Bonneagar Iompair Éireann
Transport Infrastructure Ireland

TII Publications

GE PE DN CC OP AM RE

Expansion Joints for Use in Road Bridge Decks

DN-STR-03006
February 2023

DN Design

Standards

About TII

Transport Infrastructure Ireland (TII) is responsible for managing and improving the country's national road and light rail networks.

About TII Publications

TII maintains an online suite of technical publications, which is managed through the TII Publications website. The contents of TII Publications is clearly split into 'Standards' and 'Technical' documentation. All documentation for implementation on TII schemes is collectively referred to as TII Publications (Standards), and all other documentation within the system is collectively referred to as TII Publications (Technical).

Document Attributes

Each document within TII Publications has a range of attributes associated with it, which allows for efficient access and retrieval of the document from the website. These attributes are also contained on the inside cover of each current document, for reference.

TII Publication Title	*Expansion Joints for Use in Road Bridge Decks*
TII Publication Number	*DN-STR-03006*

Activity	*Design (DN)*		**Document Set**	*Standards*
Stream	*Structures (STR)*		**Publication Date**	*February 2023*
Document Number	*03006*		**Historical Reference**	*BD 33*

TII Publications Website

This document is part of the TII publications system all of which is available free of charge at http://www.tiipublications.ie. For more information on the TII Publications system or to access further TII Publications documentation, please refer to the TII Publications website.

TII Authorisation and Contact Details

This document has been authorised by the Director of Professional Services, Transport Infrastructure Ireland. For any further guidance on the TII Publications system, please contact the following:

Contact: Standards and Research Section, Transport Infrastructure Ireland
Postal Address: Parkgate Business Centre, Parkgate Street, Dublin 8, D08 DK10
Telephone: +353 1 646 3600
Email: infoPUBS@tii.ie

TII Publications

Activity:	Design (DN)
Stream:	Structures (STR)
TII Publication Title:	Expansion Joints for Use in Road Bridge Decks
TII Publication Number:	DN-STR-03006
Publication Date:	February 2023
Set:	Standards

Contents

Updates to TII Publications resulting in changes to

Expansion Joints for Use in Road Bridge Decks DN-STR-03006

Date:	February 2023
Page No:	General
Section No:	General

Amendment Details:

General update of design standard to reflect current design and approval procedures.

Supplementary information provided regarding good detailing practice, installation and maintenance aspects.

Contents Table

1. Introduction

1.1 Aspects Covered

This document sets out the requirements applicable to expansion joints for use in road 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.

1.2 Implementation

This Standard should be used forthwith on all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of TII, the application would result in significant additional expense or delay to progress. In such cases, Design Organisations should confirm the application of this Standard to particular schemes with TII.

1.3 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 deck spans 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 European Assessment Documents (EAD) applicable to bridge deck expansion joints [Ref 16.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.

1.4 Abbreviations

Abbreviation	Definition
APJ	Asphaltic Plug Joint
CIRIA	Construction Industry Research and Information Association
DoP	Declaration of Performance
EAD	European Assessment Documents [Ref 16.N]
EMR	Elastomeric in Metal Runners (modular) joint
EOTA	European Organisation for Technical Approvals
ETA	European Technical Approval
ETAG	Guideline for European Technical Approval
IAN	Interim advice note
PTV	Pendulum test value (for skid resistance)
TAR	Technical Acceptance Report
TRL	Transport Research Laboratory

1.5 Terms and Definitions

Term	Definition
Technical Acceptance Report (TAR)	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 TAR is to be accepted by the TII Structures Section, 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]
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 Section 6 of IS EN 1991-1-5 [Ref 4.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 but the definition has been expanded to include joints with polymer-based binder.
In-joint drainage	In EAD, 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 EAD [Ref 16.N], sub-surface drainage in this document refers to a system for draining water embedded within the carriageway surfacing such as buried slotted tubes.

Term	Definition
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 Runners (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 defects arising during service result 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 to form a smooth continuous running surface.
Waterproofing system	A concrete bridge deck waterproofing system in accordance with DN-STR-03009 [Ref 15.N].
Working life	The period over which it is envisaged that the joint will function satisfactorily without the need for significant maintenance (see Section 1.2.2 of EAD [Ref 16.N]).

2. Design Principles

2.1 General

Expansion joints shall either:

1. have the appropriate European Technical Approval (ETA) and designed in accordance with the requirements contained in the EAD [Ref 16.N] and outlined in Appendix B; or,
2. be certified in accordance with NSAI or have an equivalent approval certificate.

NOTE Declarations of performance requirements from EAD are included in Appendix B for the generic groups of expansion joints, which are listed and described in Appendix A.

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 TII Structures Section.

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.

Expansion joints in road bridge decks shall be capable of sustaining the loads and accommodating movements described in EAD, and in this document, while remaining safe for all categories of road users, without damage to the surfacing or supporting structures during service.

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

Where no expansion joint is to be provided, the waterproofing shall be detailed in accordance with DN-STR-03009 [Ref 15.N] to accommodate movements and ensure continuity across the deck joint gap.

The same joint system, seal or sealant shall continue across the full width of the deck including footway, verge, hard shoulder and central reserve. A “hybrid joint” consisting of different joint types is not permitted under any circumstances. Designers shall consider the presence of services in footways, limited surfacing depths or other obstructions/constraints and ensure there is sufficient depth available to install the joint across the full width of deck in accordance with the manufacturer’s instructions.

Expansion joints should be installed in a straight line.

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.

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

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

The fixing or bonding to the bridge structure of the appropriate components of all expansion joints shall be in accordance with the manufacturer's instructions.

Where described in the manufacturer's details the expansion joint gap shall be sealed with a compression seal, elastomeric element or sealant.

All limited design life components of a joint shall be designed so that they can be easily replaced with the minimum of delay to road users.

Where prefabricated units are used, the seal between each unit shall be made watertight and in addition a secondary waterproofing system in the form of a continuous membrane shall be installed.

Kerb cover plates shall be provided to protect the expansion joint at the kerb line, and to provide a uniform level of footway surface for pedestrians across the full width of footway.

3. Selection of Joint Type

3.1 General

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

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

The key factors affecting the performance of the various types of expansion joint are shown in Table A.2 (Appendix A).

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

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.

The justification for selection of a particular joint type shall be demonstrated to the TII Structures Section. Appendix A gives guidance on the various types of typical expansion joints and aspects which should be considered in the selection, design and specification of the expansion joint.

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.

The assessment demonstrating the optimum whole life cost of the expansion joint system shall be provided as part of the Technical Acceptance Report (TAR).

NOTE Guidance on the whole life costing of bridge deck expansion joints can be obtained from TRL Report R236 [Ref 3.I].

3.2 Preliminary Design Criteria

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 site specific aspects or constraints (for example, limited depth of surfacing, high skew, presence of services).

As part of the 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.

3.3 Detailed Design Criteria

The following information about each expansion joint within a structure shall be included in the Technical Acceptance Report (TAR) for that structure.

1. location;
2. anticipated extreme ambient temperature range;
3. user category (i.e. vehicular, cycle, pedestrian, livestock);
4. 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);
5. illustrative long section of bridge (showing location of expansion joints);
6. interface with service ducts;
7. relevant TII Publications, Eurocodes (including national annexes), BSI published documents, codes of practice, and related documents; and,
8. constraints and external controls that affect installation or maintenance of the joint such as available lane closure arrangements.

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. installation temperature and any pre-setting definition; and,
3. fatigue traffic category from Table NA.4 of Irish NA to IS EN 1991-2 [Ref 13.N]

The following management and maintenance information about the bridge expansion joint system shall be recorded in the Safety File.

1. proposed joint and ancillary items;
2. declaration of performance;
3. working life;
4. expansion joint installation and maintenance procedures; and,

5. general maintenance procedures associated with access and traffic management measures associated with inspection/maintenance of expansion joint.

4. Expansion Joint Design Requirements

4.1 Functional Requirements

The following main requirements apply to expansion joints:

1. Expansion joints shall provide a flexible, safe, and comfortable transition between the approach road and the bridge deck/abutment.
2. Expansion joints shall not cause damage or reduce the design lifetime of the supporting structure.

For main requirement 1, the following functional requirements apply:

- Provision of sufficient space to allow extension, contraction, displacement in a vertical direction, and relative rotation with respect to the support points of bridge decks.
- Resistance to loads caused by the displacement of bridge decks.
- Resistance to loads generated by traffic (static and dynamic) without causing damage to the expansion joint and the connection of the expansion joint to the bridge deck/abutment.
- Allowance of safe and comfortable passage for traffic.
- Minimisation of the contact and/or pulse noise as a result of the traffic passing over the expansion joint.

For main requirement 2, the following functional requirement applies:

- Appropriate drainage (including sub-surface drainage) of the road pavement and expansion joint along with the necessary discharge facilities.

Mechanical resistance of expansion joints for road bridges shall be specified in accordance with the EAD [Ref 16.N] where applicable.

The performance requirements for the various joint types covered by EAD [Ref 16.N] are included in Appendix B.

The actions and combinations to be used for the design of supporting structures shall be in accordance with the relevant Eurocodes.

All references to Eurocodes in this document include the respective Irish national annexes and the implementation document DN-STR-03020 [Ref 14.N].

4.2 Design Working Life

4.2.1 Expansion Joint Assembly

The required design working life of the expansion joint assembly is as provided in Table 4.1.

Table 4.1 Design working life requirements for expansion joint families

Family	EAD [Ref 16.N]	Minimum Design Working Life (New build / Full replacement)
Buried Expansion Joints	Not Applicable	10 years
Flexible Plug Expansion Joints	EAD 120093-00-0107 EAD 120011-00-0107	10 years
Nosing Expansion Joints	EAD 120109-00-0107	50 years
Mat Expansion Joints	EAD 120110-00-0107	50 years
Cantilever Expansion Joints	EAD 120111-00-0107	50 years
Supported Expansion Joints	EAD 120112-00-0107	50 years
Modular Expansion Joints	EAD 120113-00-0107	50 years

4.2.2 Expansion Joint Components

The minimum requirement for the design working life (i.e. requiring maintenance other than cleaning) for replaceable rubber or polymer components in expansion joints is 15 years.

Components that require significant works or demolition for replacement are considered non-replaceable and shall have a design life according to Table 4.1. The exception to this is the case where the design of the structure is based on the assumption that certain joint components should have a design life equal to the structure.

Steel components, irrespective of whether they are replaceable, shall have a design life according to Table 4.1. If prestressing bolts are unloaded in order to replace underlying components with a lower design life, the design life of these prestressing bolts may be set as equal to the component with the lowest design life, with a minimum of 25 years.

NOTE 1 Prestressing bolts shall always be replaced after they have been unloaded.

For concrete structures, the detailing of the structure at the expansion joint and the design of the expansion joint itself shall be such that the replacement of the expansion joint or parts thereof is possible without causing damage to the underlying concrete structure. Components of the joint that are subject to degradation must be replaceable without demolition of any part of the concrete structure.

Anchored steel in expansion joints in new concrete structures must be designed such that the expansion joint components anchored in concrete do not need to be replaced. These anchored components must have the same design life as the structure.

4.3 Fatigue

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 in Table 4.1.

4.4 Movements

4.4.1 General

During the design life, the expansion joint shall be able withstand the deformations and movements of the bridge deck, or other elements of the main load bearing structure, without damage occurring to the expansion joint, the underlying structure or the adjacent pavement.

The displacement effect at the level of the expansion joint (horizontal and vertical) as a result of angular rotations of the main load bearing structure and, in particular, the end crossbeams or diaphragms must be taken into consideration.

For movements perpendicular to the direction of travel in the plane of the bridge deck, account must also be taken of the play (including wear), and degrees of freedom in the bearing articulation.

With respect to movements, a distinction can be made between:

- displacement of the bridge deck due to deformations or displacements of the bearings;
- any deformation of the bridge deck itself.

With regard to the deformations or displacement of the bearings, for bridges with a bearing scheme consisting of fixed, guided, and free bearings, the play that is present in this system (including the effects of wear during the design life) needs to be taken into account.

For bridges with a bearing scheme consisting of rubber bearings without guides, the theoretical movements due to the loads placed upon it must be determined using the appropriate idealised horizontal and vertical spring stiffness.

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

The governing movements at the location of the expansion joint shall typically be determined from a combination of characteristic values of deformations and displacements of the bridge structure due to:

1. temperature effects
2. shrinkage and creep of concrete
3. deformations of the substructure and the foundations
4. traffic loads
5. wind loads.

At skewed bridges, it is necessary to distinguish between bridge deck movements and expansion joint movements.

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.

4.4.2 Movement Due to Temperature Effects

The deformations of the bridge deck, and the resulting expansion joint movements due to temperature effects, must be determined in accordance with chapter 6 of IS EN 1991-1-5 [Ref 4.N] taking into account the additional provisions contained in this paragraph.

In EN 1991-1-5 temperature effects are defined due to:

- uniform temperature component (u_{TN})
- temperature difference component (u_{TM})

Both shall be taken into consideration.

With respect to the uniform temperature component, a temperature supplement must be used in connection with the uncertainty concerning the actual average temperature of the structure at the time of installation of the joint. See NA to IS EN 1991-1-5, NA.2.6 Subclause 6.1.3.3(3).

The temperature at which the expansion joint is set shall be specified, and thus a temperature supplement of +/-10 °C can normally be adopted.

For expansion joints, this results in a temperature range $\Delta T_{N,ej} = T_{e,max,ej} – T_{e,min,ej}$ according to Table 4.2. With reference to IS EN 1991-1-5 :

$T_{e,max,ej} = T_{e,max}$ + Supplement for installation temperature uncertainty.

$T_{e,min,ej} = T_{e,min}$ + Supplement for installation temperature uncertainty.

Table 4.2 Guidance values for uniform temperature component including certainty of installation temperature

	Steel Bridge Deck (Type 1)	Steel-Composite Bridge Deck (Type 2)	Concrete Bridge Deck (Type 3)
$T_{e,max,ej}$	+58 °C	+46 °C	+44 °C
$T_{e,min,ej}$	-27 °C	-20 °C	-16 °C
$\Delta T_{N,ej}$	85 °C	66 °C	60 °C
α_T	12e-6	10e-6	10e-6

Note: Values in table 4.2 are based on the minimum and maximum shade air temperatures which have not been adjusted for height above sea level or for micro-climate conditions.

The movement effects at the location of the expansion joint due to temperature difference components must be determined in accordance with clause 6.1.4.2 and 6.1.4.3 of IS EN-1991-1-5.

For the linear expansion coefficient, the values in Annex C of IS EN 1991-1-5 shall be used (see also Table 4.2).

4.4.3 Movement due to Creep and Shrinkage

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 (u_{sh}) and creep (u_{cr}).

Irreversible movements due to creep and shrinkage of concrete shall be calculated in accordance with IS EN 1992-2 [Ref 5.N] and IS EN 1994-2 [Ref 6.N].

4.4.4 Movement due to Deformations of the Substructure

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 (u_{set}).

4.4.5 Movement due to Traffic Loads

Deformations and displacements of the bridge deck and the resulting joint movements due to traffic load shall be determined using the traffic load models in accordance with IS EN 1991-2 [Ref 2.N].

Distinction shall be made between:

1. Horizontal translations in the direction of traffic due to braking and acceleration forces on the bridge deck in combination with freedom of movement in the bearing scheme ($u_{Q,l}$).
2. Horizontal translations perpendicular to the direction of traffic due to centrifugal forces on the bridge deck with a horizontal radius r < 1500m ($u_{Q,t}$).
3. Horizontal and vertical translations due to vertical load ($u_{Q,v}$).

4.4.6 Movement due to Wind Loads

The deformations and displacements of the bridge deck and the resulting joint movements due to wind must be determined in accordance with IS EN 1991-1-4 [Ref 3.N]. Where wind and traffic are considered to be simultaneous, the movement due to wind can be based on F^*_w as per 8.1(4) of IS EN 1991-1-4 (u_{F^*w}); otherwise, movement due to wind (u_{Fwk}) is based on F_{wk}.

4.4.7 Combination of Actions for Movement in the Serviceability Limit State (SLS)

For the determination of the maximum and minimum movement of the expansion joints in various directions (when compared to the neutral position), combined movements in each of the individual directions (x, y, z) must be calculated due to the effect of actions given in sections 4.4.2 to 4.4.6, while also taking into account the maximum and minimum value of the play in the bearing or guidance system.

The SLS characteristic movements that can occur simultaneously shall be combined in accordance with Eqn 6.14b of IS EN 1990 [Ref 7.N].

This results in the following SLS characteristic combinations with temperature (1), wind (2), and traffic (3) considered as leading variable actions.

Table 4.3 SLS characteristic combinations of actions for movement of expansion joints

Combination	Combination rule
$u_{SLS,k;1a}$	$1.0(1.0u_{TN}+0.75u_{TM}) + 0.75(u_{Q,v}) + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;1b}$	$1.0(0.35u_{TN}+1.0u_{TM}) + 0.75(u_{Q,v}) + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;2a}$	$0.75(u_{Q,v}) + 1.0u_{F^{*}w} + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;2b}$	$1.0u_{Fwk} + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;3a}$	$0.6(1.0u_{TN}+0.75u_{TM}) + 1.0u_{Q,v} + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;3b}$	$0.6(0.35u_{TN}+1.0u_{TM}) + 1.0u_{Q,v} + u_{set} + u_{cr} + u_{sh}$
$u_{SLS,k;3c}$	$1.0u_{Q,v} + \min[1.0u_{F^{*}w;}\ 0.5u_{Fwk}] + u_{set} + u_{cr} + u_{sh}$

Notes to Table 4.3:

For the calculation of the minimum opening, u_{cr} and u_{sh} should not be taken into account as these effects may not be present in the short term.

Where permanent actions are applied after the setting of the expansion joint, and movements due to these actions should be included in each of the combinations given in Table 4.3

Account shall also be taken for the maximum and minimum value of the play in the bearing or guidance system (as noted above).

4.4.8 Combinations of Movements in Ultimate Limit State (ULS)

To calculate the movement capacity in the Ultimate Limit State, the combination value of the displacement in the Serviceability Limit State shall be multiplied by a factor of 1.2:

$u_{ULS;D} = 1.2 \text{ x } u_{SLS,K}$

NOTE: If the partial factors for the ULS that are included in IS EN 1990 were to be used to calculate the deformations, this would lead to values that are too large and unrealistic.

The ULS movement shall be used to check:

- the maximum joint opening – which is used as part of the structural resistance verification of the expansion joint system and supporting structure;
- the minimum joint opening – to ensure that there is no clamping/locked-in forces in the supporting structure and in the expansion joint that may lead to the structural failure of the expansion joint and/or damage to the underlying structure.

NOTE: The movement capacity in the Ultimate Limit State refers only to the structural capacity demands. The expansion joint is, therefore, not required to meet all the functional requirements in this limit state. Upon reaching the ULS, the expansion joint shall allow safe passage of vehicles across the joint, but may, for example, exhibit some leakage.

4.4.9 Minimal Movement Capacity

Regardless of the results of the analysis, the following minimum (design) values must be taken into account (with the exception of buried expansion joints and flexible plug expansion joints):

- Horizontal translations (perpendicular to the expansion joint): -5mm/+5mm;
- Horizontal translations (parallel to the expansion joint): -3 mm/+3 mm;
- Vertical translations between adjacent structures: -3 mm/+3 mm;
- Rotations between adjacent structures (along the common axis of the bearings): -0.005rad /+0.005rad;

- Temporary difference in height between components of the expansion joint of at least 10mm at the road level, due to jacking of a bridge deck for replacement of bearings.

4.4.10 Construction Specification

The setting of the expansion joint in relation to the temperature of the structure at the time of installation shall be specified.

In the event that the expansion joint type/system does not allow adjustability in the setting of the joint, or that this is limited for practical reasons, it must be taken into account in the design. In this case, the limits of the temperature of the structure within which the expansion joint can be built into the supporting structure must be specified in the detailed design documents before the execution stage.

4.5 Structural Resistance

During the design life, the expansion joint structure shall be able to withstand the traffic load acting upon it, as well as any possible internal forces, without this leading to a collapse of the structure or unacceptably large deformations. Therefore, account must be taken, where relevant, of any loss of material due to wear and deterioration. The limit states shall comply with IS EN1990 the relevant EAD, where applicable.

The structural resistance of the expansion joint includes the anchoring system to the supporting structure.

Each theoretical lane in accordance with EN1991-2 must be considered a potential lane for heavy traffic (Lane 1), unless stated in the project specification or otherwise agreed with TII.

The general loads and loading conditions are to be applied in accordance with IS EN 1991-2 and the EAD applicable to the expansion joint system.

The internal forces which are caused by prestress and/or by imposed displacements and/or rotations of the expansion joint must also be considered in the calculations.

It must be shown that the wear capacity of the components that are subject to wear as a result of the internal motions of the joint structure is in accordance with the required design life of the structure (and its component parts) as described in Table 4.1. The effect of both traffic load and temperature load must be included.

The total wear occurring in sliding surfaces during the design working life shall not lead to the following situations:

- Insufficient mechanical resistance (both static and fatigue),
- Change in the kinematic principles (loss of original contact pressure based on structural analysis),
- Complete disappearance of component parts of the sliding system, or,
- Increase of friction to the extent that damage occurs to the expansion joint.

4.6 Joint Gaps, Grooves and Cover Plates

Joints with grooves or gaps at surface level may form a hazard to pedestrians and all such joints in footways should be provided with cover plates.

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.

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.

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

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; or,
2. a load bearing seal 5 ± 2 mm below the top surface of the joint.

The allowable surface gaps and voids shall comply with the requirements given in EAD. For carriageways where non-vehicular users have access, this may result in the need for cover plates in the carriageway. The effect of skew shall be considered in the assessment of allow surface gaps and voids, as gaps, grooves and openings can become orientated in the direction of traffic flow where the expansion joint is skewed.

Cover plates (in footpath) shall have a sufficient thickness to withstand accidental wheel loading and to provide acceptable ride quality. The cover plate arrangement shall avoid steps in the roadway surface or alignment that would cause a hazard to road users. The height of the joint should be set to accommodate the thickness of the cover plate.

4.7 Transition Strips

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.

The width of the transition strip should be no wider than 400 mm. The width of the transition strip should be kept as narrow as possible, ideally 50-100mm wide.

Premature failures of proprietary joints are often associated with unsuitable transition strips which have themselves failed. Where cementitious materials are used, consideration should be given to the provision of anti-crack reinforcement which is anchored into the bridge deck.

4.8 Skidding Resistance

The skid resistance of an expansion joint shall be at least equal to the minimum requirement for the adjacent carriageway surfacing (as defined in AM-PAV-06045 [Ref 11.N]) throughout its working life.

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.

The finish of the upper surfaces of expansion or compatible cover plates in footways and cycleways 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.

Where required by the EAD, the skid resistance shall be verified by testing in accordance with the EAD, which refers to IS EN 13036-4 [Ref 9.N].

4.9 Drainage

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.

4.9.1 Road Gullies

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

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

4.9.2 Drainage System

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

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

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

Where the presence of a joint will impede the movement of water within the basecourse or wearing course materials, sub-surface drainage shall be provided.

NOTE Requirements on the management of water from the road are given in DN-DNG-03022 [Ref 1.N] and DN-DNG-03065 [Ref 10.N].

4.9.3 In-joint Drainage

A transverse and through-deck in-joint drainage system shall be provided to prevent water build up in the pavement surfacing adjacent to the high side of the joint and 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, and can cause deterioration of the pavement surfacing.

NOTE 2 For advice relating to the waterproofing and drainage of bridge decks reference can be made to DN-STR-03009 [Ref 15.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.

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 free water flow through the drainage tubes.

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.

As an alternative to transverse slotted drains, a transverse channel may be formed in the top of the bridge deck, parallel to the joint. Where a transverse channel is used, cast-in downpipes should be provided at intervals along the channel, to clear the bearing and jacking point positions. Where a transverse channel is used, the trough should be filled with surfacing which is sufficiently permeable to permit the passage of water.

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.

The pipes should be carefully positioned in order that drips from the outlets do not damage the face of adjacent concrete.

For advice relating to the waterproofing and drainage of bridge decks reference should be made to DN-STR-03009 [Ref 15.N].

4.9.4 Outflow of Drainage

The outflow and discharge of sub-surface drainage needs consideration in the design and construction. Typically for new bridge construction, the sub-surface drainage will outflow to the abutment gallery drainage system. For replacement of existing expansion joints, it may be appropriate to discharge to the existing bearing shelf, utilising or adapting the existing drainage system at this location.

NOTE Examples of outflow of drainage systems are illustrated in Appendix A.

5. Design for Installation and Maintenance

5.1 Installation

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

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

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

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

For methods 1) and 2) above the deck joint gap and waterproofing are normally covered either with hardboard or thin plywood over a width equal to that of the joint installation and the surfacing then laid continuously over the top. The required width of surfacing is subsequently sawn and removed to the top surface of the waterproofing system. The waterproofing is then carefully cut back to expose the concrete surface, which should be prepared to receive the expansion joint system (see Figure C.1). It is very important that deck waterproofing is carefully detailed in the vicinity of the joint to ensure the continuity of the water barrier e.g. either by bond or lap. For method 3, the joint system is installed before the surfacing is laid. The joint anchor bars lapping or interlocking with the deck reinforcement are cast into boxed-out recesses in the concrete deck using small aggregate concrete. When the concrete has cured, the surfacing is normally laid to within 15-20 mm of the metal edge of the joint. This 15-20mm groove is then filled with bitumastic material (see Figure C.2).

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

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.

The sides of the joint gap shall be parallel.

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

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 E.

5.2 Inspection and Maintenance

Expansion joints shall be inspected during bridge Principal Inspections and maintained at regular set intervals, in accordance with TII Eirspan Bridge Management System, to ensure that they continue to operate in accordance with all the requirements of this document and the manufacturer's recommendations.

Details of the maintenance works completed to repair or replace the expansion joints shall be recorded in the TII Eirspan Bridge Management Database. When carriageway resurfacing operations are planned, any bridge joints which are affected should be inspected so that precautions can be taken to protect the existing joint during construction, or a decision can be made to repair or replace a joint if necessary due to joint defects, or to implement a better whole-life-cost solution for the joint. 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. These operations can usually be carried out quickly during off-peak periods of traffic flow. 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 AM-STR-06054 [Ref 8.N] and AM-STR-06055 [Ref 17.N].

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

Where relevant, a maintenance manual shall be prepared and included in the Health and Safety File.

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.

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 design phase.

NOTE 2 Table 5.1 contains the minimum information required for the maintenance manual.

Table 5.1 Indicative list of items for inclusion in maintenance 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 as 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 road network.

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	DN-DNG-03022 - Drainage Systems for National Roads (including Amendment No. 1 dated June 2015)
Ref 2.N	IS EN 1991-2, 'Eurocode 1. Actions on structures. Traffic loads on bridges'
Ref 3.N	IS EN 1991-1-4, 'Eurocode 1. Actions on structures. General Actions – Wind Actions'
Ref 4.N	IS EN 1991-1-5, 'Eurocode 1: Actions on structures. Part 1-5: General actions – Thermal actions'
Ref 5.N	IS EN 1992-2, 'Eurocode 2. Design of concrete structures. Part 2: Concrete bridges. Design and detailing rules'
Ref 6.N	IS EN 1994-2, 'Eurocode 4. Design of composite steel and concrete structures. Part 2: General rules and rules for bridges'
Ref 7.N	IS EN 1990, 'Eurocode: Basis of structural design'
Ref 8.N	AM-STR-06054. 'EIRSPAN Bridge Management System Principal Inspection Manual'
Ref 9.N	IS 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 10.N	DN-DNG-03065. 'Road Drainage and the Water Environment (including Amendment No. 1 dated June 2015)'
Ref 11.N	AM-PAV-06045. 'Skid Resistance Assessment'
Ref 12.N	DN-STR-03012. 'Design for Durability'
Ref 13.N	NA to IS EN 1991-2, Irish National Annex to Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges'
Ref 14.N	DN-STR-03020. 'The Structural Design of Road Structures'
Ref 15.N	DN-STR-03009. 'Waterproofing and Surfacing of Concrete Bridge Decks'
Ref 16.N	EAD 120093-00-0107 Flexible asphaltic plug joints for road bridges EAD 120011-00-0107 Flexible plug expansion joints for road bridges with flexible filling based on a synthetic polymer as binder EAD 120109-00-0107 Nosing expansion joint for road bridges EAD 120110-00-0107 Mat expansion joints for road bridges EAD 120111-00-0107 Cantilever expansion joints for road bridges EAD 120112-00-0107 Supported expansion joints for road bridges EAD 120113-00-0107 Modular expansion joints for road bridges
Ref 17.N	AM-STR-06055. 'EIRSPAN Bridge Management System Routine Maintenance Manual'
Ref 18.N	AM-STR-06039. 'The Management of Sub-standard Road Structures'
Ref 19.N	DN-STR-03001. 'Technical Acceptance of Road Structures on Motorways and Other National Roads'

7. Informative References

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

Ref 1.I	Highways England. CD 357, 'Bridge expansion joints'
Ref 2.I	CIRIA C764, 'Hidden defects in bridges. Guidance for detection and maintenance'
Ref 3.I	Transport Research Laboratory. TRL R236, 'Improving the performance of bridge expansion joints: Bridge Deck Expansion Joint Working Group Final Report'
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	Transport Research Laboratory. TRL LR1104, 'The performance in service of bridge deck expansion joints'
Ref 6.I	DMRB. BD 33/97, 'Expansion Joints for use in Highway Bridge Decks' (*withdrawn)*
Ref 7.I	ETAG no. 032 – Guideline for European Technical Approval of Expansion Joints for Road Bridges. Part 2: Buried 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 the EAD 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 the EAD 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 joints perform satisfactorily provided:

1. the total joint system is designed to withstand the effects of traffic loading including impact and abrasion;
2. for replacement joints, the joint is designed taking account of existing constraints including existing and proposed joint depths and presence of services;
3. the total movement at the deck joint gap is within the capacity of the joint system; and,
4. the joint is installed in accordance with the manufacturer's instructions 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 EAD series and their equivalent in BD 33

EAD [Ref 16.N] Document number and joint family	Equivalent BD 33 joint type (withdrawn)
Not applicable	Type 1 – Buried joint under continuous surfacing
EAD 120093-00-0107 Flexible asphaltic plug joints for road bridges	Type 2 – Asphaltic plug joint
EAD 120109-00-0107 Nosing expansion joint for road bridges	Type 3 – Nosing joint with poured sealant and Type 4 – Nosing with preformed compression seal
EAD 120110-00-0107 Mat expansion joints for road bridges	Type 5 – Reinforced Elastomeric
EAD 120111-00-0107 Cantilever expansion joints for road bridges	Type 7 – Cantilever comb or tooth joint
EAD 120112-00-0107 Supported expansion joints for road bridges	Not covered
EAD 120113-00-0107 Modular expansion joints for road bridges	Type 6 – Elastomeric in metal runners
EAD 120011-00-0107 Flexible plug expansion joints for road bridges with flexible filling based on a synthetic polymer as binder	Not covered

Table A.2 Key factors affecting past joint performance[1]

Joint type[2]				Buried	Flexible Asphaltic Plug [3]	Nosing	Mat	Modular	Cantilever	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 (°C)			<10	L	L	L	L	L	L	L
			10-15	M	L	M	L	L	L	M

Joint type[(2)]		**Buried**	**Flexible Asphaltic Plug [(3)]**	**Nosing**	**Mat**	**Modular**	**Cantilever**	**Transition Strip**
	>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

** Assuming joint in correct design range*
*** Assuming correct binder type N/A = Not applicable*

L - Low
M - Moderate effect on performance
H - High

Note 1: This table is reproduced from CD 357 [Ref 1.I]. It is based on a similar table in TRL LR1104 [Ref 5.I], modified to take into account information on joint performance current in 1994.
Note 2: Joint type based on families described in withdrawn BD33 [Ref 6.I] document joint type.
Note 3: In accordance with DN-ST-03012 [Ref 12.N] asphaltic plug type expansion joints shall not be used for structures carrying national roads or forming part of grade separated interchanges on national roads

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

Expansion joint family (3)	Total longitudinal movement range (mm)		Maximum vertical movement between sides of joint (mm)
	Minimum (2)	Maximum	
Buried expansion joint	5	20	1.3
Flexible asphaltic plug expansion joints	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 CD357 [Ref 1.I], but updated in line with EAD [Ref 16.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 Figure A.2 for other examples).

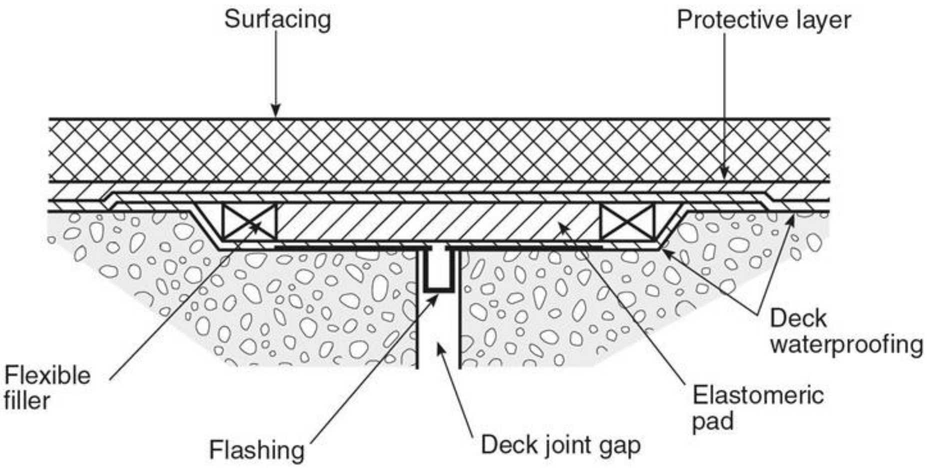
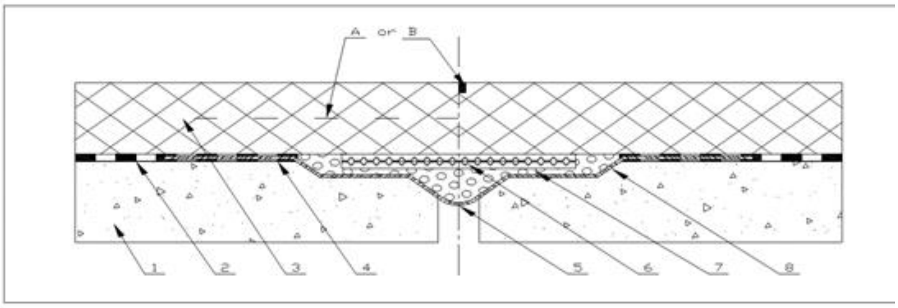


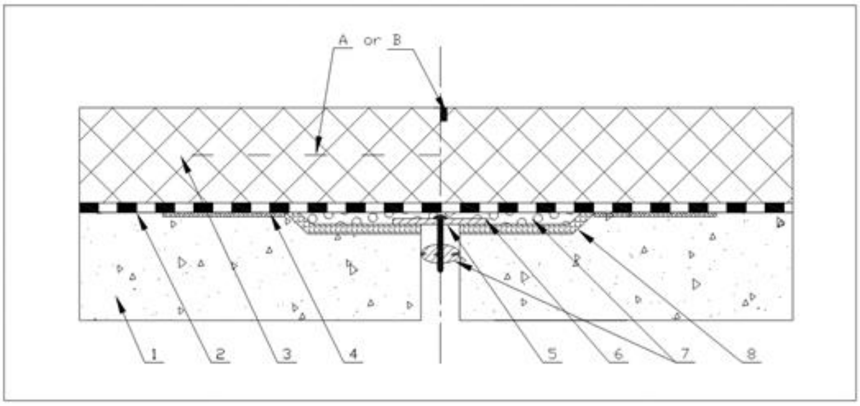
Figure A.1 Example of buried expansion joint (Source [Ref 1.I])

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 main 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.

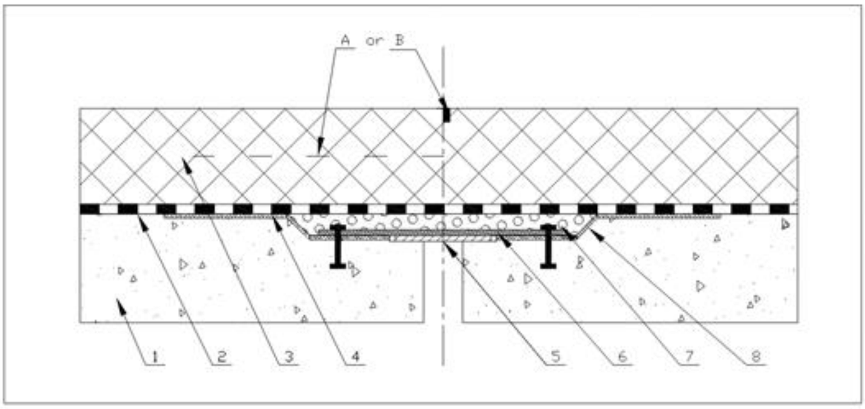
For movement ranges up to 10mm a proprietary flashing may be appropriate provided there is a minimum of 100mm surfacing. For movement ranges of 10-20mm, an elastomeric pad may be installed on top of the flashing to support surfacing 500-600mm wide. When laid as part of the joint, this improves its flexibility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



Type 1



Type 2



Type 3

KEY

*1. Bridge deck/abutment **
*2. Bridge deck waterproofing **
*3. Surfacing **
4. Waterproofing connection element
5. Supporting element (e.g. bridging plate)
6. Free sliding surface, extensible membrane or flexible plug mixture
7. Caulking
8. Waterproofing element

*A. Reinforcement * (optional)*
*B. Crack inducer sealant * (optional)*

** Not part of the kit*

Figure A.2 Other examples of buried expansion joints (Source: Ref 7.I)

A2.2 Flexible Plug Expansion Joints

Flexible plug expansion joints are typically 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.3 for an example; refer to EAD 120093-00-0107 and EAD 120011-00-0107 [Ref 16.N] for other examples). There are a number of proprietary joint systems included in this description.

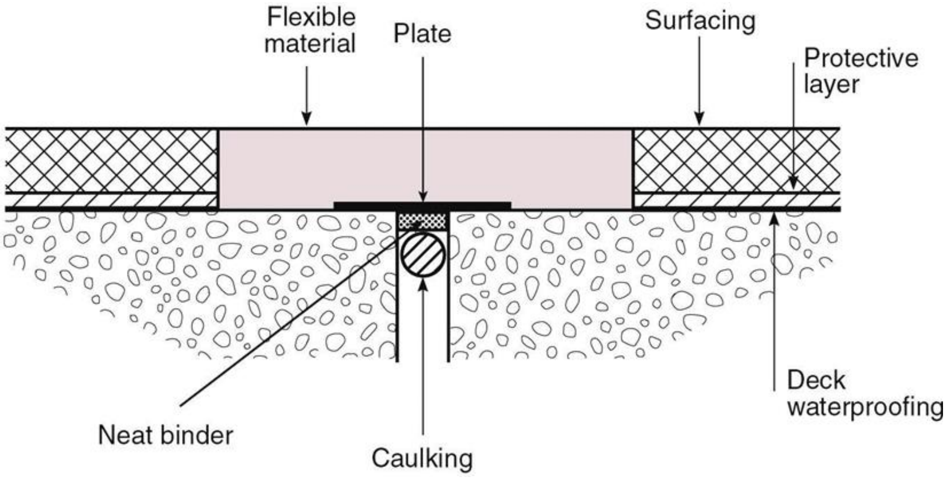


Figure A.3 Example of flexible plug expansion joints (Source [Ref 1.I])

The asphaltic version of 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. More recently, an alternative has been developed that uses a synthetic elastic polymer as a binder for aggregate, with the option to fit stabilising elements for improved resistance against deformations. This variant has the same working life category as the conventional bituminous version and the same limitations for application shall apply.

In general, flexible plug expansion 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. Premature failure has also occurred where the joint has been specified in locations where vehicles are braking, accelerating or turning directly on the joint, e.g. at or adjacent to traffic lights, roundabouts, and road junctions.

Flexible plug expansion joints should not be located where vehicles turn or stop and start (e.g. adjacent to traffic lights or a junction) as accelerated deterioration can occur.

On significant gradients the joint should be formed using a stiffer binder to reduce debonding 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.

In accordance with DN-STR-03012 [Ref 12.N] flexible plug type expansion joints shall not be used for new structures carrying national roads or forming part of grade separated interchanges on national roads. For existing bridges carrying national roads or forming part of grade separated interchanges on national roads, the use of flexible plug joints is acceptable in certain circumstances subject to TII Bridge Management approval.

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.4 for an example; refer to EAD 120109-00-0107 [Ref 16.N] for other examples).

The adjacent surfacing shall not be less than 100mm thick.

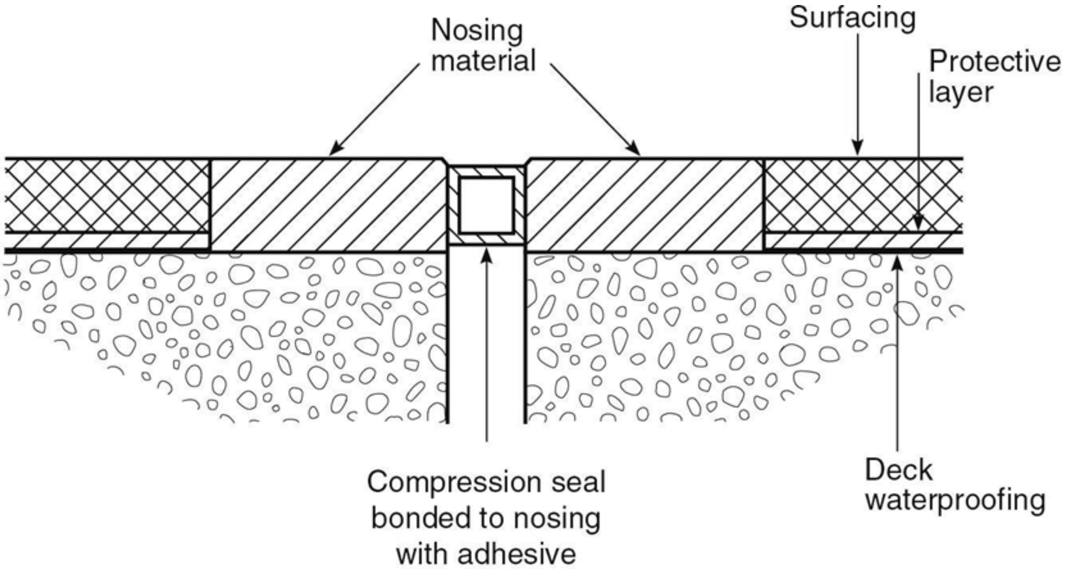


Figure A.4 Example of nosing expansion joint (Source [Ref 1.I])

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.5 for an example; refer to EAD 120110-00-0107 [Ref 16.N] for other examples.

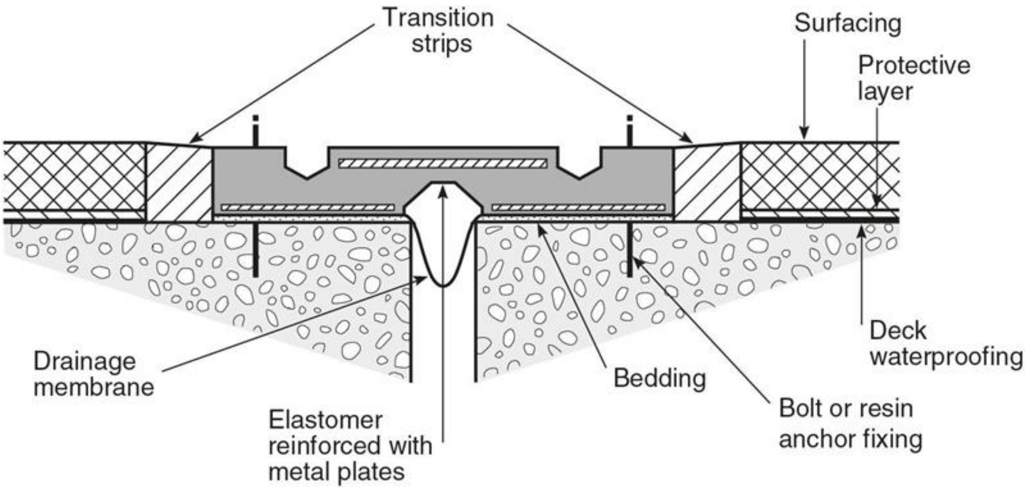


Figure A.5 Example of mat expansion joint (Source [Ref 1.I])

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. Occasionally the holding down bolt arrangement has been found to require maintenance; the elastomeric bolt seal can become loose and require replacing and for some systems the nuts can require re-tightening.

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.

The adjacent surfacing shall not be less than 100mm thick.

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.6 for an example; refer to EAD 120111-00-0107 [Ref 16.N] for other examples.

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).

The adjacent surfacing shall not be less than 100mm thick.

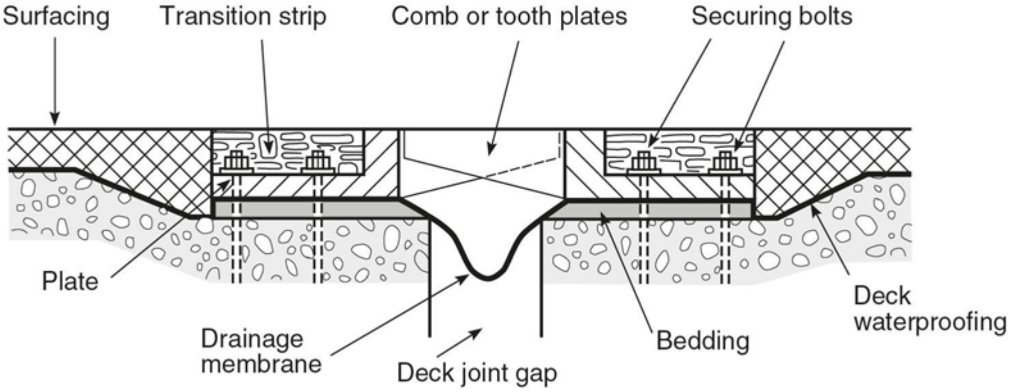


Figure A.6 Example of cantilever expansion joint (Source [Ref 1.I])

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 EAD 120112-00-0107 [Ref 16.N]. An example of a supported expansion joint is shown in Figure A.7; refer to EAD 120112-00-0107 [Ref 16.N] for other examples.

The adjacent surfacing shall not be less than 100mm thick.

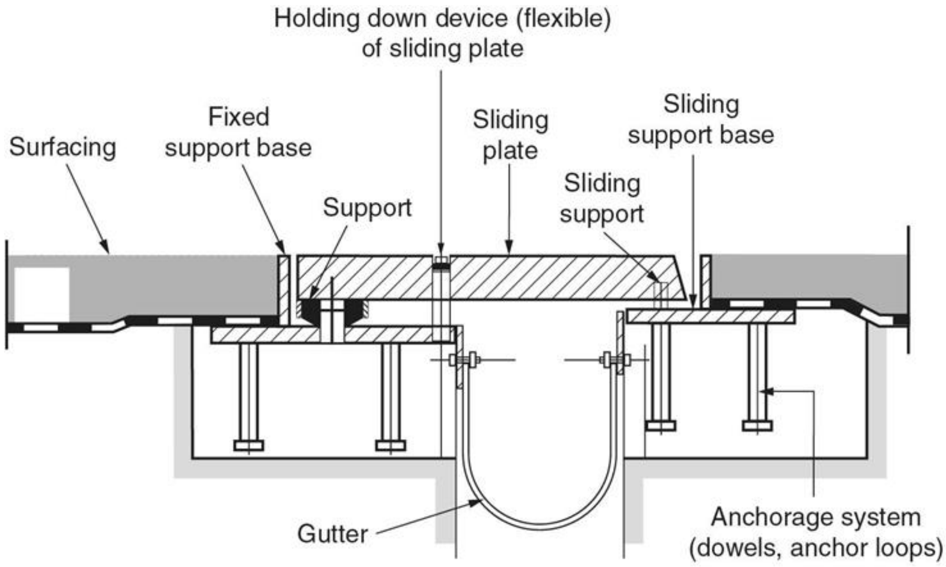


Figure A.7 Example of supported expansion joint without fingers (Source [Ref 1.I])

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 C.3 and C.4 (Appendix C).

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 (rails) 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.8; refer to EAD 120113-00-0107 [Ref 16.N] for other examples.

The adjacent surfacing shall not be less than 100mm thick.

Where possible welds in the rails (centre beam) should be avoided, and the expansion joints supplied in a complete pre-fabricated system (full bridge deck width). Welding of the rails is not permitted within in the zone of peak stress fluctuation due to wheel loading. The weld of the rail is a critical detail for the performance of the joint system, and the Weld Procedure Specification (WPS) and Weld Procedure Qualification Record (WPQR) shall be provided where welding is undertaken, either at the fabrication location or at site, along with the appropriate quality control procedures related to the execution of the welding.

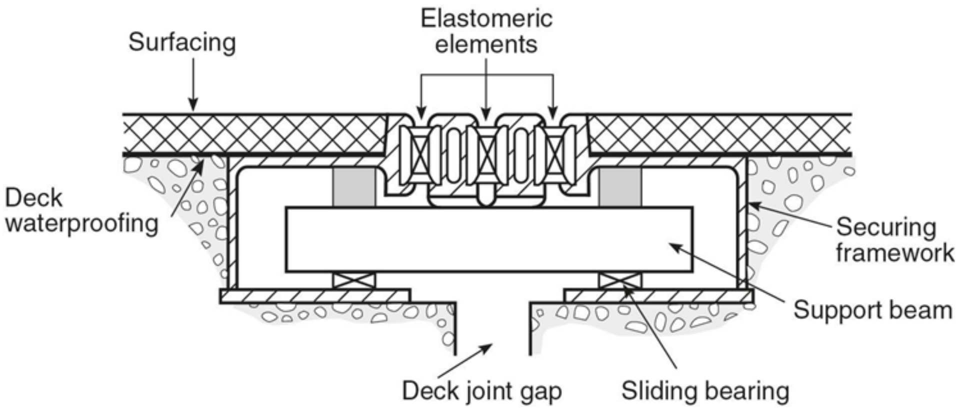


Figure A.8 Example of modular expansion joint (Source [Ref 1.I])

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. An adhesive should be applied to the locating ears of the seal which will assist installation and help resist the ingress of dirt, grit and water between the seal and metal runners.

The adjacent surfacing shall not be less than 100mm thick.

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 and deterioration of the pavement layers.

A typical detail for the provision of sub-surface drainage is shown in Figure A.9 (this is shown for a nosing joint, but a similar detail would be applicable for other joint types).

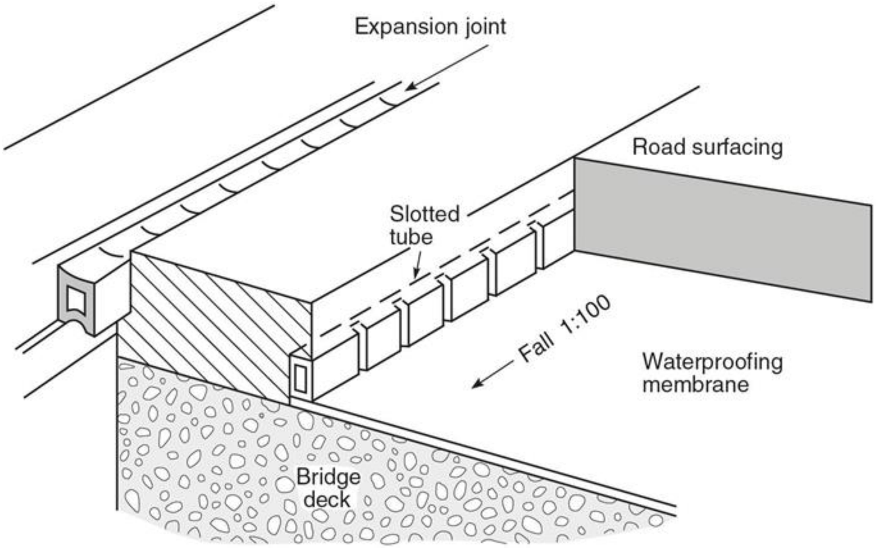


Figure A.9 Typical detail for provision of sub-surface drainage at expansion joints using transverse slotted drains (Source Ref 1.I)

As an alternative to transverse slotted drains, for new bridge construction, 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.10.

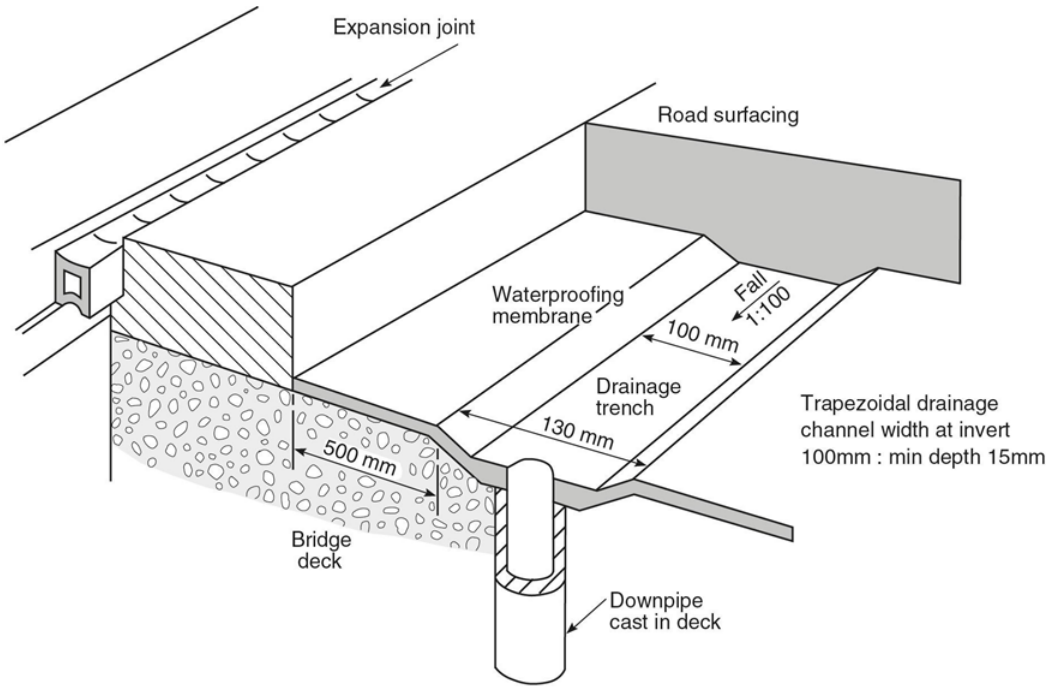


Figure A.10 Typical detail for provision of sub-surface drainage adjacent to expansion joint using a transverse channel (Source Ref 1.I)

A4 Outflow of Sub-Surface Drainage

Situation A: Drainage into abutment gallery [New bridge with bearings at end supports]

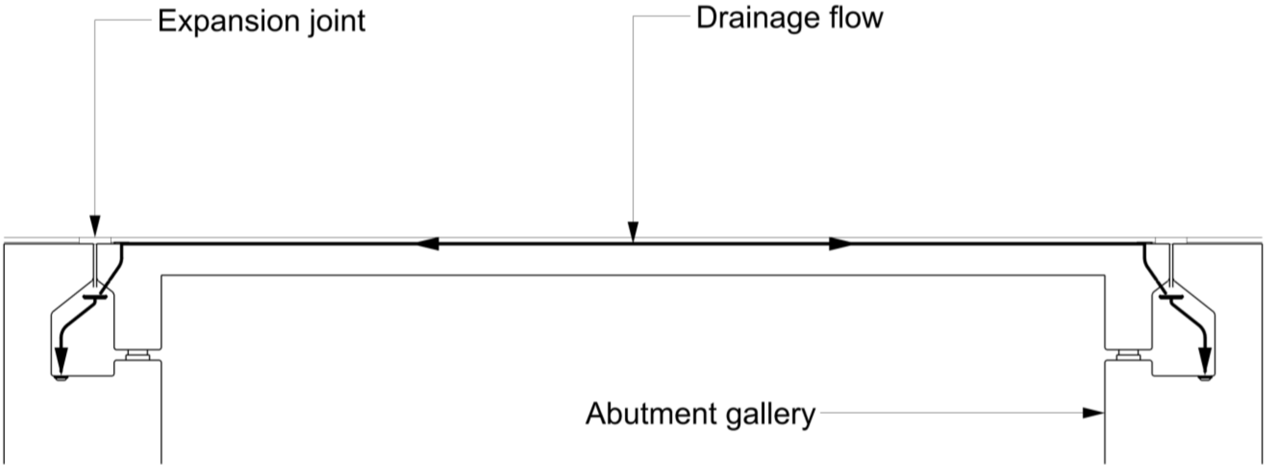


Figure A.11 Schematic illustration for sub-surface drainage into the bridge abutment gallery

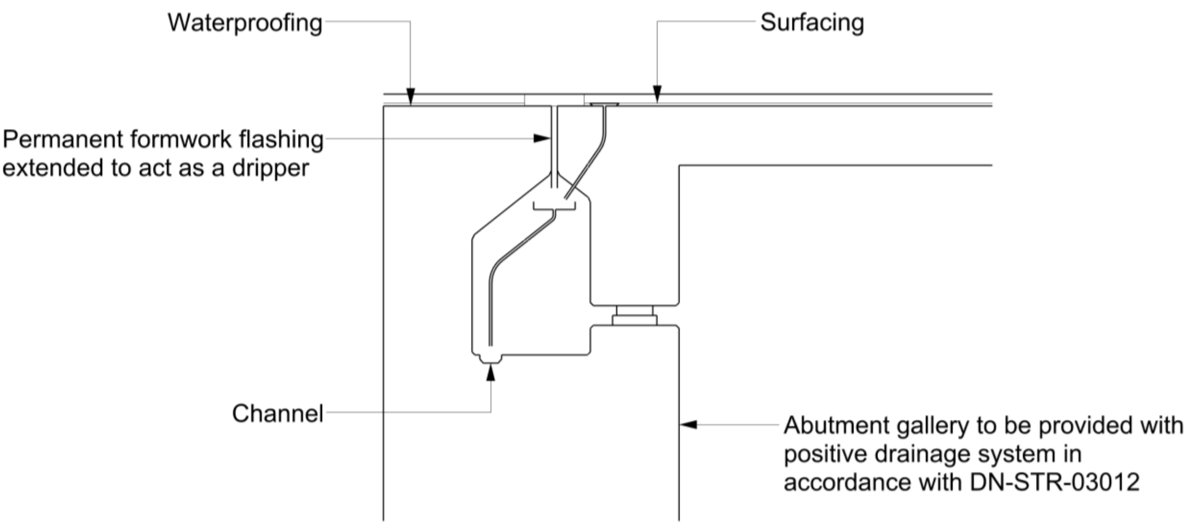


Figure A.12 Section illustration for sub-surface drainage into the bridge abutment gallery

Situation B: Drainage into bearing shelf [Bridge renovation with bearings at end supports]

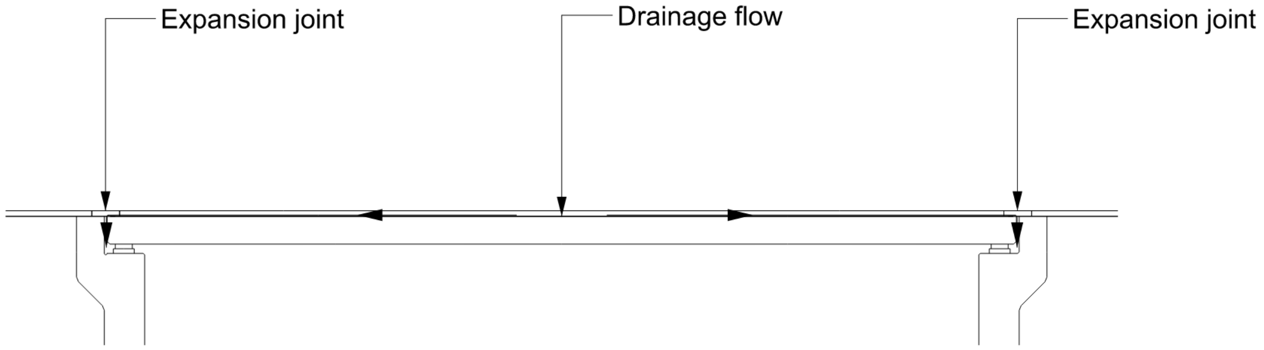


Figure A.13 Schematic illustration for sub-surface drainage into the abutment bearing shelf

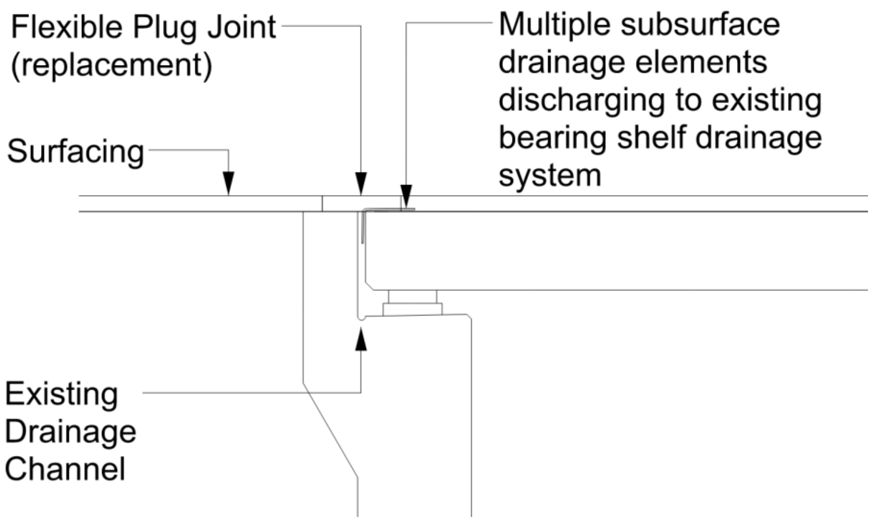


Figure A.14 Section illustration for sub-surface drainage into the abutment bearing shelf

A5 Expansion Joint Replacement and Resurfacing

A minimum length of 15m either side of the replaced expansion joint shall be re-surfaced. The surfacing material shall be produced and the layer constructed in compliance with CC-SPW-00900 with particular attention given to the transport of small quantities of bituminous material and laying temperature ensuring adequate compaction, finished layer integrity and riding quality.

TII Bridge Management shall be consulted during the design of pavement resurfacing and overlay schemes which cross TII structures.

Appendix B:

Essential Characteristics of the Product

B1 Essential Characteristics of the Product

Essential characteristics of the product to be demonstrated for the essential characteristics in the EAD [Ref 16.N] are stated in Tables B.2 to B.7 of this Appendix, for the families of expansion joints listed in Table B.1.

Table B.1 Families of expansion joints for bridges

Family	EAD document
Buried expansion joints	Not applicable
Flexible plug expansion joints	EAD 120093-00-0107 EAD 120011-00-0107
Nosing expansion joints	EAD 120109-00-0107
Mat expansion joints	EAD 120110-00-0107
Cantilever expansion joints	EAD 120111-00-0107
Supported expansion joints	EAD 120112-00-0107
Modular expansion joints	EAD 120113-00-0107
NOTE - Refer to Appendix A for examples of the different types of expansion joints.	

Table B.2 Essential characteristics of the product – Flexible asphaltic plug joints

No	Essential characteristic	EAD 120011-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Movement capacity	Clause 2.2.3	Level
4	Resistance to wear	Clause 2.2.4	Description
5	Watertightness	Clause 2.2.5	Description
6	Durability	Clause 2.2.6	Description
Basic Works Requirement 3: Hygiene, health and the environment			
7	Content, emission and/or release of dangerous substances	Clause 2.2.7	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
8	Ability to bridge gaps and levels in the running surface	Clause 2.2.8	Level
9	Skid resistance	Clause 2.2.9	Level

Table B.3a Essential characteristics of the product – Flexible plug joints with polymer as binder – assembled system

No	Essential characteristic	EAD 120011-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1.1.1	Level (reaction forces)
2	Resistance to fatigue	Clause 2.2.1.1.2	Level Description
3	Movement capacity	Clause 2.2.1.1.3	Level
4	Resistance to wear	Clause 2.2.1.1.4	Description
5	Watertightness	Clause 2.2.1.1.5	Description
Basic Works Requirement 4: Safety and accessibility in use			
6	Level differences in the running surface under unloaded conditions	Clause 2.2.1.2.1	Level
	Level differences in the running surface under loaded conditions	Clause 2.2.1.2.2	Level
9	Skid resistance	Clause 2.2.1.3	Level

Table B.3b Essential characteristics of the product – Flexible plug joints with polymer as binder – components

No	Essential characteristic	EAD 120011-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Hardness Shore A	Clause 2.2.2.1.1	Level
2	Tensile Stress	Clause 2.2.2.1.2	Level
3	Elongation at tensile stress	Clause 2.2.2.1.3	Level
4	Bond strength to support	Clause 2.2.2.1.4	Level
5	Durability	Clause 2.2.2.1.5	
	Resistance against chemicals (petrol, diesel, de-icing salt, alkali)	Clause 2.2.2.1.5.1	Description
	Ageing resulting from accelerating temperature	Clause 2.2.2.1.5.2	Description
	Ageing resulting from UV radiation and weathering	Clause 2.2.2.1.5.3	Description
	Ageing resulting from ozone	Clause 2.2.2.1.5.4	Description
	Resistance against freeze thaw including de-icing salts	Clause 2.2.2.1.5.5	Description
Basic Works Requirement 4: Safety and accessibility in use			
6	Reaction to fire	Clause 2.2.2.1.6	Class

Table B.3 Essential characteristics of the product – Nosing expansion joints

No	Essential characteristic	EAD 120109-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Watertightness	Clause 2.2.6	Description
7	Durability	Clause 2.2.7	Description
Basic Works Requirement 3: Hygiene, health and the environment			
8	Content, emission and/or release of dangerous substances	Clause 2.2.8	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
9	Ability to bridge gaps and levels in the running surface	Clause 2.2.9	Level
10	Skid resistance	Clause 2.2.10	Level
11	Drainage capacity	Clause 2.2.11	Level Description

Table B.4 Essential characteristics of the product – Mat expansion joints

No	Essential characteristic	EAD 120110-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Resistance to wear	Clause 2.2.6	Description Level (abrasion)
7	Watertightness	Clause 2.2.7	Description
8	Durability	Clause 2.2.8	Description
Basic Works Requirement 3: Hygiene, health and the environment			
9	Content, emission and/or release of dangerous substances	Clause 2.2.9	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
10	Ability to bridge gaps and levels in the running surface	Clause 2.2.10	Level

No	Essential characteristic	EAD 120110-00-0107 paragraph on assessment method	Declaration of performance requirement
11	Skid resistance	Clause 2.2.11	Level
12	Drainage capacity	Clause 2.2.12	Level Description

Table B.5 Essential characteristics of the product – Cantilever expansion joints

No	Essential characteristic	EAD 120111-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Watertightness	Clause 2.2.6	Description
7	Durability	Clause 2.2.7	Description

No	Essential characteristic	EAD 120111-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 3: Hygiene, health and the environment			
8	Content, emission and/or release of dangerous substances	Clause 2.2.8	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
9	Ability to bridge gaps and levels in the running surface	Clause 2.2.9	Level
10	Skid resistance	Clause 2.2.10	Level
11	Drainage capacity	Clause 2.2.11	Level Description

Table B.6 Essential characteristics of the product – Supported expansion joints

No	Essential characteristic	EAD 120112-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level

No	Essential characteristic	EAD 120112-00-0107 paragraph on assessment method	Declaration of performance requirement
5	Cleanability	Clause 2.2.5	Description
6	Resistance to wear	Clause 2.2.6	Description
7	Watertightness	Clause 2.2.7	Description
8	Durability	Clause 2.2.8	Description
Basic Works Requirement 3: Hygiene, health and the environment			
9	Content, emission and/or release of dangerous substances	Clause 2.2.9	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
10	Ability to bridge gaps and levels in the running surface	Clause 2.2.10	Level
11	Skid resistance	Clause 2.2.11	Level
12	Drainage capacity	Clause 2.2.12	Level Description

Table B.7 Essential characteristics of the product – Modular expansion joints

No	Essential characteristic	EAD 120113-00-0107 paragraph on assessment method	Declaration of performance requirement
Basic Works Requirement 1: Mechanical resistance and stability			
1	Mechanical resistance	Clause 2.2.1	Description
2	Resistance to fatigue	Clause 2.2.2	Description
3	Seismic behaviour	Clause 2.2.3	Description Level
4	Movement capacity	Clause 2.2.4	Level
5	Cleanability	Clause 2.2.5	Description
6	Resistance to wear	Clause 2.2.6	Description
7	Watertightness	Clause 2.2.7	Description
8	Durability	Clause 2.2.8	Description
Basic Works Requirement 3: Hygiene, health and the environment			
9	Content, emission and/or release of dangerous substances	Clause 2.2.9	Level Description
Basic Works Requirement 4: Safety and accessibility in use			
10	Ability to bridge gaps and levels in the running surface	Clause 2.2.10	Level
11	Skid resistance	Clause 2.2.11	Level

No	Essential characteristic	EAD 120113-00-0107 paragraph on assessment method	Declaration of performance requirement
12	Drainage capacity	Clause 2.2.12	Level

Appendix C:

Installation Guidance

C1 Installation Procedures for Expansion Joints

Typical installation procedures for a selection of expansion joints illustrated in this appendix, namely:

Figure C.1 - saw cut detail;

Figure C.2 - joints fixed to the deck by bond or bolts/resin anchored studs;

Figure C.3 - joints fixed to the deck using cast-in reinforcing bars or studs;

Figure C.4 – joints fixed to the deck using nosing mortar.

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.

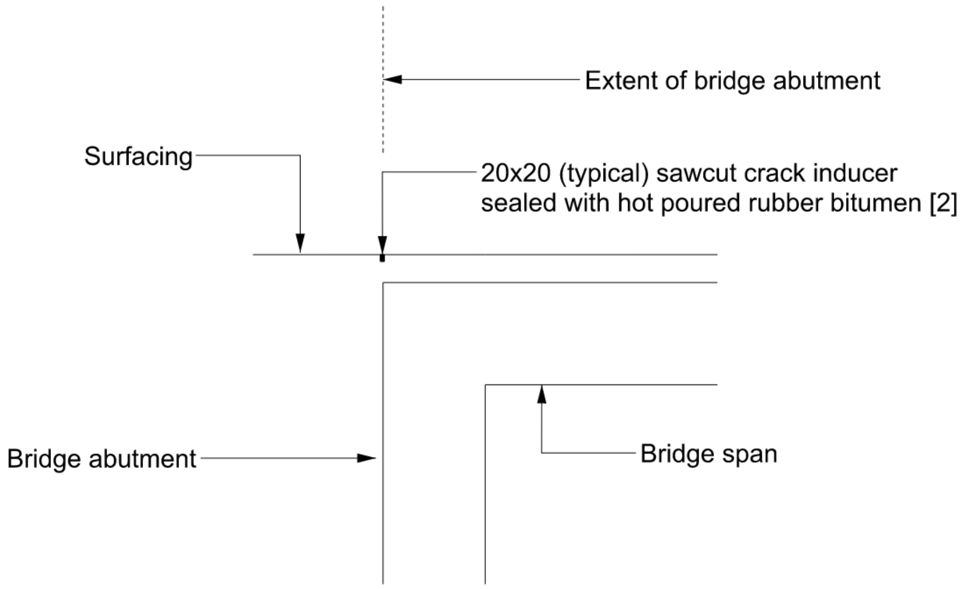


Figure C.1 Typical saw cut detail for short & medium length integral bridges [1]

NOTE 1. Saw cut joints need to be aligned with an appropriate skew and position for the bridge movement.

NOTE 2. The movement of an integral bridge is accommodated by a jointless transition between the structure and the approach roads. The design of the pavement (and underlying support elements) shall be such that it can accommodate the design movements without excessive deformations or cracking. The use of a saw cut crack inducer is a typical detail used for short and medium length integral bridges. For longer length integral bridges, the use a system of selected bituminous materials is necessary to accommodate the movements, and the use of a sawcut crack inducer is not appropriate.

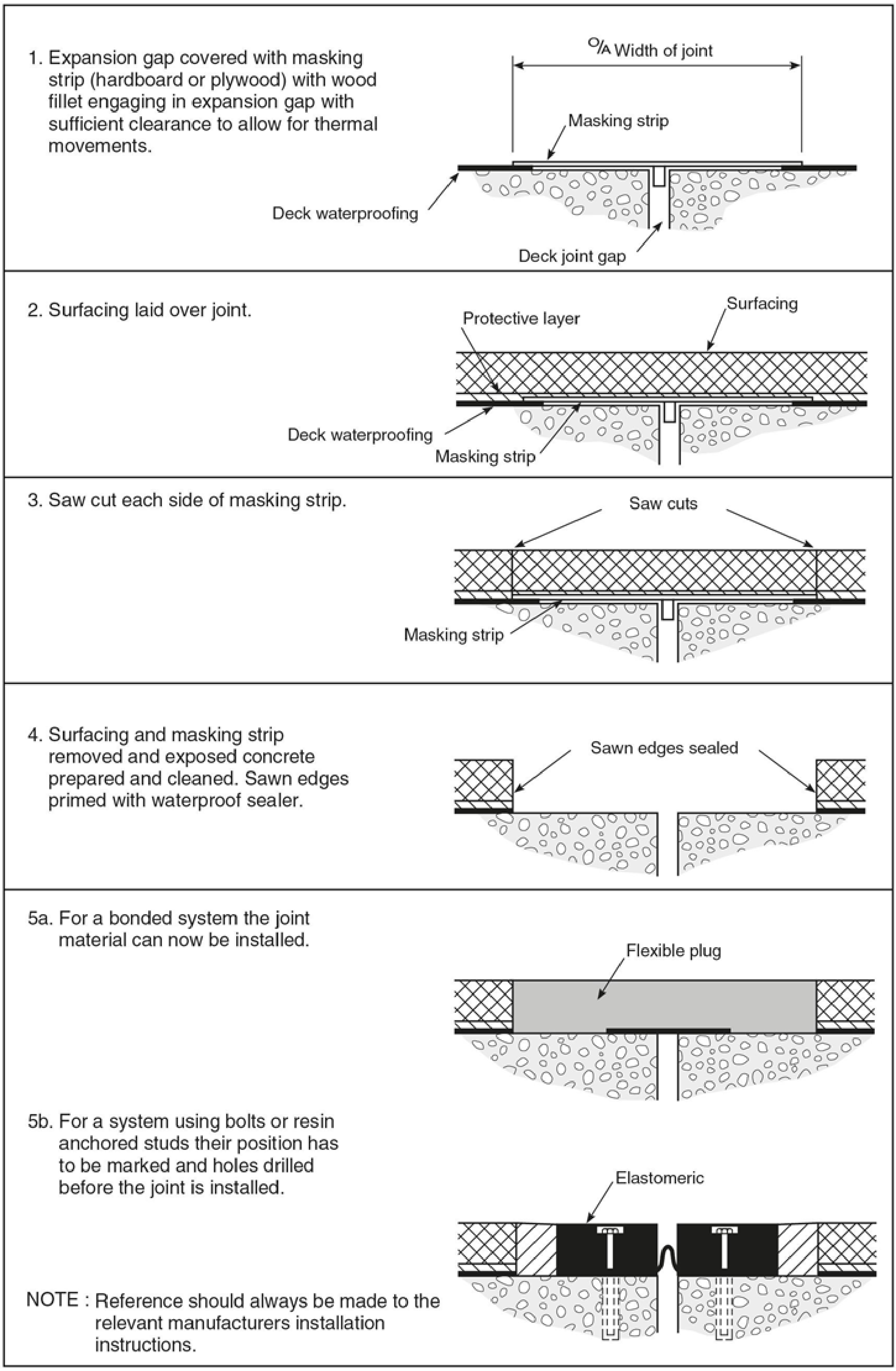


Figure C.2 Typical installation procedure for joints fixed to deck using a.) bond or b.) bolts or resin-anchored studs (Source Ref 1.I)

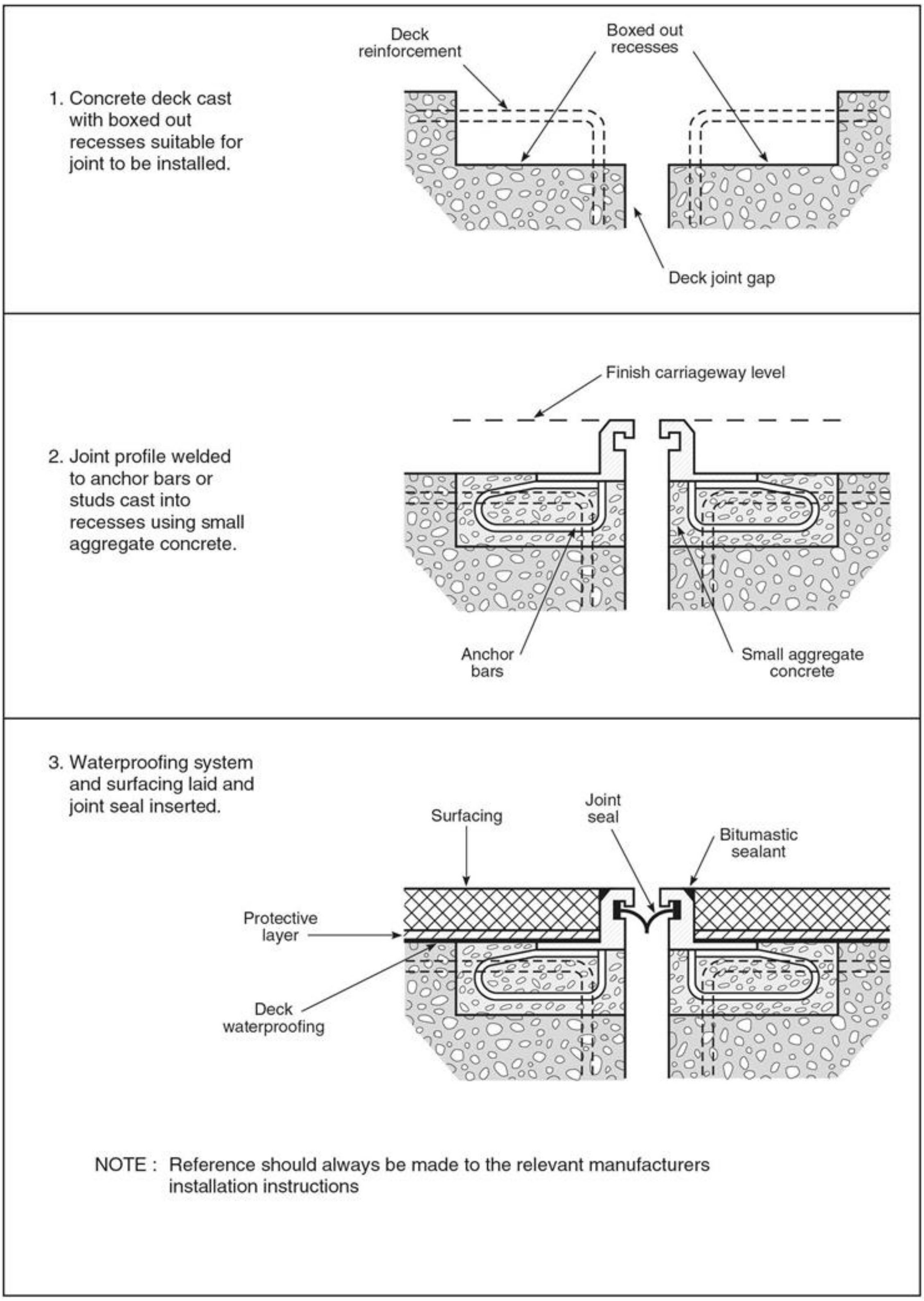


Figure C.3 Typical installation procedure for joints fixed to deck using cast-in anchor bars or studs (single element modular joint shown) (Source Ref 1.I)

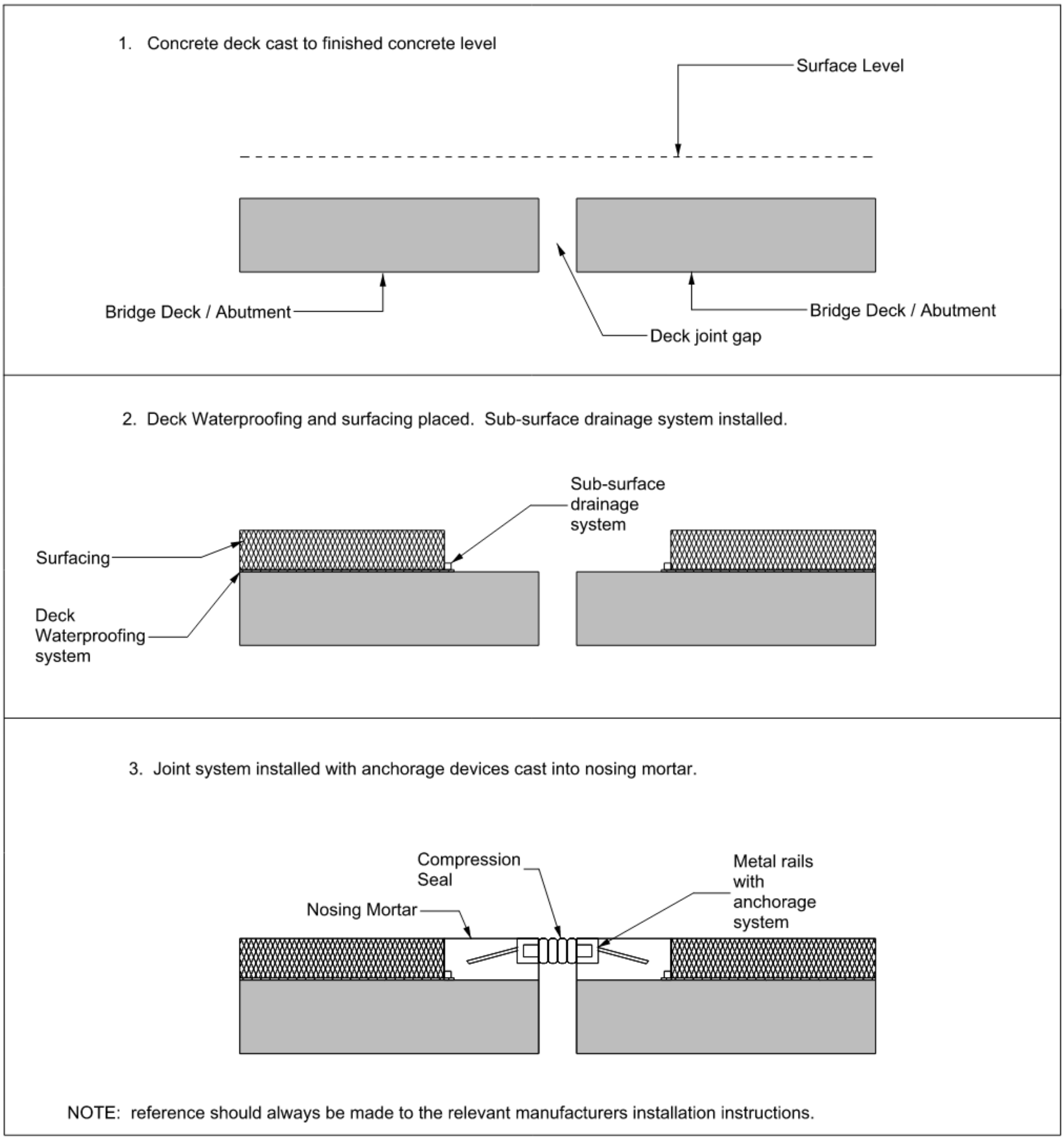


Figure C.4 Typical installation procedure for surface mounted joint attached to deck using nosing mortar (single element modular joint shown)

Appendix D:

Typical Defects in Multi-Element Modular Expansion Joints and other Joint Types

D1 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.

D2 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 road 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 road authority. The manner of the failure of these joints has the potential to cause considerable safety hazard to the public.

D2.1 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 D.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.

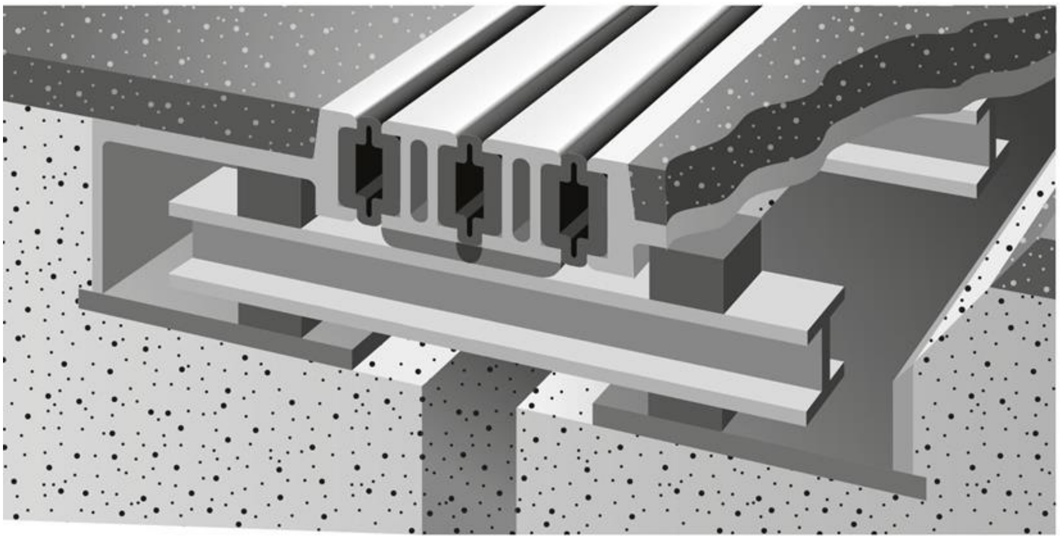


Figure D.1 Typical arrangement of a multi-element modular expansion joint (Source Ref 1.I)

D2.2 Examples of Defects Discovered

On one viaduct, the failure of one of the joint rails (Figure D.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 D.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 (Ref 1.I)

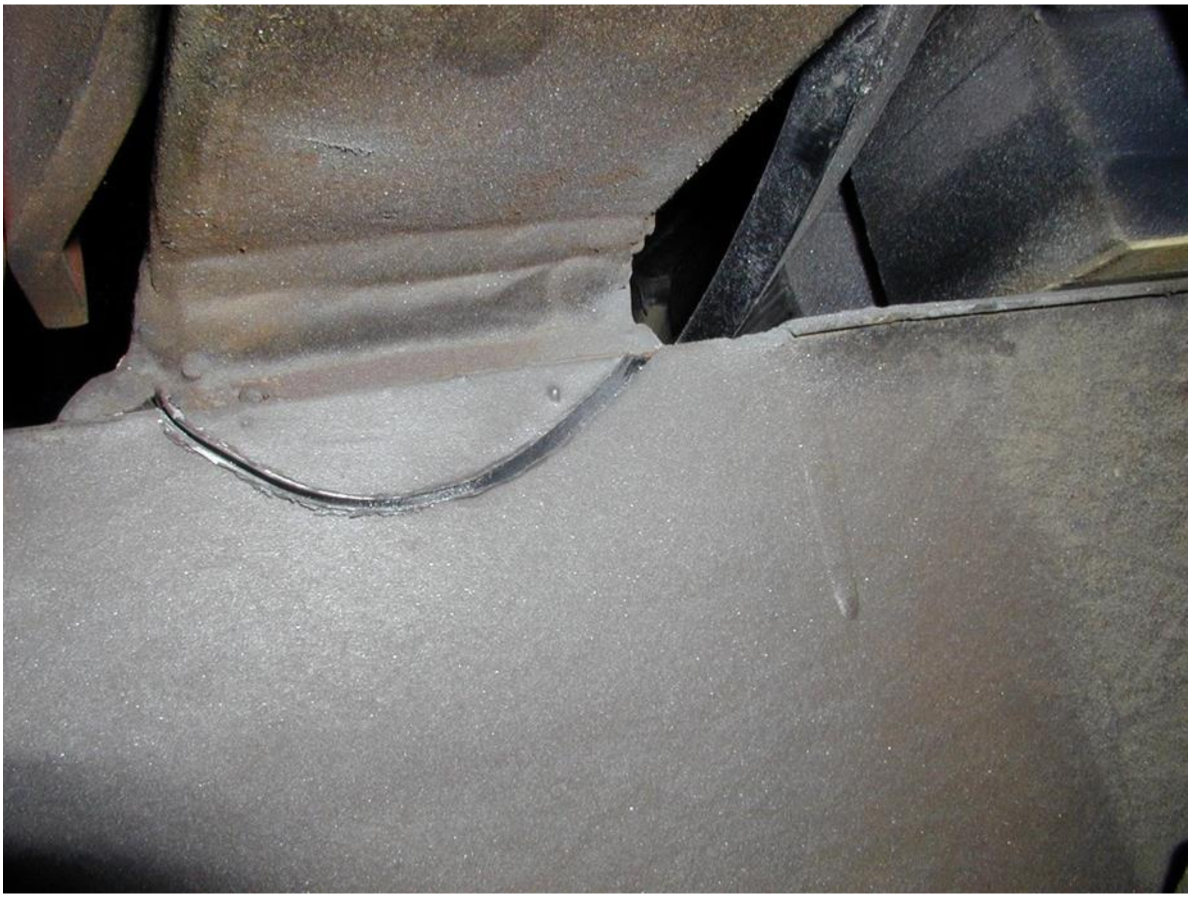
A full internal inspection of the abutment was arranged, which revealed extensive damage to the joints, with loss of components and failed bearings at the edge of lane 2 and the offside verge.

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 (Photograph 1 to Photograph 9) 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.



Photograph 1 Cable-stayed bridge (composite steel-concrete deck) Built 1991 - Fracture in the support joist immediately below the welded connection to the rail (Source Ref 1.I)

Photograph 2 Cable-stayed bridge (composite steel-concrete deck) Built 1991 - Rust staining from expansion joint over pier (Seal replacement stopped water ingress, circa 2007) (Source Ref 1.I)

Photograph 3 Cable-stayed bridge (Composite steel-concrete deck) Built 1991 - Corrosion to expansion joint sliding plates over pier, circa 2007 (Source Ref 1.I)

Photograph 4 Viaduct (Pre-cast pre-stressed concrete) Built 1976- Failure of joint footway. Seal failed between rails on carriageway (Source Ref 1.I)

Photograph 5 Cable-stayed Bridge (composite steel-concrete deck). Built 1991 - Trimmer beam support steelwork corroded. (Source Ref 1.I)

Photograph 6 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. (Source Ref 1.I)

Photograph 7 Viaduct (in-situ pre-stressed concrete). Built 1990 - Corrosion to rails and debris in seals (Source Ref 1.I)

Photograph 8 Bunratty: Modular expansion joint with cracked nosing and delaminated nosing material around the helical reinforcement. The rail weld has failed. There is a crack between the nosing material and the pavement, and cracks in the pavement itself.

Photograph 9 Sliverspings; Modular expansion joint with failed nosing, exposed rail helical reinforcement and damaged surfacing adjacent to nosing. Failure due to excessive wear from heavy vehicles turning directly on the joint.

D3 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 2.I], 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.

D4 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. The contents of a typical management plan should consider the following aspects.

a) Joint Type

- Identify type of joint – and ensure that the drawings are provided are accurate and available to the maintaining agent
- Instructions for inspection and maintenance are provided. (and are sufficiently detailed)
- Details of joint settings and special features are included. (for example is any specialist equipment required?)
- Details identifying the manufacturer and information such as availability and lead / delivery times for replacement parts are included.

b) Procedure

- Manufacturer's instructions – must set out any specific requirements for inspection or maintenance.

c) Inspections

- Recommended intervals for inspections must included as part of the management plan
- Manufacturer's manual may recommend specific areas to inspect or issues to look for, these should be incorporated into the plan.
- Levels of skill and experience of the inspector are important and should include awareness of the product.
- Is there access for inspection? – Specific guidance / arrangement may be necessary and must be included as part of the plan. It may be necessary to remove seals to view or arrange for specialist equipment.
- Plan may include specific instructions as to what to look for / record, e.g. the need to record specific issues like: Spot corrosion, unusual noises, loose components, etc.

d) Maintenance

- In accordance with the manufacturer's instructions. As a minimum:
- Clean and remove debris from the joint
- Record any issues found if apparent.
- Grease in accordance with the manufacturer's instructions

e) Life expectancy

- Identify in the plan the recommended lifespan of components such as seals, and when the date when replacement of seals is anticipated
- Expected replacement dates of other components.

f) Repair strategy

- Be aware of replacement component lifespans and replacement schedules
- Consider if stocks of hard to obtain components or components with a long lead-time should be kept (for critical routes)

D5 Implementation

Provisions for inspections and maintenance are incorporated within existing standards. This standard imposes no new requirements it just highlights the importance of these and recommends that confirmation is given that these are in place.

Appendix E:

Temporary Cover Plates

E1 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.

E2 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):
   - 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.

E3 Technical Approval Certification

The design and installation of temporary cover plates (Temporary Works Type B) should be managed using formal Technical Approval procedures, as set out in DN-ST-03001 [Ref 19.N], to ensure an adequate level of scrutiny (including the agreement of an appropriate category of checking), and that a consistent approach is adopted. The Structure Category should generally be a minimum of Category 2, unless otherwise agreed with TII.

Where a sub-standard structure is being managed under AM-STR-06039 [Ref 19.N] procedures, or there are specific issues that significantly raise the risks, then a higher category of checking should be considered.

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Ionad Ghnó Gheata na Páirce,
Stráid Gheata na Páirce,
Baile Átha Cliath 8, D08 DK10, Éire

www.tii.ie

+353 (01) 646 3600

Parkgate Business Centre,
Parkgate Street,
Dublin 8, D08 DK10, Ireland

info@tii.ie

+353 (01) 646 3601