THE HIGHWAYS AGENCY BD 33/94

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT
FOR NORTHERN IRELAND

Expansion Joints for Use in Highway Bridge Decks

Summary: This Standard supersedes BD 33/88 and covers the requirements for the use of expansion joints in highway bridge decks.

REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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VOLUME 2	HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS
SECTION 3	MATERIALS AND COMPONENTS

PART 6

BD 33/94

EXPANSION JOINTS FOR USE IN HIGHWAY BRIDGE DECKS

Contents

1. INTRODUCTION

1.1 This Standard supersedes BD 33/88.

1.2 Except where a standard specified in this document implements or is technically equivalent to a Harmonised European Standard or to a European Standard adopted for use within the European Economic Area after 31 December 1985, any requirement for products or materials to comply with the specified standard shall be satisfied by compliance with

i. a relevant standard or code of practice of a national standards institution or equivalent body of any member state of the European Economic Area

or ii. a relevant international standard recognised in any member state of the European Economic Area

or iii. a relevant specification acknowledged for use as a standard by a public authority of any member state of the European Economic Area

or iv. traditional procedures of manufacture of a member state of the European Economic Area where these are the subject of a written technical description sufficiently detailed to permit assessment of the goods or materials for the use specified

or v. a European Technical Approval (ETA) issued in accordance with the Construction Products Directive 89/106/EEC (or, until procedures are available for the issue of ETAs, a specification sufficiently detailed to permit assessment) for goods or materials of an innovative nature or subject to innovative processes of manufacture and which fulfil the purpose provided for by the specified standard

provided that the proposed standard, code of practice, technical specification, technical description, or European Technical Approval provides in use levels of safety, suitability and fitness for purpose equivalent to those required by the specified standard in so far as they are not inconsistent with the "Essential Requirements" of the Construction Products Directive (89/106/EEC).

Scope

1.3 This Standard describes the loads and movements to be used for the design of bridge deck expansion joints, and the requirements for their selection, and Departmental type approval.

1.4 The associated Advice Note BA 26 (DMRB 2.3.7) gives guidance on joint selection.

Departmental Type Approval

1.5 Bridge deck expansion joints are required to have a Departmental type approval certificate before they may be installed on bridge decks constructed, improved or maintained in compliance with the Specification for Highway Works (MCHW 1). Requirements for Departmental type approval are set out in Annex A. The type approval scheme is administered by the Highways Agency on behalf of all the Overseeing Organisations.

Implementation

1.6 This Standard should be used forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. DEFINITIONS

2.1 **Deck Joint Gap** The gap between adjacent spans in a bridge deck or between a bridge deck and an abutment curtain wall. The joint gap width will vary where the joint is designed to accommodate thermal and other movements.

2.2 **Expansion Joint Gap** The continuous gap within an expansion joint system at surfacing level along the line of the joint.

2.3 **Buried 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 deck joint gap.

2.4 **Asphaltic Plug Joint** An in-situ joint comprising a band of specially formulated flexible material, which also forms the surfacing, supported over the deck joint gap by thin metal plates or other suitable components.

2.5 **Nosing** In-situ material or fabricated component to protect the adjacent edges of the surfacing at the expansion joint.

2.6 **Reinforced Elastomeric Joint** A prefabricated joint comprising an elastomer with or without bonded metal plates.

2.7 **Elastomeric in Metal Runners** A pre-fabricated joint comprising an elastomeric seal fixed between metal runners, either in a single element or multi-element form.

2.8 **Cantilever Comb or Tooth Joint** A pre-fabricated joint comprising principally mating metal comb or saw-tooth plates which bridge the deck joint gap.

2.9 **Transition Strip** A narrow strip of infill material between a prefabricated expansion joint and the adjacent cut edge of the surfacing.

2.10 **Waterproofing System** A concrete bridge deck waterproofing system which has been granted Departmental Registration in accordance with BD 47 (DMRB 2.3.4).

2.11 **Surfacing** Carriageway or footway wearing course and basecourse materials.

2.12 **Sub-surface Drainage** A system for draining water from within the surfacing.

2.13 **Working Life** Period for which it is envisaged the joint will function satisfactorily without the need for excessive maintenance.

2.14 **Effective Bridge Deck Temperature** The temperature of the bridge deck at the time of installation of the joint determined in accordance with TRRL Supplementary Report 479.

2.15 **Cover Plate** Plate forming part of an expansion joint system at surfacing level to cover the expansion joint gap.

3. GENERAL REQUIREMENTS

3.1 Expansion joints shall have good riding quality and skid resistance and shall not cause a hazard to any class of road user, including cyclists, pedestrians and animals where they have access.

3.2 Expansion joints in highway bridge decks shall be capable of sustaining the loads and movements described in the following chapters of this Standard without damage to the surfacing or the supporting structure during their working lives.

3.3 When the total horizontal movement is less than 5mm and vertical movement is less than 0.5mm, there is no need to provide an expansion joint but the waterproofing shall be detailed to accommodate any likely small movements to ensure its continuity across the deck joint gap.

3.4 Different joint systems shall not normally be combined at one end of a deck. The same joint system, seal or sealant shall continue across the full width of the deck including footway, verge, hardshoulder and central reserve.

3.5 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.

3.6 The skid resistance of an expansion joint shall be at least equal to the minimum requirement of the adjacent carriageway surfacing, during its working life.

3.7 The upper surfaces, when new, of expansion joints in footways shall have a slip resistant finish which has a skid resistance of not less than 65 under wet conditions. The finish shall have an effective life of at least 5 years and shall retain a skid resistance of not less than 45 under wet conditions throughout this period. The skid resistance of footway surfacings shall be confirmed by the portable skid resistance pendulum tester as described in the Transport and Road Research Laboratory's Road Note 27.

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

3.9 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.

3.10 The interface between the expansion joint and the deck waterproofing system shall be watertight.

3.11 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. See BA 26 (DMRB 2.3.7).

3.12 Expansion joints shall be generally installed in a straight line and where there is an expansion joint gap it shall be of a uniform width never less than 10% of the range of movement or 6mm whichever is the greater.

3.13 The maximum width of open gap in the expansion joint at carriageway level which is acceptable for motor vehicles is 65mm. Where necessary load bearing elastomeric elements shall be used to ensure that this dimension is not exceeded.

3.14 Kerb cover plates shall be provided to protect the expansion joint at the kerb line.

3.15 Where pedestrians have access, all expansion joint gaps in the footway shall be closed using either a load bearing seal or cover plate. The top surface of the load bearing seal shall be 5±2mm below the top surface of the joint.

3.16 Where cyclists have access and the expansion joint consists of toothed or comb plates with the spaces between the mating teeth generally orientated in the direction of the traffic flow, these spaces shall not exceed 150mm in length or 20mm in width. If these dimensions are exceeded then cover plates shall be provided.

4. DESIGN

Limit State Requirements

4.1 Joints designed in accordance with this Standard shall unless specified otherwise meet the following limit state requirements.

i. Serviceability Limit State.
The design shall be such that joints will function correctly without the need for excessive maintenance during their working lives.

ii. Ultimate Limit State
The joint and its installation shall be capable of withstanding the ultimate design loads and the movement range given in this Standard ie $R^* \geq S^*$, where R* is the design resistance and S* is the design load effect.

Design Values

4.2 The loads and movements given in this Standard shall be used to derive the design load effects for each limit state. Various combinations of movements and loads shall be considered to obtain the most severe effect on the joint. In addition the joints shall be capable of meeting the requirements of Clause 5.4.8.1 of the composite version of BS 5400 Part 2, as implemented by BD 37 (DMRB 1.3) without structural damage occurring.

Design Loads and Movements

4.3 The design loads Q* shall be determined from the nominal loads specified in Chapter 5 by multiplying by the appropriate value of the partial load factor γ_{fL} also as specified in Chapter 5. The design movements shall be determined from the nominal movements specified in Chapter 6 multiplied by the appropriate value of γ_{fL} also specified in Chapter 6.

Design Load Effects

4.4 The design load effect S* shall be determined by multiplying the effects obtained by applying the design loads and movements by γ_{f3}. The values of γ_{f3} shall be taken as 1.0 for the serviceability limit state and 1.1 for the ultimate limit state.

Design Resistance

4.5 The design of steel elements, and reinforced concrete components shall be in accordance with BS 5400 Parts 3 and 4 as implemented by BD 13 (DMRB 1.3) and BD 24 (DMRB 1.3.1) respectively. The design resistance shall be calculated from the expression

$$R* = function\ \frac{(f_k)}{(\gamma_m)}$$

where f_k is the characteristic (or nominal) strength of the material and γ_m is the appropriate partial material factor. Values of f_k and γ_m shall be obtained from BS 5400 Parts 3 and 4 as appropriate.

Elastomeric Joints and Elements

4.6 Elastomeric joints and elastomeric elements shall be designed for the serviceability limit state only using the appropriate values of γ_{fL} and with $\gamma_{f3} = 1.0$.

Fatigue

4.7 Where any components of the joint such as anchor bolts are subject to fluctuating traffic loads their fatigue lives shall be calculated in accordance with BS 5400 Part 10 as implemented by BD 9 (DMRB 1.3).

5. LOADS

General

5.1 This section specifies nominal loads and values of γ_{fL} to be taken into account in the design of the joint and its constituent elements, including the anchorage arrangements but excluding the seal.

Vertical

5.2 The nominal load shall be taken either as a single wheel load of 100kN or a 200kN axle with a 1.8m track. The load from each wheel shall be uniformly distributed over a circular area assuming an effective pressure of 1.1 N/mm^2 (ie 340mm diameter). It shall be applied separately to either edge of the joint to determine which gives the more severe effect.

Horizontal

5.3 The nominal traffic load shall be taken as a uniformly distributed load of 80 kN/m run of joint, acting at right angles to the joint at carriageway level. This shall be combined with any loads that may result from strain of the joint filler or seal over the nominal range of movements in accordance with Chapter 6.

5.4 Values of γ_{fL}

	Wheel Loads	Horizontal Load
Ultimate Limit State	1.50	1.25
Servicability Limit State	1.20	1.00

Dispersal of Loads

5.5 Where the joint or joint element is sufficiently stiff the wheel loads may be spread along a length of joint up to a maximum length of 1000mm.

6. MOVEMENTS

General

6.1 This chapter describes the various types of movements that shall be taken into consideration including the relative vertical and horizontal movements between two sides of an expansion joint, arising from the passage of a live load along the bridge. Nominal values of movement that can occur simultaneously shall be combined to determine the most severe effect on the joint in question.

Values of γ_{fL}

6.2 The value of γ_{fL} shall be taken as 1.0 for both the serviceability and the ultimate limit state.

Temperature Movement

6.3 The range of longitudinal movement due to changes in temperature shall be calculated in accordance with the composite version of BS 5400 Part 2 as implemented by BD 37 (DMRB 1.3).

Creep and Shrinkage

6.4 Irreversible movements due to creep and shrinkage of concrete shall be calculated in accordance with BS 5400 Parts 4 and 5 as implemented by BD 24 (DMRB 1.3.1) and BD 16 (DMRB 1.3) respectively (see also para 9.1).

Lateral Movement

6.5 In wide, curved or skew bridges transverse movement of the deck shall be considered in association with longitudinal movement and joints designed accordingly.

Settlement

6.6 Any longitudinal and vertical movement at joints arising from the predicted differential settlement of the bridge supports shall be taken into account. If movement due to mining subsidence is expected the joint shall be designed so that it can be released or replaced with a temporary joint and reinstated after the subsidence wave has passed.

7. JOINT TYPE OPTIONS

General

7.1 The installation of an appropriate type of joint is primarily determined by the total design range of movement expected for the serviceability limit state and more than one type of joint may be suitable for a particular range of movement. This movement shall not exceed the maximum value given in Table 1 for the type of joint in question.

Traffic Noise

7.2 Where the installation is adjacent to residential property special consideration shall be given to the noise generated by traffic crossing the joint, since some joints generate much more noise than others.

Details of Various Types of Joint

7.3 Typical details and sketches of joint referred to in Table 1 are given in BA 26 (DMRB 2.3.7).

TABLE 1

(Limiting Joint Movement at SLS)

JOINT TYPE	TOTAL ACCEPTABLE LONGITUDINAL MOVEMENT		MAXIMUM ACCEPTABLE VERTICAL MOVEMENT BETWEEN TWO SIDES OF JOINT mm
	Minimum mm	Maximum mm	
1. Buried joint under continuous surfacing	5	20	1.3
2. Asphaltic Plug joint	5	40	3
3. Nosing joint with poured sealant	5	12	3
4. Nosing with preformed compression seal	5	40	3
5. Reinforced Elastometric	5	*	3
6. Elastomeric in metal runners	5	*	3
7. Cantilever comb or tooth joint	25	*	3

(i) the minimum of the range is given to indicate when the type of joint may not be economical.

* Maximum value varies according to manufacturer or type.

8. DRAINAGE

General

8.1 The provision of road gullies on the uphill side of expansion joints is required in order to collect as much surface water as possible before it reaches the joint. When Porous Asphalt surfacing is specified road and kerb gullies are essential and the detailing around the joint need to be considered at the design stage. See BA57 (DMRB 1.3.7).

8.2 An effective drainage system shall be provided immediately beneath the expansion joint with adequate access for its inspection and maintenance. Water from the drainage system shall be discharged away from the structure into a suitable road drainage system or soakaway.

Sub-surface Drainage

8.2 Where the presence of a joint will impede the movement of water within the basecourse or wearing course materials, sub-surface drainage shall also be provided and is essential when Porous Asphalt surfacing is specified. Examples are shown in BA 26 (DMRB 2.3.7).

9. REFERENCES

1. Design Manual for Roads and Bridges (DMRB)

Volume 1: Section 3 General Design

BD 13 Design of Steel Bridges. Use of BS 5400: Part 3 (DMRB 1.3)

BD 37 Loads for Highway Bridges (DMRB 1.3)

BD 16 Design of Composite Bridges. Use of BS 5400: Part 5 (DMRB 1.3)

BD 24 Design of Concrete Bridges. Use of BS 5400: Part 4 (DMRB 1.3.1)

BD 9 Implementation of BS 5400: Part 10. Code of Practice for Fatigue (DMRB 1.3).

BA 57 Design for Durability (DMRB 1.3.7).

Volume 2: Section 3 Materials and Components

BA 26 Expansion Joints for Use in Highway Bridge Decks (DMRB 2.3.7)

BD 47 Waterproofing and Surfacing of Concrete Bridge Decks (DMRB 2.3.4)

2. Manual of Contract Documents for Highway Works (MCHW)

Volume 1: Specification for Highway Works (MCHW 1)

3. SR 479. Bridge temperature for setting bearings and expansion joints. M Emerson TRRL.

4. Road Note 27. Instructions for using the portable skid-resistance tester. TRRL

5. BS 812. Testing of Aggregates:
Parts 1, 2 and 3: 1975
Parts 101 and 102: 1984
Part 103.1: 1985

10. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:-

Chief Highway Engineer
The Highways Agency
St Christopher House
Southwark Street
London SE1 OTE

T A ROCHESTER
Chief Highway Engineer

The Deputy Chief Engineer
The Scottish Office Industry Department
Roads Directorate
New St Andrew's House
Edinburgh EH1 3TG

J INNES
Deputy Chief Engineer

The Director of Highways
Welsh Office
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Belfast BT2 8GB

W J McCOUBREY
Chief Engineer - Roads Service

REQUIREMENTS FOR DEPARTMENTAL TYPE APPROVAL OF BRIDGE DECK EXPANSION JOINTS

A1 **General**

For all types of expansion joint the manufacturer or supplier shall submit in duplicate to the Highways Agency (HA) full details of the expansion joint system including installation procedures and where relevant the corrosion protection system. Where the system incorporate a transition strip or is of the Asphaltic Plug or In-situ Nosing type, full details of the formulation for the expansion joint materials, including primer and aggregate shall also be submitted under "Commercial in Confidence". The following are relevant requirements for specific joint types.

A1.1 **Asphaltic Plug, In-situ Nosings and Transition Strips**

The manufacturer or supplier shall submit to the HA the following information about the aggregate specified in the formulation:

i. The classification, in accordance with BS 812: Part 1: 1975, Parts 101 and 102:1984 and Part 103.1:1985, and source of the aggregate. These shall not be changed without the agreement of the HA.

ii. The all-in aggregate grading curve determined and presented as a cumulative percentage passing in accordance with BS 812:Part 1:1975, Parts 101 and 102:1984 and Part 103.1:1985. The grading curve of the aggregates supplied shall not vary from the grading curve submitted by more than ± 10% of the value for any given sieve size.

iii. The water absorption, impact, crushing and abrasion properties of the aggregates determined in accordance with BS 812: Parts 1 and 2: 1975.

A1.2. **Asphaltic Plug Joints**

The manufacturer or supplier shall arrange for testing of the binder material, for the physical properties shown in Table 1, to be carried out by a testing laboratory accredited in accordance with BS 7502 by the National Measurement Accreditation Service (NAMAS) for such tests, or by a laboratory in a member state of the European Economic Area which can offer suitable and satisfactory evidence of technical and professional competence and independence for the tests concerned, and forward the results to the HA. Testing and supply of information to the HA shall all be at the manufacturer's or supplier's expense. The information will be retained by the HA in the strictest confidence and constituent materials shall not be subsequently changed without the agreement of the Overseeing Organisation.

A1.3 **In-situ Nosings and Transition Strips**

The manufacturer or supplier shall arrange for testing of the hardener and resin composition, including spectrographic analysis, by a testing laboratory accredited in accordance with BS 7502 by the National Measurement Accreditation Service (NAMAS) for such tests, or by a laboratory in a member state of the European Economic Area which can offer suitable and satisfactory evidence of technical and professional competence and independence for the tests concerned, and forward the results to the HA. The tests and criteria shall be as in Table A2. All testing and supply of information shall be at the manufacturer's or supplier's expense.

A.1.4 **Testing Laboratories in Other Member States**

Where tests are carried out in other member states the requirements for laboratories given in clauses A1.2 and A1.3 will be satisfied if the laboratory is accredited in a member state of the European Economic Area in accordance with the relevant parts of the EN 45000 series of standards for the tests carried out.

A2 **Field Trial**

A2.1 On satisfactory completion of the relevant requirements the manufacturer or supplier shall undertake a field trial for workmanship and performance. It will be necessary to install a complete expansion joint, using material to the formulation submitted in accordance with paragraph A1, on a bridge carrying not less than 20,000 vehicles per day on a single carriageway of a dual two lane road or its equivalent. However an equivalent trial to the foregoing criteria in another member state of the European Economic Area will be acceptable. The trial period will be a minimum of 12 months, after which time the joint will be inspected for any defects. Where premature failure occurs the HA reserves the right to cancel the trial extend the trial period or call for a new trial, subject to notifying the manufacturer of supplier of the reason for doing so. There is no guarantee that a site will be immediately available for a new trial.

A2.2 The manufacturer or supplier will be required to meet the costs of both successful and unsuccessful field trials including traffic management costs.

A3. **Previous Tests and Trials**

Expansion joint systems already in the Motorway and Trunk Road Network do not need further assessment for Departmental type approval provided that they satisfy the criteria of paragraphs A1 and A2 with respect to test results and successful trials.

A4. **Departmental Type Approval Certificate**

A4.1. Subject to satisfactory compliance with the foregoing requirements the manufacturer's or supplier's expansion joint system will receive a Departmental type approval certificate

A4.2. The HA reserves the right to revoke a certificate subject to notifying the manufacturer or supplier of the reasons for doing so.

TABLE 1

TESTS FOR PHYSICAL REQUIREMENTS FOR DEPARTMENTAL TYPE APPROVAL OF MATERIALS FOR USE IN ASPHALTIC PLUG BRIDGE DECK EXPANSION JOINTS

STANDARD TEST METHOD	TYPICAL RESULT
BS 2000: Part 58: 1988 Softening Point R & B, °C	
BS 2499: 1973 Flow Resistance: @ 45°C, 5 Hours. @ 60°C, 5 Hours	
ASTM D1190 - Flow Resistance: 5 Hours/60°/75° Slope mm	
Penetration ASTM D5 @ 25°C, @ 0°C	
Specific Gravity @ 25°C	
Flash Point - COC (Clevelend Open Cup)	
Manufacturer's Recommended Application Temperature	
Manufacturer's Recommended Maximum Safe Heating Temperature	

TABLE 2

TESTS AND RELATED CRITERIA FOR DEPARTMENTAL TYPE APPROVAL OF MATERIALS FOR USE IN BRIDGE DECK EXPANSION JOINT IN SITU NOSINGS AND TRANSITION STRIPS

TEST	MATERIAL CHARACTERISTICS	TEMP. OF TEST	MORTAR FILLED OR UNFILLED	ACCEPTANCE CRITERIA Min	Max
FERFA Test No.2	Compressive strength	20°C	Filled	12N/mm^2	-
FERFA Test No.4	Tensile strength	20°C	Unfilled	3N/mm^2	-
FERFA Test No.4	Elongation	20°C	Unfilled	20%	-
FERFA Test No.5	Elastic Modulus in Tension	- 10°C	Unfilled		1600N/mm^2
* Aggregate Grading Test to BS 812				To conform with manufacturer's stated grading curves	
*Spectrographic Analysis				Components of mortar to remain unchanged	

NOTES:

1. FERFA refers to the Federation of Resin Formulators and Applicators.

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

3. The above testing information is strictly confidential.