ASHGHAL

Interim Advice Note No. 031/14

Expansion Joints for Highway Structures

Revision No. A1

ADVICE

This Interim Advice Note (IAN) provides guidelines on the specification for expansion joints for highway structures. This IAN takes immediate effect. The following shall be noted:

- This Interim Advice Note is for use with the existing Qatar Construction Specifications (QCS) 2014 only.
- This IAN does not make any amendments to the existing Qatar Construction Specifications (QCS) 2014.
- This IAN adds a new Section and new Part to QCS 2014, namely Section 101, Part 2, Expansion Joints for Highway Structures.

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Contents

1. Foreword

1.1 Interim Advice Notes (IANs) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Design Authority, Infrastructure Affairs.

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2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
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Position:		Address:	

Please email the completed form to:

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We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3 Introduction

3.1 This Interim Advice Note (IAN), which takes immediate effect, provides information and guidance on the Specification for Waterproofing of Concrete Decks on Highway Structures. This IAN will provide interim guidance prior to issue of a revision to the Qatar Construction Specifications (QCS).

4 Additional Standard

4.1 For application to expansion joints for highway structures; Section 101, Part 2 is additional to the existing Qatar Construction Specifications (QCS) 2014.

5 Implementation

5.1 This IAN shall be implemented with immediate effect on projects as follows:

- All Ashghal infrastructure projects in design stage
- All Ashghal infrastructure projects in tender stage

5.2 Ashghal infrastructure projects in construction stage shall be reviewed by the Supervision Consultant and Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager. This shall include an assessment on the current design to determine whether it complies with this Interim Advice Note and the practicalities of modifying the design and construction in order to achieve compliance.

5.4 If in doubt, Consultants / Contractors should seek guidance from their respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

6 Disclaimer

6.1 This Interim Advice Note and its recommendations or directions have been provided for application on Ashghal's infrastructure projects within Qatar only and they are not warranted as suitable for use on other roads, highways or infrastructure with Qatar or elsewhere. Should any third party, Consultant or Contractor choose to adopt this Interim Advice Note for purposes other than Ashghal's infrastructure projects, they shall do so at their own risk.

Appendix A – Expansion Joints for Highway Structures

QATAR CONSTRUCTION SPECIFICATIONS (QCS) 2014

Additional Section 101, Part 2, Expansion Joints for Highway Structures

Appendix A
QATAR CONSTRUCTION SPECIFICATIONS 2014
Additional Section 101, Part 2, Expansion Joints for Highway Structures

PART 2 EXPANSION JOINTS FOR HIGHWAY STRUCTURES

2.1 GENERAL

2.1.1 Introduction

1 The primary functions of an expansion joint are as follows:

(a) To be able to accommodate the full movement range of the adjacent decks (structures) ending at the joints. The movement could be vertical, horizontal, transverse and longitudinal or rotational.
(b) To provide a smooth ride and skid resistance for traffic passing over the joint.
(c) To sustain all loads subjected to it from the passing traffic without damage to the surfacing or to supporting structure during their working lives.
(d) To be fully watertight at all points, from parapet to parapet, throughout its entire movement range.

2 Regardless whether expansion joints are designed to be water-tight or not, the assumption needs to be made that joints may leak in the future, special attention therefore needs to be placed by the bridge design Engineers on the following:

(a) Protection of all concrete surfaces below the joint with the appropriate protective coating system.

(b) Provision of proper drainage (large diameter drainage pipes and adequate drainage slopes) at the level of the bearing seats to ensure that staining of the abutment exposed faces and pier sides do not occur.

(c) Provision of drip grooves at specific locations, such as under the corbels supporting the joint in an abutment gallery and along the deck soffit edges to ensure that water does not cause the contamination of reinforced concrete elements of the bridge and of bearings.

(d) Provision of bearing plinths to ensure that bearings are out of reach from any possible flooding of the abutment and pier tops.

(e) Provision of stainless steel reinforcement close to all concrete surfaces below a joint which are inaccessible for future maintenance.

3 Where reference is made to ‘bridges’ in this document, this shall not exclude any other highway structure which requires an expansion joint.

2.1.2 Application

1 This document is to act as guidelines from which Designers, Suppliers and Contractors as applicable, are to produce Detailed Drawings and Specifications for the consent of the Engineer. Where choices exist, the Designer shall produce an options report outlining capital cost, maintenance costs, technical issues associated with construction and maintenance, in order to assist the Engineer in selecting the joints.

2.2 STANDARDS

2.2.1 General

1 Unless otherwise specified, the design and manufacture of the expansion joints shall comply with the requirements outlined below.

2 All the standards outlined below and any other documents and specifications referred to in this document shall be the latest edition or superseding document and specification. In case of contradictions between the standards, the mandatory standards shall always be prevailing over the advisory standards. Conflicts or contradictions shall be referred to the Engineer for resolution and direction.

2.2.2 Mandatory Standards

1 The list below outlines the mandatory standards which shall be adhered to:

Highways Agency (UK) Design Manual for Roads and Bridges (DMRB) Volumes 1 & 2

BD 37/01	Loads for Highway Bridges
BD 33/94	Expansion Joints for Use in Highway Bridge Decks
BA 26/94	Expansion Joints for Use in Highway Bridge Decks
BD 9/81	Implementation of BS 5400: Part 10: 1980 - Code of Practice for Fatigue
BA 9/81	Implementation of BS 5400: Part 10: 1980 - Code of Practice for Fatigue [Incorporating Amendment No.1 dated November 1983]

BS EN 1991-2:2003. Eurocode 1: Actions on Structures – Part 2: Traffic loads on bridges

The following Guidelines for European Technical Approval (ETA) of Expansion Joints for Road Bridges:

ETAG nº032 Part 1 – General
ETAG nº032 Part 2 – Buried expansion joints
ETAG nº032 Part 3 – Flexible plug expansion joints
ETAG nº032 Part 4 – Nosing expansion joints
ETAG nº032 Part 5 – Mat expansion joints
ETAG nº032 Part 6 – Cantilever expansion joints
ETAG nº032 Part 7 – Supported expansion joints
ETAG nº032 Part 8 – Modular expansion joints

2.2.3 Advisory Standards

1 The list below outlines the advisory standards which shall be adhered to:

CIRIA C543	Bridge Detailing Guide
CIRIA Report 155	Bridges – Design for Improved Buildability
AASHTO LRFD	Bridge Design Specifications
AASHTO LRFD	Bridge Construction Specifications
AASHTO LRFD	Standard Specifications for Highway Bridges
ACI 224.3R-95	Joints in Concrete Construction
NCHRP Report 402	Fatigue Design of Modular Bridge Joints, Transportation, Research Board, National Research Council, Washington, DC
NCHRP Report 402	Fatigue Design of Modular Bridge Joints, Transportation, Research Board, National Research Council, Washington, DC
NCHRP Report 467	Performance Testing for Modular Bridge Joint Systems, Transportation Research Board, national Research Council, Washington, DC
TRL Report No 236	Improving the Performance of Bridge Expansion Joints

2.2.4 Other Standards

1 Other approved standards which should be used in special cases to accommodate design constraints and to be compatible with local conditions.

2.3 JOINT CONSTRUCTION WORKS

2.3.1 General

1 This work shall consist of furnishing all materials, services, labour, tools, equipment and incidentals necessary to design, fabricate, inspect, test and install and warranty the satisfactory performance of the expansion joint assemblies shown on the Drawings and/or described in the Specifications including the following:

2.3.2 Types of Joints and Seals

2.3.2.1 Concrete Nosing

1 The nosing protects the adjacent edges of the surfacing at the expansion joint at road level, provides a straight edge for the placing of joint sealants or provides the support structure for the metal runners forming part of propriety expansion joint systems. It usually consists of greater than 40MPa (preferably shrinkage compensated) concrete with maximum 13 mm aggregate. Because it is subjected to wear from vehicular traffic and therefore cannot be protected, all reinforcement within the nosing unit shall be of non-corrodible steel, preferably of stainless steel.

2 Proprietary specialist cementitious materials shall be prepared and placed strictly in accordance with the Manufacturer's specifications and recommendations and be subject to the approval of the Engineer. Concrete shall be in accordance with Section 5 of the QCS

3 These joints shall meet the requirements of ETAG nº032 Part 4.

2.3.2.2 Buried Joints

1 These joints are formed in situ using components such as the waterproofing membrane acting together with an elastomeric pad, to distribute the deformations to a greater width and to support the surfacing which is continuous over the deck joint gap. A lubricant or thin sheet of flexible material may also be installed as a debonding layer for the waterproofing membrane to prevent adhesion between selected components below the waterproofing. Crack induced cuts (8mm wide by 25mm deep) filled with a bitumen based sealant or reinforcement grids are introduced in the asphalt surfacing to control cracking above the joint. The elastomeric pad is preferably recessed into the concrete so as not to reduce the thickness of the surfacing across the joint.

2 The design longitudinal movement range for these joints could vary from very small movements of a couple of millimetres to a maximum of 20mm and the maximum vertical movement between two sides of the joint shall not exceed 1.3mm. Installed typically where the asphalt wearing surface is placed directly on top of the tunnel roof slab or underpass bridge deck, at longitudinal joints in the roof slab of tunnels or underpasses, at transverse joints between the approach slab and abutment back wall, or at expansion, contraction and construction joints in a tunnel base slab.

3 The working life of the joint is influenced by the ability of the surfacing to accommodate the movement.

4 These joints shall meet the requirements of ETAG nº032 Part 2.

2.3.2.3 Compression Seals

1 These are preformed compartmentalized or cellular elastomeric devices that function as sealants when in compression. Compression seals shall remain in compression during all movement phases of the joint. These joints are not permitted for use on bridge decks as the seals do not retain their compressibility and with time lose their waterproofing ability. However they may be used in specific locations such as at expansion joints on the inside face of tunnel walls where the water tightness is achieved by other means such as through the use of an external waterproofing membrane and the installation of an external and internal waterstop. In such cases the compression seals protect the joint gap from the accumulation of sand, dirt and debris. Joints in submerged tunnels are dealt with under Interim Advice Note (IAN) 004 – Specification for Waterproofing of Cut and Cover Tunnel and Underpass Highway Structures.

2 These joints shall meet the requirements of ETAG nº032 Part 4.

2.3.2.4 Asphaltic Plug Joints (APJ)

1 This is a proprietary in-situ joint system comprising a binder and aggregate system composed of specially blended polymer modified asphalt and specific aggregate placed in layers into a prepared expansion joint block-out. This joint system will provide a flexible waterproof bridge joint and smooth running surface, which will allow for a total joint movement of 40mm (±20mm).

2 It is a combination of a highly elastic and temperature stable bitumen binder and a close to single size road stone. The stone is the load carrying element of the joint while the binder holds the stone in place and provides the elasticity to absorb all movement at the joint. The surface of every particle or stone must be coated and all voids between the stones must be filled with binder.

3 Failures have occurred where there has been an underestimation of harsh climatic conditions for the design of the binder and where the installation procedures set out by Manufacturers have been disregarded by Contractors. With this type of joint it is of paramount importance that the Manufacturer's specifications and installation procedures are rigorously adhered to.

4 These joints shall meet the requirements of ETAG nº032 Part 3.

2.3.2.5 Reinforced Elastomeric Joints (REJ)

1 This proprietary bolted down movement joint, which spans the joint gap, consists of prefabricated reinforced elastomeric units of variable lengths joined together by means of a tongue-and-groove (male-female) connection welded with special glue. They are bolted down into block outs formed in the concrete bridge deck on each side of the expansion joint gap. Expansion and contraction is accompanied by uniform stress and strain across the width of the panel joint between anchor bolt rows.

2 For durability reasons it is necessary that all expansion joints installed on highway structures are watertight. Because of the multiple units that make up the joint and the consequential numerous connection points that exist, this type of joint is susceptible to leakages so therefore cannot be considered watertight. A secondary collection of the seepage water taken to positive drainage is therefore necessary. The details of the rubber troughs and

drainage pipes which will serve the purpose of collecting the seepage water will need careful consideration.

3 Unless the drainage system is dealt with in an acceptable manner and approved by the Engineer, this joint is not recommended for use on highway structures in Qatar.

4 Bolting down of expansion joints is also generally not recommended. Care will need to be taken in the detailing of the anchor bolts to ensure that they remain tight and do not come undone in service.

5 This joint may not be installed for deck movements exceeding ±40 mm.

6 These joints shall meet the requirements of ETAG nº032 Part 5.

2.3.2.6 Elastomeric in Metal Runners

2.3.2.6.1 General

1 Elastomeric joints in metal runners consist of either:

(a) Strip (or Box) Seal Joints (Single Element/Seal), or:

(b) Modular Joints (Multi-Elements/Seals).

2.3.2.6.2 Strip (or Box) Seal Joints

1 Strip (or Box) Seal Joints shall consist of a prefabricated unit comprising an elastomeric seal fixed between metal runners. The metal runners are made up of armoured edges with runners into which the elastomeric element is inserted to a tight fit ensuring a watertight seal. Steel claws extend into the concrete to provide the strength to the armoured edges.

2 The elastomeric elements are prefabricated units which span the deck joint gap, made continuous across the full width of the bridge and may be available in different sizes to suit various movement ranges.

2.3.2.6.2 Modular Joints

1 Modular joints are required where large movements are experienced such as in multi-span bridges and shall consist of the following:

(a) Preformed elastomeric expansion joint strip seals or box seals mechanically held in place by steel hybrid edge and separation beams (structural steel body with a stainless steel head for durability). Each separation beam shall either be supported or welded to independent multiple-support bars or supported by a single-support bar system by means of yokes welded to the separation beams. The single or multiple support bar(s) shall span the joint opening on sliding elastomeric bearings located in support boxes.

(b) The device shall provide equidistance control of the preformed seals. The equidistance control system shall develop its maximum compressive force when the joint is at its maximum opening and shall be relaxed in central position.

(c) The expansion joints shall be supplied complete with strip seals, jaw extensions, angles, anchor plates, anchor bolts, support boxes, anchor studs, cover plates, kerb plates, sliding mechanisms and installation plates as may be applicable or as may be given on the Drawings or in the Specifications.

2 These joints shall meet the requirements of ETAG nº032 Part 8.

2.3.2.7 Finger Joints

1 Finger expansion joints may be installed where large movements need to be accommodated on bridges. The sliding finger joint is made up of “male” and “female” parts. The female part consists of a steel plate with fingers fixed at the one side of the expansion gap. The male part is an opposing plate with protruding fingers which is fixed at the other side of the gap. As the bridge deck expands and contracts, the fingers of the male part slide longitudinally between the fingers of the female part, always maintaining contact with (and receiving support from) the base plate of the female part below.

2 These joints are proprietary expansion joint systems custom designed and fabricated to individual specifications and best suited when the primary movement is along the axis of the fingers themselves. They do not accommodate transverse movements very well.

3 These joints shall meet the requirements of ETAG nº032 Parts 6 and 7.

2.3.3 Related Work

1 The Designer and Contractor shall coordinate works of other related trades including:

(a) Before commencing fabrication of the work, the Contractor installing the joints is required to inspect and take field measurements of work done by other trades which may affect the work. Before commencement of the work, the Contractor shall notify the Engineer in writing, of his acceptance of work done under other Divisions or by other trades. If any conditions exist which will prejudice a proper installation of the work, the Engineer shall be notified in writing, and installation shall not proceed until deficiencies are corrected and the Engineer has received the letter of acceptance.

(b) Cooperate where items of other trades are to be built into the work or where items are to be built into the work of other trades, such items shall be procured and provided in ample time to avoid delay.

(c) The Contractor shall attend upon and cooperate with other trades in respect of the works and do everything necessary to enable the work of other trades to be completed without delay.

2.3.4 Submittals and Approvals

1 Prior to manufacturing the expansion joints, the Contractor shall submit the following information to the Engineer for consideration and approval:

(a) Written certification of the Manufacturer’s experience and list of projects and references shall be provided. The joint Manufacturer shall be ISO 9001-2000 certified with at least 30 years’ experience in designing and fabricating expansion joint systems at least matching the project requirements.

(b) Evidence of at least 5 years’ experience in the Middle East of successful installation and operation of comparable proprietary expansion joints to the satisfaction of the Engineer. These should demonstrate the suitability of the system and materials proposed, in particular, for heavy traffic and for the aggressive environment and high temperatures experienced in the Middle East.

(c) Documentation to show that modular joint designs have been successfully fatigue tested and that such testing was carried out by an independent agency in accordance with NCHRP Report 402 Appendix A.

(d) Certification that the Contractors/Manufacturers welding inspection personnel are qualified and certified according to EN/ISO standards.

(e) The Expansion Joint Manufacturer's specification containing detailed information on the design standards, materials, manufacture and technical data.

(f) A European Technical Approval (ETA) document which will guarantee the working life of the Joints to be not less than the following:

#	Types of Expansion Joints	Working Life category	Years
1	Concrete Nosing	4	50
2	Buried	2	15
3	Compression Seals	1	10
4	Asphaltic Plug	2	15
5	Reinforced Elastomeric	3	25
6	Elastomeric in Metal Runners		
	Non-replaceable elements	4	50
	Replaceable elements	2	15
7	Finger Joints		
	Non-replaceable elements	4	50
	Replaceable elements	2	15

(g) Components indicated in the ETA with a shorter assumed working life than the expansion joint shall be accessible for inspection and shall be replaceable.

(h) Shop Drawings detailing all of the work requirements.

(i) Detailed procedures/method statement to be followed during the installation, replacement and inspection of the expansion joints.

(j) A certificate of compliance from the joint Manufacturer of the work to be done.

(k) The approval of the Engineer shall not relieve the Contractor of any responsibility under the Contract for the successful completion of the work.

(l) The Expansion Joint Manufacturer shall facilitate one or more visits by the Engineer or his representative to his workshop for the purpose of quality control.

(m) Damage to the joint system during shipping or handling shall be cause for rejection of the joint system.

(n) Damage to the corrosion protection system shall be repaired to the satisfaction of the Engineer.

(o) No seals or elements of the joint system shall be cut except as recommended by the Manufacturer and approved by the Engineer.

(p) At the site all expansion joint systems shall be stored in accordance with the Manufacturer's written recommendations and as approved by the Engineer.

2.3.5 Shop Drawings

1 The Contractor shall submit Shop Drawings of the expansion joint system to the Engineer for review and approval prior to fabrication of the joint, which shall include, but not be limited to, the following information:

(a) Plan, elevation, and section of the joint system for each movement rating and roadway

width with dimensions and tolerances.

(b) Complete details of all components and sections including all materials incorporated into the expansion joint system.

(c) Recommended method of determining structure temperature and determining the gap opening at a specific structure temperature.

(d) Method of installation including sequence, setting relative to temperature, anchorage during setting, installation details at kerbs, and installation of seals.

(e) Lifting locations and lifting mechanisms.

(f) Details of stage construction joints if required.

(g) Corrosion protection system. All steel surfaces, except as noted, shall be hot dipped galvanized to EN ISO 10684.

(h) Requirements for storage of joint system and details of temporary support of joint for shipping, handling, and job site storage.

(i) Design calculations for all structural elements including all, beams, springs and bearings. The design calculations shall include fatigue design for structural elements, connections, and splices. All welded splices shall be shown on the shop plans.

(j) Replacement of parts subject to wear shall be allowed for in the design. The Contractor shall submit a written maintenance and part replacement plan prepared by the joint Manufacturer. This plan shall include a list of parts and instructions for maintenance inspection, acceptable wear tolerances, and methods of determining wear, procedures for replacing worn parts, and procedures for replacing seals. Two copies of this plan shall be sent to the Engineer. The Manufacturer shall conduct a pre-installation meeting to train the maintenance personnel of the Authority on the installation and maintenance of the modular expansion joint system.

(k) Modifications to blockout reinforcing steel to accommodate the expansion joint system.

(l) Indicate welded connections using EN/ISO standard welding symbols. Clearly indicate net weld lengths.

(m) A summarized list of all expansion joints to be installed providing the joint identification mark, type, and corresponding preset gap at installation.

2.4 DESIGN CONSIDERATIONS

2.4.1 General

1 All expansion joints proposed for installation on highway structures in Qatar shall be in compliance with the performance characteristics indicated in an approved European Technical Approval (ETA) document which shall follow the guidelines set out in the European Technical Approval of Expansion Joints for Road Bridges, ETAG nº032.

2 The Approval Body issuing the ETA shall ensure that the Manufacturer supplies the information detailed in ETAG nº032 and will form the basis on which the factory production control is assessed.

3 Where the assessment of the joint depends in part on confidential information, such information shall be included in the Manufacturer's Technical Dossier (MTD). The ETA shall refer to this MTD.

4 The following are some general requirements that are pertinent to the design of expansion joints:

(a) All expansion joints to be installed on highway structures in Qatar shall be designed to function with no signs of failure when subjected to operating temperatures ranging from 0ºC to 70ºC.

(b) Expansion joints shall have a good riding quality and should not cause a hazard to any class of road user.

(c) They shall not be a combination of different joint types at any one joint location of a bridge.

(d) All expansion joints shall be watertight and be continuous across the full width of the deck including footway, verge, hard shoulder and central reserve and up into the parapets along the deck edges at an angle of 45º to the horizontal.

(e) The fixing or bonding to the bridge structure of the appropriate components that make up the expansion joint shall be strictly in accordance with the Manufacturer's specifications and instructions.

(f) All short life components of a joint such as the elastomeric element or seal shall be designed so that they can be easily replaced with the minimum of delay to road users.

(g) The interface between the expansion joint and the deck waterproofing system shall be watertight.

(h) Expansion joints shall be generally installed in a straight line. X, L or T shaped joint transitions shall be pre-moulded sealing parts to eliminate vulcanization in areas most solicited by multidirectional movements. Due to their complexity these parts shall be installed only by the joint Manufacturers specialized technicians.

(i) Where prefabricated units are used, such as for the reinforced elastomeric joint, the seal between each unit shall be made watertight unless the water tightness is dealt with separately by other means approved by the Engineer.

(j) For joints which are not designed to be water tight, such as finger joints, a separate flexible water drainage system consisting of a trough and rigid downspouts shall be installed. Such drainage systems need to be detailed to provide easy maintenance.

(k) The upper surfaces of expansion joints in footways shall have a slip resistance finish to comply with the safety requirements for pedestrians and cyclists.

5 Gap width at different locations shall be:

(a) The bridge deck gap (structure gap) is the gap between adjacent parts of the main structure, which is bridged by the expansion joint. The bridge deck gap at abutments will remain substantially constant where the bridge bearings prevent movement in the longitudinal direction. The width will vary where the joint is designed to accommodate thermal and other movements such as creep, shrinkage, elastic deformation and rotations of the deck superstructure.

(b) The Expansion Joint Gap (Surface Gap) is the continuous gap within an expansion joint system at road surface level along the line of the joint. For a modular joint system it is the sum of the gaps between sub-components of the expansion joint at road surface level.

(c) The expansion joint gap shall be of a uniform width and never less than 10 per cent of the maximum range of movement at the joint or 6mm whichever is the greater. Where more than one gap exists such as in modular joints the individual gaps shall never be less than the greater of 10% of the maximum range of movement at the joint equally subdivided between each gap and 6mm.

(d) The maximum gap at road level between sub-components of a joint system which is acceptable for motor vehicles is 80mm. Depending on the type of traffic within urban environments, maximum gap may be reduced to 65mm.

(e) If the expansion joint gap is sealed with anything other than a load bearing element, it shall be considered to be open.

(f) All expansion joint gaps in the footway shall be closed using either a load bearing seal or cover plate.

6 The skew angle shall be the angle between the axis perpendicular to the road and the longitudinal axis of the joint.

7 The requirements for deck repairs shall be as follows:

(a) Repair mortars shall be approved by the propriety joint Manufacturer to ensure compatibility with the joint.

(b) Repairs shall be carried out and fully cured in advance of the joint installation to provide a monolithic repair. The adhesion between the repair material and the reinforcement is important to avoid debonding during joint installation and its service life.

2.4.2 Buried Joints

1 The steel bridging plate used in Buried Joints shall be stainless steel to EN 10088 or hot dipped galvanized steel, grade S235 to EN 10025.

2 The design of the buried joint system shall be carried out in conjunction with the design of the surfacing system. The Manufacturers shall provide recommendations on the surfacing specifications and test their products to demonstrate that their joints will provide the required performance in service.

3 Crack induced cuts in asphalt pavement:

(a) This work shall consist of constructing a 20mm by 20mm saw cut into the asphalt pavement over the full width of the carriageway and filling it with a rubber bitumen sealant as shown on the Drawings. The rubber bitumen sealant shall be applied hot into clean straight saw-cut chases in the road surface.

(b) Heating and application shall be carefully controlled and employ special equipment to ensure that working temperatures are correctly attained and sustained during application, strictly in accordance with the Manufacturer's recommendations.

(c) The rubber bitumen sealant shall comprise a hot applied sealant composed of bitumen, rubber extended and filler.

2.4.3 Reinforced Elastomeric Joints (REJ)

1 The joint, consisting of reinforced moulded units of rubber compound or neoprene, accommodates the movements of the structure by shear deformation of the rubber elements and shall be restrained to the structure with stainless steel grade 316 anchor bolts.

2 The bolts shall be fixed to the deck concrete by chemical anchors. Mechanical anchors will not be allowed. The nuts shall be locked using a dynamometric key such that the joint elastomeric material at the bolt location remains permanently in compression onto the

concrete surface.

3 For corrosion protection the reinforced metal profiles made of steel shall be completely inserted and vulcanized to the rubber. Cutting of the joint sections for whatsoever the reason and in so doing exposing the inserted steel profiles, as is often seen at kerbs, shall not be allowed. Only prefabricated elements of the joint where proper protection is provided to the inserted steel profiles shall be utilised during installation.

4 The rubber compound shall be formulated to resist oil, grease, petrol, salt and sand, and be UV resistant to prevent any premature ageing phenomena due to the environment.

5 All ancillaries needed for the installation of the expansion joint shall be supplied by the Manufacturer.

6 The following points need to be considered, detailed and submitted to the Engineer for approval, before this type of joint will be allowed to be installed:

(a) The details of the joint at kerbs and barriers, given that the joint needs to be made continuous from parapet to parapet and should also contain the runoff water from the roadway.

(b) The detail of the joint at kerbs and parapets for skew bridges.

(c) The limiting skew angle of the joint in relation to the direction of temperature movement of the bridge when considering its performance in service.

(d) The attachment of the rubber trough to the expansion joint edges to ensure water tightness and long term durability.

(e) The proper collection of seepage water from the troughs to be taken to other drainage points, ensuring that the trough and its drainage system results in a watertight joint during the entire working life of the joint.

(f) Consideration for ease of maintenance should debris or sand collect in the troughs and drain pipes.

(g) The robustness of the transition strips to wear and tear from traffic. The strips must not crack nor should they become detached from the deck surface for the full period of the warrantee. All transition strips shall be of adequate width to resist the loads from the joint itself during deck expansion and be positively tied to the deck with reinforcement.

(h) Because of the stiffness of the reinforced elastomer, this joint shall not be installed where transverse movements need to be accommodated at joints

(i) Ensuring that the bolts remain permanently tight in service and during the warrantee period of the joint

7 The Contractor shall be responsible for the replacement of all elements of the joint where tears or cracks have formed in the elastomer or of elements which render the joint watertight if leaks are found during the warrantee period of this joint. It shall be the responsibility of the Contractor to ensure that the joint maintains water tightness during the warrantee period of the joint.

2.4.4 Asphaltic Plug Joints (APJ)

1 Asphaltic plug joints shall be formulated to withstand the temperatures and environmental conditions for structures in the Middle East. The joint shall be stable within the temperature range stated above, i.e. 0ºC to 70ºC.

2 The bridging plates used to span the expansion gap, to function as a bond breaker and to support traffic loads shall be steel of grade S275JR conforming to EN 10025 and hot-dip galvanized to EN ISO 10684.

3 Pin holes shall be drilled at 300mm intervals along the centreline of the plate for placing 16D galvanized common nails to aid in centering the plate over the joint. Plates are cut prior to galvanizing to lengths of 1 to 2m to cover the entire length of the joint gap. Any damage to the galvanizing during installation shall be repaired with an approved zinc rich coating.

4 Depending on the gap width typical plate dimensions are as follows:

Gap width	Thickness	Plate Width
< 75mm	6.4mm	200mm
75mm to 150mm	10mm	300mm

5 A closed cell foam cylindrical backer rod, capable of withstanding the temperature of the hot modified elastomeric binder, as supplied or recommended by the Manufacturer, shall be installed in the expansion gap immediately below the bridging plates to prevent the binder from penetrating into the expansion gap.

6 Service ducts required to pass through the joint shall be properly sleeved, articulated and sealed to prevent binder ingress.

7 There shall be a minimum gap of 50mm between service ducts and bridge decks and 150mm between service ducts, to allow placement of caulking, sealing, tanking and plating to the joint. The inappropriate position of ducts within joints can seriously affect the performance of Asphaltic Plug Joints.

8 All sleeves shall be of galvanized steel and free of any cables or heat degradable materials prior to joint installation.

9 Some of the limitations of this type of joint are as follows:

(a) The dynamic vertical movement shall not exceed 1mm.

(b) The total horizontal movement due to temperature, creep and shrinkage shall not exceed 40mm and the maximum vertical movement between two sides of the joint shall not exceed 3mm.

(c) The transverse crossfall, measured along the centreline of the joint, shall not exceed 4 per cent. This is particularly important on roads with large volumes of heavy, slow moving vehicles.

(d) The skew angle of the joint shall not exceed 25º.

(e) The following locations are not suitable for Asphaltic Plug Joints:

(i) Close proximity to junctions and traffic lights and where there is a likelihood of a build-up of stationary traffic (within 50m of a traffic intersection).

(ii) Structures with tight curves.

(f) Longitudinal joints may only be considered when they are not in the wheel path.

2.4.5 Elastomeric in Metal Runners

1 The elastomeric seals shall be extruded in one continuous, smooth-surfaced piece using a vulcanized elastomeric compound containing neoprene or Natural Rubber (Polyisoprene) as the sole polymer. Seals shall not be spliced but shall be installed as one continuous piece across the full length of the joint.

2 The seal shall be resilient, resist heat, oil and ozone.

3 The seals must be able to tolerate a joint gap of 80mm under normal operating range and up to 120mm (for seismic applications) and yet still fulfil their functionality (i.e., not get torn out of the steel sections and maintain the watertight connection of two steel beams).

4 The seals shall resist pulling forces and accommodate lateral, transverse and vertical movement. The seal shall be connected to the metal runners by means of a positive or a non-positive interlocking system. They shall not rely on the compression of the seal as the sole means of restraint. It must not be fixed by means of screws, bolts, glue or other additional fixation devices. The claw in the metal runner, and the seal geometry, shall be such that any moisture on the joint will drain away from the metal runner.

5 The stress on the edge of the structural gap due to expansion and contraction of the joint should be practically nil (without substantial reaction forces).

6 Minimum thickness of any load bearing steel section incorporated in the joint assembly shall be 10mm.

7 The minimum thickness of the individual layers of polymer material that make up the seals shall be 6mm.

8 The expansion joints shall be anchored by means of loop anchors. No head studs shall be allowed. The expansion joint shall be designed to allow connection of the asphalt and the edge profile shall be designed to allow connection with the recommended asphalt thickness specified on the Drawings. The edge profile shall have a horizontal flat steel strip to allow connection of the bridge deck water proofing. The minimum length of this horizontal flat steel shall be 100 mm.

9 To avoid field splices in the metal runners, assemblies shall be designed, fabricated and delivered to the job site as a continuous unit whenever possible. The maximum length of a completed expansion joint assemblies shall be determined by practical transportation or shipping requirements. Generally, no field splices shall be allowed in the centre and edge separation beams of modular joints except as required by stage construction.

10 If field splices are unavoidable, the following is recommended:

(a) The splices shall be located in areas outside the main traffic lanes and consist of a welded separation beam splice in which the weld is a full penetration weld. The Contractor shall complete the field splices in accordance with the details and procedures included in the Shop Drawings.

(b) If field splices cannot be welded using a full penetration weld, the preferred splice detail consists of side plates bolted into recesses machined out of the centre separation beam profiles. The nuts are tack welded to the unstressed stick out end of the bolt to prevent the nuts from backing off.

(c) The expansion joints shall maintain their water tightness requirements at all bolted

and welded field splices.

2.4.6 Modular Joints

1 Documentation shall be provided to show that modular joint designs have been successfully fatigue tested and that such testing was carried out by an independent agency in accordance with NCHRP Report 402 Appendix A19:

(a) Opening Movement & Vibration (OMV) Test: The full-scale joint section on which the test is carried out shall feature noise-reducing surfacing if such surfacing is required under the contract.

(b) Seal Push Out (SPO) Test: As required by Appendix A19, this test is to be carried out following completion of the OMV test, on the same specimen.

(c) Fatigue Testing: Infinite life regime testing shall be successfully completed, with the number of load cycles being at least 6 x 10^6 cycles. The specimens on which the testing is carried out shall feature noise-reducing surfacing if such surfacing is required under the contract.

2 All fatigue-critical connections (e.g. centre beam-support bar) have to be tested by an independent laboratory, experienced with the execution of dynamic testing. A minimum service life of 50 years has to be shown by fatigue testing.

3 For the multiple support bar system, each separation beam shall be supported and welded to independent multiple support bars. The weld shall be fatigue tested in accordance with NCHRP Report 402.

4 The expansion joint system shall be designed and detailed with adequate access to all internal components in order to assure the feasibility of inspection, maintenance, and replacement activities. To this extent welded connections shall be minimized or avoided (preferred).

5 The expansion joint system shall be designed and detailed to minimize concrete cracking above the support boxes. Measures taken shall include assuring adequate support box top plate thickness, specifying any additional roadway deck steel reinforcement required, and providing adequate concrete cover.

6 The expansion joint system and roadway deck steel reinforcement shall be detailed to assure that adequate concrete consolidation can be achieved underneath all support boxes.

7 The elastomeric or urethane springs, bearings, control springs and any of the other items listed in the warranty shall be designed to be removable and replaceable. The removal and reinstallation of each strip seal shall be easily accomplished from above the joint, with a 32mm minimum gap width.

8 All wear parts (elastomeric and sliding components) of the modular joints shall be readily replaceable using bolted connections. Where allowed by the design of the bridge structure and adequate access beneath the joint is possible, inspection and replacement of all wear parts except strip seals shall be possible from beneath the modular joints without affecting traffic.

9 A gap control system shall ensure the distribution of overall bridge gap movements among the individual gaps of the modular joint. The control system shall be elastic, allowing the width

of one gap to vary from that of another and allowing centre beams to deviate from parallel – thus allowing rotations and preventing constraint forces (for example, should a gap become blocked by a stone), and improving fatigue performance. The elastomeric control elements shall function by shear deformation only in order to ensure uniform force/deformation performance (ratio) for both closing and opening movements of the modular joints, and should have neutral forces at the central opening width of the joint in order to maximize fatigue performance.

10 Mechanically fastened neoprene and steel laminated shear restriction devices which are externally mounted will not be allowed. The design of the pins (nylon rods) shall be such that they are prevented from traveling or migrating out of the equidistant control devices.

11 Except at bolted field splices and in replaceable parts, bolting in general will not be allowed, for vibration reasons. Pre-stressing of bolts cannot be always maintained.

12 Support boxes shall be designed to prevent entry of concrete during the encasement operations, to adequately protect the contents from ingress of water or dust.

13 Support bars shall be supported by sliding surfaces consisting of polytetrafluorethylene (PTFE) or special sliding material bearings on stainless steel sheets continuously welded to the support bars. The thickness of the sheets shall be such that they do not buckle or separate from the support bars in service. The stainless steel sheet shall be wider than the support bar bearing dimensions. The edge of the stainless plates shall be bent up at 45º beyond the width of the support bar to prevent damage to the bearings.

14 The support bars should never be allowed to move off their bearings in service, to ensure that the bearings are always located entirely under the stainless steel sheets.

15 For the multiple support bar system, each support bar shall utilize dual lower and upper bearings designed at each side of the support box location within the support box. Support bar bearings shall be provided with a positive method to ensure no displacement or rotation. The locating devices shall in no way negatively affect the spring or bearing compressed under maximum design load.

16 The average contact pressures for PTFE shall not exceed the following values:

	Bonded PTFE	Confined PTFE
Under Permanent Loads	20 MPa	30 MPa
Under All Loads	30 MPa	45 MPa

17 Fibre Stresses in PTFE: extreme edge fibre stresses under maximum vertical loads and maximum allowable rotations shall not exceed the following values:

	Bonded PTFE	Confined PTFE
Under Permanent Loads	25.0 MPa	37.5 MPa
Under All Loads	37.5 MPa	55.0 MPa

18 Design calculations and drawings should clearly show that the design of all aspects of the assemblies is in accordance with the requirements given in these Specifications and the applicable Drawings. Calculations and shop drawings shall be submitted to the Engineer for approval.

2.4.7 Finger Joints

1 Finger joints shall be anchored by means of a steel substructure embedded in the concrete with loop anchors. The male finger plates shall be pre-tensioned downwards onto the substructure by pre-tensioned friction-grip bolts to ensure that their fingers remain in permanent contact with the opposing sliding surface below. The fingers span the expansion gap and act as simply supported beams (without any cantilever effect.

2 To ensure that no contact occurs between the fingers of the "male" sliding plates and those of the "female" plates between which they would slide, a very high level of accuracy shall be required in the fabrication of the finger plates; a tolerance of only +/- 1mm shall be deemed necessary.

3 A large replaceable watertight drainage channel (trough) below the joint, typically partly made of reinforced neoprene shall be provided for drainage of the deck runoff water.

4 The material of the membrane of the trough shall be ozone-resistant, to avoid deterioration from the sun ray's which will pass through the fingers of the joint above and partly translucent, to enable the condition of the membrane and the amount of debris collected in it to be assessed from below.

5 Care shall be taken to ensure that when the joint is fully closed there can be no contact between the rigid parts of the drainage channel at either side of the joint, and when the joint is fully open, the flexible membrane of the drainage channel must not be pulled too tight.

6 The trough shall also be designed to limit the build-up of dirt and debris and shall have a slope of at least 8%.

7 The trough shall have a flexible discharge outlet at its low point for connection to the bridges drainage system. The trough shall be easily flushed clear of any gathered sediment (sand and debris) during periodic bridge cleaning activities. To facilitate this, an external hose connection point may be provided in the non-trafficked part of the joint and the trough be given a dirt repellent surface.

8 During the installation of the joint, stainless steel permanent shuttering plates shall provide support to the fresh concrete during placing and shall also serve as a connecting surface for the drainage channel.

9 As for reinforced elastomeric joints, it is imperative that the drainage system is properly designed. All of the issues raised above with regards to drainage and joint detail at kerbs and parapets to contain the deck runoff water to the roadway for the reinforced elastomeric joint is also applicable to this joint and shall be subject to the Engineer's approval.

2.5 MATERIALS

2.5.1 Reinforced Elastomeric Joints (REJ)

1 The rubber compound shall be formulated to resist oil, grease, petrol, salt and sand and be UV resistant.

2 All anchor bolts shall be of stainless steel and shall conform to BS EN ISO 3506. The grade shall be in accordance with the Manufacturer's requirements.

3 Special pre-manufactured elements shall be installed at kerbs and parapets where the joint shall be angled up at 45º to contain water runoff within the roadway.

4 The physical properties of the rubber compound shall be as follows:

	TYPICAL VALUES	TEST METHOD
Hardness	55±5 Shore A3	UNI ISO 7619-1
Tensile Strength	≥10 N/mm2	ISO 37
Elongation at Break	≥ 350%	ISO 37
Compression set of 25% for 24 h @ 70ºC	≤ 25%	ISO 815
Ozone resistance (50 pphm/20% strain after 100 hrs @ 40ºC)	No visible cracks	ISO 1431-1
Brittleness temperature	≤ -25ºC	UNI ISO 812
Bond Test	≥ 10 N/mm	UNI ISO 813
Shear modulus (G)	0,9 N/mm^2 ± 15%	EN 1337-3 Annex F

5 Variation after ageing for 96 hrs @ 70ºC – ISO 188-90 as follows:

	TYPICAL VALUES	TEST METHOD
Change in Hardness	Max ±15 Shore A3	UNI ISO 7619-1
Change in Tensile Strength	Max ±15%	ISO 37
Change in Elongation at Break	Max ±20%	ISO 37
Oil resistance (72 hrs @ 100ºC)	< 10%	ASTM D412

6 Other materials utilised for the installation of the joint such as the grout mortar shall be strictly in accordance with the Manufacturers specifications.

7 All structural steel shall be S355 and S235 to EN 10025 or steel with equivalent elongation at break.

2.5.2 Asphaltic Plug Joint (APJ)

1 The APJ component materials including asphaltic binder, aggregate, bridge plates, and the backer rods shall comply with ASTM D6297.

2 The binder shall be a polymer modified asphalt. It shall meet the requirements set forth in ASTM D6297 and it shall be independently tested according to the following:

	TYPICAL VALUES	ASTM TEST METHOD
Cone Penetration @ 25°C	≤ 7.5 mm	D5329
Cone Penetration @ -18°C	≥ 1.0 mm	D6297
Flow @ 60°C, 5 hr.	≤ 3.0 mm	D5329
Bond, 100% extension, 12.5mm, 3 Cycles	Pass 3 cycles	D5329
Resilience @ 25°C	40-70%	D5329
Asphalt Compatibility	Pass	D5329
Softening Point	≥ 82ºC	D36
Flexibility/Pliability @ -23°C	Pass	D5329
Ductility @ 25°C	≥ 400 mm	D113
Tensile Adhesion @ 25°C	≥ 700%	D5329
Recommended Pouring Temperature	195ºC	
Safe Heating Temperature	205ºC	
Brookfield Viscosity, 204ºC	-7ºC	D5329

3 The aggregate stone used shall primarily consist of a specially selected igneous rock, such as Granite, Basalt, Gabbro, Porphyry or Gritstones. The specified aggregate shall be crushed, double washed, dried and appropriately bagged. They shall meet the following gradation requirements:

Sieve Size	Percent Passing
22mm	95-100
16mm	40-60
13mm	15-40
10mm	0-15
6mm	0-7
No 8	-

4 All backer rods shall satisfy the requirements of ASTM D5249, Type 1.

2.5.3 Modular and Strip (or Box) Seal Joints

1 All steel sections and related hardware shall be fabricated from steel conforming to AASHTO M270, Grade 50 (345) (ASTM A709, Grade 50 (345)) or grade S355M to EN 10025-4 or approved equivalent, with properties verified by mill test certification and shall be hot-dip galvanized in accordance with EN ISO 10684 to a zinc thickness of 600 g/m$^{2.}$

2 The stainless steel sheet shall conform to EN 10088-4 grade EN 1.4401 or EN 1.4404 steel and be continuously welded to the support bar and be of minimum thickness 1.5 mm.

3 Face of the stainless steel in contact with the sliding material: bright annealed mirror (No. 8) finish (less than 0.2 µm RMS).

4 Surfaces mating with PTFE/special sliding material shall not vary from flat by more than 0.0002 Lh mm; where L (mm) is the overall length of the surface and h (mm) is the thickness of unconfined PTFE/special sliding material or the projection of confined PTFE/special sliding material above the top of the confining recess.

5 Base material for the strip seal shall be either of natural rubber, EPDM or neoprene, and shall meet the following requirements as set forth in ASTM D5973 and when independently tested according to the following standards:

PROPERTY	NOMINAL VALUES	ASTM TEST
Hardness, ° Shore A	55 ± 5 points	D2240-04
Tensile Strength (Minimum)	13.8 MPa	D412
Ultimate Elongation	250%	D412
Heat Resistance	70 hrs @ 100°C	D573
Change in Hardness, Durometer A	+10	
Change in Tensile Strength	-15%	
Change in Ultimate Elongation	-20%	
Compression Set , 70 h at 100°C	Max. 35%	D395 Method B
Ozone Resistance (wipe with solvent to remove surface contamination)	No cracks	D1149 20% Strain 40° C ± 2°C
Brittleness @ -40° C	No failure	D746 Procedure B
Low Temperature Stiffening, Durometer A	168 hrs @ -10°C 15	D2240
Oil Swell 70 hrs/100°C Oil #3 - Volume Change (%)	Max 45	D471

6 The preformed box seal shall meet the following requirements:

Property Determined on Actual Seals	Physical Requirements
High temp. recovery, 22 hrs./100°C, under 50% deflection	Min. 85% recovery
Low temp. recovery, 72 hrs./-10°C, under 50% deflection	Min. 75% recovery
Low temp. recovery, 22 hrs./-30°C, under 50% deflection	Min. 65% recovery

7 Polytetrafluorethylene (PTFE) shall be as follows:

(a) 100% virgin polymer, either unfilled or with a suitable inert filler and/or reinforcement to minimize the cold flow tendencies while maintaining the desired friction properties of the PTFE.

(b) Resistant to all acids, alkalis and petroleum products, stable at temperatures from -220°C to +260°C, non-flammable and non-absorbing of water.

8 PTFE surfaces shall not vary from flat by more than 0.2mm at any point.

9 Complete documentation and verified test data shall be supplied to fully indicate that the properties of the particular seal and the seal material are in accordance with the requirements set out above.

10 Seals shall be supplied 125mm longer than the required length shown on the Drawings. The

extra length from the seals shall be removed in the presence of the Engineer who may then request the samples to be used conduct physical tests verifying that the required properties have been achieved.

11 The Engineer shall visually inspect the seals when delivered to determine compliance with requirements such as surface quality and dimensional tolerances which do not require physical tests.

12 If any inspection, either visual or by physical testing, shows that any part of the joint assembly does not meet the requirements of this Specification, the unsatisfactory part or parts shall be replaced at no cost to the Authority.

13 An adequate amount of approved liquid lubricant/sealer shall be supplied complete with full instructions on proper, approved application procedures.

2.6 DESIGN REQUIREMENTS

2.6.1 General

1 All components of expansion joints shall be capable of sustaining the loads and movements described below without damage to itself, to the surfacing and the supporting structure during their working lives and without damage to the waterproofing characteristics of the joint itself.

2 The following characteristics shall be as specified in the expansion joints ETA document, following the guidelines of ETAG nº032:

(a) Mechanical Resistance

(b) Resistance to fatigue

(c) Seismic behaviour

(d) Movement capacity

(e) Cleanability

(f) Resistance to wear

(g) Water tightness

3 All expansion joints shall be designed using the traffic loads and combinations specified in Annex G of ETAG No 32 Part 1.

4 The design movement range shall be specific to the bridge in question. This includes the relative vertical and horizontal movements between two sides of an expansion joint, arising from the passage of a live load along the bridge. All possible direct or secondary effects on movement at the free end of a span or bridge such as creep, shrinkage, elastic deformation, steel relaxation, temperature range and temperature difference shall be considered in the design. Nominal values of movement that can occur simultaneously shall be combined to determine the most severe effect on the joint in question. Lateral movement in wide, curved or skew bridges shall also be considered.

5 Any longitudinal and vertical movement at joints arising from the predicted differential settlement of the bridge supports shall be taken into account. If large movements are expected the joint shall be designed so that it can be released with a temporary joint and

reinstated after the subsidence wave has passed.

6 Generally the maximum acceptable vertical deviation between two sides of a joint is 3 mm, except for a buried joint where it is 1.3mm. The total acceptable longitudinal movement is dependent on the joint design.

2.7 EXECUTION

2.7.1 General

1 The expansion joint system shall be fabricated in accordance with the dimensions, shapes and details shown in the approved Shop Drawings and in conformance with the Standards, Specifications and the Special Provisions of this document.

2.7.2 Fabrication

1 The Manufacturer shall produce the expansion joints in his own work shop only. Sub-contracting shall not be permitted.

2 Quality Assurance: The Manufacturer shall operate a Quality Assurance (QA) system according to ISO 9001-2008 or equivalent approved. The QA system must be in use for more than 5 years and must have successfully passed at least one repeat audit.

3 Independent monitoring: The production of expansion joints in the factory must be inspected at least twice per year by an approved independent testing authority with appropriate expertise in the field of expansion joint production.

4 Welding: For welding, the Manufacturer must be qualified according to DIN 18800 Part 7 with extension for steel road bridges according to DIN 18809 or according to EN 3834-2. All welders must be approved according to EN 287 Part 1.

2.7.3 Corrosion Protection

1 All steel surfaces, except where noted, shall be protected against corrosion by the following methods:

(a) Surface preparation: By grit blasting to SA2.5 or SSPC SP10 standards.

(b) Hot Dip Galvanization to EN ISO 10684 with a minimum thickness of 100 micron.

(c) Or alternatively protected with a paint system fulfilling the requirements of very demanding marine environment as specified in EN ISO 12944 C5M. The durability of the corrosion protection system shall be in the category High (H) - more than 15 years.

2.7.4 Delivery and Assembly

1 The expansion joint system shall be delivered to the job site and stored in accordance with the Manufacturers written requirements and as approved by the Engineer.

2 Lifting locations, lifting mechanisms, and temperature setting devices shall be as shown on the Shop Drawings. The gap on the job site shall be adjusted in accordance with the information given on the Drawings.

3 Care shall be taken to remove all buried adjustment clamps and bolts prior to casting the assembly into the blockouts.

4 Damage to the joint system during shipping or handling shall be a cause for rejection of the joint system.

5 Damage caused to the corrosion protective system during transportation or during repairs shall be made good at the Contractor's expense and to the satisfaction of the Engineer. The procedure and materials proposed for the repairs shall be issued to the Engineer for his approval prior to application.

2.7.5 Installation – General

1 The expansion joints is required to be installed under the supervision or direction of the Supplier or his authorized agent as approved by the Engineer and in strict compliance with the Manufacturer's recommendations and instructions

2 Two weeks prior to the intended installation, the Engineer shall be supplied with two copies of the written Manufacturer's recommendations and instructions.

3 A qualified installation technician shall be present at the job site to assure proper installation of each expansion joint system. This technician shall be a full time employee of the Manufacturer of the specific expansion joint system being installed with proven previous experience on the particular systems. The Contractor shall comply with all recommendations made by the joint Manufacturer's installation technician as approved by the Engineer. Each expansion joint system Manufacturer's installation technician shall certify to the Engineer that the approved installation procedures were followed. All certifications to the Engineer shall be in writing and shall be signed and dated by the Manufacturer's installation technician.

4 Following fabrication and before shipping and immediately after installation, all joints and seals are to be water-tested for failure (leakage). Field testing shall be carried out in the presence of the Engineer. The joints shall be flooded for a minimum of one hour to a minimum depth of 75mm. If leakage is observed, the expansion joint system shall be repaired at the Contractor's expense and retested until no leakages are apparent. The repair procedure shall be recommended by the Manufacturer and approved by the Engineer.

2.7.6 Installation – Reinforced Elastomeric Joint (REJ)

1 The Contractor shall obtain installation instructions from the Manufacturer of the joint and adhere to the instructions fully during the installation. Shop Drawings shall be submitted to the Engineer for approval prior to any installation. The adequacy of the joint design and installation details shall meet with the approval of the Engineer and his decisions shall be final. The Contractor shall obtain the technical assistance of a representative from the joint Manufacturer during its installation.

2 Joint assemblies shall be installed after the asphalt pavement has been laid. Before the asphalt pavement is laid the Contractor shall cover the joint opening with a strip of thin rigid material and a strip of strong paper or plastic equal in width to the joint assembly plus the transition strips on each side. After the paving is finished, saw cuts shall be made by the Contractor across the asphalt pavement either side of the joint plus transition strips and the asphalt concrete between these cuts shall be broken out. The protective strips shall then be removed and the concrete surfaces thoroughly cleaned prior to installation of the joint assembly. Once the strip of asphalt pavement is removed from between the saw cuts, the Contractor shall prevent construction traffic from crossing the joint until such time as he has installed the joint assembly.

3 The appropriate elastomeric expansion joint size is determined by the total movement range at the joint resulting from shrinkage, creep and temperature change.

4 Proper adjustments shall be made when setting the joints for the temperature at the time of installation. The accommodation of temperature effects shall be agreed with the Engineer prior to installation of the joint assembly.

5 Upon removal of the asphalt, the dowels required to connect the transition strip material to the deck concrete shall be installed. It will be up to the joint Manufacturer as to whether the transition strip is constructed before or after the installation of the joint itself. Construction of the transition strip after installation is preferred.

6 Shop Drawings shall be issued for approval by the Engineer at least one (1) month prior to the installation of the joint and shall include the following details:

(a) All details which make up the entire joint system, indicating the movement ranges that shall be accommodated by the joint, the details of the joint system at kerbs and at parapets. All joints shall be made continuous across the full width of the bridge deck and shall end in the parapets tilted upwards at an angle of 45º. Because of the stiffness of these joints it shall be preferable that joints remain at the same level and slope as the roadway at kerbs and medians. The opening resulting from such a detail in the median and footway may be spanned by steel plates, with the appropriate non-slip coating, bolted down and recessed into a raised reinforced concrete nosing on one side and supported by another nosing on the other side of the joint allowing for the full movement range of the joint.

(b) The transition strip, including the size and spacing of the dowels, type of grout used to anchor the dowels, diameter, depth and spacing of the grout holes, preparation of the surface, width of transition strip, material making up the transition strip, etc.

(c) The trough and its connection details to the bridge deck gap adjacent edges.

(d) The drain pipe and its connection to the underside of the trough and how the water shall be disposed of into drains located within the bearing seat of the piers or abutment.

(e) It is assumed that such drainage pipes cast into the abutment seats and pier columns will have been detailed on the Design Drawings if such joints are recommended for installation at structures. It is however the responsibility of the Contractor that the drains from the proposed joint has an outlet to drain the seepage water accumulating in the troughs. Such details shall be discussed with the Engineer in sufficient time and prior to the construction of the piers and abutments.

(f) Whilst every care shall be taken that the joint is designed and detailed to minimize the accumulation of the sand and debris in the drainage system, it shall be imperative that how access to the trough is gained for periodic cleaning shall be detailed in the Drawings.

7 The bridge deck gap shall be sufficiently wide to accommodate the trough and drain pipes. This is particularly important for the design of joints which result in narrow bridge deck gaps. The gaps provided shall in such cases be larger than the range of movement requirements at the joint to ensure that the trough and drainage pipes are properly accommodated. It shall be the responsibility of the Contractor and Manufacturer to prescribe the bridge deck gap needed before the concrete sections adjoining the joint are cast. Such areas of the works shall be subject to the approval of the Engineer prior to construction.

8 Prior to the installation of the trough, the concrete edges on either sides of the bridge deck gap shall be skimmed smooth by means of a concrete saw to ensure a smooth and clean surface to receive the trough. Such skimming operation shall in no way affect the cover to reinforcement of the concrete section affected.

9 Install the rubber trough and drain pipes in accordance with the Manufacturer's instructions. The trough shall be clamped with a rigid stainless steel rod and bolted with stainless steel bolts at close spacing to both sides of the joint opening with the appropriate adhesive to ensure that the connection of the trough to the sides of the concrete edges results in a watertight connection and shall function as a watertight connection for the working life of the joint. The trough shall be closed off at ends and have a drainage pipe of sufficient diameter attached to the underside of the trough.

10 Prior to the installation of the joint, the trough and drainage pipes shall be filled with water, tested for at least three hours to verify that no leaks are observed. This test shall be subject to the approval of the Engineer. Any leaks observed during such tests shall be repaired according to a recommended procedure from the Manufacturers of the joint which shall be subject to the approval of the Engineer. Only upon approval of the Engineer shall the installation of the joint resume

11 Concrete surfaces on which the reinforced elastomeric expansion joints are to be set shall be dry, clean and free from dirt, grease, latency and contaminants, level and sound with no broken or spalled concrete. No joint shall be placed until the Engineer has inspected and approved the seat conditions.

12 The reinforced elastomeric joint shall be installed following the instructions of the Manufacturer. The Manufacturer shall ensure that his representative is in attendance on site at all times during the joint installation.

13 The finished joint shall present a smooth, neat appearance with no protruding bolts or rough joints. Upon completion of an entire joint, the Contractor shall grind any uneven end butt connections flush.

14 Any openings between butt ends at tongue and groove connections not showing mastic to the top shall be cleaned and filled with mastic.

15 After installation of the joint, the remaining open concrete deck surface between the joint and the asphalt shall be cleaned to remove all traces of loose material and contamination. Care shall be taken not to damage the dowel bars located in this area. The surface shall then be dusted and blown clean with oil-free compressed air, followed by degreasing with white spirit alcohol and then drying thoroughly before the transition strip material is applied.

16 The transition strips between the asphalt surfacing and elastomeric deck joints shall be constructed strictly in accordance who the approved procedures of the Manufacturers and as detailed in the Drawings. The material that makes up the transition strip, which may be a proprietary material or simply concrete, shall be applied to the cleaned concrete surface strictly in accordance with the Manufacturers recommendations and procedures, then compacted and leveled.

17 If concrete is used then it is advised that a shrinkage compensated polymer modified cementitious material be used. This detail shall be subject to the joint Manufacturer's instructions and recommendations.

18 The above noted points shall form the minimum requirements for the installation of an elastomeric joint. Other details not mentioned which form part of the requirements of the joint Manufacturer shall be strictly followed from the Manufacturers specifications, instructions and recommendations.

2.7.7 Installation – Asphaltic Plug Joint (APJ)

1 The joint shall only be installed when the bridge superstructure surface temperature is within the allowable limits specified by the joint Manufacturer's specification.The superstructure surface temperature shall be determined from the average of three or more surface temperature readings taken, with a calibrated hand held digital infrared laser-sighted thermometer at different locations on girder surfaces protected from direct sunlight, by the Contractor as directed by the Engineer.

3 The joint shall be installed symmetrically about the deck joint opening to the dimensions shown on the plans and as directed by the Engineer.

4 Saw cut lines shall be marked on the asphalt surface prior to saw cutting. The maximum width of the joint shall not exceed 600mm unless approved by both the Engineer and Supplier. The saw cuts shall extend to the full depth of the asphalt overlay without damaging the deck waterproofing which shall extend 25mm into the joint area.

5 The existing bituminous concrete overlay, parts of the waterproofing membrane and/or existing expansion joint material, within the saw cut limits shall be removed and disposed of to create the joint cut-out.

6 Concrete surfaces, that will support the bridging plates, shall be smooth and form a plane along and across the deck joint. Rough and damaged concrete surfaces shall be repaired with suitable cementitious levelling compound as recommended by the APJ Supplier. The existing and repaired concrete surfaces shall provide continuous uniform support for the bridging plate and prevent the plate from rocking and deflecting.

7 Prior to the installation of the backer rod, all horizontal and vertical surfaces of the join cut-out shall be cleaned using a hot compressed air lance to remove any moisture and debris. The hot air lance shall be capable of producing an air stream at 1,600ºC with a velocity of 900 m/sec. Primer, if required, shall be applied to the joint cut-out surfaces as recommended by the joint Supplier.

8 Backer rod, with a diameter at least 25% greater than the existing joint opening at the time of installation, shall be installed in the existing deck joint opening between the concrete edges.

9 Prior to application, the binder shall be heated, with equipment recommended by the Supplier, to a temperature within the Supplier's recommended application temperature range. During application, the temperature of the binder shall be maintained within this range. In no case shall the temperature of the binder go below 180ºC nor exceed the Supplier's recommended maximum heating temperature.

10 After installing the backer rod in the deck joint opening, asphaltic binder shall then be poured into the joint opening until it completely fills the gap above the backer rod. A thin layer of binder shall next be applied to all horizontal and vertical surfaces to the joint cut-out.

11 Bridging plates shall be placed over the deck joint opening in the joint cut-out. The plates shall be centred over the joint opening and secured with locating pins along its centreline. The plates shall be placed end to end, without overlap, such that the gap between plates

does not exceed 6 mm. The plates shall extend to the gutter line, where concrete support exists on both sides of the joint. Within the APJ installation limits, where concrete support does not exist at both sides of the joint opening (such as where a bridge deck end abuts a bituminous concrete roadway shoulder), bridging plates shall not be installed. Installed bridging plates shall not rock or deflect in any way. After installation of bridging plates, asphaltic binder shall be applied to all exposed surfaces of the plates.

12 The remainder of the joint cut-out shall then be filled with a matrix of hot asphaltic binder and aggregate prepared in accordance with the joint Supplier's instructions and the following requirements:

(a) The aggregate shall be heated in a rotating drum mixer to the Supplier's recommended minimum temperature, but not less than 180ºC.

(b) Asphaltic binder material, heated separately to a temperature within the range specified in the Supplier's written instructions, shall be added to the mixer in a proportional amount recommended by the Manufacturer to coat the aggregate.

(c) The temperature of the aggregate and binder shall be monitored with a calibrated digital thermometer.

(d) All aggregate shall be fully coated with hot asphaltic binder in the mixer before placement in the joint cut-out.

(e) The combined matrix of hot binder and aggregate shall be installed in the joint cut-out in lifts. The combined matrix lift thickness shall not exceed the Supplier's written instructions but shall not exceed 50 mm in any case.

(f) Each intermediate lift shall be levelled and flooded with hot binder to the level of the matrix aggregate to fill voids in the surface.

(g) Following installation of the matrix in the joint cut-out, the joint shall be compacted and top-dressed in accordance with the Supplier's written instructions.

13 The Contractor shall be responsible for removing all binder material that leaks through the joint and deposits on any bridge component, including underside of decks, headers, beams, diaphragms, bearings, abutments and piers.Traffic shall not be permitted over the joint until it has cooled to 50ºC when measured with a digital infrared thermometer. Use of water to cool the completed joint is permitted.

14 Before placement of any sealing materials in parapets, kerbs, or footways, the joints shall be thoroughly cleaned of all scale, loose concrete, dirt, dust, or other foreign matter by abrasive blast cleaning. Residual dust and moisture shall then be removed by blasting with oil free compressed air using a hot air lance providing an air temperature and directional air velocity capacity recommended by the joint Manufacturer. Projections of concrete into the joint space shall also be removed. The backer rod shall be installed in the joint as shown on the plans. The joint shall be clean and dry before the joint sealant is applied. Under no circumstances is the binder material to be used as a substitute for the joint sealant.

15 Whenever blast cleaning is performed under this specification the Contractor shall take adequate measures to ensure that the blast cleaning will not cause damage to adjacent traffic or other facilities.

16 The Contractor must certify that the plug joints were installed in accordance with the Supplier's recommendations and appropriate specification.

17 Any installed APJ that exhibits evidence of failure such as debonding, cracking, rutting, or

shoving of the matrix shall be removed and replaced full-width and full-depth to a length determined by the Engineer. The reinstallation of joint shall be in accordance with the approved Work Quality Control Plan, as directed by the Engineer, following a determination of the cause of failure, all at no additional cost to the Authority.

2.7.8 Inspection

1 Each expansion joint system shall be subjected to and shall pass four levels of inspection in order to be accepted. These four levels are Quality Control Inspection, Quality Assurance Inspection, Shop Inspection and Final Inspection. The Manufacturer shall provide both Quality Control Inspection and Quality Assurance Inspection. Requirements of the four levels are as follows:

(a) Quality Control Inspection shall be provided by the Manufacturer on a full time basis during the fabrication process of all major components to assure that the materials and workmanship meet or exceed the minimum requirements of the Contract. Quality Control Inspection shall be performed by an entity having a line of responsibility distinctly different from that of the Manufacturer's fabrication Authority. A certificate of assurance shall be submitted to the Engineer in this respect.

(b) Quality Assurance Inspection shall be performed by an independent inspection agency provided by the Manufacturer. Quality Assurance Inspection is not required to be full time inspection, but shall be performed during all phases of the manufacturing process. A certificate of assurance shall be submitted to the Engineer in this respect.

(c) The Contractor shall provide access to two Engineers for the Shop Inspection which shall be carried out at the Manufacturer's fabrication shop prior to transportation to the job site. The inspection shall be primarily visual. All costs related to this inspection shall be borne by the Contractor. This provision shall only apply when installing large expansion joint systems such as modular and finger joints.

(d) Final Inspection of each expansion joint system shall be performed by the Engineer at the job site immediately prior to installation. The Contractor shall provide an accessible work area for this inspection. During final Inspection, the Engineer shall inspect each expansion joint system for proper alignment, complete bond between expansion joint box seals and steel components, and proper steel stud placement. There shall be no bends or kinks in the steel components, except as required to follow roadway grades and as specifically detailed on the approved shop plans. Straightening of unintended bends or kinks will not be permitted. Any expansion joint system exhibiting bends or kinks, other than those shown on the approved shop plans, shall be removed from the job site and replaced with a new expansion joint system at the expense of the Contractor. Expansion joint strip seals not fully bonded to the steel shall be fully bonded at the expense of the Contractor. Studs shall be visually inspected and shall be struck lightly with a hammer. Any stud which does not have a complete end weld or does not emit tintinnabulation when struck lightly with a hammer shall be replaced. Any stud located more than 25mm, in any direction, from the location specified on the shop plans shall be carefully removed and a new stud shall be welded in the proper location. All stud replacements shall be at the expense of the Contractor.

2.7.9 Acceptance

1 Each expansion joint system shall pass all four levels of inspection delineated above to qualify for acceptance. Any expansion joint system which fails any one of the four levels of inspection shall be replaced or repaired at no expense to the Authority. Any proposed remedial procedures shall be submitted to the Engineer for approval before implementation

2 The Contractor shall ascertain that the Manufacturer has met the fatigue resistance characterization and prequalification requirements of this document. The Contractor shall be responsible for any additional costs and/or time delays associated with selection of an alternative expansion joint system incurred as a result of non-compliance with these requirements, including the failure of the Manufacturer to retest revised details or material substitutions of a previously pre-qualified system.

2.8 WARRANTY

1 The Contractor shall provide a ten year warranty for the performance and durability of the expansion joints supplied and installed. Conditions constituting unsatisfactory performance and durability include, but shall not be limited to, broken welds or bolts (including field splices), cracks in steel members, fatigue damage, loss of pre-compression in control springs or bearings, debonding or damage to PTFE, springs or bearings moving out of position, breakdown of corrosion protection system and leakage. The following is a list of replaceable items subject to wear and tear during normal joint operations:

(a) Upper and lower support bar bearings.

(b) Equidistant control spring assembly.

(c) Support bar stainless steel sheets and bolted connections.

(d) Strip (or box) seals.

2 The Contractor shall replace or repair any of the above replaceable items and any other expansion joint component or other joint systems demonstrating unsatisfactory performance or durability within the ten year period commencing from the date of Substantial Completion of the contract. All labour and material costs and cost of traffic accommodation during repair or replacement shall be paid by the Contractor.

3 The Contractor shall provide a written warranty stating the following:

(a) That the expansion joints have been designed and fabricated to perform satisfactorily within the design range of movement and under the design loads for a period of ten years from the date of Substantial Completion.

(b) That the installation methods and procedures used were reviewed and inspected during the work and found to be in accordance with their recommendations.

(c) That repair or replacement of the expansion joints, at no cost to the Authority, shall be undertaken in the event that the expansion joints do not perform satisfactorily within the specified design range of movement and under the specified design loads within the indicated ten year period.

2.9 MEASUREMENT AND PAYMENT

2.9.1 Expansion Joint Systems in General

1 This work shall be measured by the linear metre in place of the expansion joints. The quantities of expansion joints measured as provided above, shall be paid for at the unit prices bid as entered in the Bill of Quantities.

2 The unit prices for the various types of expansion joints shall constitute full compensation for

design, documentation, furnishing, fabrication, protection system and hauling of all materials, preparation, installation, specialist supervision of installation, fixings, bedding and surround mortar, transition strips, drainage barriers and outlets where appropriate, and for all labour, equipment, tools, temporary works and all other items necessary for the proper completion of the work which are not specifically paid under a different item of the Bill of Quantities.

2.9.2 Asphaltic Plug Expansion Joint Systems

1 This work shall be measured for payment by the number of cubic metre of Asphaltic Plug Expansion Joint System installed and accepted within approved horizontal limits. No additional measurement will be made for furnishing and installing backer rod and joint sealant if required in the parapets, concrete medians, kerbs and/or footways.

2 This work shall be paid for at the contract unit price per cubic metre for "Asphaltic Plug Expansion Joint System", complete in place, which price shall include the saw cutting, removal and disposal of bituminous concrete, membrane waterproofing, and existing joint components and sealing elements, the furnishing and placement of the cementitious levelling compound, leaning of the joint surfaces, furnishing and installing bridging plates, furnishing and installing the asphaltic plug joint matrix, the cost of all services associated with the technical representative, and all other materials, equipment including but not limited to portable lighting, tools, and labour incidental thereto. No additional payment shall be made for the bridging plates that are required for deck joint openings with widths in excess of 75mm.

2.9.3 Pay Items

1 The following Pay Items are included:

(a)	Buried Joint System	Linear m
(b)	Hot applied Rubber Bitumen Sealant	Linear m
(c)	Asphaltic Plug Joints	m^3
(d)	Reinforced Elastomeric Joints	Linear m
(e)	Strip Seal Joints	Linear m
(f)	Modular Joints	Linear m
(g)	Finger Joints	Linear m