Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 357
Bridge expansion joints

(formerly BD 33/94, BA 26/94, IAN 168/12, IAN 169/12)

Revision 1

Summary
This document sets out the requirements for the design and specification of expansion joints for use in highway bridge decks. It also provides supporting advice on the selection, installation, management and maintenance of various types of expansion joints.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
1	Mar 2020	Revision 1 (March 2020) Revision to update references only. Revision 0 (May 2019) CD 357 replaces BD 33/94, BA 26/94, IAN 168/12 and IAN 169/12. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BD 33/94, BA 26/94, IAN 168/12 and IAN 169/12, which are withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

Bridge deck expansion joints can be installed at the transverse joints between the end of the bridge deck and abutment ballast wall, or between adjacent decks in non-continuous multi-span structures. Expansion joints can accommodate thermal and other movements that occur at the ends of the deck, while providing a level, skid-resistant running surface, capable of supporting the required traffic loads, and managing the drainage of surface or sub-surface water to avoid leakage through the joint.

A variety of proprietary joint types are available to suit different structure types and movement ranges. Expansion joints, and their constituent components, generally have a working life significantly shorter than the design working life of the structure itself, hence thought needs to be given at the design stage of how the joints are to be maintained or replaced, while minimising delay or disruption to road users.

The generic expansion joint types covered by this document are described in Appendix A.

The Guideline for European Technical Approval applicable to bridge deck expansion joints, ETAG 032 [Ref 10.N] is discussed in Appendix B, along with the Declaration of Performance for each of the generic expansion joint types referred to in Appendix A.

Assumptions made in the preparation of the document

The assumptions made in GG 101 [Ref 12.N] apply to this document.

References in this document to BS EN documents include their UK National Annexes and all relevant Published Documents (PDs).

Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 12.N].

Abbreviations

Abbreviations

Abbreviation	Definition
AIP	Approval in Principle
APJ	Asphaltic plug joint
CIRIA	Construction Industry Research and Information Association
DMRB	Design Manual for Roads and Bridges
DoP	Declaration of performance
EADs	European assessment documents
EMR	Elastomeric in metal runners (modular) joint
EOTA	European Organisation for Technical Approvals
EqIA	Equality impact assessment
ETA	European Technical Approval
ETAG	Guideline for European Technical Approval
FERFA	Federation of Resin Formulators and Applicators
hEN	harmonised European Standard
IAN	Interim advice note
ITT	Initial type testing
NAA	National Application Annex
OO	Overseeing Organisation
PTV	Pendulum test value (for skid resistance)
TAA	Technical Approval Authority
TPB	Technical Project Board
TRRL	Transport and Road Research Laboratory (now TRL - Transport Research Laboratory)
WP	Work programme

Terms and definitions

Terms

Term	Definition
Approval in Principle	A document setting out the key parameters associated with the design (or strengthening) of a structure (or part of a structure), including a description of the proposed structure, key dimensions, loads to be carried, constituent material properties, ground conditions, analysis methods and design standards to be used, and any assumptions made. The AIP is to be approved by the Technical Approval Authority (TAA) for the Overseeing Organisation, before detailed design work begins.
Bridge deck gap (Structural gap)	The gap between adjacent spans in a bridge deck or between a bridge deck and a curtain wall. The structural gap width will vary where the joint is designed to accommodate thermal and other movements.
Buried expansion joint	A joint which is formed in-situ using components, such as an elastomeric pad or a flashing, to support the surfacing which is continuous over the structural gap (formerly referred to as a 'Type 1' or Buried Joint).
Cantilever expansion joint	A pre-fabricated joint comprising principally mating metal comb or saw-tooth plates which bridge the structural gap (formerly referred to as a 'Type 7' or 'Tooth/Comb' Joint).
Cover plate	Plate forming a permanent part of an expansion joint system at surfacing level, to cover the structural gap.
Declaration of Performance	Document providing information on the performance of a construction product covered by a European standard or for which a European Technical Assessment has been issued, as required by the Construction Products Regulation 2011/305/EU [Ref 4.I].
Departmental type approval	Department of Transport (UK) legacy system for approval of proprietary expansion joint systems, retained for existing systems that do not have ETA (see Appendix C).
Design life	The period over which the designer specifies the joint system will function safely in service after installation based on the criteria which influence the joint selection.
Effective bridge deck temperature	The uniform temperature component of the bridge deck which governs the longitudinal thermal movement of the deck, determined in accordance with TRL SR479 [Ref 2.N] and Section 6 of BS EN 1991-1-5 [Ref 5.N]
Expansion joint gap (Surface gap)	The continuous gap within an expansion joint system at surfacing level along the line of the joint.
Flexible plug expansion joint	An in-situ joint comprising a band of specially formulated flexible material, which also forms the surfacing, supported over the structural gap by thin metal plates or other suitable components (formerly referred to as a 'Type 2' or Asphaltic Plug Joint).

Terms (continued)

Term	Definition
In-joint drainage	In ETAG 032 [Ref 10.N], sub-surface drainage is defined as a drainage system to collect water from an expansion joint that is not watertight, such as a gutter located beneath the joint. Except where specifically referencing ETAG 032 [Ref 10.N], sub-surface drainage in this document refers to a system for draining water embedded within the carriageway surfacing such as buried slotted tubes.
Mat expansion joint	A pre-fabricated joint comprising a mat plate spanning the joint gap formed from an elastomer with or without bonded metal plates. (Formerly referred to as a 'Type 5' or Reinforced Elastomeric Joint).
Modular expansion joint	A pre-fabricated joint comprising an elastomeric seal fixed between metal runners, either in single-element or multi-element form (Formerly referred to as a 'Type 6' or Elastomeric in Metal Rails (EMR) Joint).
Nosing	In-situ material or fabricated component to protect the adjacent edges of the surfacing at the expansion joint - possibly a steel plate or angle section, but now more usually a modified cementitious mortar or elastomeric resin.
Nosing joint	Expansion joint formed between two nosings, with the gap infilled with either a poured sealant (formerly 'Type 3' joint) or pre-formed compression seal (formerly 'Type 4' joint).
Ride quality	The quality of the experience of the travelling public when driving a vehicle over the expansion joint, affected by factors including bumps, steps or other changes in the vertical alignment, or excessive flexibility of cover pates.
Service life	The minimum period when deterioration or defect arising during service results in the replacement of the joint or any of its components in order that the joint remains safe for use and fit for purpose assuming that the joint system is routinely maintained in accordance with the manufacturer's instructions.
Supported expansion joint	Supported expansion joints include a number of joint types, such as bridging plate expansion joints (with or without fingers) and roller-shutter expansion joints.
Surfacing	Carriageway or footway surface course and binder course materials.
Temporary cover plate	A plate placed over the expansion joint in the carriageway or footway, either to protect the joint during installation or maintenance, or to carry loads over the joint in the event that it has become damaged.
Transition strip	A narrow strip of infill material between a pre-fabricated expansion joint and the adjacent cut edge of the surfacing.
Waterproofing system	A concrete bridge deck waterproofing system which has been granted Departmental registration in accordance with CD 358 [Ref 19.N].

Terms (continued)

Term	Definition
Working life	The period over which it is envisaged that the joint will function satisfactorily without the need for significant maintenance (see Section 2.3.4 of ETAG 032 [Ref 10.N]).

1. Scope

Aspects covered

1.1 This document sets out requirements for the design and specification of expansion joints for use in highway bridge decks, including footbridges and shall apply to new expansion joint works and the maintenance and repair of existing expansion joints.

NOTE 1 *This document provides advice on the selection, installation, management and maintenance of various types of expansion joint.*

NOTE 2 *Specific advice on the design of expansion joints to accommodate movement greater than that provided for by proprietary joint systems is not given in this document, although many of the same basic principles are applicable.*

Implementation

1.2 This document shall be implemented forthwith on all schemes involving expansion joints for use on bridge decks on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 12.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 12.N] shall be followed in respect of activities covered by this document.

2. Design principles

General

2.1 Expansion joints shall either be:

1) designed in accordance with the requirements contained in ETAG 032 [Ref 10.N] and outlined in Appendix B; or,
2) selected from products with a legacy Departmental Type Approval certificate.

NOTE *Declarations of performance requirements from ETAG 032 [Ref 10.N] are included in Appendix B for the generic groups of expansion joints, which are listed and described in Appendix A.*

2.1.1 The approach and relevant information for seismic behaviour may be omitted from the declaration of performance unless it has been assessed as necessary and agreed with the TAA for bridges with Importance Class III defined in BS EN 1998-2 [Ref 8.N], and Consequence Class CC3 defined in BS EN 1990 [Ref 9.N].

NOTE *Refer to PD 6698 [Ref 13.N] for further information.*

2.2 Expansion joints shall not cause a hazard to any class of road user, including motorcyclists, cyclists, pedestrians and animals where they have access.

NOTE *Section 4 includes requirements and advice relating to skid resistance and ride quality.*

2.3 Expansion joints in highway bridge decks shall be capable of sustaining the loads and accommodating movements described in ETAG 032 [Ref 10.N], and in this document, while remaining safe for all categories of road users, without damage to the surfacing or supporting structures during service.

2.3.1 When the total design horizontal movement is less than 5mm and vertical movement is less than 0.5mm, there should be no need to provide an expansion joint.

2.4 Where no expansion joint is to be provided, the waterproofing shall be detailed in accordance with CD 358 [Ref 19.N] to accommodate movements and ensure continuity across the deck joint gap.

2.5 The same joint system, seal or sealant shall continue across the full width of the deck including footway, verge, hard shoulder and central reserve.

2.5.1 Expansion joints should be installed in a straight line.

2.6 The specification of an expansion joint shall balance the ease of replacement and safety of the operatives carrying out that work, with the working life of that product.

2.7 The expansion joint shall not permit water to enter the structure, nor permit it to accumulate within the joint or structure.

2.8 The deck waterproofing system shall be compatible with the expansion joint system.

3. Selection of joint type

General

3.1 Joints shall be specified which will accommodate all the horizontal, vertical and rotational movement likely to be encountered in service.

NOTE 1 *Details of the various bridge deck expansion joint types that fall within the scope of this document are provided in Appendix A.*

NOTE 2 *The key factors affecting the performance of the various types of expansion joint are shown in:*

1) ETAG 032 [Ref 10.N] Part 1 Table 4.0; and

2) Table A.2 (Appendix A), which is based on a similar table in TRL LR1104 [Ref 11.I].

NOTE 3 *Indicative ranges of movement for various types of expansion joint are shown in Table A.3 (Appendix A).*

3.2 Where more than one type of joint is suitable for a particular range of movement or site location, other relevant factors which affect performance and whole life costs shall be identified and assessed before the final choice of joint is made.

3.3 The justification for selection of a particular joint type shall be demonstrated to the Technical Approval Authority (TAA).

3.4 The optimum whole life cost of the expansion joint system shall be achieved by assessing:-

1) the suitability of a particular joint;
2) the working life;
3) initial supply and installation costs;
4) safety of maintenance operatives;
5) road user delay costs;
6) structural damage costs;
7) joint maintenance costs;
8) joint replacement costs at end of service life.

3.5 The assessment demonstrating the optimum whole life cost of the expansion joint system shall be provided to the TAA.

NOTE *Guidance on the whole life costing of bridge deck expansion joints can be obtained from TRL RR236 [Ref 2.I].*

Preliminary design criteria

3.6 At the preliminary design stage, the basic requirements necessary to specify the expansion joint shall be established from the following:

1) required movement capacity;
2) user category (i.e. vehicular, cycle, pedestrian, livestock); and,
3) any special needs for that site (for example, limited depth of surfacing, high skew).

3.7 As part of the joint initial joint selection process, the following shall be assessed:

1) approximate joint dimensions;
2) working life;
3) ancillary items (including cover plates and drainage systems);
4) noise limits;
5) ease of replacement of components (including aspects such as speed, access and traffic management);

6) potential for joints to be replaceable under lane closures rather than full carriageway closure;
7) capital cost; and,
8) maintenance costs.

Detailed design criteria

3.8 The following information about each expansion joint within a structure shall be included in the Approval in Principle (AIP) for that structure.

1) location;
2) anticipated extreme ambient temperature range;
3) user category (i.e. vehicular, cycle, pedestrian, livestock);
4) environmental conditions such as noise constraints;
5) drainage requirements;
6) illustrative cross section of bridge deck at expansion joint location (i.e. a cross section showing full lateral extent of the required joint and the location of the carriageway and verges, including the applicability/location of vehicular traffic, cycle traffic, pedestrian traffic, and animal traffic);
7) illustrative long section of bridge (showing location of expansion joints);
8) interface with service ducts;
9) relevant DMRB documents, UK national standards, Eurocodes (including national annexes), BSI published documents, codes of practice, and related documents; and,
10) constraints and external controls that affect installation or maintenance of the joint such as available lane closure arrangements.

3.9 All of the information above plus the following additional information shall be included in the detailed specification:

1) required movement capacity (x, y, z) between extreme positions;
2) assumed installation temperature range; and,
3) fatigue traffic category from Table NA.4 of UK NA to BS EN 1991-2 [Ref 18.N].

3.10 The following management and maintenance information about the selected joint system shall be recorded in the Health and Safety file and the Overseeing Organisation's bridge management information system.

1) proposed joint and ancillary items;
2) declaration of performance;
3) working life;
4) installation and maintenance procedures; and,
5) maintenance costs (including access and traffic management costs).

Traffic noise

3.11 Where the installation is adjacent to residential property the expansion joint shall be selected and designed to limit noise levels (subject to the over-riding requirements of durability and performance).

NOTE *Joints with the lowest noise levels are those that have a continuous surface over the joint. Some information is stated in TRL RR236 [Ref 2.I] regarding mat or reinforced elastomeric joints, and nosing or elastomeric in metal runner expansion joints. Information is also available from some manufacturers regarding noise reduction measures.*

4. Detailed joint design requirements

Basis of design

4.1 Mechanical resistance of expansion joints for highway bridges shall be specified in accordance with ETAG 032 [Ref 10.N].

NOTE *The performance requirements for the various joint types covered by ETAG 032 [Ref 10.N] are included in Appendix B.*

4.2 The actions and combinations to be used for the design of supporting structures shall be in accordance with the relevant Eurocodes, including BS EN 1990 [Ref 9.N], BS EN 1991-1-5 [Ref 5.N], and BS EN 1991-2 [Ref 4.N].

NOTE *All references to Eurocodes in this document include the respective UK national annexes and the implementation document CD 350 [Ref 17.N].*

Fatigue

4.3 Where a component of the expansion joint or the supporting structure is subject to fluctuating traffic loads, the component or supporting structure shall be designed to have a fatigue life consistent with the design life of the expansion joint as specified within the AIP.

Movements

4.4 The joint shall be designed for the relative movements that could occur at the relevant limit states.

NOTE 1 *Movements can arise from the effects of actions, including thermal actions, shrinkage, creep, traffic and settlement.*

NOTE 2 *Relative movements can occur due to compression of bearings, structural deflections due to traffic on one side of the joint, or rotation of the deck.*

4.5 Bridge movements that can occur simultaneously shall be combined in accordance with BS EN 1990 [Ref 9.N].

4.6 Partial factors and combinations of actions for the calculation of bridge movements shall be in accordance with BS EN 1990 [Ref 9.N].

4.7 The longitudinal movement due to changes in temperature shall be calculated in accordance with BS EN 1991-1-5 [Ref 5.N].

4.8 On new concrete and composite bridge decks, calculations of the range of longitudinal movement of concrete elements shall include predicted changes in deck dimensions resulting from shrinkage and creep.

4.9 Irreversible movements due to creep and shrinkage of concrete shall be calculated in accordance with BS EN 1992-2 [Ref 6.N] and BS EN 1994-2 [Ref 7.N].

4.10 In wide, curved or skew bridges the joint performance requirements shall be determined according to the combination of the transverse and longitudinal movement of the deck.

4.11 Any longitudinal and vertical movement at joints arising from the predicted differential settlement between the bridge supports and the tilt of the bridge supports, such as abutment tilt, shall be included in the calculations of movement.

Joint gaps, grooves and cover plates

4.12 Where there is an expansion joint gap it shall be of a uniform width, and never less than 10% of the specified range of movement of the joint system or 6mm, whichever is the greater.

4.13 The degree of compressibility of seals, sealants and filler boards shall be incorporated into the design.

NOTE *Compression seals, sealants and filler boards can transmit significant forces across a gap.*

4.14 Seals which are not effectively restrained in metal rails shall be designed to remain in compression.

4.15 Where pedestrians have access, all expansion joints with an open joint gap at surface level in the footway shall be closed with either:

1) a cover plate; and,
2) a load bearing seal 5 ± 2 mm below the top surface of the joint.

4.16 Where the expansion joint in the carriageway consists of toothed, finger or comb plates and where motorcyclists, cyclists, wheelchair users, pedestrians or animals have access, the spaces between the mating teeth or fingers shall not exceed 150 mm in length or 20 mm in width, unless compatible cover plates are provided over the expansion joint.

4.17 Where an expansion joint is skewed, such that gaps or grooves can become orientated in the direction of traffic flow, and where motorcyclists, cyclists or wheelchair users have access, cover plates or compressible inserts shall be provided at surface level.

4.18 Cover plates shall have a sufficient thickness to withstand accidental wheel loading and to provide acceptable ride quality.

4.18.1 Steel cover plates subject to traffic (including accidental wheel loading on footways) should be at least 12 mm thick.

4.19 The cover plate arrangement shall avoid steps in the roadway surface or alignment that would cause a hazard to road users.

4.19.1 The height of the joint should be set to accommodate the thickness of the cover plate.

Transition strips

4.20 Where a joint system requires a transition strip (to infill the gap between the joint and the adjacent surfacing), the width of the strip shall be kept as narrow as possible with the edge of the strip adjacent to the joint chamfered to assist in the dissipation of wheel impact loads.

4.20.1 The width of the transition strip should be no wider than 400 mm.

Skidding resistance

4.21 The skid resistance of an expansion joint shall be at least equal to the minimum requirement for the adjacent carriageway surfacing (as defined in DMRB standard CS 228 [Ref 16.N]) throughout its working life.

4.22 The upper surfaces of expansion joints or compatible cover plates in footways and cycleways shall have a slip-resistant finish, which, when new, has a mean corrected Pendulum Test Value (PTV) of not less than 65 under wet conditions.

4.23 The finish of the upper surfaces of expansion joints or compatible in footways and cycleways cover plates shall have an effective life of at least five years and also retain a PTV of not less than 45 under wet conditions throughout this period.

4.24 Where required by ETAG 032 [Ref 10.N] Part 1 Clause 4.1.4.2(b), the skid resistance shall be verified by testing in accordance with ETAG 032 [Ref 10.N] Part 1 Clause 5.1.4.2, which refers to BS EN 13036-4 [Ref 14.N].

Drainage

4.25 Water is not permitted to accumulate on joints. Joints shall be protected from surface water and ponding through incorporating suitable falls on the carriageway around joints and the use of appropriate drainage systems.

Road gullies

4.26 Road gullies shall be provided on the upstream side of expansion joints to collect surface water before it reaches the joint.

4.27 Where porous asphalt is specified, road and kerb gullies shall be detailed to collect water flowing both on top of and within the asphalt.

Drainage system

4.28 Joints provided with a compression seal, elastomeric element or sealant at surfacing level (such as nosing joints), shall be designed to be watertight.

4.29 For joints which are not sealed at surfacing level (such as modular and comb joints), an effective secondary drainage system shall be provided immediately beneath the expansion joint with access for inspection and maintenance.

4.30 Water from the drainage system shall be discharged away from the structure into a suitable road drainage system or soakaway.

NOTE *Requirements on the management of water from the highway are given in CG 501 [Ref 3.N] and LA 113 [Ref 15.N].*

In-joint drainage

4.31 A transverse and through-deck in-joint drainage system shall be provided to prevent water leakage into the deck joint gap, and hence onto the adjacent structural elements and components.

NOTE 1 *Water trapped within the road surfacing on the high side of a deck joint can, through hydraulic pressure from wheel loading, cause failure of the bond or seal between the joint and the waterproofing systems.*

NOTE 2 *For advice relating to the waterproofing and drainage of bridge decks reference can be made to CD 358 [Ref 19.N].*

NOTE 3 *Longitudinal drainage systems can be used, for example, within flexible plug joints, where longitudinal pipes are laid across the width of the joint providing a pressure relief system from one side of the joint to the other.*

NOTE 4 *Examples of in-joint drainage systems are illustrated in Appendix A.*

4.31.1 Transverse drainage systems should be as large as possible, located in such a manner that the flow area is not interrupted and detailed to permit jetting through the drainage tubes.

4.31.2 Buried galvanised steel or aluminium slotted drainage tubes for in-joint drainage may be either circular or rectangular in cross section and discharge water via a suitable connection to the bridge deck drainage system.

4.31.3 As an alternative to transverse slotted drains, a transverse channel may be formed in the top of the bridge deck, parallel to the joint.

4.31.4 Where a transverse channel is used, cast-in down pipes should be provided at intervals along the channel, to clear the bearing and jacking point positions.

4.31.5 Where a transverse channel is used, the trough should be filled with surfacing which is sufficiently permeable to permit the passage of water.

4.31.6 The deck surface adjacent to the joint should be cast with a backfall to ensure that sub-surface water drains towards the cast-in pipes.

5. Design for installation and maintenance

Installation

5.1 Expansion joints shall be securely anchored to the underlying bridge deck in accordance with the manufacturer's instructions.

5.1.1 Where the manufacturer gives no specific anchorage instructions, attachment may be through the following means.

1) bond;
2) bolts or resin anchored studs; and,
3) anchor bars or studs.

5.2 The installation of expansion joint systems shall be undertaken by suitably accredited contractors, in accordance with the manufacturer's approved installation instructions.

NOTE *General guidance for the installation of expansion joint systems is provided in Appendix D.*

5.3 The expansion joint gap width for expansion joints in new construction or a full replacement of an existing joint system shall be set, in relation to the effective bridge deck temperature, to accommodate the range of movements calculated in accordance with Section 4 of this document.

5.4 The sides of the joint gap shall be parallel.

5.5 The expansion joint and its components (such as epoxy nosing materials or transition strips, or flexible asphalt joint fillers) shall be protected until all components have achieved the required strength.

5.5.1 Traffic should be excluded from the joint until the required material properties have been achieved.

5.6 Where the joint is to be subject to traffic prior to components achieving the required material properties, temporary cover plates capable of withstanding vehicular loading shall be provided over the expansion joints during and after installation.

NOTE 1 *Temporary cover plates can also be used to allow traffic to pass over failed expansion joints.*

NOTE 2 *Guidance on the use of temporary cover plates is provided in Appendix F.*

Inspection and maintenance

5.7 Expansion joints shall be inspected and maintained at regular set intervals to ensure that they continue to operate in accordance with all the requirements of this document and the manufacturer's recommendations.

5.8 Details of the maintenance works completed to repair or replace the expansion joints shall be recorded in the Overseeing Organisation's bridge management information system.

5.8.1 When carriageway resurfacing operations are planned, any bridge joints which are affected should be inspected so that, if necessary, replaced at the same time.

5.8.2 Items that have a shorter service life, such as split compression seals or detached sealants should be replaced; tracked flexible plug joints re-profiled; and defective modular joints partially replaced or re-set, to ensure that the joints are operating effectively and safely.

5.8.3 Faults such as blocked drainage or silted-up gaps should be detected and rectified immediately.

NOTE 1 *The overall cost of replacing an expansion joint is significantly more than the cost of the joint itself, because of the additional costs associated with traffic management, and the indirect costs of traffic delays. Even localised resurfacing around a joint can favour an early joint replacement. Replacing joints before they have reached the end of their service life can reduce whole life costs if carried out at the same time as resurfacing.*

NOTE 2 *Failure of a joint can create a serious hazard for traffic.*

NOTE 3 *Water leakage (possibly contaminated with chlorides) can have very damaging effects on reinforced concrete or steel elements in the bridge structure. Silted up gaps, such as from water passage, can permit the transmission of high forces into the joint fixing system.*

NOTE 4 *Expansion joint failure can be identified by indicators such as an increase in noise levels, components becoming loose, broken or damaged, or depressions in the carriageway on the approaches to joints.*

NOTE 5 *The inspection of a more complex expansion joint can trigger further targeted investigation and testing, to quantify the scale and nature of the issues identified during the initial routine inspection, requiring a longer period of closure to traffic than originally anticipated.*

NOTE 6 *The requirements for inspection and maintenance are incorporated within existing DMRB documents, notably CS 450 [Ref 11.N].*

NOTE 7 *A proactive joint maintenance and management regime can be very beneficial to avoid or minimise disruptions.*

5.9 A maintenance manual shall be prepared, and included in the Health and Safety File.

5.10 The maintenance manual shall be updated to include any significant maintenance and management actions such as repairs, partial replacements and changes to inspection intervals which are either carried out or recommended especially following inspections.

5.11 Delivery times for expansion joints and components shall be included in the maintenance manual for each structure for the planning of repair or replacement works.

NOTE 1 *Some components of more complex expansion joints need to be specifically fabricated - this can be identified through discussions with the manufacturer and considered during the options phase.*

NOTE 2 *Table 5.11N2 contains the minimum information required for the maintenance manual.*

Table 5.11N2 Indicative list of items for inclusion in maintanance manual for expansion joints

Expansion joint type
Confirm the expansion joint type.
Ensure that the drawings prepared and/or provided are accurate and sufficiently detailed.
Details of joint settings and special features including specialist equipment required for installation, maintenance and replacement.
Details identifying the manufacturer.
Information on the availability, lead / delivery times for replacement parts.
Procedure
Manufacturer's instructions to include specific requirements for inspection and maintenance.
Inspections
Intervals between inspections.
Specific areas to inspect or issues to look for such as spot corrosion, unusual noises, loose components as identified in the manufacturer's manual.
Level of skill and experience of the inspector necessary to include awareness of the expansion joint type.
Specific guidance on the access for inspection such the need to remove seals in order to view or arrange for specialist equipment.
Maintenance
In accordance with the manufacturer's instructions, as a minimum: 1) clean and remove debris from the joint; 2) record any issues found if apparent; and, 3) grease (if appropriate for joint type).
Checking and clearing drainage system
Service life
Identify the service life of components (e.g. seals) and the date when replacement is anticipated.
Repair strategy
Strategy to include replacement component service life and replacement schedules.
Information on stocking of hard-to-obtain components, or components with a long lead time, for critical routes on the Strategic Road Network (SRN).

6. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. CD 357, 'Bridge expansion joints'
Ref 2.N	Transport Research Laboratory. Emerson, M. TRL SR479, 'Bridge temperatures for setting bearings and expansion joints'
Ref 3.N	Highways England. CG 501, 'Design of highway drainage systems'
Ref 4.N	BSI. BS EN 1991-2, 'Eurocode 1. Actions on structures. Traffic loads on bridges'
Ref 5.N	BSI. BS EN 1991-1-5, 'Eurocode 1: Actions on structures. Part 1-5: General actions – Thermal actions'
Ref 6.N	BSI. BS EN 1992-2, 'Eurocode 2. Design of concrete structures. Part 2: Concrete bridges. Design and detailing rules'
Ref 7.N	BSI. BS EN 1994-2, 'Eurocode 4. Design of composite steel and concrete structures. Part 2: General rules and rules for bridges'
Ref 8.N	BSI. BS EN 1998-2, 'Eurocode 8. Design of structures for earthquake resistance - Part 2: Bridges'
Ref 9.N	BSI. BS EN 1990, 'Eurocode: Basis of structural design'
Ref 10.N	EOTA. ETAG 032, 'Guideline for European Technical Approval of Expansion Joints for Road Bridges '
Ref 11.N	Highways England. CS 450, 'Inspection of highway structures'
Ref 12.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 13.N	BSI. PD 6698, 'Recommendations for the design of structures for earthquake resistance to BS EN 1998'
Ref 14.N	BSI. BS EN 13036-4, 'Road and airfield surface characteristics. Test methods. Part 4- Method for measurement of slip/skid resistance of a surface: The pendulum test'
Ref 15.N	Highways England. LA 113, 'Road drainage and the water environment'
Ref 16.N	Highways England. CS 228, 'Skidding resistance'
Ref 17.N	Highways England. CD 350, 'The design of highway structures'
Ref 18.N	BSI. NA to BS EN 1991-2, 'UK National Annex to Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges'
Ref 19.N	Highways England. CD 358, 'Waterproofing and surfacing of concrete bridge decks'

7. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	CIRIA. CIRIA C764, 'Hidden defects in bridges. Guidance for detection and maintenance'
Ref 2.I	Transport Research Laboratory. TRL RR236, 'Improving the performance of bridge expansion joints: Bridge Deck Expansion Joint Working Group Final Report'
Ref 3.I	Highways England. CS 470, 'Management of sub-standard highway structures'
Ref 4.I	https:eur-lex.europa.eu - Official Journal of the European Union. European Parliament & Council. 2011/305/EU, 'Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directives 89/106/EEC'
Ref 5.I	Highways England. CG 300, 'Technical approval of highway structures'
Ref 6.I	BSI. BS 812-101, 'Testing aggregates. Guide to sampling and testing aggregates'
Ref 7.I	BSI. BS 812-103, 'Testing aggregates. Method for determination of particle size distribution. Sieve tests'
Ref 8.I	BSI. BS 812-1, 'Testing aggregates. Methods for determination of particle size and shape'
Ref 9.I	BSI. BS 812-2, 'Testing aggregates. Methods for determination of physical properties'
Ref 10.I	BSI. BS 812-102, 'Testing aggregates. Methods for sampling'
Ref 11.I	Transport Research Laboratory. TRL LR1104, 'The performance in service of bridge deck expansion joints'

Appendix A. Expansion joint types

A1 General

The various generic types of joint for different ranges of movement are described within this Appendix.

More than one type of joint may be suitable for a particular movement range or site location and other factors have to be considered before the final choice of joint is made.

A1.1 Very large movements

Descriptions of expansion joints to accommodate movement greater than that provided for by proprietary joint systems are not given this Appendix.

A2 Generic expansion joint types

The various 'families' of expansion joint type covered by the constituent parts of ETAG 032 [Ref 10.N] and their corresponding equivalent generic joint types as previously described in the withdrawn BD 33 are provided in Table A.1.

For the purposes of this document and this appendix, the expansion joint terminology used in ETAG 032 [Ref 10.N] has been adopted.

Guidance given on the selection of joints in this appendix is based on information obtained from site inspections, surveys and feedback from a number of sources.

The information compiled has shown that most types of joint perform satisfactorily provided:

1) the total joint system is designed to withstand the effects of traffic loading including impact and abrasion;
2) the total movement at the deck joint gap is within the capacity of the joint system; and,
3) the joint is installed by a competent contractor familiar with the system.

Key factors affecting the choice of a joint are shown in Table A.2. The range of longitudinal movements for which each generic joint type is suitable is shown in Table A.3.

Table A.1 Families of expansion joints in ETAG 032 and their equivalent in BD 33

ETAG 032 Part and joint family	Equivalent BD 33 joint type
Part 1 – General	
Part 2 – Buried expansion joint	Type 1 – Buried joint under continuous surfacing
Part 3 – Flexible plug joint	Type 2 – Asphaltic plug joint
Part 4 – Nosing expansion joint	Type 3 – Nosing joint with poured sealant and Type 4 – Nosing with preformed compression seal
Part 5 – Mat expansion joint	Type 5 – Reinforced Elastomeric
Part 6 – Cantilever expansion joint	Type 7 – Cantilever comb or tooth joint
Part 7 – Supported expansion joint	Not covered
Part 8 – Modular expansion joint	Type 6 – Elastomeric in metal runners

Table A.2 Key factors affecting past joint performance

Joint type				Buried	Asphaltic plug	Nosing (with sealant)	Reinforced Elastomeric	Elastomeric in Metal Runners	Cantilever Comb or Tooth joint	Transition Strip
Movements at the joint (mm)	Thermal	Horizontal	0-15	M	L	M	L*	L	L*	L
			15-50	H	M	H	L*	L	L*	L
			50+	N/A	N/A	N/A	L*	L	L*	L
	Dynamic	Horizontal	<0.05	L	L	L	L	L	L	L
			0.05-0.10	M	L	L	L	L	L	L
			>0.10	H	L	M	M	L	M	M
		Vertical	<2	L	L	L	L	L	L	L
			2-4	M	L	L	L	L	L	L
			>4	H	M	M	M	L	M	M
Traffic over joint	Frequency/Lane /Hour		<10	L	L**	L	M	L	L	L
			10-50	M	L**	M	M	L	L	M
			>50	H	M**	H	H	M	M	H
	Axial loads (kN)		<10	L	L**	L	L	L	L	L
			10-40	M	L**	M	L	L	L	M
			>40	H	M**	H	M	L	M	H
Joint design				M-H	L-M	H	M-H	M-H	M-H	M
Materials used				M-H	M	H	L-M	M	L-M	M-H
Condition of substrate				M-H	M	H	M-H	N/A	M-H	H
Installation temperature (ºC)			<10	L	L	L	L	L	L	L
			10-15	M	L	M	L	L	L	M
			>15	H	M	H	L	L	L	H
In service weathering				M-H	L	L-M	L	L	L	L
Detritus and corrosion				L	L	L-M	M-H	M	H	L-M
Site preparation and workmanship				H	M	H	H	M	M	H
Bond and anchorage				M	L	H	H	H	H	H

Table A.2 Key factors affecting past joint performance (continued)

Joint type	Buried	Asphaltic plug	Nosing (with sealant)	Reinforced Elastomeric	Elastomeric in Metal Runners	Cantilever Comb or Tooth joint	Transition Strip
* Assuming joint in correct design range ** Assuming correct binder type N/A = Not applicable							
L - Low) M - Moderate) effect on performance H - High)							
Note: This table is reproduced from CD 357 [Ref 1.N]. It is based on a similar table in [TRL LR1104 [Ref 11.I], modified to take into account information on joint performance current in 1994.							

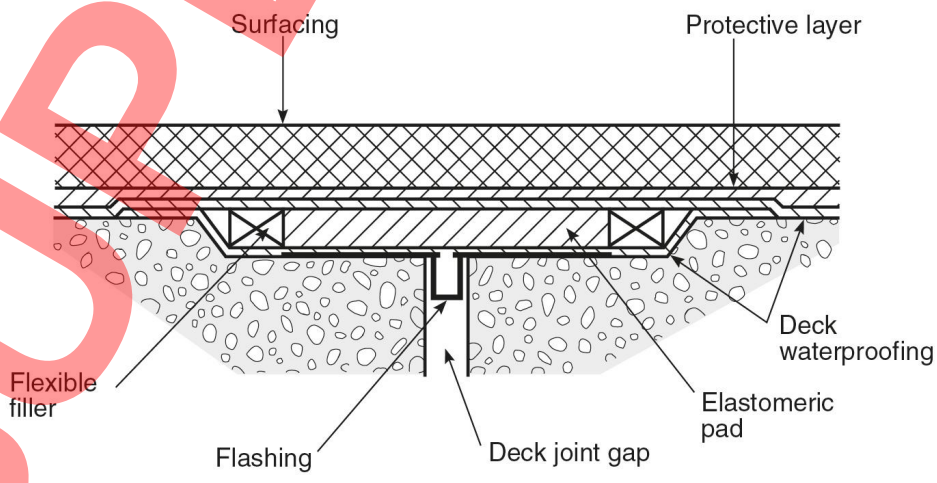
Table A.3 Indicative movement range capacities at SLS based on past experience

ETAG 032 joint family(3)	Total longitudinal movement (mm)		Maximum vertical movement between sides of joint (mm)
	Minimum(2)	Maximum	
Buried expansion joint	5	20	1.3
Flexible plug joint	5	40	3.0
Nosing expansion joint, with poured sealant	5	12	3.0
Nosing expansion joint, with pre-formed compression seal	5	40	3.0
Mat expansion joint	5	Varies(1)	3.0
Cantilever expansion joint	25	Varies(1)	3.0
Supported expansion joint	150	Varies(1)	3.0
Modular expansion joint	25	Varies(1)	3.0
(1) Maximum value varies according to manufacturer or type. (2) Minimum of the range is given to indicate when the type of joint may not be economical. (3) This table is based on information from BD 33/94, but updated in line with ETAG 032 [Ref 10.N] joint type descriptions.			

A2.1 Buried expansion joint

One or more components may be used to form the joint below the surfacing. Materials range from elastomeric pads to proprietary flashings which support the surfacing above the deck joint gap (see Figure A.1 for an example; refer to ETAG 032 [Ref 10.N], Part 2, Annex 2-M for other examples).

Figure A.1 Example of buried expansion joint



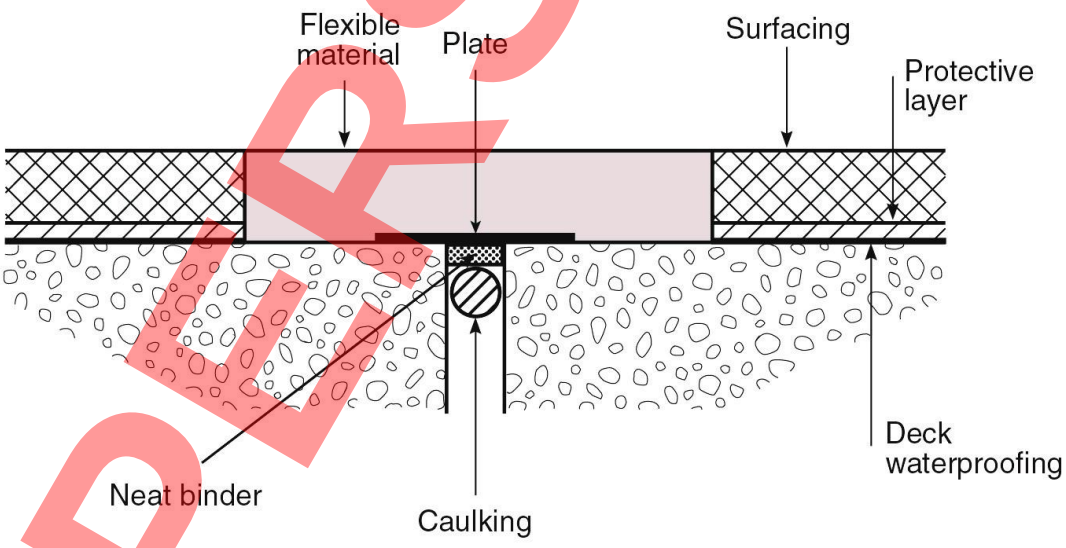
Various materials have been used to form buried joints, such as copper-lined bituminous sheeting, quarry tiles, Formica or similar, or steel plates. These materials have had varying degrees of success depending on the horizontal movements and traffic loads imposed. The principal problem where rigid plates have been used is that they are difficult to bed down properly and subsequent rocking under traffic loading has been a major cause of premature failure of the joint system.

For movements up to 10mm a proprietary flashing may be appropriate provided there is a minimum of 100mm surfacing. For movements of 10 - 20mm an elastomeric pad may be installed on top of the flashing to support surfacing 500 - 600mm wide. When laid as part of the joint this improves its flexibility and durability.

A2.2 Flexible plug expansion joint

There are a number of proprietary joint systems included in this description, formerly referred to as asphaltic plug joints. The joint is normally constructed in layers using a mixture of flexible material and aggregate to provide not only the homogeneous expansion medium but also the running surface at carriageway level (see Figure A.2 for an example; refer to ETAG 032 [Ref 10.N], Part 3 for other examples).

Figure A.2 Example of flexible plug expansion joint



This system was developed during the 1970s and was used initially to cater for small movements. In some cases the joint material was too flexible and suffered from tracking and flowing especially during hot weather. The system was improved by increasing the density and stiffness of the material, mainly in the top layers up to carriageway level.

In general, flexible plug joints are now formulated to work satisfactorily in the movement range given in Table A.3 provided the adjacent surfacing is not less than 100mm thick, the gradients and cross-falls are not too severe and the bridge deck is not noticeably 'lively' at the joints. It is difficult to define limits for the latter two but generally where premature failure has occurred one or both of these factors have been present.

On significant gradients the joint should be formed using a stiffer binder to reduce de-bonding and bulging caused by binder flow. These joints are normally installed at a nominal 500mm width but,

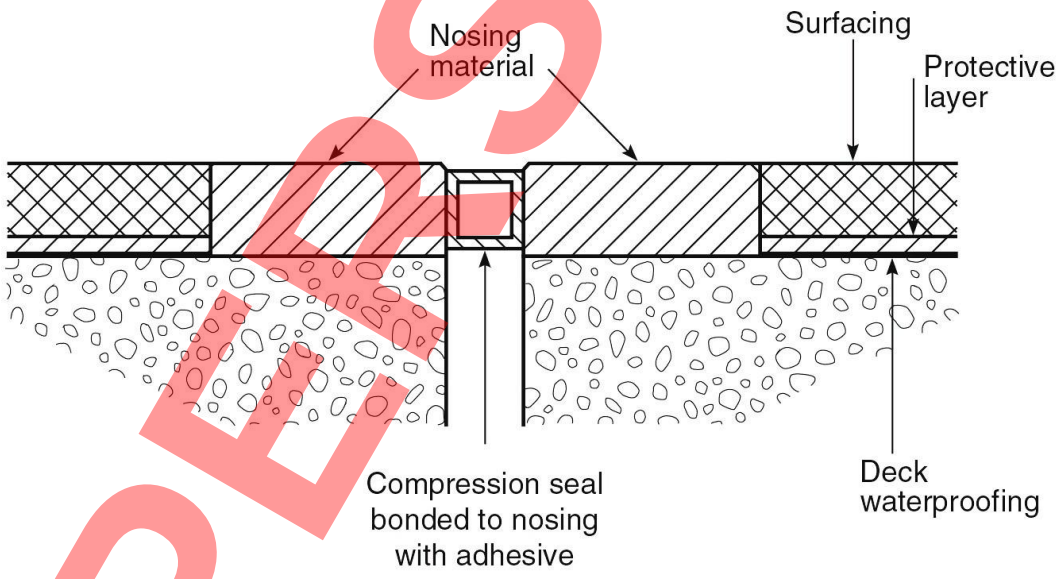
depending on the condition of the surfacing at the time of installation, joints as wide as 1000mm have been installed. Joints of this width should be avoided and where possible the maximum joint width should be limited to 850mm.

A2.3 Nosing expansion joint

Steel plates or angle sections, bolted or anchored to the deck, were commonly used to form protective nosings but are seldom used today. Epoxy mortar nosings were first used in 1964, for the replacement of faulty steel nosings, and were the most widely used type of joint in the early 1970s but did not perform as well as first anticipated. A number of factors influenced the performance including nosing design, materials and bad workmanship.

In spite of improvements in the formulations of epoxy nosings, which increased their success, they have been superseded to some extent by cementitious polyurethane and polyureide binders, which are more tolerant of adverse site conditions and have a better success rate in service (See Figure A.3 for an example; refer to ETAG 032 [Ref 10.N], Part 4 Annex 4-M for other examples).

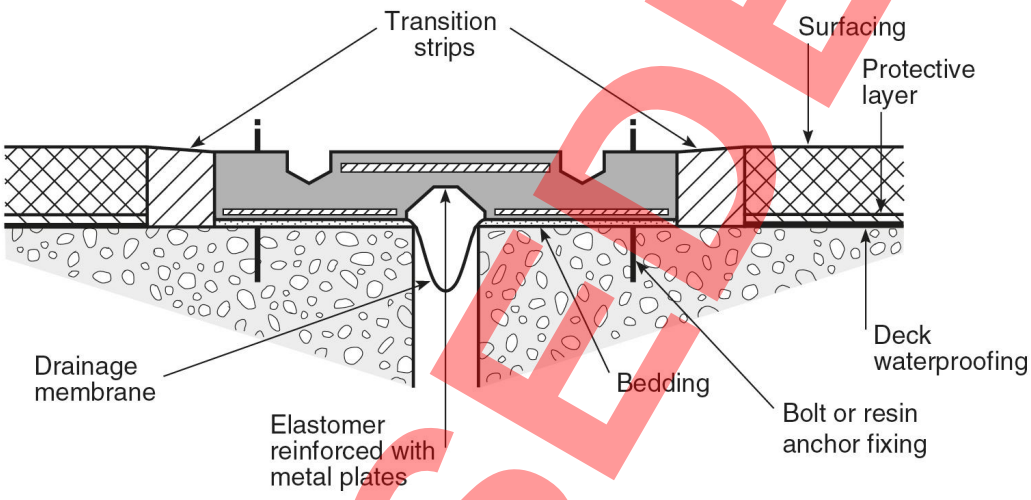
Figure A.3 Example of nosing expansion joint



A2.4 Mat expansion joints

These joints (formerly referred to as reinforced elastomeric joints) are prefabricated units which span the deck joint gap and are either an elastomer or elastomer reinforced with metal plates. They have been used for many years with a good success rate. Different sizes are available to suit various movement ranges. See Figure A.4 for an example; refer to ETAG 032 [Ref 10.N], Part 5 for other examples.

Figure A.4 Example of mat expansion joint



The larger sizes of elastomeric type joints tend to create more noise than normal under traffic. This is only usually a problem when the installation is adjacent to residential property. Some manufacturers can provide a special attachment to reduce the noise problem.

Failure of this type of joint has been from failed transition strips and splitting or excessive wear of the rubber, and subsequent exposure of the metal plates has occurred in a few cases.

Failure by exposure of the metal plates has also been recorded where lateral forces have caused accelerated wear of the covering rubber, such as at exits from roundabouts. Elastomeric joints are normally supplied in unit lengths and fixed to the deck using bolts or resin anchors. Where possible tensioned cast-in bolts should be used to anchor these joints, or if site drilled installations are used the holes should be under-reamed prior to fixing of the bolts. In either case an adequate length of bolt should be de-bonded so that any relaxation over the bolt length does not result in the complete loss of tension in the bolts. Performance of bolts should be confirmed by testing.

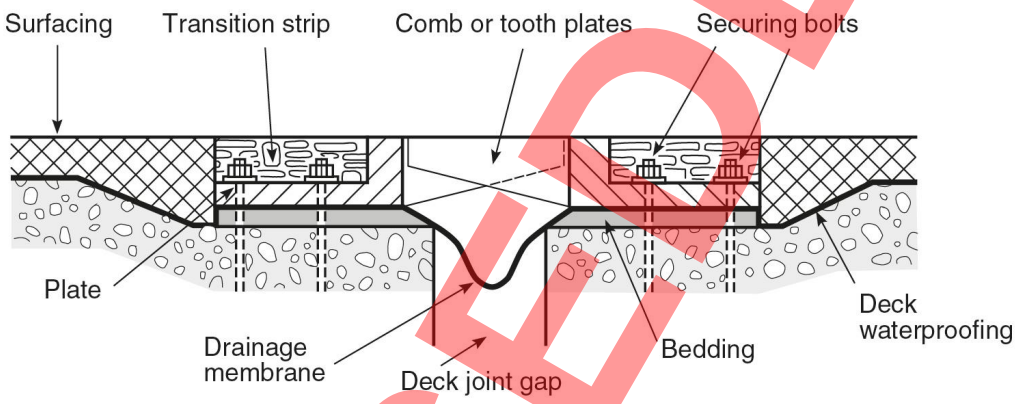
Resistance to water penetration can be improved by ensuring that either the joint is manufactured and supplied in one continuous length, or alternatively the units are bonded together on site to form one continuous length.

A2.5 Cantilever expansion joints

These joints (formerly referred to as 'comb' or 'tooth' joints) are pairs of mating toothed metal plates individually bolted to each side of the deck joint gap. They can either be purpose made for a particular installation or be proprietary units. See Figure A.5 for an example; refer to ETAG 032 [Ref 10.N], Part 6 for other examples, and its Annex 6.M for examples of finger shapes.

The gaps between the teeth can become very large, especially on skew bridges decks and the orientation of the teeth may also be significant in certain circumstances (see Section 4 of this document).

Figure A.5 Example of cantilever expansion joint

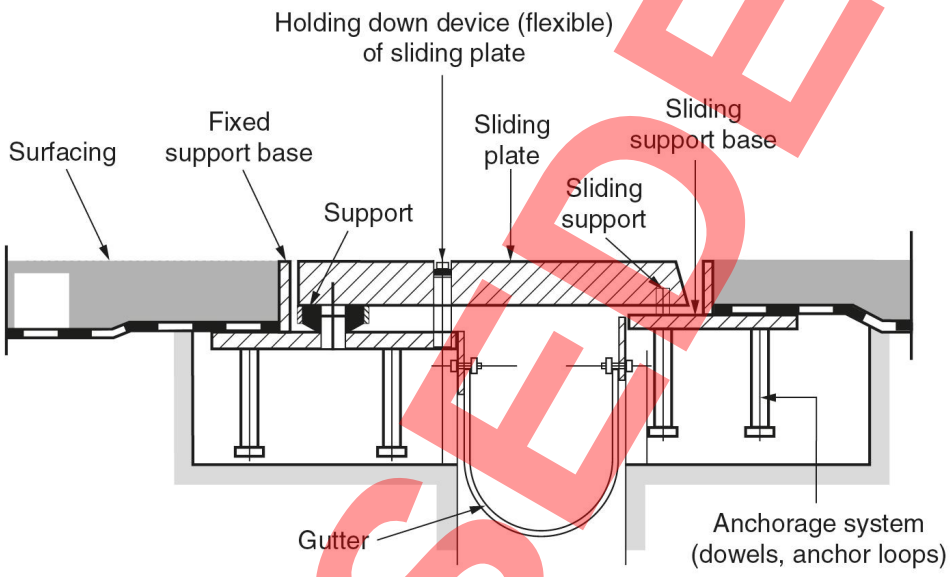


A2.6 Supported expansion joint

A supported expansion joint consists of one sub-component flush with the running surface, which is fixed by hinges on one side and sliding supports on the other side (by a second element), and which spans the deck joint gap. The expected structure movement is allowed through sliding on the non-fixed side of the hinged sub-component, i.e. on the supporting element that is anchored to the sub-structure.

Supported expansion joints can be classified in the following subfamilies: bridging plate expansion joints without fingers; bridging plate expansion joints with fingers; and roller shutter expansion joints. These subfamilies are described in ETAG 032 [Ref 10.N] Part 7. An example of a supported expansion joint is shown in Figure A.6; refer to ETAG 032 [Ref 10.N], Part 7 for other examples.

Figure A.6 Example of supported expansion joint without fingers

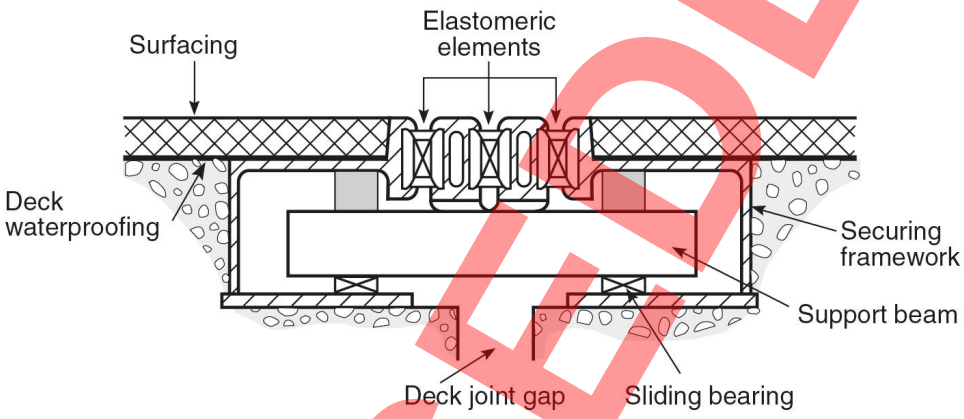


A2.7 Modular expansion joints

There are a number of proprietary joints which fit into this category (formerly known as 'elastomeric in metal runners', or EMR joints), either in a single element or multi-element form, and in a range of sizes. A single element joint consists of a profiled elastomeric seal fitted between two metal runners, one fixed to each side of the deck joint gap. A typical single-element modular joint is shown in Figure D2 (in Appendix D).

Multi-element modular joints are more complex, and can accommodate a much larger range of movements. In multi-element joints, one or more intermediate runners are provided (in addition to the runners either side of the deck joint gap), into which the elastomeric seals are fitted, and these are supported on support beams placed transversely to the joint gap. The support beams are, in turn, supported on sliding bearings, which facilitate the movement of the deck. An example of a multi-element joint is shown in Figure A.7; refer to ETAG 032 [Ref 10.N], Part 8 Annex 8P for other examples.

Figure A.7 Example of modular expansion joint



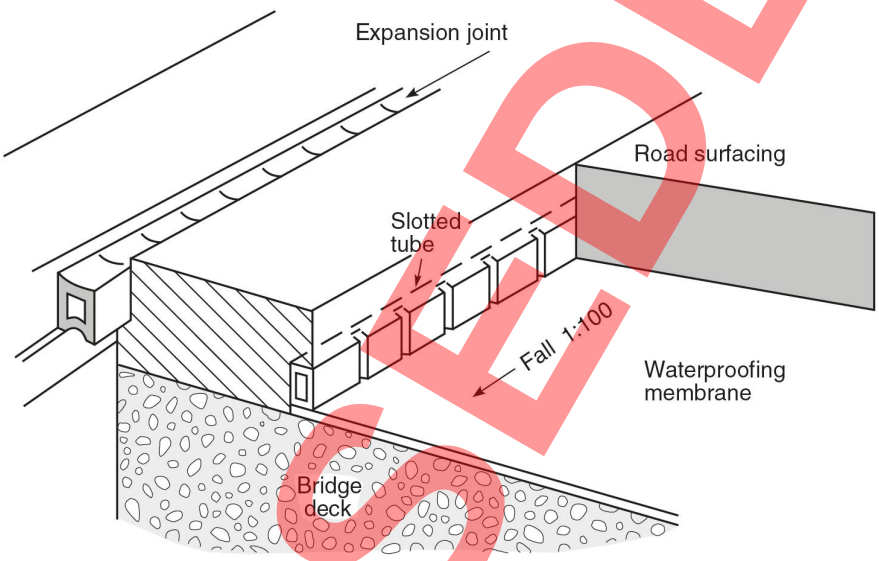
Generally the multi-element modular joints are cast in using formed recesses in the deck concrete. Depending on the type of joint used, fixings can be similar to those used in elastomeric joints or even bonded to the deck concrete. The elastomeric seals are generally of two distinct types, those which are non-load bearing membranes located below carriageway level and those which form load bearing seals at carriageway surface level.

A3 In-joint drainage at expansion joints

Water trapped within the road surfacing on the high side of a deck joint can, through hydraulic pressure from wheel loading, cause failure of the bond or seal between the joint and the waterproofing systems.

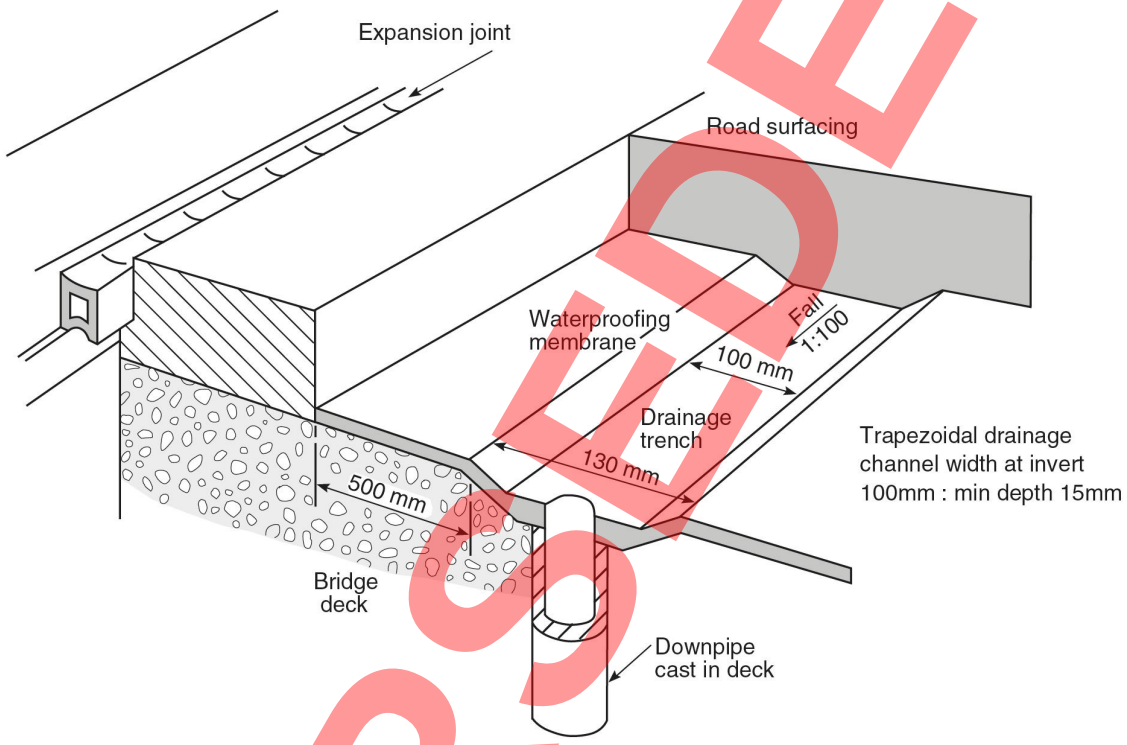
A typical detail for the provision of sub-surface drainage is shown in Figure A.8 (this is shown for a nosing joint, but a similar detail would be applicable for other joint types).

Figure A.8 Typical detail for provision of sub-surface drainage at expansion joints using tranverse slotted drains



As an alternative to transverse slotted drains, a transverse channel may be formed in the top of the bridge deck, parallel to the joint. A typical detail for this alternative is shown in Figure A.9.

Figure A.9 Typical detail for provision of sub-surface drainage adjacent to expansion joint using a transverse channel



Appendix B. Declaration of performance

B1 Declarations of performance

Declarations of performance to be demonstrated for the essential requirements (ER) in ETAG 032 are stated in Tables B.2 to B.8 of this Appendix, for the families of expansion joints listed in Table B.1.

Table B.1 Families of expansion joints for bridges

Family	ETAG 032 Part
Buried expansion joints	2
Flexible plug expansion joints	3
Nosing expansion joints	4
Mat expansion joints	5
Cantilever expansion joints	6
Supported expansion joints	7
Modular expansion joints	8
NOTE - Refer to Appendix A for examples of the different types of expansion joints.	

Table B.2 Declaration of performance - buried expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 2 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Covered by component assessment		Pass
			Supported element (e.g. bridging plate)	Pass/Fail	
	Resistance to fatigue	6.1.1.3	Pass/Fail		Pass
	Seismic behaviour	6.1.1.4	Not relevant		Not applicable
	Movement capacity	6.1.1.5	Declared values		Declared values and required surfacing properties
	Cleanability	6.1.1.6	Not relevant		Not applicable
	Resistance to wear	6.1.1.7	Not relevant		Not applicable
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required
4	Ability to bridge gaps and levels in the running surface	6.1.4.1	Not relevant		Not applicable
	Skid resistance	6.1.4.2	Not relevant		Not applicable
	Drainage capacity	6.1.4.3	Not relevant		Not applicable
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7	Corrosion	Pass/fail (considering working life category)	Declaration of pass required, if relevant*
			Chemicals	Pass/fail (considering working life category)	Declaration of pass required, if relevant*

Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.

Table B.3 Declaration of performance - flexible plug expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 3 paragraph on pro performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway and/or footpath and/or options: -accidental load on footpath -collision on kerb	Pass/Fail Refer to carriageway use category Not relevant Not relevant	Pass
	Resistance to fatigue	6.1.1.3	Pass/Fail		Pass
	Seismic behaviour	6.1.1.4	Not relevant		Not applicable
	Movement capacity	6.1.1.4	Declared values		Declared values
	Changeability	6.1.1.5	Not relevant		Not applicable
	Resistance to wear	6.1.1.7	Not relevant		Not applicable
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required
4	Allowable surface gaps and voids	6.1.4.1.1	Not relevant		Not applicable
	Level differences in the running surface	6.1.4.1.2	Level differences and steps	Pass/Fail	Pass
			After loading	Pass/Fail	Pass
	Skid resistance	6.1.4.2	On carriageway and footpath	Assessment by testing criterion: declared values	Declared values
	Drainage capacity	6.1.4.3	Not relevant		Not applicable
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable

Table B.3 Declaration of performance - flexible plug expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 3 paragraph on pro performance to be assessed	Class, use category, criterion		Declaration of performance requirement
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7	Corrosion	Pass/Fail	Pass
			Chemicals	Pass/Fail	Pass
			Ageing resulting from:		
			temperature	Pass/Fail	Pass
			UV-radiation	Pass/Fail	Pass
			ozone	Pass/Fail	Pass
			Resistance against freeze-thaw	Not relevant	Not applicable

Table B.4 Declaration of Performance - nosing expansion joints

ER	Characteristics specified in the mandate	ETAG No. 032 Part 4 paragraph on product performance to be assessed	Class, use category criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway	Pass/Fail	Declaration of pass required, if relevant*
			and/or footpath	Pass/Fail	Declaration of pass required, if relevant*
			and/or options:		
			- accidental load on footpath	Pass/Fail	Declaration of pass required, if relevant*
			- collision on kerb	Pass/Fail	Declaration of pass required, if relevant*
	Resistance to fatigue	6.1.1.3	Pass/Fail	Pass/Fail	Pass
	Seismic behaviour	6.1.1.4	Declaration of selected approach and relevant information (aspects, etc.)		Declaration required
	Movement capacity	6.1.1.5	Declared values		Declared values
	Cleanability	6.1.1.6	Pass/Fail		Pass
	Resistance to wear	6.1.1.7	Not relevant		Not applicable
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required

Table B.4 Declaration of Performance - nosing expansion joints (continued)

ER	Characteristics specified in the mandate	ETAG No. 032 Part 4 paragraph on product performance to be assessed	Class, use category criterion		Declaration of performance requirement
4	Allowable surface gaps and voids	6.1.4.1.1	Gap		
			For vehicle	Pass/Fail	Declaration of pass required, if relevant*
			Gap/recess		
			For cyclist	Pass/Fail	Declaration of pass required, if relevant*
			For pedestrian	Pass/Fail	Declaration of pass required, if relevant*
	Level differences in the running surface	6.1.4.1.2	Level differences and steps	Pass/Fail	Pass
			Level differences under loaded conditions	Pass/Fail	Pass
	Skid resistance	6.1.4.2	On carriageway		Declared value required, if relevant*
			On footpath		Declared value required, if relevant*
	Drainage capacity	6.1.4.3	Declared capacity of drainage system, if present		Declared value required, if relevant*
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable
7	Durability of the characteristics against: Corrosion, ageing,chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7	Corrosion	Pass/Fail	Pass
			Chemicals	Pass/Fail	Pass
			Ageing resulting from:		
			temperature		Pass
			UV-radiation		Pass
			ozone		Pass
			Resistance against freeze-thaw		Pass
Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.					

Table B.5 Declaration of performance - mat expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 5 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway	Pass/Fail	Declaration of pass required, if relevant*
			and/or footpath	Pass/Fail	Declaration of pass required, if relevant*
			and/or options:		
			-accidental load on footpath	Pass/Fail	Declaration of pass required, if relevant*
			-collision on kerb	Pass/Fail	Declaration of pass required, if relevant*
	Resistance to fatigue	6.1.1.3	Caused by traffic loads on the expansion joint	Pass/Fail	Pass
			Caused by bridge movements under traffic (without consideration of traffic loads on the joint)	Pass/Fail	Pass
	Seismic behaviour	6.1.1.4	Declaration of selected approach and relevant information (aspects, etc.)		Declaration required
	Movement capacity	6.1.1.5	Declared values		Declared values
	Cleanability	6.1.1.6	Pass/Fail		Pass
	Resistance to wear	6.1.1.7	Pass/fail Declaration of value of abrasion		Declaration of pass required, if available*
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required

Table B.5 Declaration of performance - mat expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 5 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
4	Allowable surface gaps and voids	6.1.4.1.1	Gap		
			For vehicle	Pass/Fail	Yes
			Gap for use in longitudinal axis	Pass/Fail	Yes
			Gap/recess		
			For cyclist	Pass/Fail	Yes
			For pedestrian	Pass/Fail	Yes
	Level differences in the running	6.1.4.1.2	Level differences and steps in unloaded conditions	Pass/Fail	Yes
			Level differences under deformed conditions	Pass/Fail	Yes
			Level differences under loaded conditions		
	Skid resistance	6.1.4.2	On carriageway	Declared value if relevant	Declared value required, if relevant*
			On footpath	Declared value if relevant	Declared value required, if relevant*
	Drainage capacity	6.1.4.3	Declared capacity of drainage system, if present		Yes
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable

Table B.5 Declaration of performance - mat expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 5 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7.1	Corrosion	Pass/fail (considering the working life category)	Pass
			Chemicals	See ETAG 032 Part 5 section 6.2	Pass
			Ageing resulting from:		
			temperature		Pass
			UV-radiation		Pass
			ozone		Pass
			other aspects		Pass
Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.					

Table B.6 Declaration of Performance - cantilever expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 6 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway	Pass/Fail	Declaration of pass required, if relevant*
			and/or footpath	Pass/Fail	Declaration of pass required, if relevant*
			and/or options:		
			accidental load on footpath	Pass/Fail	Declaration of pass required, if relevant*
			-collision on kerb	Pass/Fail	Declaration of pass required, if relevant*
	Resistance to fatigue	6.1.1.3	Caused by traffic loads on the expansion joint	Pass/Fail	Pass
			Caused by bridge movements under traffic (without consideration of traffic loads on the joint)	Not relevant	Not applicable
	Seismic behaviour	6.1.1.4	Declaration of selected approach and relevant information (aspects, etc.)		Declaration required
	Movement capacity	6.1.1.5	Declared values		Declaration required
	Cleanability	6.1.1.6	Pass/Fail		Declaration of pass required, if relevant*
	Resistance to wear	6.1.1.7	Not relevant		Not applicable
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required

Table B.6 Declaration of Performance - cantilever expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 6 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
4	Allowable surface gaps and voids	6.1.4.1.1	Gaps/voids		
			For vehicle	Pass/Fail	Declaration of pass required, if relevant*
			Gaps/voids/slots		
			For cyclist	Pass/Fail	Declaration of pass required, if relevant*
			For pedestrian	Pass/Fail	Declaration of pass required, if relevant*
	Level differences in the running surface	6.1.4.1.2			
	Skid resistance	6.1.4.2	On carriageway	Declared value if relevant	Declared value required, if relevant*
			On footpath	Declared value if relevant	Declared value required, if relevant*
	Drainage capacity	6.1.4.3	If relevant	Declared capacity (in case of drainage system)	Declared value required, if relevant*
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable

Table B.6 Declaration of Performance - cantilever expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 6 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7.1	Corrosion	Pass/fail (considering the working life category)	Pass
			Chemicals	See ETAG 032 Part 6 section 6.2	Pass
			Ageing resulting from:		
			temperature		Pass
			UV-radiation		Pass
			ozone		Pass
			resistance against freeze-thaw		Pass
Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.					

Table B.7 Declaration of performance - supported expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 7 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway	Pass/Fail	
			and/or footpath	Pass/Fail	
			and/or options:		
			-accidental load on footpath	Pass/Fail	Declaration of pass required, if relevant*
			-collision on kerb	Pass/Fail	Declaration of pass required, if relevant*
	Resistance to fatigue	6.1.1.3	Caused by traffic loads on the expansion joint	Pass/Fail	Pass
			Caused by bridge movements under traffic (without consideration of traffic loads on the joint)	Pass/Fail	Declaration of pass required, if relevant*
	Seismic behaviour	6.1.1.4	Declaration of selected approach and relevant information (aspects, etc.)		Declaration required
	Movement capacity	6.1.1.5	Declared values		Declared values
	Cleanability	6.1.1.6	Pass/Fail		Pass
	Resistance to wear	6.1.1.7	Pass/Fail		Pass
	Water-tightness	6.1.1.8	Pass/Fail		
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required

Table B.7 Declaration of performance - supported expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 7 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
4	Allowable surface gaps and voids	6.1.4.1.1	Gaps/voids		
			For vehicle	Pass/Fail	Declaration of pass required, if relevant*
			Gap/voids/recess		
			For cyclist	Pass/Fail	Declaration of pass required, if relevant*
			For pedestrian	Pass/Fail	Declaration of pass required, if relevant*
	Level differences in the running surface	6.1.4.1.2	Level differences and steps in unloaded conditions	Pass/Fail	Pass
			Level differences under loaded conditions	Pass/Fail	Pass
	Skid resistance	6.1.4.2	On carriageway	Declared value if relevant	Declaration of pass required, if relevant*
			On footpath	Declared value if relevant	Declaration of pass required, if relevant*
	Drainage capacity	6.1.4.3	If relevant	Declared capacity (in case of drainage system)	Declaration of pass required, if relevant*
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable

Table B.7 Declaration of performance - supported expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 7 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
7	Durability of the characteristics against: corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7.1	Corrosion	Pass/fail (considering the working life category) See ETAG 032 Part 7 section 6.2	Pass
			Chemicals		Pass
			Ageing resulting from:		
			temperature		Pass
			UV-radiation		Pass
			ozone		Pass
			resistance against freeze-thaw		Declaration of pass required, if relevant*
Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.					

Table B.8 Declaration of performance - modular expansion joints

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 8 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
1	Mechanical resistance	6.1.1.2	Carriageway	Pass/Fail	Declaration of pass required, if relevant*
			and/or footpath	Pass/Fail	Declaration of pass required, if relevant*
			and/or options:		
			accidental load on footpath	Pass/Fail	Declaration of pass required, if relevant*
			collision on kerb	Pass/Fail	Declaration of pass required, if relevant*
	Resistance to fatigue	6.1.1.3	Pass/Fail		Pass
	Seismic behaviour	6.1.1.4	Declaration of selected approach and relevant information (aspects, etc.)		Declaration required
	Movement capacity	6.1.1.5	Declared values with reaction forces		Declared values with reaction forces
			Minimum clearances		Declared values
			Maximum skewness		Declared value
	Cleanability	6.1.1.6	Pass/Fail		Pass
	Resistance to wear	6.1.1.7	Pass/Fail Declaration of value of abrasion		Pass
	Water-tightness	6.1.1.8	Pass/Fail		Pass
2	Safety in case of fire	6.1.2	Not relevant		Not applicable
3	Release of dangerous substances	6.1.3	Indication of dangerous substances, incl. concentration, etc. or: "No dangerous substances"		Declaration required

Table B.8 Declaration of performance - modular expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 8 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
4	Allowable surface gaps and voids	6.1.4.1.1	Gaps/voids		
			For vehicle	Pass/Fail	Declaration of pass required, if relevant*
			Gap/voids/recess		
			For cyclist	Pass/Fail	Declaration of pass required, if relevant*
			For pedestrian	Pass/Fail	Declaration of pass required, if relevant*
	Level differences in the running surface	6.1.4.1.2	Level differences and steps between edge beams and centre beams in unloaded conditions	Pass/Fail	Pass
			Level differences and steps between edge beams and centre beams under loaded conditions	Pass/Fail	Pass
	Skid resistance	6.1.4.2	On carriageway	Declared value if relevant	Declared value required, if relevant*
			On footpath	Declared value if relevant	Declared value required, if relevant*
	Drainage capacity	6.1.4.3	If relevant	Declared capacity (in case of drainage system)	Declared value required, if relevant*
5	Protection against noise	6.1.5	Not relevant		Not applicable
6	Energy economy and heat retention	6.1.6	Not relevant		Not applicable

Table B.8 Declaration of performance - modular expansion joints (continued)

ER	Characteristics specified in the Mandate	ETAG No. 032 Part 8 paragraph on product performance to be assessed	Class, use category, criterion		Declaration of performance requirement
7	Durability of the characteristics against: Corrosion, ageing, chemicals, temperature, UV-radiation, freeze-thaw, ozone	6.1.7.1	Corrosion	Pass/Fail (considering the working life capacity	Pass
			Chemicals	Pass/Fail	Pass
			Ageing resulting from:		
			temperature	Pass/Fail	Pass
			UV-radiation	Pass/Fail	Pass
			ozone	Pass/Fail	Pass
			resistance against freeze-thaw	Not relevant	Not applicable
Note: *the requirement is relevant if the class, use category or criterion is applicable to the structure under consideration.					

Appendix C. Departmental Type Approval

C1 Background

Departmental Type Approval as previously required in BD 33 is no longer available for new expansion joint systems. Expansion joints that already have a Departmental Type Approval certificate, and which are registered with the Overseeing Organisation, can still be considered for incorporation into the works.

Even with a Departmental Type Approval, any component that falls within the scope of a harmonised standard will need to have a Declaration of Performance and CE Mark to demonstrate that the product meets the equivalent performance of the original product.

It is anticipated that in the future, once there is a sufficient number of expansion joints that have an ETA, or a harmonised standard has been published, the option of using joint systems with Departmental Type Approval will be removed.

The remainder of this appendix is provided for legacy information only, and should not be used to attempt to obtain Departmental Type Approval. This appendix does not contain any current requirements.

C2 General

For all types of expansion joint the manufacturer or supplier was required to submit full details of the expansion joint system including installation procedures and where relevant the corrosion protection system. Where the system incorporated a transition strip or was of the flexible plug or in-situ nosing type, full details of the formulation for the expansion joint materials, including primer and aggregate were also required to be submitted under "Commercial in Confidence". The following were relevant requirements for specific joint types.

C2.1 Flexible plug joints, in-situ nosing joints and transition strips

The manufacturer or supplier were required to submit to the Overseeing Organisation the following information about the aggregate specified in the formulation:

i. The classification, in accordance with BS 812-1 [Ref 8.I], BS 812-101 [Ref 6.I], BS 812-102 [Ref 10.I]and BS 812-103 [Ref 7.I], and source of the aggregate. These cannot be changed without the agreement of the Overseeing Organisation.

ii. The all-in aggregate grading curve determined and presented as a cumulative percentage passing in accordance with BS 812-1 [Ref 8.I], BS 812-101 [Ref 6.I], BS 812-102 [Ref 10.I] and BS 812-103 [Ref 7.I]. The grading curve of the aggregates supplied cannot vary from the grading curve submitted by more than ± 10% of the value for any given sieve size.

iii. The water absorption, impact, crushing and abrasion properties of the aggregates determined in accordance with BS 812-1 [Ref 8.I] and BS 812-2 [Ref 9.I]

C2.2 Flexible plug joints

The manufacturer or supplier were required to arrange for testing of the binder material, for the physical properties shown in Table C.1 (reproduced from withdrawn BD 33, Annex C), to be carried out by a testing laboratory accredited in accordance with ISO/IEC 17025 by the United Kingdom Accreditation Service (UKAS) for such tests, or by a laboratory in a member state of the European Economic Area which could offer suitable and satisfactory evidence of technical and professional competence and independence for the tests concerned, and forward the results to the Overseeing Organisation. Testing and supply of information to the Overseeing Organisation were required to all be at the manufacturer's or supplier's expense. The information was to be retained by the Overseeing Organisation in the strictest confidence and constituent materials were required to not be subsequently changed without the agreement of the Overseeing Organisation.

C2.3 In-situ nosings and transition strips

The manufacturer or supplier were required to arrange for testing of the hardener and resin composition, including spectrographic analysis, by a testing laboratory accredited in accordance with ISO/IEC 17025 by the United Kingdom Accreditation Service (UKAS) for such tests, or by a laboratory in a member state of the European Economic Area which could offer suitable and satisfactory evidence of technical and professional competence and independence for the tests concerned, and forward the results to the Overseeing Organisation. The tests and criteria were required to be as in Table C.2 (reproduced from withdrawn BD 33, Annex C). All testing and supply of information were required to be at the manufacturer's or supplier's expense.

C2.4 Testing laboratories in other member states

Where tests were carried out in other member states the requirements for laboratories given in clauses C2.2 and C2.3 were required to be satisfied if the laboratory is accredited in a member state of the European Economic Area in accordance with the relevant parts of the EN 45000 series of standards for the tests carried out.

C3 Previous requirements - field trials

On satisfactory completion of the relevant requirements the manufacturer or supplier was required to undertake a field trial for workmanship and performance. It was necessary to install a complete expansion joint, using material to the formulation submitted in accordance with paragraph C2, on a bridge carrying not less than 20,000 vehicles per day on a single carriageway of a dual two lane road or its equivalent. However an equivalent trial to the foregoing criteria in another member state of the European Economic Area was acceptable. The trial period was a minimum of 12 months, after which time the joint was required to be inspected for any defects. Where premature failure occurred the Overseeing Organisation reserved the right to cancel the trial extend the trial period or call for a new trial, subject to notifying the manufacturer of supplier of the reason for doing so. There was no guarantee that a site would be immediately available for a new trial.

The manufacturer or supplier was required to meet the costs of both successful and unsuccessful field trials including traffic management costs.

C4 Previous tests and trials

Expansion joint systems already in the Motorway and Trunk Road Network did not need further assessment for Departmental type approval provided that they satisfied the criteria of paragraphs C2 and C3 with respect to test results and successful trials.

C5 Previous requirements for Departmental Type Approval certificate

Subject to satisfactory compliance with the foregoing requirements the manufacturer's or supplier's expansion joint system received a Departmental Type Approval certificate.

The Overseeing Organisation reserves the right to revoke a certificate subject to notifying the manufacturer or supplier of the reasons for doing so.

Table C.1 Tests for physical requirements for Departmental Type Approval of materials for use in flexible plug bridge deck expansion joints

Standard test method	Typical result
BS 2000: Part 58: 1988 Softening Point R & B, °CBS 2499: 1973 Flow Resistance: @ 45°C, 5 Hours. @ 60°C, 5 Hours ASTM D1190 - Flow Resistance: 5 hours/60°/75° Slope mm Penetration ASTM D5 @ 25°C, @ 0°C Specific gravity @ 25°C Flash point - COC (Cleveland Open Cup) Manufacturer's recommended application temperature Manufacturer's recommended maximum safe heating temperature	

Table C.2 Tests and related criteria for Departmental Type Approval of materials for use in bridge deck expansion joint in-situ nosings and transition strips

Test	Material characteristics	Temp. of test	Mortar-filled or unfilled	Acceptance criteria Min.	Max.
FERFA Test No. 2	Compressive strength	20°C	Filled	12 N/mm^2	-
FERFA Test No. 4	Tensile strength	20°C	Unfilled	3 N/mm^2	-
FERFA Test No. 4	Elongation	20°C	Unfilled	20%	-
FERFA Test No. 5	Elastic Modulus in tension	-10°C	Unfilled		1600 N/mm^2
* Aggregate Grading Test to BS 812				To conform with manufacturer's stated grading curves	
*Spectrographic analysis				Components of mortar to remain unchanged	

NOTE 1 *Test to identify the manufacturer's formulation and for the subsequent quality control tests.

NOTE 2 The above testing information is strictly confidential.

Appendix D. Installation guidance

D1 Installation procedures for expansion joints

Typical installation procedures for expansion joints are shown in Figure D.1 (for joints fixed to the deck by bond or bolts/resin anchored studs) and Figure D.2 (for joints fixed to the deck using cast-in reinforcing bars or studs).

These procedures are given for illustration only, and are not intended to take precedence over the installation procedures for specific proprietary joints developed by joint suppliers/manufacturers.

Figure D.1 Typical installation procedure for joints fixed to deck using a.) bond or b.) bolts or resin-anchored studs

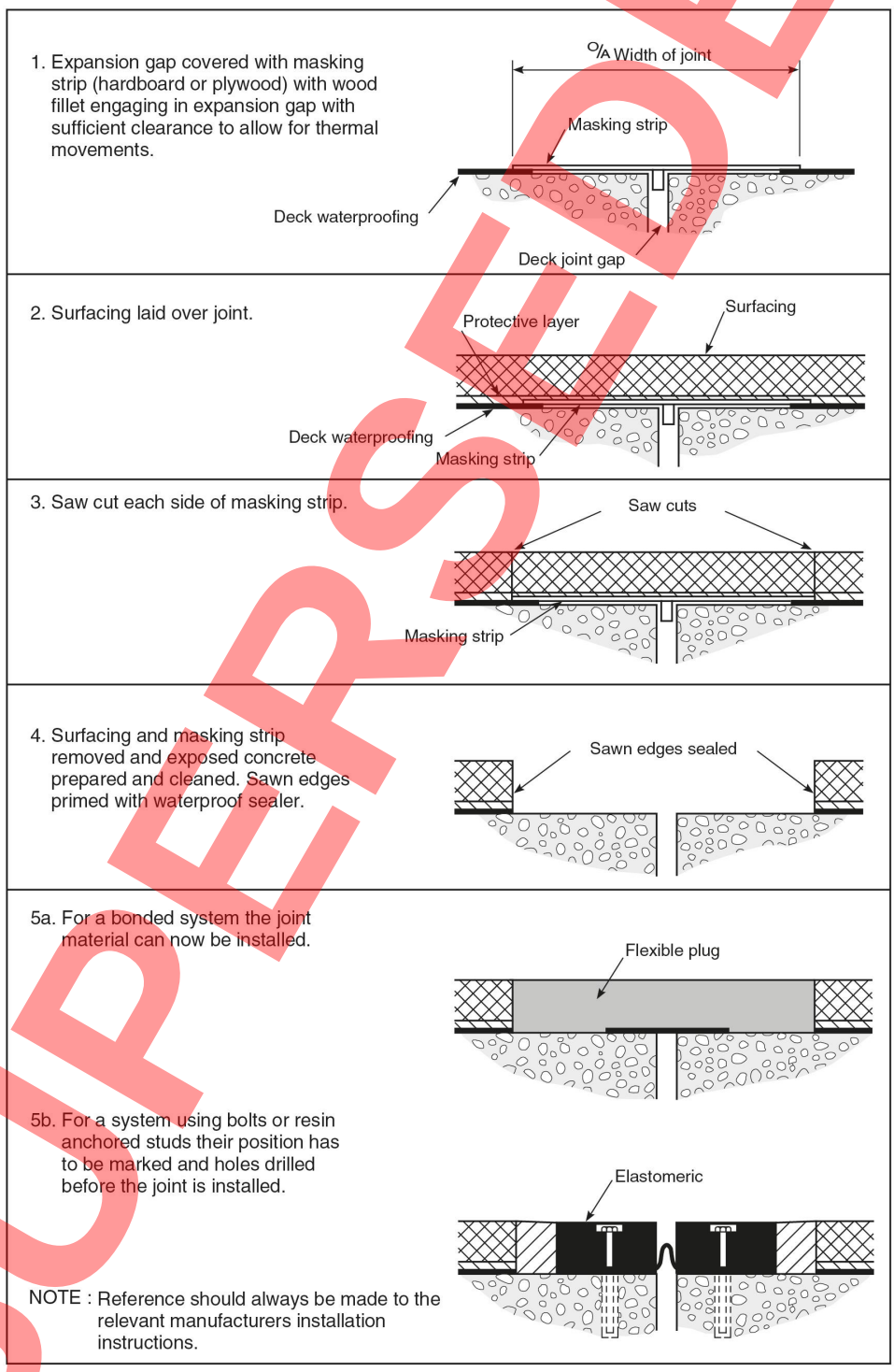
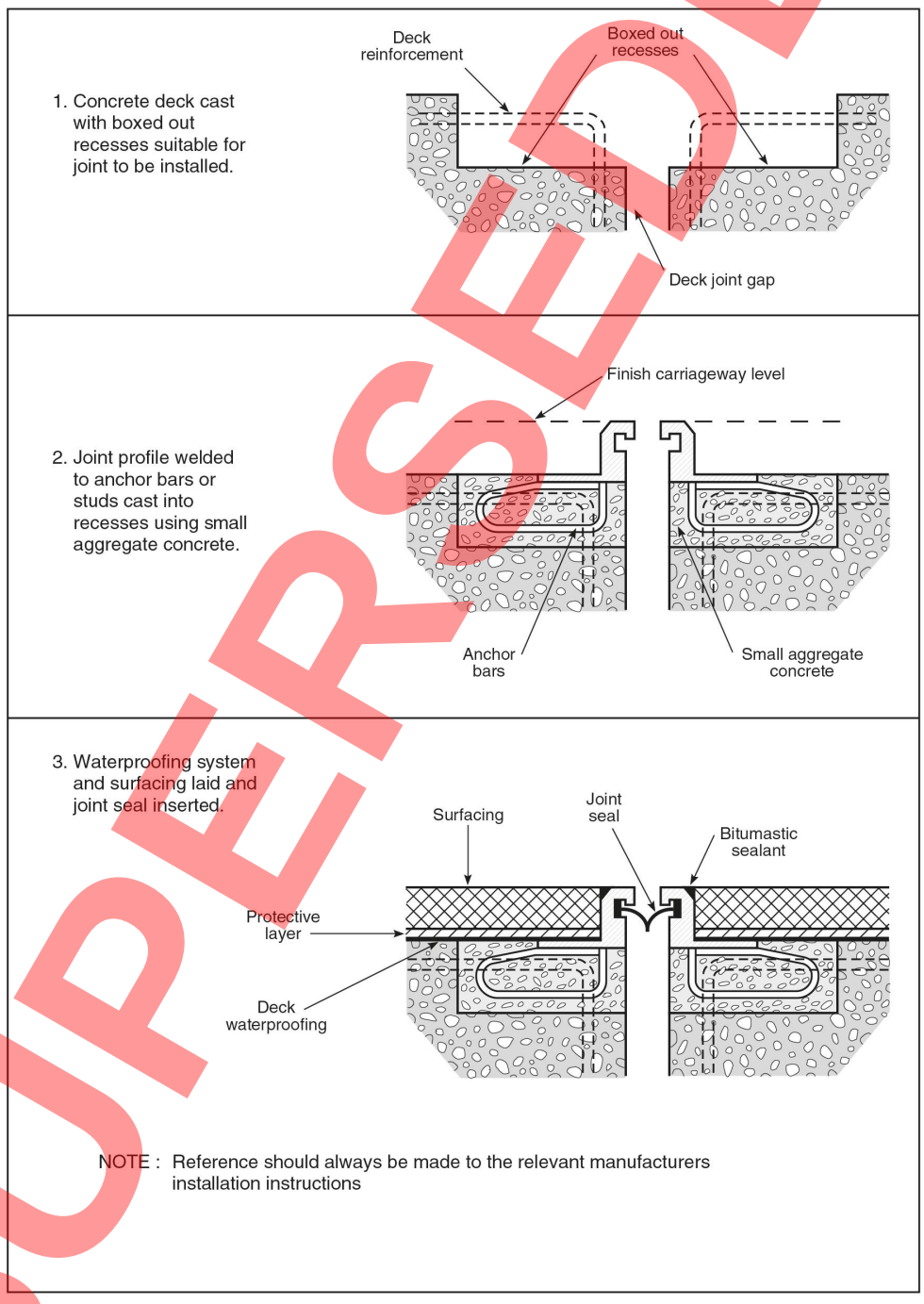


Figure D.2 Typical installation procedure for joints fixed to deck using cast-in anchor bars or studs (single element modular joint shown)



Appendix E. Typical defects in multi-element modular expansion joints

E1 Introduction

This appendix includes material relating to defects in multi-element modular (elastomeric in metal runners) joints, and also covers typical problems associated with other expansion joint types.

Some expansion joints have complex components comprising multiple parts. These need to be inspected and maintained to ensure functionality and durability. Replacement of these joints needs to be planned, as some components may need to be specially fabricated.

E2 Background to failures of multi-element modular expansion joints

There have been a number of failures of modular expansion joints (formerly referred to as multi-element elastomeric in metal rails). This type of joint is mostly used on long-span structures, on strategic parts of the highway network.

When investigating some of these failures, it was found that the maintenance requirements for some of these joints was unclear, and this had led to the maintenance contractors not being able to identify the signs of deterioration leading to the abrupt failure of the joints.

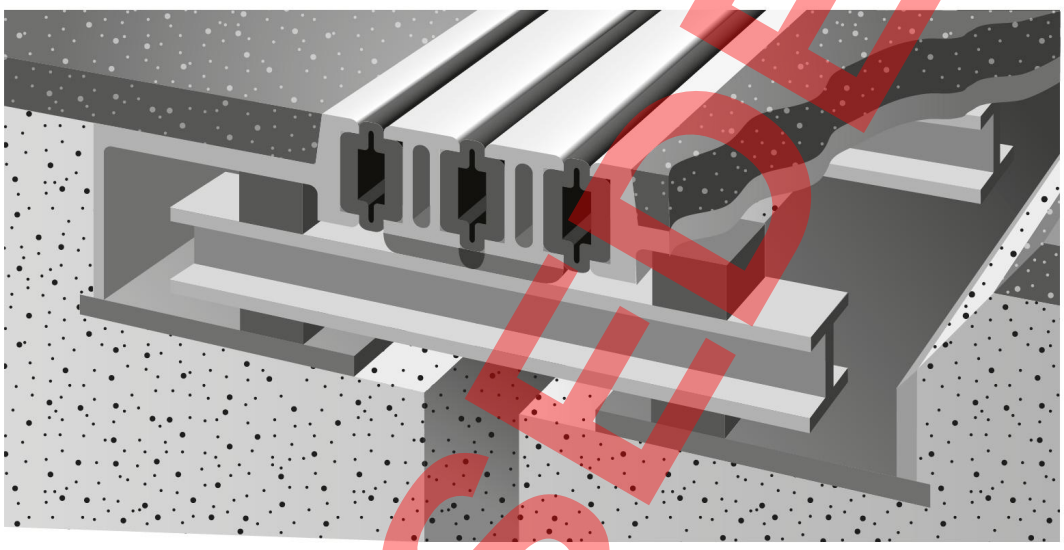
It has been reported on some structures, where failure had occurred, that the supply of replacement parts took some time as these were bespoke. The failures caused considerable disruption to the public and significant cost to the highway authority. The manner of the failure of these joints has the potential to cause considerable safety hazard to the public.

E2.1 Form of construction

Multi-element modular expansion joints typically consist of steel beams arranged in the longitudinal direction of the joint with interposed steel strips. Depending on the width to accommodate the movement more than one centre beam may be required between the edge beams, which are supported on cross bars, aligned in the direction of movement of the structure. Elastomeric sealing strips then fill the gaps between the adjacent steel beams, to ensure the water-tightness of the joint across its full range of movements.

A diagram of a typical multi-element modular joint is shown in Figure E.1 - note that the number of rails and seals will be dependent on the longitudinal movement range required, and individual manufacturers will have slightly different details.

Figure E.1 Typical arrangement of a multi-element modular expansion joint



E2.2 Examples of defects discovered

On one viaduct, the failure of one of the joint rails (Figure E.2) resulted in lane 1 of both carriageways having to be closed, causing disruption to traffic. There was no record of any inspection being carried out either within the abutment (possibly because it was designated a confined space) or the main span. On discovery of the failure, a temporary modular bridging system with speed restriction was put in place over the failed joint.

Figure E.2 Viaduct (precast prestressed concrete) built in 1993- The damaged rail has been taken out of the joint and corrosion is visible on the rails

A full internal inspection of the abutment was arranged, which revealed extensive damage to the joints,

with loss of components and failed bearings at the edge of lane 2 and the offside verge. It had been reported that there was excessive noise emanating from the joint, suggesting that the bearings supporting the transverse bearer beams were worn. It is likely that the wear and ultimate collapse of these bearings was the root cause of the transverse beam failure, leading to the collapse of the joint.

The failure of expansion joint components is generally a result of deterioration over time. Failure of the joint in many cases is preceded by indicators which include increased noise levels, or components becoming loose or vibrating.

The photographs (Figures E.3, E.4, E.5, E.6, E.7 and E.8) below are other examples of some defects which have been discovered during inspection of bridges with modular joints.

Bridge inspectors may be able to identify signs of deterioration without direct visual evidence. These should be a trigger for further investigation and testing to quantify the scale and nature of the issues. This requires the inspectors to have the necessary skills and experience, including an understanding of the specifics of the joint type and possible causes of failure.

Figure E.3 Cable-stayed bridge (composite steel-concrete deck) Built 1991 - Fracture in the support joist immediately below the welded connection to the rail

Figure E.4 Cable-stayed bridge (composite steel-concrete deck) Built 1991 - Rust staining from expansion joint over pier (Seal replacement stopped water ingress, circa 2007)

Figure E.5 Cable-stayed bridge (Composite steel-concrete deck) Built 1991 - Corrosion to expansion joint sliding plates over pier, circa 2007

Figure E.6 Viaduct (Pre-cast pre-stressed concrete) Built 1976- Failure of joint footway. Seal failed between rails on carriageway

Figure E.7 - Cable-stayed Bridge (composite steel-concrete deck). Built 1991 - Trimmer beam support steelwork corroded.

Figure E.8 Viaduct (in-situ concrete deck). Built 1986 - Damage to the west deck expansion joint - rail broken in the middle and level difference in carriageway surface

Figure E.9 Viaduct (in-situ pre-stressed concrete). Built 1990 - Corrosion to rails and debris in seals

E3 Other forms of expansion joint

The need to regularly inspect and maintain expansion joints applies to all joint types.

The CIRIA report, CIRIA C764 [Ref 1.l], provides a useful reference for typical defects associated with all the expansion joint types. In particular, Tables 9.1 and 9.2 'hidden defects encountered within common expansion joint types' details the leakage, loose elements including bolts, metal fatigue, and plugging / sealing failure which may be discovered during routine inspections of the structure.

E4 Recommendations

Expansion joints provide a means for the bridge deck to move, while limiting the gap at road surface level, and preventing the ingress of water and other deleterious materials. However, to ensure that this functionality is sustained, it is important to regularly inspect and maintain the joint. Where defects are discovered, steps should be taken to repair or replace defective components, and reduce the risk to road users.

A management plan should be developed to minimise the effect of failure of expansion joint components.

Appendix F. Temporary cover plates

F1 Introduction

This appendix is based on the withdrawn IAN 169, which was a Highways England document issued in October 2012 to draw attention to potential issues when using temporary metallic cover plates over temporary or failed bridge expansion joints, or at stages during their installation when they cannot support traffic (such as during the curing of transition strips).

Prior to the publication of IAN 169, a temporary cover plate on a bridge was dislodged, resulting in a serious accident.

This appendix provides advice relating to the use of temporary cover plates.

The advice in this appendix also applies to any temporary measures intended to allow live carriageways to be operational until permanent repair/replacement of defective expansion joints can be undertaken. This includes plates placed directly over joints, which may or may not be hinged, and other solutions like buried plates covered by pavement surfacing.

F2 Factors to consider when using temporary cover plates

It is important that sufficient scrutiny is given to the design and maintenance of any temporary works, such as temporary cover plates.

A number of factors should be considered relating to the safe use of temporary cover plates for expansion joints.

Operational issues:

1) the potential for the plate to cause an obstruction (bump/step/ramp) on the approach and transition to the cover plate;
2) the need for a speed restriction and enforcement (considering the angle of plate edge to direction of travel, geometry of site, behaviour of traffic, the need to keep noise down):
    a) cover plates have been installed on many schemes without the need for any speed restrictions, which can increase delays and the risk of accidents. Therefore, where possible, the aim should be to provide unrestricted travel;
3) the need for a weight restriction (suitable for HGVs or cars only) at the site, and how that impinges on local traffic flows;
4) identify and specify any additional requirements for pedestrians, equestrians, cyclists and motorcyclists;
5) plan the work to minimise the period that the plate is in place;
6) consider changes to noise levels that may result, and their effect on the local environment;
7) consider drainage issues and how the installation of the plate will affect these.

Engineering issues (design and installation):

1) avoid bumps, steps and ramps in the transition between road surface and cover plate;
2) ensure that the plate has adequate skid resistance (consistent with the skid resistance requirements of the joint itself, and the adjacent carriageway);
3) ensure that the plate covers the full lane width affected and that there are no gaps between the road surface and plate, or between adjacent plates;
4) ensure that the plate is suitable for the design loads and the timescale for which it will be in place;
5) ensure that the plate will carry the loads without undue deflection or displacement;
6) ensure that the cover plate and fixings can accommodate the longitudinal movements of the bridge deck;

7) ensure that the fixings and their connection to the road surface are adequate for the traffic speeds and loads - particularly the substrate for the fixing, and the robustness of the system under cyclic loading, and to facilitate periodic removal and replacement, where required;
8) consider the noise levels arising from the use of the cover plate and ensure that any mitigation measures such as speed or weight restrictions, or acoustic barriers, are put in place;
9) ensure that drainage issues, and the potential for ponding or icing, are addressed;
10) ensure that design requirements and any assumptions made for the cover plate, its fixings and the road are clearly set out;
11) when specifying a cover plate, consider fabrication, transportation and installation issues;
12) confirm the condition and profile of the carriageway surfacing has been allowed for in the design;
13) consider if weather conditions during installation will require different procedures. This may be temperature limits on fixings, extended waiting times, or if the design parameters are exceeded, etc.
14) specify an inspection and maintenance regime for the cover plate;
15) ensure that the effects of regular removal and replacement of the cover plate (if required to facilitate repair of the over-spanned expansion joint) are taken into account;
16) ensure that any manufacturer's special requirements are met;
17) ensure that the cover plate and fixings are installed by competent personnel.

Investigation of the existing bridge:

1) checks should be carried out to ensure that the load from the cover plate and the over-spanned (damaged) expansion joint does not adversely affect the existing structure;
2) sufficient investigation is carried out to identify that any anchorages can be safely installed to the required depth, will transfer loads without damage, and can be removed and the original structure reinstated.

Maintenance and inspection of temporary cover plates:

1) procedures for inspection and maintenance of the cover plate and its fixings should be set out;
2) requirements for the inspection and maintenance of the cover plate and its fixings should be minimised;
3) cover plates and their fixings are inspected and maintained by suitably qualified and competent people;
4) inspection intervals of the cover plate and fixings should be specified;
5) any defects are reported and rectified quickly.

F3 Technical Approval certification

The design and installation of temporary cover plates should be managed using formal Technical Approval procedures, as set out in CG 300 [Ref 5.I], to ensure an adequate level of scrutiny (including the agreement of an appropriate category of checking), and that a consistent approach is adopted. The category should generally be a minimum of category 2, unless otherwise agreed with the TAA.

Where a sub-standard structure is being managed under CS 470 [Ref 3.I] procedures, or there are specific issues that significantly raise the risks, then a higher category of checking should be considered.