



BRIDGE TECHNICAL DIRECTION BTD2008/10

BRIDGE DECK JOINTS

Background

Bridge deck joints can be very costly if not properly designed, installed and maintained.

The watertightness of deck joints is critical because when leaking water reaches bearings and lower bridge elements, corrosion and structural degradation can occur and major maintenance problems may result. Steel truss bridges and many older bridges have suffered severe damage resulting from long-term leakage of water through deck joints.

Deck joints, being at road surface level, are constantly impacted by traffic and, once damaged, are prone to further degradation and can become a traffic hazard.

The replacement or rehabilitation of deck joints invariably involves costly traffic management and personnel working under hazardous conditions, often at night. The better and the more appropriate the deck joint and its installation, the more money saved over the life of the bridge and the less the disruption to traffic.

An RTA policy document covering the selection, design, installation, assessment, maintenance, monitoring and rehabilitation of deck joints appropriate to specific bridges sites has been developed based on the results of field inspections of RTA bridges carried out since 1995/1996.

Bridge Technical Direction

RTA bridge policy document *Bridge Deck Joint Selection, Design, Installation and Maintenance – May 2008* shall apply to the selection, design, installation, assessment, maintenance, monitoring and rehabilitation of all bridge deck joints on RTA bridges and those that will become property of RTA.

This policy document incorporates relevant details and supersedes Bridge Technical Directions BPC2006/11, BPC2006/10, CBE 1998/10, CBE 1998/04, and BDI 1984/09.

References: BPC2006/11, BPC2006/10, CBE 1998/10, CBE 1998/04, BDI 1984/09

Effective date: 05/05/2008

Approved: Wije Ariyaratne
Principal Bridge Engineer

DISTRIBUTION:

All Bridge Engineering staff and Skill Hire Contractors
All registered holders of controlled copies of Bridge Engineering Standard Drawing sets
All holders of controlled copies of the Bridge Technical Direction Manual
Corporate Document Registrar (Hard Copy and Electronic)
Manager, Asset Management Technology (Electronic)
Manager, Project Management Office (Hard Copy and Electronic)

Contact: Greg Forster
Section: Bridge Policy & Specifications
Telephone no: 8837 0850
File no: 94M3917
Circular Number: BTD2008/10



BRIDGE DECK JOINT SELECTION, DESIGN, INSTALLATION AND MAINTENANCE

Based on Field Investigations

Date: May 2008

Prepared for: Major Infrastructure and Network Management Directorates
260 Elizabeth Street, Surry Hills NSW 2010

Regional Operations & Engineering Services Directorate
Engineering Technology
Bridge Engineering
Bridge Policy and Specifications
File: 4M1824

110 George Street, Parramatta NSW 2150

Tel: 02 8837 0850
Fax: 02 8837 0054
Email: Greg_Forster@rta.nsw.gov.au

Disclaimer

This policy document was prepared by a team managed by officers of the Roads & Traffic Authority of New South Wales (RTA) for RTA's purposes only, and apply only to the subject matter of this policy document. The contents of this policy document do not necessarily apply to organisations or users outside RTA other than those providing services or products to RTA or on behalf on RTA that are the subject matter of this policy document. No person should rely on the contents of this publication for any other than the stated use without first obtaining advice from a qualified professional person. Those persons applying any contents, opinions or conclusions contained in this policy document for other than RTA purposes that are the subject matter of this policy document do so at their own risk. RTA expressly disclaims all and any liability and responsibility to any person in respect of anything, and of the consequences of anything done, or omitted to be done by any person in reliance, whether wholly or partly, upon the contents of this publication.

Copyright

This work is copyright. Except as permitted by the Copyright Act 1968 (Cth), no part may be reproduced by any process, electronic or otherwise, without the RTA's prior written permission. Information from this work should not be stored electronically in any form without the RTA's prior written permission.

TABLE OF CONTENTS

I	General.....	1
	1.1 Scope	1
	1.2 Introduction.....	1
	1.3 Joint Movements.....	2
2	Types of Joints.....	3
	2.1 General.....	3
	2.2 Asphaltic Plug.....	4
	2.3 Bonded Metal-Elastomer	5
	2.4 Metal Fingers Bonded to Elastomer	6
	2.5 Cork or Hose Filled	7
	2.6 Elastomeric Compression Seal	8
	2.7 Hot Poured Sealant	9
	2.8 Cold Applied Sealant	9
	2.9 Fabricated Steel Fingerplate	10
	2.10 Modular.....	12
	2.11 Moulded Elastomer with Strip Seal	13
	2.12 Open Gap with Protection Angles.....	14
	2.13 Open Gap without Protection Angles	14
	2.14 Sliding Steel Plate.....	15
	2.15 Semi-Rigid Epoxy	16
	2.16 Strip Seal.....	17
	2.17 Saw Tooth	18
3	Joint Selection.....	19
	3.1 General	19
	3.2 Discontinued Joints.....	19
	3.2.1 Cork or Hose Filled.....	19
	3.2.2 Hot Poured Sealant	20
	3.2.3 Moulded Elastomer with Strip Seal	20
	3.2.4 Open Gap without Protection Angles.....	20
	3.2.5 Sliding Steel Plate (for Road Traffic).....	20
	3.2.6 Semi-Rigid Epoxy	20
	3.3 Joints for Use Following Site Specific Study	20
	3.3.1 Asphaltic Plug.....	20
	3.3.2 Bonded Metal-Elastomer	21
	3.3.3 Metal Fingers Bonded to Elastomer	21
	3.3.4 Open Gap with Protection Angles	21
	3.4 Joints for Continued Usage	21
	3.4.1 Elastomeric Compression Seal	21
	3.4.2 Cold Applied Sealant	22
	3.4.3 Fabricated Steel Fingerplate.....	22
	3.4.4 Modular.....	22
	3.4.5 Sliding Steel Plate (for Pedestrian Traffic)	22
	3.4.6 Strip Seal	23
	3.4.7 Saw Tooth.....	23
	3.5 Calculation of Joint Movements	23
	3.5.1 Thermal Movement	23
	3.5.2 Thermal Movement Calculator	23
	3.6 Joint Movement Range	23
4	Joint Design and Installation	25
	4.1 General	25
	4.2 Asphaltic Plug.....	26
	4.3 Bonded Metal-Elastomer	26

4.4	Metal Fingers Bonded to Elastomer	26
4.5	Elastomeric Compression Seals	26
4.6	Cold Applied Sealant	27
4.7	Fabricated Steel Fingerplates	28
4.8	Modular	29
4.9	Strip Seal	29
4.10	Other	29
5	Assessment of Joint Condition and Ratings	31
5.1	General	31
5.2	Assessment Details	31
5.3	Condition Rating	32
5.4	Performance Rating	32
6	Monitoring, Maintenance and Rehabilitation	33
6.1	General	33
6.2	Monitoring	33
6.3	Maintenance of Joints	33
	6.3.1 Asphaltic Plug	34
	6.3.2 Elastomeric Compression Seal	34
	6.3.3 Sealant	34
	6.3.4 Fingerplate	34
	6.3.5 Modular	34
	6.3.6 Strip Seal	34
6.4	Joint Rehabilitation	34
7	Summary	36

BRIDGE DECK JOINT SELECTION, DESIGN, INSTALLATION AND MAINTENANCE

I General

I.1 Scope

The intent of this RTA policy document is to provide background information on bridge deck joints used in RTA bridges and to specify a systematic approach to joint selection, design, installation, assessment, maintenance and rehabilitation.

Recent surveys of RTA bridge deck joints have identified sixteen types that have commonly been used. The use of some joint types is to be discontinued. This policy document shall be used to determine replacement alternatives for rehabilitation.

This policy document comprises seven chapters.

The first gives general information about this policy document and bridge deck joints. The second briefly introduces and describes the sixteen types of joints identified in RTA bridges from inspections conducted throughout NSW. The third lists discontinued joints, joints for use following site specific study and joints for continued general use, and provides brief reasons why the use of some types of joints is to be discontinued. This chapter also explains the calculation of joint thermal movements as the basis for selecting a joint type for rehabilitation and tabulates the permissible movement ranges of the eleven joint types that can be used into the future.

The fourth chapter reviews requirements for joint design and installation.

The fifth chapter reviews procedures for inspecting the condition of joints using inspection proformas prepared by RTA Bridge Engineering to enable collection of data for entry into the Bridge Joint Assessment (BJA) module delivered by RTA IT Applications to RTA Bridge Engineering's specifications, for the purposes of rating joint performance and condition to assist with the management of RTA's bridge assets.

The sixth chapter of this policy document specifies requirements for the monitoring of joint condition, the necessity for regular maintenance, and reasons for rehabilitating joints to arrest further joint and bridge damage. Some relevant maintenance issues are summarised on the eleven types selected for continued use.

The seventh chapter provides a brief concluding summary of this RTA policy document.

BTD2008/10 prescribes the use of this policy document for the selection, installation, assessment, maintenance and rehabilitation of bridge deck joints for RTA bridges or those bridges that will become property of RTA.

Bridge deck expansion joints are one of those items that listed on the list of RTA approved bridge components. Only approved components should be used in RTA funded projects or projects that will become property of RTA. The location of the lists of approved components can be found in Bridge Technical Direction BTD2008/11 issued for this purpose. Any component claimed to be approved but not published in a bridge technical direction can be verified by contacting the Senior Bridge Engineer (Policy and Specifications) Ph: (02) 8837 0850 Fax: (02) 8837 0054.

I.2 Introduction

Bridge deck joints allow movements to occur and prevent development of secondary stresses in bridge superstructures and substructures. Joints shall not permit unacceptable stresses to develop in the joint or other parts of the structure from restraints to traffic load effects, temperature changes, prestressing effects, concrete creep and shrinkage, foundation settlement, earth pressures, mining subsidence and earthquakes.

Transverse wind and stream flow loads are usually transmitted from the superstructure to the substructure through bearings, thrust blocks or similar. Deck joints are usually not affected by such loads.

Watertightness of bridge deck joints is emphasized by highway owners worldwide. Joints are heavily impacted by constant traffic. Once joints are damaged, they are prone to further degradation and can leak. When leaking water reaches the bearings and lower bridge elements, corrosion and structural degradation can occur and major maintenance problems may result. Steel truss bridges and many older bridges have suffered severe damage resulting from water leaking through expansion joints. Because of this, watertightness is important when assessing joint performance. Even though joints are rarely completely watertight, watertightness is encouraged and expected. Overseas highway owners often specify performance tests for verifying watertightness of joints.

Bridge deck joints can be very costly if not properly designed, installed and maintained. The replacement or rehabilitation of joints invariably involves costly traffic management and personnel working under hazardous conditions, often at night. The better the joint, the more money saved over the life of the bridge and the less disruption to traffic.

The intent of this RTA policy document is to provide requirements governing the selection, installation, assessment, maintenance, monitoring and rehabilitation of deck joints appropriate to specific bridges sites. It is important to know what joints to use, when joints should be rehabilitated, and how to select the appropriate joint.

During 1995/96 RTA Bridge Engineering initiated a systematic inspection of joints. The inspection regime has since evolved with detailed items having been identified for inspection. To date, three inspection programs have been carried out. These were conducted in three stages, the last one covering all RTA Regions. The Bridge Joint Assessment (BJA) module has been developed to record and store the results of all joint inspections, to provide data for reference and joint maintenance purposes, to evaluate condition and rate specific joints and joint types. Additional inspections have been carried out recently to increase the total sample and to obtain information on non-sealant type joints.

1.3 Joint Movements

The majority of bridge deck movements occur longitudinally due to temperature changes and concrete creep and shrinkage. These movements are accommodated at bridge deck expansion joints, which shall have sufficient movement capability in all the relevant directions of imposed movements to allow the bridge deck to move freely.

Bridge deck joints are also subject to small longitudinal and vertical movements resulting from superstructure flexure and deformations of the bridge bearings under traffic loads.

Deck skew can have a major influence on the behaviour and life of some joints. Longitudinal deck movements that are not perpendicular to the joint gap can cause racking of joint seals and glands.

Traditionally, bridge deck bearings are set horizontal, but the vertical alignment of the road and deck joints can sometimes be on relatively steep grades. Large movements resulting from temperature and concrete creep and shrinkage effects will occur in bridges with long and continuous superstructures. The movement at the expansion joints of such bridges with bearings set horizontally will be horizontal, and steps in the road profile will occur. This can be a significant problem in colder and hotter weather when vehicles will run into the step. To avoid this problem on longer bridges on steep grades, give consideration to setting the bridge bearings below the joint to the same grade as the road.

Instead of specifying a variable joint gap on the construction drawings the acceptable range of installation temperatures for a specific gap width may be specified for relatively small span bridges.

2 Types of Joints

2.1 General

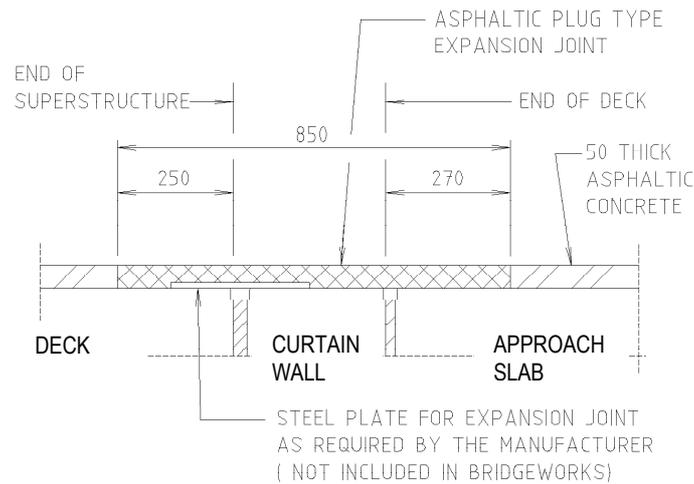
Sixteen types of joints were identified during extensive inspections of bridge deck joints in NSW. For the purposes of this policy document, these can be classified according to movement capability (small, medium, large) and functional behaviour.

Bridge deck joint types are listed below:

- Asphaltic plug
- Bonded metal-elastomer
- Metal fingers bonded to elastomer
- Cork or hose filled
- Elastomeric compression seal
- Hot poured sealant
- Cold applied sealant
- Fabricated steel fingerplates
- Modular
- Moulded elastomer with strip seal
- Open gap with protection angles
- Open gap without protection angles
- Sliding steel plate
- Semi-rigid epoxy
- Strip seal
- Saw tooth

Note that the figures clarifying the nature of the joint types described in the following clauses of this policy document may have been extracted from Drawings for a specific bridge, and, for other bridges, different dimensions and/or details will be used.

2.2 Asphaltic Plug



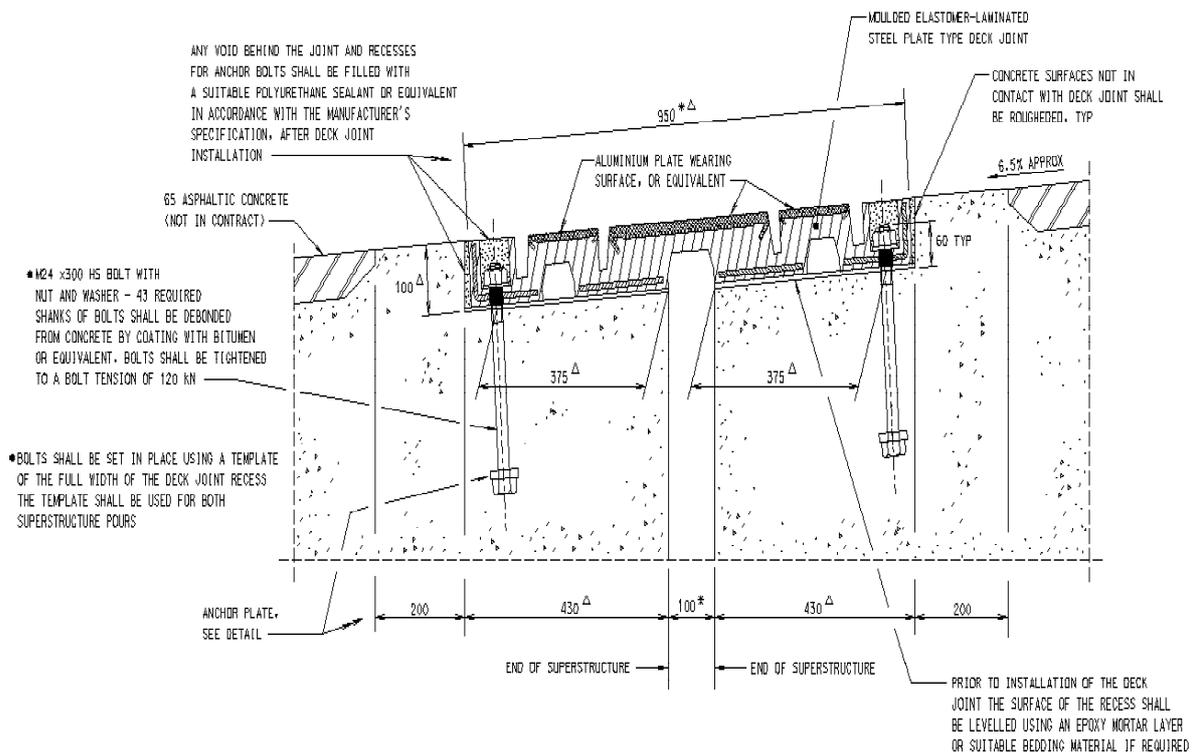
This small movement joint has a movement range of less than 50 mm.

The joint consists of a wide blockout with a depth of about 50 mm to 60 mm. After placing a backer rod in the joint gap, a steel bridging plate with thickness of about 6 mm to carry traffic loads over the joint gap is centred along the length of the blockout and the blockout is primed with hot liquid polymer modified asphalt binder. The blockout is then filled with heated special quality aggregate and the binder, and compacted and finished using additional hot binder to fill the voids. The quality of the joint is dependant on the skill of the work crew operating under the constraints that may exist at the site.

Although these joints are easy to install and repair and provide a smooth, quiet and seamless road surface for traffic, softening of the bitumen based binder in hot weather, hardening and cracking in very cold weather and rutting or delamination in heavy traffic situations are problems that have been noted in NSW. Lightly trafficked parts of the joints can shove and crack longitudinally along the joint. These joints have proved to be deficient when installed on lively bridges, for which movement is discernable under light vehicle traffic, and their use is banned for new bridges for RTA or those that will become the property of RTA and discouraged for maintenance and rehabilitation works except for locations where noise issues are predominant, and there is no suitable alternative.

Because of high recorded previous incidences of failures, before installing, maintaining or replacing an asphaltic plug-type joint, advice regarding suitable techniques and products must be obtained from the Senior Bridge Engineer (Policy and Specifications) Ph: (02) 8837 0850 Fax: (02) 8837 0054. The result of deteriorated expansion joints is damage to the adjacent surfacing and deck concrete, and corrosion of concrete reinforcement and bearings due to water leakage through the joints.

2.3 Bonded Metal-Elastomer



This medium movement joint has a movement range of 50 mm to 165 mm.

The joint comprises monolithically moulded elastomeric panels reinforced with steel plates. The Waboflex product approved by RTA in BTD2008/11 has aluminium armouring over the central section of the joint to reduce wear.

An important consideration with this joint is the reported loosening and breaking of anchor bolts under high-speed traffic. The joint usually requires total replacement when damaged.

RTA used a large number of these joints in long major bridges before concrete creep and shrinkage was fully understood. Failures were common because actual long-term joint movements were larger than joint design capacity, and failures were attributed to the joints rather than to the bridge design.

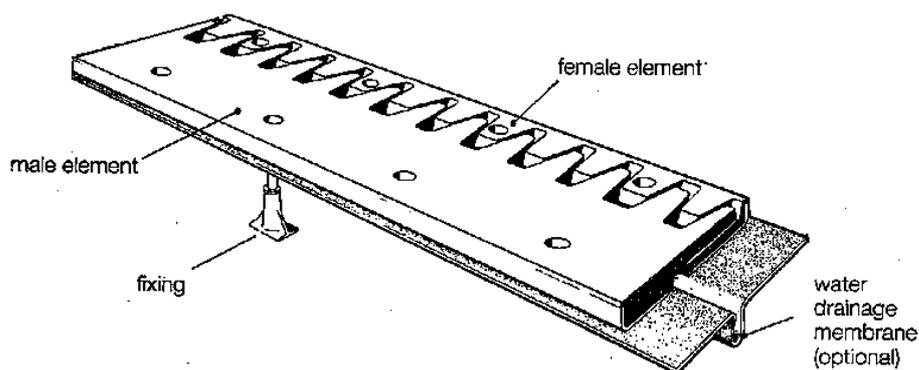
The most important factors for the successful use of these joints are selection of the correct size, and correct installation. The manufacturer's literature shall be referenced and complied with when selecting and installing the joint.

These joints develop relatively large horizontal forces, compared to fingerplates or elastomeric strip seals, that need to be resisted by the anchorages and bridge abutments.

The joints should be installed at the joint gap width appropriate for the actual bridge temperature as specified on the Drawings or in the manufacturer's specification to avoid potential problems. Setting of the joint at too cold a temperature may in hot temperature cause the joint to buckle up in the middle and result in damage by traffic. If installed in hot weather, excessive stretching in cold weather later may damage the elastomer or the anchorages.

The applicable specification is RTA B318.

2.4 Metal Fingers Bonded to Elastomer



This medium movement joint has a movement range from 50 mm up to 500 mm.

The joint comprises steel male fingers that slot into an elastomeric female seat. The female seat is vulcanised onto a relatively thin steel base plate anchored to the deck or abutment by holding down bolts. The steel male fingers are vulcanised onto an elastomeric pad which is also vulcanised onto the steel base plate. The base plates are anchored to the bridge deck or the abutment by holding down bolts. The steel male fingers rely on the vulcanised bond with the elastomer to secure it under traffic loading. Failures of these joints have occurred due to debonding of the steel male fingers from the elastomer, with the recoil of the dislodged plate as the bond breaks causing an extreme hazard.

One of earlier versions of this type of expansion joint originally supplied by PSC and now by Austress Freyssinet is known as an FT joint. It consists of independent segments ranging in length from 0.5 m to 1.0 m long. Due to ageing of the joint, incorrect installation or lack of maintenance, the bond of the rubber can fail, resulting in the steel male plate becoming detached from the rest of the joint. The bond failure typically begins at the finger side of the male half of the joint.

Remove and replace debonding segments as evidenced by lifting of the fingers. Any missing segments in the carriageway can be replaced with one from the shoulder after covering the gap by a suitable steel plate spanning the gap anchored with temporary sleeved bolts screwed into threaded holes.

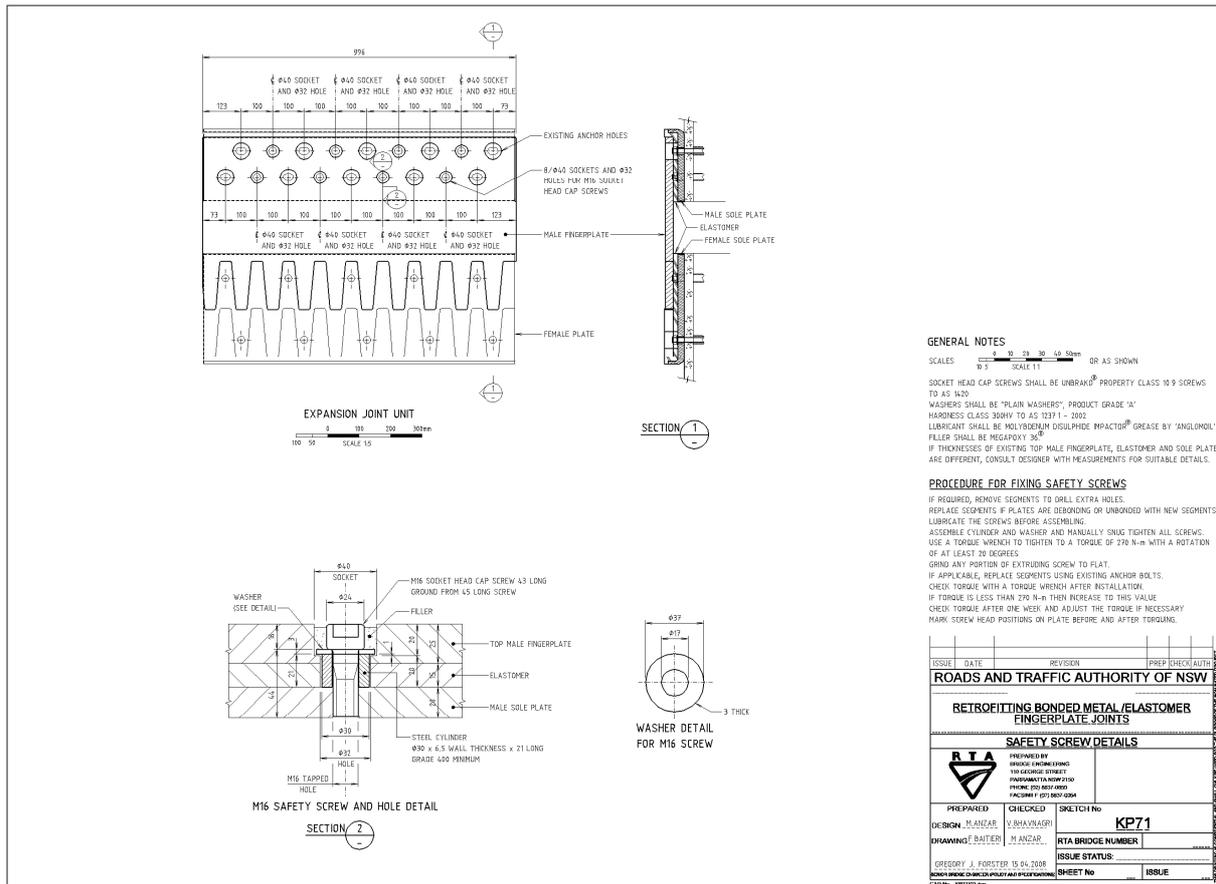
For all bridges with PSC or Freyssinet FT type or Zillmere expansion joints relying only on bonding of the top male plate, retrofitting shall be undertaken to prevent the male plates coming adrift. This shall comprise the staged removal of segments to drill extra holes through the bonded but unbolted male top plate and the lower steel base plate, and securing both plates using high strength socket head safety screws with associated sleeves, washers and nuts - see Sketch KP71 following. The segments shall then be reinstalled.

This does not strengthen the joint but provides adequate warning before it becomes a traffic hazard. Routine maintenance should include inspection for debonding of the male plates.

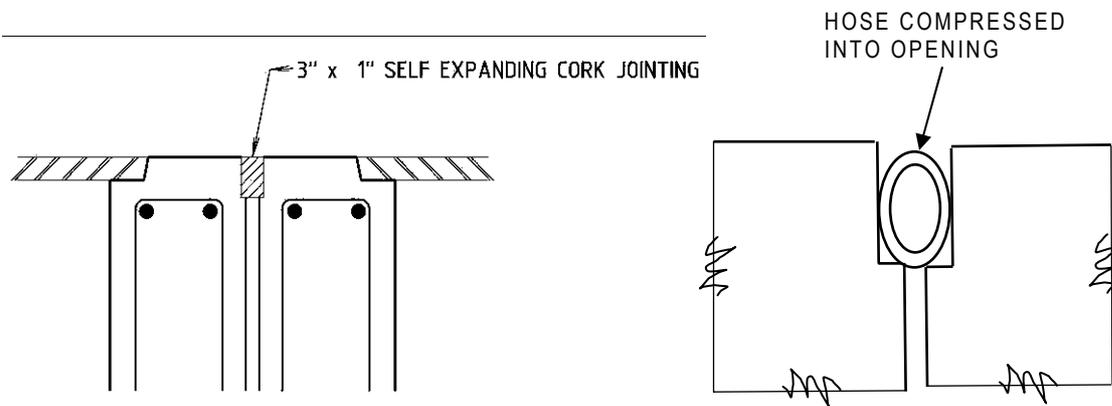
Any new joints should be ordered specifying the joints be supplied with safety screws to keep the male fingerplate secured in the event of the elastomer/steel bond failing.

There is currently no RTA specification for this joint type. These joints should only be procured from RTA approved suppliers in accordance with BTD2008/11.

Advice on the repair or replacement of these types of joints should be sought from the Senior Bridge Engineer (Policy and Specifications) Ph: (02) 8837 0850 Fax: (02) 8837 0054.



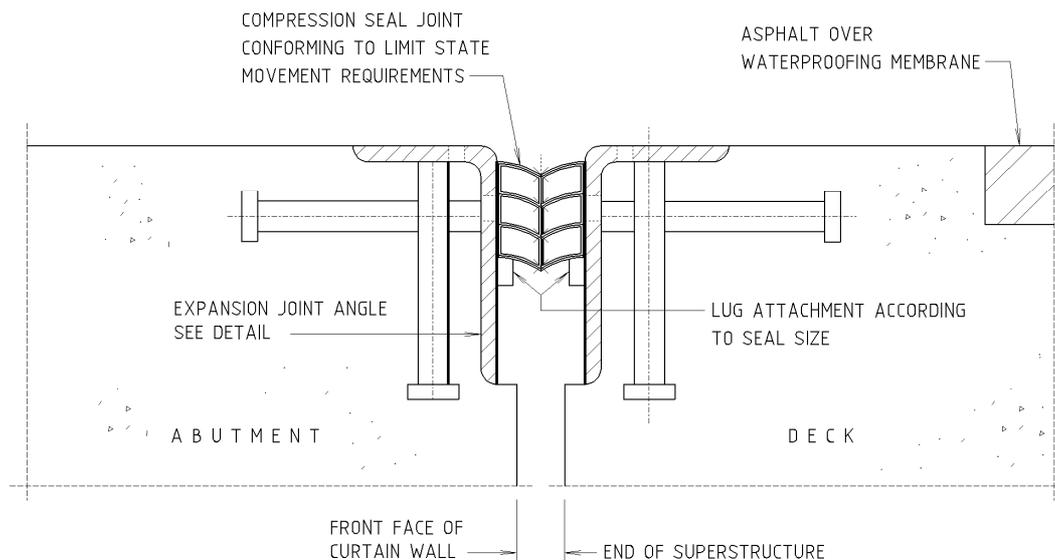
2.5 Cork or Hose Filled



These older type of joints are not watertight and were mostly used for footpaths where live load and temperature movements are small. They were sometimes used as bridge joints for movement ranges up to 5 mm. Use for bridgeworks is prohibited due to lack of watertightness.

The applicable specification is QC specification RTA 231 I.

2.6 Elastomeric Compression Seal



This small to medium movement joint has a movement range of 5 mm to 60 mm.

The box shaped elastomeric compression seals are usually of closed cell or open cell cross section. Closed cell seals are not common. Semi-hollow extruded seals with internal web stiffening are more commonly used. The elastomer shall conform to the specified strict material and testing requirements to give assurance of long-term joint performance as the quality of elastomer and its long term resilience is crucial.

The recommended practice for heavy duty compression seals in bridgeworks is the armour protected joint with projecting flat steel seating strips to prevent the seal squeezing down through the joint. The flat steel seating strips or lugs must be used as shown in the figure over the full width of the roadway pavement.

Although some overseas transport agencies have rated this type of joint highly for bridge applications, others have reportedly abandoned its usage entirely due to unreliable performance. Installation quality, seal size and material selection may be causes for contrasting performance and diverse opinions.

Specifying the seal size appropriately following the measurement of the actual joint gap width and making allowance for concrete creep and shrinkage movements in accordance with AS 5100 prior to making up the order for supply is critical to performance, as each seal size will only perform effectively within a defined movement and joint gap range.

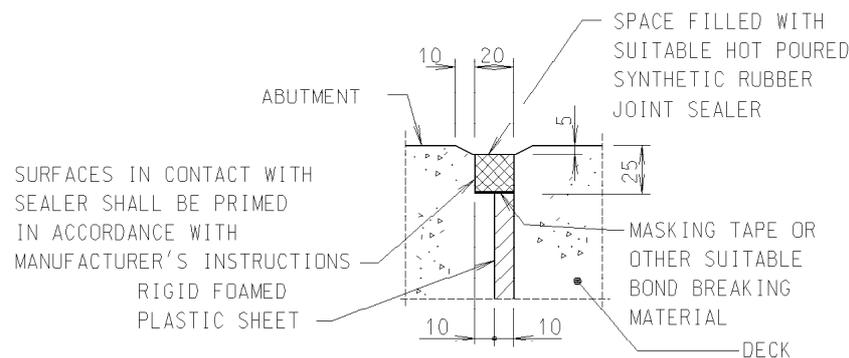
The seals for these joints shall be procured only from RTA approved suppliers with complying test results provided with each delivery.

Metal protection armouring shall be used with compression seals.

As concrete compaction under the steel protection angles is problematic, strip seal joints with wedge shaped metal retainers are preferred over compression seal joints, especially as the number of manufacturers of compression seals is reducing.

The applicable specification is RTA B310.

2.7 Hot Poured Sealant

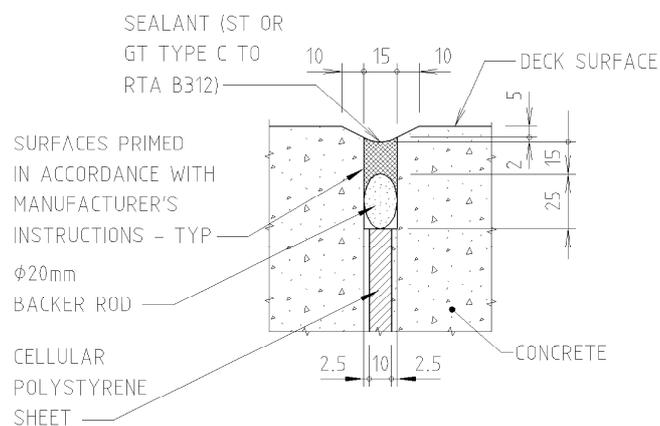


This small movement joint has a movement range of less than 6 mm.

Heated asphalt, coal tar products or synthetic rubbers are used as sealants. In older RTA bridges, "Megaprene" hot poured sealant product supplied in hard bituminous blocks was melted by heating on site and then poured into the prepared joint gaps. Being bituminous, the melting point of the material is low and on hot days this can cause the sealant to flow. On cold days, the material becomes too stiff to accommodate the opening of the joint due to contraction of the bridge deck, the sealant splits allowing debris to enter and become trapped in the joint, and water can penetrate the cracks in the sealant. The cracks can self heal when the material heats up on hot days. Over time, the entrapped debris blocks the joint gap completely, making the joint solid, with the displaced sealant being extruded onto the road surface. The bituminous material also hardens and can become brittle with age.

This type of joint was banned by RTA in 1996 by BTD1996/01 because of these deficiencies.

2.8 Cold Applied Sealant



This small movement joint has a movement range of up to about 20 mm.

Details of these joints are similar to the hot poured sealant joint but the sealant is different and is cold applied.

Due to the improved performance of newer sealants, they are now specified for RTA works.

These sealant type joints have traditionally been used on shorter bridges. However with the newer sealant materials now available, manufacturers currently propose their use for larger movements than in the past but, notwithstanding this, their design and supply shall conform to RTA B312.

Silicone and polyurethane are now the most commonly used sealants.

Only RTA approved products shall be used.

Sealant joints are easy to repair as the failed portions can be quickly removed and replaced. This reduces traffic disruption and hazards in the work area.

The performance of this type of joint is almost unaffected by sides of the joint not being perfectly parallel or vertical.

The shape factor, this being the ratio of the width to the depth of the sealant, is an important parameter for design as the sealant strain capacity increases directly in proportion to the width and inversely in proportion to the depth of the sealant in the joint. The depth of the sealant at the centre should be about half the width of the joint and it is important to prevent sealant from bonding to the backer rod below. The preparation of the joint blockout, and mixing and application of the sealant, shall be strictly in accordance with the manufacturer's instructions, RTA's B312 specification and associated Standard Bridge Drawings.

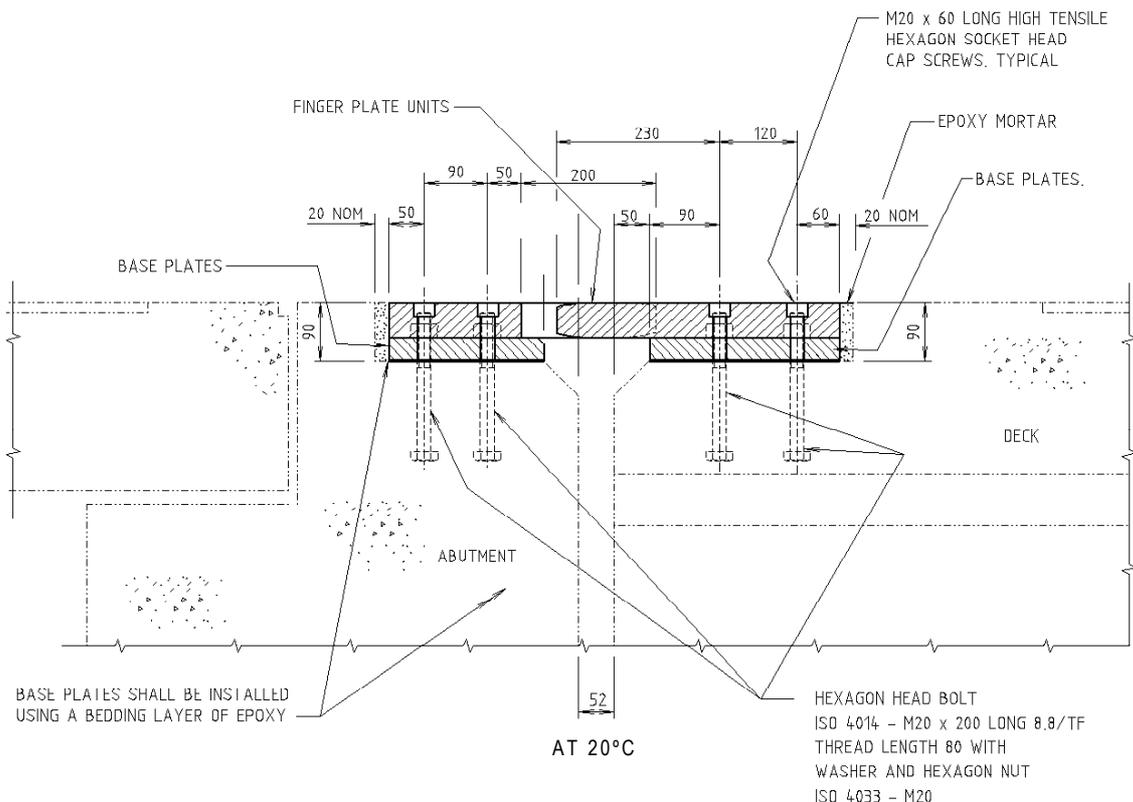
Some intermittent spalling of concrete nosings in sealant joints has been reported. The concrete must have sufficient strength and maturity at sealant installation to prevent this.

These joints can also be damaged due to rollers compacting asphalt. Care shall be taken when forming the recess during deck construction. Because of these problems, these joints are sometimes covered with asphalt or replaced using strip seal joints.

Small movement deck joints for RTA bridge works must be in accordance with the RTA Standard Bridge Drawings Nos RTAB035, RTAB035A and RTAB035B, as appropriate to the type of work.

The applicable specification is RTA B312, which closely reflects the properties of products now available on the market.

2.9 Fabricated Steel Fingerplate



This large movement joint has a movement range of 75 mm to 600 mm.

Fingerplate type joints are used for larger joint movements on major structures, and generally comprise steel top fingerplates bolted with high tensile cap screws to steel base plates cast into the deck concrete. Other anchorage systems do exist, and the relevant Works-As-Executed drawings should be checked before carrying out inspections or work on a joint.

The fingers are fabricated from steel plate, and are usually hot dipped galvanised after being given a skid resistant surfacing comprising 3 mm welds on a 100 mm x 100 mm criss-cross pattern.

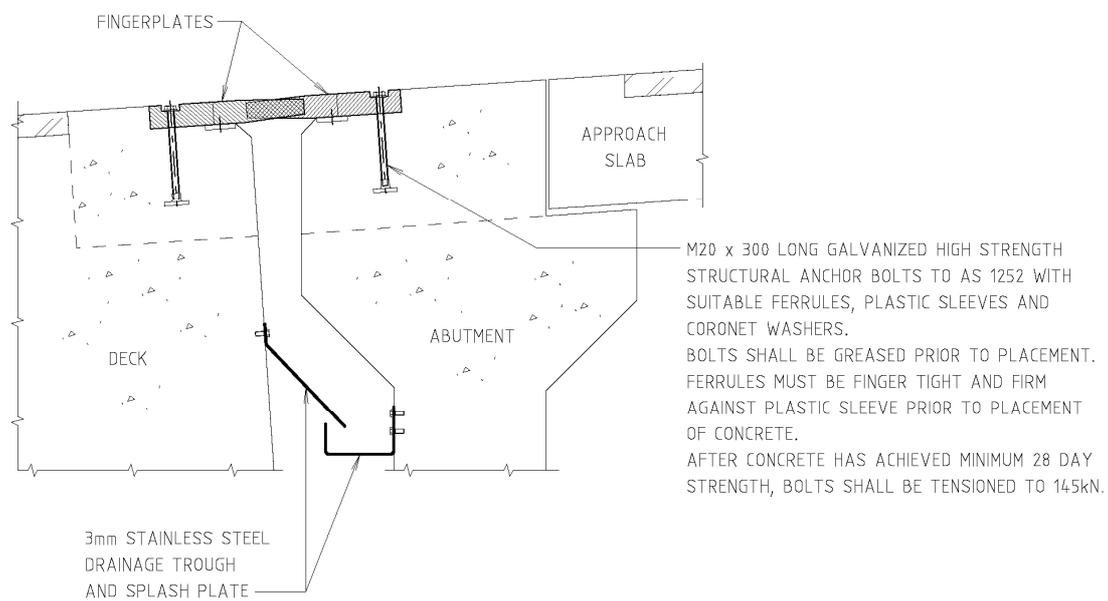
This type of expansion joint is usually provided with various types of drainage or is left open with runoff draining to an abutment gutter below. If a trough made of flexible neoprene sheet is provided under the fingerplates, a transverse slope of about 8% should be adequate for self-cleaning. The gutter shall be regularly maintained. Stainless steel drainage troughs shall be provided for new fingerplate joints.

Regular inspection and monitoring of these joints is required for public safety. Some fingerplate type joints may have anchorage problems or problems with the fingers being misaligned vertically, causing unacceptable noise or a rough riding surface. Loose plates pose a severe hazard if the holding down cap screws or the base plate anchorages fail.

In new long bridges with significant creep and shrinkage re-setting of fingerplates should be considered by providing extra bolt holes in the plates.

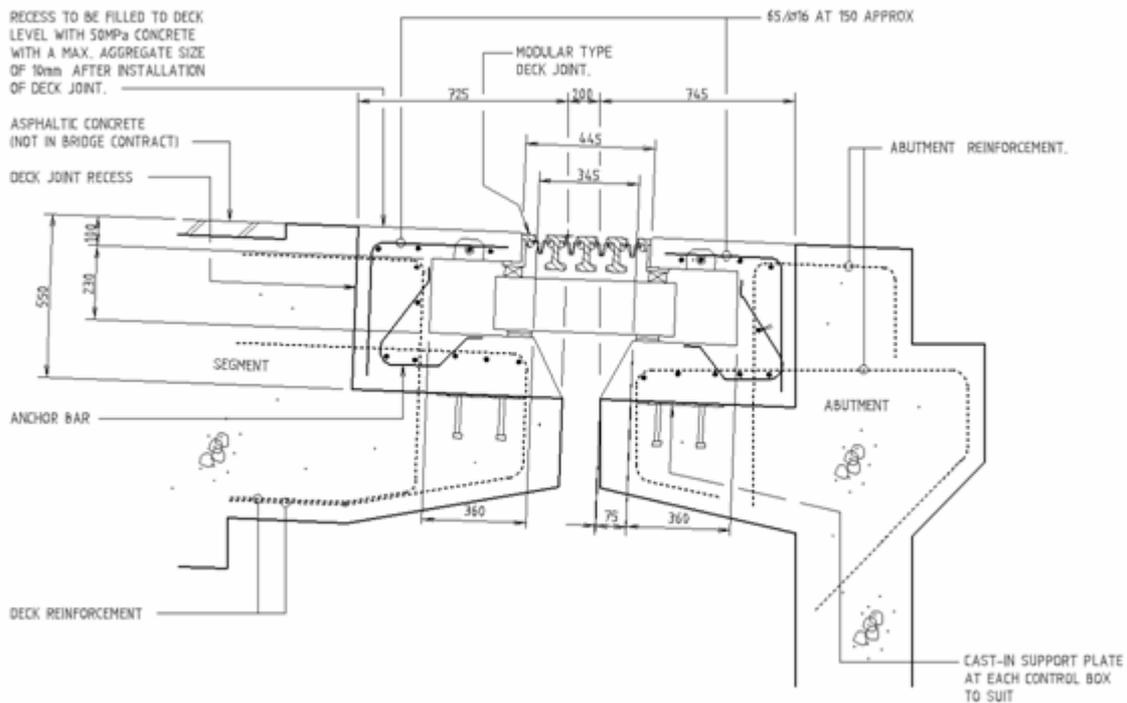
The minimum overlap of fingers during cold weather specified in AS 5100.4 is 15 mm with a maximum gap between adjacent fingers of 50 mm.

Recent fingerplate joint designs use long debonded anchor bolts to avoid the use of base plates as shown below.



The applicable specification is RTA B241.

2.10 Modular



This large movement joint has a movement range of 100 mm to 600+ mm but joints with a movement capability of over 2 m have been designed for use on very long bridges overseas. This joint is used in major bridges to accommodate large movements, with design, supply and installation requiring specialist knowledge and skills.

Modular joints are prone to various problems including fatigue cracking and damage to the support bars and bearings, to the equalizing springs, to the edge rails due to inadequate concrete compaction during installation, and to the elastomeric seals.

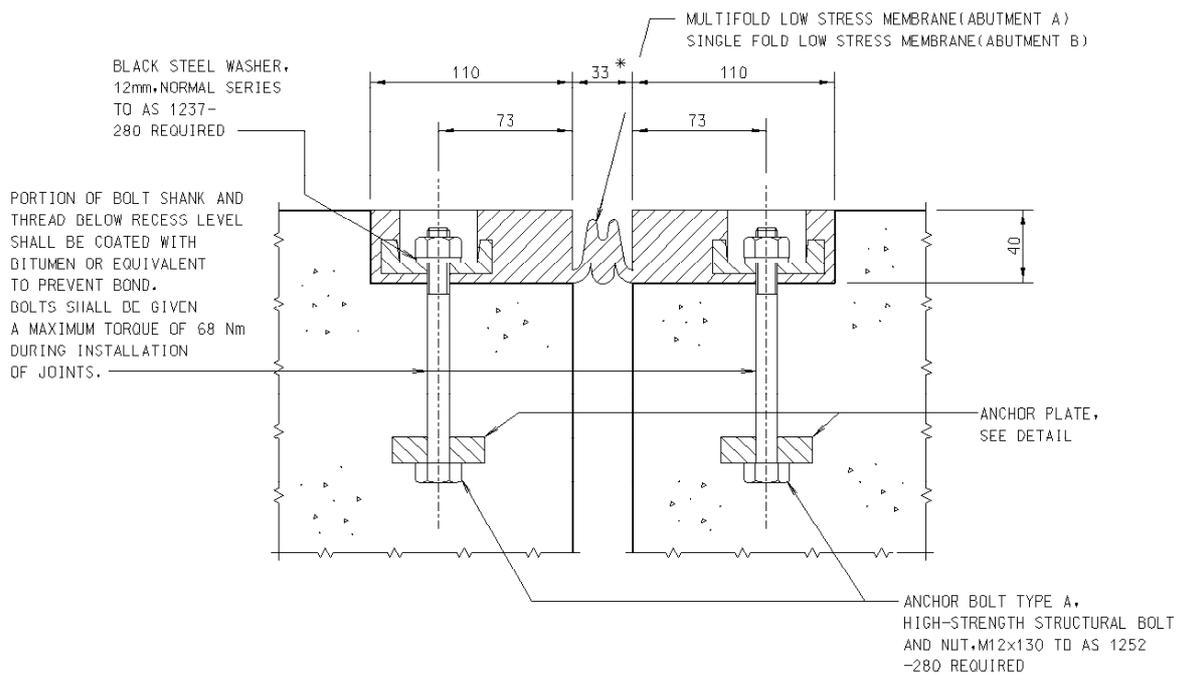
An extensive survey of modular joints across RTA has been carried out in separate studies, which should be referred to and specialist RTA advice obtained before making decisions regarding the selection of specific modular joints for major RTA bridges.

RTA has investigated and carried out research into the dynamic behaviour of these joints and has examined issues associated with these joints such as vibration, noise, excitation and damping.

Bridge Technical Direction BTD2004/08 specifies the requirements to allow for the installation of an effective noise abatement system and providing sufficient space for inspection and maintenance of the joint. Designers and Project Managers must implement BTD2004/08.

The applicable specification is RTA B316, the latest edition of which contains the outcomes of previous RTA surveys and investigations carried out over the last several years.

2.11 Moulded Elastomer with Strip Seal

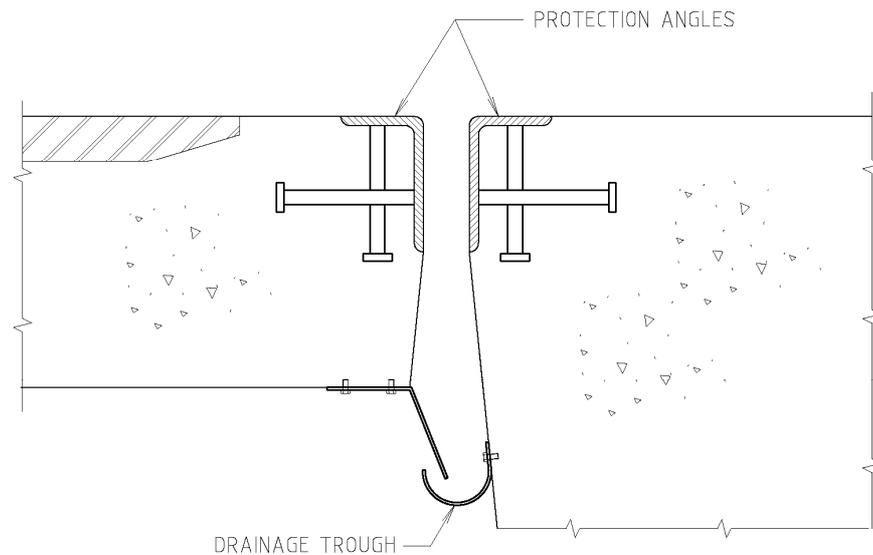


This medium movement joint has a movement range of 50 mm to 100 mm. The joint comprises a continuous folded elastomeric membrane across the joint gap, held down with elastomeric modular segments that are moulded around steel plate retainers, anchored by relatively small diameter bolts cast into the concrete at large spacings. This joint has some ability to accommodate directional changes and skews in the joint configuration, often without any need for a splice in the seal. The most common type is the Felspan type joint.

Under traffic, the elastomeric moulding around the retainers wears away. Failure of the anchorages due to repetitive live load impacts has been frequently reported which, together with splitting of the seals, means that the retainers can become loose, creating a hazard.

If the anchorages of this type of joint are inadequate or the membrane leaks, the joint should be replaced with a conforming strip seal joint, either a fabricated steel version designed for bridge deck joint rehabilitation works or a proprietary system.

2.12 Open Gap with Protection Angles



This medium movement joint has a movement range of 5 mm to 85 mm ULS, with the upper limit being that for open gaps specified by AS 5100.4.

The joint comprises a protective armouring of galvanised steel angles cast into the deck and abutments.

This joint is unsealed, and allows free entry of water and debris into the joint gap.

This joint should not be used on new bridges or for deck joint rehabilitation as it does not conform to AS 5100.4 in regards to watertightness and sealing against dirt ingress. These joints pose a hazard to stock on hooves, pedestrians and cyclists.

The applicable specification is RTA B241 for fabrication and galvanising of the protection angles.

2.13 Open Gap without Protection Angles

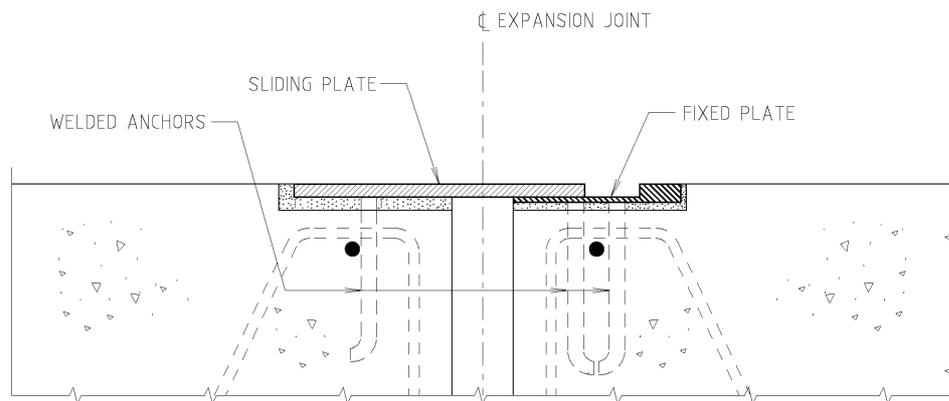
This medium movement joint has a movement range of 5 mm to 85 mm ULS, with the upper limit being that for open gaps specified by AS 5100.4.

The joint comprises an open cast concrete gap at the deck and abutment interface.

This joint is unsealed, and allows free entry of water and debris into the joint gap. The details for this joint are very similar to those of the open gap joint above but without the galvanised steel angles.

This type of joint should not be used on new bridges or for joint rehabilitation as it does not conform to AS 5100.4 in regards to watertightness and sealing. These joints pose a hazard to stock on hooves.

2.14 Sliding Steel Plate



This medium movement joint has a movement range of 50 mm to 100 mm, with the lower limit governed by the supporting steelwork beneath the sliding plate.

The joint comprises steel plates covering the joint gap, anchored on one side and free to slide on the other. This type of joint is not watertight. It becomes damaged when the anchorages fail. Because there is steel to steel contact and the plates can become loose, it can cause severe noise problems, particularly in an urban environment. The plates have to be adjusted and tightened periodically to reduce noise levels and to keep them safe. Plates improperly installed can bend, warp and break off at the anchorages due to the repetitive impact loads from heavy traffic. Relative deformations of the bearings on each side of the joint under traffic loads can impose prying type effects on the sliding plates that can cause anchorage failures.

This type of joint can prevent most debris passing through the joint but cannot effectively stop water leakage or accumulation of debris. It shall not be used for road traffic areas as it does not conform to AS 5100.4 in regards to watertightness and sealing against dirt ingress.

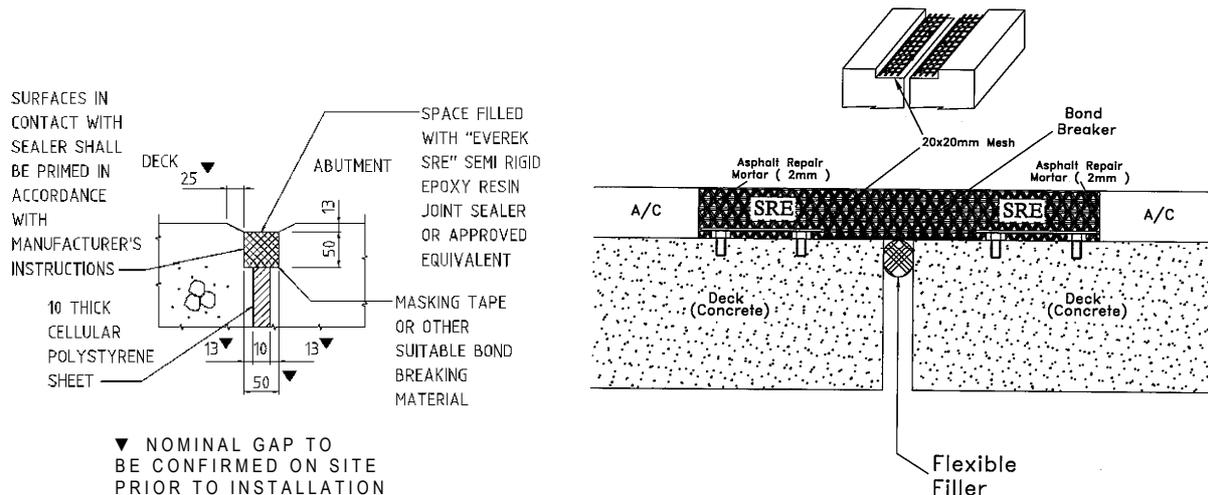
Modifications have been made over the years to these joints attempting to make them safer and quieter. The most typical modification comprises an arrangement of bolts and springs to keep the sliding faces in permanent contact.

Sliding steel plate joints are unsatisfactory on major highways as the plates can be dislodged, buckled and bent from heavy vehicles travelling over them and can become hazardous for vehicles and pedestrians. Because of the unsatisfactory performance of this type of joint, other types have replaced them.

The applicable specification is RTA B241 for fabrication and galvanising of the steel plates and RTA B240 for the anchor bolts.

AS 5100.4 does not recommend this joint under road traffic as it can generate excessive noise and problems in service.

2.15 Semi-Rigid Epoxy



This joint comes in two variants, one being a small movement joint and the other being a plug type joint. The material of these joints is a proprietary semi-rigid epoxy (SRE).

The bottom of the joint gap is covered by masking tape or other bond breaking material and the prepared blockout filled with the liquid epoxy, which sets as a rubbery solid. Traffic is able to traverse the joint soon after placement, which means that joint installation can be done quickly, which is advantageous in repair/rehabilitation type situations.

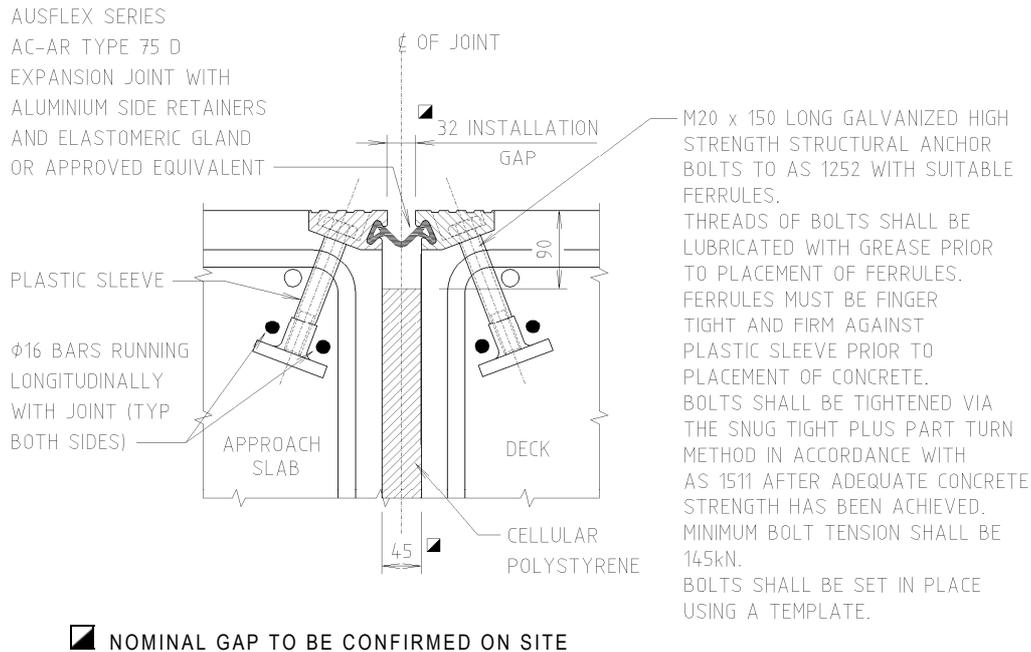
The movement capability of the small movement variant of these joints is relatively small compared to sealants, and limits their use for bridgeworks.

Everek SRE small movement joints were once approved by RTA and called up on Standard Bridge Drawings but, following the adverse findings of joint inspections across NSW and problems in service, that approval was revoked. They shall no longer be used, with cold-applied sealants conforming to RTA B312 and associated Standard Bridge Drawings used instead.

Problems with the plug type variant of this joint arise because Poisson's ratio effects result in the SRE material not remaining adhered to the primed concrete substrate, being prised off by traffic shoving the hump formed at the joint gap when the temperature rises and the joint is compressed. Conversely, when the material is cold and stiff, delamination of the joint in tension from the concrete may occur and a potential traffic hazard arises from the detached SRE plug lying loose in the blockout.

SRE plug type joints shall not be used, with use of a properly placed asphaltic plug joint possible as an alternative for replacement at some sites, following consideration of suitability. Otherwise, failed SRE joints should be replaced with a fabricated steel strip seal joint for long-term durability of the replaced joint.

2.16 Strip Seal



This medium movement joint is used for movement ranges of 0 mm to 85mm.

There are larger size strip seals on the market which do not comply with AS 5100.4 as the total gap width between retainers after accounting for concrete creep and shrinkage must be less than 85 mm ULS.

Strip seal joints currently approved under BTD2008/11 comprise extruded aluminium wedge shaped retainers cast into the concrete anchored with high strength debonded bolts threaded into ferrule type cast-in inserts. Seals/glands are extruded elastomer with stringent material and performance specification requirements for long-term performance under the severe environmental conditions experienced by bridge deck joints.

The elastomeric gland is mechanically locked on both sides of the joint by the rolled or extruded keys of the retainers. The strip seal retainers protect the edges of the deck or abutment against live load impact whilst also gripping the elastomeric gland.

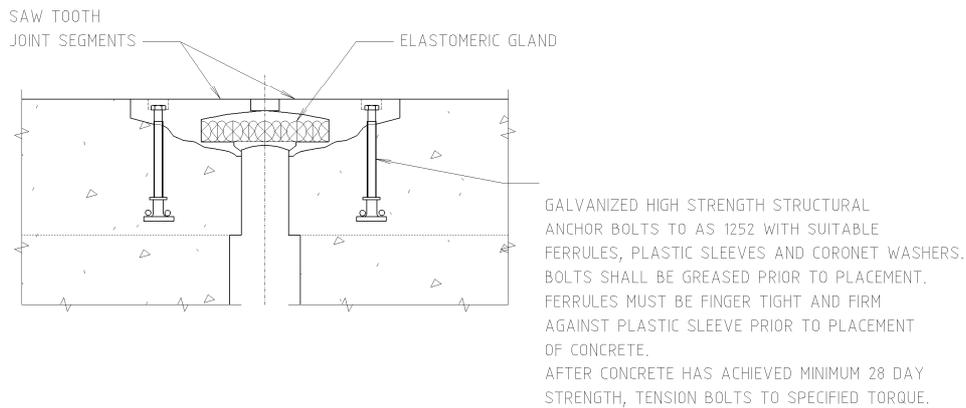
AS 5100.4 requires metal protection armouring for strip seal joints. An RTA approved version of this type of joint that complies with AS 5100.4 is shown in the above figure.

When joints are assessed for RTA approval, the metal retainers are closely examined for fatigue resistance.

Depending on the supplier, the performance of earlier aluminium versions of this joint was variable because of the design of the joint at that time. Field performance has improved over the last decade because the design was changed from a trough shape to the solid wedge shape now in use, which is now the only version approved by RTA in BTD2008/11, and is supplied by several suppliers.

The applicable specification is RTA B315.

2.17 Saw Tooth



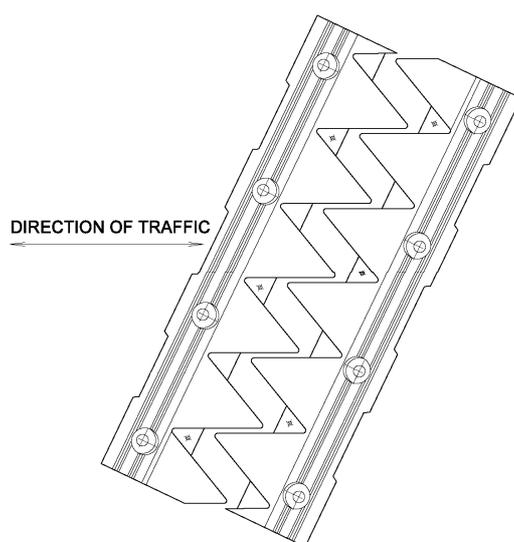
This medium movement joint is used for movement ranges of 85 to 160 mm

Proprietary cast aluminium saw tooth bridge deck joints are now commonly specified for expansion joints with mid-range movements too large to be accommodated using strip seal or compression seal type joints, but not large enough to warrant the use of fabricated steel fingerplate type joints.

At present, two makes of saw tooth joint have been approved for use on RTA funded bridges and others will appear on the list of approved components following approval.

Clause 17.3.5 of AS 5100.4 which applies to joint gap issues with fingerplate type joints was not intended to address the issues arising from the use of saw tooth type bridge deck joints.

Where these joints are used on skewed bridges, the sides of the saw teeth are at different angles to the direction of traffic and joint movement. Because the tooth configuration is not changed to adjust for the skew, gaps larger than those of joints orthogonal to traffic can occur. The sides of adjacent teeth can also be parallel or almost parallel to the direction of traffic, which can trap the wheels of two wheeled traffic to track them in and along the direction of the gaps between the teeth sides (see Figure).



These hazards to two wheeled traffic, especially motorcycles and pushbikes, are not acceptable.

Saw tooth bridge deck joints shall only be used on straight and square bridges and shall not be permitted for use on skewed bridges in order to minimise possible traffic hazards posed.

The applicable specification is RTA B319.

3 Joint Selection

3.1 General

The selection of bridge deck joints shall be based on factors including superstructure type, movement range, bridge alignment and skew, location of joint, satisfactory field performance, durability, maintenance requirements, traffic type and intensity, expected joint life, installation time, bridge life cycle cost and noise. Initial cost should not be a consideration, as the consequences of joint failure and bridge damage can far exceed the supply cost of the joint.

Various types of bridge deck joints are found in RTA's bridges, but not all of them are currently approved under BTD2008/11 for installation in new bridges or for rehabilitation of failed joints.

Sixteen joint types were identified during the inspections and the data collected for fifteen was analysed to rate their performance. Based on previous experience and these inspections, RTA has limited the use of some joints. Hot poured sealant type joints were banned by BTD1996/01 in 1996.

Deck joints should have tolerances that will cater for unanticipated movements.

The effects of the road grade and bearing alignment i.e. horizontal or on the grade of the road, acting concurrently with the thermal deck movements should be considered during joint selection, as bridges on a steep grade with horizontal bearings will experience significant relative vertical translation of both sides of the joint gap.

The bridge skew may eliminate from use some types of joints, e.g. compression seal joint.

Paint or galvanising should be used to protect steel sections.

The use of aluminium components is only permitted for joints with proven satisfactory performance. A non-metallic epoxy paint coating shall be applied to all aluminium surfaces in contact with concrete, as aluminium is very susceptible to chloride attack when the concrete is wet.

Selecting a bridge deck joint will usually depend on the calculated movements between the opposing sides of the joint gap, which will usually be at the interface between the bridge deck or approach slabs and the abutment curtain walls. Joints at the ends of suspended deck spans are selected in a similar manner.

During the life of the bridge, bearings can seize, abutments can move and close up joints, and joints can become packed full of rubbish and debris, all resulting in the observed bridge articulations and movements being different from that assumed in the original design.

The design for replacement joints in existing bridges shall assume that the structure will one day be restored to its original articulation.

The design criteria for a replacement joint are the same as for a joint on a new bridge. Replacement and new joints shall be designed in accordance with AS 5100.4 accounting for the effects of residual concrete creep and shrinkage for concrete bridges.

If the bearings are non-functional, restoration or replacement of bearings should be considered concurrently with replacement of the joint.

3.2 Discontinued Joints

Among the sixteen types of bridge deck joints identified during RTA inspections, six joints are either no longer used or expected to be used in new RTA bridges or for joint rehabilitation due to poor long-term performance. These discontinued joints are discussed below together with replacement options.

3.2.1 Cork or Hose Filled

These joint are not suitable for trafficable surfaces as they can be displaced by traffic and are not watertight. Because of their ease of installation, cost and nature, they are used widely for footpaths.

If damaged or deteriorated, these joints can be replaced by cold applied sealant joints.

3.2.2 Hot Poured Sealant

These sealants are bitumen based and become very soft during summer and hard and stiff during winter, giving the unstable behaviour which resulted in RTA banning this type of joint.

However, RTA Regional joint inspections show that the performance of this joint is perceived by the inspectors to be mainly satisfactory. The sealant's deficiencies fail to have obvious adverse effects on overall joint behaviour, which may be due to self-healing of cracks when the material heats up on a hot day or from remoulding under traffic.

Future improvements in sealant materials may help to eliminate some of the problems associated with this type of joint and may then make hot applied sealants suitable for RTA use.

Cold applied sealants shall at this time be used instead of hot applied sealants.

If failed, this joint shall be replaced by a cold applied sealant joint.

3.2.3 Moulded Elastomer with Strip Seal

This joint was identified as having inadequate anchorages and exhibiting excessive wear of the elastomeric moulding around the retainers. This joint shall not be used since failure progresses relatively rapidly after initiation.

If damaged, this joint could be replaced by either a strip seal, bonded metal elastomer, metal fingers bonded to elastomer, or steel fingerplates, depending on the required movement range.

3.2.4 Open Gap without Protection Angles

This joint is the simplest form of deck joint and its use is not permitted because metal armouring is required by AS 5100.4 for the open gap for protection of the concrete deck edges. As it does not comply with AS 5100.4, it shall not be used for new RTA bridges or those that will become the property of RTA.

This joint can be replaced by a cold applied sealant, an elastomeric compression seal or a strip seal, depending on the required movement range.

3.2.5 Sliding Steel Plate (for Road Traffic)

This joint prevents most debris passing through the opening but not water penetration. As it is common for the plates to become loose over time, this joint requires frequent tightening of the bolts to reduce noise levels.

These joints shall generally be replaced by joints such as elastomeric compression seals, strip seals or steel fingerplates, depending on the required movement range.

3.2.6 Semi-Rigid Epoxy

This proprietary semi-rigid epoxy material is too stiff at low temperatures and delaminates under tension from the concrete and in hot conditions is prised from the concrete by the traffic, and shall not be used.

This joint can be replaced by an asphaltic plug, but only at sites with a requirement for noise control, or by a cold applied sealant or elastomeric compression seal, depending on the required movement range.

3.3 Joints for Use Following Site Specific Study

3.3.1 Asphaltic Plug

Even though the use of asphaltic plug type joints is not encouraged, at present this joint can be used only when no other joint type is suitable for solving severe noise issues at a specific site.

The joint should have a uniform width of at least 600 mm.

This joint is suitable only for roadways without barriers and kerbs as effective sealing of joint upturns is difficult.

Even though this joint is easy to install and repair, it tends to rut, crack or delaminate under certain traffic conditions.

Do not use this type of joint on lightly trafficked roads or parts of the roadway e.g. wide shoulders, as deformation and binder flow outside the wheel paths may occur, creating a traffic hazard.

Binders with higher thermal stability will be required to reduce debonding and binder flow in joints on roads with steep grades or cross-falls or areas subject to sudden acceleration or deceleration such as at traffic lights and off load ramps.

If damaged, this joint could be replaced either by a cold applied sealant joint or an elastomeric compression seal joint.

3.3.2 Bonded Metal-Elastomer

Early failures of this type of joint in major RTA bridges were attributed to insufficient joint movement capacity, not bridge design, resulting from lack of understanding of the long-term effects of concrete creep and shrinkage, particularly for longer bridge decks.

Sixteen of these joints were inspected during the RTA joint inspection project, this sample size being relatively small. The performance ratings are highly variable, indicating that this joint should be specified for use with caution, taking into account its high replacement cost and variable field performance. Its failure will require complete replacement.

The bonded metal-elastomer expansion joints on the M2 Motorway were noisy due to “clapping” of the joint on the concrete because the use of a single row of anchor bolts for anchoring each side of the joints allowed this effect to occur. These joints were replaced with quiet joints a relatively short time after the opening of the motorway.

Other types of joint with equivalent movement capacity should be considered in preference to this type of joint.

3.3.3 Metal Fingers Bonded to Elastomer

The steel male plate of this joint is secured to its steel baseplate only by the vulcanised bond of the elastomer between the two plates. BTD1998/04 initially detailed the measures that shall be taken to reduce the hazards caused by debonding of the steel male plate, which will improve the joint's performance and make it suitable for continued use. These measures are included in Clause 2.4 of this document.

3.3.4 Open Gap with Protection Angles

This is one of the simplest forms of joint. Metal protection angles are used to protect the concrete edges from damage and wear. AS 5100.4 permits use of this type of joint, but only with provision of a drainage system, specifying that:

“Where a joint is not sealed, the gap shall be wider at the bottom than at the top to prevent stones and debris from lodging in the joint, and a drainage system with access for cleaning shall be provided.”

This joint shall be provided with troughs for drainage under the deck or along the top of headstocks.

This joint could be replaced by a cold applied sealant, an elastomeric compression seal or a strip seal joint, depending on the required movement range.

3.4 Joints for Continued Usage

Among the sixteen joints identified, the continued use of six joint types is permitted without qualifications. It is expected that the performance of these joints will continue to improve following further developments in materials and in installation methods.

3.4.1 Elastomeric Compression Seal

AS 5100.4 requires metal protection armour for this joint. Where this is not possible on older bridges, this type of joint should be installed by forming the gap narrower than the design width and

saw cutting with a diamond blade immediately prior to seal installation to ensure correct and uniform width for installation.

The saw cutting technique shall only be used in exceptional circumstances on older bridges.

This joint is popular due to relative ease of installation, cost effectiveness and its flexibility to accommodate different movement ranges. Do not use these joints in decks with greater than 20 degrees skew.

3.4.2 Cold Applied Sealant

Only the cold applied variants of sealant type joints are permitted for continued use.

Cold applied sealants are now specified for RTA small movement joints due to easy handling and stable behaviour.

Regardless of claimed or tested properties, sealants shall not be subjected to expansion or contraction deck movements greater than one quarter of the installation width of the sealant.

This type of joint is specified using RTA B312 and the associated RTA Standard Bridge Drawings. Where applicable, the standard details shall be adopted.

3.4.3 Fabricated Steel Fingerplate

These joints are normally provided for larger joint gaps on major structures and can tolerate only small rotational movements and vertical deflections across the joint.

The longitudinal movement capacity is limited by the length of the fingers which are subject to severe fatigue loading from repetitive wheel load impacts.

AS 5100.4 limits the gap between adjacent fingers to 50 mm. Consideration needs to be given to non-vehicular traffic to ensure that the open slots formed by this joint are within acceptable limits.

Welding for this joint, when carried out, is critical as it rapidly accumulates millions of traffic load cycles. AS 5100.4 specifies infinite fatigue load cycles for design unless a detailed site specific investigation is undertaken.

This is a stable joint and tends to have fewer problems than other joints. It can cover the majority of movement ranges, but new joints shall be provided with a stainless steel drainage trough to minimise water damage to the bridge elements underneath.

3.4.4 Modular

These joints are used in major bridges to accommodate large movements, with design and supply requiring specialist skills. Extensive survey and research on the behaviour of modular joints has been undertaken by the RTA (refer to the proceedings of the Austroads Bridge Conferences in 2004 and 2006) which should be referred to before a decision is made regarding the selection of this joint.

Because of high initial and maintenance costs, steel fingerplate joints capable of large movement ranges and with drainage troughs are becoming a cost effective alternative to lower movement range modular joints.

Replacement of modular joints with steel fingerplates is sometimes possible after the bulk of concrete shrinkage and creep losses has occurred in the structure.

This joint is the obvious option for very large movements, but should only be used when fabricated steel fingerplates are not viable.

3.4.5 Sliding Steel Plate (for Pedestrian Traffic)

Sliding steel plate joints are used on pedestrian bridges, with their continued use for such areas envisaged in the last paragraph of Clause 17.3.1 of AS 5100.4.

This joint prevents most debris passing through the opening, but not water intrusion, which should be minimised by provision of a drainage trough beneath the joint.

3.4.6 Strip Seal

Some products on the market have RTA approval under BTD2008/11. The performance of the new versions of this joint has improved over the older versions. RTA's inspectors identified this joint as having the smallest proportion of poor or failed joints of those inspected, the sample size being relatively large, indicating its suitability for bridge applications. Many highway owners around the world prefer this type of expansion joint and future continued widespread use is expected.

Build up of debris at shoulders and lightly trafficked areas can be a problem, which can be alleviated by strategically placed scuppers.

3.4.7 Saw Tooth

Two products on the market have RTA approval. As initially mandated by BTD2006/10, this joint shall not be selected for expansion joints skewed to the direction of traffic on RTA bridges or bridges that will become property of RTA.

3.5 Calculation of Joint Movements

The required movement range is the most important factor in joint selection as this will quickly reduce the number of available alternatives. Deck joints shall be designed to accommodate ultimate limit state (ULS) movements due to several effects including thermal, creep, shrinkage, differential settlement, braking forces, transverse movements especially in skew bridges and movements arising from other causes. The algebraic sum of the combination of movements shall be used to estimate the required movement range. In the case of ten or more years' old existing concrete bridges, creep and shrinkage effects become insignificant, with thermal effects usually constituting the bulk of the movement.

3.5.1 Thermal Movement

Thermal movement of bridge deck joints shall be calculated considering the articulation of the bridge, its location, altitude and type of superstructure.

The applicable temperature range to be used in calculations is specified in AS 5100.2.

3.5.2 Thermal Movement Calculator

A thermal movement calculator that includes the above factors has been developed within Bridge Engineering and has been released for use by RTA personnel. It can only be used for calculating the thermal movements of a bridge. Other movements from other causes shall be added or subtracted as appropriate to determine actual joint movements. AS 5100.4 requires the design of joints to use ultimate limit state movements. An ultimate thermal factor of 1.25 is included in the calculator.

RTA personnel can obtain the thermal movement calculator from the Senior Bridge Engineer (Policy and Specifications) Ph: (02) 8837 0850 Fax: (02) 8837 0054.

3.6 Joint Movement Range

Deck joints shall be designed for the movement range calculated in accordance with AS 5100.2.

The movement ranges applicable to some of the types of joints considered in this RTA policy document are summarized below.

Joint Type	Movement Range	Remarks
Asphaltic plug	< 50 mm	Can only be used where noise reduction is required.
Bonded metal-elastomer	50 – 165 mm	Proper installation is the key to success. 165 mm appears to be the limiting movement range.
Metal fingers bonded to elastomer	50 – 500 mm	BTD1998/04 now incorporated into Clause 2.4 of this document.
Elastomeric compression seal	> 5 mm and < 60 mm	The seal should remain in compression throughout its life.
Cold applied sealant	< 20 mm	Improvement in sealant properties has increased current nominal movement ranges to 100% elongation and 50% contraction. AS 5100.4 limits movement capacity to $\pm 25\%$ of the installation gap irrespective of claimed or tested properties.
Fabricated steel fingerplate	> 75 mm up to 600 mm	Requires a drainage trough.
Modular	> 100 mm up to 2 m	RTA studies regarding behaviour of modular joints shall be referenced before selection.
Sliding steel plate (for pedestrian traffic)	50 mm to 100 mm	Requires a drainage trough.
Strip seal	> 0 mm and < 85 mm	Claimed movement capacity more than 100 mm but restricted by AS 5100.4's 85 mm ULS maximum gap.

4 Joint Design and Installation

4.1 General

The performance of bridge deck joints depends on materials, design, installation, and maintenance.

Poor installation can lead to premature failure irrespective of design and materials used.

Joint design shall be carried out in accordance with AS 5100.4 and the relevant RTA specification.

Designers are referred to RTA papers “Design and Installation of Socket Head Cap Screws and Bolts for Expansion Joint Anchorages – April 2008”, “Locking Devices for Stressbar Nuts and Cap Screws – August 2005”, “Design of Through-Bolts for Anchoring Expansion Joints to Concrete Bridge Decks – May 2008”, “Procedures for the Design of Fingerplate Expansion Joints – May 2008”.

Joint anchorages shall not include non-metal components, except for those that do not contribute to the load carrying capacity of the anchorage e.g. plastic bolt sleeves, as such materials will result in the anchorages becoming detensioned and subsequently working loose, causing failure of the joint.

Any elastomeric drainage systems shall be attached at metal anchor points only, not through the elastomer, to prevent the attachments working loose.

Expansion joints shall not generate excessive noise or vibration under traffic.

All joint gaps and slots shall be covered where pedestrians or animals travel over the joint.

Joints shall be easily accessible for the purposes of inspection, maintenance and replacement and their components should be corrosion resistant and durable.

AS 5100.4 requires metal protection armour for compression seal and strip seal joints.

Metal protection armour should be provided to protect concrete edges, be of sufficient width and thickness to avoid welding distortion and have adequate anchorage to the deck. To prevent pull-out, anchors shall be of sufficient length into the reinforced concrete substrate. BTD1990/07 applies for protection angles with welded shear stud anchors. Anchors should preferably be cast-in.

An anti-skid treatment shall be provided to metal surfaces wider than 200 mm exposed to vehicular traffic, preferably comprising 3 mm criss-cross welds at 100 mm spacing.

Adjacent to metal protection armour, concrete nosings should be provided to minimize the risk of asphalt failure adjacent to the joint.

Compaction of the concrete surrounding the joint and armouring is critical, and is achieved by eliminating voids in the concrete. Expulsion of entrapped air underneath the joint or armouring shall be aided by providing vent or bleed holes at regular spacings along its length.

The drawings should provide clear and sufficient details of the joint and installation procedures.

In new bridge construction, provisions for diverting rainfall runoff should be in place before installing the joint to prevent as much water as possible from reaching the blockout and joint works.

A joint should be installed allowing adequate time for any bedding to cure and gain sufficient strength before being subjected to traffic. Replacement of joints in urban situations usually occurs at night just before or after midnight to minimise disruption to traffic. Temperatures at these times can be low, and curing and strength gains in epoxies and cementitious materials can be slowed, so selection of the correct product for the applicable temperature during installation is essential.

It is good practice to delay installation of deck expansion joints as long as practical, particularly for concrete bridges, to reduce the effects of creep and shrinkage.

The joint installer should adjust the setting of the joint gaps for temperatures that are different from the nominal temperature specified on the joint Drawings. This is done by taking the temperature of the bridge just prior to joint installation and multiplying the difference between the nominal and actual temperature by the length in metres between the fixed bearings/points of the bridge within which the joint lies by 0.012 for a steel bridge, and by 0.011 for a concrete bridge, and increasing the joint gap by that number in millimetres if the bridge is colder than the nominal temperature and

decreasing it if the bridge is warmer than the nominal temperature. This information should be provided on the joint design Drawings.

For large movements insert the thermometer into drilled holes in the concrete to increase the accuracy of measurement.

Cementitious mortars and concretes shall be used for joint installation, as these products are usually more compatible with the concrete substrate than non-cementitious materials and have the same material properties, including coefficient of thermal expansion. This should result in the installation being as durable as the concrete substrate with which it is composite.

Polymer concrete used for nosings for the rehabilitation of small movement joints should have low shrinkage and increased flexibility to prevent cracking and to provide a coefficient of thermal expansion similar to that of concrete for long-term durability. Such nosings and polymer concretes shall only be used where use of cementitious products is not possible.

The use of fibreglass-reinforced concrete and slurry-infiltrated fibre concrete is still in experimental stages and these products shall not be used at this time.

4.2 Asphaltic Plug

Asphaltic plug type joints shall be designed in accordance with the supplier's technical literature and specifications.

Asphaltic plug type joints shall be supplied and installed by RTA accepted suppliers, because the quality of the joint depends on the material used and method of installation.

4.3 Bonded Metal-Elastomer

This type of joint shall be installed as per the manufacturer's instructions. Anchorage bolts will need re-tightening periodically to compensate for creep of the elastomer and other loosening effects. It may be necessary to use adhesive sealants and to jack segmental panels together during installation to minimize leakage.

4.4 Metal Fingers Bonded to Elastomer

The male plate shall be installed with the fingers pointing in the direction of traffic to minimise loading of the plate and to reduce the risk of traffic snagging and lifting the male finger plate.

This type of joint shall be installed as per the manufacturer's instructions. The joint shall be provided with safety screws initially mandated by BTD1998/04 in accordance with Clause 2.4 of this document. The anchor bolts may need re-tightening periodically to compensate for effects causing loosening. It may be necessary to use adhesive sealants and to jack segmental panels together during installation to minimize leakage.

4.5 Elastomeric Compression Seals

Compression seals should be continuous and installed up the parapets or kerbs high enough to prevent water spilling over the seal ends. This joint should not be used for joints skewed more than 20 degrees.

Metal protection armour should be used to protect the joint and concrete edges in accordance with AS 5100.4. Surfaces wider than 200 mm shall be provided with an anti-skid treatment if exposed to vehicular traffic. The armouring shall be installed with uniform spacing along the joint gap.

It is good practice to measure the size of the joint gap opening and bridge temperature and estimate the probable gap width at installation between the armouring before ordering the seal to ensure the correct size and depth seal is ordered for the actual joint gap and depth which may be at variance from those specified on the Drawings.

For optimum performance, the seal should remain in compression during its service life. This is achieved by selecting the proper size compression seal taking into account all joint movements including concrete creep and shrinkage and actual gap widths and depths. Compression seals should be proportioned in a working range of 40 percent to 85 percent of uncompressed width in accordance with the manufacture's specifications to ensure positive contact against the deck joint gap

faces. It can be difficult to ensure that the seal adheres to the sides of wide joint gaps for the life of the bridge, with this possible only if the seal is supplied and installed in strict conformity with RTA B310.

Compression seals should be set below deck level to prevent protrusion above the roadway surface when fully compressed.

Correct tools should be used during installation to prevent damage. Compression seals should be set at a uniform depth without excessive longitudinal stretching by using an installing machine or other appropriate tools.

Elastomeric compression seals manufactured from ozone-sensitive neoprene compositions shall not be used as they lose resilience and harden after several years of service, this phenomenon being named compression set. The loss of elasticity leads to the seal pulling away from the sides of the joint gap opening up the joint to water penetration and choking with debris.

Forming a joint gap narrower than the design width and saw cutting immediately prior to installation of the compression seal would minimize joint width error and maximize joint performance, but this technique cannot be used for new bridges as AS 5100.4 requires metal protection armour to be provided for compression seal joints to protect concrete edges.

4.6 Cold Applied Sealant

Cold applied sealants shall have the following properties:

- a. Be resistant to water, oil, salt, stone penetration, abrasion and environmental effects.
- b. Adhere to concrete and metal.
- c. Have the ability to retain the original joint shape.
- d. Resist unacceptable softening at high service temperatures.
- e. Not harden or become unacceptably brittle at low service temperatures.
- f. Resist flow due to gravity.
- g. Deform to accommodate the design movements.
- h. Not internally rupture or fail in cohesion.
- i. Not contain substances that are harmful to road users, maintenance workers, metal protection armour, deck materials or the environment.

In the case of sealants, the manufacturer's installation specifications should always be followed and if possible, the installation should be performed by the manufacturer's representative or under the representative's supervision.

The joint design should be checked using field measured joint widths and temperatures.

Generally, sealants adhere better to concrete than to steel. Extra caution should be taken when selecting a sealant for metal protection armoured joints.

Sealants should have the specified shape factor, this being the ratio of width to depth, of approximately 2 to ensure adequate bond and strain capability. Where this is not possible, a shape factor between 1 and 2 is permitted by RTA B312. The selection of sealants should be based on sealant strain capacity at high and low temperatures and on predicted or measured joint openings and movements, whichever is the greatest.

Sealants for concrete deck joints should have a minimum depth of 10 mm and a minimum installation width of 15 mm. Maximum installation widths vary with the type of sealant used. Minimum shape factor requirements may need to be waived to accommodate joints with small gaps as the full strain capability of the sealant is not utilised in such joints.

Mastics, thermoplastics, and solvent-release thermosetting sealants can be used in joint openings up to 38 mm wide with allowable movements up to 6 mm.

Chemically-cured thermosetting sealants can accommodate up to 42 mm movement range and can be used in joint openings up to 85 mm ULS wide.

Two-component sealants shall be mixed thoroughly, usually have a limited working (pot) life after mixing and cure faster on hot days. Joint sealants should only be installed if the bridge deck temperature is between 5°C and 30°C.

Sealants should not be installed before primers are dry and should never be applied to a joint that is damp or wet. Sealants should be tooled to ensure that the sealant is adequately pressed against the joint gap faces to the correct depth and that all air voids are removed. Curing compounds should not be allowed to contaminate the joint faces.

Backer rods should be soft and flexible, not adhere to or react with the sealant and not absorb water. They should compress without expelling the sealant when the deck expands and recover to retain contact with the bottom joint face when the joint opens. Backer rods shall be installed at the correct depth without twisting and contaminating the cleaned joint faces above. Uncompressed backer rods should have at least a 25 percent greater width than the maximum joint opening to ensure compression between the concrete joint gap faces at all times.

When required, joint sawing should be performed to the specified depth and width after the concrete has hardened. Early sawing of fresh hardened concrete can result in spalling of the edges and plucking of the aggregate. Late sawing can cause random cracking.

The concrete surface should be prepared by grit blasting free of all original adhesives or sealants, tar and asphalt, discolorations, stains and any other contaminants to expose clean concrete surfaces. Any blasting grit should be removed from the vicinity of the joint prior to installation of the sealant.

4.7 Fabricated Steel Fingerplates

Fingerplate joints have little capacity for accommodating differential deflection, rotation, or settlement across the joint and should not be used if significant movements from these effects are expected. The side of the joint that is attached to the superstructure is subject to small rotations relative to the other side of the joint due to flexure of the deck under thermal and traffic effects that is magnified at the tips of the fingers due to their length. This relative displacement can cause the tips of opposing fingers to be displaced vertically relative to the other, causing increased impact loads on the joint and possible tyre damage in extreme cases. The tips of the fingers should always have a bevel larger than the calculated displacement.

The following safety related requirements in AS 5100.4 apply:

- a. The maximum opening between adjacent fingers on the same side of the joint shall be 50 mm. Further consideration is required for bicycles travelling over longitudinal slots.
- b. AS 5100.4 specifies that the minimum overlap of the fingers be 15 mm for the worst combination of movements. This occurs at the lowest temperature after all concrete creep and shrinkage has taken place.
- c. AS 5100.4 does not specify a minimum joint opening in the longitudinal direction, but this should be taken as zero. To ensure the joint does not close up at high temperatures, some designers specify a minimum permanent opening.
- d. Road shoulders should be provided with sliding plate joints when pedestrian use is anticipated.

Fingerplates should have adequate stiffness to prevent excessive vibration and have sufficient flexural capacity to prevent bending and fatigue failures.

The natural frequencies of the fingers should be checked to ensure that wheel loads at signposted traffic speed do not produce undesirable high frequency noise from the fingers acting like tuning forks. The anchoring of the joint to the concrete may be sufficient to dampen such vibrations.

Fingers should be aligned at the direction of movement to avoid exerting excessive forces on opposing fingers.

Anchorage shall have sufficient tensile and shear strength to resist loads from heavy traffic including impact, and sufficient bolt tension so that the load in the bolts does not change under the design ULS traffic load, to prevent fatigue failures of the anchorages.

Fingerplate joints for new bridges shall have stainless steel drainage troughs with cross-falls of at least 8 %. If possible, greater cross-falls should be provided to prevent debris accumulation. Use stainless steel bolts, nuts and washers. If elastomeric materials are used as drainage troughs for joint rehabilitation works, reinforced high-durometer hardness elastomers with properties similar to conveyor belts should be selected. Regular maintenance and cleaning of troughs is essential.

4.8 Modular

Modular joints should not generate excessive noise. They shall be watertight and resist without damage braking or other horizontal forces applied directly to the joint as well the design loads specified in AS 5100.4 and RTA B316.

The maximum roadway surface gap of 85 mm ULS specified in AS 5100.4 between the transverse beams shall not be exceeded. Joint components should comply with the fatigue test specification of NCHRP 402 or recognized equivalent, in accordance with RTA B316.

Manufacturers shall be responsible for both supply and installation and shall provide a guarantee or warranty on the serviceability of the joint for a minimum period of five years after installation.

4.9 Strip Seal

Strip seals should not be used on bridges with skews greater than 30 degrees. Wherever possible, glands should be inserted in a continuous length across the width of the bridge deck from parapet to parapet or kerb to kerb to improve the watertightness of the joint. No field splices of strip seals should be permitted, as this weakens the gland, unless there is no alternative. Mechanical locking within the retainer should be sufficient to hold seal in place without use of bonding agents. Lubricant adhesives are usually used to aid seal installation.

Strip seals require a minimum installation width measured normal to the joint, which shall be accounted for during the joint design.

Even though manufacturers claim a large movement capacity for strip seal joints, the maximum allowable width is 85 mm ULS, in accordance with AS 5100.4. This requirement reduces the effects of traffic impact loads, improves ride and reduces hazards to two-wheeled traffic and stock on hooves.

Glands can collect incompressible debris which may lead to tearing, puncturing or pulling out under passing traffic or from joint movements. As the joint closes up with incompressible debris wedged in the gland crevice, this can cause glands to rupture. Traffic wheel loads transferred to glands through built up debris may tear the gland or pull it out from the metal retainers. To avoid this situation on roads with gravel or other debris, use of a flush internally stiffened gland is preferred over a draped single layer gland. During design, specification of too large a size gland on the Drawings will result in early dirt entrapment in draped glands in service. Regular cleaning will increase joint life.

Bent or mitred retainers shall be used at kerb and traffic barrier upturns.

Glands should be protected from damage from high heeled shoes in pedestrian traffic by using a sliding plate joint instead.

Anchorage shall be designed to resist all static and dynamic loads (including impact). The anchorages shall be thoroughly bonded to the concrete and the concrete shall be thoroughly consolidated without entrapped air voids. The metal retainers shall have regularly spaced vent holes to allow air to escape, unless venting is provided by the anchor bolt holes.

4.10 Other

Other types of joints could be permitted for specific sites if the performance of these joints is superior for the governing constraints at the site to that of RTA approved joints, following the approval of the Senior Bridge Engineer (Policy & Specifications) Ph: (02) 8837 0850
Fax: (02) 8837 0054 after submission of joint details and design calculations.

The joint, transition strips and the adjacent deck surfaces should be on the same grade to provide good ride quality.

Traffic barriers or kerbs passing over the joint should be slotted so that full joint depth and continuity can be maintained. Slotted kerbs or barriers will need to be checked for conformity to AS 5100.

The substrate should be thoroughly dried with all loose material removed before installation of joint. The bottom of the joint gap should be sealed or covered to prevent intrusion of construction debris into the joint gap.

Proven installation methods should be used.

5 Assessment of Joint Condition and Ratings

5.1 General

The bridge joint assessment process shall comprise field inspections by RTA Regional staff of the joint and reporting on the items listed on the joint inspection proforma downloadable from the RTA's Bridge Joint Assessment (BJA) module that has been developed by RTA Bridge Engineering in partnership with IT Applications. The BJA module is accessible from within the Bridge Information System (BIS)

Inspection data shall then be entered into the BJA module by Regional staff.

The inspection data are used within the BJA module to rate the condition and performance of inspected joints.

5.2 Assessment Details

Within the BJA module in the BIS, the assessment and rating of bridge deck joints uses the field inspection reports for the items listed on the inspection proforma. These items are divided into two groups, one group for assessing severity of damage to the joint, the other group for assessing joint condition.

The eleven inspection items related to the severity of damage to the joint are:

1. Damage to adjacent deck/slab;
2. Damage to nosing/transition strip;
3. Damage to retainer/protection angles;
4. Seal splitting/puncture/tracking/flow;
5. Joint debonding from blockout;
6. Noise;
7. Joint dislodgment/seal sticking out;
8. Misalignment/twisting/jamming;
9. Debris in joint;
10. Leakage; and
11. Wear to anti-skid surfaces of joint.

The seven inspection items are used for assessing the condition of the joint. Apart from the bridge inspector's overall assessment of the joint, the six remaining items are:

1. Bolting/anchorage;
2. Riding quality;
3. Joint movement capability;
4. Kerbs;
5. Members underneath; and
6. Protective coating.

The items for severity of damage shall be reported by the bridge inspector on a scale of 1–4 where these numbers indicate respectively no or minor defect, moderate, high, and severe.

The items for condition shall be reported as good, satisfactory, poor or failed.

The bridge inspector's assessment of the overall joint condition is required as a check that the outcome of the BJA module's joint condition assessment and ratings accounting for the above individual inspection items tallies with that of the inspector's, which is given an increased weighting during the rating compared to the other items.

When reporting the overall condition of a specific inspected joint, the report on the overall condition item should be carefully considered, as the inspector's assessment significantly affects the condition and performance rating of the joint.

5.3 Condition Rating

The condition rating of the joint is also evaluated by the BJA module using all of the items reported.

The overall joint condition as assessed by the inspectors is given a higher weighting as opposed to the other items which have been given equal weightings.

5.4 Performance Rating

Based on the inspector's inspection report for these items, the BJA module rates the performance of the joint. The overall accuracy of the rating is improved by reporting on as many as possible of items listed on the inspection proforma.

The performance rating uses all of the reported damage items and all of the reported condition items. More details of the calculations done within the BJA module are available in the report "Inspections of RTA Bridge Deck Joints up to August 2007" and in the BJA module's "User Guide".

6 Monitoring, Maintenance and Rehabilitation

6.1 General

Once a joint has been assessed by RTA's Regional Bridge Maintenance Planner, using the BJA module's ratings as appropriate, as being in need of attention, the available options are to immediately start maintenance or rehabilitation work or to monitor the joint's behaviour and its overall effects on the bridge and hazard to road users when deciding on the course of action to be taken.

Do not permit spray seals or asphalt to be overlaid on top of any bridge deck joints, as this will cause damage to the joint, inhibit its performance and cause ride and later bridge maintenance problems.

Overlays of bridge decks should always only be undertaken with the concurrence of the Regional Bridge Maintenance Planner in consultation with RTA Bridge Engineering.

6.2 Monitoring

Monitoring a joint can be undertaken to better understand the condition of the joint and severity of the damage and to evaluate options before any rehabilitation work is done. Some damaged joints may require immediate attention or rehabilitation while others can continue to function satisfactorily if the damage is being aggravated only slowly by traffic. The latter joints can be left untouched if the behaviour of the joint is satisfactory for the time being. Monitoring will assist programming of joint works and assessment of functionality of the joint. Rehabilitation works can be delayed while concentrating on more critical projects. However, the severity of damage and its progression shall be evaluated to prevent any major damage to the joints or creating safety issues for road users. If safety issues are prominent, immediate action shall be taken to rectify them.

Joint areas under wheel lines in particular shall be constantly monitored for joint wear and damage.

Monitoring methods and tools should be carefully selected to provide ample warning about any impending failures or to provide sufficient information to make right decisions.

Risk management techniques can be applied to aid decision making.

6.3 Maintenance of Joints

Adequate maintenance of bridge deck joints ensures the safety of the travelling public, maintains the load carrying capacity of the bridge and its serviceability and performance at an acceptable level and minimizes the costs of repairs and bridge life cycle cost.

Joint maintenance is carried out to minimize the risk of damage by rectifying possible causes.

Regular inspections of joints should be conducted to identify maintenance or rehabilitation needs and preventive measures required to improve the quality of the joint.

Joints shall be maintained starting from their installation when the bridge is new and shall continue throughout the whole life of the bridge, to prevent the need for major expensive rehabilitation works.

Regular maintenance of joints shall be ongoing to avoid serious consequences.

Maintenance can comprise cleaning and washing of scuppers and joints, removing debris, growth and silt, which could be undertaken by road patrols or maintenance crews using simple equipment.

Maintenance can also include replacing and repairing parts of the joints, this work being classified as rehabilitation.

Leaking of water through the joint should be arrested as early as possible to control the damage possible to other bridge components and elements before this becomes too late.

Some joint type specific maintenance actions are given below.

6.3.1 Asphaltic Plug

If the road surface adjacent to a failed joint deteriorates, the deteriorated surfacing and the joint should be replaced to improve ride quality and overall durability.

Any cracked or shoved sections of joint shall be replaced as soon as practicable, to minimise water damage and traffic hazards, respectively. Maintenance may also include filling of cracks, and sealing of the interface between joint and asphalt and the like.

6.3.2 Elastomeric Compression Seal

The condition of the metal protection armour should be inspected for corrosion periodically if the protective coating fails, and the protection renewed if required. Slippery surfaces shall be made skid-resistant, as appropriate to the site. Clear the joint gap of debris, and push protruding seals back.

6.3.3 Sealant

Sealants should be replaced in accordance with the manufacturer's instructions when the ambient temperature is close to expected average temperature in spring or autumn or at times of day when the temperature is stable or increasing, to reduce the strain imposed on the sealant to improve sealant performance.

6.3.4 Fingerplate

Drainage troughs should be cleaned at least once a year, or more often as required.

Damaged fingers shall be repaired.

The joint shall be kept free of corrosion.

Any loose nuts or screws should be investigated and remedial action taken urgently, as loose nuts or screws will quickly result in fatigue failure of the anchor bolts and uplift of the fingerplates under traffic.

6.3.5 Modular

Modular joints shall be maintained in accordance with the maintenance manual supplied with the joint in accordance with RTA B316.

Where no maintenance manual exists, queries regarding joint condition and appropriate actions to be taken should be referred to RTA Bridge Engineering for specialist advice.

6.3.6 Strip Seal

Clear the joint gap and gland of debris and retighten loose nuts/bolts.

Failed glands can be patched using a new length of gland if partial repairs are necessary.

Failed joints shall be replaced with new strip seal joints designed in accordance with this policy document.

6.4 Joint Rehabilitation

Joint rehabilitation in RTA is triggered by systematic inspections of bridges that are undertaken approximately every two years.

Rehabilitation and repairs are necessitated by joint failures arising from wear and tear, use of inappropriate materials, poor installation, heavy and repetitive wheel loads, deterioration or decay of materials, changes in bridge articulation, underestimations of concrete creep and shrinkage, or a combination of these effects. Deterioration of steel elements can also be due to corrosion, fatigue, welding cracks and imperfections, buckling, loose connections, or failure of corrosion protection systems.

The BJA module's joint inspection proformas, records and ratings can assist in identifying any joint rehabilitation works required.

Any joint requiring corrective action shall be checked to assess whether a replacement or a repair is necessary.

If joint replacement is required, an acceptable joint type shall be identified that can cater for the required movement range. Sometimes a joint with less movement capacity than the original joint can be used if the bulk of concrete creep and shrinkage movements has occurred.

The remaining bridge life and difficulties in placing anchors between existing steel reinforcement shall be considered during the design of rehabilitation works. Works-As-Executed drawings are essential, with field surveys using cover meters or ground radar possibly being required to determine reinforcing bar locations.

Wherever possible and depending on the site, a failed joint shall be fully replaced with a new joint conforming to AS 5100.4 and RTA's requirements including those of this policy, as it is difficult to completely seal interfaces between existing and new joints where partial replacement is undertaken.

7 Summary

This RTA policy document provides information and requirements for commonly used bridge deck joints in RTA bridges or those bridges that will become property of RTA.

Further use of some existing types of joints has been discontinued with alternatives identified and discussed.

The selection of suitable joints for new and existing bridges depends mainly on daily and seasonal temperature variations and bridge articulation.

The severity of conditions such as the number of heavy vehicles traversing the joint, skew, environment and climate all need to be considered in design.

Preventing water leaking through expansion joints is important to avoid damage to the remainder of the bridge, especially the bearings.

Bridge deck joint performance depends on the quality of the joint materials, the skills of the bridge design engineer, the use of specialist installation contractors, the provision of robust anchorage systems and the establishment of effective maintenance programs.

This RTA policy document provides information for the selection, installation, assessment and maintenance of joints and specifies that joints be:

- Selected appropriate to the site;
- RTA approved types where possible;
- Designed in accordance with AS 5100.4, the relevant RTA specification and this policy document;
- Installed in accordance with the joint manufacturer's instructions;
- Maintained consistently starting from installation;
- Inspected periodically with priority of maintenance and rehabilitation works dictated by need;
- Inspected using the inspection form downloaded from the BJA module in the BIS; and
- Assessed regularly in accordance with the defined criteria within the BJA module and subsequent actions taken using risk management techniques where appropriate.

----- 0 0 0 0 0 -----