VOLUME 2 HIGHWAY STRUCTURES DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS

SECTION 3 MATERIALS AND COMPONENTS

PART 7

BA 26/94

EXPANSION JOINTS FOR USE IN HIGHWAY BRIDGE DECKS

SUMMARY

This Advice Note gives guidance on the selection and installation of expansion joints in highway bridge decks, together with advice on the commonly used type of joint.

INTRODUCTION

1. Remove BA 26/88, which is superseded by this Advice Note, from Volume 2 Section 3 and archive as appropriate.

2. Insert BA 26/94 into Volume 2, Section 3.

3. Archive this sheet as appropriate.

Note: A new contents page is available with BD 33/94.

THE HIGHWAYS AGENCY BA 26/94

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 Advice Note gives guidance on the selection and installation of expansion joints in highway bridge decks, together with advice on the commonly used type of joint.

REGISTRATION OF AMENDMENTS

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Contents

Chapter

1. INTRODUCTION

1.1 This Advice Note provides general information on the selection and installation of various types of joint and should be read in conjunction with BD 33 (DMRB 2.3.6).

1.2 Except where a standard specified in this document implements or is technically equivalent to a Harmonised European Standard adopted for use within the European Economic Area after 31 December 1985, any requirements 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 ETA 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 document is advisory in nature and amplifies many of the principles and methods given in BD 33 (DMRB 2.3.6). It gives guidance on the selection and installation of the most commonly used bridge deck expansion joints including buried, asphaltic plug, nosing, elastomeric and cantilever type joints.

2. DESCRIPTION OF JOINTS AND FILLERS

Buried

2.1 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 1).

Asphaltic Plug

2.2 There are a number of proprietary joint systems included in this description. The joint is normally constructed in layers using a mixture of flexible material and aggregate to provide not only the homogeneous expansion medium but also the running surface at carriageway level (see figure 2).

Nosing

2.3 Materials which have been used to form in-situ nosings include: steel plates or angle sections bolted or anchored to the deck and epoxy mortar. Nosings nowadays are generally formed using cementitious, polyurethane or polyureide binders (see figure 3).

Reinforced Elastomeric

2.4 These joints are prefabricated units which span the deck joint gap and are either an elastomer or elastomer reinforced with metal plates. Different sizes are available to suit various movement ranges (see figure 4).

Elastomeric in Metal Runners

2.5 There are a number of proprietary joints which fit into this category, either in a single element or multi-element form. A single element joint consists of an elastomeric seal fitted between two metal runners, one fixed to each side of the deck joint gap (see figure 10). An example of a multi-element joint is shown in figure 5.

Cantilever Comb or Tooth Joints

2.6 These are pairs of mating toothed metal plates individually bolted to each side of the deck joint gap. They can either be a proprietary system or purpose made for a specific installation (see figure 6).

Transition Strip

2.7 Bituminous or resinous material used to fill the space between a prefabricated joint and the cut edge of the surfacing to form a smooth continuous running surface.

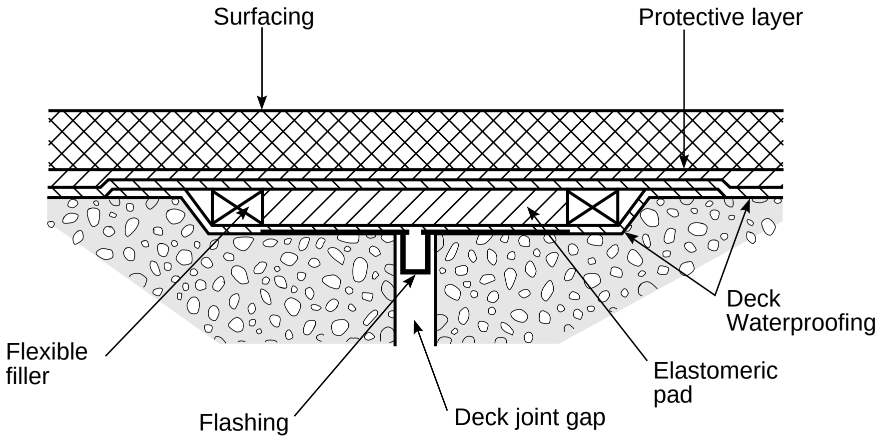


FIGURE 1 - BURIED

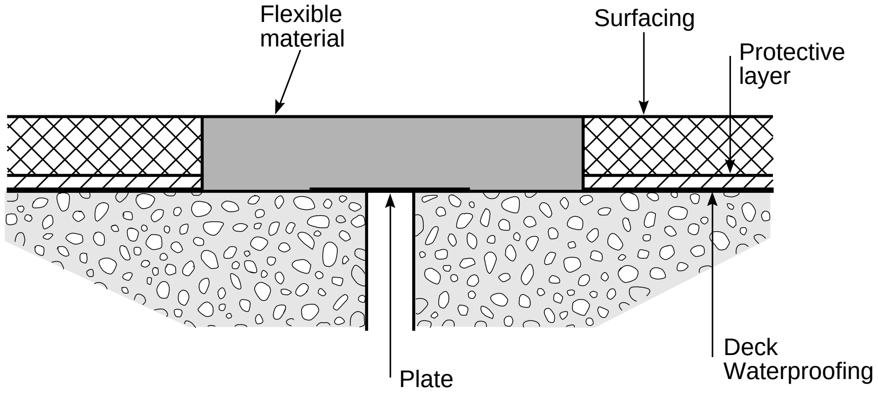


FIGURE 2 - ASPHALTIC PLUG

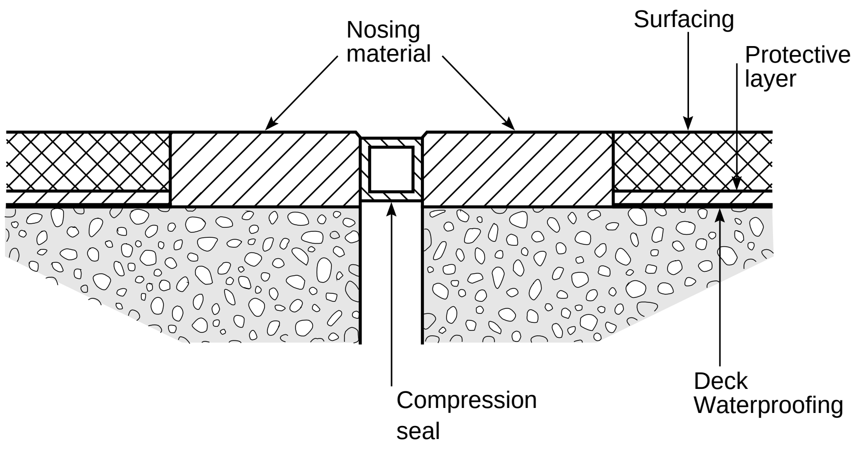


FIGURE 3 - NOSING

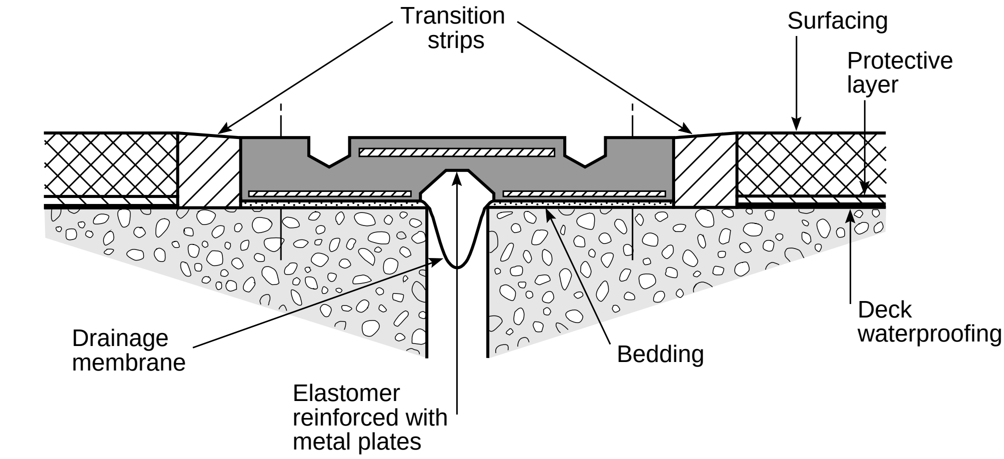


FIGURE 4 - REINFORCED ELASTOMERIC

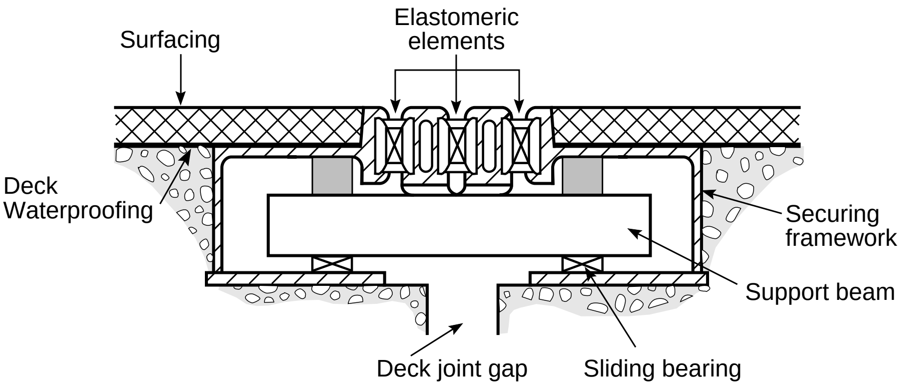


FIGURE 5 - ELASTOMERIC IN METAL RUNNERS

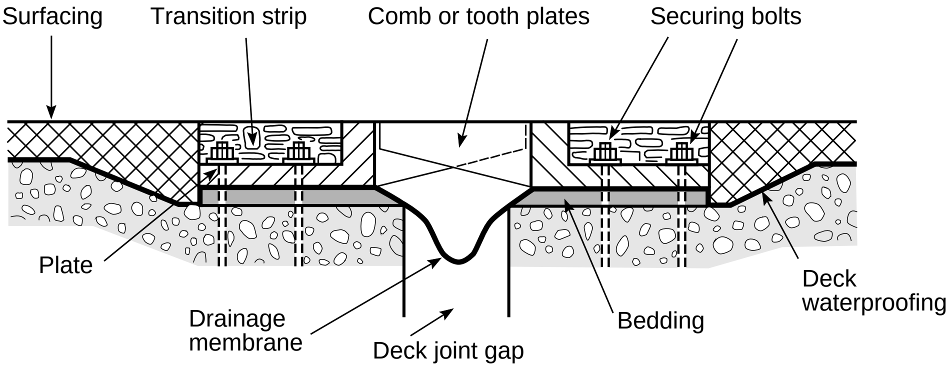


FIGURE 6 - CANTILEVER COMB OR TOOTH JOINTS

3. SEALING OF GAPS

3.1 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. Similarly grooves and gaps orientated generally in the direction of traffic flow such as can occur with comb joints or heavily skewed joints may form a hazard to cyclists and such installations may require cover plates in the carriageway or depending on the type of joint a compressible insert can be installed to reduce the gap size at surface level.

3.2 Normally 12 mm thick steel cover plates are sufficiently stiff for most carriageway applications and do not interfere with ride quality. In footways, although thinner plates could be used, it is advisable to use the same thickness in order to withstand any accidental wheel loading. The joint itself may need to be set lower in the footway to accommodate the thickness of any cover plate needed.

3.3 Where compression seals, sealant and filler board materials are used their compressibility may transmit significant forces across the gap. The compressibilty of the material used in this situation should therefore be taken into account at the design stage.

4. JOINT TYPE OPTIONS

General

4.1 Joints should be installed which will accommodate all the vertical and horizontal movement likely to be encountered in service. The various types of joint for different ranges of movement are shown in Table 1 in BD 33 (DMRB 2.3.6). However 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. See clause 4.4.

Transition Strips

4.2 Where a joint system requires a transition strip, the width of the strip should be kept as narrow as possible, ideally 50-100 mm wide (see figure 4) with the edge of the strip adjacent to the joint chamfered to assist in the dissipation of wheel impact loads. 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 tied into the deck.

Very Large Movements

4.3 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 the basic principles still apply.

Proprietary Joint

4.4 Guidance given in the following sub-clauses on the selection of joints is based on information obtained from site inspections, surveys and feedback from various sources. The information compiled has shown that most types of joint perform satisfactorily provided:

i. The total joint system is designed to withstand the effects of traffic loading including impact and abrasion.

ii. The total movement at the deck joint gap is within the capacity of the joint system.

iii. The joint is installed by a competent contractor familiar with the system.

Key factors affecting the choice of a joint are shown in Table 1, which has been reproduced from TRRL report LR1104.

Buried Joints

4.5 In the past various materials have been used to form buried joints eg copper lined bituminous sheeting, quarry tiles, formica or steel plates. All these materials have had varying degrees of success depending on the horizontal movements and traffic loads imposed. The principal problem where rigid plates have been used is that they are difficult to bed down properly and subsequent rocking under traffic loading has been a major cause of premature failure of the joint system.

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

Asphaltic Plug

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

In general asphaltic plug joints are now formulated to work satisfactorily in the movement range given in Table 1 of BD 33 (DMRB 2.3.6) provided the adjacent surfacing is not less than 100 mm thick, the gradients and crossfalls are not too severe and the bridge deck is not noticeably lively at the joints. It is difficult to define limits for the latter two but generally where premature failure has occurred one or both of these factors have been present.

On significant gradients the joint should be formed using a stiffer binder to reduce 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 800mm or 1m have been installed.

Where possible joints of this width should be avoided.

Nosings

4.8 Steel plates or angle sections, bolted or anchored to the deck, were at one time 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.

Reinforced Elastomeric

4.9 This joint comes in various forms from different manufacturers and is supplied in a range of sizes. It has been used for many years with a good success rate. The larger sizes of elastomeric type joints tend to create more noise than normal under traffic but 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 (see clause 4.2) and splitting or excessive wear of the rubber and subsequent exposure of the metal plates has occurred in a few cases. Failure by exposure of the metal plates has also been recorded where lateral forces have caused accelerated wear of the covering rubber, eg 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 debonded so that any relaxation over the bolt length does not result in the complete loss of tension in the bolts. Resistance to water penetration can be improved by ensuring that either the joint is manufactured and supplied in one continuous length or the units are vulcanised together on site to form one continuous length.

Elastomeric in Metal Runners

4.10 This type of joint also comes in various forms from different manufacturers, either as single or multi-element in a range of sizes. Generally the joints are cast in using formed recesses in the deck concrete. However depending on the type of joint used, fixings can be similar to those used in elastomeric joints or even bonded to the deck concrete. In consideration of the requirements of paragraph 3.13 from BD 33/94 (DMRB 2.3.6) 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.

Cantilever Comb or Tooth Joints

4.11 These joints can either be purpose made for a particular installation or be proprietary joints. 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 BD 33/94 paragraph 3.16. DMRB 2.3.6).

TABLE 1 KEY FACTORS AFFECTING JOINT PERFORMANCE

Joint Type	Movements at the joint (mm)									Traffic over joint						Joint Design	Materials Used	Condition of Substrate	Installation temperature °C			In service weathering	Detritus and corrosion	Site preparation and workmanship	Bond and anchorage
	Thermal			Dynamic						Frequency/ Lane/Hour			Axle loads (k/N)												
	Horizontal			Horizontal			Vertical																		
	0-15	15-50	50+	<0.05	0.05-0.10	>0.10	<2	2-4	>4	<10	10-50	>50	<10	10-40	>40				<10	10-15	>15				
Buried	M	H	N/A	L	M	H	L	M	H	L	M	H	L	M	H	M-H	M-H	M-H	L	M	H	M-H	L	H	M
Asphaltic Plug	L	M	N/A	L	L	L	L	L	M	L**	L**	M**	L**	L**	M**	L-M	M	M	L	L	M	L	L	M	L
Nosing (with sealant)	M	H	N/A	L	L	M	L	L	M	L	M	H	L	M	H	H	H	H	L	M	H	L-M	L-M	H	H
Reinforced Elastomeric	L*	L*	L*	L	L	M	L	L	M	M	M	H	L	L	M	M-H	L-M	M-H	L	L	L	L	M-H	H	H
Elastomeric in Metal Runners	L	L	L	L	L	L	L	L	L	L	L	M	L	L	L	M-H	M	N/A	L	L	L	L	M	M	H
Comb or Tooth Joints	L*	L*	L*	L	L	M	L	L	M	L	L	M	L	L	M	M-H	L-M	M-H	L	L	L	L	H	M	H
Transition Strip	L	L	L	L	L	M	L	L	M	L	M	H	L	M	H	M	M-H	H	L	M	H	L	L-M	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: This table is based on a similar table from TRRL Report LR1104, but has been modified and takes into account current information on joint performance

5. DRAINAGE

Seals

5.1 Where seals of the type described in BD 33 clause 3.8 (DMRB 2.3.6) are installed these should be watertight. Seals will also assist in the exclusion of grit and dirt which would otherwise find its way into the joint drainage system. An additional membrane should also be incorporated with certain joint types as shown in Figures 4 and 6.

Sub-surface Drainage

5.2 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. This may result in water leakage into the deck joint gap and hence into the adjacent concrete. To prevent this from occurring a transverse and through deck sub-surface drainage system may be provided, as illustrated in Figures 7 and 8, which illustrate some of the forms that sub-surface drainage may take. Although in-situ nosings have been illustrated the drainage details are easily adapted for different types of joint.

5.3 Fig 7 is typical of current practice in France and Germany and certain UK systems. The buried galvanised steel or aluminium slotted drain tube may be either circular or rectangular in cross section and discharge water via a suitable connection to the bridge drainage system. Transverse drainage systems should be as large as possible,located in such a manner that the flow area is not interrupted and detailed to permit jetting through of the drainage tubes.

Longitudinal drainage systems have been used, mainly with Asphaltic 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.

5.4 Fig 8 shows another detail developed in Italy. The down pipes are spaced at intervals to suit the bearing and jacking point positions. The trough is filled with surfacing which is sufficiently permeable to permit the passage of water. The pipes should be carefully positioned in order that drips from the outlets do not damage the face of adjacent concrete. Through deck drainage should be installed at the low points in the deck and 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. For advice relating to the waterproofing and drainage of bridge decks reference should be made to BA 47 (DMRB 2.3.5).

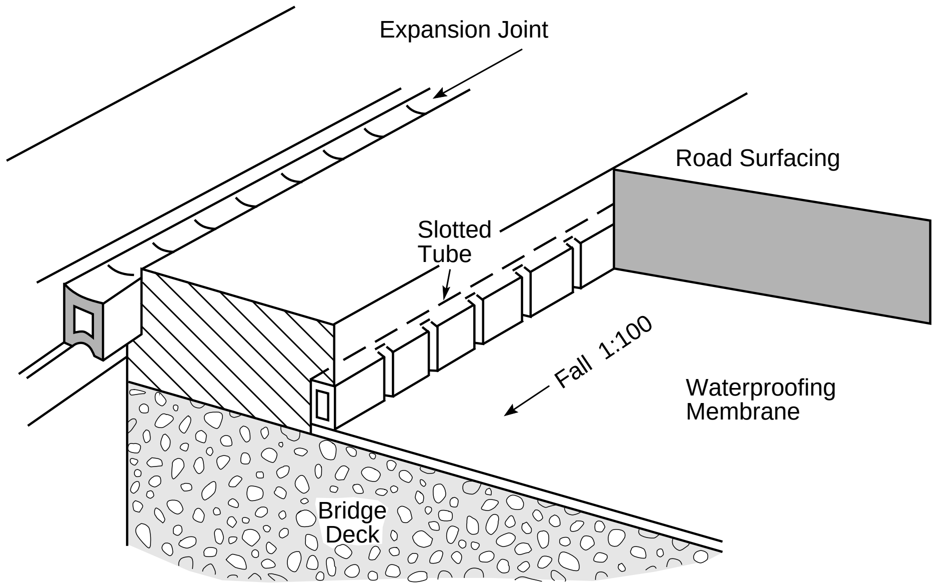


FIGURE 7

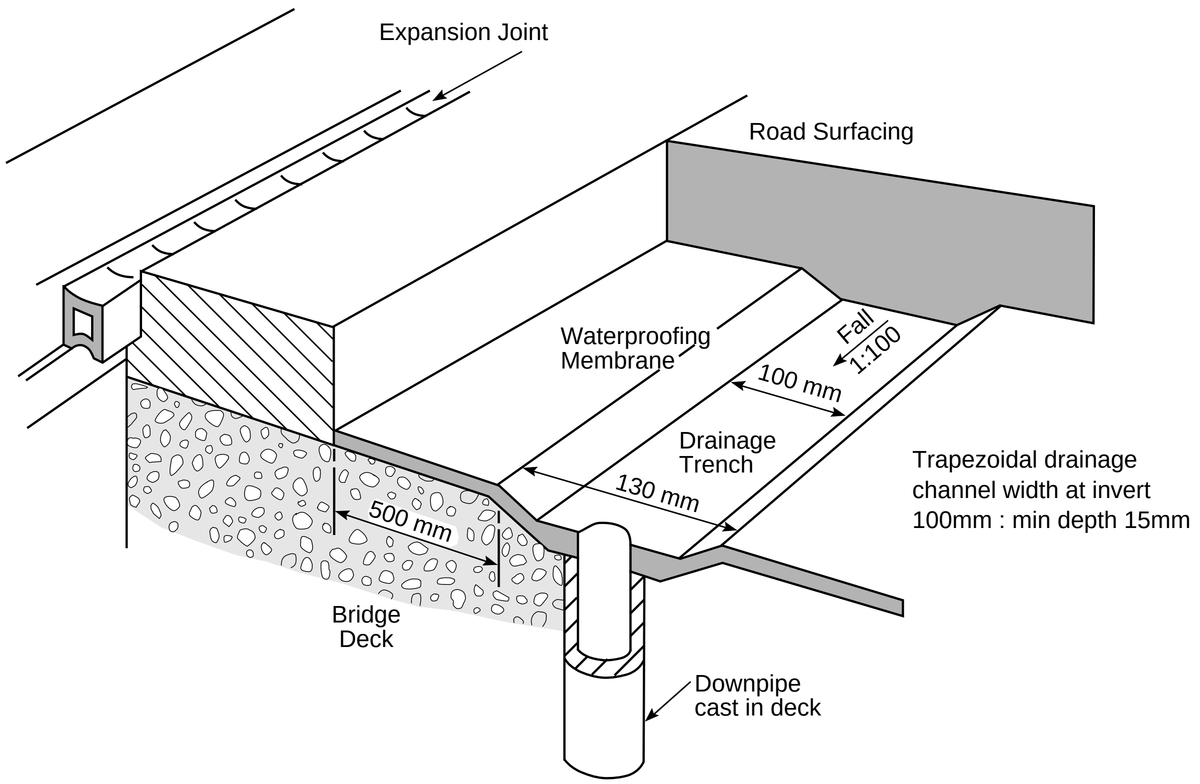


FIGURE 8

6. INSTALLATION

Fixing of Joints

6.1 Joints are fixed to the deck concrete by one of the following means:

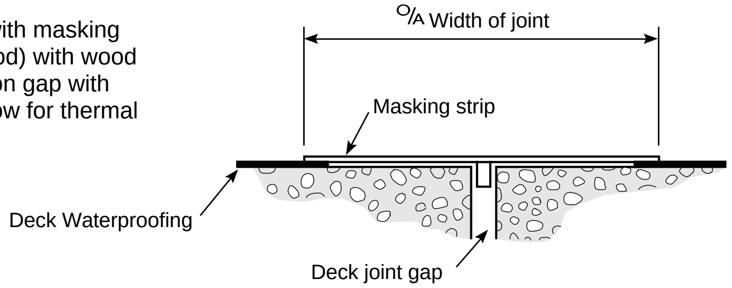
i. Bond
ii. Bolts or resin anchored studs
iii. Anchor bars.

For methods i. and ii. 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 9). It is very important that deck waterproofing is carefully detailed in the vicinity of the joint to ensure the continuity of the waterbarrier, eg either by bond or lap. For method iii. 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 15-20 mm groove is then filled with bitumastic material (see figure 10).

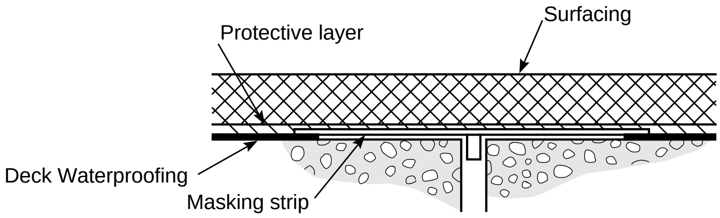
6.2 The installation procedures in clause 6.1 are general descriptions and are not intended to represent any particular type of joint system. For the procedure applicable to a specific system, reference should be made to the relevant manufacturer's installation instructions. However in all cases the requirements of BD 33 (DMRB 2.3.6) must be satisfied.

FIGURE 9 - TYPICAL INSTALLATION PROCEDURE
(i) Bond
(ii) Bolts or resin anchored studs

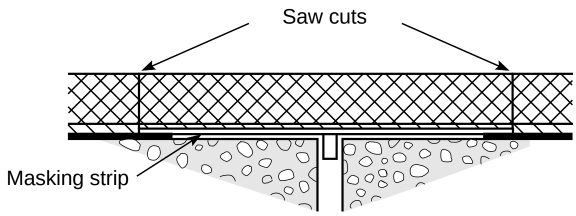
1. Expansion gap covered with masking strip (hardboard or plywood) with wood fillet engaging in expansion gap with sufficient clearance to allow for thermal movements.



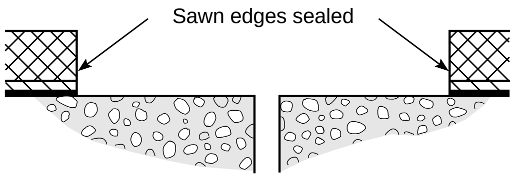
2. Surfacing laid over joint.



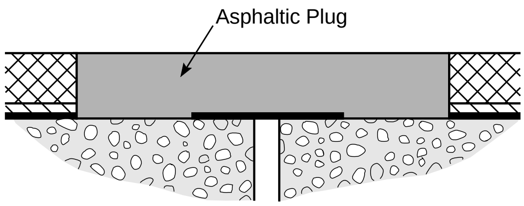
3. Saw cut each side of masking strip.



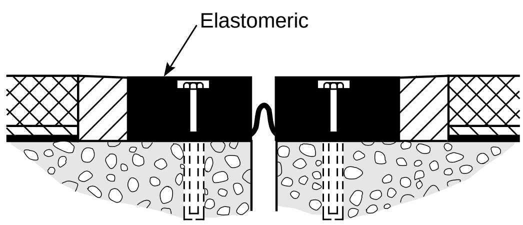
4. Surfacing and masking strip removed and exposed concrete prepared and cleaned. Sawn edges primed with waterproof sealer.



5a. For a bonded system the joint material can now be installed.

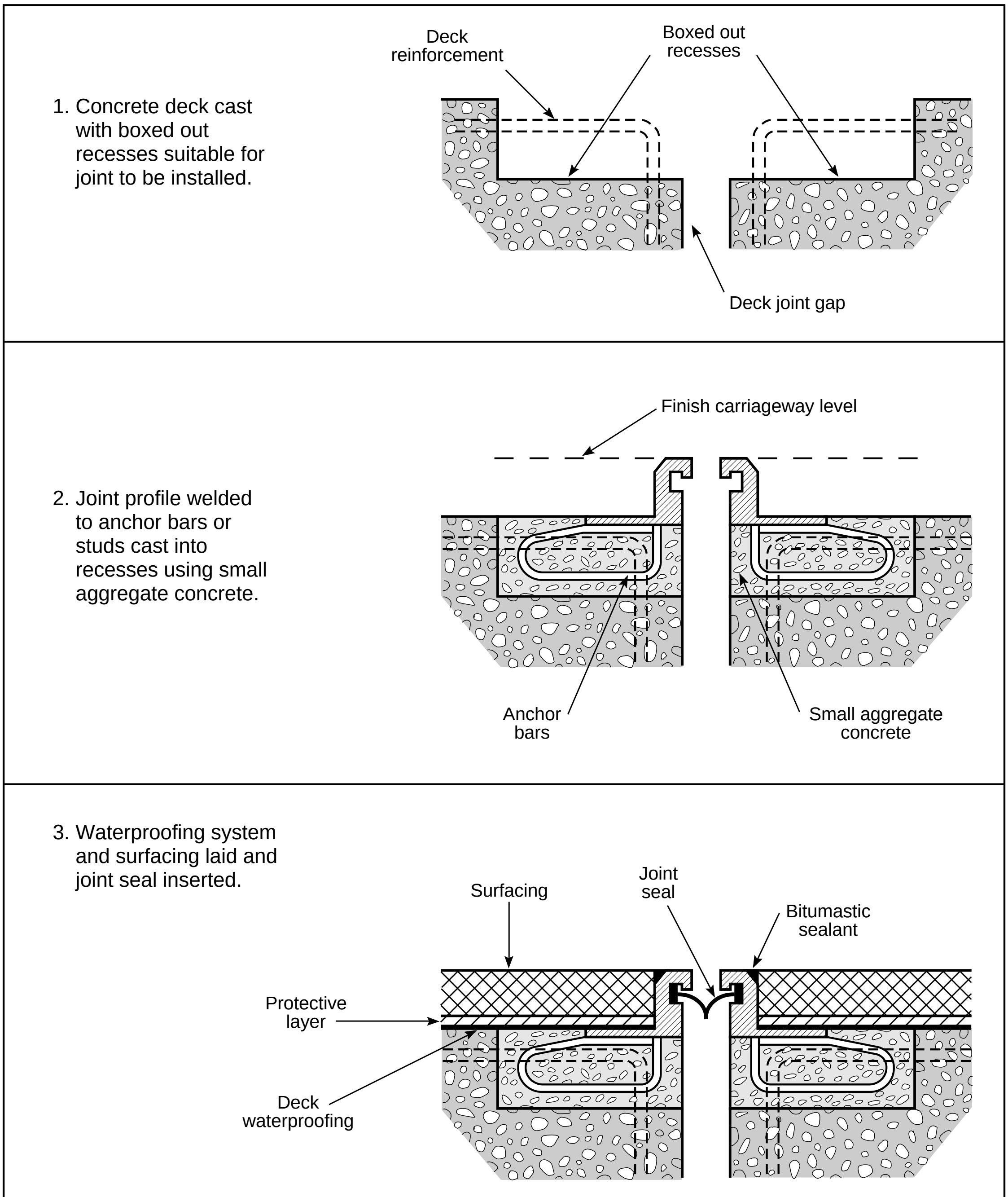


5b. For a system using bolts or resin anchored studs their position has to be marked and holes drilled before the joint is installed.



NOTE : Reference should always be made to the relevant manufacturers installation instructions.

FIGURE 10 - TYPICAL INSTALLATION PROCEDURE
(iii) Anchor bars or studs



NOTE : Reference should always be made to the relevant manufacturers installation instructions

7. INSPECTION AND MAINTENANCE

7.1 Failure of an expansion joint can create a serious hazard for traffic therefore it is strongly recommended that expansion joints are regularly inspected to ensure that they continue to operate in accordance with all the requirements of BD 33 (DMRB 2.3.6).

7.2 An expansion joint will not usually have the same length of working life as the bridge itself. Indeed many of the materials used in certain types of joint are known to have much shorter lives and such items as split compression seals or detached sealants will need replacement, asphaltic plug joints may need levelling-up and elastomeric joints may need partial replacement or resetting. These operations can usually be carried out quickly during off-peak periods of traffic flow.

7.3 It is important also that faults such as blocked drainage or silted-up gaps are detected at an early stage since water leakage containing chlorides can have very damaging effects of reinforced concrete or steel elements in the bridge structure. Silted up gaps can permit the transmission of high forces into the joint fixing system.

7.4 Replacement of expansion joints is relatively very expensive because of the substantial costs of traffic management and the indirect costs of traffic delays which are additional to the costs of merely replacing the joint. Therefore when carriageway resurfacing operations are planned, any bridge joints which are affected should be examined carefully so that if necessary they can be replaced at the same time. In some cases it may be preferable to replace joints before they have reached the end of their useful lives if the work can be combined with other maintenance activities.

8. REFERENCES

1. Design Manual for Roads and Bridges **(DMRB)**

Volume 2: Section 3 Materials and Components

BD 33 Expansion Joints for Use in Highway Bridge Decks (DMRB 2.3.6)

BA 47 Waterproofing and Surfacing of Concrete Bridge Deck (DMRB 2.3.5)

2. LR 1104. The performance in service of bridge deck expansion joints. A R Price. TRRL.

9. ENQUIRIES

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

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