and fire resistant, and must be concealed from public view.

All drainage structures must be vandal proof and accessible for cleaning, operation and maintenance purposes.

BDC 1 - 16  Utilities (Services)

Where possible, services must be concealed from public view within the bridge Superstructure, and adequate provision must be made for future inspection, maintenance and possible replacement.

The Consultant must obtain the agreement of the relevant Authority or private owner in writing to the conditions contained in Appendix B of the Road and Traffic Engineering Branch’s Document No. 67-08-108, Guide to the Relocation or Protection of Services.

Spare ducts comprising two 100 mm conduits must be provided on each side of the bridge terminating with capped ends beyond the deck and approach slab.
Part 2 – DESIGN LOADS

Design Loads shall be in accordance with the CODE, DIS 3912/02/05 “Design Vehicle Loadings” where required, and as follows:

BDC 2 - 5.3 Superimposed Dead Load
Road bridge structures with an open graded asphalt wearing surface must be designed for a total asphalt thickness of 100 mm. All other road bridges must be designed for asphalt surfacing 75 mm thick.

BDC 2 - 10.2 Collision Load from Road Traffic
All Columns in the median and adjacent to shoulders must be designed to resist traffic impact forces, regardless of whether they are protected by safety barriers or not.

BDC 2 - 21 Construction Forces and Effects
Refer to DIS 3912/02-9 “Construction Forces and Effects”.

Part 4 – BEARINGS AND DECK JOINTS

BDC 4 - 5 Functions of Bearings and Deck Joints
The bridge deck slab shall be continuous between abutments, without deck joints.

BDC 4 - 12.1 Elastomeric Bearings - General
Where the use of elastomeric bearings is proposed bearings must be selected from Appendix A of the CODE.

BDC 4 - 12.6.7 Fixing of Bearings
Bearings must be restrained in position by recessed pockets in concrete Substructures or by mechanical devices.

BDC 4 - 17 Deck Joints
For small to medium movements, prefabricated rubber extrusion type joints between heavy reinforcing angles shall be used. For larger movements, alternative types of joint, such as a multi-element joint shall be used. Bonded steel/rubber and finger plate type joints shall not be used. Joints must not inhibit the proper placement of concrete.

Where the deck joint is attached by bolts cast into a concrete substrate, fully tensioned high tensile bolts must be used. Where the deck joint is attached by bars cast into concrete, flat bars must be used.

BDC 4 - 17.5 Deck Joints - Drainage
Deck joints must be designed to ensure the joint is watertight over the full width of the Deck.

Prefabricated extrusion joints must be turned up directly behind the carriageway kerbs to maintain the same installation depth from the deck or superstructure surface and to contain runoff. Joints in shared path bridges or across raised parts of the deck or
superstructure including paths, medians and parapets must be waterproofed using a recessed steel cover plate. Deck or superstructure crossfall must be designed to prevent water leakage or spillage from the deck or superstructure at the joints.

**Part 5 – CONCRETE**

The following requirements are applicable to both superstructure and substructure design.

**BDC 5 - 2.8 Cracking**

Where bridge elements are fully restrained from expanding or contracting horizontally due to shrinkage or temperature, eg for concrete bridge girders where webs and flanges are not cast in a single pour, then minimum reinforcement requirements for horizontal reinforcement for crack control must be in accordance with clause BDC 5 - 11.6.2.

**BDC 5 - 4.3 Exposure Classification**

Protective surface coatings must not be taken into account in the assessment of the exposure classification.

**BDC 5 - 6.2.1 Strength and Ductility**

Only normal (N) grade reinforcement will be permitted.

**OTHER STRUCTURAL DESIGN REQUIREMENTS**

1. Reinforced Soil Walls

   Reinforced soil walls must be designed in accordance with AS 4678, *Earth Retaining Structures*.

   Load bearing reinforced soil structures must comprise precast concrete facing panels.

   Polymeric material used as reinforcing strips for load bearing reinforced soil structures must satisfy the following conditions:

   (i) The reinforced soil wall system must be approved by Senior Engineer Structures;

   (ii) The reinforced soil wall system must be an approved RTA NSW system used only for the applications listed, refer RTA specification R57, Appendix R57/E available on-line at www.rta.nsw.gov.au/doingbusinesswithus/specifications; and

   (iii) There must be 150mm minimum clear cover from the front of the concrete panel to the geosynthetic reinforcement embedded in the panel.

   Where mechanically stabilised earth (MSE) panels are used for the bridge abutments or retaining walls, the superstructure must be independently supported on piles or columns founded below the reinforced soil block. Piles and columns must be fully fixed at the connection to the sillbeam, if used, and
in all cases designed to carry full abutment bending and axial loads, with provision for up to 1.0m loss of MSE wall backfill under the top of the piles or columns for the full width of the superstructure.

The MSE panels must extend to the underside of the superstructure with minimum clearance sufficient to enable the maintenance and replacement of the bearings.

2. Precast Prestressed Concrete Beams

If precast prestressed concrete beams are used, no more than 50% of the prestressing strands must be debonded at any section, including beam ends, in order to prevent the development of intersecting horizontal cracks between the strands. Debonding of adjacent strands must not be permitted.

3. Median Columns

All columns in the median and adjacent to shoulders must be designed to resist traffic impact forces, regardless of whether they are protected by safety barriers.

4. Access for Inspections and Maintenance

Design shall consider discreetly located access/steps to the substructure/underside of the bridge to assist in safe future inspection and maintenance by experienced personnel.

2.4 DESIGN SUMMARY SHEETS

A Design Summary Sheet shall be prepared by the Design Engineer for all new road bridges, dual use path bridges with vehicle access and large culvert structures with clear barrel spans over 3.0m, on completion of the design and design verification (refer Procedure for the Design of Structures, Document 3912/01/05 Clause 6.3, Step 12).

The Design Summary Sheet is important as it contains a summary of all the major features of the design. It is used for future checking of the structure for heavy load movements, structural alterations or if there are any major maintenance problems. The actual contents will vary depending on the size and complexity of the structure. Typical Summary Sheet details for a simply supported structure and a continuous structure are attached at Appendix B and C respectively and should be adhered to as closely as possible.

The main items to include on the Design Summary Sheet are:

- Details of the span configuration.
- The design cross-sections used in the analysis at critical positions, eg support and midspan.
- The section properties of these design cross-sections.
- Details of the reinforcement and/or prestress and the section capacities at the critical sections.
- The serviceability design moments and resulting stresses at the critical sections.
- Live Load Distribution Factors for different loadings.
- The available live load capacity at the critical sections, for use in checking heavy load movements.
- Foundation information, i.e., design bearing pressures for spread footings, design pile loads for piled foundations.
- Design scour allowance.
- Load rating information in accordance with 2.4.1 below.

### 2.4.1 Load Rating Information for Design Summary Sheets

All new structures shall be rated for the vehicles detailed in DIS 3912/02-4 “Load Rating Existing Bridges”.

The rating shall be done by the Designer at the time of completing the design. This information is to facilitate future heavy load movement checks and is to be recorded on the Design Summary Sheet.
APPENDICES

APPENDIX A  Preliminary Design Process
APPENDIX B  Design Summary Sheet (Simply Supported)
APPENDIX C  Design Summary Sheet (Continuous)
APPENDIX A   PRELIMINARY DESIGN PROCESS

Step 1: assess the site where the bridge is to be located. The site constraints will influence the bridge type, configuration and method of construction.

Step 2: an appropriate option for bridge type (reinforced or prestressed concrete, steel or composite), configuration (number and length of spans, bridge width), foundations (piled or spread footings) and construction methodology (in situ, precast, segmental, incremental launch).

Step 3: preliminary design can range from simple global models and simplified distribution analysis to use of grillage or FE models, depending on the complexity of the bridge.

Step 4: preliminary drawings showing general details of the overall bridge configuration, superstructure and substructure together with relevant sections and details will assist with estimating construction costs and visualising the bridge.

Step 5: construction costs are estimated (usually by a Quantity Surveyor) based on the details provided in the preliminary drawings, and are required to assess the economic attributes and cost-effectiveness of the various options.

Step 6: select the best option that meets all specified criteria to proceed to final design.
### Table 6.1 - Moment Capacity for Critical Load Cases

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<td>TM600</td>
<td>9.44 tonnes plus 1.2m of awl</td>
<td>2.30</td>
<td>222</td>
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<td>211</td>
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<tr>
<td>MLP 600</td>
<td>Gross excluding mass 2m</td>
<td>2.40</td>
<td>231</td>
<td>129</td>
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<tr>
<td>MLP 600</td>
<td>Gross excluding mass 2m</td>
<td>2.40</td>
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<tr>
<td>MLP 600</td>
<td>Gross excluding mass 2m</td>
<td>2.40</td>
<td>231</td>
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<td>249</td>
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<td>2.40</td>
<td>231</td>
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<td>211</td>
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<tr>
<td>Group One - Vehicle Three</td>
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<td>2.40</td>
<td>231</td>
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<td>211</td>
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<tr>
<td>Group One - Vehicle Four</td>
<td>PMA - 5Tonne Tandem (GCM 16 tonnes)</td>
<td>2.40</td>
<td>231</td>
<td>129</td>
<td>211</td>
</tr>
<tr>
<td>Group Two - Vehicle One</td>
<td>PMA - 5Tonne Tandem (GCM 16 tonnes)</td>
<td>2.40</td>
<td>231</td>
<td>129</td>
<td>211</td>
</tr>
<tr>
<td>Group Two - Vehicle Two</td>
<td>PMA - 5Tonne Tandem (GCM 16 tonnes)</td>
<td>2.40</td>
<td>231</td>
<td>129</td>
<td>211</td>
</tr>
<tr>
<td>Group Two - Vehicle Three</td>
<td>PMA - 5Tonne Tandem (GCM 16 tonnes)</td>
<td>2.40</td>
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<tr>
<td>Group Two - Vehicle Four</td>
<td>PMA - 5Tonne Tandem (GCM 16 tonnes)</td>
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<td>Group Two - Vehicle Five</td>
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<td>Group Two - Vehicle Six</td>
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<td>211</td>
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<tr>
<td>Group Two - Vehicle Eight</td>
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<td>2.40</td>
<td>231</td>
<td>129</td>
<td>211</td>
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</tbody>
</table>

### General Notes:
1. Permanent effects comprise self weight and superimposed dead load.
2. Exceptional loads are determined for the bridge per metre run or deck area.
3. Dynamic load allowance for vehicles delivering loads at speeds of more than 50 km/h are taken as 0.1.
4. Loads applied are based on an elastic analysis of the structure. The structure is assumed to be fully supported.
5. Superimposed dead load is shown as 0.2 for the span(s) as per AS 5100.5.

### Notation:
- $k$: Gross Load on the Vehicle
- $w$: Dynamic Load Allowance
- $s$: Vehicles delivering loads at speeds of more than 0.1
- $x$: Ultimate bearing stress of the deck
- $y$: Ultimate bearing stress of the deck
- $z$: Ultimate bearing stress of the deck
- $t$: Ultimate bearing stress of the deck
- $u$: Ultimate bearing stress of the deck

### Amendments:
- Simply Supported Bridge Design Summary - Sheet No. 2 of 2
- Sample Only
### LOAD RATING

#### Table 7.1

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<thead>
<tr>
<th>Vehicle Type and Configuration</th>
<th>Design Vehicle Configuration: 2 Axles + 10.3m</th>
<th>Sag Moments</th>
<th>Hug Moments</th>
<th>Shear</th>
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<tr>
<td></td>
<td>Ultimate Limit State</td>
<td>Service Limit State</td>
<td>Ultimate Limit State</td>
<td>Service Limit State</td>
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<tr>
<td></td>
<td>Sag Moments</td>
<td>Hug Moments</td>
<td>Sag Moments</td>
<td>Hug Moments</td>
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<tr>
<td>Mid-Long</td>
<td>218%</td>
<td>29%</td>
<td>10%</td>
<td>85%</td>
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<td>Twin / Long</td>
<td>478%</td>
<td>88%</td>
<td>68%</td>
<td>64%</td>
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<tr>
<td>Group One - Vehicle One</td>
<td>457%</td>
<td>88%</td>
<td>34%</td>
<td>64%</td>
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<td>Group One - Vehicle Two</td>
<td>387%</td>
<td>51%</td>
<td>38%</td>
<td>44%</td>
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<td>Group One - Vehicle Three</td>
<td>372%</td>
<td>54%</td>
<td>19%</td>
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<tr>
<td>Group Two - Vehicle Two</td>
<td>476%</td>
<td>56%</td>
<td>36%</td>
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<tr>
<td>Group Two - Vehicle Three</td>
<td>386%</td>
<td>57%</td>
<td>33%</td>
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<tr>
<td>Group Two - Vehicle Four</td>
<td>395%</td>
<td>57%</td>
<td>26%</td>
<td>52%</td>
</tr>
<tr>
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<tr>
<td>Group Two - Vehicle Six</td>
<td>197%**</td>
<td>58%**</td>
<td>9%**</td>
<td>27%**</td>
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<td>Group Two - Vehicle Seven</td>
<td>124%</td>
<td>19%</td>
<td>4%</td>
<td>30%</td>
</tr>
</tbody>
</table>

#### General Notes:

1. Permanent effects comprise of the sum of superimposed load, wind load, snow load and an allowance for unbalanced settlement at abutments and piers.

2. Load effects due to unbalanced settlement are based on an effective modulus of elasticity that takes into account long term effects due to creep for concrete beams.

3. Installed allowances for the bridge deck are:
   - Time Hysteresis: Concrete, Hysteresis between years - 0.3% kN/m²
   - Time Load: Concrete, Hysteresis between years - 0.3% kN/m²
   - Steel Rebars: 0.3% kN/m²
   - Time Load: Steel Girder, Hysteresis between years - 0.5% kN/m²

4. The temperature effects caused by the thermal gradients are shown.

5. The design vehicle is spaced per AS 5100. The worst design effect is provided by 2 lanes of this load rating.

#### Notes Table 7.1:

1. Group One vehicles are treated as per the loading as per the Dynamic Load Allowance, limit state load factors, lane deflections etc. All the above cases are assumed relative to the same vehicle type.

2. Group Two vehicles are treated as per the loading with respect to the Dynamic Load Allowance, limit state load factors, including dynamic effects of 1.25 in the same vehicle type.

3. ** Represents the controlling vehicle.

4. "2" represents uncontrolled movement. Refer to Section 3.5 of the Bridge Design Information Manual (Doc. 301/03) for details.

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THIS DRAWING IS AN AMENDMENT OF THE APPROVED DRAWING
SECTION 3 – REFURBISHMENT AND STRENGTHENING DESIGN

This information is Part 3 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information

A LIM
SENIOR ENGINEER STRUCTURES
Date: 11/01/19

Document No: 3912/02-3
SECTION 3

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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 30/08/18
3 REFURBISHMENT AND STRENGTHENING DESIGN

3.1 Introduction
This Section of the Design Information Manual shall be used for the design of refurbishment and strengthening of existing bridges. The refurbishment and strengthening design process is essentially split into two basic stages as follows:

Stage 1 – Load Rating
This stage analyses the load capacity of the existing structure in its current condition to determine structural deficiencies, and involves modelling the bridge in its current form utilising all available information on actual geometric, material and condition parameters. The load rating stage shall be carried out in accordance with DIS 3912/02-4 “Load Rating Existing Bridges” for non-timber bridges, or Document No. 6706-02-2227 “Load Rating and Refurbishment Design Manual for Existing Timber Bridges” for timber bridges.
The designer is required to confirm the analysis vehicles with EBL.

Stage 2 – Refurbishment and/or Strengthening Design
This stage follows logically from stage 1, which has identified areas of structural deficiency or zones requiring strengthening to accommodate the required refurbishment (widenning, raising, strengthening, additional traffic lanes etc). The refurbishment and/or strengthening design stage shall be carried out in accordance with the requirements detailed below.
The designer is required to confirm the design vehicles with EBL.

3.2 Non-Timber Bridges
Refurbishment and strengthening designs shall be to the CODE and for the vehicles specified by EBL, except where varied by the Bridge Branch Design Information Manual. If it has been demonstrated that CODE standards cannot be achieved then a lower level of service may be accepted.

3.3 Timber Bridges
Refurbishment and strengthening designs for existing timber bridges shall be carried out in accordance with the “Load Rating and Refurbishment Design Manual for Existing Timber Bridges”, Document No. 6706-02-2227.
The design shall, as far as practical, include the appropriate standard repair details contained within the Pavements & Structures Engineering Practice Notes, Document Nos. 6702/02/221, 222, 223. Such details are provided for general information only. Although structural sizes are given, reference must be made to approved drawings for each specific job, and all standard details must be assessed and confirmed as suitable by an engineering analysis.
South-West Region and Structures Engineering are developing Project Standard Drawings. These are akin to Standard Drawings for timber maintenance/refurbishment. Until such time as these are authorised by SES, all Project Standard Drawings are to be treated as project specific drawings. That is, given a project specific drawing number and submitted for review alongside other project specific drawings.
3.4 Construction Considerations

During construction of a refurbishment or strengthening design it is common for the road to remain at least partially open to traffic. The Designer must provide for this in the design by either propping various elements as required or designating traffic restrictions that are required.

The bridge must be analysed for each stage during construction (for example, a two stage RCO construction), giving allowable traffic loads for at least the three modes of tri-axle group vehicles if applicable, outlined in Document No. 6706-02-2227 “Load Rating and Refurbishment Design Manual for Existing Timber Bridges” for timber bridges and the Group 1 Vehicle 2 and Group 2 Vehicle 1 at both spreads in DIS 3912/02-4 “Load Rating Existing Bridges”, Appendix 4D for non-timber bridges. This information is required for heavy load assessments during construction and shall be forwarded to EBL prior to construction.

Construction staging and associated load restrictions should also be specified on the Drawings in line with staged load assessments as above.
SECTION 4 – LOAD RATING EXISTING BRIDGES

This information is Part 4 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures. Engineer Bridge Loading is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

R F SCANLON
SENIOR ENGINEER STRUCTURES

Date: 10/01/11

Document No: 3912/02-4

Controlled Copies shall be marked accordingly
SECTION 4

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Revision Authorisation

R F SCANLON
Senior Engineer Structures
Date: 10/01/11
4 LOAD RATING OF EXISTING BRIDGES

4.1 INTRODUCTION

This Section of the Manual shall be used to determine the load capacity of existing timber, steel and concrete bridges in Western Australia (WA), and to determine the load limit posting requirements for bridges with deficient load capacity.

Load ratings are generally carried out on bridges identified through a detailed inspection as possibly being of substandard capacity for Vehicle Standards Regulations (VSR) loads. If the load rating indicates that a bridge is incapable of accommodating VSR loads, then, in the interests of public safety, the structure is either repaired or a load limit is posted.

The aim of load rating analysis is to determine the theoretical capacity of a bridge by calculating what proportion of the T44/L44 design vehicle, AS 5100, Bridge Design (CODE) M1600 design vehicle, and various other rating vehicles it can carry.

The calculated capacity of the bridge for each of the vehicles is also used to update the bridge rating values in the MRWA bridge database. These values are used for the assessment of heavy haulage movements throughout the State.

Section 4 has been prepared to ensure there is a standard approach to analysing and reporting.

While the general analytical approach follows the CODE, there are some differences as it is an actual load on an existing bridge which is being analysed.

4.2 LOAD RATING OF EXISTING TIMBER BRIDGES

Load rating of existing timber bridges shall be carried out in accordance with the “Load Rating and Refurbishment Design Manual for Existing Timber Bridges”, Document No. 6706-02-2227.
4.3 LOAD RATING OF STEEL AND CONCRETE BRIDGES

4.3.1 Introduction
This section of the procedure is typically for use on MRWA “standard” type bridges, e.g., RC flat slabs of 6 and 7 metre spans, PSC plank bridges of 10 and 12 metre spans, PSC beam bridges of 18 metres spans, and steel/concrete composite bridges of 18 to 24 metre spans. The general principles and approach can of course be extended to other types and sizes of bridges.

The general approach is summarised in the flow chart at Appendix A.

4.3.2 Drawings and Other Information
The first step in carrying out an assessment is to obtain accurate up-to-date drawings of the bridge. These will usually be available from the MRWA Structures Engineering Drawing Office, either in book form, or on microfilm. A full set of drawings should be obtained, so as to be able to check for any non-standard features, and ensure they are the latest, with all as-constructed, repair, refurbishment details, etc noted.

Also obtain a copy of the latest inspection report, or arrange to have an inspection carried out if none available. Although assessments are usually on the basis of “as-new” condition, the actual state of the bridge is obviously important and could lead to a downgrading of the assessed capacity. Where actual material properties are known, these should be incorporated into the rating analysis.

It is also valuable to check the old bridge records and files in the Heavy Loads office. Although there is not information on all bridges, these files often contain material not recorded elsewhere, which could have an important bearing on the bridge capacity, e.g. results of past inspections, information on past load approvals, details of precast members, load tests, load limits, etc.

If no drawings can be found there is a problem. It is possible the bridge was built along with other identical ones in the same contract and no separate drawings were prepared, but this may be difficult to confirm. Where drawings are not available, the only option is to load test the bridge, which can be an expensive, disruptive and inconclusive exercise. When the bridge in question is thought to be similar to another, for which drawings are available, then if both are load tested this may provide some confirmation.

4.3.3 Reading Old Drawings
Care is necessary when reading old drawings, especially pre-metric ones. Imperial dimensions can be converted readily, but care is needed with concrete strengths, reinforcement sizes and grades, prestressing steel grade, and structural steelwork sizes and grades.

Concrete - On old drawings, concrete strengths are given in pounds per square inch or “psi”, and on the older bridges this will be the crushing strength of a standard 6” cube, rather than the cylinder strength. The cube strength is not exactly the same as the cylinder strength. However, with concrete so old, and given that concrete crushing is rarely a limiting factor, it is usually accurate enough to make a direct conversion, as below:
3,000 psi = 20 MPa
4,500 psi = 30 MPa
6,000 psi = 40 MPa
7,500 psi = 50 MPa

Old concretes generally exceeded the minimum specification requirements for strength so using concrete strengths on the drawings will generally be conservative. If the decision to strengthen is based purely on the assumption of concrete strength, material sampling can be undertaken within the provisions of the CODE.

**Reinforcement** - Imperial reinforcement is called up either by diameter, e.g. ⅝” @ 6” c/c, or by a number, e.g. D9045 @ 8” c/c. The first is reasonably straightforward. In the second, the first digit, (or the first two if the bar diameter ≥ 1¼”), is the bar diameter in ⅛”, e.g., 9=1¼”, the rest is the bar mark.

The grade of old reinforcement will generally be either of the following:

- ordinary mild steel (plain or deformed), with a yield of 230 MPa and an allowable stress of 125 MPa, also known as Grade S, or Structural Grade, or
- cold worked deformed, also known as CW60, with a yield of 410 MPa and an allowable stress of 170 MPa.

The grade should be stated on the drawings, but generally only mild steel was available until the mid-late 60s, with cold worked steel gradually replacing it and taking over almost completely by the mid 70s. If in doubt refer to the bar schedules, which were usually included with the drawings. Mild steel could be bent round a 2D pin, whereas cold worked used a minimum of 4D. Take care though, as often cold worked was used for the main straight bars and mild steel for stirrups and ligatures. If still in doubt, it is possible to take a sample for testing, from a non-critical region, otherwise err on the side of caution. Refer also to DIS 3912/02-6 “Stress Limits in Structural Concrete” for allowable stresses for various steel grades.

A conversion table for imperial bars is provided below.

<table>
<thead>
<tr>
<th>Bar Diameter (inches)</th>
<th>⅝”</th>
<th>⅜”</th>
<th>⅜”</th>
<th>⅞”</th>
<th>⅜”</th>
<th>⅜”</th>
<th>⅞”</th>
<th>1”</th>
<th>1⅛”</th>
<th>1¼”</th>
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<tr>
<td>Bar Area (mm²)</td>
<td>71</td>
<td>126</td>
<td>198</td>
<td>285</td>
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<td>641</td>
<td>792</td>
<td>958</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Prestress** - Prestressing steel details must be checked to obtain the correct properties. Usually, even on the older bridges, for wire or strand the yield will be around 1700 MPa, with 1250 MPa for prestressing bar. One problem with older prestressing steel is that it will probably be normal relaxation, as low relaxation steel only became generally available in the mid 70s. This will considerably increase long-term losses. It may be difficult to identify the steel in older bridges, especially in prefabricated, precast elements, as a number of different types, including a lot of imported steel were used. With prestress it is not usually possible to take a sample for testing, except perhaps from the end of a pre-tensioned member, so again err on the side of caution.

**Structural Steelwork** - Structural steelwork in older bridges, e.g., rolled or fabricated beams, can be of a number of different sizes, grades and origins. For the more recent of the older bridges, i.e., post 1960, beams will probably be BHP RSJs or UBs, Grade
250. Section properties for some of these pre-metric beams are attached at Appendix B. Older beams may well be imported, usually from England, and detailed measurements will have to be taken to calculate section properties. Again Grade 250 can usually be assumed safely, but some really old beams, (e.g., Horseshoe and Barrack St Bridges), were made of a very brittle, high carbon steel and should be checked carefully, and perhaps a sample taken for testing. Higher strength grades should only be used where they are clearly indicated on the drawings.

4.3.4 Rating Vehicles

For non-timber bridges, unless otherwise specified, ratings should be carried out for the standard rating vehicles given in Appendix D, all design vehicles and for the CODE T44 vehicle and MS1600 design vehicles. EBL shall also be consulted for any special vehicle loadings requiring load rating.

The rating vehicles shall be applied to the structure in the following manner:

T44 and MS1600 Vehicles

- As per the CODE

Group 1 Vehicles

- Treated as per the CODE T44 vehicle for position, dynamic load allowance etc.
- All design lanes are assumed occupied by the same vehicle positioned to give worst effects, with lane modification factors applied as per the CODE, AS5100.7, Table A2. One vehicle may be critical to the load rating and shall be checked as a separate load case to determine the most critical loading pattern for the bridge.

Group 2 Vehicles With Supervision Condition

- Treated as per the CODE HLP vehicle for position, dynamic load allowance etc.
- For undivided bridges, vehicles are to be placed ± 1.0m from the bridge centreline with no other coincident live loading.
- For divided carriageway bridges, the rating vehicles are to be placed ± 1.0m from the centreline of the direction of travel carriageway. 50% of the MS1600 loading is to be applied in the other carriageway positioned to give the worst effects (accompanying lane factors shall be applied to the loading in this carriageway in accordance with the CODE, AS5100.2, Table 6.6).

Group 2 Vehicles Without Supervision Condition (For Vehicles 4 and 5)

- Travel without supervision entails the vehicle being positioned centrally in the direction of travel ± 1.0m from the carriageway centreline (refer Appendix F for diagrams). A minimum clearance of 200mm is to be used between the kerb and tyres. Maximum speed is limited to 25km/h therefore a DLA of 0.3 is used.
- For undivided bridges with a single lane in the direction of travel, no other coincident live loading is to be included. For bridges with multiple lanes 50% of the MS1600 loading is to be applied in the other carriageway positioned to give the worst effects (accompanying lane factors shall be applied to the
loading in this carriageway in accordance with the CODE, AS5100.2, Table 6.6).

- For divided carriageway bridges, 50% of the MS1600 loading is to be applied in the other carriageway positioned to give the worst effects (accompanying lane factors shall be applied to the loading in this carriageway in accordance with the CODE, AS5100.2, Table 6.6).

It is important to use the correct dimensions and axle loads. Where dimensions can vary, the full range of axle spacing must be covered, as different lengths may be critical for sag and hog moments.

4.3.5 Loads and Load Factors

The loadings used in a load rating assessment are based on those given in Part 2 of the CODE, with a number of important modifications as detailed below.

**Dead Load and Superimposed Dead Load** - As the structure exists, it is theoretically possible to measure it and obtain an accurate measure of actual self-weight. However this is rarely done, and dimensions on the drawings are commonly used. A more accurate assessment of superimposed dead loads can be made though, especially the thickness of any surfacing. This should be measured during the inspection, if not assume 50 mm.

**Live Load** - Live loads shall be applied in the manner outlined in DIS 3912/02-5 “Design Vehicle Loadings” and as outlined above.

On longer bridges consideration shall be given to the possibility of getting two loaded vehicles in a lane at the same time. This has to be assessed by the engineer, but the habit of standard width vehicles to travel in convoy must be noted. A minimum headway of 15 metres shall be used in such cases. Loading in adjacent and other traffic lanes shall be considered with reference to DIS 3912/02-5.

**Dynamic Load Allowance** - As per the CODE or DIS 3912/02-5 for each vehicle.

**Differential Temperature** - As per the CODE and Section 4 of the Bridge Branch Design Manual Document No. 3912/03. The CODE requires that the vertical differential temperature gradient through a bridge superstructure be used to determine load effects. This is generally taken as the primary stresses, and where the structure is statically indeterminate, the secondary longitudinal parasitic effects. The Commentary provides guidance on the circumstances for which the primary thermal stresses can be ignored, and the secondary effects can be reduced by 50% to allow for cracking reducing the structure’s stiffness -. It could be argued that at the ULS as the structure approaches failure and development of plastic hinges, that the stress-induced secondary effects could be totally ignored in the rating for strength. Ratings for both cases shall be carried out to assess the effects of differential temperature.

Differential temperature effects should not control the strength (ULS) rating of the structure for the T44/L44 vehicle. That is, if the ULS ratings for the T44/L44 vehicle fall below 100% when the effects of differential temperature are included, and where the bridge condition is good with no notable evidence of structural distress, consideration shall be given to excluding the differential temperature effects.

**Differential Settlement** - As per the CODE and Section 4 of the Bridge Branch Design Manual Document No. 3912/03. However, as this is a long-term effect, and
will be reduced by creep, the long-term Elastic Modulus is to be used (it is usually sufficiently accurate to take \( \frac{1}{3} \) of the normal value). The following values shall be adopted for the analysis of differential settlement:

<table>
<thead>
<tr>
<th>Foundation Condition</th>
<th>Abutment Settlement</th>
<th>Pier Settlement</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread Footings (non-cohesive soils)</td>
<td>10 mm</td>
<td>20 mm</td>
<td>Free draining granular sands</td>
</tr>
<tr>
<td>Spread Footings (cohesive soils)</td>
<td>Varies</td>
<td>Varies</td>
<td>Requires assessment based on geotechnical data</td>
</tr>
<tr>
<td>Spread Footings (on sound rock)</td>
<td>5 mm</td>
<td>5 mm</td>
<td>If borelogs indicate sound rock, or rock bit refused, reduce to 0</td>
</tr>
<tr>
<td>Piled Foundations</td>
<td>5 mm</td>
<td>5 mm</td>
<td>If borelogs indicate very dense soil or rock with SPT values &gt; 120 at pile toe, reduce to 0</td>
</tr>
</tbody>
</table>

A load factor of 1.0 shall be used for differential settlement effects at both the serviceability and ultimate limit states.

As with differential temperature effects discussed above, it could be argued that at the ULS as the structure approaches failure and development of plastic hinges, that the strain-induced secondary effects could be totally ignored in the rating for strength. Ratings for the cases of including and excluding differential settlement shall be carried out.

**Shrinkage and Creep** - Both must be considered for prestressed structures, (to calculate losses); and shrinkage (modified for creep) for continuous composite structures. Only important for serviceability checks, not at ultimate.

**Prestress Parasitics** - As per the CODE.

**Other Loads** - Other loads, which may be important for design, e.g., wind, flood, earthquake etc, are not considered for load rating assessments, except in exceptional circumstances.

**Load Factors** - As per the CODE, as appropriate for the rating effect and vehicle, shall be used.

### 4.3.6 Analysis

Methods of analysis for load rating are basically the same as for normal bridge design, and information on this is provided in the Bridge Branch Design Manual Document 3912/03. However to assist, some rating methodology guidelines are provided at Appendix C.

### 4.3.7 Reporting

The assessment is placed on the specific bridge maintenance file and forwarded to EBL who is responsible for updating HLR and the bridge database. It is important to state all assumptions. A typical load rating report for a non-timber bridge is attached at Appendix E.

The assessed strength capacity is expressed as the % of the specific vehicle that can be safely carried and is obtained from the section ultimate capacity. It is calculated by
dividing the section available live load capacity, (total section capacity less permanent effects and temperature), by the live load ultimate moment. For bending moment at the ultimate limit state the load rating capacity will be given by:

\[
\% \text{ Rating} = \frac{\phi M_U - (\gamma_G M_D + \gamma_{GS} M_{DS} + M_P + M_S + \gamma T M_T)}{\gamma_L * (1+DLA) * M_L}
\]

Where:
- \(\phi\) = Capacity reduction factor
- \(M_U\) = Calculated ultimate moment capacity
- \(\gamma_G\) = Factor given in Table 5.2 of the CODE, Part 2
- \(M_D\) = Moment due to dead load
- \(\gamma_{GS}\) = Factor given in Table 5.3 of the CODE, Part 2
- \(M_{DS}\) = Moment due to superimposed dead load
- \(M_P\) = Moment due to parasitic effects of prestress
- \(M_S\) = Secondary Moment due to differential settlement
- \(\gamma T\) = Factor given in Section 17 of the CODE, Part 2
- \(M_T\) = Secondary Moment due to differential temperature (reduced as appropriate, see the CODE Commentary, Part 2)
- \(\gamma_L\) = Factor given in Table 6.10(A) of the CODE, Part 2 as appropriate
- \(DLA\) = Dynamic Load Allowance as determined in accordance with Clause 6.7 or A2.2.10 of the CODE, Part 2 as appropriate
- \(M_L\) = Moment due to live load incorporating multiple lane modification factors or accompanying lane factors as appropriate

**Note 1:** MP, Ms, may be ignored for ductile steel structures. For concrete structures, the provisions of the CODE, Part 5 Clause 7.2.8 for moment redistribution may be applied to the moments in the above formula (refer to Appendix C).

**Note 2:** For steel and steel composite slender structures, both primary and secondary effects should be considered.

**Note 3:** The live load and differential temperature load factors will depend on the load combination used. In most situations this will be:

\[
PE + \text{ultimate traffic loads} + \text{serviceability thermal effects}
\]

For bending moment at the serviceability limit state based on the load combination given by:

\[
PE + \text{serviceability transient load} + k \text{ additional transient or thermal load}
\]

The load rating capacity will be given by:

\[
\% \text{ Rating} = \frac{M_S - (\gamma_G M_D + \gamma_{GS} M_{DS} + M_P + M_S + k \gamma T M_T)}{\gamma_L * (1+DLA) * M_L}
\]

Where:
- \(M_S\) = Calculated serviceability moment capacity
- \(k\) = Coefficient for additional transient load effects (CODE Clause 22.3) and in most instances with one additional load effect it will be 0.7.

**Note 4:** The primary effect due to differential temperature is a stress and when it is required to include it as a load effect, all other load effects will need to be calculated as stresses and the load rating equation modified to suit.

**Note 5:** The coefficient \(k\) here does not have the same meaning as the factor \(k\) used in the CODE Commentary, Part 2 C17.4 (b).

**Note 6:** As the differential temperature primary stresses are usually small, it has been standard practice at MRWA to ignore them for reinforced and prestressed
concrete bridges. In these cases the secondary moment due to differential temperature in hog must not be reduced. The secondary moment in sag can still be reduced to allow for cracking as appropriate.
APPENDICES

APPENDIX A  Load Rating Assessment - Flow Chart
APPENDIX B  Typical Steel Section Properties (Old Imperial Beams)
APPENDIX C  Load Rating Analysis Guidelines
APPENDIX D  Rating Vehicles for Non-Timber Bridges
APPENDIX E  Typical Assessment Report (Non-Timber Bridges)
APPENDIX F  Vehicle Position For Load Rating Of Group 2 Vehicles
APPENDIX A

Load Rating Assessment - Flow Chart
Load Rating Assessment - Flow Chart

IDENTIFY BRIDGE PROPERTIES
- As-constructed drawings
- Check bridge database information
- Check condition from inspection report
- Scan old heavy loads files for any comments

IDENTIFY REQUIRED RATING VEHICLES
- DIS 3912/02-2
- DIS 3912/02-4
- As directed by Engineer Bridge Loading

OBTAIN GLOBAL DEAD LOAD EFFECTS
- PCBEAMAN, global line beam analysis

OBTAIN GLOBAL LIVE LOAD EFFECTS
- PCBEAMAN, global line beam analysis

CALCULATE DISTRIBUTION FACTORS (1)
- Grillage model using ACES, or folded plate model using STLBEAM, unless very skew (see Note 1)
- Calculate DFs for each vehicle spread

DETERMINE DISTRIBUTED LOAD EFFECTS
- D/L as normal, (but check construction method)
- L/L from above

CALCULATE SECTION CAPACITIES
- CONKS or PARTIAL or hand calculations

CALCULATE LIVE LOAD CAPACITIES (LONG)

CALCULATE LIVE LOAD CAPACITIES (TRANS)
- Use judgement as to how detailed this needs to be

CHECK SUBSTRUCTURE
- Type and configuration will determine how detailed this needs to be

RATE EACH VEHICLE (ULS & SLS)
- Take lowest ULS strength rating for each vehicle as controlling rating. Tabulate all ULS and SLS ratings.

PREPARE LOAD RATING REPORT
- Specify assumptions
- Specify vehicles and ratings
- Specify distribution factors
- Send to EBL to update HLR and the bridge database

Note (1): for skews greater than 30%, use actual member loads directly from grillage or folded plate model and go to “Calculate Section Capacities”
APPENDIX B

Typical Steel Section Properties (Old Imperial Beams)
### Properties for Designing

All universal beams produced in Australia have parallel flanges and the section properties listed are based on this geometry.

#### Designation

**Nominal Size, Wt per Foot**

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#### Web Height

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**Note:** The table above provides properties for universal beams produced in Australia. The weights and moments of inertia are typical for such beams.
### ROLLED STEEL JOISTS
#### DIMENSIONS AND PROPERTIES

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<th>Standard Thickness Inches</th>
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<td>55</td>
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<td>13-24</td>
<td>-042 1-011 73</td>
<td>-38 15-03</td>
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<td></td>
</tr>
<tr>
<td>ASB 121</td>
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<td>30</td>
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<td>15-44</td>
<td>-060 1-011 73</td>
<td>-38 13-00</td>
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<td></td>
</tr>
<tr>
<td>ASB 120</td>
<td>15 x 6</td>
<td>40</td>
<td>75-20</td>
<td>11-15</td>
<td>-065 1-011 73</td>
<td>-38 12-75</td>
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<td></td>
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<td>40</td>
<td>61-68</td>
<td>9-02</td>
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<td>-38 11-75</td>
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<tr>
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<td>13 x 5</td>
<td>35</td>
<td>50-28</td>
<td>7-26</td>
<td>-054 1-011 73</td>
<td>-38 10-53</td>
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<tr>
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<td>65</td>
<td>50-26</td>
<td>6-23</td>
<td>-054 1-011 73</td>
<td>-38 8-50</td>
<td></td>
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</tr>
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<td>ASB 116</td>
<td>12 x 5</td>
<td>50</td>
<td>50-18</td>
<td>6-05</td>
<td>-046 1-011 73</td>
<td>-38 6-33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 115</td>
<td>10 x 6</td>
<td>50</td>
<td>63-65</td>
<td>22-59</td>
<td>-073 1-011 73</td>
<td>-38 6-00</td>
<td></td>
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<tr>
<td>ASB 114</td>
<td>10 x 6</td>
<td>40</td>
<td>45-74</td>
<td>11-85</td>
<td>-070 1-011 73</td>
<td>-38 5-00</td>
<td></td>
<td></td>
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<tr>
<td>ASB 113</td>
<td>10 x 6</td>
<td>40</td>
<td>45-74</td>
<td>11-85</td>
<td>-070 1-011 73</td>
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<tr>
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<td>25</td>
<td>28-07</td>
<td>8-48</td>
<td>-055 1-011 73</td>
<td>-38 4-06</td>
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<td></td>
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<tr>
<td>ASB 111</td>
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<td>16-67</td>
<td>-085 1-011 73</td>
<td>-38 3-61</td>
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<td></td>
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<tr>
<td>ASB 110</td>
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<td>21</td>
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<td>3-51</td>
<td>-047 1-011 73</td>
<td>-38 2-10</td>
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<tr>
<td>ASB 109</td>
<td>8 x 6</td>
<td>35</td>
<td>32-94</td>
<td>10-71</td>
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<td>-38 2-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 108</td>
<td>8 x 6</td>
<td>35</td>
<td>32-94</td>
<td>10-71</td>
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<td>-38 2-10</td>
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<td></td>
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<tr>
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<td>11-70</td>
<td>7-00</td>
<td>-080 1-011 73</td>
<td>-38 2-05</td>
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<td></td>
</tr>
<tr>
<td>ASB 106</td>
<td>6 x 5</td>
<td>25</td>
<td>17-50</td>
<td>6-45</td>
<td>-081 1-011 73</td>
<td>-38 3-00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 105</td>
<td>6 x 5</td>
<td>12</td>
<td>8-08</td>
<td>1-65</td>
<td>-064 1-011 73</td>
<td>-38 1-75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 104</td>
<td>5 x 3/4&quot;</td>
<td>9</td>
<td>5-98</td>
<td>1-03</td>
<td>-047 1-011 73</td>
<td>-38 1-75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 103</td>
<td>4 x 3</td>
<td>10</td>
<td>4-94</td>
<td>1-47</td>
<td>-037 1-011 73</td>
<td>-38 1-75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB 102</td>
<td>4 x 1/2&quot;</td>
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<td>2-15</td>
<td>1-37</td>
<td>-029 1-011 73</td>
<td>-38 1-75</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Nominal size — Actual width is 7/6 inches.
†Nominal size — Actual thickness is -63/5 inches.
APPENDIX C

Load Rating Analysis Guidelines
C Load Rating Analysis Guidelines

C.1 General

The whole of the structure should be analysed as part of the load rating assessment. The superstructure is to be checked for both longitudinal and transverse load effects and for shear. The substructure is also to be checked, including an assessment of the forces on the bridge bearings where present.

An assessment of the longitudinal braking forces should be carried out, and the effects on the substructure taken into account as part of the rating for these elements. However, for remote rural bridges subject to relatively infrequent vehicle loading events, the full braking loads associated with multiple vehicle presence is considered to have a low probability of occurrence, and should not control the ratings in this instance. Specific details shall be submitted to SES for review.

C.2 Superstructure

Superstructure analysis for the common structural types considered in this Section, is covered fairly extensively in the Bridge Branch Design Manual Document 3912/03, particularly Chapter 10. The methodology applicable for the rating is shown in Appendix A Load Rating Assessment Flow Chart.

C2.1 Critical Sections for Analysis

Critical sections to be checked are the obvious points of peak bending over the supports and at mid-span regions and shear at supports. In addition, all regions of curtailed reinforcement must also be checked, as these can often control the ratings.

C2.2 Moment Redistribution

Moment re-distribution can be included in the rating analysis and the allowable percentage of moment calculated in accordance with the CODE, Part 5 Clauses 7.2.8 and 7.2.9. However, for rating of existing bridges with member section capacities calculated from actual or assumed material properties, this allowable percentage is further limited as follows.

The hog bending moments may be reduced, but only to the point where the hog and sag ratings balance, as there is no point in re-distributing hog moment to the point where the sag region rating becomes controlling. This limit, based on balancing the hog and sag ratings, may be less than the allowable percentage as determined by the CODE.

Further, it is important when undertaking re-distribution of moment that the rotational capacity of the section is not exceeded at a plastic hinge (i.e. rupture failure occurs). Therefore, the maximum amount of moment available for re-distribution is directly related to the ultimate section capacity, and is limited to the allowable percentage as determined by the CODE multiplied by the member section capacity (NOT the vehicle design moment) at the specific support being assessed.

The lesser value of the above two conditions is to be used in the determination of the ratings.
C2.3 Distribution Factors and Skew Effects

For bridge decks with less than 30 degrees skew, they can be modelled and analysed as square bridges with sufficient accuracy. In this case, distribution factors or magnification factors (see Section 10.7 of the Bridge Branch Bridge Design Manual), can be calculated and applied to the global line beam moments. For peak moment over supports, the distribution factor should be calculated at a distance of D away from the pier centreline for a more realistic value, to allow for the thickness of the deck. If required, use can be made of the rounding effect of a finite support width to reduce peak hog moments.

The use of distribution or magnification factors reduces the possibility for error, (it is easier to check if the distribution factor is reasonable than if a single moment figure from a grillage run is correct). It also ensures the members have the capacity to carry all the load in bending, as in the more refined models, loads may also be carried by in-plane actions in the plate members.

For bridge decks with a skew greater than 30 degrees, the load effects can be taken directly from the grillage or folded plate model.

C2.4 Edge Beams and Kerbs

For most structures, the effect of the kerb, or edge beam, may be ignored. If it is included it usually attracts a high moment, much more than it can carry, so it will only crack and re-distribute anyway. If the edge beam is stiff and heavily reinforced it may need to be considered, but an iterative approach may be required to assess the amount of load it attracts and balance this to its capacity.

C.3 Substructure

Analysis of piers, columns, capbeams and bearings shall be in accordance with the CODE. It is important to check the “as-is” situation, as any out of plumb of the columns, or misplacement of bearings can considerably increase forces. Also any deterioration, e.g. chloride attack at the base of columns or corrosion of steel columns etc, may need to be allowed for.

Check for loads calculated as above, although if critical, it may also be necessary to include stream forces for substructure checks. This will generally be specified when required.

C.4 Foundations

Foundations are only usually checked if there is some doubt about their condition, e.g. following scour from flooding. Any analysis that is deemed required shall be undertaken in accordance with the CODE.
APPENDIX D

Rating Vehicles for Non-Timber Bridges
1. **PRIME MOVER + 18 TONNE TANDEM**  
   (G.C.M. = 42 TONNES)

2. **PRIME MOVER + 18 TONNE DOLLY + 27 TONNE TRIAXLE**  
   (G.C.M. = 69 TONNES)

3. **PRIME MOVER + 18 TONNE DOLLY + 36 TONNE STANDARD QUAD**  
   (G.C.M. = 78 TONNES)

4. **PRIME MOVER + 18 TONNE DOLLY + 36 TONNE 484 QUAD**  
   (G.C.M. = 78 TONNES)

**NOTE**

0/A WIDTH OF ALL VEHICLES 2.4m

GROUP 1 RATING VEHICLES
**NOTE**

VEHICLES 1+2 CAN HAVE AN O/A WIDTH OF EITHER
3.0m OR 3.7m.
VEHICLE 3 IS 3.0m O/A
VEHICLE 4 IS 3.7m O/A

---

1. **PRIME MOVER + 36 TONNE DOLLY + 54 TONNE TRIAXLE**
   (G.C.M. = 114 TONNES)

<table>
<thead>
<tr>
<th>64</th>
<th>104</th>
<th>364</th>
<th>544</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9</td>
<td>12</td>
<td>12</td>
<td>65</td>
</tr>
</tbody>
</table>

2. **PRIME MOVER + 36 TONNE DOLLY + 72 TONNE SPREAD QUAD**
   (G.C.M. = 132 TONNES)

<table>
<thead>
<tr>
<th>64</th>
<th>104</th>
<th>364</th>
<th>724</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9</td>
<td>12</td>
<td>12</td>
<td>65</td>
</tr>
</tbody>
</table>

3. **PRIME MOVER + 36 TONNE DOLLY + 144 TONNE 8-LINE PLATFORM**
   (G.C.M. = 204 TONNES)

<table>
<thead>
<tr>
<th>64</th>
<th>104</th>
<th>364</th>
<th>1444</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9</td>
<td>12</td>
<td>12</td>
<td>65</td>
</tr>
</tbody>
</table>

4. **PRIME MOVER + 216 TONNE 12-LINE PLATFORM**
   (G.C.M. = 240 TONNES)

<table>
<thead>
<tr>
<th>64</th>
<th>104</th>
<th>216</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.9</td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>145</td>
<td>145</td>
<td>145</td>
</tr>
</tbody>
</table>

---

**Figure 16.4**

GROUP 2 RATING VEHICLES
7. **PRIME MOVER + 4.32 TONNE 16-LINE PLATFORM 3 FILE**  
(G.C.M. = 4.56 TONNES)

VEHICLE SEVEN IS 4.81m O/A

```
440 290 440 650 440 290 440 650 440 290 440
```

8. **PRIME MOVER + 576 TONNE 16-LINE PLATFORM 4 FILE**  
(G.C.M. = 600 TONNES)

VEHICLE EIGHT IS 6.22m O/A

```
440 290 440 650 440 290 440 290 440 290 440 290
```

GROUP 2 RATING VEHICLES
APPENDIX E

Typical Assessment Report (Non-Timber Bridges)
1. In response to your request to assess the above bridge, I have carried out a load rating check for only the T44, Group 1 and Group 2 vehicles from the standard rating vehicles list.

2. The bridge is 20 spans (20 x 10.06m) with 5 units of 4 continuous spans. The deck is a concrete flat slab with a 4.27m width between kerbs and 4.88m overall. The substructure consists of reinforced concrete wall-type piers, which are founded on a spread footing. The structure was built in June 1963.

3. My analysis incorporates the following assumptions:
   - All material is in an “as-new” condition.
   - Only one lane of traffic on the bridge.
   - A Yield Stress in the reinforcement of 230MPa.
   - f’c of the concrete to be 30MPa.
   - The bridge was considered to be in the coastal sub-tropical zone of Western Australia for exposure classification.
   - The long-term modulus was used to determine differential settlement effects, assuming 10mm settlement at the piers.
   - Moment re-distribution has not been taken into account in this load rating.
   - A load rating based on shear capacity has also been undertaken assuming the whole bridge width as being effective, thus a distribution factor of 1.0.

4. All sections along the first two spans have been checked at 0.503m intervals, rather than simply checking sag at midspan and hog at the pier. This is due to the fact that the change in section capacity (based on curtailment and thus varying deck reinforcement) may have resulted in a more severe rating at locations other than hog at the pier and sag at midspan.

5. The bridge was analysed using ACES and PCBEAMAN computer programs. The section capacities were obtained using the Excel spreadsheet, “ULS Section Design to AS3600”, developed by M.J.S. Davies.

6. Tables 1a-1c contain the bending load ratings for 3 different situations. Firstly, including all permanent effects and settlement effects, secondly excluding the effect of settlement and lastly excluding the effects of settlement and temperature.

7. The shear capacity of the bridge deck was also checked to ensure that the rating reflected the true capacity and not only a rating based on moment capacity. These results are shown in Table 1d and it is clear that the moment capacity is the governing factor for all vehicles considered.
8. Based on the above criteria, the following capacities for the different vehicles were calculated as listed in Table 2 for each consideration. The following table shows the calculated distribution factors for different vehicles:

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Sag Distribution Factor</th>
<th>Hog Distribution Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>T44</td>
<td>0.2188</td>
<td>0.2411</td>
</tr>
<tr>
<td>G1V1</td>
<td>0.2230</td>
<td>0.2380</td>
</tr>
<tr>
<td>G1V2</td>
<td>0.2230</td>
<td>0.2380</td>
</tr>
<tr>
<td>G1V3</td>
<td>0.2230</td>
<td>0.2380</td>
</tr>
<tr>
<td>G1V4</td>
<td>0.2230</td>
<td>0.2380</td>
</tr>
<tr>
<td>G2V1</td>
<td>0.2179</td>
<td>0.2434</td>
</tr>
<tr>
<td>G2V2</td>
<td>0.2179</td>
<td>0.2434</td>
</tr>
<tr>
<td>G2V4</td>
<td>0.2109</td>
<td>0.2220</td>
</tr>
<tr>
<td>G2V5</td>
<td>0.2176</td>
<td>0.2419</td>
</tr>
<tr>
<td>G2V7*</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>G2V8*</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Note: G2V7 and G2V8 do not fit in the available width between kerbs.

9. I have not checked the foundations.

10. For your information, as requested.

ENGINEER

31 July 2005
## Table 1a - Bending Load Ratings

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Condition</th>
<th>Rating</th>
<th>Location (Distance from left support) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T44 (3m)</td>
<td>Hog</td>
<td>29.7%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>97.6%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>66.1%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>125.7%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>T44 (6.5m)</td>
<td>Hog</td>
<td>57.2%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>140.9%</td>
<td>12.575</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>63.0%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>155.6%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G1V1</td>
<td>Hog</td>
<td>65.8%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>146.5%</td>
<td>19.114</td>
</tr>
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<td></td>
<td>Hog</td>
<td>72.5%</td>
<td>At Pier</td>
</tr>
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<td></td>
<td>Sag</td>
<td>176.5%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G1V2</td>
<td>Hog</td>
<td>47.7%</td>
<td>20.12</td>
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<td></td>
<td>Sag</td>
<td>118.5%</td>
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</tr>
<tr>
<td></td>
<td>Hog</td>
<td>49.6%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>126.1%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G1V3</td>
<td>Hog</td>
<td>35.1%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>92.4%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>45.8%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>104.8%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G1V4</td>
<td>Hog</td>
<td>38.5%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>100.7%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>48.9%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>125.5%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G2V1</td>
<td>Hog</td>
<td>41.2%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>102.5%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>34.8%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>115.6%</td>
<td>At Midspan</td>
</tr>
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<td>G2V2</td>
<td>Hog</td>
<td>28.0%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>82.2%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>38.6%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>101.9%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G2V4</td>
<td>Hog</td>
<td>26.7%</td>
<td>4.527</td>
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<td></td>
<td>Sag</td>
<td>90.5%</td>
<td>4.527</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>28.2%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>93.4%</td>
<td>At Midspan</td>
</tr>
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<td>G2V5</td>
<td>Hog</td>
<td>22.9%</td>
<td>4.527</td>
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<td></td>
<td>Sag</td>
<td>60.2%</td>
<td>20.12</td>
</tr>
<tr>
<td></td>
<td>Hog</td>
<td>26.0%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>75.7%</td>
<td>At Midspan</td>
</tr>
<tr>
<td>G2V7</td>
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<td>Vehicle does not fit in available width between kerbs!!</td>
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</tr>
<tr>
<td></td>
<td>Sag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G2V8</td>
<td>Hog</td>
<td>Vehicle does not fit in available width between kerbs!!</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Locations are to the nearest 0.503m
(Actual location of worst HOG moment is 4.877m from left support)
<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Condition</th>
<th>Rating</th>
<th>Location (Distance from left support) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T44 (3m)</td>
<td>Hog</td>
<td>46.4%</td>
<td>4.527</td>
</tr>
<tr>
<td>Sag</td>
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<td>Sag</td>
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<td>Sag</td>
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<tr>
<td>Hog</td>
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<td>Sag</td>
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</tr>
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* Locations are to the nearest 0.503m
(Actual location of worst HOG moment is 4.877m from left support)
<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Condition</th>
<th>Rating</th>
<th>Location (Distance from left support) (m)</th>
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<tbody>
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<td>T44 (3m)</td>
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<td>Sag</td>
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<td>4.024</td>
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<td></td>
<td>Hog</td>
<td>101.1%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>113.0%</td>
<td>At Midspan</td>
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<td>Hog</td>
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<td>Hog</td>
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<td>At Pier</td>
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<tr>
<td></td>
<td>Sag</td>
<td>177.2%</td>
<td>At Midspan</td>
</tr>
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<td>G1V1</td>
<td>Hog</td>
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<td>Hog</td>
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<td>At Pier</td>
</tr>
<tr>
<td></td>
<td>Sag</td>
<td>201.0%</td>
<td>At Midspan</td>
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<td>Sag</td>
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<td></td>
<td>Hog</td>
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<td>Sag</td>
<td>119.4%</td>
<td>At Midspan</td>
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<td>G1V4</td>
<td>Hog</td>
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<td>Hog</td>
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<td>At Midspan</td>
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<td>Hog</td>
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<td>Sag</td>
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<td>4.024</td>
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<tr>
<td></td>
<td>Hog</td>
<td>60.2%</td>
<td>At Pier</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td>Sag</td>
<td>86.3%</td>
<td>At Midspan</td>
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<tr>
<td>G2V7</td>
<td>Hog</td>
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<tr>
<td></td>
<td>Sag</td>
<td></td>
<td>width between kerbs!!</td>
</tr>
<tr>
<td>G2V8</td>
<td>Hog</td>
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</tr>
<tr>
<td></td>
<td>Sag</td>
<td></td>
<td>width between kerbs!!</td>
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</table>

* Locations are to the nearest 0.503m
(Actual location of worst HOG moment is 4.877m from left support)
### Table 1d - Shear Load Ratings

<table>
<thead>
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<th>Vehicle</th>
<th>Condition</th>
<th>Rating</th>
<th>Location (Distance from left support) (m)</th>
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<td>0.503</td>
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<td>9.054</td>
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<td>0.503</td>
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<td>148.0%</td>
<td>9.054</td>
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<td>-</td>
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</table>

* Locations are to the nearest 0.503m
** Results ignore Pier locations where there is no shear, only bearing
*** Worst Locations as indicated above are approximately at worst shear location of ‘2d’ from face of support
### Load Rating Summary (Bridge No. 817)

<table>
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<tr>
<th>Rating Type</th>
<th>Standard (inc. all PE)</th>
<th>Ignoring Settlement</th>
<th>Ignoring Settlement &amp; Diff. Temp</th>
<th>Shear Force</th>
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<td><strong>Condition</strong></td>
<td><strong>Rating</strong></td>
<td><strong>Critical Location</strong></td>
<td><strong>Rating</strong></td>
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<td>46.4%</td>
<td>4.527</td>
</tr>
<tr>
<td>Sag 34.8%</td>
<td>126.5%</td>
<td>At Midspan</td>
<td>150.9%</td>
<td>12.575</td>
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<tr>
<td>T44 (6.5m)</td>
<td>Hog 57.2%</td>
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<td>20.12</td>
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<tr>
<td>Sag 155.6%</td>
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<td>At Midspan</td>
<td>177.2%</td>
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<tr>
<td>G1V1</td>
<td>Hog 65.8%</td>
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<td>81.5%</td>
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</tr>
<tr>
<td>Sag 176.5%</td>
<td>At Midspan</td>
<td>182.7%</td>
<td>At Midspan</td>
<td>201.0%</td>
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<tr>
<td>G1V2</td>
<td>Hog 72.5%</td>
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<td>84.7%</td>
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<tr>
<td>Sag 176.5%</td>
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<td>10.06</td>
</tr>
<tr>
<td>Sag 102.5%</td>
<td>At Midspan</td>
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<td>At Midspan</td>
<td>143.6%</td>
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<tr>
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<td>Hog 45.8%</td>
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<td>Sag 125.5%</td>
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<td>At Midspan</td>
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<tr>
<td>G2V2</td>
<td>Hog 28.0%</td>
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<td>43.9%</td>
<td>4.527</td>
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<td>Sag 34.8%</td>
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<td>At Midspan</td>
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<td>41.8%</td>
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<tr>
<td>Sag 109.8%</td>
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<tr>
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<td>At Midspan</td>
<td>120.1%</td>
<td>At Midspan</td>
<td>138.1%</td>
</tr>
</tbody>
</table>

* Critical Locations are to the nearest 0.503m

*** For Shear Ratings, Capacities are for Positive and Negative Shear respectively, not HOG and SAG as indicated

**** The Cracking Moment Capacity (\(\phi M_c\)) has been used for the sections where no steel exists in the top of slab for HOG condition

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APPENDIX F

Vehicle Position for Load Rating of Group 2 Vehicles
SECTION 5 – DESIGN VEHICLE LOADINGS

This information is Part 5 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Engineer Bridge Loading is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 27/08/18

Document No: 3912/02-5
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Custodian Endorsement

C Lu
Engineer Bridge Loading
Date: 12/04/18
5 DESIGN VEHICLE LOADINGS

5.1 Introduction

Generally vehicular (and pedestrian) loadings to be applied for the design of new structures shall be in accordance with AS 5100, Bridge Design (CODE). There are additional MRWA requirements and these are described below. Where there is any conflict between the requirements of the CODE and the following, the latter shall take precedence.

For load rating of existing bridges the CODE, Bridge Branch Design Information Manual Document No. 3912/04 “Load Rating Existing Bridges” and Document No. 6706-02-2227 “Load Rating and Refurbishment Design Manual for Existing Timber Bridges” are applicable.

5.2 Special Vehicle Loading

Structures located on highways, main roads and designated Heavy Haulage Routes shall be designed to Group 2 Vehicle 4 and Group 2 Vehicle 5 heavy load platform vehicles in accordance to the Document 3912/02-4 unless EBL specifies otherwise.

If any pedestrian bridge is required to be designed for a service vehicle, a modified M-truck can be used for this purpose. For M-trucks and service vehicles refer to Figure 5.1. Care shall be taken to use the M-truck and service vehicle terminology correctly, they are not interchangeable.

Refer also to the Structures Engineering Management System Document 3912/01/05 “Procedure for the Design of Structures” and the Bridge Branch Design Information Manual Document No. 3912/03.

5.3 High/Wide Load Vehicles

The design criteria for high/wide load special vehicles shall be applied as additional specific load cases for all structures located on designated High/Wide Load Routes. Details of these special vehicles, designated routes and design guidelines are located online at www.mainroads.wa.gov.au, Building Roads, Standards and Technical, Road and Traffic Engineering, Guide to Road Design, High Wide Loads, Guide to Design and Operation of High Wide Load Corridors (D11#318284).

The application of High/Wide Load vehicles for the design of new structures shall be confirmed with the Design Criteria Sheet and approved by SES.

5.4 Reduction of Standard Highway Loading

The use of less than full loading as outlined above on structures should only be considered in special cases as it is often a false economy and removes an important safety factor against overloading. Each instance must be approved individually by SES.
FIGURE 5.1
M-TRUCK & SERVICE VEHICLE

Where $W = 100\text{KN}$

An M-Truck shall be modelled as per T44 in Austroads '92 BDC, refer to 3912/02/16 Section 16.2.7.

On footbridges a service vehicle shall be modelled as an M-truck except the designer may consider reducing dynamic load allowance to a minimum of 1.1 and ultimate limit state factor to a minimum of 1.5 if appropriate.
SECTION 6 – STRESS LIMITS IN STRUCTURAL CONCRETE

This information is Part 6 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

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A LIM
SENIOR ENGINEER STRUCTURES

Date: 10/05/18

Document No: 3912/02-6
SECTION 6

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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 10/05/18
6 STRESS LIMITS IN STRUCTURAL CONCRETE

6.1 PRESTRESSED CONCRETE

When carrying out prestressed concrete design one of the Serviceability Limit State checks is for crack control in flexure. This is covered in AS 5100, Bridge Design (CODE), Part 5, Clauses 8.6.2 and 9.4.2 for the design of new bridges or load rating of bridges constructed using 500MPa steel reinforcement.

Additional requirements for prestressed concrete design limits on steel stress at the serviceability limit state are given in Table 6.1 for load rating of bridges constructed using different steel grades, and are applicable to both superstructure and substructure design. The values below are the limit on the increment in reinforcement bar stress between decompression and the applicable SLS load combination.

Table 6.1

<table>
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<th>Nominal Steel Grade (MPa)</th>
<th>Serviceability Stress Limits for Prestressed Concrete</th>
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<td>80</td>
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<td>230</td>
<td>90</td>
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<tr>
<td>400</td>
<td>160</td>
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6.2 REINFORCED CONCRETE

Reinforced concrete requires different limitations on stress for serviceability compared to partially prestressed concrete due to the lower vulnerability of reinforcement to fatigue and corrosion.

When carrying out reinforced concrete design one of the Serviceability Limit State checks is for crack control in tension and flexure. This is covered in the CODE, Part 5, Clauses 8.6.1 and 9.4.1 for the design of new bridges or load rating of bridges constructed using 500MPa steel reinforcement.

Additional requirements for reinforced concrete design limits on steel stress at the serviceability limit state are given in Table 6.2 for load rating of bridges constructed using different steel grades, and are applicable to both superstructure and substructure design.

Table 6.2

<table>
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<td>T44/L44 &amp; Road Trains</td>
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<tr>
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SECTION 7 – RAILINGS AND BARRIERS

This information is Part 7 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures. The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 11/01/19

Document No: 3912/02-7
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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 30/08/18
7 RAILINGS AND BARRIERS

7.1 Traffic Barriers

7.1.1 General
Traffic barriers are all barriers attached to a structure including bridges, underpasses, tunnels, culverts, retaining walls, traffic barrier footings and any associated approach slabs.

The same traffic barrier system should be used on both sides of the structure. Differing barriers may be used if required to simultaneously cater for pedestrian/cyclist access and passage of High Wide Loads.

Post holding down bolts must be designed such that they can be easily replaced if damaged during a crash.

The setback distance from the kerb face to the traffic barrier and height of rail above the road surface must be in accordance with Main Roads’ standard drawings.

The CODE does not allow design of a barrier system by calculation, only design of prototypes for crash testing and design of modifications. It is important to note that crash testing or in-service performance evaluation to AS3845-2015 is required to confirm barrier performance. Since the 2015 update to AS3845 the barrier performance standard has been updated from NCHRP-350 to MASH. At the time of writing there are no barriers with steel sections available in Australia that have been tested to MASH requirements.

7.1.2 Steel Barriers
To prevent a variety of barrier proposals with unknown performance levels it is currently permitted to install AS5100-2004 compliant steel barrier systems and design the bridge to allow retrofit of an AS5100-2017 compliant barrier. Note:

1. Barrier design shall reference AS5100-2004 as the applicable standard on the design summary (typically located on the General Arrangement drawing)

2. The bridge (including anchorage) shall be designed for the increased loads from AS5100-2017

3. Post spacing can be assumed to be the same as existing standards

4. Line of sight implications for AS5100-2017 barrier geometry shall be checked with outcomes recorded in the design report & drawings

5. The above is only applicable whilst there is no approved AS5100-2017 regular performance steel barrier

Where sufficient rail height is required for cyclists and an AS5100-2004 low performance barrier is acceptable, heritage rail with toprail or low performance thriebeam (side-mounted PFC posts and PFC blockouts) with toprail should be considered. Note that toprail on a UC post is not a tested configuration and is therefore not accepted. Four rail should be considered where an AS5100-2004 regular performance system is required.
7.1.3  **Concrete Barriers**

For concrete barriers:

1. The preferred barrier shape of barriers on the edge of deck or edge of footpath is the F Type, due to the shape being less intrusive on shy lines.

2. For F-Type barriers, geometrically extending an NCHRP-350 barrier or adding toprail to achieve the required effective height will be accepted as a medium performance barrier to MASH.

3. Median barriers are preferred to be constant slope.

4. For constant slope barriers, geometrically extending an NCHRP-350 barrier will be accepted as a medium performance barrier to MASH. Toprail is not acceptable.

5. Other amendments to the shape of the barrier, eg: changing an edge to be vertical, is not preferred and is done at risk of the consultant. Eg: this has been a trend to meet footpath width requirements whilst minimising bridge width.

6. Where the barrier system requires restraint, eg: by 75mm embedment into 3m of asphalt, this shall be increased accordingly for AS5100-2017 loads. This may require deeper embedment into asphalt to be effective.

Concrete traffic barriers on bridges must not be considered as part of the deck and therefore must not contribute to its strength.

7.1.4  **Transitions, Extents and Clear Zones**

Start and end points of barriers must comply with ‘length of need’ requirements and extend adequately off the bridge to protect motorists from hazards in accordance with Austroads Guide to Road Design Part 6 and the associated Main Roads supplement. Examples of hazards include vertical drop, steep embankment, road or highway, railway, hazards in the median, or any combination of these.

Where access prevents installation of the required length of need or preferred barrier this is generally considered acceptable, but it must be demonstrated that vehicles accessing/leaving property are not subject to site specific safety concerns, increased risk due to crash histories, line of sight, etc. In some instances it will be required to liaise with the property owner to consider moving access to create a win-win outcome. Access for inspection and maintenance may also be justification for reducing the extent of guardrail, but can generally be worked around by providing one embankment behind the barriers that enables safe parking near the bridge.

Transitions from one barrier type to another must be done such that the performance of either barrier is not compromised, no unsafe ends are exposed and the appearance is neat. To avoid sudden changes in stiffness, short lengths of barrier joining onto a longer length of a different type of barrier must be avoided.

The ends of all approach and departure barriers must be terminated with a crashworthy end terminal in accordance with Austroads Guide to Road Design Part 6 and the associated Main Roads Supplement. It should be noted that the concept of clear zones is to allow 95% of sedan-class vehicles to recover. The statistical reliability of the research that clear zones is based on is low and no testing was done with regards to recovery of larger vehicles.
Due to the above, the shift to a safe systems approach within Main Roads and the changes in costs assigned to major incidents, providing the minimum Clear Zone as per Austroads does not generally negate the need for Guardrail. Any new structure or refurbishment omitting guardrail must justify the decision, considering factors such as whether existing guardrail is present, whether there is a local crash history, local road hazards and road geometry, the type of vehicles using/expected to use the crossing, AADT, etc.

7.2 Balustrades

Balustrades on road bridges, and on underpass headwalls and wingwalls where the wingwall is within 3m in plan of the edge of the path, must be standard Main Roads rectangular hollow section balustrade with solid balusters.

Balustrades on shared path bridges and associated ramps must comprise circular rails and circular balusters spaced in accordance with CODE requirements.

The standard Main Roads balustrade must extend no less than 3 complete panel lengths off the bridge from the abutment bearing centreline, and for bridges with abutment wingwalls adjacent to shared paths or footpaths the balustrade must extend at least 3m from the end of the wingwalls. A different type of barrier separating path users from hazards can be used beyond this point.

It should be noted that the standard Main Roads balustrade was not developed for crowd loading. The use of a flush mid-rail in place of a protruding grab-rail was via agreement with relevant internal and external stakeholders, note that acceptance was conditional on limiting use to paths of grade 1:50 and less.

The Memorandum of Understanding between Main Roads and the Public Transport Authority defines the ownership of Railway Protection Screens, refer D11#290707. In essence, Railway Protection Screens are owned by Main Roads if they are integral with balustrade or bridge barriers. All other Railway Protection Screens are owned by the PTA. Note that Railway Protection Screens should not be confused with screens used for privacy and other purposes.

The designer shall be considerate of detailing that allows ingress of water to tight spaces, eg: between edge-mounted steel plates and/or the deck. The retention of water may cause localised durability issues, such as rusting of anchor rods and consequently cracking & spalling of the deck well in advance of the design life. Note that silicon for water proofing is considered high maintenance and difficult to fund, therefore it should be avoided when possible. This is because the silicon perishes or hardens in a relatively short timeframe and if the bridge does not have other specific maintenance items then the silicon maintenance becomes a relatively low priority for maintenance funding. This is an especially common scenario for footbridges.

7.3 Standards and Approval

Refer to D11#307369 List of Approved Road Safety Barrier Systems for further information. Refer also to standard barrier and balustrade drawings in the Structures Engineering Standard Drawings Manual.

The omission of barriers or reduction in length of need will not be supported by Structures Engineering without detailed justification in the design report.
This information is Part 8 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

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A LIM
SENIOR ENGINEER STRUCTURES

Date: 10/05/18

Document No: 3912/02-8
SECTION 8

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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 10/05/18
8 BEARINGS AND JOINTS

8.1 Bearing Design

The design of bearings is covered extensively in Part 4 of AS 5100, Bridge Design (CODE). Chapter 16 of the Bridge Branch Design Manual Document 3912/03 also contains useful information.

Elastomeric Bearings

Bearing design life is to be taken as a maximum of 50 years. In MRWA experience, the actual life achieved is 40-60 years. Manufacturer claims of up to 100 years are not considered appropriate.

Design Summary Notes, usually presented on the General Arrangement drawings, shall indicate the expected movement ranges so that asset managers can determine whether measured deflections are within the design range. This ensures that bearings that are operating within specification are not mistaken as defective and flagged for maintenance. This has been an ongoing problem for long span bridges where creep and shrinkage are significant.

The ability to replace and re-set bearings is required as part of the bridge design. This will typically require structural design and geometric allowance for temporary jack locations and summarising pertinent information (eg: allowable jacking sequences and limitations on differential & total jacking).

Keeper plates top and bottom are preferred, regardless of whether minimum compression loads are met as per the CODE. The designer is to allow for the reduced effective height of the bearing due to the keeper plates. Bolted plates are preferred over welded plates. Plates that are welded on a single side cannot provide a moment couple and are therefore not allowed.

Elastomeric bearings may be designed for 25% overstress at SLS for HLP and special vehicles. Failure can result in large transverse displacements, but elastomeric bearings are tested to higher stresses so overstress should not be a problem.

Other bearing types

There can be problems with over stressing pot bearings – particularly with a rotation movement under pressure. There is a ring underneath the elastomer that prevents egress down the piston when the elastomer is compressed. The ring can fail, which is particularly common for bearings that have the ends of the ring welded together. Consequently the elastomer can flow through the gap that is created and be permanently damaged.

8.2 Expansion Joints

Some form of expansion joint is required on most bridges to cater for longitudinal movements due to temperature change, concrete shrinkage and concrete creep. In fact one of the first decisions in a bridge design is what restraint system is to be adopted, i.e., where is the structure to be fixed and therefore where and in what direction is movement permitted.
The magnitude of anticipated movements due to temperature, creep and shrinkage can be calculated from figures given in the CODE. Temperature movement can be +ve or -ve (expansion or contraction), whereas creep and shrinkage are only -ve (contraction). It is essential to ensure that there is adequate capacity for movement over the full temperature range, both early in the life of the bridge before much creep and shrinkage has occurred and ultimately after full creep and shrinkage. Transverse movements need also be considered.

The concrete surrounding the expansion joint shall incorporate an upstand to suit the following seal types. The following table indicates typical values that should be confirmed with pavement design requirements for final design.

<table>
<thead>
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<td>2-coat seal (typical rural treatment)</td>
<td>20 mm</td>
</tr>
<tr>
<td>Asphalt / Hot-mix (rural)</td>
<td>40 mm</td>
</tr>
<tr>
<td>Asphalt / Hot mix (urban)</td>
<td>50 mm</td>
</tr>
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The options available for expansion joints vary according to the anticipated range of movement and the type of structure, and reference to the Bridge Branch Design Manual Document 3912/03 should be made for details of the various types of joint and their applications. Chapter 16 of 3912/03 also gives a guide to the selection of an appropriate expansion joints for different bridge lengths.

Where finger plate joints are used, the fingers are to remain simply supported by extending across the joint. Cantilevered fingers have failed due to overstress or fatigue.

Modular joints must have a noise attenuation system if used in an urban area. The noise attenuation system must be fitted by the joint manufacturer and cannot incorporate welded surface mounted plates.

MRWA is currently testing several joint technologies. Regional preferences may exist based on construction requirements and performance experience.

- Elastic polymer plug joints have been installed on Bridge 1009 Mill Point Road over Kwinana Freeway in 2016. Performance has been satisfactory with one small zone of asphalt/concrete adjacent to the joint failing. This joint has also been installed on Bridges 87, 228, 270A, 572A, 1272, 5370.

- Poured flexible sealant has been used on multiple bridges, either between existing expansion joint angles or with new polymer nosing. The performance is extremely dependent on the quality of the installation. A good bond is often not achieved between existing expansion joint angles and the joint sealant. No comment is available on suitability when used with polymer nosings.

- Precompressed silicone and foam hybrid is currently being trialled, initial impressions of waterproofing are positive. One construction drawback is that some products are supplied in 2m segment lengths, requiring numerous joints with joining silicone.

Where accessible by cyclists, anti-slip surfaces and gap widths between teeth (etc) shall be considered.

- For new bridges, cyclist requirements must be met without requiring modification of the proposed product.
• Where anti-slip plates have been welded to existing joints it has been found that the plates have dislodged and have the potential to become missiles. Furthermore there is question as to whether the underlying joints have been damaged due to continued re-welding of the anti-slip plates. This and the ongoing maintenance needs to be considered versus the safety benefits.

8.3 Approach Slabs

Approach slabs are required for several reasons, including mitigation of settlement of approach embankment fill, provision of anchorage for expansion joints and approach transitions to reduce impact and sudden bumps.

Approach slabs shall be sufficiently thick to provide adequate support and anchorage for expansion joint angles and guardrail post anchor bolts, with consideration given to the ability of the slab to span over potential hollows or voids which may occur beneath the slab due to settlement or wash-out. Consideration must also be given to drainage and provision of kerbs etc.

If the road embankment is supported by solid rock and the abutment foundation is a spread footing on solid rock, then the approach slab shall be designed as a slab on elastic foundations. Controlled fill embankments with no possibility of scour or large settlements shall also be designed in this manner.

However, if underlying soils are soft and have the propensity for long term settlements then the approach slab shall be designed as simply supported, to span from the abutment support to the centreline of the trailing edge support of the approach slab.

Approach slabs designed in conjunction with timber bridge concrete overlays shall be in accordance with Document No. 6706-02-223, Structures Engineering Practice Notes.

Several approach slab technologies that may be suitable for rural bridges are being trialled. Performance information will not be available for some time.
SECTION 9 – CONSTRUCTION FORCES AND EFFECTS

This information is Part 9 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 16/04/18

Document No: 3912/02-9
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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 13/04/18
9 CONSTRUCTION FORCES AND EFFECTS

When carrying out the design of a new structure, the forces and effects induced by the method of construction and the construction staging requirements are important design considerations.

For the design of precast concrete bridges and incrementally launched prestressed concrete bridges, in addition to CODE requirements, the following criteria shall apply during the construction stage:

- Construction Live Load of 1.0 kPa minimum on entire surface
- Differential Settlement shall be monitored and controlled during construction, but in no circumstances shall be more than 25mm.
SECTION 10 – CONCRETE STRENGTHS AND FINISHES

This information is Part 10 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

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A LIM  
SENIOR ENGINEER STRUCTURES

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Custodian Endorsement

M RAJAKARUNA
Structures Design and Standards Engineer
Date: 13/04/18
10 CONCRETE STRENGTHS AND FINISHES

10.1 CONCRETE STRENGTHS

Unless otherwise approved by the SES, the following standard concrete strengths shall be used in the design of new bridges and the refurbishment design of existing bridges:

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<tbody>
<tr>
<td>20MPa</td>
<td>N20</td>
<td>Non-structural works only where durability is not an important factor, e.g., – blinding, post footings, mass concrete fill, paths etc.</td>
</tr>
<tr>
<td>35MPa</td>
<td>S35/10</td>
<td>Standard reinforced concrete for precast parapet panels</td>
</tr>
<tr>
<td>40MPa</td>
<td>S40</td>
<td>Standard reinforced concrete and prestressed concrete, e.g., – foundations, piers, decks, concrete overlays, beams etc.</td>
</tr>
<tr>
<td>50MPa</td>
<td>S50</td>
<td>Precast reinforced concrete, precast prestressed concrete, precast piles, beams, stress anchorages etc.</td>
</tr>
<tr>
<td></td>
<td>S50M</td>
<td>Reinforced concrete substructures in marine applications.</td>
</tr>
<tr>
<td>65MPa</td>
<td>S65</td>
<td>Precast prestressed beams</td>
</tr>
</tbody>
</table>

The 20 MPa is a standard AS 3600 mix and is designated N20. All others are specifically defined mixes as per MRWA Specification 820.

Although higher concrete strengths are included in the Bridge Code, parameters for higher strength mixes do not currently form part of Main Roads Specification 820. Higher strength mixes and/or special concretes can be used in special situations, e.g., prestressed concrete footbridges, precast work, high early strength, self-compacting concrete, sulphate resisting etc. The use of higher strength and/or special concretes is to be confirmed in the Design Criteria Sheet and approved by the SES.

10.2 FINISHES

All concrete surfaces should have the standard of finish indicated on the Drawings. There are two broad groups of concrete finishes – formed and unformed surfaces.

**Formed Surface Finishes** - shall comply with the requirements of Section 3 of AS 3610 - "Formwork for Concrete". Finishes Type 2, 3 and 4 cover most situations for bridge works and Table 10.1 gives guidance as to where they are to be used. Refer to the Standard for full details of allowable tolerances, colour variation, etc for each finish. Special formed finishes may also be used, e.g. ribbed, rope, board marked etc, but the above three cover the majority of cases.

**Unformed Surface Finishes** - four classes, U1 to U4 as per Table 10.2, cover all normal requirements. Note that the finishes and irregularities do not scale from best to worst as per formed finishes. The user is referred to the “typical location” in Table 10.2 to ensure appropriate unformed finishes are selected.
10.3 PROPRIETARY MORTAR AND REPAIR GROUTS

Proprietary mortars and grouts are often used for bearing pads, concrete repairs, infill concrete and other special applications. They shall be selected based on the appropriate requirements for strength, workability, performance or other special characteristics from well-known suppliers and/or manufacturers.

In general, such proprietary products should be readily available within Western Australia or Australia, and supported with detailed Technical and Safety Data Sheets.

Where a particular product has not been used previously on a MRWA project, it shall be approved by the SES prior to use in the Works. Consultants proposing the use of new products shall seek approval for its use prior to finalising the design or Works commencing.
<table>
<thead>
<tr>
<th>Designated Finish</th>
<th>Typical Location</th>
<th>Type of Concrete Finish&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Maximum Allowable Surface Irregularities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Exposed surfaces, general external and internal surfaces intended to be viewed in detail</td>
<td>Smooth, dense and dust free concrete finish uniform in colour and accurately formed to specified dimensions and tolerances. Joint marks to be unobtrusive and concrete surfaces to be free from air holes and effects of water migration. Panels to be arranged in an approved regular pattern conforming to the structural geometry.</td>
<td>3 mm abrupt or 6 mm in a 1.5m template</td>
</tr>
<tr>
<td>2X</td>
<td>As specified on the Drawings</td>
<td>Sandblasted concrete finish, or special architectural applications, otherwise as per Type 2 above.</td>
<td>As specified</td>
</tr>
<tr>
<td>3</td>
<td>General external or internal surfaces intended to be viewed as a whole, or unexposed surfaces hidden from view</td>
<td>Regular, dense and dust free concrete surface entirely free from honeycombing and effects of cement paste leakage.</td>
<td>5 mm abrupt or 7 mm in a 1.5m template</td>
</tr>
<tr>
<td>4</td>
<td>Footings and buried surfaces</td>
<td>Structurally sound and durable concrete with a dense surface free from honeycombing.</td>
<td>8 mm abrupt or 10 mm in a 1.5m template</td>
</tr>
</tbody>
</table>

Note: Table 10.1 provides a general description only. Refer to AS 3610 for detailed descriptions and classifications.
### TABLE 10.2 – UNIFORMED SURFACE FINISHES FOR CONCRETE

<table>
<thead>
<tr>
<th>Designated Finish</th>
<th>Typical Location</th>
<th>Type of Concrete Finish</th>
<th>Maximum Allowable Surface Irregularities</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>Unexposed surfaces</td>
<td>A wood floated finish to produce a uniform, dense concrete surface free of surface pitting or cavities.</td>
<td>5 mm abrupt or 15 mm in a 3m template</td>
</tr>
<tr>
<td>U2</td>
<td>Upper exposed surfaces</td>
<td>A high quality steel trowelled finish to produce a uniform, dense, smooth and impervious concrete surface finish free of surface pitting or cavities.</td>
<td>Nil abrupt or 5 mm in a 3m template</td>
</tr>
<tr>
<td>U3</td>
<td>Upper surfaces of bridge decks and approach slabs/spans</td>
<td>A high quality mechanical steel trowelled finish to produce a uniform, dense impervious concrete surface finish free of surface pitting or cavities.</td>
<td>2 mm abrupt or 5 mm in a 3m template</td>
</tr>
<tr>
<td>U4</td>
<td>Upper surfaces of bridge deck concrete overlays, footpaths and medians</td>
<td>A high quality wood floated finish to produce a uniform surface free of surface pitting or cavities followed by a broom finish to produce a uniformly roughened concrete surface free of excessive drag marks and overlaps.</td>
<td>2 mm abrupt or 5 mm in a 3m template</td>
</tr>
</tbody>
</table>
SECTION 11 – BRIDGE WIDTHS

This information is Part 11 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures. The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 27/07/2018

Document No: 3912/02-11
SECTION 11

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  11.1 Urban Bridges ..............................................................................3
  11.2 Rural Bridges .............................................................................3
  11.3 Asset Owners Advice ..................................................................3
  11.4 Actions by Structures Engineering ...........................................3
  11.5 Responsibilities for Consultants .................................................4
  11.6 Bridge Width Requirements ..........................................................4

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<th>Rev. Date</th>
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<td>13/11/14</td>
<td>Updated Principal Design Engineer position in R&amp;TE branch.</td>
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<td>5</td>
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<td>13/11/14</td>
<td>Table 11 - revised width requirements for roads other than National Highways</td>
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<td>19/07/17</td>
<td>Complete review against AS5100.1-2017. No changes required.</td>
</tr>
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<td>3-4</td>
<td>3</td>
<td>19/07/17</td>
<td>Asset Owner, endorsements and approvals updated.</td>
</tr>
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<td>5</td>
<td>3</td>
<td>19/07/17</td>
<td>“Sealed Shoulder Width” amended to “Total Sealed Shoulder Width” and notes adjusted accordingly.</td>
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<td>3</td>
<td>4</td>
<td>21/09/17</td>
<td>Endorsements and approvals amended</td>
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<tr>
<td>5</td>
<td>5</td>
<td>21/05/18</td>
<td>Table 11 AADT ranges updated. Rural Bridge Width Approval Form revision number amended.</td>
</tr>
</tbody>
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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 26/07/18
11 BRIDGE WIDTH APPROVAL PROCEDURE

This Section covers the procedure to be adopted for the determination and approval of bridge widths. It is split into two parts, Urban and Rural, as the criteria for assessing each are different. Rural bridge widths are standardised and determined based mainly on anticipated traffic flows. Urban bridge widths are subject to more variation.

The definition of ‘urban’ and ‘rural’ in this context is fairly subjective, being based more on the type of road/structure than its geographic location. The Structures Design & Standards Engineer shall be responsible for deciding which part of the procedure to follow.

In all cases, consideration should be given to the possible need for future widening.

11.1 URBAN BRIDGES

The Designer shall seek advice from the Principal Design Engineer, Road & Traffic Engineering Branch, on the required bridge width, including carriageway widths, shoulders, medians, dual use paths etc.

These requirements shall be incorporated into a schematic bridge cross-section, placed on the Bridge Design Part File and circulated for approval as per Paragraphs 11.3 and 11.4 below.

11.2 RURAL BRIDGES

For each rural bridge, the Designer shall place a Rural Bridge Width Approval Form 3912/02/11 and a copy of the best available map on file for the relevant Region. The map should show the location of the bridge site including details of the road and the Local Government area in which it is located.

Bridge width requirements are described in Section 11.6 below.

11.3 ASSET OWNERS ADVICE

The Designer shall obtain advice from the Asset Owner as to local requirements for bridge width. For MRWA owned bridges, the Asset Owner is the regional Asset Manager Structures.

11.4 ENDORSEMENTS AND APPROVALS

The schematic bridge cross-section (in the case of urban bridges) or the completed Rural Bridge Width Approval Form (in the case of rural bridges) shall be sent to:

- Asset Owner for advice
- Principal Design Engineer for advice (urban bridges only)
- regional Asset Manager Structures for endorsement

Following endorsement, forwarded to:

- Senior Engineer Structures for authorisation
Following authorisation, the regional Asset Manager Structures is responsible for placing the signed Rural Bridge Width Approval Form on the specific bridge design or maintenance file as appropriate.

11.5 RESPONSIBILITIES FOR CONSULTANTS
When the design is undertaken by Consultants, then unless otherwise specified in the consultants brief, the Consultant shall assume all the responsibilities of the Designer in the above procedure except that the MRWA Project Manager shall arrange for filing and returning a copy to the Consultant after actions by Structures Engineering as detailed above.

11.6 BRIDGE WIDTH REQUIREMENTS
The recommended minimum rural road and bridge width between kerbs for Roads other than Main Roads and Highways shall be in accordance with Table 11.

The minimum bridge width between kerbs on Main roads and Highways shall be:
• Width of Traffic Lanes + 2.4m unless the road is rarely trafficked by heavy vehicles and the AADT < 1000/lane in which case the width can be Width of Traffic Lanes + 1.2m.
• For bridges with less than 20 m in length, the width shall be full formation width.

For any curve widening width requirements, refer to Section 7.9 of Austroads Guide to Road Design: Part 3 the Geometric Design.

These width requirements do not apply to existing bridge refurbishment and widening work.
# TABLE 11  RECOMMENDED MINIMUM RURAL ROAD AND BRIDGE WIDTHS
(Roads other than Main Roads and Highways)

<table>
<thead>
<tr>
<th>DESIGN AADT (VPD)</th>
<th>UNSEALED ROADS</th>
<th>SEALED ROADS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SINGLE LANE</td>
<td>TWO LANES</td>
</tr>
<tr>
<td>&lt;100</td>
<td>&lt;150</td>
<td>150-500</td>
</tr>
<tr>
<td></td>
<td>150-500</td>
<td>500-1000</td>
</tr>
<tr>
<td></td>
<td>500-1000</td>
<td>1000-2000</td>
</tr>
<tr>
<td></td>
<td>1000-2000</td>
<td>2000-8000</td>
</tr>
<tr>
<td>Sealed Trafficway Width</td>
<td>Not Applicable</td>
<td>3.5</td>
</tr>
<tr>
<td>Total Sealed Shoulder Width (1)</td>
<td>Not Applicable</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>Formation Width</td>
<td>As Appropriate</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Bridge Width Between Kerbs (2)</td>
<td>4.2 (3, 4)</td>
<td>4.2 (3, 4)</td>
</tr>
</tbody>
</table>

**Abbreviations:**

AADT – Annual Average Daily Traffic
VPD – Vehicles Per day

**NOTES:**

1. The Total Sealed Shoulder Width is the sum of both shoulders
2. Where there is a kerbed footway on the bridge, the kerb shall be set back a minimum of 600mm from the edge of the adjacent traffic lane
3. Where sight distance is inadequate or bridge length is less than 10m, the minimum width shall be 7.2m
4. For length of bridge 6m or less, the width shall be full formation width
5. For length of bridge 9m or less, the width shall be full formation width
6. For length of bridge 15m or less, the width shall be full formation width

**References:**

AS 5100-2017, Bridge Design, Part 1
AUSTROADS Guide to Road Design, Part 3: Geometric Design
# RURAL BRIDGE WIDTH APPROVAL FORM

**3912/02/11/02**

## LOCATION

<table>
<thead>
<tr>
<th>BRIDGE NUMBER</th>
<th>ROAD NUMBER</th>
<th>ROAD NAME</th>
</tr>
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<table>
<thead>
<tr>
<th>BRIDGE OVER</th>
<th>AT SLK</th>
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</tr>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>ASSET OWNER</th>
<th>REGION</th>
<th>LOCAL GOV</th>
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## PROPOSED STRUCTURE

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<th>TYPE OF BRIDGE</th>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>NUMBER OF SPANS</th>
<th>TOTAL LENGTH</th>
</tr>
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## TRAFFIC DATA

<table>
<thead>
<tr>
<th>ACTUAL AADT (vpd)</th>
<th>DESIGN AADT (vpd)</th>
<th>DESIGN SPEED (km / hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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### TABLE

<table>
<thead>
<tr>
<th>TRAFFICWAY WIDTH (m)</th>
<th>CURVE WIDENINGS (m) (IF REQUIRED)</th>
<th>TOTAL SHOULDER WIDTH (m)</th>
<th>FORMATION WIDTH (m)</th>
<th>BRIDGE WIDTH BETWEEN KERBS (m)</th>
</tr>
</thead>
<tbody>
<tr>
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<th>Proposed</th>
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(1) From Table 11

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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Recommended By: ___________________________ Date: _______ / _____ / ________

**DESIGN ENGINEER**

Endorsed By: ___________________________ Date: _______ / _____ / ________

**DESIGN SECTION LEADER**

## Asset Manager Structures Endorsement

<table>
<thead>
<tr>
<th>SES Authorisation</th>
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</tr>
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Advice from Asset Owner at Folio: (May be N/A for MRWA Asset Owners)

**Note:** endorsement is required prior to submitting to SES for authorisation
SECTION 12 – CLEARANCES AND HIGH LOAD ROUTES

This information is Part 12 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Asset Policy Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 28/08/18

Document No: 3912/02-12
SECTION 12

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12.2 Road Over Road Bridges and Footbridges .................................................................................... 3
12.3 Road Over Rail Bridges .................................................................................................................. 3
12.4 Bridges Over Water ....................................................................................................................... 4
12.5 Clearances During Construction .................................................................................................. 4
12.6 High Load Routes .......................................................................................................................... 4
12.7 High/Wide Load Routes .................................................................................................................. 4

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<td>1</td>
<td>04/03/04</td>
<td>Figure 12.1 amended</td>
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<td>Figure Nos changed</td>
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<td>6,7</td>
<td>1</td>
<td>24/8/07</td>
<td>Figure 12.2 drawing updated</td>
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<td>24/8/07</td>
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<tr>
<td>9 to 11</td>
<td>1</td>
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<td>20/08/18</td>
<td>Complete review for introduction of AS5100-2017</td>
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</tbody>
</table>

Custodian Endorsement

J PARVIN
Structures Asset Policy Engineer
Date: 24/08/18
12 DESIGN VEHICLE LOADINGS

12.1 Introduction

This Section sets out the minimum clearances, both horizontal and vertical, to be used in the design of bridges. It generally follows the requirements of Part 1, Clause 13 of AS 5100, Bridge Design (CODE), but where there is any conflict this document shall take precedence. Where none of the following considerations are applicable the minimum vertical clearance shall be set at 1.0m clear headroom to assist in safe future inspections and maintenance activities.

12.2 Road Over Road Bridges and Footbridges

Horizontal clearances shall be in accordance with Figure 12.1 attached. The minimum clearance shown on Figure 12.1 is derived for highway and main roads. Clearances below those specified may be used if suitable traffic barriers are installed.

Traffic barriers may be flexible (e.g. wire rope safety barriers or w-beam) or rigid (e.g. concrete barriers). Refer further DIS 3912/02-2 “Design of New Structures”, Section 2.3 and Road and Traffic Engineering Branch’s Document No. D11#38472, MRWA Supplement to Austroads Guide to Road Design – Part 6.

For any situation not covered in this section, reference may be made to AUSTROADS Guide to the Geometric Design of Major Urban Roads.

Vertical clearances shall be in accordance with Part 1, Clause 13.7 of the CODE, but shall be approved by the SD&SE.

12.3 Road Over Rail Bridges

Clearances shall be in accordance with the Public Transport Authority (PTA) clearance requirements. The clearance diagrams from PTA dated 28 Feb 2018 are shown at Figures 12.2 to 12.4. In all cases confirmation must be obtained from PTA.

On electrified routes, suitable protective screens must be installed on over-bridges to prevent people from touching the wires. Screens shall accommodate the minimum clearances as required by PTA. Screens must be provided on both sides of the bridge and must extend as per Public Transport Authority Specification “Protection Screens for Bridges over Electrified Railways”.

Because of the potentially catastrophic consequences of a train hitting a bridge pier, wherever possible railway lines should be crossed in a single span with solid abutments. Where a single span is not possible, piers shall be positioned and designed in accordance with the CODE and DIS 3912/02-2 “Design of New Structures”, Section 2.3.
12.4 Bridges Over Water

Navigation clearances are not usually a requirement for bridges in WA, but where they may be required, the relevant figures must be obtained from the Department for Planning and Infrastructure, Marine Information.

12.5 Clearances During Construction

During construction, it is often possible to reduce the above requirements. For road bridges, horizontal clearances may be reduced to the minimum required for safe working space with suitable protection works provided alternate routes are available for the transport of over-height vehicles. Vertical clearances may be reduced to 4.7 m or lower in specific circumstances. However, this may require special protective measures to be taken during construction and each case must be approved by SES. The preferred minimum clearance during construction is 4.90m.

For rail bridges, no reduction in horizontal clearance is permitted, however reduction in vertical clearance may be possible. Each case must be checked individually with PTA. In particular, construction over electrified lines will require special measures to be taken.

12.6 High Load Routes

There are a number of specific transport routes which are designated High Load Routes for the transport of large, indivisible loads. It is important that the vertical clearances on these routes are not encroached upon.

Details of existing and future preferred High Load Routes are shown in the attached Figures 12.5 and 12.6.

Designers shall ensure that all road bridges over these roads conform to these requirements. Clearances to footbridges should be an additional 300 mm greater than those shown.

The required vertical clearance shall be entered on the Design Criteria Sheet.

12.7 High/Wide Load Routes

High/Wide Load Routes incorporate the High Wide Load Corridor Project involving the development of suitable transport envelopes that will accommodate over-dimension loads up to 8m high, 8m wide and 24m long, and with a maximum 270 tonne net load along the designated routes that link key heavy industry centres in the Perth Metropolitan area. For other routes, clearance requirements need be obtained from Access Manager of Heavy Vehicle Services MRWA.


The use of clearances for High/Wide Load vehicles for the design of new structures shall be confirmed with the Design Criteria Sheet and approved by the SES.
FIGURE 12.1

HORIZONTAL CLEARANCE TO SUBSTRUCTURE
COMPONENTS OF BRIDGES OVER ROADWAYS

MIN ‘A’ = 5m (DESIGN SPEEDS ≤ 60 km/h)
MIN ‘A’ = 7m (60 km/h < DESIGN SPEEDS < 90 km/h)
MIN ‘A’ = 10m (90 km/h ≤ DESIGN SPEEDS)

* MINIMUM CLEARANCE ‘A’

ABUTMENT FACE

COLUMN FACE

DECK SOFFIT

MINIMUM CLEARANCE ‘A’

EDGE OF TRAVELLED WAY

TRAFFIC LANES

* MINIMUM CLEARANCE WIDTH ‘A’ IS MEASURED FROM THE EDGE OF TRAVELLED WAY. FILL BATTER SLOPE WITHIN ‘A’ SHALL BE 1 IN 5.5 OR FLATTER AND CUT BATTER SLOPE SHALL BE 1 IN 3 OR FLATTER.
FIGURES 12.2 TO 12.4
RAILWAY CLEARANCE REQUIREMENTS
NARROW GAUGE LINES (See Sheet 1)

1. NOTES ON TRACK CENTRES

1.1 Maximum nominal track centres for tangent track:
1.1.1 Single track, with marginal rails: 590mm.
1.1.2 Central track centres 633mm for curved track.

1.2 Minimum track centres in mm for curved track:

\[ \text{Centre} = \frac{400 \times \text{Curve Radius} + 772}{1000} \text{ where } \text{R} \text{ is greater than } 1000 \]

\[ \text{Centre} = \frac{400 \times \text{Curve Radius} + 772}{2100} \text{ where } \text{R} \text{ is greater than } 1000 \]

1.3 All new curving structures to be constructed with a minimum overhang clearance in accordance with the Design Brief for the Construction of Curved Track Structures (Curved Track Structures, No. 6005, dated 1980).

2. NOTES ON PLATFORMS AND STATION STRUCTURES

2.1 Platform Clearance:

2.1.1 Platforms are a maximum 1200mm above the track centerline for curves and 1100mm above the track centerline for straight track.

2.1.2 The width of the platform shall be a minimum of 2500mm at any point.

2.1.3 The length of the platform shall be a minimum of 3000mm.

2.1.4 The height of the platform from the track centerline shall be a minimum of 915mm.

3. NOTES ON ROLLINGSTOCK & LOADING OUTLINES

3.1 All new passenger rolling stock shall be built to the Urban Passenger Rolling Stock Outline.

3.2 The maximum longitudinal dimension for rolling stock and related outfalls are:

- Length over body: 20 m
- Height (meters): 3.5
- Width (meters): 3.5
- Wheelbase (meters): 7.5
- Overall length (meters): 20

The values in Tables 1 and 2 are based upon these dimensions.

STANDARD AND DUAL GAUGE LINES (See Sheet 2)

5. NOTES ON TRACK CENTRES

5.1 Minimum track centres for tangent track:

5.1.1 Single track, with marginal rails: 590mm.

5.1.2 Central track centres 633mm for curved track.

5.2 Passenger Rollingstock and Loading Outlines:

5.2.1 Tandem Centre:

\[ \text{Centre} = \frac{400 \times \text{Curve Radius} + 772}{1000} \text{ where } \text{R} \text{ is greater than } 1000 \]

\[ \text{Centre} = \frac{400 \times \text{Curve Radius} + 772}{2100} \text{ where } \text{R} \text{ is greater than } 1000 \]

5.2.2 Terrain Centre:

\[ \text{Centre} = \frac{400 \times \text{Curve Radius} + 772}{1000} \text{ where } \text{R} \text{ is greater than } 1000 \]

6. NOTES ON STRUCTURAL CLEARANCE OUTLINE

6.1 Minimum structural clearance of 2765mm (89.48") to be increased by:

- 100mm for the travel comfort of the passenger.
- 100mm for the clear height of the structure.

6.2 All new curving structures to be constructed with a minimum overhang clearance in accordance with the Design Brief for the Construction of Curved Track Structures (Curved Track Structures, No. 6005, dated 1980).

7. NOTES ON PLATFORMS AND STATION STRUCTURES

7.1 Platform Clearance:

7.1.1 Platforms are a maximum 1200mm above the track centerline for curves and 1100mm above the track centerline for straight track.

7.1.2 The width of the platform shall be a minimum of 2500mm at any point.

7.1.3 The length of the platform shall be a minimum of 3000mm.

7.1.4 The height of the platform from the track centerline shall be a minimum of 915mm.

8. NOTES ON ROLLINGSTOCK & LOADING OUTLINES

8.1 Platform Clearance:

8.1.1 Platforms are a maximum 1200mm above the track centerline for curves and 1100mm above the track centerline for straight track.

8.1.2 The width of the platform shall be a minimum of 2500mm at any point.

8.1.3 The length of the platform shall be a minimum of 3000mm.

8.1.4 The height of the platform from the track centerline shall be a minimum of 915mm.

GENERAL NOTES (Sheets 1 and 2)

9. GENERAL NOTES

9.1 For special situations, conventional structural clearances may be considered as the Vice-President and Director of Civil Engineering or the Chief Executive Officer, subject to the approval of the Board of Directors and the Board of Trustees, in accordance with the General Design Criteria for the Construction of Curved Track Structures (Curved Track Structures, No. 6005, dated 1980).

9.2 Under no circumstances shall the clearances be reduced to less than those specified in the Standard Design Guidelines.

9.3 The width of the platform shall be increased by 100mm for the travel comfort of the passenger.

9.4 The height of the platform from the track centerline shall be increased by 100mm for the clear height of the structure.

STANDARDS FOR URBAN NETWORK

STRUCTURAL CLEARANCE AND ROLLINGSTOCK OUTLINES

NOTES RELATING TO CLEARANCES

PTA Drawing No: 00-1-00-0078 Rev: 1
STANDARD OUTLINES FOR STRUCTURAL CLEARANCE, ROLLINGSTOCK AND LOADING

STATIC OUTLINE FOR STANDARD PASSENGER RAILCARS

NOTES
1. All dimensions shown on this drawing are in mm.
2. For referenced notes refer drawing 00-C-04-0074.
3. For clearance and rollingstock outlines on standard and dual gauge lines refer drawing 00-C-04-0077.
4. Refer to AS 7557. RISB reference vehicle 13.14 and 31 for Narrow Gauge vehicle.
**FEST PERTH - MIDLAND RAILWAY**

**DUAL GAUGE STRUCTURAL & STANDARD GAUGE ROLLINGSTOCK OUTLINES**

**NOTES**

1. All dimensions shown on this drawing are in **mm**.
2. For referenced notes refer drawing 00-C-04-0078.
3. For Clearance and Rollingstock Outlines on Narrow Gauge Lines refer drawing 00-C-04-0076.
4. North Fremantle to Kombi Jetty Railway - see note 7.4.

**STANDARDS FOR URBAN NETWORK**

**CLEARANCES**

**STANDARDS AND DUAL GAUGE LINES**

**PTA Drawing No:** 00-C-04-0077 | **REV:** 1
FIGURE 12.5
METROPOLITAN BRIDGE HEIGHTS - EXISTING & PROPOSED
SECTION 13 – BRIDGE WATERWAYS INVESTIGATION AND FLOOD ESTIMATION

This information is Part 13 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Senior Waterways Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 15/08/18

Document No: 3912/02-13
SECTION 13

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Custodian Endorsement

E. CHEUNG
A/Senior Waterways Engineer
Date: 15/08/18
13 BRIDGE WATERWAYS INVESTIGATION AND FLOOD ESTIMATION

13.1 Bridge Waterways Design Computer Programs

13.1.1 Introduction

This section contains a brief outline of some of the suitable and common waterways programs used for hydrological and hydraulic analyses to design bridges for Main Roads. A detailed manual is available for most of the programs giving full information on theoretical background, inputs and outputs.

The programs mentioned in this section are not exclusive. There are other waterways programs that are also suitable and acceptable for hydrological and hydraulic analyses to design bridges for Main Roads.

It is recommended that this section be read in conjunction with Austroads Guide to Bridge Technology Part 8 – Hydraulic Design of Waterway Structures – Section 3.6: Computer Modelling. Other sections in the Austroads Guide which are recommended for reading include Section 2.2: Estimation of Design Floods, Section 4.3: Analysis Methods, Section 4.4: 1D Bridge Hydraulic Analysis and Section 4.5: 2D Bridge Hydraulic Analysis.

13.1.2 HEC-RAS (River Analysis System)

This program can calculate water surface profiles for steady gradually varied flow in channels in a one dimensional (1D) model. Profiles may be calculated for both sub critical and super critical flow. The program can model obstructions such as bridges, culverts, weirs and levees. The computational procedure is based on the solution of the one dimensional energy equation with energy loss due to friction evaluated with Manning’s Equation.

This program can also calculate water surface and velocity profiles for unsteady flow in channels and wider floodplains in a 1D, two dimensional (2D) and combined 1D/2D model. Full Shallow Water or Diffusion Wave equations may be selected for the computational procedure, where full Shallow Water is applicable to a wider range of problems and Diffusion Wave allows the program to run faster and have greater stability properties. Flows can be generated in the 2D model through hydrograph and direct rainfall inputs.

13.1.3 HEC-HMS (Hydrologic Modeling System)

This program simulates the hydrologic processes of watershed systems utilising traditional hydrologic analysis procedures including event infiltration, unit hydrographs, and hydrologic routing to generate hydrographs which can be input into hydraulic models. Advanced capabilities are available for gridded runoff simulation using the linear quasi-distributed runoff transform method (ModClark). Supplemental analysis tools are also available for model optimisation, forecasting streamflow, depth-area reduction, assessing model uncertainty, erosion and sediment transport, and water quality.
13.1.4 **HEC-SSP (Statistical Software Package)**

This program performs statistical analyses of hydrologic data and can calculate the expected probability curve and confidence limits of flood flow. The program can perform flood frequency analysis based on Bulletin 17B (Interagency Advisory Committee on Water Data, 1982), Bulletin 17C (England, et al., 2015) and also a generalised frequency analysis on not only flow data but other hydrologic data as well. Both Bulletin’s recommend log-Pearson Type III distribution however Bulletin 17C advances in several areas including adopting the Expected Moments Algorithm and Multiple Grubbs Beck Test to address low outliers, and correcting confidence intervals for the flood frequency curve. It is recommended that the practitioner check that the results output from this program are in accordance with Australian guidelines.

13.1.5 **RORB (Runoff Routing ‘B’)**

This program is based on runoff routing concepts and is used for hydrological analysis of catchment areas to produce design hydrographs. The model is aerially distributed, nonlinear, and applicable to both urban and rural catchments. The program has the capability of simulating storage and allows ‘DESIGN’ runs using design rainfall and temporal patterns to estimate design flows, or ‘FIT’ runs where actual rainfall events may be fitted to known flows in order to estimate catchment parameters. The program also has capability to vary parameters over sub-catchments and carry out batch runs and Monte Carlo simulations.

13.1.6 **TUFLOW**

This program can calculate water surface and velocity profiles in channels and wider floodplains in a 1D, 2D and combined 1D/2D model. It is ideally suited to modelling flooding of rivers and creeks with complex flow patterns, overland and piped flows through urban areas and coastal scenarios. The program can model obstructions such as bridges and culverts in 1D models, and also in 2D models provided that the flow width of the structure is of similar or larger size than the 2D cell size. The 1D Solver utilises the Saint-Venant equations and the 2D implicit solver is based on Stelling (1984) and Syme (1991) and solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow. The models can be run using several engines including Classic, HPC (Heavily Parallelised Compute) and FV (Finite Volume) to optimise run times and obtain results as appropriate.

13.1.7 **TUFLOW FLIKE**

This program calculates the probability of flood events based on historical records to calculate the expected probability curve and confidence limits of flood flow. The primary purpose of the program is to carry out flood frequency analysis however it can be applied to extreme value analysis. A range of probability models distributions can be applied to the analysis. The program uses the Bayesian inference methodology which allows the ability to use historic data outside of the gauged record, incorporate the multiple Grubbs-Beck test for low outliers and incorporate regional information as prior knowledge.
13.1.8 MIKEFLOOD

The MIKEFLOOD package contains several 1D and 2D simulation engines which can model rivers, open channels, sewer and drainage networks, and overland flow. These engines can be coupled with one another to create an integrated model to calculate water surface and velocity profiles in channels and wider floodplains. The program can model obstructions such as bridges, culverts and weirs. The package can also be used to design and assess coastal structures, offshore structures, dams and environmental flood impacts. The 2D component of MIKEFLOOD, MIKE 21 HD, is a general numerical modelling system that utilises the conservation of mass and momentum integrated over the vertical equations to describe flow and water level variations. Run times can be optimised by enabling parallel 2D engines.

13.1.9 XP-STORM

This program can simulate stormwater and river flows using models comprising of 1D channels and pipes coupled to a 2D surface grid. All hydrologic processes including snowmelt, evaporation, infiltration, surface ponding and ground-surface water exchanges can be included in the model. Rainfall can be selected through design storms or actual recorded rainfall events, and the program provides numerous methods for computing runoff from the rainfall. This program utilises the Saint-Venant equation as the hydraulic computational procedure in 1D models to calculate backwater effects, flow reversal and surcharging. The program can model obstructions and control structures such as bridges, culverts, and detention basins in the 1D model. The 2D modelling package incorporates the TUFLOW engine into the XP graphical interface.

13.1.10 XP-RAFTS

This program may be used to simulate runoff hydrographs at defined points throughout a watershed for a set of catchment conditions and rainfall events and is suitable for application on both rural and urbanised catchments of all sizes. The watershed can be divided into a number of sub-catchments and storage both small and large in volume may be assigned to nodes. Rainfall events can be generated from Intensity-Frequency-Duration data together with storm temporal patterns or standard pre-set storm data. The program uses the Laurenson non-linear runoff routing procedure to develop hydrographs and a number of loss models can be selected to calculate rainfall excess.

13.1.11 AFFLUX

This program carries out surface water analysis in channels based on Manning’s Equation and also computes backwater as a result of obstructions. The program models the natural stream properties and superimposes a bridge template over this natural stream. The bridge template includes information such as deck level, abutment chainages, abutment type, number of piers and skew. Scour and floodways may also be added to the model. Outputs from this program consists of discharge, velocities and backwater height for each specified stage height. It is recommended that this program only be considered for simple scenarios of bridges operating with or without floodways.
13.1.12 CRC-FORGE FOR WESTERN AUSTRALIA

This tool is a regional frequency analysis method used for estimating large to rare rainfalls in Western Australia. This method is based on the concept that additional information can be gained by pooling standardised data from a number of rainfall sites at a regional scale and standardised. Growth curves of design rainfalls are generated by plotting at-site data and pooling additional data from rainfall sites within areas of increasing size to estimate rainfalls with decreasing Annual Exceedance Probabilities (AEP). A seasonal approach to extreme flood estimation has specifically been adopted for Western Australia due to rainfall characteristics evident in this state.

13.1.13 RFFE (Regional Flood Frequency Estimation Model)

This model calculates discharge and provides confidence limits based on catchment location and characteristics using data from relevant gauged catchments. The application of this model is most relevant in ungauged catchment scenarios. This model provides an approach which is consistent nationally and smooths discrepancies at state boundaries which previously existed. The Region of Influence approach is adopted to iteratively determine the lowest prediction error and maximise the regression model predictive skill. The reliability of results is highly dependent on data availability and quality. This model is recommended in the Australian Rainfall and Runoff 2016 guidelines for ungauged catchments and the practitioner must recognise and understand the limitations of this model prior to using it.

There is no specific program to calculate discharge using the regional methods in the Australian Rainfall and Runoff 1987 guidelines, however it is noted that Main Roads currently still recommends practitioners carry out these calculations in conjunction with the RFFE model.
SECTION 14 – STRUCTURAL DESIGN AND ANALYSIS SOFTWARE

This information is Part 14 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date:  16/04/18

Document No: 3912/02-14
SECTION 14

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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 13/04/18
14 BRIDGE STRUCTURAL DESIGN COMPUTER PROGRAMS

14.1 INTRODUCTION
This Section contains a brief outline of structural design and analysis software programs normally used within Main Roads.

Structures Engineering prefers to receive computer models prepared using the below programs so that the models can be used internally if required.

For full information on input, output and theoretical background, refer to program user guides and manuals.

14.2 ACES
This is a general structural analysis software package performing linear elastic static analysis. Applications include 2 and 3 dimensional frames, grillage and finite element analysis of plane, plate and shell structures.

ACES-BEAM provides a continuous bridge beam module for linear elastic analysis with any span configuration.

ACES Incremental Launching module calculates and displays effects of an incrementally launched girder, using an iterative linear-elastic analysis.

ACES Section Properties module allows properties to be calculated of an arbitrary shaped section, including hollow sections, and sections with a number of voids.

The basic input is composed of the following:

- Geometry of the structure - defined by a series of nodes, connected by members or elements.
- Physical properties of all members and/or elements.
- Location and types of support (rigid or elastic).
- Load data, including self-weight, temperature, differential settlement and traffic load. The program has several in-built AS 5100, Bridge Design (CODE) traffic vehicles and facility to set-up standard vehicles for load application.

Output consists of all nodal, member and/or element displacements and forces (moments, shear and reactions). The program has graphical facilities for mesh generation, vehicle loadings, to validate input data and to plot output information.

14.3 COLDES
This program performs section analysis and assists with the design of 'short' reinforced concrete columns. It calculates the ultimate strength, ultimate balanced strength and minimum reinforcement to take the applied axial and/or bending moment, and plots the axial-bending moment interaction diagram. Torsion and shear are not considered.

It also provides a screen plot of the section to enable checking of input data and axial-bending moment interaction diagram to enable selection of a suitable column.
14.4 CONKS
This program carries out a cracked section analysis of reinforced and prestressed concrete under serviceability and ultimate moments.
Output gives the ultimate moment capacity of the section plus concrete and steel stresses under serviceability moments.

14.5 CSI BRIDGE
This is an advanced software package produced by Computers & Structures Inc. for use in more complex projects. Useful for analysis, design, load rating and reporting.

14.6 GRLWEAP
A program for analysing dynamic pile driving response. Inputs consist of soil profile (shear modulus), pile details (weight, length material etc), hammer (rated energy, weight of ram, type etc). Outputs are pile driving response, set, pile stresses etc.
The program is useful in selecting the appropriate pile driving hammer, helmet, packing material etc to achieve the nominated pile capacity, and to design the pile for driving conditions.

14.7 HLR
HLR is a computer program to enable indicative assessment of load-carrying capacity of bridge structures and to monitor passage of heavy vehicles on a defined road network.

14.8 LIMSTEEL
Interactive design of steel members to AS 4100.

14.9 LOADIST
This program interactively performs Guyon-Massonet analysis of an orthotropic simply supported bridge superstructure. The analysis is linear elastic. It is used for determining the distribution of longitudinal moments due to traffic load in a multi-beam bridge structures. MRWA only recommends its use for distribution factor comparative analysis.

14.10 MULTBEAM
Transverse distribution of longitudinal movements in linked plank bridges. Cannot input specific vehicles but good as a check for distribution factors from ACES.
14.11 PARTIAL

This program analyses partially prestressed continuous beams. It will allow for nonlinear effects due to differential temperature gradient and shrinkage with cracking, plasticity and creep of both concrete and steel. Because of the general nature of the analysis it will also handle reinforced and fully prestressed beams and columns and analyse effects due to constructing staging.

Input consists of:

- Definition of structure - the beam must be subdivided into a number of sections longitudinally and the cross-section modelled as a number of layers with specified width and thickness.
- Definition of steel.
- Applied external loads, prestress forces, sequence of construction/staging, etc.

Output gives a prestress friction analysis, the deflected shape of the beam, moments and shears. The stresses and strains in each layer of steel and concrete can also be obtained at selected sections.

The program uses an iterative method of analysis aimed at achieving equilibrium throughout the structure under the given loading conditions and material's stress-strain relationship.

14.12 PCBEAMAN

This program performs linear elastic analysis of a continuous beam with any span configuration. It allows for varying moment of inertia, construction staging of a multi-stage bridge and composite section (beam and slab acting together).

Input is composed of the span configuration, section properties (moment of inertia, area, etc), details of construction staging if necessary and the applied external loads. The program has several in-built live loads including NAASRA traffic vehicles, and facility to enable setting-up of a user defined vehicle for load application. The program also has an in-built differential settlement facility.

Output gives the bending moments, shear forces, deflections and normal and shear stresses at the specified or result points and reactions of supports. The result can be presented in table format and/or graphically. The graphical viewing enables determination of position of a live load for maximum moment, shear or deflection and enables assessment of the variation of bending moments, shears and deflections caused by a moving live load.

14.13 PIGLET

This program analyses the load/deformation response of a pile group under general loading conditions.

Input consists of data on the pile group, soil parameters and loading. The pile cap is assumed to be rigid, with the piles pinned or fixed to the pile cap. The group may contain up to 85 piles, which can be vertical or raked in any direction. Coordinates and structural data are required. The only soil parameters necessary are Poisson's
ratio and a shear modulus profile with depth. Only linear profiles are permissible. Loading may be general 3-D loads to the pile cap or individual piles or imposed deformations to the pile cap or individual piles.

Both a full and a summarised output are available. The "slimline" output gives the forces and moments in each pile and deformations of the pile cap. Full output gives the response of the group to unit deformations of the pile cap and overall stiffness and flexibility matrices for the group.

Analysis is based on a number of approximate, compact solutions for the response of single piles, with due allowance for interaction effects. The soil is assumed to behave as a linear elastic medium.

**14.14 RETWALL**
Interactive design of concrete retaining walls.

**14.15 SPACEGASS**
General purpose frame analysis program.

**14.16 STLBEAM**
STLBEAM performs static elastic analysis of a prismatic continuous bridge using a Fourier Transform of loading and support conditions. The analysis is based on harmonic folded plate theory. Applications include analysis of steel, concrete or composite bridge superstructures, particularly box girders.

The structure must be square at the abutments and prismatic. The structure is modelled as a collection of folded plates which may be isotropic or orthotropic. Longitudinal beam members can also be included in the assembly. Internal supports can be rigid or elastic, but only knife-edge supports are allowed at the abutment.

Advantages of STLBEAM over finite element programs are in the speed of modelling (using the graphic user interface and vehicle load generation) and the accuracy and speed of the analysis for transverse effects of vehicle loadings.

Results can be selected interactively for viewing and plotting. The output includes moments, forces plate stresses, displacements, etc.

**14.17 STRUCTURAL BRIDGE DESIGN**
This is an advanced software package produced by Autodesk for use in more complex projects. Useful for analysis, design, load rating and reporting.

**14.18 TIMBAR**
An interactive program using an ACES analysis engine for the rating and refurbishment design of timber bridges.
SECTION 15 – INVENTORY INFORMATION

This information is Part 15 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.

The Bridge Condition Manager is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 16/04/18

Document No: 3912/02-15
SECTION 15

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Custodian Endorsement

G. Johnston
Bridge Condition Manager
Date: 12/04/18
15 INVENTORY INFORMATION

15.1 Purpose

This Section defines the extent of information to be supplied for the Main Roads Bridge Inventory System to allow for efficient management of the State’s infrastructure.

15.2 Scope

This Section shall be followed as part of the completion of the design of any bridge, tunnel, or culvert replacing an existing bridge, within or over a public road within WA.

15.3 References

This Section is provided for reference by the following Procedures of the Structures Engineering Management System Document 3912/01:

- Procedure for the Management of Bridge Data & Information 3912/01/04
- Procedure for the Design of Structures 3912/01/05
- Procedure for Design Review 3912/01/11
- Procedure for Updating Bridge Inventory and Construction Information 3912/01/12

15.4 Definitions

IRIS - Integrated Road Information System, which contains a database of inventory for each bridge from information supplied in accordance with this Section.

Designer - The person with sufficient knowledge of the design of the bridge to be able to provide the required information accurately.

Project Manager - Generic title referring to the person responsible for the delivery of the structural project.

Ownership - The Owner in IRIS is defined as the party responsible for maintenance, not the party that owns the asset.

Tunnel - A structure is defined as a Tunnel where its principal function provides access for road or rail and is generally buried within and surrounded by soil. Pedestrian and fauna under/overpasses are not recorded as tunnels in IRIS.

Rail Carriage – A superstructure formed using the undercarriage of a rail car.

Other Composite Steel Beams & Concrete Deck – This is for structures that are not composite I-beams, box girders, cable stayed or rail carriage. The only occurrence at time of writing is Third Avenue Bridge 905A, which embeds fabricated steel boxes into structural concrete band-beams.

Inverted U-beam – This refers to all U-beams that are not Rocla M-Lock Precast Bridge U-beams.

Solid Slab Reinforced with Steel Beams – this is a concrete slab with cast-in beams, typically spare or re-purposed rail beams, not designed for composite action.

Pavement Type – Refer to Appendix A of the Detailed Visual Bridge Inspection Guidelines for Timber Bridges (Level 2 Inspections).

Surface Type – Refer to Appendix A of the Detailed Visual Bridge Inspection Guidelines for Timber Bridges (Level 2 Inspections).

Delineation post – typically a plastic post with reflective marker.

Visibility Barrier – A continuous barrier that does not offer appropriate performance under vehicle impact.
15.5 Procedure

The process for collecting and providing inventory information to Structures Engineering is managed through:

1) Complete the appropriate inventory form at a time when the design, including drafting, may be reasonably deemed to be complete and final. Inventory forms are available on the public Main Roads Western Australian website via Building Roads, Standard and Technical, Structures Engineering, Asset Management, Inventory Forms (link).

2) The Regional Asset Manager Structures shall ensure that these Attachments are promptly sent to StructEngReviews@mainroads.wa.gov.au.

15.6 Inventory Form Guidance

- General Bridge Inventory
  The General Bridge Inventory form shall be completed for all new structures, replacement structures and bridge refurbishments wherein either the bridge geometry or bridge type is changed.

- Sign Gantry Inventory
  The Sign Gantry Inventory Form shall be completed for any overhead structure spanning, or partially spanning (if cantilevered), a road carriageway for the specific purpose of carrying regulatory, advisory, warning, variable message (VMS) or directional sign.

- Culvert Inventory Information
  The Culvert Inventory Information form shall be completed for any culvert that replaces a numbered bridge.

- Tunnel Inventory Information
  The Section 15.4 definition of a tunnel should be used to confirm whether the Tunnel Inventory Information form or General Bridge Inventory form is applicable.
SECTION 16 – HISTORICAL DESIGN AND LOAD RATING VEHICLES

This information is Part 16 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures. Engineer Bridge Loading is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

R SCANLON
SENIOR ENGINEER STRUCTURES

Date: 22/01/08

Document No: 3912/02-16

Controlled Copies shall be marked accordingly
SECTION 16

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Revision Authorisation

R SCANLON
Senior Engineer Structures
Date: 22/01/08
16 HISTORICAL DESIGN AND LOAD RATING VEHICLES

16.1 INTRODUCTION

This Section of the Manual shall be used to determine the load capacity of existing steel and concrete bridges in Western Australia (WA) from historical design vehicles and load rating vehicles.

The aim of load rating analysis is to determine the theoretical capacity of a bridge by calculating what proportion of different vehicles it can carry. These values are used for the assessment of heavy haulage movements throughout the State.

Section 16 has been prepared to provide details of historical vehicles that bridges may have been designed or load rated for that are no longer in current CODES or in Section 4 of this Manual. Comparisons can then be made between these vehicles and current rating vehicles to assist in the assessment of heavy vehicles.

16.2 HISTORICAL DESIGN VEHICLES

16.2.1 1965 Highway Bridge Design Specification (NAASRA)

- Type of Code – Working stress

Truck and Lane Loads

- Live Loads – Standard trucks or lane loads corresponding to truck trains. H loadings and H-S loadings (as below)
- Design Lane Width – 10-ft
- Location – One vehicle per design lane applied anywhere on the structure
- Lane Reduction Factors – 1 or 2 lanes 100%  
  3 lanes 90%  
  ≥ 4 lanes 75%

- Dynamic Load Allowance – \( DLA = \frac{5000}{L+125} \) % where L = span length in feet
  Max. 30% and Min. 10%
**STANDARD HS TRUCKS**

* In the design of steel grid & timber decks only, for H20-S16 loading, one axle load of 24,000 lb or two axle loads of 16,000 lb each spaced 4 ft. apart shall be used, whichever produces the greater stress, instead of the 30,000 lb axle shown. Concrete slabs shall be designed for the 32,000 lb axle.

**STANDARD H TRUCKS**

* In the design of steel grid & timber decks only, for H20 loading, one axle load of 24,000 lb or axle loads of 16,000 lb each spaced 4 ft. apart shall be used, whichever produces the greater stress, instead of the 32,004 lb axle shown. Concrete slabs shall be designed for the 32,000 lb axle.

† Ton here means a weight of 2,000 lb.
** H LANE & HS LANE LOADINGS

** To follow or precede, or be on both sides of the concentrated loads to produce the maximum stress.

* NOTE: For the loading of continuous spans involving lane loading, an additional concentrated load shall be placed in or other span in such a position as to produce maximum negative moment.
16.2.2  1970 Highway Bridge Design Specification (NAASRA)

- Type of Code – Working stress

**Truck and Lane Loads**

- Live Loads – Standard trucks or lane loads corresponding to truck trains. H loadings and HS loadings (as below)
- Design Lane Width – 10-ft
- Location – One vehicle per design lane applied anywhere on the structure
- Lane Reduction Factors –
  - 1 or 2 lanes: 100%
  - 3 lanes: 90%
  - ≥ 4 lanes: 75%

- Dynamic Load Allowance – \( DLA = \frac{5000}{L + 125} \) % where \( L \) = span length in feet
  
  Max. 30% and Min. 10%

---

**NOTES**

1. In the design of steel grid and timber decks only, for H 70 loading, one axle load of 24,000 pounds or two axle loads of 18,000 pounds each spaced 4 feet apart shall be used, whenever produces the greater stress, instead of the 32,000 pounds axle shown.

   All other deck systems shall be designed for the 32,000 pounds axle. (The reason for the use of reduced loading on timber and steel grid decks is the ease and relative economy with which they can be replaced.)

2. Ton here means a weight of 2000 pounds.

**STANDARD H TRUCKS**
H LANE & HS LANE LOADINGS

NOTES
1. For the loading of continuous spans involving lane loading an additional concentrated load shall be placed in one other span in such a position as to produce maximum negative moment.

2. To follow or precede, or be on both sides of the concentrated loads to produce the maximum stress.

STANDARD HS TRUCKS

1. In the design of steel grid and timber decks only, for HS 20 loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each spaced 4 feet apart shall be used, whichever produces the greater stress, instead of the 32,000 pounds axle shown. All other deck systems shall be designed for the 32,000 pounds axle shown.

2. Ton here means a weight of 2000 pounds.
16.2.3 1973 Highway Bridge Design Specification (NAASRA) Metric Version

- Type of Code – Working stress
- All vehicles as per AS5100.7 Clause A2.4

16.2.4 1973 MRWA Road Train and Abnormal Vehicle

- Type of Code – Working stress

Road Train

- Live Load – Road Train (as below)
- Design Lane Width – N/A
- Location – One vehicle per bridge applied anywhere on the structure without concurrent loading
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – \( DLA = \frac{5000}{L+125} \)% where \( L \) = span length in feet

Max. 30% and Min. 10%
Abnormal Vehicle

- Live Load – Abnormal Load Vehicle (as below)
- Design Lane Width – N/A
- Location – One vehicle per bridge applied centrally without concurrent loading
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – 10%

16.2.5 1976 NAASRA Bridge Design Specification

- Type of Code – Working stress

Axle Load

- A14 as per AS5100.7 Clause A2.3

Vehicle Load

- T44 truck and lane loading as per AS5100.7 Clause A2.3

Abnormal Load

- Live Load – Standard Abnormal Vehicle as per AS5100.7 Clause A2.3 and MRWA own increases to the axle loads (as below)
- Design Lane Width – N/A
- Location – As per AS5100.7 Clause A2.3.3
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – As per AS5100.7 Clause A2.3.7.2
16.2.6 **1989 MRWA Bridge Design Manual Road Train**

- Type of Code – Ultimate limit state
- Live Load – 4 or 6 x 16.5t Tandem Axles (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 2.0
- Location – One vehicle per bridge applied anywhere on the structure without concurrent loading
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – As per AS5100.7 Clause A2.2.10
16.2.7 **1992 Austroads Bridge Design Code**
- Type of Code – Ultimate limit state
- W7, T44, L44, HLP320 and HLP400 live loads as per AS5100.7 Clause A2.2

16.2.8 **1998 MRWA Bridge Branch Design Information Manual Standard Road Trains**
- Type of Code – Ultimate limit state
- Live Loads – 101t Double Bottom Road Train and 146t Triple Bottom Road Train (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 2.0
- Location – As per T44, refer AS5100.7 Clause A2.2.2
- Lane Reduction Factors – As per T44, refer AS5100.7 Clause A2.2.6
- Dynamic Load Allowance – As per AS5100.7 Clause A2.2.10
16.2.9 1999 MRWA NRTC Vehicles

- Type of Code – Ultimate limit state
- Live Loads – Semi Trailer, Tri-Tri B-Double, Double Bottom Road Train and Triple Bottom Road Train at road friendly suspension weights (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 2.0
- Location – As per T44, refer AS5100.7 Clause A2.2.2
- Lane Reduction Factors – As per T44, refer AS5100.7 Clause A2.2.6
- Dynamic Load Allowance – As per AS5100.7 Clause A2.2.10
16.2.10  1999 MRWA Interim Bridge Design Loads

- Type of Code – Ultimate limit state

Wheel Load
- W80 as per AS5100.2 Clause 6.2.1

Axle Load
- Live Load – A160 axle load (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 1.8
- Location – As per AS5100.2 Clause 6.2.2
- Lane Reduction Factors – As per AS5100.2 Clause 6.6
- Dynamic Load Allowance – 30%

Moving Traffic Load
- Live Load – M1600 moving traffic load (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 1.8
- Location – As per AS5100.2 Clause 6.2.3
- Lane Reduction Factors – As per AS5100.2 Clause 6.6
- Dynamic Load Allowance – As per AS5100.7 Clause A2.2.10
Stationary Traffic Load

- Live Load – S1600 stationary traffic load (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 1.8
- Location – As per AS5100.2 Clause 6.2.4
- Lane Reduction Factors – As per AS5100.2 Clause 6.6
- Dynamic Load Allowance – 0%
16.3 HISTORICAL LOAD RATING VEHICLES

16.3.1 1993 MRWA Bridge Branch Design Information Manual

- Type of Code – Ultimate limit state
- Live Loads – Rating Vehicles 1-4 (as below)
- Design Lane Width – N/A
- Ultimate Limit State Factor – 1.5
- Location – One vehicle for single carriageway bridges ± 1m of the bridge centreline without concurrent loading
  One Vehicle 1-2 for dual carriageway bridges ± 1m of the carriageway centreline with 50% T44/L44 on the other carriageway
  One Vehicle 3-4 for dual carriageway bridges ± 1m of the carriageway centreline without concurrent loading
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – 10%
VEHICLE 2

PRIME MOVER + DOLLY + 6 LINE PLATFORM = 168 TONNES ALL-UP.

\[
\begin{array}{cccccccc}
4.1 & 12.5 & 2.4 & 13.5 & \text{VARIES} & 4.2 & 8.0 & 1.8 & 1.8 & 1.8 & 1.8 & 1.8 \\
& & & & & & & & & & & \\
6^T & 18^T & 36^T & 108^T & & & & & & & & \\
\end{array}
\]

TRANSVERSELY

\[
\begin{array}{c}
\text{STEER} \\
\text{DRIVE} \\
\text{NARROW DOLLY USUALLY GOVERS.}
\end{array}
\]

VEHICLE 3

16 LINE 3m WIDE PLATFORM WITH LINE SPACING AT 1.5m. (128 TONNES GROSS) PLUS 3 PRIME MOVERS (2 AT FRONT AND 1 AT REAR)

\[
\begin{array}{c|c|c|c|c}
\text{P.M. N° 1} & \text{P.M. N° 2} & \text{2PM = 16/LINE} & \text{P.M. N° 3} \\
\hline
5 & 5 & 181 & 5 \\
91 & 91 & 101 & 91
\end{array}
\]

\[
\begin{array}{c|c|c|c|c}
\text{2PM = 16/LINE} & \text{P.M. N° 1} & \text{P.M. N° 2} & \text{P.M. N° 3} \\
\hline
16 lines at 1.5m & 5 & 5 & 91 & 91
\end{array}
\]

\[
\begin{array}{c|c|c|c|c}
\text{P.M. N° 1} & \text{P.M. N° 2} & \text{P.M. N° 3} \\
\hline
4.59 & 4.51 & 0.75 & 0.75 & 0.75
\end{array}
\]

TRANVERSE

(3m WIDE)

VEHICLE 4

2/12 LINE PLATFORMS AT 1.45m. (192 WHEELS) PLUS 3 PRIME MOVERS

\[
\begin{array}{c|c|c|c|c|c|c|c}
\text{P.M. N° 1} & \text{P.M. N° 2} & \text{P.M. N° 3} & \text{2PM = 16/LINE} & \text{2PM = 16/LINE} & \text{2PM = 16/LINE} & \text{P.M. N° 1} & \text{P.M. N° 2} \\
\hline
2 PMs for 31 & 4.4 & 6.4 & 4.4 & 4.4 & 4.4 & 1 PM & 1 PM
\end{array}
\]

\[
\begin{array}{c|c|c|c|c|c|c|c}
\text{P.M. N° 1} & \text{P.M. N° 2} & \text{P.M. N° 3} & \text{2PM = 16/LINE} \\
\hline
12 lines at 1.45m & 4 & 4 & 4.4
\end{array}
\]

TRANVERSE AS FOR 3.
16.3.2  1993 MRWA Load Rating Vehicles

- Type of Code – Ultimate limit state
- Live Loads – Vehicles 1-8 representing various semi trailers, b-doubles and road trains (as below)
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 2.0
- Location – As per T44, refer AS5100.7 Clause A2.2.2
- Lane Reduction Factors – As per T44, refer AS5100.7 Clause A2.2.6
- Dynamic Load Allowance – As per T44, refer AS5100.7 Clause A2.2.10

### VEHICLE 1: TRUCK PLUS 4 AXLE DOG TRAILER
\( G.C.M = 65 \text{ tonnes} \)

### VEHICLE 2: SHORT "B" DOUBLE TRI-TANDEM
\( G.C.M = 71 \text{ tonnes} \)

### VEHICLE 3: SHORT "B" DOUBLE TANDEM-TRI
\( G.C.M = 71 \text{ tonnes} \)

### VEHICLE 4: LONG "B" DOUBLE TRI-TANDEM
\( G.C.M = 71 \text{ tonnes} \)
VEHICLE 5: LONG "B" DOUBLE TANDEM-TRI  
(G.C.M = 71 tonnes)

VEHICLE 6: TRI-TRI "B" DOUBLE  
(G.C.M = 77 tonnes)

VEHICLE 7: SHORT DOUBLE BOTTOM ROAD TRAIN  
(G.C.M = 95 tonnes)

VEHICLE 8: LONG DOUBLE BOTTOM ROAD TRAIN  
(G.C.M = 95 tonnes)
16.3.3 1995 MRWA Bridge Branch Design Information Manual

- Type of Code – Ultimate limit state

**Group 1 Vehicles**

- Live Load – Group 1 Vehicles 1-3 as per the same vehicles in Section 4 of this Manual
- Design Lane Width – 3.0m
- Ultimate Limit State Factor – 2.0
- Location – As per T44, refer AS5100.7 Clause A2.2.2, but only one rating vehicle to be on the bridge with T44/L44 in the other lane(s) positioned to give the worst effects
- Lane Reduction Factors – As per T44, refer AS5100.7 Clause A2.2.6
- Dynamic Load Allowance – As per T44, refer AS5100.7 Clause A2.2.10

**Group 2 Vehicles**

- Live Loads – Group 2 Vehicles 1-6 (as below)
  Note: Group 2 Vehicles 1-2 and 5 are identical to the same vehicles in Section 4 of this Manual and Group 2 Vehicle 4 is identical in configuration to the same vehicle in Section 4 of this Manual but was considered at both vehicle platform spreads
- Design Lane Width – N/A
- Ultimate Limit State Factor – 1.5
- Location – One vehicle for single carriageway bridges ± 1m of the bridge centreline without concurrent loading
  One vehicle for dual carriageway bridges ± 1m of the carriageway centreline with T44/L44 on the other carriageway
- Lane Reduction Factors – N/A
- Dynamic Load Allowance – 10%
1. PRIME MOVER + 36 TONE DOLLY + 54 TONNE TRIAXLE
   (G.C.M. = 114 TONNES)

2. PRIME MOVER + 36 TONNE DOLLY + 72 TONNE SPREAD QUAD
   (G.C.M. = 132 TONNES)

3. PRIME MOVER + 36 TONNE DOLLY + 108 TONNE 6-LINE PLATFORM
   (G.C.M. = 168 TONNES)

4. PRIME MOVER + 36 TONNE DOLLY + 144 TONNE 8-LINE PLATFORM
   (G.C.M. = 204 TONNES)

5. PRIME MOVER + 216 TONNE 12-LINE PLATFORM
   (G.C.M. = 240 TONNES)

6. PRIME MOVER + 324 TONNE 18-LINE PLATFORM
   (G.C.M. = 348 TONNES)

NOTE
VEHICLES 1-4 CAN HAVE
AN O/A WIDTH OF EITHER
3.0m OR 3.7m.
VEHICLE 5 IS 3.0m O/A
VEHICLE 6 IS 3.7m O/A
SECTION 17 – EXTERNAL AUTHORITIES

This information is Part 17 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures.
The Structures Design & Standards Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

A LIM
SENIOR ENGINEER STRUCTURES

Date: 16/04/18

Document No: 3912/02-17
SECTION 17

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<td>13/04/18</td>
<td>Complete review</td>
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Custodian Endorsement

M RAJAKARUNA
Structures Design & Standards Engineer
Date: 13/04/18
17 LIST OF EXTERNAL AUTHORITIES

Before the commencement of a design project it is necessary to contact ALL known appropriate external authorities that may be affected. This applies mostly to proposed works but is nevertheless appropriate to maintenance works, particularly where pile driving or temporary works are likely to cause disruption to the immediate environment, community or traffic.

This list records various known authorities with comments on area of authority, responsibility or interest. It should be noted that this list does not include Main Roads Regions, Mining Companies, Landowners, etc.

Different authorities will need to be contacted for different jobs. It is the responsibility of the Designer to check that all authorities likely to be affected by a project are contacted.

It should not be assumed that this list is comprehensive or final.
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<th>AUTHORITIES</th>
<th>AREA OF RESPONSIBILITY OR INTEREST</th>
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<tr>
<td>Department of Agriculture and Water Resources</td>
<td>Matters likely to impact land in an agricultural sense, e.g. backwater, salinity, waterway diversion of realignment.</td>
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<tr>
<td>Department of Primary Industries and Regional Development</td>
<td>Initial contact via Main Roads.</td>
</tr>
<tr>
<td>Department of Planning, Lands and Heritage</td>
<td>Manages the location of Aboriginal sites of significance and matters concerning social and economic equity for Indigenous people, respect for the land or unique heritage and culture. See also Local Aboriginal Groups. Includes listed structures of historical significance. See also Australian Heritage Council.</td>
</tr>
<tr>
<td>Australian Heritage Council</td>
<td>Matters concerning significant historical sites where Federal funding is involved.</td>
</tr>
<tr>
<td>Local Aboriginal Groups</td>
<td>Matters concerning social and economic equity for Indigenous people, respect for the land or unique heritage and culture.</td>
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<td>Independent Regional Development, eg:</td>
<td>Independent Partners to the Department of Primary Industries and Regional Development.</td>
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<td>• Regional Development Council</td>
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<tr>
<td>• Western Australian Regional Development Trust</td>
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<td>• Gascoyne Development Commission (DC)</td>
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<td>• Wheatbelt DC</td>
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<td>Department of Transport – Cycling</td>
<td>Cycle path requirements.</td>
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<td>WestCycle</td>
<td>Peak cycling body for WA</td>
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<tr>
<td>Department of the Environment and Energy</td>
<td>Designs and implements Australian Government policy and programs to protect and conserve the environment, water and heritage, promote climate action, and provide adequate, reliable and affordable energy.</td>
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<tr>
<td>Conservation Council of WA</td>
<td>Matters relating to environmentally sensitive areas. Matters relating to Wetlands Conservation Society will be identified by Conservation Council.</td>
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<tr>
<td>Department of Biodiversity, Conservation and Attractions</td>
<td>Matters relating to works likely to have an environmental impact re-National Parks, State Forests, Marine Parks, Conservation Parks, dieback control, flora and fauna etc, the Swan and Canning Rivers / tributaries and adjoining land.</td>
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</table>
| Department of Fire & Emergency Services  
- Fire and Rescue Service  
- St. John Ambulance  
- Police Service WA | All emergency services to be advised of intent to close bridge/road. To be done at design stage in case of access or staging problems. |
| Department of Water and Environmental Regulation | The DWER conducts environmental impact assessments and develops policies to protect the environment. The DWER also monitors compliance with the conditions of Ministerial Statements.  
Responsible for the waters and associated land within declared management areas. Must approve any alteration to the bed or banks of waterways within declared management areas of the State. |
<p>| Landgate | Responsible for land tenure throughout WA. For mining tenements see Department of Industry, Innovation and Science. |
| Local Government Authority | Road or bridge closures, scheme approval, drainage methods, footpath requirements, services etc. |
| Department of Transport | Preparation of land use strategies and development. Responsible to ensure planned development is in accordance with sound planning principles. Initial contact via Main Roads. |
| Department of Transport (Marine) | Responsible to ensure that any navigable body of water is not modified in any way likely to create a navigation hazard. Jurisdiction includes recreational waters set aside for water skiing, sailing etc. |
| Department of Mines, Industry Regulation and Safety | Geological and hydrological advice such as site investigation, water bores, quarries, road cuttings etc. |
| National Trust (WA) | Details of National Estates. Copy of National Estates Register held in Main Roads Library. No statutory requirement for contact, however where historical sites are involved, contact is advised as a courtesy. |</p>
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<th>Mandatory contact required for possible relocation of existing service or requirement for new service.</th>
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<td>• Natural Gas Pipelines</td>
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<td>• Telecommunication Groups (Telstra, Optus, etc)</td>
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<td>• Water (Water Corporation of WA, Harvey Water, Aqwest (Bunbury), Busselton Water Board)</td>
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<th>Bus servicing considerations for engineering design, scheduling and/or disruptions to services. Mandatory contact for all passenger rail impacts and interfaces.</th>
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<th>Private Rail Operators, eg:</th>
<th>Mandatory contact for all private rail impacts and interfaces.</th>
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<tr>
<td>• Rio Tinto</td>
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<td>• BHP</td>
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<tr>
<th>WA Farmers Federation</th>
<th>Mandatory contact required for all proposed new bridge construction in the rural areas of the State.</th>
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<tr>
<th>Other Environmental and Resource Groups, eg:</th>
<th>Various non-government groups.</th>
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<tr>
<td>• Landcare District Committees</td>
<td>Landcare District Committees - found throughout the State, refer Department of Agriculture and Water Resources.</td>
</tr>
<tr>
<td>• Pastoralists and Graziers Association</td>
<td>Pastoralists &amp; Graziers Association - mostly Northern Areas of the State.</td>
</tr>
<tr>
<td>• Environments Kimberley</td>
<td></td>
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<tr>
<td>• North Metro Conservation Group</td>
<td></td>
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<tr>
<td>• Northern Agricultural Catchment Council</td>
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<tr>
<td>• Perth Region NRM</td>
<td></td>
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<tr>
<td>• Rangelands Natural Resource Management WA</td>
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<tr>
<td>• South Coast National Resource Management Inc.</td>
<td></td>
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<tr>
<td>• South West Catchment Council</td>
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<tr>
<td>• Urban Bushland Council</td>
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SECTION 18 – PREPARATION OF DESIGN REPORT
(OCCUPATIONAL SAFETY AND HEALTH)

This information is Part 18 of the Bridge Branch Design Information Manual and is owned and controlled by the Senior Engineer Structures. Senior Design Engineer is the delegated custodian. All comments and requests for changes should be submitted to the delegated custodian.

Authorisation

As head of Structures Engineering of Main Roads Western Australia, I authorise this issue and the use of this Information.

R F Scanlon  
R SCANLON  
SENIOR ENGINEER STRUCTURES  
Date: 16 June 2009

Document No.: 3912/02-18

Controlled Copies shall be marked accordingly
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<th>Rev. Date</th>
<th>Revision Description</th>
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Revision Authorisation

R SCANLON
Senior Engineer Structures
Date:
18 PREPARATION OF DESIGN REPORT (OCCUPATIONAL SAFETY AND HEALTH)

18.1 Introduction

This Section of the Manual describes the mandatory requirements for Designers to provide clients with a written report on the occupational safety and health (OSH) aspects of their designs. In addition it provides guidance to Designers on a basis for identifying the types and extent of hazards and risks to be addressed.

18.2 Background

Regulations relating to the National Standard for Construction Work came into operation for the civil/commercial construction sector on 3rd January 2008.

These regulations introduce requirements relating to the provision of information, consultation, planning, documentation and other measures to ensure occupational safety and health in the building and construction industry.

These regulations are contained in Division 12 of Part 3 of the Occupational Safety and Health Regulations 1996.

The regulations apply to main contractors and people with control of construction work, clients commissioning design and construction work and designers doing design work for construction projects. This manual covers design requirements only.

18.3 Designer’s Requirements

Designers must provide their clients with a written report on the occupational safety and health aspects of their designs. The client must ensure that this information is passed on to the main contractor and to anyone who obtains the end product of the construction work from the client.

18.4 Design Report

18.4.1 Requirements under the Regulations

In accordance with Regulation 3.140 of Division 12 of Part 3 of the Occupational Safety and Health Regulations 1996, the Designer’s OSH report must identify the following aspects of the design for the constructor to consider:

- The hazards associated with the construction work required to build the design, (for example, hazardous structural features, hazardous construction materials or hazardous procedures or practices);
- The designer’s assessment of the risk of injury or harm resulting from those hazards;
- The action the designer has taken to reduce those risks, (for example, changes to the design or changes to construction methods or construction materials); and
- Any parts of the design where the hazards have been identified but not resolved.
18.4.2 Preparation of the Report

The extent and type of hazards are only broadly defined within the Regulations. Given that a construction site is potentially a hazardous environment due to the nature of the work, the Designers might elect to include all hazards associated with the work site and prepare mitigation actions accordingly.

Structures Engineering considers that in most cases this would result in a report that had a level of detail that would be a duplication of other processes whilst not adding value in achieving the objectives of the regulations. One reason for this is that MRWA has a pre-qualification system for contractors that ensures the constructor is qualified and experienced to undertake the construction works. In addition, the contractor is required within the contract to prepare a range of management plans that include for site safety.

Therefore in preparing the Report the Designer may assume that the constructor is an experienced builder, unless it is known to the contrary, and identify only those hazards that may be of a non-standard nature, unusual, specific to the design or otherwise noteworthy. Some examples are given in Appendix B to illustrate the types of design specific hazards that should be included in the Report. Other hazards that are typically found on construction sites such as traffic, working at heights or with machinery and tools may be considered to be of a standard nature, familiar to the Contractor and within its responsibility.
APPENDIX A - PROCEDURE FOR DEVELOPMENT OF THE REPORT

1. The Designer during the design stage must assess the following:

   - Is the design complex with potential hazards associated with the complexity of the design impacting on the level of construction hazard?
   - Are there any designer identified construction hazards associated with the site conditions, features, topography, site constraints etc.?
   - Is the design innovative or unusual, requiring construction methodology, techniques and equipment which may not be familiar to an appropriately pre-qualified constructor?
   - Is the design straightforward, but with certain hazards associated with the construction?
   - Are there any specific or unusual interfaces with other agencies that might constitute an unusual hazard during construction?

2. Based on the above assessments, the Designer must identify and document construction activities and materials that are potentially hazardous. It is considered that designs of standard type structures which are regularly constructed would require minimum input into a Report prepared by the Designer, compared to more complex or innovative designs.

3. The next step is to assess and rate the risk associated with the identified potential hazard. Refer to the 'Corporate Risk Management Policy and Procedure'. A suitable pro-forma for recording the identified hazard and assessment is shown in Appendix C.

4. It is the preferred approach that the Designer develops strategies to mitigate those activities with high risk and include them in the Report. The residual risk must then be rated in accordance with MRWA Risk-Web matrix in the 'Corporate Risk Management Policy and Procedure'. Refer to the extract in Appendix D.

5. The residual risk must then be compared to what is considered acceptable by MRWA that is, Low or Medium.

6. The Designer must then document the risk in the Report. The Design Report must be signed by the Designer and endorsed by a Senior Designer before issue.
APPENDIX B – EXAMPLES OF DESIGN RISKS

(Note that these are illustrative examples only and in every instance the hazard, likelihood and consequence must be assessed on its merits). Assessment of risk rating before and after Design may vary depending on specific site circumstances.

<table>
<thead>
<tr>
<th>Construction Activity</th>
<th>Designer Identified Hazard</th>
<th>Likelihood Level</th>
<th>Consequence Level</th>
<th>Risk Rating</th>
<th>Action Designer has taken to Reduce Risk</th>
<th>Residual Risk Rating</th>
<th>Residual Risk Acceptable?</th>
</tr>
</thead>
</table>
| Bridge Launching      | • Uncontrolled movement of bridge during launching  
                        • Locations of high load and stress | 1 | 4 | Medium | Designer ensures details of all design assumptions are included on the Drawings and Specification. | Low | Yes |
| Working over or near a Railway | Conflict between site staff/plant with  
                                      • trains and  
                                      • overhead electrified cables | 1 | 4 | Medium | Designer liaises with the Rail Authority at the design stage and identifies a process enabling the successful completion of works. Specifications require Rail Authority personnel to be present on site during critical stages of construction. | Low | Yes |
| Structural Alterations requiring Temporary Supports | Instability and possible collapse | 2 | 4 | High | Designer to provide the loads required for propping/temporary works | Medium | Yes |
| Lifting of large precast concrete members | • Instability during lifting  
                                          • Inadequate capacity in lifting points  
                                          • Access for cranes, capacity for lift  
                                          • Safe landing and location and fixing of precast member | 2 | 4 | High | Designer to provide lifting loads, position of lifting points, anchorage requirements for lifters. Also, seek advice from specialists if necessary. | Medium | Yes |
## APPENDIX C - DESIGN REPORT PRO-FORMA

<table>
<thead>
<tr>
<th>Construction Activity</th>
<th>Designer Identified Hazard</th>
<th>Likelihood Level</th>
<th>Consequence Level</th>
<th>Assessment of Risk</th>
<th>Action Designer has taken to Reduce Risk</th>
<th>Residual Risk Rating</th>
<th>Residual Risk Acceptable?</th>
<th>Sign off</th>
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</tbody>
</table>
APPENDIX D - MAIN ROADS RISK REFERENCE TABLES

QUALITATIVE MEASURES OF LIKELIHOOD

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTOR</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rare</td>
<td>Less than once in 10 years</td>
</tr>
<tr>
<td>2</td>
<td>Unlikely</td>
<td>At least once in 10 years</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>At least once in 3 years</td>
</tr>
<tr>
<td>4</td>
<td>Likely</td>
<td>At least once per 1 year</td>
</tr>
<tr>
<td>5</td>
<td>Almost certain</td>
<td>More than once per year</td>
</tr>
<tr>
<td>LEVEL</td>
<td>RANK</td>
<td>INJURIES</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Insignificant</td>
<td>No injuries.</td>
</tr>
<tr>
<td>2</td>
<td>Minor</td>
<td>First aid treatment.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Medical treatment required.</td>
</tr>
<tr>
<td>4</td>
<td>Major</td>
<td>Death or extensive injuries.</td>
</tr>
<tr>
<td>5</td>
<td>Catastrophic</td>
<td>Multiple deaths or severe permanent disabements.</td>
</tr>
</tbody>
</table>
### RISK-WEB RISK RATING CHART

<table>
<thead>
<tr>
<th>Consequences</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>VH</td>
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</tr>
</tbody>
</table>

**Likelihood**

1 – Rare, 2 – Unlikely, 3 – Moderate, 4 – Likely, 5 – Almost Certain