Guidelines for the evaluation of bridge deck joints
**Title:** Guidelines for the evaluation of bridge deck joints.

**Authors:** WJvdM Steyn, D Silbernagl, P Nordangen

**Client:** Agrément South Africa

**Project No:** TIM12

**Client Reference No:** OE2: 9433: Infrastructure Systems

**Date:** July 2001

**Abstract:**

CSIR Transportek was contracted by SANRAL and Agrément SA to develop a guideline for the evaluation and certification of bridge deck joints in South Africa. This report serves as the final report for the project. It provides the necessary guidelines and also incorporates information regarding bridge deck joint types and quality assurance procedures. The document should be used by Agrément SA to base evaluations for bridge deck joint certification on.

**Keywords:** Bridge deck joints, Agrément, certification

**Proposals for implementation:**

This document should be used as a guideline for evaluating applications for certification of bridge deck joints by Agrément South Africa.

**Related documents:**

None

**Signatures:**

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<td>Technical Reviewer</td>
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EXECUTIVE SUMMARY

SANRAL and Agrément SA set up a steering committee to investigate the problem of bridge deck joint performance, as SANRAL observed these joints to fail and was of the opinion that road authorities are not positioned to accredit any joints. They required a method by which bridge deck joints (both new and existing) could be evaluated before installation to obtain indications on their suitability for the specific project. Agrément SA provides a service in South Africa to assist with development and enforcement of guidelines for non-standard products.

The steering committee contracted CSIR Transportek together with consultants as the project team to investigate the problem and ultimately to develop the guidelines to be used when evaluating bridge deck joints for Agrément certification. The objectives of the subsequent study were to:

1. Identify the types of bridge deck joints typically found in South Africa;
2. Identify criteria for evaluation of bridge deck joint suitability;
3. Identify suitable tests/specifications to evaluate the defined bridge deck joint criteria, and
4. Develop a guideline for evaluation of bridge deck joints.

A draft guideline was developed indicating the process to be followed by evaluators when a manufacturer applies for Agrément certification of bridge deck joints. In these guidelines the various issues to be investigated by the evaluators are indicated, and the typical criteria that each type of joint has to adhere to are described. Test and specification information is also supplied. In this final report, the final guidelines for certification of bridge deck joints in South Africa by Agrément SA are provided. It is intended that this document serve as the main reference for referees during the certification process.

The recommended criteria, specifications and test methods for bridge deck joints are provided from which evaluators have to select the most appropriate one for the specific joint. The reason for this approach is that joints differ in small details, and specifications or test methods that may be appropriate for one joint may not be appropriate for another joint, although they are of similar type. It is recommended that Agrément SA implement the guidelines for the certification of bridge deck joints.
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1. INTRODUCTION

This report describes the project on the development of evaluation criteria for bridge deck joints in South Africa. The project was funded by Agrément South Africa and the South African National Roads Agency (SANRAL) with time inputs from other parties, and conducted by CSIR Transportek. The objectives of the project were to:

1. Identify the types of bridge deck joints typically found in South Africa;
2. Identify criteria for evaluation of bridge deck joint suitability;
3. Identify suitable tests/specifications to evaluate the defined bridge deck joint criteria, and
4. Develop a guideline for evaluation of bridge deck joints.

It falls within the scope of this report to provide information on the following issues:

1. The preliminary work performed during development of these guidelines;
2. The guidelines for evaluating bridge deck joints according to the Agrément regulations, and
3. Related information required in understanding the above issues.

It falls outside the scope of this report to investigate the following issues:

1. Development of new tests to evaluate aspects of bridge deck joint performance, and
2. Investigation of the appropriateness of various tests and standards through physical testing.

It is important to understand the process that led to this report. SANRAL and Agrément SA set up a steering committee to investigate the problem of bridge deck joint performance as SANRAL observed these joints to fail and was of the opinion that road authorities are not positioned to accredit any joints. They therefore required a method by which bridge deck joints (both new and existing) could be evaluated before installation to obtain indications on their suitability for the specific project. Agrément SA provides a service in South Africa to assist with development and enforcement of guidelines for non-standard products.

The steering committee selected CSIR Transportek, together with consultants, as the project team to investigate the problem and ultimately to develop the guidelines to be used when evaluating bridge deck joints for Agrément certification. Over a period of approximately 1 year the project team worked on the problem and regularly informed the
steering committee of progress on the project. Through this process two intermediate reports were prepared (Steyn et al, 2000a; Steyn et al, 2000b) and various comments were received from the steering committee. These two reports are shown in this document as Appendices A and B. The two reports were sent to international reviewers to provide an objective view of the work performed (Appendix C).

After positive comments were received from these reviewers, a draft guideline was developed indicating the process to be followed by evaluators when a manufacturer applies for Agrément certification of bridge deck joints. In these guidelines the various issues to be investigated by the evaluators are indicated, and the typical criteria that each type of joint has to adhere to are described. Test and specification information is also supplied.

In this final report, the final guidelines for certification of bridge deck joints in South Africa by Agrément SA are provided. It is intended that this document serve as the main reference for referees during the certification process.
2. GUIDELINES FOR CERTIFICATION OF BRIDGE DECK JOINTS

2.1. INTRODUCTION

This part of the report contains the detailed guidelines to be used by evaluators when evaluating bridge deck joints submitted for certification by Agrément SA. The philosophy is to provide a framework document in which the main parameters for the evaluation of a joint for certification are provided as well as guidelines for evaluation of a joint against these parameters. It is the responsibility of the applicant to provide Agrément with all the relevant information in the application.

The framework focuses on identification of the relevant parameters, guidelines on important information that needs to be included in the application as well as evaluated and expected ranges for the parameters to be evaluated.

Information provided by DSC-ZENDON, RADFLEX and FEDERAL MOGUL CORPORATION in South Africa was also used in the development of the guidelines.

2.2. DESCRIPTION OF GUIDELINES

The applicant must supply a complete description of the joint to be certified, including drawings and material properties. Confidential information must be clearly marked as such. The following information must be supplied:

2.2.1 Applicant's affiliation
The relationship between the applicant and the joint (i.e. manufacturer, supplier, installation contractor etc) should be indicated. The applicant's relationship with the manufacturer / supplier / installation contractor etc should be indicated.

2.2.2 Brand name
The brand name should indicate the name normally used when supplying the joint commercially.

2.2.3 Description of joint
The description of the joint should provide a short (1 paragraph) description of the joint. No details to be supplied.
2.2.4 Generic joint type

The generic joint type under which the specific joint classifies should be selected from the following list:

1. Buried expansion joints
   - With anchorage
   - Without anchorage
2. Flexible plug expansion joints
   - Asphalt
   - Polymer
3. Nosing expansion joints
   - Without metallic edge beams
   - With metallic edge beams
4. Modular expansion joints
   - Single seal
   - Multiple seal
5. Mat expansion joints
   - Single mat
   - Multiple mat
6. Cantilever expansion joints
   - Cantilever finger
   - Cantilever comb
7. Supported expansion joints
   - Sliding plate
   - Sliding finger
   - Multi-section roller shutter
8. Special joints

Typical photos of each of these categories of joints are shown in Appendix D and a short description is provided here below, together with an indication of its use in South Africa:

**Buried expansion joints** (widely used for nominal movements):
This expansion joint is formed in-situ using components such as waterproofing membranes or an elastomeric pad to distribute the generally nominal movements over a wider area of the surfacing, which is continuous over the joint gap.

**Flexible plug expansion joints** (widely used for small movements):
This type of expansion joint consists of a layer of specially formulated flexible material (binder and aggregates), which can accommodate the movement via a bridging plate...
over the gap and an optional de-bonding strip, through the thickness of the layer to the riding surface.

**Nosing expansion joints** (widely used for small to medium movements, especially in the past, in combination with neoprene compression seals):
This expansion joint consists of an edge strip of concrete, resin or elastomeric material with or without armoured edges. The sealing element (poured sealant or pre-formed elastomeric material) accommodates the required movement.

**Modular expansion joints** (presently used almost exclusively for medium to large movements):
This expansion joint consists of two edge profiles and series of supported intermediate beams and seals in a modular way to accommodate the movements of the joint. The edge profiles are generally cast into a nosing of the structure and the supports for the intermediate members typically consist of beams with neoprene springs or pantograph type structures, which also control the equal movement of the joint gaps.

**Mat joints expansion** (some usage in the past - for small to medium movements, but experience general problems with bolt-down type anchorage):
Also known as elastomeric cushion expansion joint and typically bolted down. This expansion joint uses the elastic properties of an elastomeric pad/ gland combination to accommodate the movements of the joint.

**Cantilever expansion joints** (some usage in the past - for medium to large movements, especially the finger type):
This expansion joint consists of elements (comb or saw-tooth plates or fingers) that are anchored on the one side of the joint gap and cantilever over the gap, inter-linking with similar elements from the other side.

**Supported expansion joints** (some usage in the past - for medium to large movements, especially the finger- and roller shutter type):
This type of joint consists of one principal component which is anchored on the one side of the joint gap and vertically supported on the other side. The required movement of the joint is accommodated by sliding action on the non-anchored side.

**Special joints**
Joints, which do not belong to any of the above categories.
2.2.5 Manufacturer
The manufacturer of the joint should be indicated together with contact details and manufacturing plant details. It must be clearly indicated whether the joint is:

1. Locally manufactured under licence from an international firm;
2. Internationally manufactured and imported as a unit;
3. Locally manufactured by a local supplier, or
4. Partially manufactured internationally and partially locally.

2.2.6 Status of local agent / supplier / manufacturer
The status of the local end-supplier of the joint should be indicated in terms of:

1. Local licensed agent;
2. Sole supplier, or
3. Sole manufacturer.

2.2.7 Engineer drawings
A complete set of engineer’s drawings of the joint and details for the joint should be supplied.

2.2.8 Specifications of all relevant components
Detailed specifications of all components and assemblies (where applicable) of the joint should be supplied. These specifications should include the component description, material, test criteria and test results.

2.2.9 Manufacturer experience
The manufacturers experience in terms of supplying / manufacturing / installation of bridge deck joints in general should be supplied. Information such as the number of years in business, number of joints manufactured / supplied / installed, and the experience with the specific joint for which the application is submitted should be provided.

2.2.10 Joint history
The history of the joint for which the application is made should be provided. This should address issues such as:

1. Who developed the original joint;
2. Is this the original, a modification or a copy of a specific joint;
3. The number of these joints already in service (indicate where joint and components were manufactured);
4. The number of years the joint has been in service, and
5. Information on specific sites and the number of years in service.

Any specific problems encountered with the specific joint should be indicated.

2.2.11 Joint warrantee / guarantee

An indication should be provided of any warrantee and / or guarantee supplied for the specific joint. The conditions under which the warrantee and / or guarantee is supplied should also be stipulated. The details regarding the warrantee and / or guarantee should be clearly stipulated.

2.2.12 Expected service life

An indication of the expected service life for the joint should be provided. This information should be based on existing experience of the joint’s performance.

2.3. CRITERIA USED FOR GUIDELINES

The applicant must supply proof (through acceptable test certificates) that the joint adheres to the criteria listed in Tables 1 to 8.

Two types of criteria are supplied. The first type is product specification criteria which are provided to identify the product and its components, and to ensure that the various components of the joint adhere to acceptable specifications. During the certification process the applicant should indicate to Agrément SA which materials are used in his product, and the acceptable criteria and values for each of the criteria indicated. These submitted values and criteria would then be evaluated by Agrément SA to ensure that all appropriate criteria are included and that the values indicated by the applicant are sufficient to ensure that the product is of acceptable quality.

The second criteria type is performance criteria. These criteria indicate the absolute criteria to which the various joints should adhere. For these criteria the applicant may not select his own applicable parameters, but has to supply proof that his product adheres to the stated criteria. If such proof cannot be supplied, a representative sample of the joints must be supplied for evaluation by Agrément, at the applicant’s cost.

The following specifications will apply:

- COLTO: Standard Specifications for Road and Bridge Works for State Road Authorities:
  - Section 6200: Falsework, formwork and concrete finish
  - Section 6300: Steel reinforcement for structures
- Section 6400: Concrete for Structures
- Section 6600: No-fines concrete, joints, bearings, bolt groups for electrification, parapets and drainage for structures
- Section 6700: Structural steelwork.
Table 1: Product specification for metallic components.

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<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
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<tr>
<td>Metals</td>
<td>Beams</td>
<td>BS 4360</td>
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<td>Shear connector</td>
<td>SABS 1431</td>
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<td>Cover plate specification</td>
<td>ASTM A108</td>
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<td>Edge beam</td>
<td>ASTM A240</td>
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<td>Centre beam</td>
<td>ASTM A480</td>
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<td>Connecting piece</td>
<td>ASTM A480M</td>
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<td>Support bar</td>
<td>ÖNORM M 3116</td>
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<td>Sliding plate</td>
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<td>Sliding spring</td>
<td>S355J2G3</td>
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<td>Sliding bearing</td>
<td>DIN 17100 (Extruded profiles)</td>
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<td>Reinforcing steel</td>
<td>BS 5135 (Welding)</td>
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<td>Intermediate beam</td>
<td>SABS 763 (Galvanizing)</td>
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<td>Joist box</td>
<td>SABS 675:1993 (Zinc coated wire)</td>
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<td>Joist beam</td>
<td>BS 5493: 1977 (Corrosion)</td>
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<td>Bolts and washers</td>
<td>SABS (Paint)</td>
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<td>Shuttering plate</td>
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<td>Anchors</td>
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<td>Control spring cover</td>
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<td>Control spring connection plate</td>
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<td>Extruded profile</td>
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<td>Structural steel plates</td>
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<td>Expanded metal reinforcement</td>
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<td>Zinc-coated wire</td>
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<td>Backer rods</td>
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<td>Bridging plate</td>
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Table 2: Product specification criteria for liquid sealants

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<th>LIST OF APPROVED TESTS</th>
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<td>Liquid sealants</td>
<td>Silicone sealant</td>
<td>Federal specification TT-S-001543A Class A (expansion and contraction - rubber)</td>
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<td>Bitumens for sealing purpose</td>
<td>ASTM C920 (expansion and contraction - elastomeric)</td>
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<td>Polyurethane</td>
<td>Canadian Specification 19GP9 Type 1</td>
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<td>Polysulphide</td>
<td>FAA Engineering Brief Number 36 – Silicone joint sealants</td>
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<td>ASTM D2240 / ISO 868 (Durometer shore hardness)</td>
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<td>ASTM C920 (Flow/ sag/ slump)</td>
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<td>ASTM C920 (Extrusion rate)</td>
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<td>ASTM C920 (Tack-free time)</td>
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<td>Resilience</td>
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<td>ASTM C510-90 (Staining and colour change of single or multi-component joint sealants)</td>
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Table 3:  Product specification criteria for rubber extrusions

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<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber extrusions</td>
<td>Continuous seal&lt;br&gt;Elastomeric sliding springs&lt;br&gt;Sliding bearing pads&lt;br&gt;Replaceable sealing strip&lt;br&gt;Strip seal&lt;br-Control spring&lt;br&gt;Unsupported extrusions&lt;br&gt;EPDM (Ethylene Propylene Diene Modified)&lt;br&gt;EPDM compression seal&lt;br&gt;Steel reinforced EPDM nosing&lt;br&gt;Neoprene&lt;br&gt;Replaceable sealing strips&lt;br&gt;Glands&lt;br&gt;Adiprene&lt;br&gt;Polyoxymethylene&lt;br&gt;Polychloroprene rubber&lt;br&gt;Chloroprene rubber&lt;br&gt;Cellular polyurethane</td>
<td>Specific gravity&lt;br&gt;Elongation @ break&lt;br&gt;Tensile strength&lt;br&gt;ASTM C920 (Colour)&lt;br&gt;Composition&lt;br&gt;Temperature range&lt;br&gt;ASTM C920 (extrusion rate)&lt;br&gt;ASTM C920 (hardness)&lt;br&gt;SABS 1023 (Seal recovery)&lt;br&gt;ASTM D2240 / ISO 868 (Durometer shore hardness)&lt;br&gt;German BMV Test 2 code (strip seal)&lt;br&gt;ISO 3302 Class E (unsupported extrusions)&lt;br&gt;ASTM C920 (expansion and contraction - rubber)</td>
</tr>
</tbody>
</table>
Table 4: Product specification criteria for bituminous binders

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bituminous binders</td>
<td>Polymer modified bitumens</td>
<td>ASTMD36-86 (softening point)</td>
</tr>
<tr>
<td></td>
<td>Modified bitumen</td>
<td>ASTM D5 (Penetration)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D-1190 (Cone penetration)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Density)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brookfield (Viscosity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Filler content)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Impact)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Peel)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Sag)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PhØnix (Ageing)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4147 (Bend)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DIN 52013 (Ductility)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM D-1190 (Flow resistance)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flash point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSP 3/1</td>
</tr>
</tbody>
</table>
### Table 5: Product specification criteria for aggregates

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate</td>
<td>Aggregate for concrete</td>
<td>SABS 1083</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 845</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 718</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSP 3/1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 1200M 1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TMH1 Method B3 (flakiness index)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 841 (aggregate crushing value)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 829 (grading)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 845 (void content)</td>
</tr>
</tbody>
</table>
### Table 6: Product specification criteria for polymers and monomers

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer</td>
<td>Joist box shuttering plate</td>
<td>Density</td>
</tr>
<tr>
<td>Monomer</td>
<td>PVC plate</td>
<td>ASTM D2240 / ISO 868 (Durometer shore hardness)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tensile strength</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elongation @ break</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tear resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardness change after ageing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tensile strength after ageing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elongation @ break after ageing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard detergent test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard HCl test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard NaOH test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 PPM @ 40±2°C 96 hours 20% elongation (ozone resistance)</td>
</tr>
</tbody>
</table>
Table 7: Product specification criteria for concrete

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>LIST OF COMPONENTS</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td></td>
<td>Density (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td>Cement matrix</td>
<td></td>
<td>Tensile strength (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td>Cement</td>
<td>Elongation @ break (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td>Filler</td>
<td>Compression (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td>Elastomeric modifiers</td>
<td>Tear resistance (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td>Concrete</td>
<td>Hardness change after ageing (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tensile strength after ageing (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elongation @ break after ageing (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard detergent test (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard HCL test (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volume change after standard NaOH test (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ozone resistance (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compressometer (flexibility) (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Slump (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement content (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gel time (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Curing time (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 626 (Portland blast furnace cement) (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SABS 471 (Portland cement and rapid-hardening Portland cement) (\text{ASTM D2240 / ISO 868 (Durometer shore hardness)})</td>
</tr>
</tbody>
</table>
Table 8: Performance criteria for bridge deck joints

<table>
<thead>
<tr>
<th>MATERIAL / COMPONENT</th>
<th>LIST OF CRITERIA</th>
<th>LIST OF APPROVED TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic load</td>
<td>BS 5400</td>
<td>BS 5400 Part 10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RVS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue load</td>
<td>BS 5400 Part 10</td>
<td>RVS</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact load</td>
<td>No current test approved</td>
<td></td>
</tr>
<tr>
<td>Resistance to reaction forces</td>
<td>RVS</td>
<td></td>
</tr>
<tr>
<td>Shape stability</td>
<td>RVS</td>
<td></td>
</tr>
<tr>
<td>Deformation</td>
<td>No current test approved</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>No current test approved</td>
<td></td>
</tr>
<tr>
<td>Waterproofing</td>
<td>Dyke and pond with water after installation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to a depth of 50 mm for &gt; 4 hours.</td>
<td>No visible signs of leakage.</td>
</tr>
<tr>
<td>Ageing</td>
<td>No current test approved</td>
<td></td>
</tr>
<tr>
<td>Movement range (including racking)*</td>
<td>RVS</td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>No current test approved</td>
<td></td>
</tr>
<tr>
<td>Riding quality</td>
<td>No current test approved</td>
<td></td>
</tr>
</tbody>
</table>

* As would occur on joints installed skew with regard to the longitudinal movement of the bridge. See Figure 11.
2.4. **QUALITY ASSURANCE**

The applicant must supply a copy of his quality management programme for the design, manufacture, installation and maintenance of the joint. This programme must include the following vital information:

A requirement for certification by Agrément South Africa is that each certificate holder has a simple, approved quality management system in place. This system must be based on the recommendations of the ISO 9000 series. The system is required to ensure that good quality materials and satisfactory standards of design, manufacture and, where appropriate, erection are consistently maintained within defined parameters.

When there is employee turnover the quality management system is an aid to ensure continuity of operations as quality is dependent on a system rather than individuals. It helps to avoid unacceptable changes in practice that may occur as a result of changes in personnel. To achieve this, guidelines for the preparation of a quality management system have been prepared by Agrément South Africa to assist certificate holders and applicants to prepare and implement acceptable quality schemes for their products or construction systems. These guidelines for the preparation of a quality management system are available from Agrément South Africa. The quality management document must deal separately with the procedures for the manufacturing process and the transport and erection or installation process. It must be emphasized that the points mentioned in this document merely illustrate the type of information required; each certificate holder and applicant is required to develop a quality system and checklist based on the specific requirements of the system or product.

The South African Bureau of Standards (SABS) is available (on request through Agrément South Africa) to advise certificate holders on the drawing up of a simple but adequate quality management system. Alternatively several specialist quality management consultants are active in the technical market in South Africa. The SABS or other consultant will be requested by Agrément South Africa to scrutinise proposed quality management systems before they are submitted to the Board of Agrément South Africa for approval.

Note: No certificate will be granted until a satisfactory quality management document has been received and approved by the Board of Agrément South Africa.

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1 At the time of preparing this document, changes were being incorporated into the ISO 9000 system. However, these changes were not available before finalisation of the report. When this document is used the users should familiarise themselves with possible changes to ISO 9000.
GENERAL
The quality management system must be planned and drawn up in harmony with a company’s existing administrative and technical programmes. It must ensure quality throughout all operations, such as design and development, training, incoming materials, processing and manufacturing, testing and quality checks, assembly, maintenance, in-house inspections, corrective actions, packaging, documentation, storage, shipment, erection, etc.

Personnel who perform quality functions must have sufficient experience and well-defined authority, responsibility, and the freedom to identify, evaluate and rectify quality problems. Quality procedures for manufacturing must be drawn up separately from the quality procedures for installation or erection.

IMPLEMENTATION
To achieve consistent quality within defined parameters in any process, there are important operations and materials that should be identified as essential. Once these operations and materials have been identified, they should be listed and form part of a checklist which is part of the quality scheme. Each item on the checklist must be approved or rejected and the checklist must be signed by a competent person responsible for carrying out inspections. The quality scheme should contain instructions on the procedures to be taken in the case of any non-conformity. In cases of variance the requirements of the Agrément certificate and the quality scheme document shall have precedence over other specifications, codes of practice and product manuals.

2.5. INSTALLATION

The applicant must supply information on the installation procedures for the joint for both new bridges and rehabilitation of bridges. The following critical information must be included:

New and existing (rehabilitation) bridges
Equipment needed for installation:
1. List of equipment;
2. Indication of whether equipment is specialised or not;
3. Equipment to be supplied by contractor or supplied by supplier / manufacturer;
4. Need for crane and storage area.
Manpower required for installation:
1. Manpower required from contractor;
2. Manpower available from supplier;
3. Skill level required;
4. Man-hours required.

Preparation for installation required from bridge contractor:
1. Dimensions of cavity for joint;
2. Preparation of adjoining surfaces;
3. Condition of surfaces before joint installation can commence;
4. Work area required;
5. Connection points to be incorporated into existing bridge (i.e. reinforcement).

Preparation for installation to be performed by manufacturer / installer:
1. Lead-time required for orders;
2. Information required on bridge and operational conditions.

Time required for installation:
1. Time required to move joint to site;
2. Time required for preparatory work;
3. Time required for installation of joint.

Time between installation and first use:
Time required for all curing processes to finish and first traffic to be allowed on joint.

Critical elements in installation:
List of all critical path elements needed to receive special attention during installation process. These are the elements that could cause the joint to fail prematurely.

Information supplied to bridge contractor on installation:
Information regarding dimensions, preparation and installation that the bridge contractor can expect to receive from the supplier.

Information required by manufacturer / supplier / installer for installation:
Information on bridge details necessary to supply correct joint.

**Existing (rehabilitation) bridges only**
The following additional information must be supplied by the applicant in the case of replacement/repair of existing joints.
Specific requirements regarding removal of existing joints:
1. Information required on type of joint to be removed from bridge;
2. Information required on time between removal and supply of new joint.

Specific requirements regarding preparation of surfacing after removal of existing joint:
1. Removal of excess material if recess is too small for new joint;
2. Filling of excess recess if new joint is smaller than old joint;
3. Preparation of existing surface for new joint;
4. Methods to prepare bridge to ensure riding quality.

Procedure for installation under various conditions (e.g. only night work allowed, old concrete surfacings, additional asphalt surfacings, etc):
Any special procedures required to install the new joint in areas where the existing joint was removed.

2.6. MAINTENANCE

The applicant must supply information regarding the maintenance plan for the joint during the expected life of the joint. The maintenance plan must include the following critical information:

Maintenance procedures:
Step-by-step procedures required for routine maintenance.

Critical elements for maintenance:
Any element of the maintenance plan that, if omitted, could result in failure of the joint.

Duration of maintenance action:
Time required to carry out maintenance.

Recommended frequency of maintenance:
1. Frequency of routine maintenance;
2. Frequency of major maintenance.

Equipment required for maintenance:
1. List of equipment required to perform all types of maintenance;
2. Indication of special (manufacturer-supplied) equipment and normal equipment.
Manpower required for maintenance:
1. Manpower required from contractor;
2. Manpower available from supplier;
3. Skill level required;
4. Man-hours required.

Expected effect of lack of maintenance:
1. Effect of lack of specific maintenance steps on joint performance;
2. Critical maintenance steps that could affect the life of the joint.

Expected cost of maintenance:
Cost breakdown for all types of maintenance (routine and special).

2.7. DESIGN REQUIREMENTS

The applicant must supply information regarding the critical design requirements for the joint, both for new and rehabilitation projects. The requirements must address the following critical parameters:

Detailing of joint connection to new bridge deck
Detailing of joint connection to existing (rehabilitation) bridge deck
Detailing of joint at kerbs
Detailing of joint at sidewalks
Detailing of skew joints (maximum skewness to be specified)
Detail and suitability of joint for joints longitudinally in direction of traffic (also specific minimum gap possible and ability to move in longitudinal and vertical directions)
Detailing of service pipes through joints (maximum size of pipes etc to be indicated)

2.8. SUMMARY AND CONCLUSIONS

In this chapter an indication of the guidelines to be used by applicants and evaluators on bridge deck joints are provided. The guidelines provide information on all the relevant data required from applicants, and provide the evaluators with guidelines on the respective specifications, criteria and tests that may be requested for specific joints and joint materials.
3. TESTS AND SPECIFICATIONS

3.1. INTRODUCTION

A number of tests and specifications were indicated in Section 2 for evaluation of various criteria regarding bridge deck joints. In this section the references for these tests and specifications are provided as a list with their appropriate ASTM designations. The objective of this information is to familiarise evaluators and applicants with the various tests and to provide them with a list of possible tests to select appropriate evaluation criteria from for a specific joint.

3.2. SOURCES FOR VARIOUS TEST METHODS

The main sources for most of the tests described in Section 4 are the American Society for Testing and Materials (ASTM), the South African Bureau of Standards (SABS), the Deutsches Institut für Normung eV (DIN), and the Austrian Guidelines for Bridge Joints.

3.3. PRACTICALITIES

During the project to develop the guidelines it became apparent that facilities for conducting the various tests identified in these guidelines may be difficult and costly to set up in South Africa. It is proposed that the committee that evaluates an application for certification would have to firstly evaluate whether it is necessary to conduct all the specific tests (based on the test results supplied by the applicant) and then decide on an appropriate route for testing those aspects that still need validation. Such testing may be performed internationally if conditions require it.

3.4. DESCRIPTIONS

In this section the title and number of a range of specifications for various aspects of joints are provided. These are to be used as references when specific tests and specifications are required. The test for design loadings is provided in more detail as it is not readily available.

**Design loadings**

The expansion joint system shall be designed in accordance with British Standards BS5400 and the British Department of Transport Departmental Standard BD 33/88 / BD 33/94 to withstand the following nominal loads:
Vertical loads
A nominal vehicle load of either a single wheel load of 100 kN or a 200 kN axle with a
1.8 m track. The load from each wheel shall be uniformly distributed over a circular area
assuming an effective pressure of 1.1 MPA (i.e. 340 mm diameter) applied separately to
either edge of the joint for the most severe effect.

Horizontal loads
A nominal traffic load taken as a uniformly distributed horizontal load of 80 kN/m run of
joint, acting at right angles to the joint at carriageway level.

Design load effects

<table>
<thead>
<tr>
<th></th>
<th>Wheel loads</th>
<th>Horizontal loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate limit state</td>
<td>1.5x1.1=1.65</td>
<td>1.25x1.0=1.25</td>
</tr>
<tr>
<td>Serviceability limit state</td>
<td>1.2x1.0=1.20</td>
<td>1.0x1.0=1.0</td>
</tr>
</tbody>
</table>

Design for fatigue complies with BS 5400 Part 10 (British Department of Transport
Departmental Standard BA 9/81) and physical testing should be carried out in accordance
with it using a joint test unit. This test shall allow for a wheel load of 20 kN over an area of
200x200 mm² for 7.5 million cycles (equivalent of 5 years).

South African loads:
As the UK legal axle load for single axles (that the design loadings are based on) is
higher than the South African legal load for single axles, the design loads are kept as is in
the British Standard for South African conditions.

**ASTM specifications**

**Bridge deck joints**
D6297-98 Standard Specification for Asphaltic Plug Joints for Bridges
D6153-97 Standard Specification for Materials for Bridge Deck Waterproofing Membrane
Systems
D4070-91(1996)e1 Standard Specification for Adhesive Lubricant for Installation of
Preformed Elastomeric Bridge Compression Seals in Concrete Structures
D1190-97 Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
C1193-00 Standard Guide for Use of Joint Sealants
C920-98e1 Standard Specification for Elastomeric Joint Sealants

**Metals**
A480/A480M-99b Standard Specification for General Requirements for Flat-Rolled
Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
Silicone sealants
C920-98e1 Standard Specification for Elastomeric Joint Sealants
C1183 Test Method for Extrusion Rate of Elastomeric Sealants
C1193 Guide for Use of Joint Sealants
C1246 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants After Cure
C1247 Test Method for Sealants Exposed to Constant Immersion in Liquids
C510 Test Method for Staining and Colour Change of Single- or Multicomponent Joint Sealants
C639 Test Method for Rheological (Flow) Properties of Elastomeric Sealants
C661 Test Method for Indentation Hardness of Elastomeric-Type Sealants by Means of a Durometer
C679 Test Method for Tack-Free Time of Elastomeric Sealants
C717 Terminology of Building Seals and Sealants
C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)
C793 Test Method for Effects of Accelerated Weathering on Elastomeric Joint Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
D1475 Test Method for Density of Liquid Coatings, Inks and Related Products
D2452 Test Method for Extrudability of Oil- and Resin-Base Caulking Compounds
C1083 Test Method for Water Absorption of Cellular Elastomeric Gaskets and Sealing Materials
C1135 Test Method for Determining Adhesion Properties of Structural Sealants
C1247 Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids
C1248 Test Method for Staining of Porous Substrate by Joint Sealants
C1299 Guide for Use in Selection of Liquid-Applied Sealants
C1311 Specification for Solvent Release Sealants
C1330 Specification for Cylindrical Sealant Backing for Use with Cold Liquid-Applied Sealants
C1375 Guide for Substrates Used in Testing Building Seals and Sealants
C1442 Practice for Conducting Tests on Sealants Using Artificial Weathering Apparatus
C1472 Guide for Calculating Movement and Other Effects When Establishing Sealant Joint Width
C510 Test Method for Staining and Colour Change of Single- or Multicomponent Joint Sealants
C792 Test Method for Effects of Heat Aging on Weight Loss, Cracking and Chalking of Elastomeric Sealants
C794 Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants
C834 Specification for Latex Sealants
C920 Specification for Elastomeric Joint Sealants
D2203 Test Method for Staining from Sealants

**Rubber extrusions**
D1052 Test Method for Rubber Deterioration-Cut Growth Using Ross Flexing Apparatus
D1149 Test Method for Rubber Deterioration-Surface Ozone Cracking in a Chamber
D2240 Test Method for Rubber Property-Durometer Hardness
D3183 Practice for Rubber-Preparation of Pieces for Test Purposes from Products
D395 Test Methods for Rubber Property-Compression Set
D412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension
D471 Test Method for Rubber Property-Effect of Liquids
D518 Test Method for Rubber Deterioration-Surface Cracking
D573 Test Method for Rubber-Deterioration in an Air Oven
D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
D746 Test Method for Britleness Temperature of Plastics and Elastomers by Impact
D792 Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D865 Test Method for Rubber-Deterioration by Heating in Air (Test Tube Enclosure)
E1399 Test Method for Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems

**Bituminous materials**
D545-99 Standard Test Methods for Preformed Expansion Joint Fillers for Concrete Construction (Nonextruding and Resilient Types)
D6297-98 Standard Specification for Asphaltic Plug Joints for Bridges
D6153-97 Standard Specification for Materials for Bridge Deck Waterproofing Membrane Systems
D113-99 Standard Test Method for Ductility of Bituminous Materials
D36-95(2000)e1 Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)
D5-97 Standard Test Method for Penetration of Bituminous Materials

**Polymer**
D5849-95 Standard Test Method for Evaluating Resistance of Modified, Bituminous
Roofing Membranes to Cyclic Joint Displacement
C717-00 Standard Terminology of Building Seals and Sealants

Cement
D3581-96 Standard Specification for Joint Sealant, Hot-Applied, Jet-Fuel-Resistant Type, for Portland Cement Concrete and Tar-Concrete Pavements
D3405-97 Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements
D1190-97 Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
D6297-98 Standard Specification for Asphaltic Plug Joints for Bridges
D545-99 Standard Test Methods for Preformed Expansion Joint Fillers for Concrete Construction (Nonextruding and Resilient Types)
C1247-98 Standard Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids
C794-93 Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants

3.5. **RVS specification tests**

The following is an extract from the RVS (Austrian Guidelines for Bridge Joints), consisting of section 4 – Design, which is related to the testing of bridge deck joints. The original numbering system is shown in brackets at the end of headings for easier reference. As the Austrian legal axle load for single axles (that the design loadings are based on) is higher than the South African legal load for single axles, the design loads specified in the RVS are considered applicable for South African conditions.
3.5.1 **Strength (4.1)**

The critical loading for the verification of the strength results from traffic loading and deformation of the structure. The relevant component of the traffic loading is the single axle. The load is transferred through the contact area. The load is defined by the wheel load, or part of it, for components that are only loaded partially.

3.5.1.1. **Load carrying capacity (4.1.1)**

The following details of wheel load and distance between wheels are based on the 25t vehicle (carriageways) and 16t vehicle (pedestrian walk) in accordance with ÖNORM B 4002.

3.5.1.1.1. **Loading (4.1.1.1)**

3.5.1.1.2. **Wheel loads on carriageway (4.1.1.1.1)**

Two wheel loads are to be applied in the most critical position. The distance, at right angle to the centreline of the bridge, is 1.6m (Fig. 4.1). The vertical and horizontal components, $R_v$ and $R_h$ respectively, including the dynamic factor, are:

\[
R_v = 140 \text{ kN} \quad \text{equation (1.1)}
\]
\[
R_h = R_v \times 0.3 = 42 \text{ kN} \quad \text{equation (1.2)}
\]

$R_h$ acts in direction of longitudinal axis of the bridge. The contact area is $l_{br} \times b$. The length of the contact area $l_{br}$ has to be determined according to (b) below. The width $b$ is 500 mm. The area of loading is limited by the kerb (Figure 1).

3.5.1.1.3. **Partial wheel loads (4.1.1.1.2)**

If components of an expansion joint are only loaded by parts of the wheel load, the corresponding parts of the wheel load are to be determined as follows:

\[
l_{br} = 235 + 0.3 \times s_F
\]
\[
l_n = l_{br} - s_F
\]
\[
a_r = b/l_n
\]
\[
R_{avr} = R_v \times a_r \times a_a \quad \text{equation (2.1)}
\]
\[
R_{ahr} = R_h \times a_r \times a_a \quad \text{equation (2.2a)}
\]

Equations (2.1) and (2.2a) apply for all load carrying components with the exception of edge profile “RP” and their anchorage “V”. For edge profiles “RP” equations (2.1) and (2.2b) are applicable:
\[ R_{\text{wh}} = R_{\text{hl}} \quad \text{equation (2.2b)} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_{\text{br}} )</td>
<td>length of contact area of wheel (mm)</td>
</tr>
<tr>
<td>( L_n )</td>
<td>net length of contact area of wheel (mm)</td>
</tr>
<tr>
<td>( S_{\text{Fmi}} )</td>
<td>max. joint width at maximum permissible opening of joint (mm)</td>
</tr>
<tr>
<td>( S_F )</td>
<td>sum of joint widths covered by contact area at maximum opening</td>
</tr>
<tr>
<td>( s_F = \sum F_i ) (mm)</td>
<td>(Figure 2)</td>
</tr>
<tr>
<td>( b )</td>
<td>width of load carrying component (mm)</td>
</tr>
<tr>
<td>( a )</td>
<td>relative load component</td>
</tr>
<tr>
<td>( a_\alpha )</td>
<td>factor for skewness of expansion joint (Figure 2)</td>
</tr>
<tr>
<td>( R_{\text{ov}}, R_{\text{ah}} )</td>
<td>parts of wheel load components</td>
</tr>
</tbody>
</table>

### 3.5.1.1.4. Wheel loads and portions at pedestrian walks (4.1.1.1.3)

In areas of pedestrian walks, safety strips, cycle ways and medians, the component of the wheel load normal to the surface \( R_{\text{ov}} \) is:

\[ R_{\text{ov}} = 77 \text{ kN} \quad \text{equation (3.1)} \]

No component of the wheel load in direction of the surface \( R_{\text{Gh}} \) has to be considered. The contact area is:

\[ L_{\text{br}} \times L_2 = 200 \times 350 \text{ mm}. \]

The most extreme position of the contact area is set by the kerb (Figure 1). The portion of the wheel load in the pedestrian area has to be determined by \( L_{\text{br}} = 200 \text{ mm} \).

### 3.5.1.2. Verifications (4.1.1.2)

According to ÖNORM B 4600 part 2 the most critical stresses caused by the loading in accordance with (a) may be determined using the theory of linear elasticity. For the second moment of area of the steel components the plastic second moment of area may be used. The increased permissible stresses in accordance with Ö-NORM B4600 are applicable. Tests have to be done with the same safety factors as the theoretical checks and have to be continued until failure, if possible. The mode of failure has to be recorded.

Joints made of aluminium and other materials have to be treated in a similar manner.
Figure 1: Arrangement of wheel loads for load carrying capacity test.
Figure 2: Determination of portions of wheel load in the area of the carriageway.
3.5.1.3. **Fatigue (4.1.2)**

Fatigue stresses have to be checked for the load carrying steel components and their anchorage of a joint in a carriageway. To assess the actual traffic loading realistically details below apply regarding wheel loads, contact area and distance between wheels (differing from 4.1.1). No loading has to be applied to pedestrian walks, safety strips, cycle ways and medians.

3.5.1.5. **Loading (4.1.2.1)**

3.5.1.6. **Wheel loads (4.1.2.1.1)**

Two wheel loads have to be applied in the most critical location and no relieving effect of a wheel may be considered. The distance between wheels at right angle to the longitudinal axis of the bridge is \( s = 1800 \text{ mm} \) (Figure 3). The components of the wheel load, at right angle and parallel to the riding surface, \( R_v \) and \( R_h \) respectively, are as follows:

\[
R_v = 65\text{kN} \quad \text{equation (4.1)} \\
R_h = R_v \times 0.2 = 13\text{kN} \quad \text{equation (4.2)}
\]

These wheel loads have to be increased by a dynamic factor \( \varphi_v = 1.4 \) and \( \varphi_h = 1.4 \). \( R_h \) is acting in direction of the longitudinal axes of the bridge. The contact area is \( l_{cr} \times b_1 \). The theoretical length of the contact area has to be determined in accordance with 4.1.1(a)ii and the width \( b_1 = 500 \text{ mm} \). The area of possible loading is limited by the kerb and the contact area and the minimum distance from the kerb is 100 mm (Figure 3).

3.5.1.7. **Wheel load components (4.1.2.1.1)**

If load-bearing components of a joint are only loaded by parts of the wheel load, the corresponding components \( R_{av} \) and \( R_{ah} \) are to be determined in accordance with 4.1.2(a)I and 4.1.1(a)ii.
Figure 3: Arrangement of wheel loads for fatigue test.
Figure 4: Position of vehicle.

Figure 5: Test arrangement for joint types – M (Mat joints).
Figure 6: Test arrangement for supported joint types.
Figure 7: Test arrangement for cantilever joint types.

Figure 8: Test arrangement for joint types – P (single seal).
Figure 9: Test arrangement for joint types – PZ (modular joints)

a) Testing of connection between ‘ZP’ and ‘TK’.
b) Testing of intermediate sections ‘ZP’ at the support.
c) Testing of intermediate sections ‘ZP’ at the span. If no horizontal bearing is placed at the span, this test may be omitted. Welding connection of a ‘ZP’ type joint has to be tested in a similar way (without horizontal bearing).
d) Testing of support structure ‘TK’.
e) Testing of ‘TK’ and the connection between ‘ZP’ and ‘TK’ of a “lazy tongue” type support.
3.5.1.8. Verifications (4.1.2.2)

Stresses caused by fatigue have to be verified in accordance with ÖStV-RL (commission of Austrian Steel Construction: “Guidelines for the design for fatigue of steel constructions”). \( \alpha \) has to be taken as 0.4 and the number of loadings \( N_e = 100 \) mill. The procedure involves the comparison of the theoretical stresses with the resistance determined through testing. The relation between the minimum and maximum stress \( \alpha \) has to be taken into consideration. If notch cases are available, the second moment of area may be taken from there. If not available from standard tests, the “hot spot points” of the construction have to be determined and the second moment of area for these points are to be determined through a set of three tests each. The determination of the stresses in the test sample have to be supported by stress measurements (strain gauges or similar).

3.5.2 Kinematic (4.2)

3.5.2.1. Movements in the joint (4.2.1)

Movements of the edges of the joint between decks and abutments or between adjacent decks occur due to deformation of the structure, displacements of columns and abutments or rehabilitation work (replacement of bearings). The requirements for expansion joints have to be determined in accordance with the items below, as well as ÖNORM B 4202, B 4502 and B 4602 respectively (Figure 10).

3.5.1.1.9. Movement capacity (4.2.1.1)

3.5.1.1.10. Movements in plane of the riding surface (4.2.1.1.1)

Movements in the plane of the riding surface are first of all determined by the movement vector \( \Delta l \). The direction of this vector is determined by the arrangements of the bearings for the deck. The size of the vector corresponds to the size determined in accordance with ÖNORM B 4202, B 4502, etc and B 4602 respectively. If the direction between the movement vector \( \Delta l \) and the joint \( \beta = 90^\circ \) (Figure 11), the movements \( \Delta s \) and \( \Delta q \) within the riding surface are as follows:

\[
\begin{align*}
\Delta s &= \Delta l \times \sin \beta \\
\Delta q &= \Delta l \times \cos \beta
\end{align*}
\]

equation (6.1a)

Besides the components \( \Delta s \) and \( \Delta q \) (equation 6.1a), caused by the longitudinal changes of the length of the deck, components resulting from the rotation \( \phi \) of the support (Figure 12) have to be considered. At skew decks a rotation \( \phi \) of the support may result in a transverse movement \( \Delta q \). Rotations of the support may be caused by the following actions:
3.5.1.1.1 Movements normal to the riding surface (4.2.1.1.2)

If the riding surface is at a longitudinal slope $\gamma$, movements $\Delta h$ normal to the riding surface will occur (Figure 13):

$$\Delta H = \Delta l \cdot \sin \gamma$$

equation (6.1b)

Besides the components $\Delta h$ (equation 6.1a) caused by the longitudinal changes of the length of the deck, movements $\Delta h$, resulting from the following, have to be considered:

- Rotation of the support (Figure 14);
- Long-term deflection of cantilever slabs (Figure 15);
- Raising of the deck (i.e. repair of bearings) (Figure 16).

3.5.2.2 Tests (4.2.2)

Test samples have to be made in such a way that they represent the kinematic system “expansion joint” as realistically as possible. A principal sketch of the test sample and the test arrangement is available in Figure 17.

a. Tests related to movements $\Delta s$ and $\Delta q$ in the riding surface

Starting from the positions “completely closed” and “completely open”, (Figure 18) a movement cycle “open and close” has to has to be made 2500 times. The movement of the joint corresponds to one third of the maximum permissible movement of the joint (Figure 18). The duration of one cycle has to be at least half a minute.

b. Tests related to movements $\Delta h$ normal to the riding surface

Starting from the position: “joint width = one quarter of maximum permissible movement and no vertical displacement $h$ of the joint edges”, a movement cycle "up and down” has to be made 2500 times. The applied movement $\Delta h$ has to be 4.5% of the maximum permissible movement $\Delta l$ (Figure 19).

3.5.2.3 Certification (4.2.3)

Certification is related to the relative displacement of the joint edges $\Delta s$, $\Delta q$ and $\Delta h$, as indicated under item 4.2.1 (a). Joints have to accommodate a relative movement of at
least $\Delta q = 5$ mm. Verification is accepted if no damage can be seen after the execution of the tests indicated above.

### 3.5.3 Adjusting Forces (4.3)

Due to the longitudinal stiffness of the elements, resistance to the movement is created, which is called adjusting forces. Depending on the material these forces can be temperature related. The dispersion of the adjusting forces via the anchorage into the structure (deck, abutment) has to be verified. The magnitude of the adjusting forces has to be determined in accordance with the tests below. They are dependent on the system test under room temperatures and determined at $-20^\circ$ C by the components test.

#### 3.5.3.1. System test (4.3.1)

Test samples have to be made in such a way that they represent the kinematic system “expansion joint” as realistically as possible (refer to 4.2.2). Verification has to be done at room temperature. Starting from the median position, the joint has to be completely opened and closed three times ($\Delta S_{\text{max}}$). One movement cycle may not exceed 24 hours. The arithmetic average of the adjusting forces has to be shown as a force-movement diagram for the whole cycle.

#### 3.5.3.2. Components test (4.3.2)

Test samples have to be made in such a way that the elastic behaviour of the components of the joint, which are responsible for the resistance against movement and their influence on the adjusting force, may be determined. A principal sketch of the test sample and the test arrangement is shown in Figure 20. Verification has to be done at room temperature and at a temperature of $-20^\circ$. Speed of movement and maximum opening to be selected as for the system test. Adjusting forces have to be determined for the two temperatures and the full movement range. The extension may not be less than 1/3 of the one from the system test.
<table>
<thead>
<tr>
<th>ÖNORM</th>
<th>TEMPERATURE (°C)</th>
<th>Additional movement a</th>
<th>l = distance FÜ - FP (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bridges</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steel</strong></td>
<td>Uniform temperature variation : T</td>
<td>+55</td>
<td>a= 5l &lt; 20m</td>
</tr>
<tr>
<td>ÖNORM B 4622</td>
<td>- 35</td>
<td>a= 10l &gt; 20m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical temperature gradient; various components and cross-sections : ΔT</td>
<td>± 15</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Vertical temperature gradient; plate girder : ΔT</td>
<td>+ 20</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Horizontal temperature gradient : ΔT</td>
<td>± 15</td>
<td>-</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td>Uniform temperature variation : T</td>
<td>+ 40</td>
<td>a= 5l &lt; 20m</td>
</tr>
<tr>
<td><strong>Bridges</strong></td>
<td>- 35</td>
<td>a= 10l &gt; 20m</td>
<td></td>
</tr>
<tr>
<td>ÖNORM B 4202</td>
<td>Reinforced concrete : shrinkage</td>
<td>0,15 mm/m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pre-stressed concrete; shrinkage and creep</td>
<td>ÖNORM B4250, sections 8.2 and 8.3, increase values by 1.3</td>
<td></td>
</tr>
<tr>
<td><strong>Composite</strong></td>
<td>Uniform temperature variation : T</td>
<td>+ 50</td>
<td>a= 5l &lt; 20m</td>
</tr>
<tr>
<td><strong>Bridges</strong></td>
<td>- 35</td>
<td>a= 10l &gt; 20m</td>
<td></td>
</tr>
<tr>
<td>ÖNORM B 4502</td>
<td>Vertical temperature gradient; various components and cross-sections : ΔT</td>
<td>St ± 15</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>B ± 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vertical temperature gradient; plate girder : ΔT</td>
<td>± 10</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Temperature jump; concrete steel</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Horizontal temperature gradient : ΔT</td>
<td>! 0</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 10: Summary of temperatures and long term movements according to ÖNORM B4622 (1.8.1975), B4502 (1.5.1981), B4202 (1.3.1975) and B4250 (1.8.1991).
Figure 11: Movement of bridge deck.

Figure 12: Horizontal movement due to rotation
Figure 13: Movement due to longitudinal slope of deck.

Figure 14: Vertical movement due to rotation of support
Figure 15: Movement due to long-term deflection of cantilevers.

Figure 16: Movement due to lifting of structure.
Figure 17: Test of movement orthogonal to carriageway (a).
3.5.4 Shape Stability (4.4)

3.5.4.1 Requirements (4.4.1)

If materials are used which are directly trafficked and their material properties are not regulated (i.e. joint type "P" with special pourable material "VM", surface joints "BD"), the permanent shape consistency has to be verified. Verification is accepted if testing in accordance with the roll-over test, described below, shows no changes which would

Figure 18: Test of movement in plane of carriageway

Figure 19: Test of movement orthogonal to carriageway (b).
influence the functionality of the joint. Functionality as well as water tightness has to be maintained. Permanent deformations may not exceed values given in 5.5.1.6.

3.5.4.2. Verification (4.4.2)

The test sample has to be made in such a way that the whole joint system is modelled as realistically as possible. The test is a roll-over test and has to be done in a test bench in accordance with Figure 4.21. The load is an axle of 90 kN with a tyre pressure of 10 bar. A total of 200 000 cycles and, for 1% of the cycles, a braking force of 10% has to be applied. A lateral oscillating movement of approx. 2cm has to be simulated during the test. The test has to be done for 10 000 cycles at frost, 10 000 cycles at 0 degrees, 2 000 cycles at +45 degrees and the remaining cycles at room temperature. The test speed should be 0.2 m/sec of continuous movement.
Figure 20: Schematic sketch of test sample and arrangement (component test).
Figure 21: Test arrangement (schematic) for roll-over test

Longitudinal movement = ± Joint width + 2x coating thickness

LKW- Standard Tyre load applied

Pressure cylinder for lateral deflection

Pressure cylinder for horizontal movement

Braking force

Vertical load (axle load)

Concrete

Longitudinal movement

Visco-elastic plug material

Steel frame

Pressure cylinder for vertical load

Pressure cylinder for lateral deflection
3.6. **SUMMARY AND CONCLUSIONS**

In this chapter information was provided regarding the various specification documents and test methods available for use when evaluating bridge deck joints for certification. The information is provided as applicable and with relevant specification and/or test method numbers, and it is up to the evaluators of the specific bridge deck joint to make a final selection for appropriate specifications and test methods for a specific bridge deck joint. The text of the RVS test method is provided to enable a better understanding of the various joint performance tests proposed. Some of the text (i.e. reference to specific joint types using the RVS joint type definitions) has been omitted in this edition of the document, as it differs from the proposed joint type classification.
4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

This document serves as a guideline for Agrément certificate evaluators of bridge deck joints. The purpose of the document is to provide the relevant guidelines so that both the applicants and evaluators understand what is required from the certification process.

The recommended criteria, specifications and test methods for bridge deck joints are provided from which evaluators have to select the most appropriate one for the specific joint. The reason for this approach is that joints differ in small details, and specifications or test methods that may be appropriate for one joint may not be appropriate for another joint, although they are both of a similar type.

4.2. RECOMMENDATIONS

It is recommended that Agrément SA implement the guidelines for the certification of bridge deck joints.
5. REFERENCES


RVS 15.45 see Austrian bridge code
SILBERNAGL, D. 2000. Personal communication on use of bridge deck joint specifications and tests in Europe (Maurer and Stalko). Director, UWP Engineers, Bryanston.


APPENDIX  A. FIRST REPORT TO STEERING COMMITTEE ON BRIDGE DECK JOINTS

A.1. INTRODUCTION

The first report described phase one of the project on the development of evaluation criteria for bridge deck joints in South Africa and aimed to:

1. Identify the types of bridge deck joints typically found in South Africa through a literature and industry scan;
2. Identify initial criteria for evaluation of bridge deck joints, and
3. Propose an initial suite of tests to check the fitness-for-purpose of bridge deck joints based on the identified criteria.

Burke (1991) indicates that one of the primary reasons why failures occur in bridge deck joints is due to the assumptions made by design engineers regarding the functionality and quality of such joints. He argues that value engineering demands that functions or quality of components be defined in only two words, a verb and a measurable noun. If a noun cannot be measured, it represents a fictitious attribute and its use must be abandoned. Typical flawed assumptions are those concerning bearing fit and actual movements in bridge components. Poor performance and failures of bridge deck joints cannot be used as a general condemnation of the devices themselves. Their quality, mechanical efficiency, material integrity, strength, toughness and durability are not independent characteristics. The success or failure of a particular design is directly related to the expertise of those responsible for its creation, development and application.

The methodology followed in phase 1 of this project was to identify the types of bridge deck joints available and to classify them into representative classes, to identify the typical failures experienced on such joints and use these to classify the performance criteria for which bridge deck joints should be tested. An empirical method is thus used, as a wealth of information on the typical failures exists, and it is believed that this information should give a correct indication of the weak points in the various bridge deck joints.

A.2. DEFINITIONS AND BACKGROUND TO BRIDGE DECK JOINTS

Literature originated from both South African and international resources. It consisted of academic papers, popular articles, test reports, specifications and marketing and
promotional material. Little general literature related to bridge deck joints is available. The Austrian Guidelines for Bridge Joints, RVS 15.45, is considered the most generic one and has therefore been used extensively.

A.2.1 Purpose and definition

Johnson and McAndrew (1993) indicate the purpose of bridge deck joints as permitting movement to take place whilst ensuring that the riding quality and watertightness of the joint are not unacceptably affected. It is important that the joint is able to freely accommodate the design movements expected without transferring potentially damaging forces into the structure. Friedland et al (1989) states the primary function of closed deck joints as permitting cyclic and long-term movement, support of traffic, repelling of water and debris, and survival of service.

Based on these descriptions, the purpose of a bridge deck joint can be defined as: permitting all movements between bridge decks and abutments respectively, without affecting the functionality or performance of the bridge deck joint.

A.2.2 Components

Bridge expansion joints typically consist of the following main components:

1. Anchorage
2. Edge profiles
3. Intermediate supports
4. Sealing elements

Each component has a specific purpose and depending on the type of the joint some of the components may be integrated into one unit or omitted altogether.

A.2.3 Types

Various authors have identified the types of joints available for use in bridge decks. Different terminology is used in different countries and references. Many types of joints are identified based on the references consulted (Johnson and McAndrew, 1993; Puccio, 1984; Friedland et al, 1989; UWP et al, 1996; Rassalski, 1991). This information, the Austrian Guidelines for Bridge Joints (RVS 15.45, 1993) and discussions with practitioners and manufacturers of bridge expansion joints in South Africa were used to categorise types of bridge expansion joints. An attempt was also made to keep the categories as generic as possible and to use descriptions also used in other countries for similar developments. The following eight categories were identified:

1. Buried expansion joints
With anchorage
Without anchorage

2. Flexible plug expansion joints
   - Asphalt
   - Polymer

3. Nosing expansion joints
   - Without metallic edge beams
   - With metallic edge beams

4. Modular expansion joints
   - Single seal
   - Multiple seal

5. Mat expansion joints
   - Single mat
   - Multiple mat

6. Cantilever expansion joints
   - Cantilever finger
   - Cantilever comb

7. Supported expansion joints
   - Sliding plate
   - Sliding finger
   - Multi-section roller shutter

8. Special joints

Typical photos of each of these categories of joints are shown in Appendix D and a short description is provided below, together with an indication of its use in South Africa:

**Buried expansion joints** (widely used for nominal movements):
This expansion joint is formed in-situ using components such as waterproofing membranes or an elastomeric pad to distribute the generally nominal movements over a wider area of the surfacing, which is continuous over the joint gap.

**Flexible plug expansion joints** (widely used for small movements):
This type of expansion joint consists of a layer of specially formulated flexible material (binder and aggregates), which can accommodate the movement via a bridging plate over the gap and an optional de-bonding strip, through the thickness of the layer to the riding surface.

**Nosing expansion joints** (widely used for small to medium movements, especially in the past in combination with neoprene compression seals):
This expansion joint consists of an edge strip of concrete, resin or elastomeric material, with or without armoured edges. The sealing element (poured sealant or pre-formed elastomeric material) accommodates the required movement.

**Modular expansion joints** (presently almost exclusively used for medium to large movements):
This expansion joint consists of two edge profiles and series of supported intermediate beams and seals in a modular way to accommodate the movements of the joint. The edge profiles are generally cast into a nosing of the structure and the supports for the intermediate members typically consist of beams with neoprene springs or pantograph type structures, which also control the equal movement of the joint gaps.

**Mat joints expansion** (some usage in the past - for small to medium movements, but general problems with bolt-down type anchorage):
Also known as elastomeric cushion expansion joint and typically bolted down. This expansion joint uses the elastic properties of an elastomeric pad/ gland combination to accommodate the movements of the joint.

**Cantilever expansion joints** (some usage in the past - for medium to large movements, especially the finger type):
This expansion joint consists of elements (comb or saw tooth plates or fingers) that are anchored on the one side of the joint gap and cantilevering over the gap, inter-linking with similar elements from the other side.

**Supported expansion joints** (some usage in the past - for medium to large movements, especially the finger- and roller shutter type):
This type of joint consists of one principal component, which is anchored on the one side of the joint gap and vertically supported on the other side. The required movement of the joint is accommodated by sliding action on the non-anchored side.

**Special joints**
Are joints, which do not belong to any of the above categories.

A.2.4 **Joint behaviour**
Criteria need to be defined for the evaluation of bridge deck joints. The focus of these criteria is on the performance of new and / or novel as well as existing bridge deck joints that have exhibited good performance through successful installation and long-term field trials.
The criteria should focus on the critical components and actions in the joint, as these are the areas where failure is expected.

The first category for such criteria is an investigation of the possible movements of a bridge deck joint. Conformance to these criteria should indicate that a joint should be able to accommodate movements in the field.

The next category for defining criteria is to establish typical failure modes and mechanisms for joints. Conformance to these criteria should indicate that a joint could withstand the typical failures observed in the field.

The next category for defining criteria is to specify the properties and durability of the materials used in the joint. Conformance to these criteria should indicate that the components of the joint should withstand normal usage.

The last category for defining criteria is to establish any other critical issues that may be relevant to the specific joint that could affect its performance.

Evaluation of current literature indicates the following aspects of joint behaviour as indicative of the performance of bridge deck joints in each of the categories. These aspects were developed based on theoretical analyses, common-sense perception and typical problems encountered in the field (Friedland et al, 1989; Hill and Shirolé, 1984; Johnson and McAndrew, 1993; Price, 1984, UWP et al, 1996;):

**Movement**

Total movement could result from:

1. **Axial movement** due to temperature variation, shrinkage, creep, traffic, movement of abutments due to earth pressure, restrained movement (blocked joints, jammed bearings, etc);
2. **Lateral movement** due to traffic (centrifugal forces), skew, misaligned bearings;
3. **Vertical movement** due to traffic, temperature gradient, differential settlement (including mining subsidence), and
4. **Rotational movement**, mainly due to traffic and temperature gradient.

**Typical failure modes and mechanisms** (listed in order of perceived importance indicated):
1. Poor workmanship during installation;
2. Incompatibility between the performance of different materials in the joint and the bridge deck;
3. Poor manufacturing;
4. Poor design/detailing;
5. Debris (foreign matter) build-up due to inadequate cleaning (causing restrained movement) (debris may also damage seals or glands causing leakage);
6. Deterioration of joint components due to heavy wheel loads;
7. Corrosion of uncoated joint components;
8. Abutment movements due to earth pressure (this may be a factor due to incorrect movement prediction);
9. Deck movements due to bearing or fixity failure and incorrect movement prediction;
10. Settlement and misalignment of joints;
11. Vibrations and accident damage;
12. Untimely maintenance;
13. Inadequate drainage, and
14. Leakage through failure of joint seals.

Critical issues:

1. Motorcycle usage;
2. Skid resistance;
3. Ease of maintenance;
4. Ease of installation (critical actions);
5. Joint design;
6. Condition of substrate;
7. Weather and temperature;
8. Site preparation and workmanship, and
9. Permissible joint orientation in relation to traffic flow as well as suitability of application (i.e. only transverse up to a maximum angle of skew or full range including longitudinal).

Some of the issues in the above three categories overlap and they have been shown in all categories where they are relevant.

It appears that there are some general problems that are the primary cause for the specific failures identified. These can be summarised as inadequate designs, inadequate quality control during installation and lack of adequate maintenance. In order to ensure good performance from joints the proposed guidelines and specifications should focus on these three broad areas.
A.2.5 **Industry scan**

The industry scan consisted of a questionnaire that was distributed to prominent clients, consultants, contractors and manufacturers of bridge deck joints in South Africa. The questionnaires are shown in Appendix E. The questionnaires focussed on the experience of users, typical bridge deck joints used in South Africa, typical problems encountered and suggested criteria and tests for fitness-for-purpose evaluation. They also contained a section of the company's perception regarding Agrément South Africa and the need for a fitness-for-purpose evaluation system for bridge deck joints.

**Industry response**

Fifty per cent of manufacturers, clients and consultants responded to the questionnaires. A summary of the responses received to each of the questions is presented in this section. A more complete version of the responses is provided in Appendix F.

It is important to understand that the responses from industry often reflect perceptions rather than facts. However, these perceptions will have an effect on the implementation of a certification procedure and should thus be addressed to ensure optimum results are obtained.

**CLIENTS**

Only 41 per cent (7 out of 17) of the clients returned their questionnaires, even after reminders were sent. All clients who responded were in favour of an acceptance specification system. The perceived benefits included achieving standardisation in the area and enabling clients to make easier distinctions and choices from available joint systems.

Most clients raised concerns regarding the specifications. These were mainly around the reliability and objectiveness of the body performing the inspections, funding, and whether the specifications would include all relevant aspects of joint performance. The idea of also approving the organisation supplying the joints was suggested. Most of the respondents have an operational bridge management system. These systems are at various phases of development / implementation. The respondents had between 5 and 2 055 bridges falling under their responsibility.

Most respondents were satisfied with the proposed types of joints. Some revisions were requested for more clarity regarding the terminology. The question was posed as to where older joints such as Therma joints and soft board joints would fall in these classes. A distinction was requested between nosing joints with pre-manufactured and poured sections.
Most respondents were satisfied with the criteria proposed. Some comments included the addition of axial movement due to settlement or rotation of footings or pile caps, inadequate movement precision, chemical corrosion, dynamic loading and traffic volumes. Some respondents were of the opinion that rotational movement is negligible and that the classification system requires more thought in order to distinguish between failure modes, criteria and causes for failure.

Other remarks included the testing of the installed joint, ability to adjust gaps for ambient temperature and addition of quality control and durability. It was indicated that some clients are expecting a 10 year bank guarantee in addition to a workmanship guarantee to form a product performance guarantee system (PPGS) contract with the contractor.

In summary, clients are positive towards the proposed acceptance criteria with some specific aspects that they would like to have included.

CONSULTANTS
A total of 63 per cent (5 out of 8) of the consultants returned their questionnaires. All consultants replied positively to the idea of an acceptance specification and view it as essential. They are, however, concerned about objectiveness and equitability, the effect of the cost of the specifications to new systems and acceptance by authorities. They are also concerned about the way in which locally made components will be handled in internationally certified joints.

Only one of the consultants indicated that they are involved in a bridge management system, although all of them indicated that they are involved in the design of bridges and specification of joints for these bridges. All respondents were satisfied with the classes of joints proposed.

All respondents were satisfied with the criteria proposed. Some additional criteria were proposed for inclusion. A request came for a clearer definition of failure and that the basic specification should focus on the ability of the joint to fulfil its design purpose. The consequences of a failure to the bridge user and client should be incorporated in the specifications. It was proposed that international agencies such as the British Board of Agreement be contacted to prevent duplication of work.

MANUFACTURERS
Responses were received from 67 per cent (2 out of 3) of the manufacturers contacted. Their attitude towards the acceptance specifications were mixed. Although they would appreciate such a system, a feeling exists that enough knowledge and experience exists
to make responsible selections of joints. Actual field performance should be used, especially for some products. The chances of obtaining funds from industry to pay for something that they do not really see necessary appear slim.

Up to 10 new products may be subjected to certification in the next two years (only one supplier answered this question). One respondent agreed with the classes proposed, with another respondent proposing a slightly different range of classes (see summary of questionnaires).

Respondents agreed with the criteria, but would like to see an emphasis on the initial conditions under which the specific joint was selected, as well as incorporation of the original design life of joints before any statements regarding failure (especially outside their design life) are made. The blame should not be placed on the joint if other parts of the system failed and therefore resulted in the joint being used outside its design scope.

A.2.6 Summary
In this section a definition for the purpose of bridge deck joints was developed, components and types of bridge deck joints were identified and bridge deck joint behaviour investigated based on published information. The perception of industry regarding bridge deck joints and the proposed classification and criteria was also discussed.

A.3. FRAMEWORK FOR CRITERIA
A.3.1 Identification of appropriate performance indicators
Appropriate performance indicators are needed to ensure that the expected performance from a joint is clearly defined. Using these indicators, the appropriateness and fitness-for-purpose of a product can be evaluated. Jooste et al (1998) indicated that ideally, performance indicators should:

1. Have a definite and validated relationship with the performance aspect in question;
2. Be easily and precisely determinable, and
3. Be sensitive to all important material and environmental components.

Based on the definition and typical behaviour of bridge deck joints evaluated, the following broad performance indicators for bridge deck joints are defined:

1. Accommodation of the full range of movements (translation and rotation);
2. Not impart undue stresses to the structure;
3. Resist the applied loadings;
4. Be watertight, or allow drainage of water in such a way that damage to the structural elements is minimised;
5. Provide good riding quality and not present a safety hazard to pedestrians and cyclists;
6. Facilitate maintenance (all components should be accessible for inspection and maintenance);
7. Should not be unacceptably affected by installation errors;
8. Be reasonably silent and vibration free;
9. Be able to be raised to accommodate future resurfacing (if allowed), and
10. Be able to withstand the environmental conditions under which it is operating (e.g. ultraviolet radiation).

Performance indicators are divided into structural and functional indicators (TL/TP-FÜ 92, 1992). Structural performance indicators include design loads, material properties, stresses and deformations, safety factors and forces introduced to adjacent structures (TL/TP-FÜ 92, indicators 1 to 3). Functional performance indicators include the components, movements, noise reduction and service and maintenance of the joints (TL/TP-FÜ 92, indicators 4 to 10).

It is proposed that the structural indicators (1 to 3) be used in an absolute performance evaluation and that the functional indicators be used in a relative performance evaluation. This would ensure that the required structural performance levels are met, while the functional performance of the joint would be as good as or better than existing joints. This will also allow the certification procedure to be implemented more quickly as fundamental research on the exact functional performance of bridges and joints will not be necessary.

A.3.2 Development of fitness-for-purpose criteria

Fitness-for-purpose criteria are needed to ensure that specific properties (criteria) of the product can be evaluated in order to determine whether the product will fulfil its intended purpose. The criteria developed are mainly based on the information regarding the components, typical failure modes and mechanisms and critical issues identified.

Adherence to the fitness-for-purpose criteria should ensure that the tested joint provides the required structural and functional performance to the user.

For the structural performance indicators (indicators 1 to 3) these values can be obtained from the required movements, expected stresses and loads for the nominal bridge type where the new joint is expected to function. The following broad guidelines for criteria are proposed:
Accommodation of movements:
The criteria should indicate the expected movement in orthogonal directions (and combinations of these movements) at the location of the joint. The new joint should allow (with consideration of possible inadequate installation, lack of debris cleaning and other limitations) these expected movements for a defined number of load applications, without affecting any of the other performance indicators.

Stresses imparted to the structure:
The criteria should indicate the expected stresses at the location of the joint and evaluate whether these stresses will be transferred through the joint or absorbed by the joint. The level of stresses to be absorbed by the joint, without affecting any of the other performance indicators, should be the guideline criterion.

Resistance of applied loadings:
The criteria should indicate the expected loads on the joint due to movement of bridge components, traffic and the environment. The joint should be able to accommodate these loads for a specified number of load applications without affecting any of the other structural or functional performance indicators.

For the functional performance indicators (indicators 4 to 10) it is not always possible to attach a numerical value to the criteria. The following broad guidelines are proposed for these criteria:

Watertightness and drainage:
The criterion for watertightness and drainage should be set as a specified time for which the joint should not allow leakages. Several such tests exist and can be used for this criterion.

Riding quality and safety hazards:
The criteria for riding quality and safety hazards should ensure that the joint does not protrude above or sink below the surface of the pavement to such an extent that the joint causes an unacceptable impact load to vehicles. Furthermore, components should not pose a safety hazard during normal use. This criterion should thus check for the long-term stability of the joint, and the relative movements between the joint and the bridge deck. A nominal indicator of the maximum allowable protrusion or rut can be used. Some indication of ruggedness of components should also be included in this criterion. An important factor in determining riding quality is the initial level to which the joint is installed. Errors in installation levels would cause riding quality problems.
Maintenance:
This criterion should be used to indicate whether maintenance of the joint would pose a problem for normal traffic and/or the maintenance team. It is a criterion that cannot be numerically described but suggested maintenance procedures should be included in the application for certification and compared with other joints’ maintenance procedures.

Installation errors:
This criterion should indicate the expected effect of installation errors on the performance of the joint. Once again, it is not a criterion that can be numerically described but the critical steps in the installation of the joint should be clearly identified and methods to ensure proper installation provided. The supplier of the joint should be involved in the process of installation, and should sign off on the installation process.

Noise and vibration:
This criterion should indicate the maximum expected noise levels to be caused by the presence of the joint in the bridge deck when traffic passes over it. It should be measured relative to the noise from the bridge deck itself and relative to other existing joints. The vibration caused by the joint to vehicles should be evaluated in conjunction with the criteria on riding quality and safety hazards.

Accommodation of future resurfacing:
This criterion should indicate the measures to be taken when future resurfacing on the bridge deck/road surface is performed to ensure that the joint remains level with the bridge deck. This criterion can once again not be evaluated numerically but a procedure for retrofitting of the joint should be provided.

Environmental operating conditions:
This criterion should indicate whether the joint can withstand environmental conditions such as ultraviolet radiation, corrosion and extreme temperatures under operational conditions. This is an important criterion as many joints are designed in Europe and their performance under African environmental conditions may be not have been evaluated.

A.3.3 Logistics of product certification
The main objectives of Agrément with regard to product certification are to ensure that products conform to a specific standard and not to add more testing to the development of new products. It is therefore proposed that the logistics around Agrément certification of a product follow the ensuing general guidelines:

When an existing or new joint is proposed for certification, the first duty of the applicant would be to supply Agrément with as much information as is possible regarding the tests
and specifications that the product already adheres to. It is important to include background on the geographical area for which such testing is valid (i.e. coastal or dry areas). This will mean that a product that has already been tested by approved institutions and according to approved specifications will not necessarily need to be re-tested for those specific criteria. Submission of such a certificate will significantly reduce both the cost and the time required to approve a product. The information required is discussed in more detail in Section 7.4. The applicant will carry any further tests as well as the evaluation procedure’s costs.

Agrément will decide whether any further testing on the specific product is required. Such additional tests would typically include tests regarding the operational conditions and/or environmental conditions to which the specific joint will be subjected in South Africa, should these conditions be different from those for which the specific test certificates have been issued. This approach will to a large extent prevent unnecessary duplication of tests. Finally the applicant must satisfy Agrément SA that an approved Quality Assurance process is in place for the manufacturing and installation of the joint.

A.3.4 Summary
A broad framework for the development of fitness-for-purpose criteria was developed. This framework indicates that structural performance indicators should be evaluated using an absolute performance evaluation, while functional performance indicators should be evaluated using a relative performance evaluation. Nine broad indicators (three structural and six functional) were identified for evaluation. Guidelines regarding logistics for submission of a product for certification were discussed.

A.4. TEST ISSUES

This section proposes a framework for a suite of tests for the evaluation of fitness-for-purpose testing of the identified bridge deck joints. These tests and protocols are based on the Austrian Guidelines for Bridge Joints (RVS15.45, 1993), as discussions with clients and contractors in Europe indicated that this specification is one of the best and most generally used bridge deck joint specifications available (Silbernagl, 2000). Each of the subsections is shown in which typical tests for evaluating a specific fitness-for-purpose criterion can be identified. For the evaluation of a specific bridge deck joint, the most suitable tests will be selected from the available suite.

Each of the proposed tests should indicate the specific criterion evaluated using the test, the test specifications and the expected outcome of the test for a joint to be classified unacceptable or acceptable. It is proposed that an applicant would be required to either furnish certification that the product to be evaluated does conform to the specified
requirements, or allow testing of the product. It would be preferable that the applicant provides this certificate for the standard tests indicated. Agrément will then focus their tests on those aspects of the specific bridge deck joint that it perceives as being critical to the performance of the product.

In this chapter only the framework is proposed for evaluation of joint performance. In the following two sections the framework, as indicated in the current Austrian Guidelines for Bridge Joints, is listed.

**Suite 1: Structural performance**

The following criteria are included in the test suite for structural performance:

Accommodation of movements, stresses imparted to the structure and resistance to applied loadings. The aspects covered in the Austrian Guidelines for Bridge Joints regarding design for these criteria are:

- **Accommodation of movements:**
  - Kinematics (RVS 15.45 section 4.2)

- **Stresses imparted to the structure:**
  - Reaction forces (RVS 15.45 section 4.3)

- **Resistance to applied loadings:**
  - Strength (RVS 15.45 section 4.1)
  - Load carrying capacity (RVS 15.45 section 4.1.1)
  - Fatigue (RVS 15.45 section 4.1.2)
  - Shape consistency (RVS 15.45 section 4.4)

**Suite 2: Functional performance**

Functional performance mostly covers those aspects related to construction, maintenance, rehabilitation and performance of the joints. The following criteria are included in the test suite for functional performance:

Watertightness and drainage, riding quality and safety hazards, maintenance, installation errors, noise and vibration, accommodation of future resurfacing, and environmental conditions.

The aspects covered in the Austrian Guidelines for Bridge Joints regarding construction of joints for these criteria are:
Watertightness and drainage, riding quality and safety hazards, maintenance, noise and vibration, future resurfacing:

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<tr>
<th>Details</th>
<th>(RVS 15.45 section 5.1)</th>
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<tr>
<td>Movement control</td>
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<td>Road edges</td>
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<td>Joint gaps</td>
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<td>Drainage</td>
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<td>Cable ducts</td>
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<td>Riding surface tolerances</td>
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<td>Connection to sealing layer</td>
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<td>Replaceability of wearing parts</td>
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<td>Joints in girders</td>
<td>(RVS 15.45 section 5.3)</td>
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<td>Miscellaneous</td>
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<td>Traffic noise</td>
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<td>Covers for pedestrian walks</td>
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<td>Covers for kerbs</td>
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<td>Fixing during transport</td>
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<td>Raising of joint</td>
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<td>Corrosion resistance</td>
<td>(RVS 15.45 section 5.4)</td>
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<tr>
<td>Steel</td>
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<tr>
<td>Alloys and other materials</td>
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| Maintenance                                                             | (RVS 15.45 section 7)                                        |
| Maintenance and repair                                                 | (RVS 15.45 section 7.2)                                     |
| Accessibility                                                          | (RVS 15.45 section 9)                                       |
| Cover plates                                                           | (RVS 15.45 section 9.1)                                     |
| Evenness and noise pollution                                           | (RVS 15.45 section 9.2)                                     |
| Joints                                                                 | (RVS 15.45 section 9.3)                                     |
| Concrete nosing                                                        | (RVS 15.45 section 9.4)                                     |
| Accessibility                                                          | (RVS 15.45 section 9.5)                                     |

| Installation:                                                           | (RVS 15.45 section 5.2)                                     |
| Anchorages                                                             |                                                              |
| Carriageways                                                           |                                                              |
| Pedestrian walks and medians                                           |                                                              |
| Steel members                                                          |                                                              |
| Structural details                                                     |                                                              |
Installation and connection to surfacing (RVS 15.45 section 6.3)
Materials (RVS 15.45 section 5.5)
   Metallic
   Sealing elements without loading function
   Elastic joints
   Special pouring material
Supervision (RVS 15.45 section 7.1)
Quality assurance (RVS 15.45 section 8)
Internal supervision (RVS 15.45 section 8.1)
External supervision (RVS 15.45 section 8.2)

Environmental conditions:
There are currently no tests that deal with environmental conditions in the Austrian Guidelines for Bridge Joints, and local experience in these types of tests, specifically for the waterproofing materials (e.g. rubber), should be sourced.

A.4.1 Summary
A preliminary framework for tests, based on the Austrian Guidelines for Bridge Joints, was identified in this section for performance testing of both structural and functional performance indicators. This framework can be used in the evaluation of tests for products submitted for certification. It should be the responsibility of the applicant to supply information regarding equivalent tests used by Agrément, for evaluation of the applicability of such tests. The specific criteria set for each of the performance indicators should be met before the results of tests will be approved for use as input in the certification process.

A.5. SUMMARY AND CONCLUSIONS

The first report covered the initial development of bridge deck joint types, and performance indicators for bridge deck joints. It was mainly based on the results of a literature survey of existing practice surrounding bridge deck joint performance and testing, with some additional information collected from industry and clients through a questionnaire.

A definition for the purpose of bridge deck joints was developed, components and types of bridge deck joints were identified, and bridge deck joint behaviour investigated based on published information. The perception of industry regarding bridge deck joints and the proposed classification and criteria was also discussed.
A broad framework for the development of fitness-for-purpose criteria was developed. This framework indicates that structural performance indicators should be evaluated using an absolute performance evaluation, while functional performance indicators should be evaluated using a relative performance evaluation. Nine broad indicators (three structural and six functional) were identified for evaluation.

A provisional framework for tests to be considered for evaluation of the selected performance criteria is provided. This framework is mainly based on the Austrian Guidelines for Bridge Joints, which is perceived to be one of the most comprehensive guides available.

It is proposed that the structural and functional performances of a bridge deck joint be evaluated separately. Structural performance should be evaluated using an absolute criterion to ensure that the joint can withstand the applied loads and movements. Functional performance should be evaluated using a relative performance criterion, to ensure that the performance of the joint will be as good as or better than existing joints.

It is also proposed that manufacturers can (and preferably should) submit certificates from approved institutions indicating their conformance to most of the performance criteria. Agrément will then only request additional tests in those areas where it is perceived that the operational and environmental conditions in South Africa differ substantially from those for which the test certificate has been supplied.

The following recommendations are made based on the information and discussion in this report:

1. The bridge deck joint types proposed should be used as standard terminology in South Africa;
2. The criteria proposed be used for evaluation of new and existing bridge deck joints for certification by Agrément South Africa, and
3. The certification system be implemented as proposed, with refinement in the areas of specific criteria values.
APPENDIX B. SECOND REPORT TO BRIDGE DECK JOINT
STEERING COMMITTEE

As the text of the first and second reports are included in this final guideline document as appendices, areas where duplication of information existed between the original documents has been omitted on the second and later occasions. Reference is made in such areas that information has been deleted from the appendix. The full text of the two reports is available as original reports under their separate references.

B.1. REPORT 2 SUMMARY AND ISSUES

The objectives of the second report were to:

1. Provide a framework for the certification of bridge deck joints;
2. Identify possible certifiable and external criteria;
3. Identify test principles for evaluating the certifiable criteria, and
4. Discuss some issues that may be unclear in the certification process.

The second report built on the results of the first report, as well as the discussions at the first steering committee meeting (27 March 2000) and other discussions and meetings.

B.2. FRAMEWORK

B.2.1 Introduction

A framework is proposed to formalise the process of certification of bridge deck joints. This framework is based on the Austrian Guidelines for Bridge Joints (RVS 15.45, 1993) to ensure that all relevant aspects are covered. However, the Austrian guidelines also covers aspects of design, construction, maintenance, and accessibility that are beyond the scope of a performance certificate. These aspects are covered by reference to accepted standards and specifications in the proposed certification process.

B.2.2 Proposed framework for certification

The general framework for the certification is based on the Austrian Guidelines for Bridge Joints. This guideline provides the following main sections:

1. Joint type definitions;
2. Design;
3. Construction;
4. Transport, storage and installation;
5. Maintenance;
6. Quality assurance, and
7. Accessibility.

As this is a certification document and not a specification, the document entails definitions of joint types, refers to acceptable specifications and procedures for design, construction, transport, storage and installation, maintenance, quality assurance and accessibility, and provides information on the certifiable criteria and appropriate tests for each of these criteria.

The detailed framework for the certification process thus includes the following sections:

1. Introduction and scope;
2. Joint type definitions;
3. Certifiable criteria (definitions, appropriate tests and categories);
4. Non-certifiable criteria (definitions, acceptable specifications and categories), and
5. Quality assurance.

B.2.3 Definitions of certificates and specifications

It is vital to distinguish between a product specification and a product certificate. A specification is defined as ‘a detailed description of the construction, workmanship, materials etc of work done or to be done...’, while a certificate is defined as ‘a formal document attesting a fact, ... fulfilment of requirements ... etc’. The main difference between a specification and a certificate is thus that a specification describes a process to be followed or an expected outcome, while a certificate indicates the manner in which the product fulfils the requirements.

In the current project, which is the development of a certification system for bridge deck joints, the outcome is thus a standard form (certificate) that indicates to the potential user that the specific product (bridge deck joint) conforms to specific requirements. The certificate may and should include reference to a specification for design, detailing, installation and maintenance of the bridge deck joint. This is, however, not included in detail in the certificate or certification process.

This project thus focuses on the development of the certification process and appropriate tests to evaluate the joint for certification. Reference will be made to the specifications for construction, design, detailing, installation and maintenance as available from the various manufacturers.

By including reference to these specifications, it is intended that the steering committee will also familiarise themselves with these documents and agree to them as being
acceptable for the industry. However, no tests are prescribed to establish whether or not this is the case. These specifications are agreed upon based on a subjective industry/specialist view regarding their acceptability. This is in agreement with standard Agrément South Africa practice.

**B.2.4 Guarantee versus Certificate**

It is also important to distinguish between a guarantee and a certificate for a specific product. A guarantee is defined as ‘... an assurance of the quality of or the length of use to be expected from a product offered for sale, accompanied by a promise to replace it or to pay the customer back...’ while a certificate is defined as ‘... a formal document attesting a fact, ... fulfilment of requirements ... etc’.

An Agrément certificate is by definition not a guarantee for the product. A guarantee is normally issued when little or no knowledge of the expected performance of the product is available and the risk is carried by the provider of the product to ensure that the product will be functional for a specified period.

However, when a certificate is available indicating the level of performance to be expected from the product for a certain period, a guarantee may become unnecessary, as the certificate already indicates the performance expected from the product. However, if the client still requires a guarantee it is his prerogative. Furthermore, this expected performance has been tested and validated and therefore should provide the user with more confidence than a guarantee.

If, however, a user specifies performance criteria beyond the scope of the certificate for the specific bridge deck joint, these may and should be covered by a guarantee, as the original certificate will no longer be applicable.

**B.2.5 Agrément viewpoint on Quality assurance**

A requirement for certification by Agrément South Africa is that each certificate holder has a simple, approved quality assurance system in place. This system must be based on the recommendations of the ISO 9000 series\(^2\). The system is required to ensure that good quality materials and satisfactory standards of design, manufacture and, where appropriate, erection are consistently maintained within defined criteria. The quality assurance document must deal separately with the procedures for the manufacturing process and the transport and erection or installation process.

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\(^2\) At the time of preparing this document, changes were being incorporated into the ISO 9000 system. However, these changes were not available before finalisation of the report. When this document is used the user should familiarise themselves with possible changes to ISO 9000.
Information regarding the quality assurance process is provided in Section 2.4 of the main report, and the original text of report 2 omitted in this appendix.

**B.2.6 Approval Process**

Agrément South Africa evaluates the fitness-for-purpose of non-standardised construction products and systems against performance-based criteria. Performance criteria and test methods are established in consultation with relevant experts, as required. Agrément criteria may apply to any type of construction process or construction product. All certificate holders are required to have a quality management system, the implementation of which is monitored annually. If the subject of an evaluation is assessed to be fit-for-purpose, the Board of Agrément South Africa grants it an Agrément Certificate. The subject of a certificate is reappraised if the certificate holder makes any changes to the subject, or if there are any changes to Agrément South Africa’s criteria that affect the subject.

Only the certificate holder or his licensees who are registered with Agrément South Africa may claim compliance with a certificate. The quality management of licensees is also monitored by Agrément South Africa.

**B.2.7 Implementation proposal**

The proposed process for the certification of bridge deck joints can be summarised as follows:

1. identification of certifiable criteria;
2. identification of tests to verify certifiable criteria;
3. development of pro forma for application for certification;
4. development of pro forma for selection of appropriate joints, and
5. development of database of certified joints.

**B.2.8 Practicalities**

It is important to define the process for certification. Agrément will develop the certification process that outlines the certifiable criteria, tests to evaluate these criteria and related information.

Manufacturers of bridge deck joints will apply for certification of their specific joints by submitting a request for certification. This request will include information regarding the joint, its capabilities, its uses, tests that have already been performed on the joint and the intended classification from the manufacturer (i.e. open joint, watertight joint etc). It is important to realise that a manufacturer may request certification of a joint even if the joint has not yet been tested for all the criteria. Agrément South Africa will, in consultation
with appropriate technical specialists from the CSIR, universities, the professions and the bridge deck joint industry, identify applicable criteria, tests or other assessment methods and then determine whether the criteria are met by the joint, for the specified uses.

The resulting certificate will indicate for which uses the bridge deck joint is intended and to what extent the joint satisfies the criteria. Using this process, a manufacturer might obtain certificates for all his joints immediately when certification comes on line, without the need for additional tests. On the other hand, if the manufacturer has done no or inadequate testing, Agrément South Africa will in any case perform the necessary technical assessment.

The manufacturer must also indicate the specifications according to which the bridge deck joint has been manufactured (quality assurance process) and to which specification the joint must be designed, detailed, installed and maintained.

Once this certificate is issued, the information regarding the bridge deck joint and its certificate will be included in a database of certified joints. This database may be made available to consultants and clients (on a CD or other suitable media).

If the bridge deck joint is one that has not been in service before, this will be indicated on the certificate. This indication will be removed from the certificate once the manufacturer can provide Agrément South Africa with proof that the joint has been installed and successfully used on a bridge with a traffic load equal to the certified traffic load and where the design movement is at least 50 per cent of the total capacity of the joint.

The client/consultant will complete a pro forma request-for-joint-certificate, in which the requirements for the specific bridge deck joint will be indicated. A list of joints that comply with the requirements will be provided to the client/consultant for final selection of a joint. If the client / consultant decides to select a joint outside the certified scope, the selected joint will no longer be covered under its certificate for the specific project, as it has been used outside the scope of the certificate.

If a client does not follow the specifications for design, detailing, installation and maintenance indicated in the certificate, the certificate will be void for the specific project and the client would not be able to hold the manufacturer or Agrément South Africa responsible for any loss or damage. However, if a joint agreement is reached between the client and the supplier of the joint (holder of the certificate) that smaller changes may be made to any aspect of the joint specification, installation and / or maintenance procedures, then the original certificate may still be valid. Such changes have to be clearly documented.
CERTIFIABLE CRITERIA

B.3.1 Introduction
In this section the criteria that are certifiable through various tests and procedures are defined and discussed. Specific tests are not discussed as they are included in Chapter 4.

B.3.2 Range of criteria that can be certified
The range of certifiable criteria includes all those aspects of the bridge deck joints that can be measured. Measurement either entails physical measurement of a dimension (e.g. the movement range of a joint) or measurement of a property (e.g. level of waterproofing). The following criteria are defined as being certifiable:

1. movement range
2. strength
3. fatigue
4. adjusting forces
5. shape stability
6. environmental resistance
7. waterproofing ability

Movement range
The movement range is the simplest criterion as it indicates the physical movement that the bridge deck joint can accommodate in all six degrees of freedom (i.e. translation and rotation). It should be evaluated and certified at which angles of skewness and slope the movement can occur without damage to the joint. A graph indicating decreasing movement with increasing skewness and/or slope may be appropriate.

Strength
The strength of a bridge deck joint should be a simple criterion to evaluate - the resistance to specified loads applied to the joint would be measured. The load used for the strength test of a specific joint needs to be defined in relation to standard loads expected on the joint. The first distinction for the selection of the test load is between joints for vehicle and pedestrian traffic. Based on this, a test load will be defined in accordance to the expected loads on a typical structure.

Fatigue
The fatigue resistance of a bridge deck joint should be evaluated to determine the number of load applications (and associated load intensity) that the joint can withstand.
before failure. A specific load and number of load repetitions need to be defined for both pedestrian and vehicular traffic.

Adjusting forces
Adjusting forces are defined as those forces that develop in a bridge deck joint due to resistance to movement. Certification for adjusting forces will include a table indicating the expected adjusting forces for a specific joint.

Shape stability
The shape stability of a bridge deck joint indicates whether the components of the joint will change shape when trafficked. The certificate will indicate the load and temperature range (static) for which the joint will be stable. Essentially this will indicate whether a joint can be used in areas experiencing high ambient temperatures and slow-moving/stationary traffic.

Environmental resistance
The environmental resistance would indicate the resistance of the bridge deck joint materials to factors such as corrosion, UV radiation, etc. Again, a category for each of the parameters should be created in order for the certificate to indicate the level of resistance to specific environmental conditions. This will also relate to the protection systems used for a specific joint.

Waterproofing ability
The ability of the joint to prevent water ingress can be measured and indicated in categories of waterproof, water resistant and open. These categories will be defined to indicate the amount of water resistance over a specific time for the specific category.

B.4. TESTS FOR CERTIFIABLE CRITERIA

B.4.1 Introduction
Certifiable criteria were identified previously as:

1. movement range;
2. strength;
3. fatigue;
4. adjusting forces;
5. shape stability;
6. environmental resistance, and
7. waterproofing ability.
Principles for appropriate tests are listed for each of these criteria in this section. These principles are sourced from existing specifications and reports. Details of these tests are available but will be incorporated when the principles for each test have been agreed on. New tests or modifications to these tests may be added to the list at a later stage.

### B.4.2 Tests proposed to evaluate certifiable criteria

For each of the certifiable criteria listed, the general philosophy behind the nominal test is first provided, followed by some discussion on the test principles.

### B.4.3 Full-scale versus component tests

A decision must be made regarding the specific tests that have to be performed on a full-scale sample of the bridge deck joint and those that can be performed on specific components of the joint. Ultimately, evaluation of in-service performance of joints will provide full-scale test results for amendments to current certificates. The decision should thus focus on those criteria where full-scale tests are too expensive and/or impractical to perform, and where results from component testing would adequately indicate the full-scale behaviour of the joint. For these criteria, component tests can be prescribed with backup from in-service joints.

The following sub-sections provide general guidelines for the selection of either component or full-scale tests. These will be finalised once final decisions regarding test protocols have been made.

### B.4.4 Movement range

Tests for movement range should entail measurement of the physical horizontal and vertical movements (rotation) allowable for the specific bridge deck joint without damage to the joint or excessive reactions / forces applied to the supporting components of the structure. The number of repetitions of such movement should be defined and will be related to the traffic class and expected life of the joint. The movement range should be verified individually for each of the vertical and horizontal movements as well as combined with each other. The movement range should be evaluated at different slopes and skewness angles to enable certification into a specific class.

The Austrian guidelines provides a set of tests to verify the movement range of various joint types.

Movement range certifies the ability of certain components of the joint to open and close in order to allow a specific amount of movement of the bridge deck. It is proposed that component testing could be used to evaluate only those components of the joint that are affected by the movement.
B.4.5  **Strength**

Strength tests should entail measurement of the ultimate load that the specific bridge deck joint and its components can withstand. These loads should be related to the intended use of the specific joint (e.g. pedestrian or vehicle). Appropriate test loads will be defined for each of these two categories based on current loads experienced on bridges with an adequate safety factor to allow for overloading. The strength tests should provide an indication of the ultimate strength of the joint.

The Austrian guidelines provides a set of tests to verify the strength of various joint types.

Strength tests evaluate the ability of the whole joint to withstand ultimate loads. The whole joint should thus be tested for resistance to such ultimate loads. If full-scale tests are initially too expensive or impractical, theoretical analysis of the ability of the joint to withstand certain loads should be performed and augmented with load tests on specific critical components of the joint. The strength certification of the joint can then be amended when in-service performance data becomes available to support the strength classification of the joint.

B.4.6  **Fatigue**

Fatigue tests are needed to evaluate the resistance of the bridge deck joint to repeated loads of a specified magnitude. Fatigue tests should entail a repeated load applied to the joint and its components until failure occurs. The minimum movement during each of the load repetitions will be specified as not less than 50 per cent of the allowable movement range for the specific joint. The load magnitude and number of load repetitions should be related to the traffic class for which the joint is intended.

The Austrian guideline provides a set of tests to verify the fatigue of various joint types. Rassalski (1991) described a test to evaluate the cyclic motion of a joint.

Fatigue testing evaluates the resistance of the joint and its components to repeated load cycles. Full-scale testing of the joint should be performed to evaluate all components and connections between components. However, critical components (or combinations of components) can be identified and tested in the laboratory. The results of such testing can be amended by theoretical calculations of the fatigue resistance of relevant components and finally by in-service performance data.
B.4.7 Adjusting forces

Tests for adjusting forces should focus on the stresses and strains developed in the joint and its components when it is subjected to stresses that may be expected to develop in the bridge deck.

The Austrian guideline provides a set of tests to verify the adjusting forces of various joint types.

Adjusting forces should be tested on the full-scale joint, as the interrelationship between the various components must be investigated and evaluated. The initial evaluation may be made based on theoretical analysis of the joint and known forces, with final amendment of certification based on in-service performance.

B.4.8 Shape stability

Tests for shape stability (visco-elastic behaviour) should focus on the ability of the bridge deck joint and its components to retain their original shape under repeated loads (especially slow-moving and stationary loads at high ambient temperatures). This test will form part of the fatigue and strength tests, with additional evaluation of changes to the shape of the joint after a predefined number of load applications or maximum (defined) load.

The Austrian guideline provides a set of tests to verify the shape stability of various joint types. Rassalski (1991) described a test to evaluate the vehicular braking and traction resistance of a joint.

As shape stability is primarily concerned with the effect of loads on the visco-elastic components of the joint, these tests can be performed at a component level.

B.4.9 Environmental resistance

Tests evaluating environmental resistance should evaluate the effect of different environmental conditions on the long-term performance of the bridge deck joint and its components. This entails environmental effects of water (corrosion), salts (corrosion), ultra violet radiation and other related conditions. These tests should evaluate the performance of the components critical to the type of environmental attack expected in the field. The result of the tests should be a classification indicating under which conditions the specific joint should provide adequate performance. This excludes the waterproofing ability of the joint.

Rassalski (1991) described a test to evaluate the temperature range of a joint.
Tests for environmental resistance of the joint can be performed at component level, as the possible effect of parameters such as corrosion and UV radiation can be estimated on each of the components, and the tests then applied to those components most likely to be affected by the specific parameter.

**B.4.10 Waterproofing ability**

The waterproofing ability of a bridge deck joint should indicate whether a joint is waterproof, watertight or open. A waterproof classification should identify the joint to be waterproof for a certain period under aggressive conditions, while a watertight classification should indicate that the joint may prevent some water ingress but should not be used where total waterproof conditions are required. An open joint will not provide any protection against water ingress. Tests for watertightness will entail measurement of the amount of water penetrating a joint under specified loading conditions.

Rassalski (1991) described a test to evaluate the ponding behaviour of a joint.

Waterproofing ability needs to be performed on full-scale joints. However, initial tests can focus on those components (or combinations of components) that are primarily responsible for providing the waterproofing capacity of the joint. Final certification will depend on the full-scale in-service field performance of the joint.

**B.5. EXTERNAL FACTORS**

**B.5.1 Introduction**

Various factors affect the performance of a bridge deck joint but cannot be measured and certified. These include parameters such as the installation, maintenance, riding quality and expected service life. Methods of accommodating these aspects in the proposed certification process are discussed in this section.

In general most of these factors can be accommodated in the certification procedure by reference to specifications from the manufacturers or client (i.e. COLTO or similar) or by supplying the relevant documentation describing the process during application for certification.

**B.5.2 External factors to criteria**

**Installation**

The installation procedure for a specific bridge deck joint is a critical factor in determining the performance of the joint. Installation procedures should be included in the certification application, and will be binding after certification, although a client and supplier of a joint may by mutual agreement change smaller details for specific project.
The proposed certification will indicate that the certificate is only valid if the specific installation procedure provided by the manufacturer has been followed. It is the responsibility of the joint supplier to ensure compliance to such installation procedure.

The specifications provided by manufacturers for installation of their respective joints can be scrutinised by industry to provide an objective opinion of whether the procedure is adequate for the specific joint or not. However, the final responsibility for the procedure remains with the manufacturer.

Maintenance
The development of a maintenance procedure for a specific bridge deck joint is the responsibility of the manufacturer. Such a procedure must once again be accepted by industry as a practical procedure, as well as by clients as a cost-effective procedure. The client's maintenance team will be responsible for applying the specified maintenance procedure. Here too, the final responsibility for the procedure lies with the manufacturer.

External movements and forces
External movements from bridge components (e.g. abutments and piers) occur in reality. However, the additional stresses and movements that these movements cause in the joint cannot be certified for, as it will most probably cause the joint to be used outside its normal certification range. A joint can thus not be certified to accommodate additional movements caused by factors not included in the initial design.

Riding quality
The riding quality of a joint can be specified in terms of the maximum vertical movement of the bridge deck joint and would mainly be a function of installation. The certificate can only indicate the maximum vertical movement that the joint can accommodate. The designer should ensure that the maximum expected vertical movement in the joint will not cause undue deterioration of riding quality.

Detailing and design
The detailing and design of a bridge deck joint in a specific bridge is the responsibility of the bridge design engineer. The bridge engineer should take cognisance of all possible movements and loads when designing the system, to ensure that the joint selected will be able to fulfil its intended purpose. A joint cannot be expected to solve design and detailing errors. It is impractical to include specific design and detailing information into the certificate for a specific joint. Specifications for the use of the joint may be referred to, but these cannot be evaluated for each specific bridge design.
Expected service life

The expected service life of a bridge deck joint can be expressed in terms of factors such as its fatigue resistance and the service life of its components. However, confidence can only be gained in these expected lives once joints have been exposed to actual conditions for specific periods.

The expected service life of a joint can be amended with time as more information regarding the performance of the joint in the field becomes available. It will be the manufacturers responsibility to provide Agrément South Africa with new information on actual performance of joints if they require the expected life of the joint to be amended in the certificate.

Based on the information gained from the laboratory tests and relevant experience with the specific joints in the field, an estimate of the relative expected service life for the specific joint can be provided. Such expected life will, however, only be an indication, as in-field conditions for every specific joint will invariably differ and affect the real life of the joint.

B.6. CERTIFICATION PRO FORMA

B.6.1 Introduction

This section provides information regarding the application form and certificate for joint systems. These are currently open for discussion and amendment and are only provided to guide the reader to the effect of using a certification system for bridge deck joints.

B.6.2 Application form

The application form should include the following information:

1. identification of the joint;
2. identification of the manufacturer;
3. information regarding quality assurance system of manufacturer;
4. certificate applied for;
5. information of certifiable criteria for which test data exist;
6. information regarding non-certifiable criteria for which specifications exist;
7. probable classification based on available test data and specifications, and
8. probable classification if further tests are completed successfully.

In order for a bridge deck joint to be certified, certain minimum criteria will exist. These are an acceptable quality assurance system and adequate test data for those criteria that are not to be tested by Agrément South Africa. Adequate test data will be defined as
sufficient data to enable a statistically significant decision regarding the performance of the joint.

### B.6.3 Certificate

The certificate for a specific bridge deck joint should include the following information:

1. identification of the joint;
2. identification of the manufacturer;
3. uses of the joint (vehicle / pedestrian traffic);
4. description of the technical assessment performed and conclusions with regard to compliance with criteria;
5. classification of the joint;
6. information regarding quality assurance system of manufacturer;
7. reference to non-certifiable criteria for which specifications exists;
8. description and drawings of the joint (adequate information should be supplied to allow the engineer to evaluate the appropriateness of the joint for the specified conditions and to allow effective monitoring of installation and maintenance), and
9. exemptions / limitations.

It will always be indicated that a certificate is only valid while Agrément South Africa is satisfied with the quality assurance system of the manufacturer and while the same manufacturer manufactures the joints under the conditions for which the original certificate was issued. Any changes in the manufacturing process or materials will require an amendment to the certificate for the specific joint.

### B.6.4 Request for use of a joint

A request for a listing of Agrément approved and certified bridge deck joints should include the following information:

1. requirements in terms of certifiable criteria, and
2. specific requirements in terms of non-certifiable criteria (e.g. specific installation or maintenance requirements).

It should be clear from the request which of the certifiable criteria are critical for the specific project and which are not. If any information exists indicating why specific joints (that may otherwise be adequate) should not be included in the request, it should be provided. Information indicating non-compliance with specific non-certifiable criteria (i.e. installation method etc) should be provided.
The system should function in such a way that a request from a potential user will generate a list of joints that fulfil the specified criteria. This list will indicate the specific joints, their specific criteria and specifications as well as an indication of costs. If the user selects one of the recommended certified joints, the relevant Agrément certificate will be provided. However, if the user selects a joint that does not comply with the specified criteria, the risk of failure will be carried by the user and not by Agrément South Africa or the manufacturer.

**B.7. SUMMARY AND CONCLUSIONS**

Based on the information in this report, the following conclusions and recommendations are made:

**Conclusions**

1. A certificate and specification for a product have different functions;
2. Certification by Agrément South Africa can only verify adherence of a joint to certifiable criteria and recommend certain specifications and procedures for installation, maintenance etc;
3. Certifiable criteria were identified as movement range, strength, fatigue, adjusting forces, shape stability, environmental resistance and waterproofing ability;
4. Indications of relative expected life based on results of laboratory tests and previous experience can be provided;
5. A range of tests is suggested that may be used to evaluate certifiable criteria in the certification of joints, and
6. External factors that affect the performance of a bridge deck joint, but cannot be measured and certified, were identified as installation, maintenance and riding quality.

**Recommendations**

1. The proposed certifiable criteria are accepted as criteria for certification of bridge deck joints in South Africa;
2. The proposed tests are evaluated as tests for certifiable criteria of bridge deck joints in South Africa;
3. The proposed procedure, framework and pro formas are used for certification of bridge deck joints in South Africa.
APPENDIX C. REVIEWERS’ COMMENTS ON REPORTS 1 AND 2

C.1. RESPONSE FROM MR DEREK IVES TO BRIDGE DECK JOINT REPORTS 1 AND 2

Attached the response from Mr Derek Ives to the first two reports on the Bridge Deck Joint project. Mr Ives is working at the Highways Agency in the United Kingdom.

“Dear Mr Steyn

Apologies again for the delay in responding to your request for comments. I have now had a chance to look through the documents and I thought I would send you my impressions. It would probably be better if I could talk to you about expansion joints rather than put my thoughts into an email but as that would take some time and arranging I will try to do my best.

Overall I think you are approaching the certification of expansion joints in a very professional way and the Austrian test methods seem reasonable in the absence of others.

However, it is not easy to simulate the performance of an expansion joint in the laboratory as there are so many variables that can affect the result. We have a full scale test machine at the Transport Research Laboratory and even with that it can be very difficult to reproduce all the movements, traffic, weather conditions, etc that have to be taken into account.

I am a member of a European Working Group that is tasked with producing a Standard for expansion joints and we are progressing on similar lines to yourselves. Austria is involved with this work and similar test methods are being put forward. You seem to be addressing all the same issues as us.

There is also the cost of testing to take into account. While we would like to introduce a full range of tests to ensure good performance, we would not like to deter some of the smaller companies from registering who may have a very good product. Somewhere we will have to compromise.

I still believe that there is a lot to be learnt from site trials as perhaps the final part of the registration process. This is really the only means of truly simulating the performance of
an expansion joint. In France they tend to monitor a joint over a long period of time and as it demonstrates better performance, the registration is extended accordingly.

Another significant factor is the standard of workmanship during installation. If the joint is poorly installed then the life will be affected and it will suffer premature failure. You have referred to the installation procedure being followed and I think it is important that in the registration procedure we should include some form of registration for installers.

I agree that a maintenance manual should be produced and issued to the Client. Unfortunately the Client does not always heed this advice and often early failures have occurred due to the Client's neglect.

There are a couple of other references that give useful advice on expansion joints:-
A document produced by SETRA in France under reference F8886 in 1988 (English version) called "Expansion Joints in Road Bridges".
Two Transport Research Laboratory reports:- "Improving the performance of bridge deck expansion joints: Bridge deck expansion joint working group final report" by C P Barnard and J R Cuninghame TRL report 236 -ISSN 0968-4107, and "Practical guide to the use of bridge expansion joints" by C P Barnard and J R Cuninghame TRL Application Guide 29 -ISSN 1365-6929.

I hope these comments are helpful to you.

Good Luck

Derek Ives
The Highways Agency
8 November 2000
C.2. RESPONSE FROM DR.-ING. CHRISTIAN BRAUN (MAURER SÖHNE GMBH & CO. KG) TO BRIDGE DECK JOINT REPORTS 1 AND 2

Bridge Joint Deck Certification in South Africa
Dear Mr. Silbernagel,

Next to perusal of reports 1 and 2, today I would like to make the following remarks:

As already announced, a guideline for the European technical approval of expansion joints is on the point of being elaborated. Meanwhile, the work programme was accepted by the European Commission, copy of which please find enclosed. From this document you cannot only derive the seven product families provided for the approval but also the so-called „essential requirements“ (ER). Concerning the expansion joints it is our task to define the criteria to fulfil the four essential requirements that are deemed important. As you can see from the document, the product characteristics largely correspond to the statements made in your documents. There are some types missing in your list, which essentially are the sliding plate expansion joints, which also include the roller leaf joints, as well as disposed cantilever finger joints. Just for your information please also find enclosed the subdivision of the product families as suggested by us.

Up to now in Germany restriction has been made to regulation of those types that are really applied. Due to continuous discussion regarding noise protection, there is also a demand for cantilever finger joints, application of which, however, is strongly restricted due to problems of traffic safety.

Discussion in Europe on the subject of watertightness is quite essential. It meets with general approval that only those expansion joints are designated watertight where no surface water can penetrate into the joint gap, which means it is guided on the carriageway surface. Drainage channels can be provided as an alternative. This, however, will result in extensive maintenance becoming necessary. That is why it is essential to also point out distinctions of that kind in the Technical Approval Guideline. Otherwise you will run the risk that in the end all types covered by the Guideline will be designated equal. Please pay attention to this.

Another important distinctive mark is the life expectancy. Conformable to nature a flexible plug joint cannot achieve the life span of a modular expansion joint. That is why distinctive criteria will have to be determined here as well. Experience made in Austria shows that this criterion was not sufficiently appraised and without any chance for the purchaser to make good his claims later. We proposed to form two groups. Lifetime of the first group to be characterized by such of the road surfacing, i.e. each renewal of road surfacing also necessitates renewal of the expansion joints. The other group should be such dimensioned that the life cycle of a bridge brings about the necessity of max.
two or three times exchange of an expansion joint. So far both in Austria and Germany no distinction was made dependent on the traffic concentration on the individual bridge with the expansion joints being dimensioned to the max. stress to be expected. This subject can be discussed, we are sure, but there is always the risk that for cost reasons a product of poor quality will be chosen.

There are several failure origins listed in your document 1. We should like to state that both in Austria and also in Germany mainly the fatigue damages to steel structures as well as the failures of anchorages and screwings at the other types gave rise to work out these Guidelines. We think the document does not sufficiently outline the subject „fatigue“ as well as the difficulty of screwed anchorages. On principle we suggest certain things to be regulated from the beginning. i.e. those damages already known must be excluded from the beginning. So, for example in Germany the screwing of sealing elements is generally forbidden. Regarding absorption and displacements it must be said, that also the deformation speed is of considerable importance as well as the cumulated way of displacement during that time. May I request you to please complete these criteria. In article 4.3 of document 1 you point out that for rubber and similar parts additional environmental conditions will have to be fixed. I should like to inform you that table 5.1 of RVS provides for example for ageing and ozone resistance tests.

In Germany approvals are granted on experience, which means new developments will first of all have to be tested individually for their ability. Next to approx. 1 to 2 years of experience a general authorisation will then be given. I could imagine you to assume these proceedings as well. By this you could avoid bad surprise as for example faced with in Austria recently where a modular expansion joint had been developed according to theoretical points of view only and was then put into the market.

Re.: document 2
Quality safety:
The notes given in article 2.5 of document 2 are generally correct and essentially describe the rough copy of ISO 9000. Though there is no explicit demand, it might be obvious and customary being certified according to ISO 9001. Even more important than systemizing the quality safety is the check at the product itself. That is why both in Germany and Austria and also in France there is a binding necessity not only for internal supervision but also for external supervision. This is realised from statistical principles and is indispensable. Without product control the ISO 9000-certificate remains a mere document.
re: 2.8 Practicalities
Judgement whether examinations made already fulfil the requirements is very sumptuous. To do this we form our own work groups. As a rule there is often no way but to make certain tests once again, in particular if the Guidelines in question do not really match. Just for this reason we really think it appropriate to create a certain standardization worldwide. With this, however, it is necessary to also consider the costs. In Germany and Austria the work groups work either free of charge or charge the ministry of traffic, whereas the tests of the various proofs are charged to the manufacturer. Clear statements are required here as well. The applicant needs to have some protection against „drivers on pig’s back“.

As far as article 3 of document 2 is concerned, we would once again refer to the European work programme.

re: 4. Tests
Majority of the functional properties can only be proved by tests. In article 4.3 full scale are compared to component tests. It is our philosophy to always execute tests scaled 1 : 1, i.e. full scale, however, due to complexity prefer doing component tests. It goes without saying that the formation of the test specimen is also dependent on the product family. It is not for economical reasons that component tests are executed but instead the fact that there is a variety of different load combinations with a different load combination for each component becoming essential for the failure. On the other hand for the execution of component tests, the carrying capacity of the total structure will have to be considered correctly. That is why according to Austrian and meanwhile also to German Guideline the load deformation behaviour of the structure (in particular this applies to modular expansion joints) is defined by structures under traffic. A calibrated vehicle at prescribed speeds serves to measure the load deformation behaviour. This behaviour is also important to correctly appraise the fatigue resistance of the structure and must be examined. Regarding the displacements we should once again refer to the importance of the displacement speed.

re 6. Certification Pro Forma
Most of the expansion joints are manufactured in modular design (not to be mixed up with modular joints), which means depending on way and size of movement there is a modular design system.

The application for approval as well as the approval itself will have to define the exact range of application of the expansion joint. This also includes the admissible movements in all directions, and also the admissible skewed position of the expansion joint as well as the admissible longitudinal slope of the carriageway and similar. As far as the subject of
the longitudinal slope is concerned it should be noted that there are latest trends showing that certain expansion joints are not suitable for large longitudinal slopes. Reasons for this are sensitiveness to forces parallel to the surface on the one hand and penetration of the joint edges at horizontal support of the structure on the other hand.

In general it can be said that the documents presented are of a very complete character. That is why I think the next step will be particularly important, i.e. regulations with the actual figures are being missing. As already mentioned before, it really would be very dangerous if each product had performance characteristics of its own with no way to harmonize them. Expansion joints of similar design should have similar life span, similar carrying capacity and also similar functional properties.

Hope my comment will be of assistance to you.
Yours faithfully,
Maurer Söhne GmbH & Co. KG
Dr.-Ing. Christian Braun
APPENDIX D. SKETCHES OF BRIDGE DECK JOINTS

Sketches of some of the bridge deck joints identified in Chapter 2.3 are shown in this Appendix. This serves as additional description of each of the types of bridge deck joints in the proposed terminology list. The types of bridge deck joints identified are:

1. Buried expansion joints
   a. With anchorage
   b. Without anchorage
2. Flexible plug expansion joints
   a. Asphalt
   b. Polymer
3. Nosing expansion joints
   a. Without metallic edge beams
   b. With metallic edge beams
4. Modular expansion joints
   a. Single seal
   b. Multiple seal
5. Mat expansion joints
   a. Single mat
   b. Multiple mat
6. Cantilever expansion joints
   a. Cantilever finger
   b. Cantilever comb
7. Supported expansion joints
   a. Sliding plate
   b. Sliding finger
   c. Multi-section roller shutter
8. Special joints
Figure 22: Nosing expansion joint - without metallic edge beams.

Figure 23: Flexible plug expansion joint – asphaltic.
Figure 24: Modular expansion joint - single seal.

Figure 25: Modular expansion joint - single seal with cover plate for pedestrian walk.
Figure 26: Mat expansion joint - single mat (bolt down anchorage).

Figure 27: Cantilever expansion joint - cantilever finger (bolt down anchorage).
Figure 28: Modular expansion joint - multiple seal with beam support.

Figure 29: Modular expansion joint - multiple seal with pantograph type support.
Figure 30: Supported expansion joints - multi section roller shutter.

Figure 31: Supported expansion joint - sliding finger.
Figure 32: Supported expansion joint - multi section roller shutter
APPENDIX E. PHOTOGRAPHS OF DAMAGED JOINTS

In this appendix photographs of typical problems with joints and failed joints are shown. These photographs are included to indicate what a typical failure would look like in the field.

Figure 33: Cantilever finger joint: completely jammed with debris.

Figure 34: Buried joint: cracked surfacing.
Figure 35: Single seal modular expansion joint: discontinuity in profile.

Figure 36: Sliding finger expansion joint: broken “fingers”.
Figure 37: Sliding finger expansion joint: misaligned “fingers”.

Figure 38: Cantilever finger expansion joints: missing and loose panels.
Figure 39: Cantilever finger expansion joint: broken panel.

Figure 40: Supported expansion joint: sliding plate.
Figure 41: Concrete nosing expansion joint: missing seal.

Figure 42: Cantilever finger joint: misaligned fingers due to pressure from debris.
Figure 43: Cantilever finger expansion joints: cracked nosing.

Figure 44: Concrete nosing expansion joint with neoprene compression seals (modified): horizontal misalignment.
Figure 45: Asphaltic plug expansion joint: flowing of binder.

Figure 46: Concrete nosing expansion joints: deteriorated nosing.
Figure 47: Concrete nosing expansion joints: missing seal.

Figure 48: Single seal joint in aluminium profile and elastomeric concrete nosing: heavily cracked nosing and broken edge profile.
Figure 49: Concrete nosing expansion joint with silicon sealant: debonding and cracked sealant.

Figure 50: Asphaltic plug expansion joint: cracks in non trafficked section.
APPENDIX F. INDUSTRY QUESTIONNAIRE ON BRIDGE DECK JOINTS

F.1. INDUSTRY SURVEY – PERFORMANCE CRITERIA FOR BRIDGE DECK JOINTS

F.1.1 TEXT FOR COVERING FAX
Regarding: Agrément bridge deck joint certification

Dear Sir

The CSIR, on behalf of AGREMENT South Africa, is currently in the process of developing a product certification system for bridge deck joints. The idea behind the system is to provide a means of evaluating and certifying the expected performance of both conventional and non-conventional bridge deck joints.

One of the greatest barriers to the acceptance of a new bridge deck joint is clients’ lack of knowledge of and confidence in the new product. Further, comparison with existing products used in different applications is also not always possible. The product certification process would in effect compare the performance of products (new and existing) with generally expected performance levels. Product certification could therefore help potential clients to better understand and gain confidence in the certified product, thereby facilitating easier entry of the product into the market.

The CSIR and AGREMENT regard transparency of the certification system development process as one of the keys to the successful implementation of the planned system. It is therefore important to us that members of industry are provided with an opportunity to contribute to the development of a product certification system. To achieve this, various recognised practitioners are on the steering committee for the product certification development process. We also plan to provide timely feedback to industry to test methods and procedures that will be employed in the certification process.

As part of the process of involving industry in the product certification development process, we have compiled a brief questionnaire that will enable us to assess the scope and number of products that may be submitted for certification, as well as to identify possible barriers to the acceptance of the planned system. It will therefore be greatly appreciated if you could complete the attached questionnaire and return it to us on or before 31 March 2000. All replies will be regarded as strictly confidential.
You are welcome to contact me should you have any questions or comments regarding the questionnaire. Your help in this matter will be greatly appreciated.

Yours sincerely

P Nordengen
(Project manager)

F.2. QUESTIONNAIRE FOR MANUFACTURERS

1. Do you have a positive attitude towards the implementation of a certification system for bridge deck joints?

2. What are your greatest concerns regarding a product certification system for bridge deck joints?

3. If a product certification system for bridge deck joints is implemented, how many products would you possibly submit within the next 2 / 5 years?

3. The following classes of bridge deck joints were identified as representative of the available products:

- Flexible joints (asphaltic);
- Buried joints;
- Nosing joints (Elastomeric or steel retainers / headers, in metal runners, tension-compression type);
- Mat joints (Reinforced Elastomeric joints);
- Finger or tooth joints (i.e. beam finger);
- Modular / multi-seal / multi-element joints;
- Claw and gland seal; and
- Special types (i.e. seal-slab-seal).

Are these classes adequate to describe the bridge deck joints available in your view?

5. Are there any other classes that you would prefer to be added to this list?
6. The following criteria were identified as being important to be considered in the
development of product certification tests:

- **Total movement resulting from:**
  - **Axial movement** due to temperature variation, shrinkage, creep, traffic, blocked
    joints;
  - **Lateral movement** due to centrifugal forces, skew;
  - **Vertical movement** due to traffic, temperature gradient, differential settlement
    (including mining subsidence);
  - **Rotational movement**, mainly due to traffic and temperature gradient.

**Typical failure modes and mechanisms** (in order of perceived importance)
- Poor workmanship during installation;
- Anchor material failures;
- Debris (foreign matter) build-up and inadequate cleaning (causing restrained
  movement);
- Deterioration of joint components due to heavy wheel loads;
- Incompatibility between the performance of different materials in the joint and the
  bridge deck;
- Corrosion of uncoated joint components;
- Abutment movements due to earth pressure;
- Settlement and misalignment of joints;
- Vibrations and accident damage;
- Untimely maintenance;
- Inadequate drainage, and
- Leakage of joint seals.

**Critical issues**
- Motorcycle usage;
- Skid resistance;
- Ease of maintenance;
- Ease of installation (critical actions);
- Joint design;
- Condition of substrate;
- Weather and temperature, and
- Site preparation and workmanship.

Are you satisfied that these criteria cover the range of possible criteria to be tested?
7. Are there any other criteria that you would like to add, or are there any of these criteria that you perceive as not necessary to be included in the tests?

F.3. QUESTIONNAIRE FOR CLIENTS

1. Do you have a positive attitude towards the implementation of a certification system for bridge deck joints?

2. What are your greatest concerns regarding a product certification system for bridge deck joints?

3. The following classes of bridge deck joints were identified as representative of the available products:
   - Flexible joints (asphaltic);
   - Buried joints;
   - Nosing joints (Elastomeric or steel retainers / headers, in metal runners, tension-compression type);
   - Mat joints (Reinforced Elastomeric joints);
   - Finger or tooth joints (i.e. beam finger);
   - Modular / multi-seal / multi-element joints;
   - Claw and gland seal; and
   - Special types (i.e. seal-slab-seal).

Are these classes adequate to describe the bridge deck joints available in your view?

4. Are there any other classes that you would prefer to be added to this list?

5. The following criteria were identified as being important to be considered in the development of product certification tests:

   **Total movement resulting from:**
   - **Axial movement** due to temperature variation, shrinkage, creep, traffic, blocked joints;
   - **Lateral movement** due to centrifugal forces, skew;
   - **Vertical movement** due to traffic, temperature gradient, differential settlement (including mining subsidence);
   - **Rotational movement,** mainly due to traffic and temperature gradient.

   **Typical failure modes and mechanisms** (in order of perceived importance)
   - Poor workmanship during installation;
• Anchor material failures;
• Debris (foreign matter) build-up and inadequate cleaning (causing restrained movement);
• Deterioration of joint components due to heavy wheel loads;
• Incompatibility between the performance of different materials in the joint and the bridge deck;
• Corrosion of uncoated joint components;
• Abutment movements due to earth pressure;
• Settlement and misalignment of joints;
• Vibrations and accident damage;
• Untimely maintenance;
• Inadequate drainage, and
• Leakage of joint seals.

Critical issues
• Motorcycle usage;
• Skid resistance;
• Ease of maintenance;
• Ease of installation (critical actions);
• Joint design;
• Condition of substrate;
• Weather and temperature, and
• Site preparation and workmanship.

Are you satisfied that these criteria cover the range of possible criteria to be tested?

6. Are there any other criteria that you would like to add, or are there any of these criteria that you perceive as not necessary to be included in the tests?
APPENDIX G. RESPONSES RECEIVED FROM INDUSTRY TO QUESTIONNAIRE.

G.1. RESPONSES TO BRIDGE DECK JOINT QUESTIONNAIRE

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>SUMMARY OF ANSWERS</th>
<th>CLIENTS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Attitude</td>
<td>Yes; Yes; Yes; Yes; Yes;</td>
<td>17</td>
<td>7 (41 %)</td>
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<td></td>
<td>Would be more standardized local system;</td>
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<td>Comparison between new and existing system could reveal flaws due to confidence in existing approved systems;</td>
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<td>Need for control, comparison and confidence in product;</td>
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<td>Appropriate in the light of high incidence of bridge joint failures on network;</td>
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<td>2. Concerns</td>
<td>Yes; Yes; No; Yes; yes;</td>
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<td>Should be strict limitations to approval;</td>
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<td></td>
<td>Not look only at product certification for approval but also overall status and experience of organization;</td>
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<td>Does product perform according to specification;</td>
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<td>Certification to be done by independent reliable institution;</td>
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<td>System may be incomplete and new joints will not be classified;</td>
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<td>Need comparison with actual performance to validate – will take too long;</td>
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<td>Funding in the long term;</td>
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<td>Clear guidelines as to establishment of liability for joint failures needed;</td>
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<td>3. BMS</td>
<td>Yes; No; Yes; Yes; Yes</td>
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<td>BMS for past 2 years;</td>
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<td></td>
<td>Inspections have been performed, structural rehabilitation contracts are due;</td>
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<td>Under implementation;</td>
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<td></td>
<td>Are adding joint management system;</td>
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<td></td>
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<td>4. # of bridges</td>
<td>Owns 2 055 structures; 5; 250; 2 000; 321; 2 000;</td>
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<td>5. Classes</td>
<td>Yes; Yes; Yes; No; Yes; No;</td>
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<td>Moves towards open joints with proper maintenance – reduces future maintenance costs;</td>
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<td></td>
<td>Need revision for sake of clarity (i.e. difference between modular and claw and gland seal);</td>
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</tbody>
</table>
### 6. Other classes

| No; No; No; Yes; No; Yes; | Add Therma joint and soft board joints (older bridges); Distinction needed between pre-manufactured and poured joints – Nosing joints; |

### 7. Criteria

| Yes; Yes; Yes; Yes; No; | Add axial movement due to settlement or rotation of footings or pile caps; Add inadequate movement precision, chemical corrosion and dynamic loading; Rotational movement of joint is negligible in all cases – needs no consideration; Main effect of deck rotation is axial and/or lateral movement; Classification of criteria needs more thought – poor workmanship and debris built-up are not failure modes or mechanisms but causes; Traffic volume should be added; |

### 8. Other

| Yes; No; Yes; Yes; No; Yes; | Listed criteria sufficient; Look at testing of completed joints (e.g. watertightness, load tests, fatigue tests) Agency requires 10 year bank guarantee in addition to workmanship guarantee –PPGS contract; Cognisance of materials to last for guarantee period – repair during this period is for the contractor's account; Ability for gap to be adjusted for ambient temperature (modular joints); Easy separation of modular joints when concrete sets during installation to avoid damage and loosening of the joint anchor in the immature concrete due to overnight movement of the deck; Add quality control and durability; Criteria and classification need further discussion; |

### General

A low response was obtained despite follow-up calls to all outstanding clients after the due date for the questionnaires.
<table>
<thead>
<tr>
<th>QUESTION</th>
<th>SUMMARY OF ANSWERS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Attitude</strong></td>
<td>Good; Yes; Yes; Yes; Yes</td>
<td>Certification should be objective and equitable, may mean different standards/criteria to different joints; Certification system is essential;</td>
</tr>
<tr>
<td><strong>2. Concerns</strong></td>
<td>None; None; Yes; Yes; Yes</td>
<td>Specification should not be cast in stone, should be open for revision; Cost barrier to new systems; Acceptance by authorities; How will locally made components of internationally certified joint be included in certification;</td>
</tr>
<tr>
<td><strong>3. BMS</strong></td>
<td>No answer; N/A; N/A; Involved in provincial and national BMSs; No; No</td>
<td></td>
</tr>
<tr>
<td><strong>4. # of bridges</strong></td>
<td>No answer; N/A; N/A; N/A; N/A</td>
<td></td>
</tr>
<tr>
<td><strong>5. Classes</strong></td>
<td>Good; Yes; Yes; Adequate as generic; Yes; Adequate</td>
<td></td>
</tr>
<tr>
<td><strong>6. Other classes</strong></td>
<td>None; No; No; No; N/A</td>
<td></td>
</tr>
<tr>
<td><strong>7. Criteria</strong></td>
<td>Good; Yes; Yes; Good</td>
<td>Add shear moment to lateral movement; Add design life to joint design; Add probable physical life of joint system to critical issues; Rotational movement also occurs due to secondary prestress effects; Define failure more clearly (i.e. Leakage of joint seals a failure); Put debris built-up under Untimely maintenance; Most critical issue is: Does the joint fulfill the purpose of its design? – focus on basic needs; Joint design covers very large field – need careful consideration; Turn-ups at kerbs are most critical to water tightness; Transverse joints in reinforced edges often cause problems;</td>
</tr>
<tr>
<td><strong>8. Other</strong></td>
<td>None; None; No; No</td>
<td>Make contact with British Board of Agreement to ensure that duplication does not occur; Criteria should focus on different categories of consequences of failure (i.e. failures may be expensive to remedy but occur infrequently); Add category ‘biggest cost to owner’; Do not reinvent the wheel;</td>
</tr>
</tbody>
</table>
## Summary of Answers

### Questions

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<th>SUMMARY OF ANSWERS</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Attitude</td>
<td>Positive; mixed</td>
<td>Enough knowledge (case histories and product data) already exists to make responsible selections. Supplier has back-up of engineering calculations. Method should be based on actual field trials and installations. Proof of design, calculations and properties can be added. Field trials are more informative for joints such as asphaltic plugs. Installation process should also be specified. Market is too small to justify further monetary contribution. Further product testing will be kept to the minimum.</td>
</tr>
<tr>
<td>2. Concerns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. # of products</td>
<td>Up to 10:</td>
<td></td>
</tr>
<tr>
<td>4. Classes</td>
<td>Yes;</td>
<td>Armoured edge joints set in concrete, Armoured edge joints set in elastomeric concrete, Asphaltic plug joints, Elastomeric liquid sealants, Open joints, Bolt down joints (not extension of armoured edge joints)</td>
</tr>
<tr>
<td>5. Other classes</td>
<td>No;</td>
<td></td>
</tr>
<tr>
<td>6. Criteria</td>
<td>Yes; Agree</td>
<td>Take into account economic restraints at time of construction, operating restraints that dictate the choice of joint and insufficient heed to joint limitations. Do not base decision on failure of a joint that has surpassed its expected life.</td>
</tr>
<tr>
<td>7. Other</td>
<td>Mechanical, temperature and chemical fatigue;</td>
<td>Investigate reasons for failures timeously. Do not put blame on joint if something else caused the failure (i.e. settlement at bridge abutments causing impact on joint nosing). Define exact goals to achieve with project and base process on empirical knowledge.</td>
</tr>
</tbody>
</table>