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FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification RMS B316 Edition 2 Revision 1.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. Additional Text.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. Deleted Text.
RMS QA SPECIFICATION B316
MODULAR BRIDGE EXPANSION JOINTS

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the design, fabrication, testing, supply and installation of modular bridge expansion joints (MBEJ) covering both single and multiple support bar MBEJ systems. In addition to meeting the above requirements, the work under this Specification includes the provision of a Maintenance Manual setting out requirements for inspection and maintenance of the joint.

The MBEJ accommodates expansion, contraction and rotation of the bridge superstructure due to temperature and other effects.

The owner of the MBEJ system must have at least five years recent experience in the supply of MBEJ systems similar to those to be furnished under this project. The same owner must supply all MBEJ systems required for the Contract.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 Details of Work

Project specific requirements are shown in Annexure B316/A.

1.2.2 Resolution of Nonconformities

The method of acceptance of materials and work must comply with Annexure B316/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure B316/C list the HOLD POINTS and WITNESS POINTS that must be observed. Refer to Specification RMS Q for the definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure B316/C are Identified Records for the purposes of RMS Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure B316/D and must be implemented.
1.2.5 Design Methodology

Clause 3 lists the basic design requirements. The detailed requirements and methodology to be followed is outlined in Annexure B316/E. The notation is also listed in this Annexure.

1.2.6 Testing Procedures

Annexure B316/L outlines the test procedure for experimental modal analysis.

1.2.7 Referenced Documents and Abbreviations

Unless specified otherwise or is specifically supplied by the Principal, the applicable issue of a referenced document must be the issue current at the date one week before the closing date of tenders, or where no issue is current at that date, the most recent issue.

Codes, standards, specifications and test methods are referred to in abbreviated form (eg. AS 1234). For convenience, the full titles are given in Annexure B316/M.

1.3 DEFINITIONS

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

(a) **Multiple Support Bar MBEJ System**: Multiple support bar modular joints (MSBJ) (refer Figure B316.1) have transverse centre beams which are connected to longitudinal support bars. Each support bar supports only one centre beam. The support bars span across the joint opening and slide between elastomeric springs and bearings in support boxes. The support boxes are cast into the concrete on both sides of the joint.

(b) **Single Support Bar MBEJ System**: Single support bar modular joints (SSBJ) (refer Figure B316.2) have transverse centre beams which are attached to support bars using steel yokes and elastomeric springs and bearings. Each support bar supports a number of centre beams. The support bars span across the joint opening and slide between elastomeric springs and bearings in support boxes. The support boxes are cast into the concrete on both sides of the joint and accommodate the required number of support bars.

The swivel joist system is a variant of this design.

(c) **Swivel Joist System**: A special type of single support bar MBEJ system with swivelling single support bars.

(d) **NATA**: National Association of Testing Authorities (Australia) or internationally equivalent accreditation as provided by NATA’s Mutual Recognition Arrangement Partners (refer to RMS Q).

(e) **MBEJ System Owner**: The principal entity that holds the intellectual property in the MBEJ.

(f) **Dynamic Amplification Factor (DAF)**: The factor (χ) by which the static force or stress must be multiplied to give the total dynamic force or stress. Note that

\[ \chi = 1 + \alpha \]

where \( \alpha \) is the Dynamic Load Allowance defined in AS 5100.2.
(g) **Notation Mathematical:** Notation is defined in Clause E2 of Annexure B316/E.

![Figure B316.1 - Example of a Multiple Support Bar MBEJ System](image1)

![Figure B316.2 – Example of a Single Support Bar MBEJ System (shown inverted)](image2)
1.4 MBEJ SYSTEM OWNER

The MBEJ required pursuant to this Specification will be determined by the Principal using the tender submissions received. Offers of at least three separately owned MBEJ systems must be provided, with all offers received submitted. Each offer must include an offer for a multiple support bar type and (where available) an offer for a single support bar type. Other types may be offered.

The MBEJ System Owner must:

(a) certify that the MBEJ supplied meets the requirements of the specification with respect to the:
   (i) design;
   (ii) conformance of the shop drawings to the design and this Specification;
   (iii) materials and components;
   (iv) fabrication and assembly of the MBEJ;
   (v) installation of the MBEJ; and
   (vi) maintenance manual for the MBEJ;

(b) provide to the Principal a warranty on the quality and performance of the joint for a period of 5 years, commencing from the date of opening of the bridge on which the joint has been installed or from the date of the Principal’s receipt of the warranty, whichever occurs later;

(c) supply a joint system meeting the requirements of this Specification, together with a Maintenance Manual to ensure that the life of the joint can be achieved;

(d) warrant that it will supply replacement parts in a timely manner;

(d) supply sufficient technical details of materials, components, design and testing to enable the Principal to maintain the joint in the event that the Principal can no longer obtain components from the MBEJ System Owner in a timely manner. This information will be regarded by the Principal as being Commercial-in-Confidence; and

(e) where components of the MBEJ are subject to intellectual property rights, advise the Principal of the holder of these rights, and of any changes to these rights or the holder of these rights.

Manufacturing tolerances are the responsibility of the Principal MBEJ System Owner. Supply evidence that the proposed tolerances are adequate for the correct functioning of the joint.

1.5 MBEJ SYSTEM OWNER’S AGENT

The MBEJ System Owner may delegate day to day tasks to an Agent.

The Agent is responsible for the delivery of the MBEJ and for its installation in the bridge in accordance with the requirements of this Specification.

1.6 SUBMISSIONS

Preference will be given to designs that have been tested in accordance with the procedures set out in Appendix A of NCHRP Report 467.

Include in all offers, the following, as a minimum:
Modular Bridge Expansion Joints

(a) The name and contact details of the MBEJ System Owner;

(b) The name, contact details and curriculum vitae of the MBEJ System Owner’s Agent;

(c) Names and details of bridges where modular bridge expansion joints of the MBEJ system type have been installed, together with the movement capability, installation date, and the name, telephone number and facsimile number of the maintaining authority for each bridge;

(d) Noise test reports of the performance of the MBEJ system under traffic (where available);

(e) An experimental modal analysis study (as per Annexure B316/L) conducted on a comparable size and type of dynamically similar joint from the supplier, or a written commitment that the study will be provided if the supplier is successful;

(f) Evidence of compliance with the fatigue test specification requirements set out in Appendix B of NCHRP Report 402;

(g) Results of NCHRP Report 467 testing (where available);

(h) Statement of where the proposed materials and fabrication do not comply with this Specification. This Statement must include the technical justification for the variations and a clause by clause comparison between the specified requirement and the proposed substitution;

(i) Four (4) sets of any non-metallic components excluding seals, including four (4) of each type of elastomeric bearing and four (4) of each type of elastomeric springs proposed for use in the modular joint(s), together with a description denoting which joint type(s) and at what location(s) each bearing and spring is to be used, and what pre-compression is applied to each bearing and spring;

(j) The name and address of the proposed fabricator, together with documentation of past experience of the fabricator in complex heavy steel fabrication and pre-qualified weld procedures.

Note: The Principal will undertake a fabrication shop assessment including inspection of weld procedures, testing, macros, past records of nonconformities and WHS system and practices prior to accepting the proposed fabricator.

Submit all documents in the English language. Where it is proposed to submit a primary or supporting document written in a language other than English, include a certified English language translation of the document including all text, tables, figures, photographs and appendices from the source document.

Submit all MBEJ drawings, regardless of the time of submission, as both hard copies (Size A1) and in electronic format (.DWG, .DXF or .PDF). Record electronic copies onto a CD-ROM that is labelled with the drawing number(s), sheet number(s) and revision number(s). All drawings must comply with AS/NZS 1100.501 and dimensions must be in SI units.

2 SHOP DRAWINGS

Prepare shop drawings for the fabrication of all members. These drawings must be verified by personnel other than those directly involved in the drafting of the shop drawings [refer to RMS Q Clause 4.1.2(c)]. The details shown on the shop drawings must be consistent with the Drawings.
Comply with the following requirements:-

(a) Show tolerances on all members and assemblies;

(b) Show the location and orientation of the joint in the bridge on the marking plan;

(c) Shop drawings must conform to AS/NZS 1100.501 as appropriate. Drawings showing only the cutting dimensions of beams, flanges and the like must not be considered as shop drawings;

(d) Welding and cutting definitions must conform to AS 2812;

(e) Welding symbols must conform to AS 1101.3;

(f) Show complete information regarding the location, type, category, size and extent of all welds on the shop drawings. These drawings must clearly distinguish between shop and field welds;

(g) Note on the drawings the joints or groups of joints in which it is especially important that the welding sequence and technique of welding be carefully controlled to minimise shrinkage stresses and distortion. Clearly indicate the joints where no welding is permitted. Weld lengths specified on the drawings must be the required effective lengths;

(h) Clearly identify each MBEJ with the identification marks shown on the Drawings. Further, identify each part of the MBEJ to readily distinguish it from all other parts;

(i) Show all associated bolting, accessories and/or joining details for assemblies on the shop drawings;

(j) Show details of all holes and attachments required for temporary work such as lifting lugs and methods of sealing all such holes;

(k) Provide step by step instructions for installation.

Submit four (4) copies of the drawings certified as complying with the above requirements to the Principal at least ten (10) working days before fabrication commences.

Submit two (2) copies of the "Works as Executed" shop drawings to the Principal within four (4) weeks of the completion of fabrication and installation of the MBEJ.

3 DESIGN

Detailed design requirements are prescribed in Annexure B316/E. This annexure specifies the design loads, various factors to be applied to the loads, the procedures to be followed to satisfy the three limit states of fatigue, strength and serviceability and the requirements of these limit states. The design load is the A160 axle specified in AS 5100.2.

For any items not covered in Annexure B316/E, follow the requirements of AS 5100.4 and AS 5100.6.

3.1 GENERAL ARRANGEMENT

The centre beams must be continuous over the full width of the carriageway. Do not use field splices in centre beams.
The maximum clear gap between the tops of the centre beams must be 85 mm at the joint opening corresponding to the ultimate limit state.

The spacing between centrelines of the support bars must not exceed 1500 mm.

Modular bridge joint systems offered may utilise either positive mechanical control (eg. pantographs, etc.) or elastomeric springs to provide equidistant centre beam spacing. However, where the joint is to be installed at a slope (in the direction of vehicular traffic) exceeding 0.5°, the supplier must demonstrate that the equidistant system proposed is capable of maintaining equal centre beam spacing under all possible operating conditions for the life of the joint.

3.2 DESIGN SERVICE LIFE

Design the following joint components to have:
(a) a minimum 15-year service life and to be replaceable without traffic closures:
   (i) Compression and control springs;
   (ii) Support bearings;
(b) a minimum 20-year service life and to be replaceable with either a total road closure not exceeding 2 hours or not more than two lanes of the bridge at a time closed to traffic:
   (i) Joint seals;
(c) a minimum 100-year service life:
   (i) Centre beams, including welded attachments;
   (ii) Support bars, including welded attachments;
   (iii) Support boxes and attachments.

3.3 LIMIT STATE REQUIREMENTS

The nominal yield strength ($f_y$) and nominal tensile strength ($f_u$) must comply with the following:
(a) the nominal yield strength must not be less than 250 MPa or greater than 350 MPa for structural steel members, unless otherwise approved by the Principal; and
(b) the nominal tensile strength must not be less than 830 MPa for bolts and 480 MPa for welds.

The structural design must be in accordance with the principles of limit state design. The following relationship must be satisfied:

$$S^* \leq \phi R_{lim}$$  \hspace{1cm} (3.1)

where

- $S^*$ = the design action effect (force, stress, stress range, etc) for the appropriate limit state
- $\phi$ = the capacity reduction factor
- $R_{lim}$ = the nominal strength, corresponding to $S^*$, for the appropriate limit state

Check the limit states of fatigue, strength and serviceability. The design methodology is prescribed in detail in Annexure B316/E and is briefly as follows:

Obtain the joint opening and other Project Specific Requirements from Annexure B316/A.
The axle load and the manner in which it is to be applied are specified in Clause E4. Obtain the design load by factoring the axle load by appropriate factors specified in Clauses E5 to E9. Design the joint so as to satisfy Equation 3.1 for each member and detail, as follows:

(i) For the fatigue limit state, \( S^* \) denotes the stress range and \( R^* \) denotes the fatigue resistance for the appropriate Detail Category, for infinite cycles of stress (the cut-off limit stress range);

(ii) For the strength limit state, \( S^* \) denotes the bending moments, shears and axial forces and \( R^* \) denotes the section capacity and member capacity, based on the yield stress \( f_y \) or the tensile strength \( f_u \);

(iii) The serviceability limit state requirements deal mainly with noise and damping of vibrations. Refer Clause 3.8 for noise requirements. The supplier must demonstrate by testing in accordance with Annexure B316/L that its modular bridge expansion joint systems exhibit damping of at least 5% of critical damping.

### 3.5 ANCHORAGE

#### 3.5.1 Edge Beams

Where edge beams are not integral with the support boxes, design the edge beams in accordance with Clause 17.4 of AS 5100.4 and detail them in accordance with Figure B316.3 below. Studs that anchor the joint into the concrete must be 19 mm minimum diameter, 150 mm in length (after welding) and at maximum 300 mm spacing.

Where edge beams are integral with the support boxes, assume the edge beam to support box fillet welds along the base of the edge beam to carry not more than 50% of the horizontal component of load.

Where the clear spacing between support boxes exceeds 300 mm, provide additional anchors conforming to Clause 17.4 of AS 5100.4. Where studs are used, design them in accordance with the preceding paragraph.

The minimum concrete cover over welded studs, cleats and other fixtures must be 50 mm but 75 mm is preferred.

The preformed elastomeric joint seal retainer profile is at the discretion of the manufacturer.

![Figure B316.3 - Example of Edge Beam Anchorage](image)
3.5.2 Support Boxes

Horizontal studs that anchor the support box into the concrete must be 19 mm minimum diameter, 150 mm in length (after welding) and at maximum 300 mm spacing. Vertical studs that anchor the support box into the concrete must be 13 mm minimum diameter, 75 mm in length (after welding) and at maximum 300 mm spacing.

Alternative forms of anchorage that do not rely upon resistance-welded studs are permitted and must be designed in accordance with Clause 17.4 of AS 5100.4.

Design anchor bars that attach the joint into the concrete as follows:

(a) stud welded shear connectors must only be welded by resistance welding using a welding gun;
and

(b) welds holding anchor bars to the joint must develop the full strength of the bar.

3.6 Weld Detailing

All welds in centre beams and support bars must be full penetration butt welds – Category FP. All welds attaching anything to centre beams or support bars, within 10 mm of the top or bottom surface, must be full penetration butt welds – Category FP. This requirement excludes the welding of stainless steel sliding surfaces. All other welds, except stud welds, must be Category SP.

3.7 Features

Provide suitable handling attachments or lifting points to assist in the handling and location of the joint.

The preformed elastomeric joint seals must resist penetration by material such as aggregate under traffic loading (See NCHRP Report 467 seal push-out (SPO) test requirement in Clause 4.3).

The joint must provide exposed surfaces that assist in the rejection or reduction of debris accumulation and allow access for clearing of debris if present.

In service, the joints must be capable of the movement capacity specified on the Drawings at all times.

3.8 Noise Under Traffic

MBEJ must not generate excessive noise or vibration under traffic. The joint must represent “best practice” in achieving minimum noise levels under traffic. The MBEJ System Owner must include a best practices guide for noise mitigation for its joints.

Tender submissions for the supply of MBEJ must be accompanied with noise test data reports indicating its performance under traffic, including relevant site specific information.

Carry out noise testing in accordance with AS 2702, with measurements taken for drive-by noise performance and underneath the bridge.

Provide physical information about the bridge on which the noise testing was performed, relating to the acoustic behaviour of the bridge at the MBEJ.
3.9 MAINTENANCE

The design of modular bridge expansion joints must ensure that all performance criteria for the joint are met with minimum maintenance for the design life of the joint.

MBEJs with 3 or less seals must be detailed with support boxes with removable tops. Design must allow for ready access to the joints and provide sufficient space for inspection, maintenance and replacement of joint components as required.

Simultaneously with the delivery of the joint, provide a Maintenance Manual. The manual must detail the required inspection and maintenance schedule for the joint, together with work procedures required to carry out repairs and/or replacement of each component of the joint.

<table>
<thead>
<tr>
<th>HOLD POINT</th>
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<tbody>
<tr>
<td>Process Held:</td>
</tr>
<tr>
<td>Submission Details:</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
</tr>
</tbody>
</table>

3.10 DESIGN DOCUMENTATION

Submit adequate drawings and detailed design calculations, to enable a complete check of the design to be done in accordance with Annexure B316/E. Include in the submission, as a minimum, the following:

(a) General arrangement;
(b) Details of all members, support boxes and yokes, if any;
(c) All dimensional tolerances for fabrication and fatigue categories of all welds;
(d) Adequate details of all connections to enable these to be checked for fatigue in accordance with Clause E12;
(e) Drawings indicating the force transmission system for the control spring buffer;
(f) Static and dynamic design calculations for all structural components, including the anchorages. Calculations must also show that a joint manufactured to the tolerances shown on the Drawings will perform satisfactorily. All engineering calculations must be in SI units.
(g) Certification that the materials and fatigue sensitive details proposed for use on the project have been pre-tested and will meet the requirements as stated in the current product literature;
(h) Any additions or alterations required to the existing structure for erection. The safety and integrity of the joint during transport and erection will not be checked by the Principal.
HOLD POINT

Process Held: Fabrication of the MBEJ
Submission Details: Supplier to submit Design Documentation (Clause 3.10), Procedures (Clause D2) and Shop Drawings (Clause 2) at least ten (10) working days prior to commencement of fabrication work.
Release of Hold Point: The Principal must forward the submitted documents and components to the Manager, Bridge Policies Standards & Records, Asset & Project Technology Branch, for determination prior to authorising the release of the Hold Point.

4 MATERIALS AND FABRICATION

WITNESS POINT

Process Witnessed: Testing of materials
Submission Details: The Supplier must notify the Principal a minimum of two (2) weeks prior to the testing of any materials to be used in the MBEJ.

4.1 GENERAL

Fabricate the centre beams, edge beams, support bars, control arms, and control boxes from steel. Do not use aluminium components. Do not use weld repaired steel. Examine all steel intended for use as centre beams or support bars by non-destructive methods prior to cutting to ensure soundness of material. Do not use unsound material in areas to be welded.

Carry out all welding of steel in accordance with Specification RMS B201.

All Category FP welds must be 100% visually and 100% non-destructively examined using methods conforming to RMS B201.

The requirements for inspection and/or testing of Category SP welds are set out in RMS B201 Annexure L, Clause L1 “Inspection of Welding” and Table B201.L1 (b). The requirements for testing of anchor studs is set out in RMS B201 Annexure L, Clause L2 “Inspection and Testing of Welded Shear Studs for Composite Steel and Concrete Structures”.

Use only fasteners (bolts, nuts, screws and washers) complying with RMS B201.

Provide a skid resistant surface treatment to support/control boxes exposed to traffic. All such parts must be resistant to attrition and vehicular impact.

Comply with the standards and specifications shown on the Drawings for all materials supplied, unless specified otherwise.

Where joints are made at locations not shown on the Drawings or at locations other than those shown on the Drawings, include details of the position of the joints in the Works-as-Executed Drawings.
Mark each MBEJ with durable identification marks and mark its total mass clearly upon it.

Provide documents stating the equivalent grade in an Australian Standard for all materials supplied to other than Australian Standards and specifications. A mill certificate with appropriate NATA registration from the material supplier will constitute documentary evidence of compliance with a standard or specification.

Establish and maintain a comprehensive system of identification records and keep them up to date. The records must include which items are cut from each piece of material and where each item is used in each member. Forward two copies of these records to the Principal on request.

4.2 JIGS

Fabricate the whole MBEJ using jigs during any welding of the centre beams.

4.3 DIMENSIONAL CHECKS

Perform dimensional checks after completion of welding of the first centre beam, for each type of connection.

Dimensional checks must verify that:
(a) all centre beams, support bars and other components are in their design planes;
(b) centre beams to support bar connections and other components are orthogonal; and
(c) centre beams and support bars are straight.

<table>
<thead>
<tr>
<th>WITNESS POINT</th>
<th>Dimensional checks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Witnessed:</td>
<td>Fabrication of prototype of each component and fabrication of the first centre beam to support bar connection.</td>
</tr>
<tr>
<td>Submission Details:</td>
<td>Fabrication drawings of all components. Welding procedures.</td>
</tr>
</tbody>
</table>

4.4 PROTOTYPES

Weld and check prototypes of each set of components of the MBEJ for dimensional accuracy prior to the remaining fabrication of the MBEJ.

<table>
<thead>
<tr>
<th>HOLD POINT</th>
<th>Welding of prototypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Held:</td>
<td>The Supplier must submit to the Principal at least ten (10) working days prior to the commencement of the trial assembly of the MBEJ and test results required in Clause 4.1.</td>
</tr>
<tr>
<td>Submission Details:</td>
<td>The MBEJ and the submitted documents will be examined by the Principal or a nominated representative prior to authorising the release of the Hold Point.</td>
</tr>
<tr>
<td>Release of Hold Point:</td>
<td>The MBEJ and the submitted documents will be examined by the Principal or a nominated representative prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>
4.5 FABRICATION OF STEELWORK

4.5.1 General

All steel must be manufactured by companies using quality management system certified to AS/NZS ISO 9001 by a third party accredited or recognised by the Joint Accreditation System of Australia and New Zealand.

Any cutting or shaping of steel shapes and sections after the steel has left the steel mill must be regarded as fabrication work and must be carried out in accordance with the requirements of this Specification.

Where defects arising from the manufacture of the steel become evident at any stage of fabrication, the steel must be deemed to be nonconforming.

4.5.2 Tolerances

Fabrication dimensions must comply with the tolerances given on the Drawings. Where a tolerance is not specified otherwise, it must be ±2 mm. Tolerances must be such that all parts fit together within the specified tolerances.

Before any marking out or other work is done, all bars and sections must be made straight and free from twist to achieve the design tolerances. The methods adopted must be such as to not damage the material.

4.5.3 Cutting

Cutting may be by flame cutting, sawing or shearing unless otherwise specified. Surfaces produced by such cutting must be representative of good workmanship, finished square (unless a bevelled edge is called for), true to the required dimensions and free from defects, such as excessive roughness, which would impair the service performance or seriously interfere with subsequent fabrication and protective treatment. Do not carry out shearing of items over 16 mm thick when the item must be galvanised and subject to tensile stresses, unless the item is subsequently stress relieved. Remove any distortions caused by shearing.

Smoothly round off all re-entrant corners to a radius of 20 mm. Unless shown otherwise on the Drawings, round all corners on exposed edges to a radius of approximately 1.5 mm, except where such edges are subsequently to be welded. Rolled edges need not be rounded, provided the corners have a similar radius.

Any cut surface to be incorporated in a weld must comply with AS/NZS 1554 and the depth of isolated gouges must not be greater than 2 mm.

Carry out flame cutting of plates, sections and other components with surfaces which will be used in the "as-cut" condition with procedures giving minimum reduction in properties at the cut surface and satisfying the requirements given below.

Any cut surfaces to be used in the "as cut" condition must have:-

(a) surface roughness (CLA) not greater than 12 µm (i.e. WTIA Roughness Class 2 as shown in WTIA Technical Note 5);

(b) depth of isolated gouges not greater than 3 mm; and

(c) surface quality which will not impair subsequent fabrication and protective coating requirements.
Cut surfaces may be ground to obtain the specified surface roughness. Grinding marks must be parallel to the direction of the cut. Note that the flame cut surface may require a light surface grind to render it suitable for subsequent protective coating requirements.

Repair all gouges less than 3 mm in depth by tapering out smoothly for a distance of at least 75 mm on both sides of the defect. For steel with a flame cut surface which is to be used in the "as-cut" condition, edges with occasional striations or gouges which are less than 3 mm in depth may be accepted, provided that these defects are corrected by grinding.

### 4.5.4 Drilling

The diameters of the bolt holes must be in accordance with the requirements of AS 5100.6 Appendix G, (the nominal diameter of a completed hole must be 2 mm larger than the nominal bolt diameter for a bolt not greater than 24 mm in diameter, and not more than 3 mm larger for a bolt of greater diameter), unless specified otherwise on the Drawings.

Holes may be either drilled full-size or reamed to full-size after sub-drilling or sub-punching. Sub-punched and sub-drilled holes must be smaller in diameter than the nominal diameter of bolts by 3 mm. For sub-punched holes, the diameter of the die must not exceed the diameter of the punch by more than 1 mm. Holes must be clean cut, without torn or ragged edges. Reamed or drilled holes must be cylindrical and perpendicular to the face of the member unless shown otherwise on the Drawings. Carry out reaming and drilling by mechanical means.

Connecting parts must be assembled and held securely while being reamed or drilled and must be match-marked before separating the parts.

Remove all burrs. If necessary, assembled parts must be taken apart for removal of burrs caused by drilling and reaming.

### 4.5.5 Jointing and Assembly

Joints in the component parts of welded members must be made before the parts are assembled.

Where joints are made at locations not shown on the Drawings or at locations other than those shown on the Drawings, include details of the position of the joints in the Works-As-Executed Drawings.

Bending and forming plates, bars or sections during fabrication must conform to the steel manufacturer's recommendations.

Distortion and residual stresses resulting from welding and fabrication may be corrected by mechanical or thermal means in accordance with the methods and conditions given in RMS B201.

### 4.5.6 Packing, Storing and Transporting

Protect all open joints, ends and projecting parts from damage in transit in such a manner as to stiffen the member and prevent distortion.

Take special care in packing and in methods of support and lifting during handling of all structural steelwork, to prevent distortion or damage to the steelwork and its protective coating.

Store all steel, whether fabricated or not, in such a manner that it will not be bent or damaged and will be adequately protected against corrosion. Generally, storage at least 200 mm above the ground on platforms, slabs, or other supports under cover will be satisfactory.
4.6 **CORROSION PROTECTION**

Steel components other than stainless steel must be coated on all surfaces with an inorganic zinc primer/MIO epoxy system in accordance with Specification RMS B220.

If the MBEJ Manufacturer proposes a corrosion protection system that does not comply with RMS B220, the Manufacturer must provide a direct comparison between the requirements of AS/NZS 2312 for Atmospheric Corrosivity Category C: Medium, and the proposed corrosion protection system.

Stainless steel must comply with the material properties specified in Specification RMS B282.

4.7 **SEALS**

Preformed elastomeric joint seals must comply with the requirements of Specification RMS B315 or ASTM 5973.

Preformed elastomeric joint seals including those deemed to comply must be tested in accordance with the seal push-out (SPO) test procedure laid down in NCHRP Report 467 and must successfully pass testing without failure.

The seals must possess the necessary compression, extension and deformation properties to give the required range of movements specified by the bridge Designer, whilst remaining water tight.

The permissible tolerance is: Nil to + 2 mm in relaxed width of seal.

4.8 **PTFE (POLYTETRAFLUOROETHYLENE)**

PTFE must comply with the material properties specified in RMS B282.

4.9 **SPRINGS**

Elastomeric components used above and below support bars and between centre beams and support bars in the MBEJ must be tested in accordance with the opening movement and vibration (OMV) procedure laid down in NCHRP Report 467 and must successfully pass 70 hours of continuous testing without failure.

5 **CERTIFICATION**

Submit certification and results from testing of fabricated components by a NATA registered laboratory that the materials proposed for use in the MBEJ including steel, stainless steel, joint seals, PTFE and elastomeric springs meet the requirements of this Specification.
HOLD POINT

Process Held: Assembly of the MBEJ

Submission Details: Submit to the Principal at least ten (10) working days prior to the commencement of assembly of the MBEJ all certificates and test results required in Clause 4.

Release of Hold Point: The MBEJ and the submitted documents will be examined by the Principal or a nominated representative prior to authorising the release of the Hold Point.

6 ASSEMBLY

WITNESS POINT

Process Witnessed: Assembly of the MBEJ

Submission Details: The Supplier must notify the Principal a minimum of three (3) weeks prior to the commencement of assembly of the MBEJ.

Provide documentation showing the procedures for the assembly of the MBEJ including manufacturing and assembly tolerances. Provide evidence that the tolerances specified are adequate for the correct functioning of the joint.

Documentation of the actual assembly processes must include, but not be limited to, dynamic stiffness and damping testing of the springs and bearings, their preload and fitting procedures (as per Annexure B316/L).

Carry out all welding in accordance with RMS B201.

The Supplier must provide documentary evidence that inspection and non-destructive examination (NDE) of every weld has been performed. Welding Procedure documents that comply with Appendix C of AS/NZS 1554.5 are the minimum acceptable requirement.

The Supplier must provide a quality control log documenting the measured heights of all the support box bearings.

7 INSPECTION OF COMPLETED MBEJ

The Supplier must arrange suitable facilities for the inspection of the completed MBEJ system. The inspection must allow free access to all sections of the MBEJ system to ensure compliance to the requirements of this Specification. It is preferable that this inspection takes place before the elastomeric seals are installed.

The Principal or a nominated representative will inspect the completed MBEJ at the place of manufacture. The Supplier must bear all costs related to the inspection of the MBEJ.
WITNESS POINT

Process Witnessed: Installation of the MBEJ seals.

Submission Details: The Supplier must notify the Principal a minimum of fifteen (15) working days prior to the installation of the seals.

HOLD POINT

Process Held: Transportation of the MBEJ to site.

Submission Details: Submit to the Principal, at least five (5) working days prior to the commencement of transportation of the MBEJ to the location of supply, certification that the fabricated MBEJ conforms to the design.

Release of Hold Point: The submitted documents will be examined by the Principal or a nominated representative prior to authorising the release of the Hold Point.

8 INSTALLATION OF MBEJ

HOLD POINT

Process Held: Installation of MBEJ.

Submission Details: Submit the documents specified in Clauses 2 and D2 to the Principal at least ten (10) working days prior to commencement of installation.

Release of Hold Point: The Principal’s Bridge Engineer, Policy & Specifications will examine the submitted documents prior to authorising the release of the Hold Point.

The MBEJ System Owner’s Agent must be present while the MBEJ system is being installed.

The MBEJ System Owner’s Agent must certify to the Principal that the proper installation procedures have been followed. All certification to the Principal must be in writing, signed and dated.

The MBEJ System Owner’s Agent must inspect the installed MBEJ after removal of all formwork and certify to the Principal that proper installation has been achieved and there has been no deleterious leakage of concrete slurry into the support boxes.

9 TESTING FOR WATERTIGHTNESS

The MBEJ must be tested for watertightness not less than two (2) weeks after installation of the completed joint. Submit procedures to the Principal for testing the joint for watertightness that are consistent with the following procedure:
(a) At least two weeks after completion of each modular expansion joint installation, perform a water test on the top surface to detect any leakage. Cover the roadway section of the joint from kerb to kerb, or barrier rail to barrier rail, with water, either ponded or flowing, not less than 25 mm above the roadway surface at all points. Block footpath sections and secure a water hose delivering approximately 4 litres of water per minute to the inside face of the bridge railing, trained in a downward position about 150 mm above the footpath, such that there is continuous flow of water across the footpath and down the kerb face of the joint;

(b) Maintain the ponding or flowing of water on the roadway and continuous flow across footpaths and kerbs for a period of 5 hours. At the conclusion of the test, closely examine the underside of the joint for leakage. Seals are considered watertight if no obvious wetness is visible on a finger touching a number of under-deck areas. Damp concrete that does not impart wetness to the finger is not considered a sign of leakage. Condensation or other moisture may be expected underneath the joint and will not constitute leakage unless the flow is sufficient to cause continuous dripping at least every 20 seconds or a visible continuous stream of water;

(c) If the joint system leaks, locate the place(s) of leakage and take any repair measures necessary to stop the leakage at no additional cost to the Principal. Use recommended repair measures approved by the Principal prior to beginning repair work;

(d) If measures to eliminate leakage are taken, perform a subsequent water integrity test the same way as the original test. Subsequent tests must be performed at no additional cost to the Principal.

Alternatively, prove the water tightness of the sealing system by pre-testing in the factory.

**WITNESS POINT**

<table>
<thead>
<tr>
<th>Process Witnessed:</th>
<th>Each test for watertightness.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Details:</td>
<td>The Supplier must notify the Principal a minimum of 3 working days prior to the test of the date and location of the test.</td>
</tr>
</tbody>
</table>
ANNEXURE B316/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.1.2.

NOTE: The format of this information is for the guidance of the Design Engineer only, and may be changed as required for specific projects.

A1 EXPANSION JOINT OPENINGS

The following information is required:

(a) Maximum average bridge temperature (refer to AS 5100.2, Clause 17.2) \( T_{\text{max}} = \) ______ °C

(b) Minimum average bridge temperature \( T_{\text{min}} = \) ______ °C

(c) Expected temperature at initial condition* \( T_i = \) ______ °C

(d) Gap at initial condition \( J_i = \) _____ mm

(e) Change in width of gap for 1°C change in average bridge temperature \( e_s = \) _____ mm/°C

(f) Total creep and shrinkage movement until the end of the design life \( c_s = \) _____ mm

* For a new bridge \( J_i \) is the gap specified on the drawing for the assumed temperature \( T_i \). For replacing a joint on an existing bridge \( J_i \) and \( T_i \) must be measured at site.

Compute the following joint openings (refer to Figure B316.4):

(i) The minimum joint opening at serviceability: \( J_{s,\text{min}} = J_i - e_s (T_{\text{max}} - T_i) = \) _____ mm

(ii) The maximum joint opening at serviceability: \( J_{s,\text{max}} = J_i + c_s + e_s (T_i - T_{\text{min}}) = \) _____ mm

(iii) The joint opening for ultimate limit state: \( J_u = J_i + 1.2c_s + 1.25e_s (T_i - T_{\text{min}}) = \) _____ mm

(iv) Joint opening for fatigue limit state# \( J_f = \) _____ mm

# The joint opening for fatigue design recommended by NCHRP is the mean value

\[ J_f = \left( \frac{J_{s,\text{min}} + J_{s,\text{max}}}{2} \right) \]

A slightly more conservative value is the “root mean cube”, based on the fact that fatigue damage varies as the 3\(^{rd}\) power of the stress and stress due to a concentrated load varies linearly as the span.

\[ J_f = \left[ \frac{J_{s,\text{min}} + J_{s,\text{max}}}{2} \right]^{\frac{1}{3}} \]

If detailed temperature records are available, a logical choice is to assess the mean daily temperature experienced by the bridge for most days of the year (\( T_f \)) and compute the joint opening for fatigue as:

\[ J_f = J_i + c_s + e_s (T_i - T_f) \]
B316 Modular Bridge Expansion Joints

(a) Initial gap, measured (for existing) or specified (for new) joint

(b) Minimum gap for design

(c) Maximum gap for design

(d) Gap for fatigue design

NOTE: The gaps are different for serviceability, ultimate and fatigue design.

Figure B316.4 – Expansion Joint Movements

A2 HORIZONTAL FORCES

The longitudinal force coefficient (refer Clause E9)

\[ \eta = \text{_____} \]

Notes:
1. \( \eta = 0.35 \) in accordance with Clause 17.3.2 of AS 5100.4
2. NCHRP 402 recommends a value of 0.2 for normal conditions, which must be increased for locations where there are steep gradients or where hard braking is expected close to traffic signals, to a maximum value of 0.5.

The transverse force coefficient (refer Clause E9)

\[ r = \text{_____} \]

A3 ADDITIONAL REQUIREMENTS FOR SKEWED EXPANSION JOINTS

Transverse movement due to thermal distortion of skewed deck

Note: Other requirements in this clause may need to be specified when the case arises.
ANNEXURE B316/B – PAYMENT AND RESOLUTION OF NONCONFORMITIES

Refer to Clause 1.2.2.

B1 PAYMENT

The item is to include the cost of all work required by this specification including the design, fabrication, testing, supply and installation of modular bridge expansion joints (MBEJ) covering both single and multiple support bar MBEJ systems. In the Schedule of Prices accompanying the Lump Sum Tender, the cost of modular bridge expansion joints shall be divided into the following items, as appropriate. Pay Items (a), (b) and (c) must all be priced. Additional pay items may be submitted where more than 3 MBEJ systems are proposed:

(a) Modular Bridge Expansion Joints – Option One

You must nominate in the Schedule of Prices the MBEJ System proposed for the Tender Price (Option 1).

The unit of measurement is Lump Sum to supply all systems required for the Works in accordance with this Specification.

(b) Modular Bridge Expansion Joints – Option 2 in lieu of Option 1
- Provisional Quantity

This is a Provisional Quantity. The unit of measurement is Lump Sum to supply all systems required for the Works in accordance with this Specification.

You must nominate in the Schedule of Prices the MBEJ System proposed as Option 2. The price shall be for the extra over cost of providing Option 2 in lieu of Option 1.

(c) Modular Bridge Expansion Joints – Option 3 in lieu of Option 1
- Provisional Quantity

This is a Provisional Quantity. The unit of measurement is Lump Sum to supply all systems required for the Works in accordance with this Specification.

You must nominate in the Schedule of Prices the MBEJ System proposed as Option 3. The price shall be for the extra over cost of providing Option 3 in lieu of Option 1.

B2 RESOLUTION OF NONCONFORMITIES

Work and materials must be rejected unless they conform to the requirements of this Specification or are accepted with the pro rata deductions.
ANNEXURE B316/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS

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<tr>
<td>3.10</td>
<td>Fabrication of the MBEJ</td>
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<td>4.4</td>
<td>Welding of prototypes</td>
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<td>5</td>
<td>Assembly of the MBEJ</td>
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<tr>
<td>7</td>
<td>Transportation of the MBEJ to site</td>
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<td>8</td>
<td>Acceptance of MBEJ</td>
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</table>

C2 SCHEDULE OF WITNESS POINTS

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<thead>
<tr>
<th>Clause</th>
<th>Description</th>
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<td>Testing of materials</td>
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<td>4.3</td>
<td>Dimensional checks</td>
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<td>6</td>
<td>Assembly of the MBEJ</td>
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<td>Installation of the MBEJ seals</td>
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<tr>
<td>9</td>
<td>Each test for watertightness</td>
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</table>
C3 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of RMS Q Annexure Q/E.

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<th>Clause</th>
<th>Description of Identified Record</th>
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<tbody>
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<td>Tender submission</td>
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<tr>
<td>2</td>
<td>Shop drawings</td>
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<tr>
<td>3.10</td>
<td>Design documentation</td>
</tr>
<tr>
<td>4.1</td>
<td>Location of joints in steelwork not shown on design Drawings</td>
</tr>
<tr>
<td>4.6, 4.7, 4.9</td>
<td>NATA laboratory certificate of conformance</td>
</tr>
<tr>
<td>5</td>
<td>Certification and testing of materials</td>
</tr>
<tr>
<td>6</td>
<td>Weld NDE and inspection reports</td>
</tr>
<tr>
<td>6</td>
<td>Assembly documentation</td>
</tr>
<tr>
<td>7</td>
<td>Certification that the fabricated MBEJ conforms to the design</td>
</tr>
<tr>
<td>8</td>
<td>Manufacturer’s certification of installation procedures</td>
</tr>
<tr>
<td>8</td>
<td>Manufacturer’s certification following post-installation inspection</td>
</tr>
<tr>
<td>9</td>
<td>Procedures and results of testing the joint for watertightness</td>
</tr>
</tbody>
</table>
ANNEXURE B316/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The documents that must be included in the PROJECT QUALITY PLAN are listed in Clause 1.6.

D1 QUALITY MANAGEMENT

The quality management system operating for the work must comply with the requirements of RMS Q.

Implement a Quality Management System complying with AS/NZS ISO 9001 for joint supply and fabrication.

Submit a PROJECT QUALITY PLAN for the supply of the MBEJ. The PROJECT QUALITY PLAN must cover the design, fabrication, inspection, testing and installation of the joint.

D2 PROCEDURES

Submit details of the procedures for assembly and fabrication with the PROJECT QUALITY PLAN. These procedures must be comprehensive and must cover all aspects of the work.

All procedures, work instructions etc. must make reference to and include appropriate safe working practices and requirements.

The procedures must include, but not be limited to:

(a) fabrication including dimensional control, manufacturing tolerances and details of manufacturing jigs;
(b) welding procedures;
(c) assembly;
(d) repairs and corrections;
(e) preparations for work on site; and
(f) transport, handling and storage, including measures to prevent distortion and damage to the joint and its protective coating.

Include the procedures required under the Clause "Painting Procedures and Programming" in RMS B220.

D3 FABRICATION PROGRAM

Submit a fabrication program as part of the PROJECT QUALITY PLAN (refer to RMS Q) showing the proposed sequence of operations and the proposed time required for all members and/or parts, which must be identified by name and mark.

The requirements of this Specification and others included in the Contract must be reviewed to determine additional documentation requirements.
ANNEXURE B316/E – DESIGN METHODOLOGY

Refer to Clauses 1.2.5 and 3.

E1 GENERAL

This section describes the approach to design of the modular joint to satisfy the requirements of fatigue, strength and serviceability as outlined in Clause 3.

The provisions of this section assume that the joint is perpendicular to the direction of traffic. For a skewed joint, additional considerations will be necessary, outlined in Annexure B316/A, whenever required.

E2 NOTATION

If a symbol is not defined locally, where it is used, the following general notation applies:

E2.1 Symbols

- \( B_c \) = width of centre beam at top
- \( B_w \) = width of tyre footprint in direction perpendicular to traffic
- \( f^* \) = design stress range
- \( f_{5} \) = Detail Category fatigue strength at cut-off limit (at \( 10^8 \) i.e. infinite number of cycles)
- \( f_{\text{rd}} \) = fatigue Detail Category defined in AS 5100.6, which is the uncorrected fatigue strength (in MPa) at \( 2 \times 10^6 \) cycles
- \( f_u \) = ultimate tensile strength used in design
- \( f_y \) = yield stress used in design
- \( g_c \) = gap between centre beams at appropriate joint opening
- \( H^* \) = design longitudinal load
- \( J \) = joint opening at top (clear gap between edge beams)
- \( L_w \) = length of tyre footprint in direction parallel to traffic
- \( Q^* \) = design vertical load
- \( R \) = support reaction
- \( R_{\text{lim}} \) = nominal strength for the appropriate limit state
- \( S^* \) = design action in general
- \( T^* \) = design transverse load
- \( W \) = Wheel load
- \( \beta \) = distribution factor (fraction of wheel load carried by one centre beam)
- \( \chi \) = Dynamic Amplification Factor (DAF)
- \( \eta \) = ratio of longitudinal load to vertical load
- \( \tau \) = ratio of transverse load to vertical load
- \( \phi \) = capacity reduction factor
\( \gamma \) = load factor

### E2.2 Subscripts

The above symbols may be qualified by one or more of the following subscripts:

- \( f \) = value at fatigue limit state
- \( s \) = value at serviceability limit state
- \( u \) = value at strength limit state
- \( \text{avg} \) = average
- \( \text{dn} \) = downward component
- \( \text{max} \) = maximum
- \( \text{min} \) = minimum
- \( \text{up} \) = upward component

### E3 Joint Opening

Obtain the expansion joint openings for design for the limit states of fatigue \( (J_f) \), strength \( (J_u) \) and serviceability \( (J_s) \) from the Project Specific requirements in Annexure B316/A.

### E4 Axle Load

The static axle load is the A160 axle defined in AS 5100.2 and illustrated below for reference. It comprises two wheel loads of 80 kN with contact areas shown in Figure B316.5.

![Figure B316.5 – A160 Design Axle](image)

Place the axle anywhere along the centre beam for maximum effects; however, the centre of the wheel need not be closer than 600 mm from the face of the kerb for the fatigue and serviceability limit states and 300 mm for the strength limit states.

### E5 Load Factors

Factor the axle load by \( \gamma \) for the appropriate limit state under consideration, as follows:

- \( \gamma_f = 0.6 \) for the fatigue limit state (E.1a)
- \( \gamma_u = 1.8 \) for the strength limit state (E.1b)
- \( \gamma_s = 1.0 \) for the serviceability limit state (E.1c)
E6  **DISTRIBUTION FACTOR**

The maximum wheel load carried by one centre beam is $\beta W$ where the Distribution Factor ($\beta$) is given by

$$\beta = \frac{B_c + g_c}{L_w} \quad 0.5 \leq \beta \leq 0.8 \quad (E.2)$$

Calculate the gap $g_c$ for the appropriate joint opening ($J_c$, $J_u$ or $J_e$) depending on the limit state under consideration.

Divide the remaining wheel load equally between the two adjacent centre beams or between a centre beam and edge beam, depending on the position of the wheel.

E7  **HORIZONTAL FORCE FACTORS**

Apply horizontal forces at each wheel to the top of the centre beams to account for forces due to traction, braking or acceleration, centrifugal force, etc.

The longitudinal force, in the direction of traffic, is given by $\eta W$, where the factor ($\eta$) is obtained from the Project Specific Requirements in Annexure 316/A.

If the joint is located on a curve or significant crossfall, apply transverse forces at the top of the centre beams. The transverse force under each wheel is $\tau W$, where the factor ($\tau$) is obtained from the Project Specific Requirements in Annexure 316/A.

If the joint is skewed to the direction of traffic, resolve the forces $\eta W$ and $\tau W$ in directions normal and axial to the centre beams, for design of the members.

E8  **DYNAMIC AMPLIFICATION FACTOR (DAF)**

The static axle load is multiplied by a factor ($\chi$) to account for dynamic effects.

For components not subject to vibrations, such as support boxes and edge beams

$$\chi_o = 1.6 \quad (E.3)$$

For centre beams, support bars and associated components, derive the DAF by one of the three methods outlined in Clause E10. Further, the DAF comprises an upward component ($\chi_{up}$) and a downward component ($\chi_{dn}$), given by:

$$\chi_{up} = 0.33 \chi \quad (E.4a)$$
$$\chi_{dn} = 0.67 \chi \quad (E.4b)$$

For computing the stress range for the fatigue limit state, the DAF is

$$\chi_f = \chi_{up} + \chi_{dn} \quad (E.5)$$

For the strength limit state

$$\chi_u = \chi_{dn} \quad (E.6)$$

For the serviceability limit state

$$\chi_s = \chi_{dn} \quad (E.7)$$
E9 DESIGN LOADS

The design loads due to each wheel, applied to the top of the critical centre beam, for each limit state, are as follows.

The vertical design load is:
\[ Q^* = \gamma \beta \chi W \]  
(E.8)

The longitudinal design load, in the direction of traffic, is:
\[ H^* = \gamma \beta \eta W \]  
(E.9)

The transverse design load, if applicable, is:
\[ T^* = \gamma \beta \tau W \]  
(E.10)

Use the appropriate values of the factors \( \gamma \) and \( \chi \), as per Clauses E5 and E8 respectively, for the limit state under consideration.

Analyse the centre beam as a continuous beam on elastic supports, the vertical spring stiffnesses of which are computed from the properties of the support bar bearings.

E10 ALTERNATIVE METHODS FOR EVALUATING DAF

Evaluate the dynamic amplification factor by one of the following three methods:

Method 1: Design based on the simple static method recommended in the NCHRP Report 402, with the following factors in lieu of the factors recommended by NCHRP:
\[ \chi = 2.0 \quad \text{for Multiple Support Bar Systems} \]  
(E.11a)
\[ \chi = 2.5 \quad \text{for Single Support Bar Systems} \]  
(E.11b)

Method 2: Conduct an experimental modal analysis study in accordance with Annexure B316/L, and obtain the maximum overall dynamic amplification factor, \( \chi_{\text{mod}} \). The factors to be used for design are:
\[ \chi = 0.67 \chi_{\text{mod}} \quad \text{for Multiple Support Bar Systems} \]  
(E.12a)
\[ \chi = 0.50 \chi_{\text{mod}} \quad \text{for Single Support Bar Systems} \]  
(E.12b)

The structural analysis may then be done by the simple static method recommended in the NCHRP Report 402.

Method 3: Undertake dynamic Finite Element Analysis (FEA) using a recognised software system for the finite element modelling and post-processing. However, this option will not be regarded as definitive unless the FEA has been calibrated using experimental modal analysis and strain gauge data as set out in Annexure B316/L. The Finite Element modelling must incorporate multiple axle loading of multiple centre beams. The axle must be stepped over the joint at velocities ranging from 90 km/h to 110 km/h in 5 km/hr intervals, unless otherwise specified by the Principal.

E11 LIMIT STATES

The procedure for checking the limit states of fatigue, strength and serviceability must generally comply with AS 5100.6. As a guide to designers not familiar with this standard, its essential
provisions are summarised in the following sections, for items that are expected to be applicable to
the design of MBEJs. Nevertheless, all required provisions of AS 5100.6 must be satisfied.

Equation 1 of Clause 3 of this specification must be satisfied for the three limit states of fatigue,
strength and serviceability. The design actions \((S^*)\) are the effects of \(Q^*, H^*\) and \(T^*\) specified in
Clause E9.

**E11.1 Limit State of Fatigue**

The action effect is the maximum resultant stress range due to the effects of \(Q^f, H^f\) and \(T^f\).

If normal stresses \(f_1\) and \(f_2\) act in two orthogonal directions, the resultant stress is

\[
\sigma_r = \sqrt{\sigma_1^2 + \sigma_2^2}
\]

(E.13)

If a normal stress \(f\) is to be combined with a shear stress \(s\), the principal stress is given by

\[
\sigma_r = \frac{f}{2} + \sqrt{\left(\frac{f}{2}\right)^2 + s^2}
\]

(E.14)

It is emphasised that fatigue stresses at joints and connections can often be critical. Some of the
details and connections that need to be checked are detailed in Clause E12.

The capacity factor for fatigue \(\phi_f\) can be taken as 1.0.

The resistance must be the cut-off limit stress \(f_5\) defined in Section 13 of AS 5100.6, which is the
resistance for \(10^8\) cycles (effectively infinite number of stress cycles). For certain standard details and
connections employed for modular joints, the fatigue detail categories have been classified in
accordance with Table 13.5.1 of AS 5100 and corresponding values of \(f_5\) extracted from Figure 13.6.1
of AS 5100 and the results given in Table B316/E.1.
Table B316/E.1 – Detail Classifications for Fatigue Based on AS 5100.6

<table>
<thead>
<tr>
<th>Item</th>
<th>Member or Connection</th>
<th>Detail Category</th>
<th>Category $f_{cm}$</th>
<th>Illustration No.</th>
<th>Cut-off limit $f_s$ (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Centre beam, support bar</td>
<td>Polished steel bar</td>
<td>180</td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>Flats for yokes</td>
<td>Rolled products</td>
<td>160</td>
<td>(1)</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>Centre beam at bolt hole</td>
<td>Bolted connection</td>
<td>140</td>
<td>(5)</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>Sliding plate welded to support bar</td>
<td>Cover plate welded full length, both sides</td>
<td>125</td>
<td>(9)</td>
<td>51</td>
</tr>
<tr>
<td>5</td>
<td>Centre beam splice</td>
<td>Butt weld, 100% NDT</td>
<td>112</td>
<td>(16)</td>
<td>$45\beta_t f_t$ Note 3</td>
</tr>
<tr>
<td>6</td>
<td>Centre beam to support bar</td>
<td>Butt weld with extra fillets</td>
<td>90</td>
<td>Note 1</td>
<td>36</td>
</tr>
<tr>
<td>7</td>
<td>Yoke to centre beam</td>
<td>Transverse butt weld</td>
<td>90</td>
<td>Note 2</td>
<td>36</td>
</tr>
<tr>
<td>8</td>
<td>Connections of yoke members</td>
<td>Shear stress in fillet weld</td>
<td>80</td>
<td>(39)</td>
<td>32</td>
</tr>
<tr>
<td>9</td>
<td>Sliding joint between centre beam and support bar</td>
<td>Longitudinal weld for sliding device, if local or intermittent</td>
<td>80</td>
<td>(14)</td>
<td>32</td>
</tr>
</tbody>
</table>
| 10   | Attachment for equidistancing buffer | Cleat attachments: $t \leq 12$ mm  
$t > 12$ mm  
($t = \text{thickness of cleat}$) | 80 (71) (35)(36) | 32 (29)          |                         |

Notes:

1. The welded connection between centre beam and support bar is classified as Category C of AASHTO by NCHRP. This is approximately equivalent to Detail Category 90 of AS 5100.6.

2. The fatigue category for this connection is assumed equivalent to Category C of AASHTO.

3. $\beta_t$ is a “thickness correction factor” defined in AS 5100.6 and given by

$$\beta_t = \left(\frac{25}{t_p}\right)^{0.25}$$

where $t_p$ is the thickness of the plate, i.e. width of centre beam, in mm.

For details which cannot be classified in accordance with Table B316/E.1, an appropriate Detail Category must be selected from Table 13.5.1 of AS 5100.6 and if no Category is deemed applicable, an authoritative reference must be submitted to support the value of $f_s$ adopted.

E11.2 Limit State of Strength

The action effects are the bending moment, shear force and axial force due to the effects of $Q^u$, $H^u$ and $T^u$.

The design strengths are the section capacity and member capacity in bending and shear. Axial forces may also require consideration for skewed joints or where $T^u$ is significant.
The capacity reduction factor ($\phi_u$) must be as follows:

- 0.9 for structural steel members
- 0.8 for bolted connections
- 0.9 for SP Category complete penetration butt welds
- 0.8 for SP Category fillet welds
- 0.85 for shear stud connectors

For details not included in the above, refer to Table 3.2 of AS 5100.6.

The strength is based on the nominal yield stress ($f_y$) and tensile strength ($f_u$). For materials supplied to Australian standards, adopt the values in Table 2.1 of AS 5100.6. Where materials are supplied to other standards, such as ASTM, adopt the values in these standards. Comply with the minimum values of $f_y$ specified in Clause 3.3.

Satisfy Clause 5.2 of AS 5100.6 for the section capacity in bending.

Satisfy Clause 5.6 of AS 5100 for the member capacity of centre beams and support bars. Let the effective lengths of the members be as follows:

- For support bars, the length between centres of bearings at joint opening $J_u$.
- For overhanging portions of centre beams, twice the length of the cantilever.
- For internal spans of centre beams, 0.7 times the span for centre beams welded to support bars and 1.2 times the span for centre beams connected to support bars by yokes.

Check the shear capacity in accordance with Clause 5.10 of AS 5100.6.

Requirements for bolted, pin and welded connections are in Section 12 of AS 5100.6.

E11.3 Limit State of Serviceability

The requirements for noise and vibration, as outlined in relevant portions of this Specification comprise the serviceability requirements.

The capacity reduction factor ($\phi_s$) must be 1.0 for structural steel members.

Check the capacity of bearings for the serviceability limit state.

E12 Fatigue Limit State Details

Calculate the stress ranges causing fatigue by applying the following loads to the MBEJ model:

\[
Q^*_f = \gamma_f \beta_f \chi_f W \\
H^*_f = \gamma_f \beta_f \eta W \\
T^*_f = \gamma_f \beta_f \tau W \quad \text{if applicable}
\]

(E.15a)  
(E.15b)  
(E.15c)

E12.1 Centre Beams

The longitudinal bending stress due to vertical and horizontal loads $Q^*_f$ and $H^*_f$, plus the axial stress due to $T^*_f$, if any, must comply with Item 1 in Table B316/E.1.
If centre beams are spliced, the fatigue stress in the butt weld must be as per Item 5 in Table B316/E.1.

If yokes are connected by bolts to the centre beams, the stresses in the centre beams must be based on the net section at the bolt holes. The stress range in the centre beam at the bolt hole must be limited as per Item 3 in Table B316/E.1.

**E12.2 Support Bars**

Design support bars for the maximum loads transmitted by their individual centre beams in a multiple support bar system, or for the total wheel load transmitted through 3 centre beams, in a single support bar system. Consider any forces that may arise from deformations of the elastomers and frictional resistance within the MBEJ.

The stress range in the base metal of the support bar must comply with Item 1 in Table B316/E.1.

To enable the support bar to slide smoothly between its support bearings, the support bar may have stainless steel sliding plates welded to its top and bottom surfaces. If the welds are for the full length of the support bar, the maximum stress range must comply with Item 4 in Table B316/E.1, whereas if the welding is near the supports only, with Item 9 in Table B316/E.1.

**E12.3 Welded Connection Between Support Bar and Centre Beam**

All dimensions of the weld connecting the centre beam to the support bar in MSBJ systems must be detailed on the drawing.

Check the resultant of the vertical and horizontal stresses in the weld, due to the design load, for the three effects, A, B and C, listed below. Position the A160 axle on the centre beam for the maximum effect in each of the three cases.

A Resultant stress at the interface of the weld and soffit of the centre beam.

B Resultant stress at the interface of the weld and the top of the support bar.

C Resultant stress at the throat of the weld between the centre beam and the support bar.

**Note:** The above stresses are designated as stresses due to Type A, Type B and Type C cracking, respectively, in the NCHRP 402 Report and the method given in this reference may be followed for design. The welded connection is classified as AASHTO Category C, which is approximately equivalent to Item 6 in Table B316/E.1.

**E12.4 Yoke and its Connections**

In a SSB MBEJ system the connection between the centre beam and support bar is through a yoke, which enables a sliding joint. All components of the yoke system must be designed to resist the fatigue stress cycles generated in the system by application of the loads $Q^*$, $H^*$ and $T^*$ in Equations 15(a) to (c). If any pre-compression is applied to the yoke bearings it must be ensured that the pre-compression is not lost due to stress cycles caused by the above loads.

It must be demonstrated that the yoke system has the ability to resist the horizontal forces together with overturning moments due to application of the above loads, without causing instability or fatigue failure of any component or connection. (Advantage may be taken of the dynamic characteristics of the system, by employing Method 3 of Clause E10, to account for the reduction in longitudinal force experienced by the system due to the short duration of the applied load).

Alternatively, the adequacy of the yoke system must be demonstrated by performance testing.

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E12.4.1 Bolted Yoke Connection

Where the yoke is connected to the centre beam by bolts, a tensile force \( Q_{up}^* \) must be applied to the bolts, given by

\[
Q_{up}^* = \gamma f \beta f \chi_{up} R \tag{E.16}
\]

where \( R \) is the maximum support reaction due to the static A160 axle loads.

The stress range in the bolt due to the force \( Q_{up}^* \) must not exceed 0.3 times the pre-tension in the bolt.

Only high strength bolts complying with 8.8/TF bolting category of AS 5100 (friction grip connection) are acceptable.

E12.4.2 Welded Yoke Connection

Where the yoke members are connected to the centre beam by complete penetration butt welds, the nominal stress range at the welded connection must be the sum of the longitudinal stress ranges resulting from horizontal and vertical bending of the centre beam. The effects of forces in the yoke need not be added. The stress range at the weld must comply with Item 7 in Table B316/E.1. Fillet welded connections are not acceptable.

E12.4.3 Welded Plates for Sliding Surfaces

The contact surfaces between the support bar and centre beam may require a special sliding arrangement. If the sliding device is welded to the edges of the centre beam by short lengths of longitudinal fillet welds, the flexural stress range in the centre beam at the weld location must be limited as per Item 9 in Table B316/E.1, whereas for continuous welds it must comply with Item 4 in the table.

E12.5 Spring Buffer Attachments

Where equidistancing spring buffers are attached to the centrebeam by welded cleats, the nominal stress range at the welded connection must be the sum of the longitudinal stress ranges resulting from horizontal and vertical bending of the centre beam. The effects of forces in the equidistancing buffers due to thermal movements need not be added. The stress range at the weld must comply with Item 10 in Table B316/E.1.

E12.6 Replaceable Items

Design replaceable items for fatigue as follows:

(a) Where a joint of similar type with the same replaceable components (materials, manufacture, design) has sustained 70 hours under the test regime described in NCHRP Report 467, no further design is required.

(b) For all other cases, design the component to resist the design number of stress cycles calculated as:

\[
n_{dc} = 500,000 (N_c + n_e) DL \tag{E.17}
\]

where:

\[
\begin{align*}
n_{dc} & = \text{the design number of stress cycles caused by the design load}, \\
N_c & = \text{the number of centre beams supported on a support bar},
\end{align*}
\]
\[ n_e = \text{the number of effective cycles of vibration following excitation and can be derived using the method shown in Annexure B316/L; and} \]

\[ D_L = \text{the design life of the component in years.} \]

**E12.7 Other Types of Connections**

MBEJ designers are free to develop appropriate details and connections. Submit all calculations for checking to the Principal. All designs and details will be treated as Commercial-in-Confidence. Fatigue detail categories that cannot be classified in accordance with AS 5100.6 must be supported by authoritative references for the cut-off limit stress adopted.

**E13 STRENGTH LIMIT STATE DETAILS**

**E13.1 Centre Beams**

If centre beams are subjected to significant axial force, which may arise if the joint is skewed or the transverse force is significant, check their capacity for axial load with biaxial bending in accordance with Clause 11 of AS 5100.6.

**E13.2 Edge Beams**

Edge beams must be adequately anchored into the concrete and the anchors must be able to resist an ultimate horizontal force 60 kN per metre length of the edge beam.

Design the section of the edge beam which spans across the openings of the support boxes, in accordance with Clause E13.3.

**E13.3 Support Boxes**

The top plate of each support box must be designed to carry an ultimate load given by

\[ P^* = \gamma_u \chi_o W \quad \text{(E.18)} \]

Hence

\[ P^* = 1.8 \times 1.6 \times 80 = 230 \text{ kN} \]

This load may be distributed over an area of \((L_o+t)\times(B_o+t)\), where \(t\) is the thickness of the overlying concrete and permanent surfacing layer. Composite action with the overlying structural concrete and the edge beam may be taken into consideration, provided all connections and shear studs are adequately designed for this.

On the three sides of each support box, adequate shear studs must be provided to transfer the vertical load \(P^*\) and its horizontal components \(\eta P^*\) and \(\tau P^*\) into the surrounding concrete, without assuming any support at the base of the box.

The bottom plate of the support box must be designed to carry one-third (\(\frac{1}{3}\)) of the maximum ultimate bearing reaction of the support bar, treated as a uniformly distributed load, by spanning between the three sides of the support box without any support from the underlying concrete. (This requirement is based on the observation that concrete under the support box is often difficult to consolidate and may contain voids).
E13.4 Connections

Check all connections, whether by bolts, screws, pins or welds, for the strength limit state in accordance with Section 12 of AS 5100.6.

For the strength limit state, assume that the loads $Q^*$, $H^*$, and $T^*$ act concurrently. Calculate the stresses due to vertical and horizontal bending of the centrebeam or support bar and the stresses at connections such as welds of yokes or equidistancing buffer cleats. Calculate the resultant stress by means of Equations E.13 or E.14 and show that it is less than the design strength of the weld or parent material, whichever is lower.

E14 Serviceability Limit State Details

E14.1 Structural

Check bolts or screws acting in friction grip mode for serviceability loads in accordance with AS 5100.6 Clause 12.5.4, in addition to strength.

If shear connectors are provided, design them for the serviceability limit state in order to comply with Section 6 of AS 5100.6.

For noise requirements refer Clause 3.8.

For vibration damping requirements refer Item (c) of Clause 3.3.

E14.2 Elastomeric Bearings

Report the physical properties of the elastomer used: durometer hardness, shear modulus and bulk modulus.

Design elastomeric bearings to resist serviceability loads and movements, in accordance with AS 5100.4 Clause 12.

The stiffness of the bearings may be either:

(a) Derived by calculation in accordance with Clause 12 of AS 5100.4, if analysis by Method 1 of Clause E10 is adopted; or

(b) Obtained by testing in accordance with Clause L2(b) if analysis by Method 2 or Method 3 is adopted.

Derive the stiffnesses of the spring supports for the analytical model from the combined stiffness of bearings provided for the support bars.
ANNEXURES B316/F TO B316/K – (NOT USED)

ANNEXURE B316/L – OUTLINE OF TEST PROCEDURE FOR EXPERIMENTAL MODAL ANALYSIS

L1 TEST DESCRIPTION

The measurement and definition of the natural frequencies and mode shapes of a structure is referred to as Modal Analysis. The general test etiquette and methodology for such analysis is described below (see also reference by Ewins D J in Annexure B316/M1). The main aims of the test described below are to determine the mode shapes, natural frequencies, modal damping and Dynamic Amplification Factor (DAF) for the MBEJ System plus the dynamic compression stiffness and damping factors of the bearings and pre-compression springs, under a simulated load case. Data obtained from an experimental modal analysis must be used to calibrate any dynamic finite element (FE) method model developed to assist in the fatigue design of project specific modular joints. This is seen as being a two-part process. Firstly, the dynamic FE model must accurately represent the mode shapes and modal frequencies from the experimental study and, secondly, the FE model must be able to duplicate measured static and dynamic strain gauge results. Matching the dynamic strains may require some adjustment to the applied wheel load. This “adjustment” is in effect an additional “calibration factor”.

L2 MEASUREMENT OF FREQUENCY RESPONSE FUNCTIONS

L2.1 MBEJ System

These measurements involve the simultaneous measurement of input force and vibration response. In these tests, force, over the frequency range of interest, must be imparted to the structure using a suitable shaker or force hammer. The shaker must be connected to the structure via a force transducer. The vibration response must then be measured at selected locations using at least one accelerometer attached to the structure with a magnetic base or other suitable attachment method. In the case of in-situ modal testing, the measurements must only be conducted in the absence of traffic crossing the expansion joint. Where measurements are undertaken on an expansion joint at the place of manufacture, great care must be exercised to ensure that the boundary conditions closely match those of an installed joint.

A “dynamically similar” modular joint is one in which the design (single support bar or multiple support bar, etc.), bearings, pre-compression springs, centering mechanism and structural steel components are identical to the joint proposed in conformance with this specification. However, the spacing of support bars and the number of centre beams does not need to be identical.

The input force and vibration response at each location must be simultaneously measured using a minimum two-channel FFT analyser. Frequency Response Functions (FRF’s) must then be stored for each measurement.

A minimum of 100 measurement locations are considered necessary to adequately define relevant MBEJ System mode shapes (unless otherwise justified). The extent of measurements must include at least two bays of the expansion joint. (In this context, a “bay” is defined as the space between two consecutive support boxes).
Measurements must be in three component directions (i.e. vertical, transverse and longitudinal) at each location. Simultaneous measurement at all (minimum 100) locations is not necessary and simultaneous two channel measurements at a time are acceptable (i.e. Channel A – Reference Accelerometer, Channel B – Roving Accelerometer or Force Hammer).

**L2.2 Bearings & Pre-compression Springs**

The bearings and pre-compression springs to be tested, must be placed in a suitable test apparatus as follows:

**L2.2.1 Test Procedure:**

Support the under side of the test bearings on a rigid flat surface with a vertical stiffness of at least 10 times that of the test bearings.

Arrange the test bearings to support a test mass in a stable manner. For a typical bridge MBEJ the test mass must equal a nominal 600 kg per test bearing. (i.e. a 2400 kg test mass supported evenly by four test bearings would be suitable).

**L2.2.2 Alternative Test Procedure No.1:**

As an alternative to the above test apparatus, a two mass arrangement may be used. A base mass is supported on soft springs upon which the primary mass is mounted via test bearings. The natural frequency of the primary suspension mode must be less than 6 Hz. The dynamic stiffness and damping properties are extracted from the second vertical bounce mode, i.e. out of phase motion of the primary and base masses. Details of the dynamic stiffness property calculations must be fully documented in the test report.

**L2.2.3 Alternative Test Procedure No.2:**

The following test procedure is also available as an alternative:

(i) Mount a suitable rigid mass, i.e. solid steel block (nominal mass to be supported by each bearing assembly, e.g. 100 kg), in a suitable test frame;

(ii) Arrange the test frame to mount the test mass on top of the test linear bearing and below the test top spring. A hydraulic jack or suitable calibrated preload device must be mounted in series;

(iii) Apply the nominal design pre-load prior to dynamic testing;

(iv) Carry out modal testing of test mass in sufficient detail to identify the fundamental bounce mode of the test mass suspended between the test bearings;

(v) Extract dynamic stiffness and damping for test bearing set;

(vi) Simultaneously measure the input force and vibration response at each location using a minimum two-channel FFT analyser. Frequency Response Functions (FRF’s) must then be stored for each measurement.

The test frame must be a minimum ten times stiffer than the combined stiffness of the test bearing set, (i.e. the test frame and preload device must not significantly contribute to the controlling stiffness of the target bounce mode).

A minimum of four measurement locations are considered necessary to adequately define relevant mode shapes (unless otherwise justified). Measurements must be in three component directions (i.e. vertical, transverse and longitudinal) at each location.
An example of a typical measurement instrumentation set-up for all dynamic tests is shown in Figure B316.6.

**L3 EXTRACTION OF MODAL PARAMETERS**

This must be achieved by processing the FRF measurements with suitable modal analysis software such as SMS STARStruct® or equivalent.

The stages in this process must be:

(i) Identify the first 5 vertical modes;

(ii) Curve fit FRF measurements and produce modal parameters (frequency and damping tables, mode shape tables);

(iii) Animate and display the mode shapes;

(iv) Animate and display the mode shapes again within the modal software by entering the three dimensional coordinates of all measurement points to produce a line drawing of the structure;

(v) Superimpose the resulting residues (from the shape tables above) on the line drawing and animate for viewing.

**L4 ANALYSIS AND REPORT**

The above resulting Natural Mode Data must be used in order to determine:

(a) an understanding of the dynamic response of the structure under actual vehicle pass-by excitation; and

(b) an understanding of the dynamic amplification factors, (DAF) which may contribute to the structural failures (e.g. weld cracking at centre beam to support bar connection).

In the determination of the DAF, consideration must be given to:

(i) the mode shapes involved;

(ii) the modal damping for critical modes;

(iii) the wheel pass frequency range;

(iv) the vehicle speed and axle spacing for multi-axle vehicles;

(v) the structural continuity of the joint system;

(vi) the damped natural frequency of the fundamental bounce mode of the test mass for the bearings and the pre-compression springs;

(vii) the damping factors associated with the bearing and pre-compression spring modes;

(viii) the dynamic compression stiffness for the bearings, and the pre-compression springs.

The test report must detail all test procedures, conclusions and recommendations, including detailed steps used in the determination of the modal parameters.

**Note:** In the case of insitu testing, the determination of the DAF range may be assisted by component vibration measurements under traffic excitation, i.e. traffic response vibration tests.
The test report must detail all test procedures, conclusions and recommendations, including detailed steps used in the determination of the DAF range. The test report must also provide full size A4 plots (landscape) of representative FRF’s for every natural mode identified (magnitude and phase).

Where the DAF assessment produces a probable range of values, the design DAF must be calculated as follows:

\[
\chi_{mod} = \left( \frac{3 \chi_{UB} + \chi_{LB}}{4} \right)
\]  

(L.1)

where \( \chi_{UB} \) and \( \chi_{LB} \) are the upper and lower bound values of the DAF.

Animation and display of mode shapes must be achieved again within the modal software by entering the three dimensional coordinates of all measurement points to produce a line drawing of the structure.

The resulting residues (from the shape tables above) must then be superimposed on the line drawing and animated for viewing. The main purpose of mode shape animation in these tests is to identify whole body and flexural modes of the MBEJ System and to positively identify the fundamental bounce mode of the bearing test mass.
Figure B316.6 - Example of a Typical Measurement Instrumentation Set-up
ANNEXURE B316/M – REFERENCED DOCUMENTS AND ACRONYMS

Refer to Clause 1.2.7.

M1 REFERENCES

RMS QA Specifications

RMS Q  Quality Management System
RMS B201  Steelwork for Bridges
RMS B220  Protective Treatment of Bridge Steelwork
RMS B282  Confined Elastomeric (Pot Type) Bearings
RMS B315  Elastomeric Strip Seal Expansion Joints

Australian Standards

AS 1101.3  Graphical symbols for general engineering - Welding and non-destructive examination.
AS 2702  Acoustics – Methods for the measurement of road traffic noise
AS 2812  Welding, brazing and cutting of metals - Glossary of terms
AS 5100  Bridge design
AS 5100.2  Part 2: Design loads
AS 5100.4  Part 4: Bearings and deck joints
AS 5100.6  Part 6: Steel and composite construction

Joint Australian/New Zealand & ISO Standards

AS/NZS 1100.501  Technical drawing – Structural engineering drawing
AS/NZS 1554  Structural steel welding
AS/NZS 1554.1  Part 1: Welding of steel structures
AS/NZS 1554.5  Part 5: Welding of steel structures subject to high levels of fatigue loading
AS/NZS 2312  Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS/NZS ISO 9001  Quality management systems - Requirements

Other Documents

ASTM D5973  Standard Specification for Elastomeric Strip Seals with Steel Locking Edge Rails Used in Expansion Joint Sealing
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Modular Bridge Expansion Joints


WTIA Technical Note 5 “Flame Cutting of Steels”


M2 ACRONYMS

NATA National Association of Testing Authorities, Australia
NCHRP National Cooperative Highway Research Program
RMS Roads and Maritime Services
MBEJ Modular Bridge Expansion Joint
MSBJ Multiple Support Bar Modular Joint
SSBJ Single Support Bar Modular Joint
DAF Dynamic Amplification Factor
DLA Dynamic Load Allowance