Inspection guidance for bridge expansion joints

Part 1 – Reference guide

Contents

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Peter Jones

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1 Summary

Deck expansion joints are an important bridge component. In order to maintain road user safety and bridge durability, they must be maintained in good condition. Some types of expansion joint are susceptible to posing a sudden danger to traffic. Therefore, effective inspections at appropriate frequencies are necessary to understand the level of risk and identify and plan necessary maintenance and replacement work.

This document provides guidance on inspecting bridge expansion joints effectively, consistently and to a high standard, to ensure that the expansion joints across the Transport for London Road Network (TLRN) are kept in good and safe condition.

This document is in two parts, in similar fashion to the Inspection Manual for Highway Structures (1). The first part contains useful information and literature review on the different types of expansion joints and the identification of defects, while part two is intended to be an on-site reference guide to assist bridge inspectors.

The motivation behind this document was a number of unanticipated expansion joint failures on the TLRN, which happened over a relatively short period of time. Investigations into the condition of expansion joints and the inspection procedure showed that the inspection was not accurately reporting the condition of expansion joints. A programme of inspector training was initiated to resolve this; this document is part of that process.

1.1 TfL recommendations

Recommendations in the report are highlighted with a black border. The following is a summary of the recommendations contained in this document:

- A photographic record of the condition of every expansion joint should be contained within each inspection report, to allow the condition of expansion joints to be tracked over time.
- Joint specific pro formas for recording the results of the inspection of expansion joints for each type of expansion joint are included in the appendices to this document. These have been developed in response to the current deficiencies in the inspection process, where expansion joints are concerned.
- Various temporary remedial measures are suggested, drawing on experience from the TLRN, highlighting both methods that were successful and those that were not.
- A recommendation for the interval between detailed inspections of expansion joints is provided, for each Highways Agency defined joint type.
- The element importance for expansion joints used to calculate the overall bridge condition indicator should be raised to “very high” in extraordinary circumstances, depending on the structure and route specifics.
- A method for entering the condition data into the TfL structures management system is recommended as a short-term measure to ensure the overall bridge condition score is calculated correctly.
- It is proposed that the current defect category 10.x is replaced with new categories 17.x and 18.1.

2 Background

Many bridge deck expansion joints on the TLRN are coming to the end of their design life. During winter 2009 and throughout 2010, several expansion joints failed on the network leading to emergency repairs and replacements. These were disruptive and, in a minority of cases, caused a short-term risk to road-users.

The failures were unexpected. Inspectors were reporting the joints were in a reasonable condition and yet they were failing, sometimes within months of the last inspection being completed. It became clear that the current inspection regime is not effective and that inspectors’ knowledge of expansion joints and their failure mechanisms was limited. There was also a lack of guidance to inspectors to enable expansion joint defects to be reported in a consistent manner.

2.1 Case Study: A potentially dangerous joint failure

Photo 2.1 Failed elastomeric expansion joint on a major dual carriageway
The joint was only five years old. A recent principal inspection had given the joint a condition rating of 2B (early signs of deterioration, minor defect/damage, no reduction in functionality, along not more than 5% of the surface length). The inspection recommended that works to resolve leakage through the joint should take place within the next five years. Only eighteen months later, the joint failed spectacularly, leaving a dangerous obstruction in the carriageway. Luckily, the incident happened at night when traffic volume was low, damaging ten vehicles. There were no fatalities.

The TfL Structures Management Team (SMT) is responsible for the management of structures on the TLRN. The work of the SMT is governed by the Mayor's Transport Strategy (MTS) (2). The MTS commits TfL to "maintaining road network assets in a state of good repair." The MTS also recognises improving the resilience of the TLRN is vitally important because the network is currently largely saturated (2). Any unplanned disruption can quickly lead to significant congestion, delays and cost to the economy, as well as the cost of the emergency repair itself, which often only has very limited life.

Over the past 18 months, a number of expansion joints have been identified as a threat to network resilience, following safety inspections and initial investigations. Knowledge gained on the deficiencies in the existing inspection and reporting strategy and a better understanding of the consequences of failure and mitigation measures required will reduce the risk from defective joints. This guidance document has been developed to support the bridge inspectors improve the quality of inspecting and reporting on bridge expansion joints.

3 Aims

This guidance document supplements the existing information on inspecting bridge expansion joints and provides inspectors with a reference for the inspection of expansion joints on TLRN structures.

The aims of the document are to assist the inspector in:

- Identifying the type of joint and understand its merits and weaknesses.
- Identifying common and possible expansion joint defects and appreciate their causes and consequences.
- Making a judgment on the severity and extent of the defect that would be consistent with other inspectors' judgement.
- Making an informed decision on residual life.
- Making appropriate recommendations for remedial works.

Success of the document will support the MTS aims:

- To maintain the network in a state of good repair.
- To improve network resilience.

4 Layout

The document comprises two parts. Part one summarises and references existing guidance and provides useful definitions and information on bridge deck expansion joints, defects and their symptoms and the inspection process. This attempts to bring together existing knowledge and literature to improve understanding of expansion joints. Part two is intended to be an on-site practical reference for inspectors to carry with them when undertaking inspections.

5 Literature Review

There are several documents in existence relevant to bridge expansion joints. The Highways Agency (HA) Design Manual for Roads and Bridges (DMRB) (3), 'The Blue Book,' includes several standards and advice notes relevant to inspection and maintenance of expansion joints. References to documents from the DMRB are listed individually. The Inspection Manual for Highway Structures (1), Transport Research Laboratory (TRL) papers and Bridge Joint Association (BJA) papers also provide useful information. This section summarises information on expansion joints from existing literature.

5.1 Function of expansion joints

TRL defines a bridge expansion joint as:

"A device to support the surfacing, or provide a running surface, across the expansion gap and (usually) prevent the passage of water below deck level, while allowing changes in the size of the expansion gap to take place without damage." (4)

In order to inspect effectively, the inspector must be aware of the complete role of the expansion joint, and be able to assess how well the joint is fulfilling its function and how well it will be able to do so in future.

There is almost always a gap between a bridge abutment and a bridge deck (except on very short span bridges) at least at one end, to accommodate movement of the deck. In longer bridges, there may be gaps between spans. Movement; transverse, longitudinal or rotational; could be a result of any of the following (4):

- Temperature changes
- Dynamic loading (live loads)
- Foundation settlement
- Creep
- Shrinkage

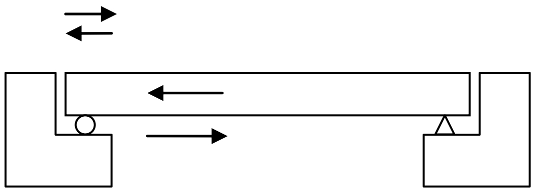
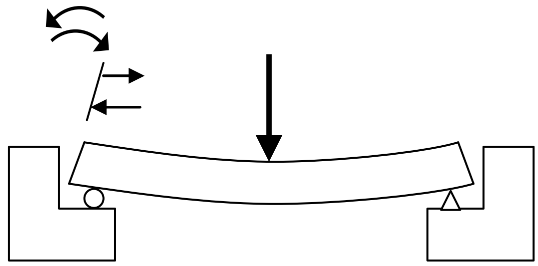
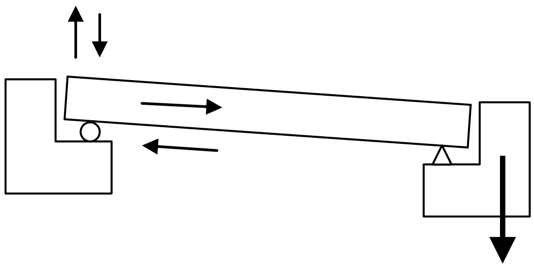
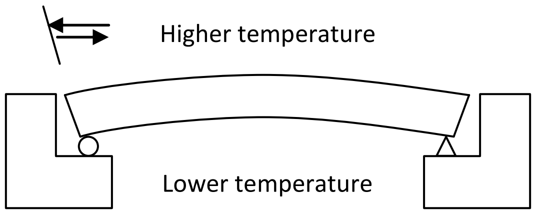
 Temperature changes causingexpansion or contraction will cause horizontal movement. Concrete shrinkage causing horizontal movement. Traffic braking and acceleration forces may also cause horizontal movement.	 Dynamic (live) loading causing sagging bending of the deck will cause rotation at the supports.
 Foundation settlement causing rotation and vertical movement	 Differential temperature change, where the upper surface expands more than the underside will lead to hogging bending of the deck. This will cause rotation at the supports.

Figure 5.1 Causes of relative movement between abutments and bridge decks

The major design requirements of a bridge deck expansion joint are listed below, summarised from BJA/028 Current Practice Sheet (5) by the Bridge Joint Association and BD33-Expansion Joints for Use in Highway Bridge Decks (6).

- To withstand traffic loading.
- To accommodate movements of the bridge without inducing unacceptable stresses in the joint or other parts of the structure.
- To provide a good riding quality and not cause inconvenience to any class of road user (including cyclists, pedestrians and animals where they have access).
- To maintain an acceptable level of skid resistance, at least equal to the minimum required of adjacent carriageway surfacing. The footway should also have acceptable skid resistance.
- To avoid the generation of excessive noise or vibration from the passage of traffic.
- Easy to inspect, maintain and have parts liable to fail easily replaceable.
- Resilient to sudden deterioration likely to cause a hazard to traffic.

The same references also set out further best practice and requirements for expansion joint installation:

- Interface between expansion joint and deck waterproofing should be watertight, as well as the joint itself, which should also be waterproof.
- Secondary waterproofing in the form of a continuous membrane should be installed.
- The same joint system should exist across the full width of the deck, including footway, verge, hard-shoulder and central reserve.
- The maximum acceptable gap width at carriageway level for motor vehicles is 65mm.

- Kerb plates should be provided to protect the joint at the kerb line.
- Gaps in the footway should be closed, where pedestrians have access, using load bearing seals or cover plates.
- Where cyclists have access and the joint consists of toothed or comb plates with the spaces between the teeth generally oriented in the direction of traffic flow, these spaces shall not exceed 150mm in length or 20mm in width.
- Installation of joints should follow recommendations of BD33.

BD33 (6) provides a standard for acceptable movement ranges for different joint types, both longitudinally and vertically. The requirements and recommendations from BD33 and advice note BA26-Expansion joints for use in highway bridge decks (7) are the baseline standard for bridge expansion joints on the trunk roads and motorways. These have been adopted by TfL. The lifespan of a typical expansion joints is generally much shorter than that of the whole bridge itself (1). This is why regular inspections of the joints are necessary. Designers should request expected service life/design life information from manufacturers (4).

5.2 Consequences of expansion joint failure

Expansion joints are considered a "durability" bridge element (1). Therefore, the inspection must consider the joint in this context. An expansion joint in poor condition will not cause the structure to fail in the short-term, but over time, it can lead to significant deterioration and shortening of the life of the structure. A defective expansion joint can also cause safety problems for road users.

Aside from danger to road users, water damage is the biggest problem caused by failed or leaking expansion joints. Salt water contains chlorides, which in high concentrations will absorb into the concrete and lead to steel corrosion. Once the steel starts to rust, it will expand, which leads to spalling of the concrete, further exposing the steel. In the most extreme cases, a failed expansion joint can be a contributing factor to fatal structural collapse, as happened in Canada in 2006 (see case study 5.3).

5.3 Case Study: Concorde Highway, Montreal, Canada


Photo 5.2 Collapse of Concorde Highway, Montreal, Canada (8)

This bridge, in Montreal, collapsed on 30th September 2006 about one hour after a bridge inspector had declared it safe, following reports of pieces of concrete falling from the bridge. Five people were killed when the cantilevered support to the central span failed, bringing the central span down onto the motorway below. The support that failed was located directly beneath an expansion joint, and had suffered extremely heavy corrosion, probably due to the road-salts used to keep the road ice-free during Canada's cold winters. The expansion joint leaked. Had the road been busier, the number of fatalities could have been much higher.

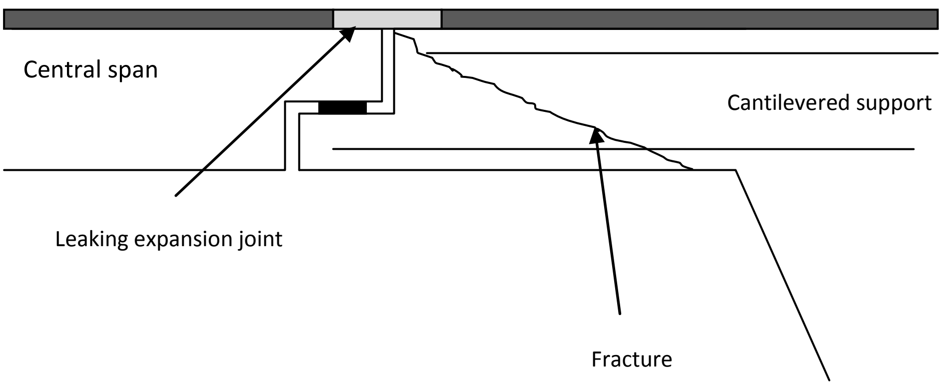


Figure 5.3 Illustration of deck joint arrangement and fracture causing the collapse of Concorde Highway (8)

In this example, failure was not directly due to a failed expansion joint; it was due to the deterioration of the reinforced concrete deck and the fracture of the support. However, the fracture may not have occurred had the reinforcement in the concrete support not become severely corroded, which was due to water leaking through the expansion joint. The bridge had been regularly inspected, and yet the poor performance of the expansion joint had not been identified or remedied, nor had the condition of the half joint, which was the component that ultimately failed.

5.4 Factors that can contribute to expansion joint failure

Very few joints fail because their total movement capacity has been exceeded. Typical contributing factors to failure are listed below (4):

- Traffic loading
- Faulty installation or materials
- Poor detailing
- Small movements (daily thermal cycles and/or traffic induced movements)
- Extended service life

The Montreal bridge collapse (see case study 5.3) demonstrated the effect of unmanaged water and highlighted the importance of the condition and watertightness of expansion joints. Joints are designed to be compatible with waterproofing systems, but it is almost inevitable that all joints will leak during their lifetime (9). Therefore, management of water is extremely important to reduce as much as possible the volume of water able to leak through a joint and affect primary deck elements. Possible causes of a loss of watertightness include

- Poor workmanship at installation
- Failure of the bond between surfacing and expansion joint, due to deterioration of surfacing or due to movement of the deck.
- Debris collecting in the seals can puncture the seals under traffic loading
- Extended service life

Unmanaged water can lead to corrosion of metal components. Some types of joints have metal components which may corrode or bearings may seize due to corrosion, restricting deck movement. Water can also lead to corrosion of the reinforced concrete components of a bridge or corrosion of pre-stressing cables.

The presence of sub-surface drainage is also important. Road surfacing is porous, and water will flow through the surfacing. However, an expansion joint will form a dam across the surfacing on the uphill side of an expansion joint, causing water to collect. This is called ponding. This, in turn, will cause the surfacing to break up, as vehicle loading on the saturated surfacing will generate high internal hydraulic forces. Water inside the carriageway surfacing can cause it to deteriorate under freeze-thaw action. Damage to the surfacing adjacent to expansion joints will lead to the edges of the joint becoming exposed and subject to much greater forces from traffic loading.

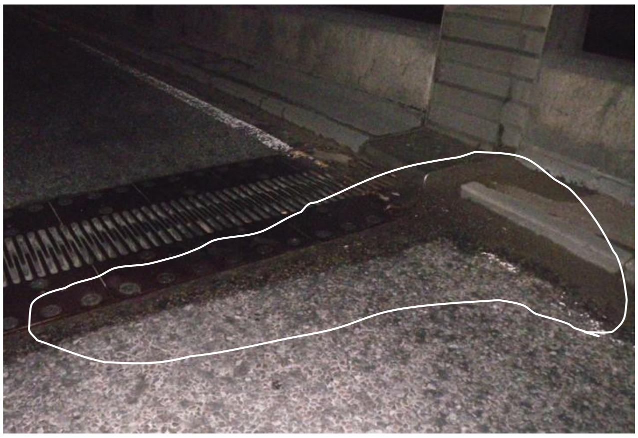


Photo 5.4 In both examples, the carriageway is wet on one side of the joint, showing that the surfacing is saturated.

Road gullies should be provided to collect water uphill of the expansion joints to prevent as much water as possible from reaching the expansion joint (6). These gullies must be kept clear to maintain their effectiveness.

Sub-surface drainage should be provided and kept clear typically on the bridge side of expansion joints, along the length of the joint and across the joint on to the other side, to drain sub-surface water and release pore pressure away from the deck and carriageway surfacing. This should discharge, ideally through the deck, into the road drainage system. Where it discharges onto a bearing shelf, drainage must be provided to stop water remaining on this part of the structure.

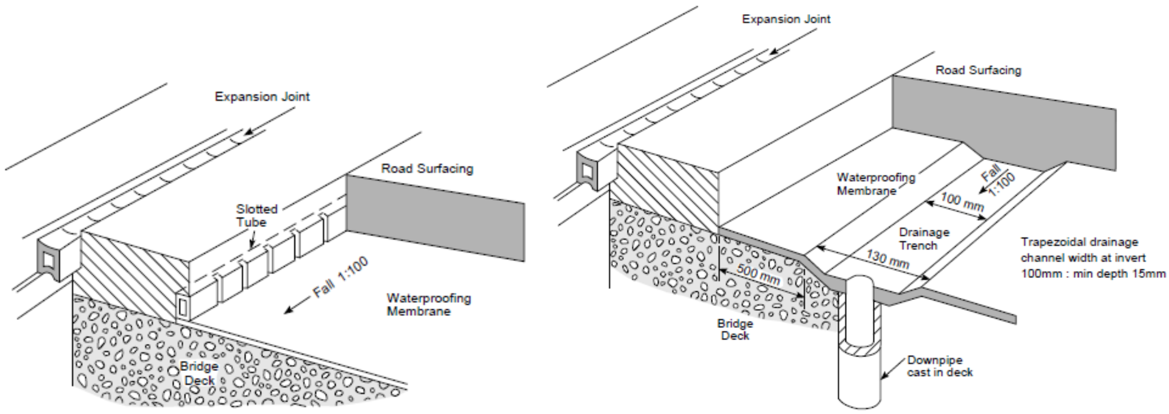


Figure 5.5 Extract from BA26 - Typical expansion joint sub-surface drainage details (7)

5.5 Inspection of highway structures

Expansion joints are inspected as one of 38 standard elements of a bridge structure. Inspections are carried out in accordance with BD63-Inspection of Highway Structures (10), the Inspection Manual for Highway Structures (1) and the CSS Bridge Condition Indicators Commission Report (11). BD63 describes four types of regular inspection relevant to this guidance document:

- Safety inspection
- General inspection
- Principal inspection
- Special inspection

The Inspection Manual for Highway Structures (1), gives limited background information and guidance on expansion joints. The CSS volume 2 report (12) describes how to rate the generic defects, but again makes little direct reference to expansion joints. The standard BD63 makes no specific reference to bridge expansion joints, but the provides principles that can be easily applied to expansion joints. This guidance document expands on these documents, both in explanation of defects (part 1) and with photographs and examples of defects (part 2).

During a safety inspection, joints are usually inspected from emergency lane closures or from a slow moving vehicle. These are undertaken at frequencies which ensure the timely identification of safety related defects, depending on the condition and importance of a particular route or asset. It is a quick superficial inspection, and will only identify obvious signs of deterioration, and so it is vitally important that the inspector is aware of what to look for before inspection. These are usually undertaken by highway inspectors who do not have specific bridge experience or knowledge.

The intention of these inspections is to detect safety critical defects on the highway. In general, these defects are obvious, but with bridge expansion joints they are not to an untrained eye. Defects that appear insignificant can rapidly lead to failure. This is why training of highway safety inspectors is especially important. It is also unlikely that sufficient detail can be identified from a moving vehicle, and so, where possible, safety inspections should be from outside of a vehicle.

A general inspection occurs typically every two years and covers all aspects of the structure that are visible without the need for specialist access equipment or traffic management. The inspectors are required to review the structure's records to familiarise themselves with the joint details and possible defects, the condition at the time of the last inspection and any significant recent maintenance/modifications since (10). Limited access means that expansion joints are generally not examined closely, and examination from underneath may not be possible. The general inspection takes place visually and typically from road level. A general inspection must record, as a minimum, the location, severity, extent and type of any defects (10).

Without traffic management, it will be more difficult to detect small defects, such as hairline cracks or tears in an expansion joint component. However, it also seems that insufficient emphasis is given to expansion joints, and so the time required to identify such defects from the verge is not taken. As such, the inspector does not see the defects at the earlier stages of their development.

A principal inspection is nominally every six years; however, TfL vary this interval up to a maximum of 12 years, following a risk assessment. This is permitted in BD63, clause 3.32 (10). The principal inspection is a detailed inspection from within touching distance of all inspectable parts of the structure. Traffic management and special access procedures/equipment should be used, including railway possessions, lane closures or full closures (10). This means that the joints are inspected at close range.

While the principal inspection allows for a closer examination, eliminating the possibly of being unable to see the defect, the problem with a lack of understanding of the importance of expansion joint defects is still relevant. Variable traffic management should be used to inspect the full length of expansion joints from within touching distance, thus enabling all defects to be identified.

General and principal inspections are usually undertaken by staff with specialist experience and knowledge of bridge structures.

5.6 TfL recommendation

Sometimes, parts of joints are not inspectable without special access arrangements, specialist inspection equipment or the removal of parts for access. For example, some joints have components below the surface, which should they deteriorate significantly would cause a sudden failure of the joint at road level. Inspection of these components will provide an increased level of confidence to the inspection result, or will identify necessary remedial works to ensure that the joint does not fail, which otherwise would not have been carried out if inspection from just from the road level.

In these cases a special inspection should be arranged to gain missing data and complete the requirements of a full inspection and assessment of the condition of the joints. This should be done when there is concern over the condition of the joint, or before the expected lifespan of the joint expires, whichever comes first. The recommendation to carry out such a special inspection should be a result of a principal or general inspection.

5.7 CSS Bridge condition indicator (BCI)

An already established procedure exists for reporting the condition of bridges. The Management of Highway Structures Code of Practice (13), requires that the inspection:

- ensures that the bridge is safe for use and fit for purpose;
- collects data for the asset management regime.

The Bridge Condition Indicators Commission Report (11) provides guidance on how the data should be collected. This is the approach in the Inspection Manual for Highway Structures (1) and is the method adopted by TfL. Inspectors should be aware of this procedure, and should refer to the relevant documents, when necessary. Some of the definitions are repeated below, for ease of reference.

Defect severity is defined as the degree to which the defect/damage affects the function of the element or other elements on the bridge. Extent is defined as the area, length or number (as appropriate) of the bridge element affected by the defect/damage (12).

Severity	
Code	**Description**
1	As new condition or defect has no significant effect on the element (visually or functionally).
2	Early signs of deterioration, minor defect/damage, no reduction in functionality of element.
3	Moderate defect/damage, some loss of functionality could be expected
4	Severe defect/damage, significant loss of functionality and/or element is close to failure/collapse
5	The element is non-functional/failed

Extent	
Code	**Description**
A	No significant defect
B	Slight, not more than 5% of surface area/length/number
C	Moderate, 5% - 20% of surface area/length/number
D	Wide: 20% - 50% of surface area/length/number
E	Extensive, more than 50% of surface area/length/number

Table 5.1 Defect severity and extent definitions from BCI Commission Report (11)

The BCI Commission Report also provides guidance for reporting the severity and extent of defects when more than one defect is affecting a particular element. This is based on whether there is one dominant defect, or whether several defects are either interacting or the cumulative effect of several defects is more important than the effect of any one. The guidance is reproduced in the following table, for ease of reference:

	Dominant Defect is Present:	**Interacting Defects, or No Dominant Defect is Present:**
Severity	When the severity of one defect is adjudged to be at least one severity category higher (Appendix C) than any other defect on the element, the Severity for the element is defined based on this dominant defect, **AND** Other defects do not reduce the functionality of the element beyond that caused by the dominant defect.	Where the cumulative effect of several defects is adjudged to be the same as, or worse than, the effect of the dominant defect then the severity code should be reported based on the cumulative effect of all the defects on the element, **OR** Where no dominant defect is evident, the severity should be based on the cumulative effect of the defects the inspector feels are relevant.
Extent	The extent code in this case should correspond to the area affected by the dominant defect alone.	The extent code in this case should correspond to the area affected by all defects considered in assessing the severity

Table 5.2 Definition of dominant or interacting defects from CSS guidance notes (12)

Further guidance on the application of this table is provided in section 11.1.

The overall, or average, BCI (BCI_{ave}) is calculated from the severity and extent rating of all the elements of the structure. The BCI methodology considers expansion joints as "high" importance, on a scale of very high, high, medium and low (11). The element condition score is weighted according to the element's importance in the calculation of an overall bridge condition score. Further information can be read in the BCI Commission Report (11). A critical BCI (BCI_{crit}) is calculated, using the worst condition score from the most critical elements of the structure (classed as of "very high" importance), which does not include expansion joints.

5.8 TfL experience

In recent years the reporting of defects to expansion joints has been varied. Inspection reports have tended to miss defects that may appear insignificant unless the role and nature of expansion joints are well understood. When defects have been identified, they have often not been given a severity or impact rating that truly reflects the nature of the defect. There have also been examples of expansion joints being incorrectly described or labelled, showing a lack of very basic knowledge in some cases.

This document intends to fill the knowledge gap to ensure that defects are fully and accurately recorded to ensure that defect rectification is planned early enough to avoid complete joint failures.

5.9 TfL recommendation

Consideration should be given to increasing the importance of expansion joints to "very high" in exceptional circumstances. This would be dependent on the joint type and route importance. The effect of this would be to include the condition rating of expansion joints in the BCI_{crit} calculation, and so a defective expansion joint would significantly reduce this index. The effect on the BCI_{ave} would be much smaller.

At present, Bridgestation does not enable a manual alteration to the element importance, but recommendations for changing the element importance of expansion joints should be made, where considered appropriate.

6 Types of bridge deck expansion joints

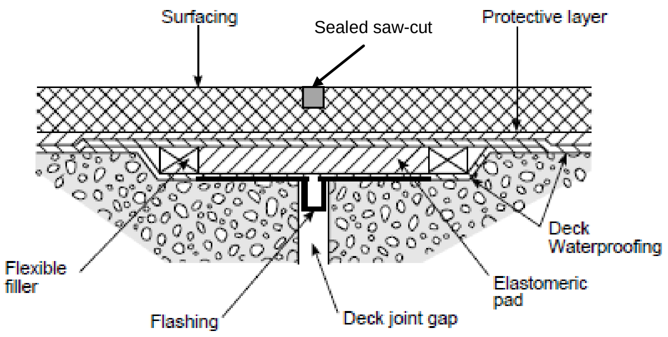
It is important for the inspector to be familiar with the different types of expansion joint in use, and be able to identify them from inspection of bridge drawings and on site. The following fact-sheets show cross sections of typical expansion joint types, with some information about each joint type, including common defects, their symptoms and some of their possible causes.

A recommended inspection frequency is also suggested. This is the recommended frequency of close-up inspections, as the joint would be inspected during a principal inspection. Inspections more frequent than the nominal six yearly principal inspection are recommended where the joint's expected lifespan is similar to or less than six years. It is recognised that joints often remain serviceable for longer than expected, and so a shorter inspection interval is recommended following the end of the expected service life.

The information presented in the following sections (6.1 to 6.7) is collated from the Practical guide to the use of bridge expansion joints (4) and the Inspection manual for highway structures (1), as well as TfL records and maintenance works.

6.1 HA type 1: Buried joint	Expected lifespan: 10-12 years

Recommended inspection interval: 6 years or 2 years after the end of the expected service life



From BA26 (7)

A buried joint is formed from a flexible component such as an elastomeric pad installed beneath continuous surfacing. This type of joint is selected for smaller movement ranges (up to 20mm horizontally and 1.3mm vertically (6)). One of the main advantages is that it does not form a water dam across the highway because the surfacing is continuous over the joint. The deck waterproofing can also be applied in a continuous layer over the pad, eliminating any joints or overlaps. A sealed saw-cut crack inducer should be installed to protect the surfacing.

Defect	Comment
Surfacing cracking or breaking up	This is likely to be caused by deck movement, which the surfacing has been unable to accommodate (indicated by cracks across the carriageway). Once cracked, water and vehicle impact will lead to further break up. The top of a crack may close on a heavily trafficked route due to the flexible nature of the surfacing, but it will still be open to water and liable to break up.
Crack inducer defects	Cracking can be managed by a crack inducer, typically a saw-cut across the surfacing, filled with flexible sealant. This allows some movement without generating stresses in the surfacing. The sealant in the crack can be pushed out, as the saw-cut will tend to close under traffic loading. The sealant will also deteriorate with time, cracking itself. A lack of seal in the saw-cut will allow the surfacing to break up as it will be unsupported at the saw-cut.
Leakage	Leakage is less likely in buried joints than most other joint types because the waterproofing is continuous. One possible cause of leakage is a discontinuous flashing across the deck.

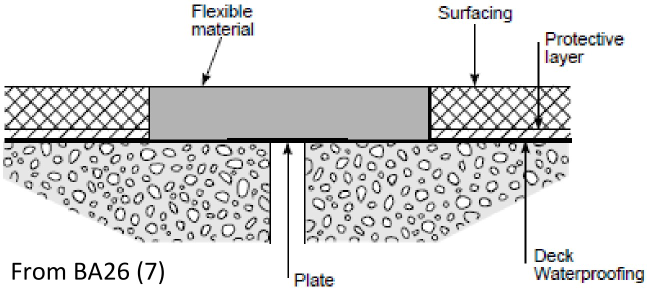
Buried joint, appears in good condition as no sign on the surfacing of its existance. No crack inducer is evident in the carriageway. This could be because it is at the fixed end of the bridge.

Wide crack across the full width of the carriageway, with no sealant.

6.2 HA type 2: Asphaltic plug joint

Expected lifespan: 5 years

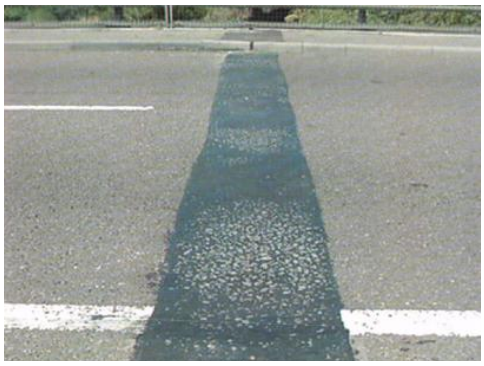
Recommended inspection interval: 2 years



From BA26 (7)

An asphaltic plug is formed from a flexible material, which also forms the road surface over the expansion joint gap. Typically a metal plate, or other similar component, spans the gap to support the plug. This joint is for smaller movement ranges, though greater than the buried joint (typically up to 40mm horizontally and 3mm veritcally (6)).

Defect	Comment
Tracking and flow of binder over adjacent road surface	If the plug material is too soft, it will become depressed under tyre loading, and will also flow out of the joint and onto the adjacent surfacing. This is most likely under slow moving traffic or at higher temperatures. This usually happens at constant volume, with mounds of plug material forming at the edges. Tracking leads to breaking up of the plug and loss of support to the adjacent surfacing.
Debonding between joint and road surfacing	The watertight ability of the joint is dependent on a good bond between the plug and the deck and surfacing. Debonding allows water into the joint. A lack of bond will also lead to damage to the top edges of the plug and adjacent surfacing leading to break up of both plug and surfacing. Debonding is most likely where the plug material is stiff and the movement range is large.
Breaking up of road surface adjacent to joint	When the joint becomes debonded, the edge of the surfacing becomes unsupported, which leads to break-up. It could also be caused by water underneath the surfacing being unable to dissipate due to blocked or no sub-surface drainage. It is most likely to occur on the higher side of the joint, where the water has drained to and then stopped as the joint forms a dam across the road. Break up of surfacing will expose the plug, leading to its break up, deteriorated ride quality and access for water to the joint.
Cracking	Cracks are most likely at a position coincident with the plate and in this case are probably caused by an uneven joint base causing the plate to bend. Cracks are also possible when the movement range is large.
Breaking up of plug material	As well as the causes above, break up can be caused by water saturating the plug, usually after debonding from the surfacing. Hydraulic forces then lead to break up. Poor workmanship at installation may cause break up of the plug, due to a lack of binder in lower levels or the binder and aggregate becoming detached. Break up leads to deterioration of ride quality, damage to surfacing and water access.
Leakage	Leakage caused by the defects described above will affect the durability of the structure.



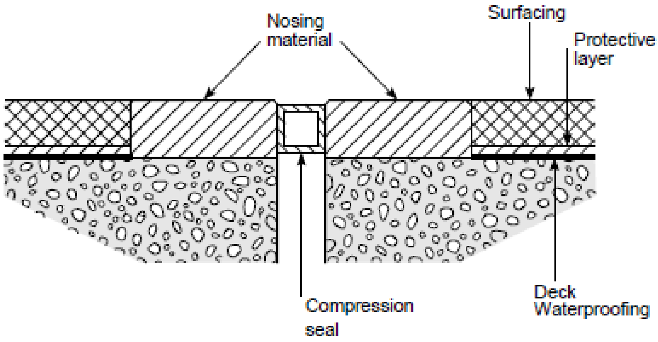
Asphaltic plug in fair condition, although it appears very smooth.

Plug material is missing and pot holes are forming.

6.3 HA type 3 and 4: Nosing joint

Expected lifespan: 5 years

Recommended inspection interval: 2 years



From BD33 (7)

The nosing materials protect the adjacent edges of the road surfacing, and may be pre-fabricated or cast in-situ. The two nosings support a seal. The joint relies on the adhesion of the seal on the vertical interfaces with the nosing material. The seal can be replaced, without interfering with the nosings.
An HA type 3 joint has a poured sealant (maximum movement of 12mm (6)), while an HA type 4 joint has a pre-formed compression seal (as shown in the diagram, maximum movement 40mm (6)).

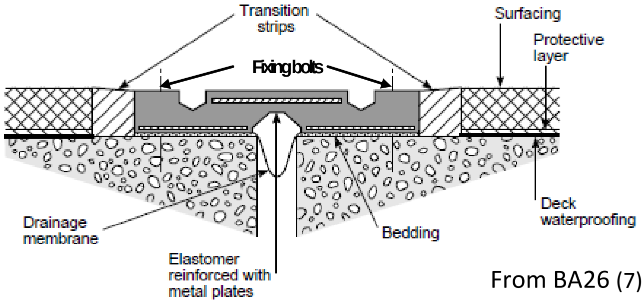
Defect	Comment
Seal can work loose and fail under temperature extremes	Temperature extremes will test the resistance of the adhesive holding the seal. If the seal fails, water will be able to access the joint.
Debris can displace seal	Debris build up on the seal will allow greater forces to be transmitted from vehicles to the seal, leading to debonding from the nosing material.
Ponding at back of nosing due to failure of drainage	The nosing material forms a barrier across the permeable surfacing material. Blocked, non-existent or otherwise failed drainage will not allow this water to dissipate, and so subject the surfacing to internal hydraulic pressures as traffic crosses. This will cause the surfacing to break up, leaving the nosing material exposed. An exposed nosing will be subject to horizontal forces and start to break up or detach from the concrete deck.
Nosing break up and debonding from adjacent surfacing	Break up of the nosing usually follows debonding or deterioration of the adjacent surfacing. Break up then happens as the edge is unsupported and so subject to increased traffic forces and is not restrained.
Impact from HGV causes underlying concrete to break up	HGV loading may be transferred through the nosing material and impact on the structure below the joint.
Leakage	Once the seal is displaced, water will leak through onto the structure below. This will lead to durability problems for the structure.

The joint type is very uncommon on the TLRN, but it is useful to be aware of its existence for completeness.

6.4 HA type 5: Reinforced elastomeric

Expected lifespan: 6 years

Recommended inspection interval: 2 years or annually after the end of expected service life



From BA26 (7)

The major component comprises of a elastomeric unit, reinforced by metal plates. It is secured to the deck concrete with fixing bolts, which are sealed with resin plugs. Transition strips provide a continuous running surface between the road surface and joint unit. They come in a variety of shapes and sizes, with varying movement ranges up to approximately 330mm (14).

Defect	Comment
Breaking up or cracking of transition strips	This is generally caused by the transition strip becoming debonded, either from the surfacing or from the deck or abutment. Once debonded, the edge will be unsupported, and start to break up. This can happen to the transition strip and adjacent surfacing. Tracking of the adjacent surface can lead to the transition strip becoming exposed, and therefore subject to much greater forces from traffic loading, causing break up.
Bolt cover pads missing	The cover pads can be flicked out by traffic, leaving the bolts underneath exposed. Corrosion of the bolts will lead to premature bolt failures.
Bolts loose	This will lead to movement of the units, detected either through noise or visible under vehicles. This will lead to further bolts becoming loose.
Bolt failures causing joint to lift	Sufficient bolt failures will cause the joint to move under traffic. This will lead to impact damage to the deck below the joint.
Debris in grooves	Debris in grooves will restrict movement and under vehicle pressure will wear the rubber.
Wear of rubber ribs on top of joint.	Wear will reduce the skid resistance. Significant wear will expose the steel plates beneath the rubber, leading to delamination.
Delamination of elastomer/ metal plate interface	Heavy wear and tears in the elastromer will result in delamination, exposing the steel plate over significant areas of the joint. The metal is smooth, and so skid resistance will be limited. The exposed metal plate may also lift up, causing an obstruction in the carriageway.
Leakage	This could be caused by any of the defects above, or failure of the drainage membrane. The effects could be damage to the carriageway either side of the joint, or early deterioration of the bridge structure.


Wide joint, in fair condition. Note debris in grooves.


Narrower version, but in poor condition. Note missing resin plugs, top plate and rubber. Also note depression in carriageway to left of joint, and cracks to the surfacing adjacent to transition strip, which is beginning to break up.

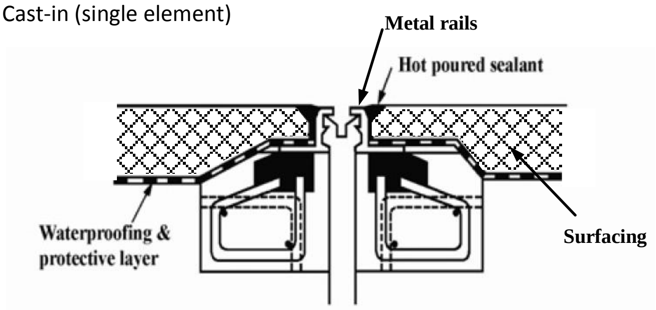
A disadvantage of this joint is that "failure is likely to cause a hazard to traffic and for this reason frequent inspection is necessary" (9)

6.5 HA type 6: Elastomeric in metal runners (cast-in and resin encapsulated)

Expected lifespan: 20 years (cast-in), 10 years (resin encapsulated)

Recommended inspection interval: 6 years or 2 years after the end of the expected service life

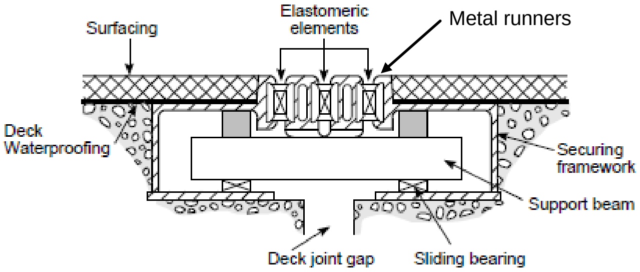
Cast-in (single element)



Adapted from BJA/028 Current Practice Sheet (5)

In this joint the outer rails are secured into the deck and abutment with reinforcement as shown in the drawing. On the deck, there is no transition strip; the surfacing is seperated from the rails only by sealant. Movement ranges are typically up to 80mm (15), although BD33/94 restricts the width of an open gap to 65mm.

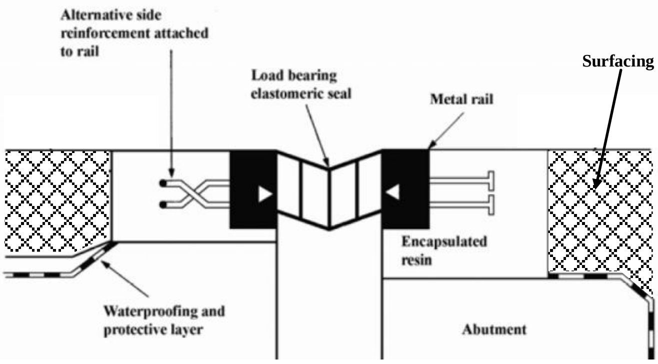
Cast-in (multiple element)



From BA26 (7)

To accommodate greater movement, this type of joint can feature several rails in the configuration shown. The bearing components of the joint permit movement, while the elastomeric elements keep the surface continuous and seal the joint. The securing framework is cast into the deck and abutment. The joint can be made from multiple rails depending on the movement range required, up to around 640mm (16).

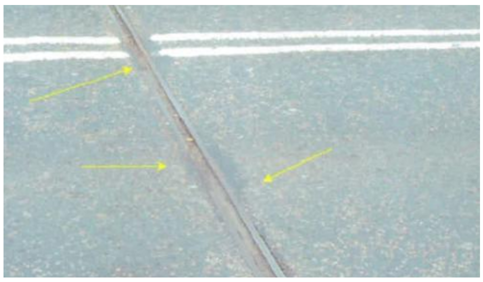
Resin encapsulated



Adapted from BJA/028 Current Practice Sheet (5)

This joint type functions on a similar principle to the top joint, above. The elastomeric seal is attached to the metal rails. The rails are held in place by reinforcement, which is encapsulated in a resin which is bonded to the deck/abutment. The movement range will depend on manufacturer/model, but is typically up to 150mm (17), , although BD33/94 restricts the width of an open gap to 65mm.

Defect	Comment
Elastomeric seal breaks up or pulls out	Siltation and debris will enable forces from passing vehicles to exert forces on the seal, leading to failure. This will then cause leakage. Debris can be left following resurfacing works. The seals on resin encapsulated joints are wider, and so larger and more debris can collect, leaving this seal more vulnerable. Excessive movement may cause the seal to pull out.
Seal can be punctured	Stones or other sharp object may be pushed through the seal by traffic. The breach may be difficult to identify without close inspection, or inspection from underneath.



No central rail configuration, cast-in type.

Several central rails configuration

Continued from previous page

Surfacing or resin breaks up or cracks adjacent to metal rails	This is usually caused by water ingress and aided by vehicle loading. Wet weather, followed by freezing conditions will accelerate deterioration of adjacent surfacing. This will at first leave the resin exposed, which is often relatively brittle and will deteriorate quickly. The metal rails then become exposed and so will be subject to lateral vehicle loading, causing distortion. Break up of the resin can also leave the reinforcement exposed (see third photo from top, right).
Worn metal rails	Worn runners will be polished and a hazard to vehicles, particularly motorcyclists and particularly if located on a skew or at a curve in the road.
Distorted metal rails	Tracking of the adjacent surfacing, or of the resin, will leave the leading rail exposed to lateral traffic forces. This will cause that rail to twist or rotate. This can also be caused by resurfacing works not being completed to the correct level. Distorted runners can be caught by trailing elements of vehicles or snow-ploughs, pulling them out.
Fatigue of metal components	Fatigue damage is caused by cyclic loading of a component. This is exactly what happens as traffic crosses the joint. Eventually the component will fracture. Welded joints are prone to fatigue failure. Fatigue is difficult to detect prior to fracture, but age of component and expected lifespan can provide an estimate to residual life. A heavily trafficked route or a route with a high number of HGVs will increase cycle frequency and increase loading range, both of which reduce fatigue life.
Top plate which secures seal can snap allowing seal to break free	This could be caused by fatigue. If the seal breaks free water will be able to enter the joint, causing damage to the joint components, as well as to the bridge structure.
Leakage	Research has shown that the cast-in type joints are the least likely to leak. However, leakage is still a definite possibility, and will have an impact on the durability of the structure.
Sub-surface components	The multi-element joints have a support mechanism below the surface level rails. This supports the rails and keeps them evenly spaced and parallel as the bridge deck moves. Leakage into the joint could cause corrosion of these parts, ultimately leading to failure of the joint.
Vegetation	Vegetation can grow where debris builds up in the void underneath the joint, allowing for greater accumulation of water inside the joint and greater interference with the smooth operation of the mechanical parts.
Debris in seal	Debris in the seal can restrict movement of the joint, as well as leading to increased forces on the seal.


Resin encapsulated (resin visible either side of rails).


Deformed metal rail.

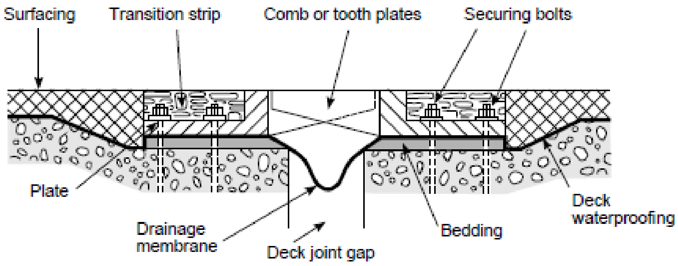

Resin has broken down, exposing reinforcement


Rail has dropped, visible from underneath.

6.6 HA type 7: Cantilever comb or tooth

Expected lifespan: 25 years

Recommended inspection interval: 6 years or 2 years after end of expected service life



From BA26 (7)

These joints can be purpose made for a particular installation and can accommodate very large movement ranges, up to a maximum of approximately 1000mm (18). The gaps between the teeth open and close as the bridge contracts and expands.

Defect	Comment
Wear of metal surfaces	Friction from vehicles will smooth and polish the metal, reducing the skid resistance, increasing the potential for accident, especially on skewed joints, curved roads or at junction approaches.
Loosening of securing bolts/failure of concrete anchorage	Initially this will cause movement of the plates, causing noise and increasing the probability of further bolt failures. This could lead to misaligned teeth or damage to adjacent surfacing or bedding material through impact.
Misaligned teeth	Lateral displacement of one set of teeth means the teeth are no longer aligned. This is more likely to happen on skewed joints, or where vehicles are turning, which produces lateral forces. The result will be a restricted movement range.
Drainage membrane splits	Permits water to enter the expansion gap, leading to durability problems for the structural elements of the bridge.
Debris / Corrosion	A build up of debris will may cause the joint to seize up, restricting movement and imposing undesired forces on the bridge structure. The debris will also hold water, and the combined effect of wear caused by the debris and the moisture will lead to corrosion of the components. Corrosion will lead to loss of section of the teeth, thus loss of load capacity, and will also lead to a loss of ductility. These two factors may lead to teeth breaking.
Hairline cracks	Hairline cracks are the early signs of future tooth failures. Where discovered, the highway authority should be made aware immediately.
Breakage of teeth	Missing teeth can be a hazard to cyclists and several missing teeth can be a hazard to motorcyclists, as wheels can slip or become trapped.


Gaps in teeth need cleaning and metal surface appears polished.


Plate missing in centre of photograph.


Teeth, broken from the main component.

6.7 Other joint types

Lifespan varies, see manufacturer's notes

Recommended inspection interval: typically 6 years during service life

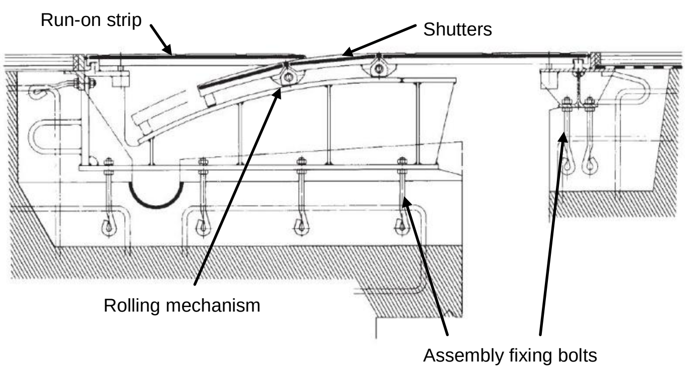


Diagram adapted from Ekspan's brochure (19).

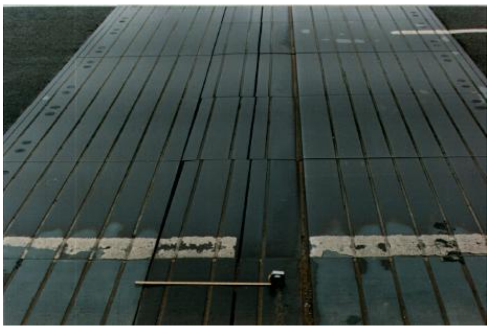
There are some joints on long structures which experience very large movements and often standard off-the-shelf joints are not suitable.

In these cases, special joints are used. These are rare on the TLRN, but one similar to the example shown (left) is located on section 4 of the A40 Westway. These types of joints are suitable for expansion movement ranges greater than 800mm.

As the deck expands, the shutters roll out from underneath the cover to provide a continuous surface for the motorist.

Defect	Comment
Cracks	The often metal components of these joints can fracture. Close inspection may reveal small, hairline cracks in the components.
Misalignment	Careful attention should be paid to how well the components are aligned. Misalignment may indicate problems with the mechanism below the surface.
Missing components	Broken, or missing plates may be hazardous, but should be straight-forward to identify. These should be replaced immediately.
Corrosion	These joints are usually constructed from metal plates, which may be susceptible to corrosion, if the corrosion protection fails. The mechanism below the surface may suffer from corrosion and could seize, fracture or collapse. Evidence of movement should be assessed to show that the joint is working. On such large movement ranges, it would be expected that this would be easy to identify.

The scale of these joints is demonstrated by the size of the car to the right.



In this photograph, the plates are not well aligned.

7 Bridge deck expansion joint ancillary details

"The same joint system, seal or sealant shall continue across the full width of the deck including footway, verge, hardshoulder and central reserve." (6)

A cross section through a bridge at the expansion gap will include footways, kerbs, parapets, vehicle barriers, railings and service ducts/pipes. All of these fittings must be designed to ensure that they do not restrict movement, and ensure that the joint can be continuous across the full width of the deck.

7.1 Kerb plates

On the footway, the joint can either follow the contour of the footway, or continue to follow the contour of the carriageway surface. In the first case, the joint may not be able to accommodate the kerb gradient, and so it will follow a shallower gradient and a cover plate will ensure that the footway is continuous. If, in the second case, the joint is lower than the level of the footway, typically, a cover plate will be required for the full width of the footway.

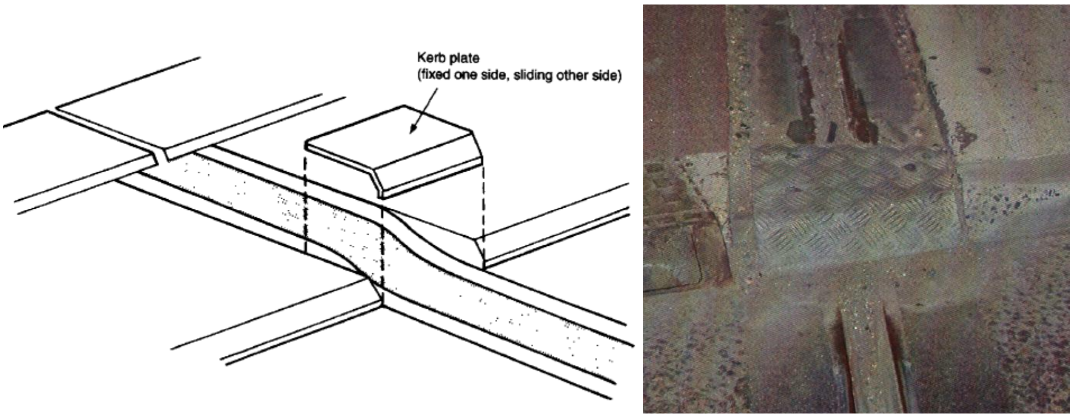


Figure 7.1 Kerb cover plate

In this example, the expansion joint is flush with the surfacing both on the road surface and on the footway. The joint, however, does not follow the steep gradient of the kerb, and so a cover plate is fitted, fixed to one side of the joint, to ensure continuity of the kerb line, eliminating the trip hazard and allowing movement of the bridge deck. In other examples, the cover plate may cover the complete width of the footway, while the joint remains at the surfacing level underneath.

Some joint systems have large gaps, which are unsuitable for pedestrian use and so these should be covered with a plate. Inspectors should assess the skid resistance of cover plates and the potential for a trip hazard.

If possible, during a principal inspection, the cover plates should be removed. This will allow a degree of visibility below the joint, and may assist in identifying defects not visible from the surface. It may also highlight joint leakage and the condition of the deck/abutment below surface level.

7.2 Parapets and barriers

The parapets and any barriers or railings must allow for movement at the expansion joint. The containment systems must also be continuous, to ensure protection for vehicles. The photographs below show how this is achieved in a number of different situations.

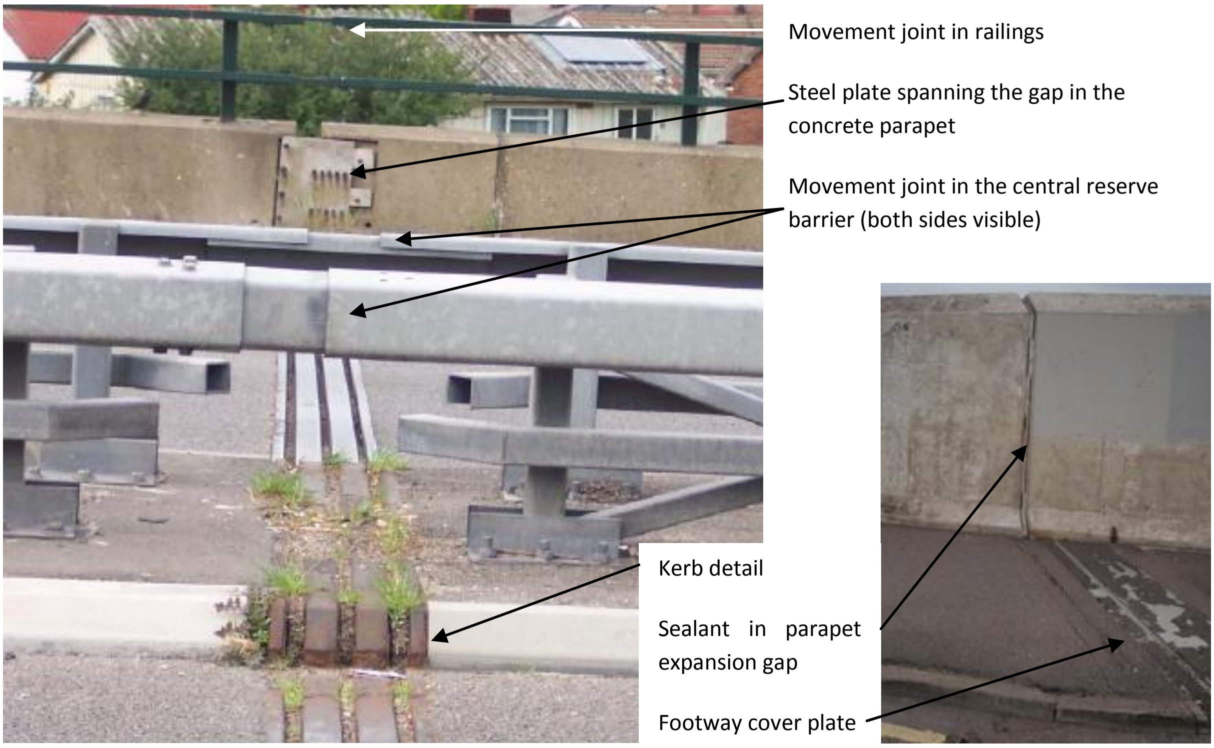


Photo 7.2 Examples of bridge deck expansion joint parapet/barrier details
These photographs show various details at a typical bridge expansion joint. In the main photograph the concrete parapet contains an expansion gap, which is covered by a steel plate to ensure continuity. The central reserve road restraint system also have an expansion gap; while protection continuity is maintained by the smaller section slotted inside, bolted to the barrier on one side only. The green railings above the concrete parapet have a similar system. Also visible is the detail at the kerb, where the shape of the joint maintains the kerb profile across the joint. In the smaller photograph, the expansion gap in the parapet is filled with a flexible sealant, while the footway is completely covered with a steel plate and covered by a skid-resistant surfacing, which is moderately worn. Also note the vegetation growing from between the rails in the central reserve. This will create a moist environment and lead to corrosion.

Sliding joints such as those in the photographs above provide evidence to demonstrate that the joint is functioning. Close inspection of the sliding parts should reveal a clean or polished surface, which shows that movement has been occurring. If there is no evidence of movement, the bridge may be stuck and subject to additional internal stresses, and comment in the report should acknowledge this.

Photo 7.3 Parapet expansion joint
There is clear evidence of movement in this photograph, taken in winter. However, in summer, when the bridge has expanded, this evidence may be hidden.

7.3 Skewed joints

Expansion joints are not always perpendicular to the direction of traffic on the carriageway. In cases where a bridge crosses an obstacle at an angle other than 90°, the expansion joint will most likely be at a skew across the carriageway, as the abutments will be parallel to the obstruction. A skewed expansion joint has to be able to resist forces in the direction of the joint, in addition to forces perpendicular to it.

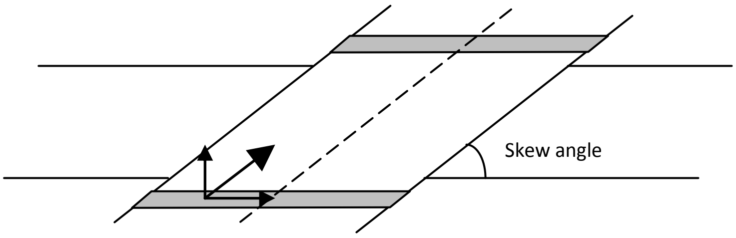


Figure 7.4 Forces on a skewed expansion joint

If the force applied by the vehicle is in the direction of travel, it can be divided into a component perpendicular to the joint and a component parallel to the joint. A square joint will only generally be subject to perpendicular forces, which can usually be resisted by a combination of fixing bolts and the presence of nosing or surfacing material. In the parallel direction, however, there is no physical barrier to movement, so the bolts or adhesive will have to perform.

Bridge expansion/contraction will result in a shear deformation of the joint, rather than a simple uniaxial compression/tension. Skewed joints are also wider in the direction of vehicle movement, and so skid resistance is of greater importance. Also, as the joint is not perpendicular to the direction of travel, any defect can be particularly hazardous to cyclists and motorcyclists.

Expansion joints that are in locations where vehicles turn are subject to greater and more complex forces. A vehicle turning exerts a force on the road perpendicular to its direction of travel. The turning of the wheels will also exert a turning force on localised areas of the carriageway. This situation can sometimes explain damage at certain locations along a joint, when the remainder of the joint is in a fair condition.

7.4 Joints at curves or at junctions

Similar to skewed joints, joints located on horizontal curves or at junctions are subject to greater forces than those on straight roads. The case study below demonstrates the effect of vehicles turning over a joint.

7.5 Case study: Interchange overbridge

This expansion joint, on a bridge over a busy urban dual carriageway, was in a very poor condition at a particular location across the carriageway. It was identified that the defect was where vehicles, often HGVs from a nearby industrial estate, were turning right onto a slip-road, and so the joint was subject to greater than normal forces.

Photo 7.5 Expansion joint at a turning point
This expansion joint is located where vehicles are turning, which generates additional forces as the wheels turn. The central photograph shows the damage that has occurred to the resin, exposing the steel reinforcement beneath. The right hand photograph shows the rear wheel of an articulated lorry, passing directly over the damaged area. The left hand photograph shows the front wheels of a goods vehicle crossing the since repaired area.

7.6 Longitudinal joints

Sometimes adjacent carriageways lie on separate structures, for example a slip road adjacent to the main carriageway, or the two carriageways of a dual carriageway. A joint exists to create a watertight barrier, and is generally a simple construction of a seal fixed to the structures on both sides of the air gap.

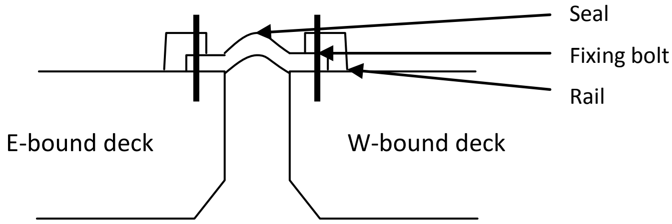


Figure 7.6 Cross section of longitudinal expansion joint
The longitudinal joint protects the air gap between parallel spans from water. It does not carry traffic loading.

Other longitudinal joints are of the same form as transverse expansion joints, and are designed to carry traffic loading.

7.7 Footbridges

Footbridges also have expansion joints, with the main difference being that they are not subject to traffic loading. The joint will often be covered with a steel plate with a skid resistant covering, to eliminate the possibility of the joint becoming a trip/slip hazard. The joints should be inspected with the same level of care. It is often easier to inspect below a footbridge and the inspector should take full advantage of this, both at general and principal inspections.

8 Defect categories

At present, to complete the inspection, the inspector must categorise the defects according to the defect categories in Appendix C of Addendum to CSS Guidance Note on Bridge Condition Indicators Volume 2 (20). There are a total of twelve different defect categories listed for expansion joints, numbered 10.x.

The following table is derived from this existing table, but some categories have been amended and some additional categories have been added. The numbering has been changed to a more logical order, and the defect category has been changed to 17.x to distinguish from defects recorded using the existing guidance. This should assist the inspector on site and enable the results of the inspection to be more useful. Part two of this document provides further interpretation of each defect category and examples of each defect at each severity level.

Defect	**Photograph**
Defects relevant to nearly all joints	
17.1 Joint leakage All joints may leak, and any leakage should be recorded in this category. This will generally require inspection of the bearing shelves or abutments.	
17.2 Joint sub-surface drainage In addition to reporting on highway drainage, the joint sub-surface drainage condition should be reported. This additional category is proposed to allow for the condition of the joint drainage to be reported independently, and for its condition to contribute to the condition score of the expansion joint, and not the drainage system. In practice this will probably only be able to be detected through visible ponding.	
17.3 Deteriorated adjacent road surfacing This defect refers to the condition of the surfacing on either side of the joint. The only exception is where cracking has taken place directly over a buried joint (see defect 10.10). This could include cracks, tracking, pot-holes, depressed or any other defect to the surfacing, that is related to the expansion joint.	
17.4 Loose/damaged fixtures Fixtures should generally be considered as ancillary parts, such as cover plates in the footway.	

17.5 Joint vegetation Vegetation growing from a joint will have an adverse effect on joint durability, and is to be classed separately from general vegetation defects already available to the inspector under the existing guidance. This defect should be resolved during cyclic maintenance, but should still be recorded if present at the time of inspection.	
Defects affecting HA type 1 buried joints	
17.6 Surface cracking over buried joint When the joint is a buried joint, and the cracks are generally perpendicular to the road, then the defect should be recorded in this category.	
17.7 Deteriorated crack inducer sealant Where the joint is a buried joint, and the surfacing has been saw-cut with a seal applied, any defects to that seal should be recorded in this category.	
Defects affecting HA type 2 asphaltic plug joints	
17.8 Debonding between asphaltic plug and road This defect refers to the condition of the bond between the asphaltic plug material and the adjacent surfacing.	
17.9Loss of material from asphaltic plug As stated, this defect refers to a loss of binder or aggregate from the plug material.	
17.10 Tracking and flow of binder from asphaltic plug Simply, this defect category describes tracking of the plug joint and any flow of binder onto the adjacent carriageway surfacing.	

Defects affecting all other joint types (where relevant)	
17.11 Deteriorated nosing This defect refers to the nosing, transition strip or resin strip that provides the surface between the joint itself and the adjacent carriageway surfacing.	
17.12 Missing/loose bolts This defect requires no further comment.	
17.13 Deteriorated seal This defect category refers to the condition of any seals in the joint, with the exception of a sealed saw-cut over a buried joint (see defect 10.11). This refers to both breached seals and seals containing debris.	
17.14 Defects to components Components should be considered to be the major parts of the joint, such as an elastomeric component, or a rail.	
18.1 Movement/Construction joints This new defect category is proposed to distinguish defects to movement joints in retaining walls and parapets from defects to seals in deck expansion joints, so that the condition of these does not influence the condition score of the deck expansion joint.	
8.x Highway drainage Defects to carriageway drainage should be reported under defect category 8. Wet areas of surfacing should be identified, for example on the higher side of the expansion joint, as indicators that there may be a problem with the drainage system.	

Table 8.1 Joint categories from Inspection Manual for Highway Structures (1)

These defect categories form the basis of part two of this document and the joint-specific inspection pro formas provided in the appendices of this document.

8.1 TfL recommendation

For the purposes of TfL inspections, the existing defect category in the CSS documentation (20) and in the Inspection Manual for Highway Structures (1), 10.x, should be removed and the above defect categories, 17.x and 18.1, appended.

9 Preparing for inspection

A successful inspection will be well prepared. Before attending the structure, the inspector should review the structure's records, making a note of the following salient points (which are particularly relevant to expansion joints; other information should also be noted as part of the overall inspection):

- Joint details; including type, manufacturer, age, if available.
- Drainage details from general arrangement/as-built drawings, including where the drainage outlets are for the expansion joint drainage, so they can be inspected.
- Bridge articulation – identify the free and the fixed ends of the span. This will give an indication of the type of movement expected at the joints. A fixed end will only be subject to rotational movements from loading, whereas a free end will also be subject to longitudinal movement.
- Access methods. Previous inspection reports should provide information on access to the whole structure, including equipment that was required and any special procedures that were necessary, for example a railway possession or access procedures to adjacent land.
- Joint condition from previous inspection reports, including any recommendations for remedial works.

By reviewing the joint's history, and then inspecting the joint on site, the inspector should be able to build up a substantial knowledge on expansion joint performance and rates of deterioration. This will greatly assist in making recommendations at future inspections.

10 Inspection and recording findings on site

A methodical approach to inspecting the expansion joint is essential to ensure that every defect and its importance is identified and recorded accurately. This section details the various parts of the structure relevant to the expansion joint that require attention. A check-list is provided in part 2 as an aide-memoire.

Inspection

The table below gives guidance to inspecting various elements of the expansion joint. Guidance is provided only in the context of expansion joints. The general inspection requires less information than the principal inspection, for example it may not be possible to view the joints closely without traffic management, nor may it be possible to view the joints from underneath the bridge deck, depending on site-specific circumstances. However, the principal inspection requires that appropriate measures are arranged to ensure that close inspection is possible.

Joints should be inspected with respect to their performance criteria. The criteria from section 5.1 are listed in the table below, with advice on how the joint should be inspected.

Requirement	Check
Withstand traffic loading	Visual inspection to check for vertical movement under traffic loading. Particularly watch under HGV loading. Listen for noise as vehicles cross the joint. Noise is an indication that the joint is not withstanding loading.
Accommodate movement	Visual inspection of parapets or cover plates in the footway may provide evidence of movement, to show the expansion joint is permitting unrestrained movement. Restricted movement may be due to ceased

	bearings, and not necessarily due to the expansion joint. An alternative cause could be debris in the gap restricting movement. This may not be visible in summer months, when the bridge has expanded and the gap has contracted. It is more likely to be visible in winter.
Good ride quality	Visual inspection of the joint itself, but also of any transition strip/nosing material/resin strip and of the adjacent road surfacing. The check should look for cracks, tracking, pot holes, unacceptable gaps, missing plates. Where pedestrians, cyclists or animals have access, their requirements should also be checked. Visibility of ponding will indicate a failed sub-surface drainage system, which will lead to early deterioration of the surfacing and thus the joint. Where possible this should be reported, although in dry conditions it will not be evident.
Skid resistance	Visual inspection and assessment of the joint itself, but also of any transition strip/nosing material/resin strip. Signs of wear that have reduced the grip should be looked for. This applies to the carriageway and footway. Metal components may have polished surfaces, which will have poor skid resistance.
Avoids excessive noise/vibration	Listen as traffic crosses the joint. Excessive noise may indicate an underlying problem. If there is high noise, look to see if any part of the joint is moving under loading – this may indicate the cause and a defect. Listening from underneath the deck, where possible, will be more effective.
Avoids sudden deterioration	Close visual inspection, looking for any cracks (possibly hairline), tears and deformities in the joint components, which may lead to a sudden failure. A low-level view should detect any protruding components, which may get caught by passing vehicles, or will fail prematurely due to the increased loading. A visual inspection of adjacent surfacing should be made. Areas of deteriorated surfacing may quickly lead to rapid deterioration of the expansion joint, should these areas of surfacing subsequently break up.
Watertight	Visual inspection of any seals in the joint, looking for cracks, breaches or missing sealant. Also a visual inspection of the bond between components, transition strips and adjacent surfacing should be made. Visual inspection underneath the deck, looking for signs of water below the joint, on the abutment wall or bearing shelf. Adequate and working drainage will also reduce the potential for leakage. Any drainage outlets should be checked that they are clear. In addition, signs of ponding on the high side of the joint should be looked for, as this may indicate failure of sub-surface drainage. As part of this check, the bearing shelf drainage should also be checked, to ensure that any leakage from the joint is properly drained.
Same joint throughout	If this is not the case, it should be recorded in the inspection report so when the joint is programmed for replacement, this is detected early and can be rectified if appropriate.

Table 10.1 Inspection areas of attention

Categorising and describing defects

The defect categories in Table 8.1 are the basis for classifying defects and recording the defect severity. As well as identifying the most appropriate defect category, severity, extent and impact codes, the inspector must describe the defect, in detail for a principal inspection. This should include measurements and defect sketches, where appropriate, and a clear indication of the location.

The reporting of defects for a principal inspection should include:

- Location and description, including dimensions
- Possible cause
- Risk to structure and traffic and/or the public without remedial works
- Suggested remedial works and a timescale for completion
- Consequences of not resolving the defect in the recommended timescale.
- Suggested revised inspection routine (before and after remedial works).

Part 2 of this document provides guidance for correctly classifying defect category, severity and extent. The overall condition score for expansion joints should be formulated using the guidance in Table 5.2, taking into account multiple defects on a single joint and defects on all joints.

Describing location of defects

It is important for the inspector to accurately and clearly describe the location of defects. The guidance below should help inspectors describe the location of defects so engineers and future inspectors can easily identify the location of a particular reported defect, so any change in condition can be confidently reported.

The TfL Inspection contract (21) section 4.1.2 provides guidance on the numbering of bridge components:

"The convention for referring to elements of the structure shall be that the substructure and spans shall be numbered commencing with "1" from the element nearest to the west or south depending on orientation."

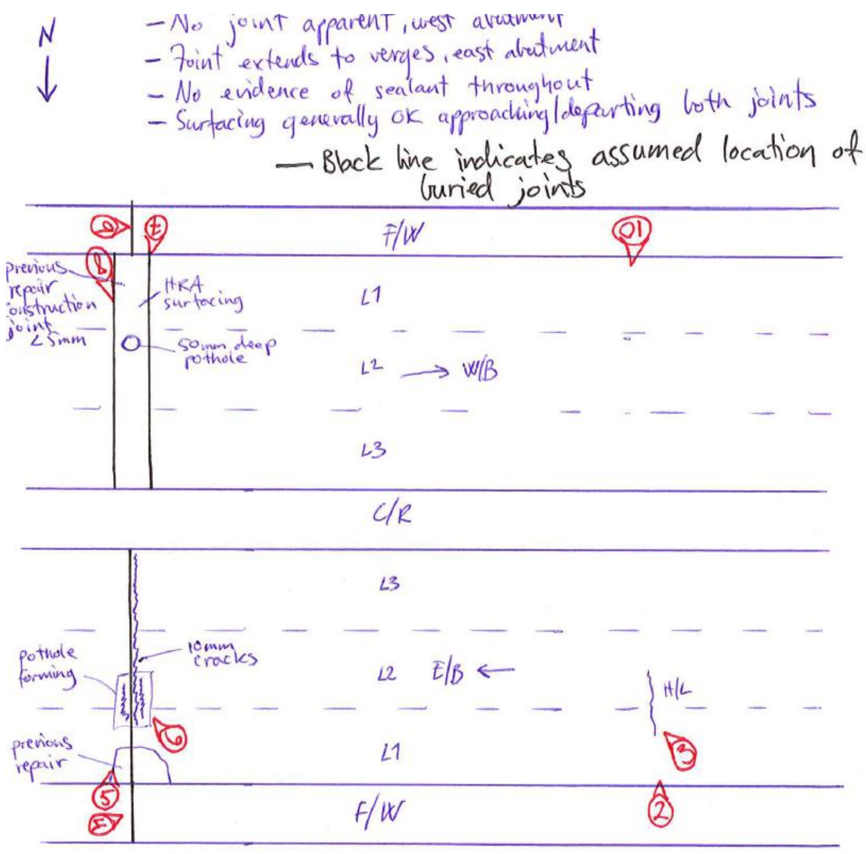


Figure 10.1 Sample site sketch of expansion joint defects
The sketch shows location of defects and photographs. Sufficient annotations are provided to identify the orientation (compass points, E/B / W/B labels, etc). Appropriate measurements are also given, for example crack widths and pot-hole depths.

10.1 Photography

Photographs are an excellent source of evidence to back up the written report, but must not substitute a clear explanation of defects. When writing the inspection report, each photograph of an expansion joint to be included must have a clear purpose for inclusion. If it is not clear what information the photograph provides the client, it should not be included.

10.2 TfL experience

In reviewing inspection reports it has been noted that selection and clarity of photography has often been poor. Photographs have made it into issued reports that are blurred, have the object of the photograph obscured, have the object of the photograph located just in the corner of the frame and when the camera has not been held level. The use of a digital camera should enable inspectors to quickly check photographs before leaving site, and re-take photographs that have not appeared as intended.

Photographs should:

- Be carefully framed to ensure the most relevant view is captured. The subject should fill the majority of the frame. Cropping can be useful in this respect, although remember the location of the timestamp and frame the photograph appropriately so cropping will occur from the opposite sides.
- Not be included if blurred. Photographs at night require more care to hold the camera steady and a tripod may be considered useful.
- Be labelled to give the reader details of location and orientation of the view.

- Be annotated if appropriate to highlight or indicate the salient defects and dimensions. A scale held in place while the photograph is taken will provide the user with a true indication of scale.

In addition, a sketch of the plan of the bridge should be included, showing the location and orientation of the photographs (see Figure 10.1). This should be drawn on the joint specific pro formas provided in Appendix 2.

10.3 Making recommendations

As well as assessing the condition of the structure, the inspector should make recommendations based on what he has observed on site. These recommendations will fall into a number of different categories:

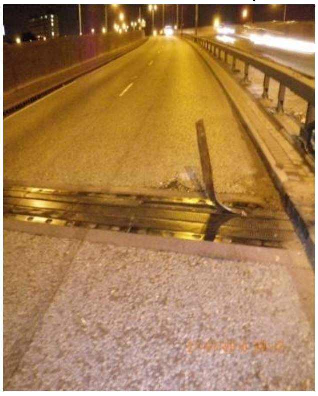
- Remedial works
- Maintenance activities
- Inspection and monitoring recommendations
- Residual life

Remedial works

Some defects will require interim measures to be implemented without delay. While a final repair/replacement will not be able to be implemented quickly, due to programming and financial constraints, several quick and inexpensive temporary measures can keep the road open until the major work can be completed. The main aim of these temporary measures is to maintain network resilience. All temporary measures must be regularly inspected (as often as daily in some cases) to ensure that they are continuing to function correctly.

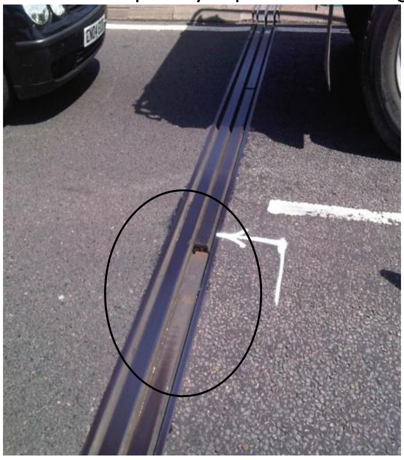
The table below highlights some possible repairs, drawing on recent experience from TfL's Highways Operations Team.

1	**Fill holes/patch surfacing repairs**
	A quick temporary repair to joints, which ensures a safe running surface for road users and will reduce further joint damage, is to fill with surfacing material. This may be the filling of pot-holes on the joint approaches or the replacement of damaged components with surfacing until a permanent repair can be carried out.    In this example, the elastomeric component was broken. The affected component was removed and the space filled with surfacing material on a temporary basis.   In this second example, the rails on the type 6 joint had fractured. A weld to repair the rails was attempted, but only survived a few days due to the very limited surface area available to the welder. As an alternative, the affected lengths of rails were completely removed, the air gap securely bridged and the space surfaced until full joint replacement.

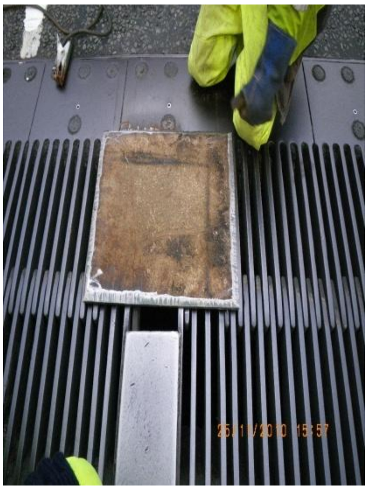
	   This joint was repaired with a patch-surfacing repair, which lasted around two months before the reinforcement began to show and the rails became more deformed. This demonstrates the importance of regular inspection of the repairs and also of ensuring that joint replacement schemes are added to the programme as soon as possible to secure funding and resources for prompt delivery.
2	**Replace/remove components**
	Some joints are comprised of modular components that can be fairly easily replaced during a lane closure, for example, type 5 joints are generally off-the-shelf components. Sometimes, part of a component that has potential to cause a problem can be removed, for example the reinforced elastomeric plates on type 5 joints.    In the example above on the left, the plate was removed and the joint was still intact as there are more plates below the top (see centre). On the right hand side the plate was removed to avoid a failure such as that on the left, and joint replacement was adding to the renewal programme.

3 **Fix temporary plates, either by welding or bolts**

As highlighted above, welding the rails of a type 6 joint is not effective, but welding plates can be a suitable temporary repair as a much greater surface area is available and so the weld is able to hold.




In this example, the rail had broken. In the very short term an emergency patch material was used to correct the level over the expansion joint. Within 24 hours, the rail was welded back in place, but this repair again proved unsuccessful. A more robust solution was to weld a metal plate over the entire joint, with anti-skid surfacing applied to the metal plate to ensure skid-resistance. This solution can only be temporary as it will not survive large temperature ranges. A solution to weld the plate to one side will not be considered acceptable due to the noise generated at the free end.

Broken teeth on type 7 joints can be repaired by welding a plate over the gap. Experience has found that the plate should be welded to at least four teeth each side of the gap. By welding to only one or two teeth each side puts excessive pressure on the weld, but also the teeth. This type of repair could last a few months, possibly up to a year. The metal plate edges should be chamfered and a skid-resistant covering should be considered.

It has also been suggested that, on a temporary basis, a 15mm steel metal plate could be used to replace a HA type 5 unit, by bolting the plate to the existing fixings on one side of the joint only, and covering to finished level with surfacing material. It has also been recommended that HRA surfacing will provide a longer-lasting finish, although this will remain a short-term fix only, and must be subject to frequent inspection.

	  All plates should be added such that a joint is not below a wheel track. Ideally plates should be positioned from white line to white line, or from mid-lane to mid-lane.
4	**Replace seal**
	The seals in type 3, 4 and some type 6 joints can be replaced. There is generally no requirement for an interim temporary repair for seal issues, unless there are safety critical issues. When the seal is replaced, it should be replaced across the full width, as partial replacement is very likely to be unsuccessful.
5	**Replace bolt seal caps**
	Bolt seal caps seal the holding down bolts, preventing water entering the joint and protecting the bolts against corrosion. Where missing, they should be replaced.
6	**Saw cut and seal**
	The presence of a buried joint can lead to reflective cracking on the surfacing. One method to reduce the effects of this cracking is to saw-cut across the joint and install a crack inducing seal. The flexible sealant will absorb any movement, preventing deterioration of the surfacing. Severely deteriorated seals should be replaced to maintain protection of the surfacing.
7	**Clear drainage**
	 Blocked drainage stops water draining from the carriageway. Instead it will drain through any breaches in the joint seal and possibly lead to early deterioration of the structure, or the water will saturate the surfacing, leading to break up. Clearing the drainage and ensuring the outlets are clear (including the sub-surface drainage outlets) will help reduce the effects of water. Drainage channels on abutment shelves should also be cleared so water does not sit on the abutment shelves, affecting the abutment and bearings.

Table 10.2Suggestions of possible remedial works that may be recommended

Maintenance activities

The inspector may recommend revision of the routine maintenance activities, including the activities undertaken and the frequencies at which they occur. See section 12 for more information regarding possible maintenance activities and some suggested frequencies.

Inspections

There will be situations when the joint is in a deteriorated condition but there is little that simple remedial works can do to extend the life, or where major works are required. In these cases, the inspector may recommend an inspection routine.

1	**Frequent safety inspections (monitoring)**
	Where the condition of the joint is very poor, and there is a chance of a sudden failure, the inspector should recommend frequent inspections to monitor future deterioration until such a time that works can be carried out to repair/replace the joint. Following a temporary repair, the joint should also be frequently monitored to ensure integrity of the joint. The nature of the inspection should reflect the risk; the inspection could be either a remote inspection, drive-through inspection or walkover inspection. The engineer should confirm the type of inspection and the inspector should confirm whether that type of inspection is sufficient.
2	**Special attention at future general/principal inspections**
	If an aspect of the joint is in a slightly deteriorated state, the inspector may recommend this aspect receives special attention at the next routine general/principal inspection to monitor long-term. Future inspections may reveal that there is no further deterioration.
3	**Special inspection**
	Special inspections are required when investigation beyond that of a principal inspection is required to determine the cause of a particular defect. For example, there may be significant leakage, but this could be caused by a failure of the joint, the drainage or the bridge waterproofing system and this may not be clear. The special inspection will take the appropriate measures to correctly identify the cause and suggest appropriate remedial measures. The inspector should detail what the special inspection should focus on and provide other relevant information in the inspection report to assist with planning the special inspection.

Table 10.3 Examples of inspection recommendations

Residual life

Residual life is difficult to predict, and it is often over-estimated. The expected life in the joint factsheets (section 6 of this document) should give some indication, if the age of the joints is known. The manufacturer should also be able to provide an estimated service life. Rate of deterioration can be estimated by using previous inspection reports and comparing the condition reported to the present condition, as all joints will deteriorate at different rates, depending on traffic loading, bridge movements and many other site-specific factors.

Where remedial works have been suggested, the additional lifetime that these will provide should also be indicated in the report.

Some recent research suggests that bridge expansion joints are being subjected to increasing forces. The use of super single tyre assemblies for HGVs in place of dual wheel assembly has increased the pressure applied to the surfacing and also to the joint according to TRL (22). Their research found that the wear sustained by the pavements trafficked by the super single assembly after 0.5 million equivalent standard axle applications was 4 times greater than that produced by 1.8 million equivalent standard axles applied through the dual wheel assembly . This will not only accelerate the wear of the surfacing material, but also the joint, especially if the joint is exposed and subject to horizontal forces as well as vertical forces. When judging the cause of defects, the number of HGVs on the route should be considered.

11 Writing the inspection report

The report on the condition of expansion joints should be produced in accordance with the brief for the inspection. For general and principal inspections, report on the condition of the expansion joints should be included in the report on the entire structure. Special inspections will need to follow the requirements of the inspection, and will depend on the site-specific circumstances. Safety inspections will also depend on the nature of the structure and route.

The following guidance explains how the expansion joint condition should be reported as part of different types of structural inspection.

11.1 Overall expansion joint condition

In some cases there will be more than one defect to expansion joints on a particular structure, but the inspection pro forma requires a single element condition factor to calculate the BCI correctly. Table 5.2 repeats the existing guidance, and this should be applied by the inspector.

In general, when one defect is clearly the dominant defect (has a severity score higher than any other defects), the overall joint condition score will be the same as the condition score for that particular defect. In cases where the inspector judges that there is not one dominant defect, but that the defects have a cumulative effect on the expansion joint that is greater than the effect of any one defect, the inspector should judge the overall severity due to these defects and then provide the extent according to the overall area affected by these multiple defects.

When an overall condition score for each expansion joint has been decided, the overall element condition score for expansion joints should be equal to that of the joint which has the highest severity rating.

Defect	Condition	
10.4	3E	Transition strip has debonded from surfacing.
10.7	3C	Surfacing is uneven on far side.
10.8	2E	The majority of bolt-seals are missing.
10.9	4D	The rubber has worn on top of the metal plates.
10.12	3D	Moderate leakage, not causing structural damage, at less than 50% of the width of the abutment.
There is one defect with a severity code higher than any other. In this case no other defect reduces the functionality of the expansion joint beyond that caused by this dominant defect. The condition score for this expansion joint is 4D. If the other joint on this bridge was given a condition score of 3E, the overall element condition score would be 4D.		

Table 11.1 Example of defect, joint and overall element condition scoring

11.2 Entering condition data into Bridgestation

TfL use a computerised structures management system, called Bridgestation. The results of general, principal and special inspections are entered onto the system. Each element condition score and defect is entered, and the BCI scores are calculated. For consistency, and to ensure that data is the most useful, the following procedure should be followed when entering the condition data for expansion joints.

The overall element condition rating should be entered under element 18 (Expansion/movement joints), along with the associated defect category (for the dominant defect, or if no dominant defect, the defect with the greatest significance) and notes relating to that defect. Multiple defects should be entered as normal, however the severity and extent scores should be entered in the comments field and not the severity/extent fields. The normal severity and extent fields should be left blank for all subsequent defects, so only one defect score is taken into account by Bridgestation when calculating the BCI.

The only exception to the above is when there are defects to movement or construction joints, and the severity of these defects is greater than the severity for expansion joints. In this case the condition score for the movement joint should be entered into element 18, with defect code 10.17. Defects to the expansion joints should be entered as multiple defects, with the severity and extent scores in the comments field only.

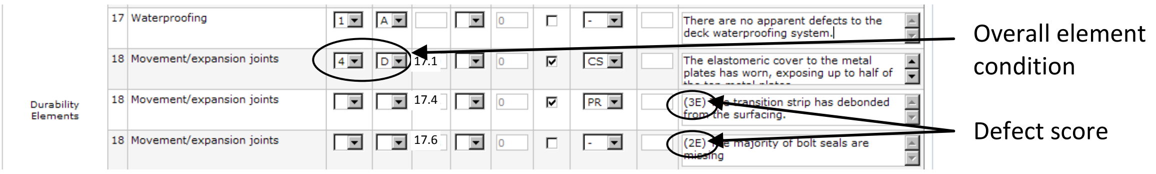


Figure 11.1 Screen shot from Bridgestation
Example of how multiple defects should be entered on the structure inspection proforma

All works, relevant to all defects identified, should be entered into the appropriate part of the pro forma, as individual items. The impact of the defect should also be recorded when the data is entered into Bridgestation.

11.3 TfL recommendation

The above recommended format for entering condition scores for multiple defects to a single element should be adopted in the short-term. Consultation with the Bridgestation development team will look to amend the system so that multiple defects can be entered as intended and the BCI score will be calculated according to the established procedure.

11.4 Joint-specific inspection pro forma

TfL have developed a pro forma for recording the detailed inspection of bridge expansion joints. There is a different pro forma for each HA approved joint type. These are included in this document in Appendix 2. The rationale behind their layout is to provide the inspector with the most likely possible defects for that joint type, enabling him or her to actively state “Y” or “N” to each defect. There is also space for a sketch and other information about the joint.

The additional comments field allows the inspector to add supplementary information. This should include, but not be limited to, any restrictions to the inspection, such as inability to view from underneath, for example.

11.5 Safety inspections

A safety inspection will normally consist of the bridge inspection pro forma alone, with some supporting photographs of any defects. The main objective of these inspections is to identify any safety critical defects, so emphasis on reporting these should be given over reporting very minor defects.

The joint-specific pro forma is not normally required for a safety inspection.

11.6 General inspection report

The TfL version of the CSS pro forma forms the major part of the general inspection report submission, and should be completed with reference to part 2 of this document. In addition, the standard TfL general inspection report template should be completed. This part of the submission contains the structure details and photographs from the inspection.

Where detailed inspection of the bridge’s expansion joints is required (see recommended inspection frequencies in section 6), the joint-specific pro forma should be completed for each expansion joint, and included as appendices to the general inspection report.

Care should be taken to ensure that the detailed inspection of expansion joint is completed where required. Where the recommended interval is six years, this should not be assumed to coincide with the structure's principal inspection because with the introduction of risk-based principal inspection intervals the principal inspection interval may be greater than six years.

From time to time, TfL may instruct a detailed inspection of a particular joint at a time not coincident with the recommended inspection frequency. This may happen, for example, if there is some concern over a particular joint or joint type.

11.7 Principal inspection report

The principal inspection uses the same structure inspection pro forma as the general inspection, but this completed pro forma is supplementary to a detailed condition report. The requirements for a completed principal inspection report are detailed below.

- The TfL Inspection of Highway Structures Contract (21) states that for a principal inspection, "a detailed description shall be provided including suggested reasons for the defect occurring and recommended remedial measures. The severity and extent of each defect shall also be recorded. Photographs and defect diagrams shall be provided where deemed appropriate."
- BD33 requires the location, severity, extent and type of all defects on the structure, including, where appropriate, detailed descriptions and/or photographs (or sketches) of the defects that clearly identify their location and illustrate the severity/extent of the damage to be reported.

Part two of this document should assist the inspector in identifying the information to complete the report. Each defect should then be written up, including all of the above information.

A joint-specific inspection pro forma should be completed for each joint at every principal inspection, and included in the inspection report as appendices to the report.

The principal inspection should include an update of the structure records. This is relevant to expansion joints in ensuring that the records identify the correct expansion joint type(s), arrangement(s) and age(s). A database of expansion joints and of expansion joint service lives should be developed to assist with future joint replacement planning.

11.8 Special inspection

Where a special inspection of an expansion joint is instructed, the joint specific pro forma should be completed and included as an appendix to the special inspection report.

11.9 Non-HA approved joint types

Where a structure has a joint that is not one of the seven types approved by the HA, the inspection should be equally thorough, using the information in Part two of this document as far as is possible to produce a detailed inspection report, containing all the same pieces of information as requested by the HA approved joints pro forma.

11.10 TfL recommendations

When the recommended detailed inspection interval for the expansion joints does not coincide with the principal inspection, a joint specific pro forma should be completed for each expansion joint at the time of the general inspection, and included as an appendix to the general inspection report.

A joint specific pro forma should be completed for each expansion joint inspected during a principal inspection, and at each occasion when a detailed inspection of a joint is required, according to the recommended inspection interval. Pro forma for each joint type are included in Appendix two of this document. The intention is that they act as an aide-memoire for all types of defects applicable to a particular joint type, and prompt the inspector to collect all the necessary information while on site.

Each detailed joint inspection should include a photograph of each joint on the structure, clearly labelled, as a record of overall joint condition.

A joint specific inspection pro forma should also be completed during each special inspection of an expansion joint.

12 Routine maintenance activities

Proper maintenance of expansion joints is important to ensure good performance. Each structure will have its own specific maintenance regime, which will depend on various factors including the nature of the structure, its age and the route's importance. In general, the maintenance involves cleaning the joint to remove any debris, and also remove salt deposits following the winter gritting period. It may be advantageous to arrange maintenance activities to take place prior to inspection.

Recommended activities are listed in the table below. Suggested frequencies should be varied as appropriate for some structures.

All joints		
Activity	**Comments**	**Suggested frequency**
Clean bearing shelves	While not part of the expansion joint, the bearing shelf will collect any leakage from the joint. Cleaning will reduce the effect of leakage on the bearing shelf, bearings and abutment. The bearing shelf drainage should also be cleaned and checked.	Annually, after the winter gritting season has ended. Where railway possessions are required this may be less frequent. Maintenance should be completed at the same time as an inspection possession, and an intermediate possession, where possible.
Clear sub-surface drainage	It is unlikely this can be cleaned, but if possible, it should be. However, the outlet(s) should be identified and cleared (if possible).	Annually. Quarterly on heavily trafficked routes.
Remove cover plates and clean	Where cover plates are present, they should be lifted and the joint cleaned, as far as is possible.	Annually. Quarterly on heavily trafficked routes.
Clear vegetation	All vegetation growing from the joint, including in the verges, footways and reserve should be removed.	Annually.
HA type 5 joint		
Clean	High pressure jet-wash the grooves in the elastomeric components to clear out the debris and remove all detritus.	Twice annually, as a minimum.
Replace broken/dangerous components	Any component that is broken should be replaced. This will require a specialist contractor to complete the work.	When required.
Bolts	A visual check for loose bolts should be undertaken, and any loose bolts tightened.	Annually
HA type 6 joint		
Clean	Debris in the seals should be cleaned using a high pressure jet-wash and remove all detritus.	Annually, following the end of the winter gritting period. Quarterly on heavily trafficked routes.
Relocate seals	Loose seals on some joints can be relocated. Once clean, the maintenance crew should check for loose seals and relocate.	As above
Sub-surface	Multi-element joints have mechanisms below the	At alternate principal inspections

components	rails. These should be cleaned and inspected. This will generally need to be undertaken by the manufacturer.	
HA type 7 joint		
Clean	The joint should be cleaned using a high-pressure jet-wash, including the components above and beneath the teeth and remove all detritus. Where the arrangement of the joint permits, debris should be removed from the below and teeth and disposed of	Twice annually; prior to, and following, the end of the winter gritting period. Quarterly on heavily trafficked routes.
Bolts	A visual check for loose bolts should be undertaken, and any loose bolts tightened.	As above

Table 12.1 Recommended maintenance activities

13 References

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2. **The Mayor of London.** *The Mayor's Transport Strategy.* London : Greater London Authority, 2010.

3. **Highways Agency.** *Design manual for roads and bridges.* Norwich, UK : The Stationery Office, 2010.

4. **Barnard, CP and Cuninghame, JR.** *Practical guide to the use of bride expansion joints.* Crowthorne, Berkshire : Transport Research Laboratory, 1997.

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16. —. *Girder grid joints (D640).* Munich : s.n., 1998.

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23. **Transport for London.** *Guidance note GN07001 Inspection of highway structures priority and impact of defects.* London : TfL, 2007.

24. **Johnson, I. D. and McAndrew, S. P.** *Reseach into the condition and performance of bridge deck expansion joints.* Crowthorne, UK : Transport Research Laboratory, 1993.

25. **Transport for London.** *Hammersmith Flyover post-tensioned inspection project.* London, UK : Transport for London, 2008-2011.

Appendix 1 Sample inspection pro forma

The following pages represent an example safety inspection report for a bridge expansion joint.

This inspection pro forma was developed by TfL's HMWC for the North Area, Amey, and was part of a strategy adopted in Summer 2010 in response to the increase in the number of expansion joint failures on TLRN (North).

The suggested inspection pro formas in appendix 2 are based on this one. Subsequent revisions of this manual will include examples of the proposed pro forma in appendix 1.

Structure Name	Structure ID	Date (DD/MM/YYYY)	Time (24 hr)	Weather	Air Temperature (°C)
Kensington Road	A40/21.90	20.10.2010	10:15	Sunny	10

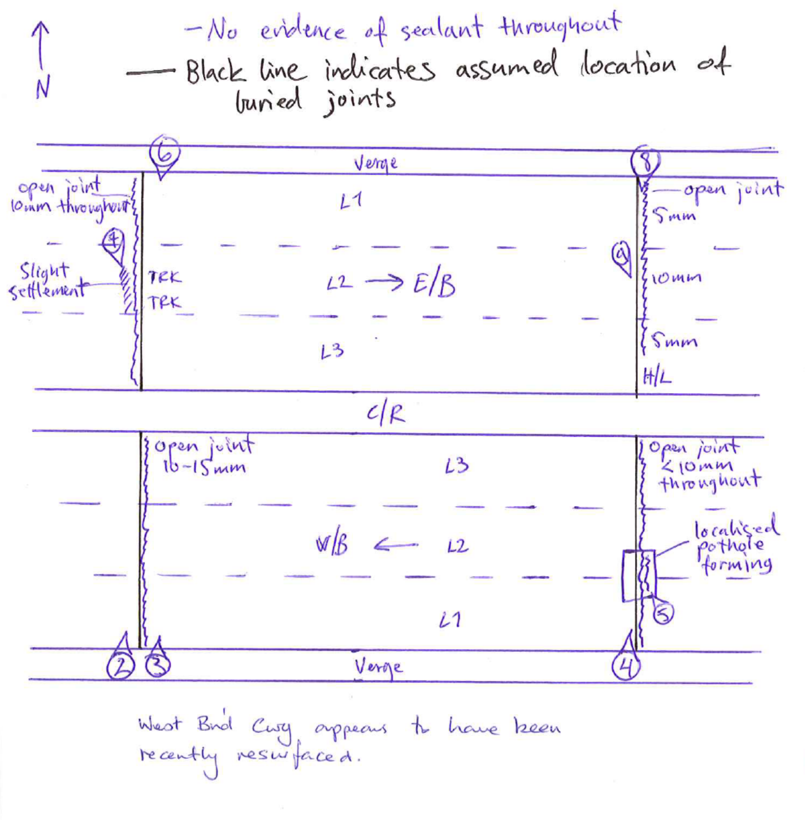
Joint Information

Manufacturer	Model	Dated	Type*
Unknown ?			Buried joints

The date, time and weather conditions are recorded.
The type of joint is also recorded.

Sketch of joint:

Joint Location/ID: East and West abutments



Photograph locations should be included on the plan, and a photo schedule attached. Include sections of the front back and sides of each joint where possible.

The sketch clearly indicates the location of defects, including crack dimensions.

The location and direction of the photographs are also recorded on the site sketch.

Proximity (m)	Defect*	Severity	Extent	Comments	Safety Critical
				Eastbound direction	
1	10.10	4	E	East abutment – open joint 5-10mm throughout lanes 1 & 2 leading to hairline crack in lane 3.	
1	10.10	5	E	West abutment – 10mm crack full width of c/w, slight settlement in lane 2.	
				Westbound direction	
1	10.10	5	C	East abutment – pothole forming in lane 1 and 2. Open joint <10mm throughout all 3 lanes.	
1	10.10	4	E	West abutment – open joint 10-15mm throughout full width of the c/w.	
				Surfacing (EB & WB)	
	9.1	2	E	Minor wear but surfacing generally ok.	
	9.2	2	C	Very light tracking in lane 2 (eastbound direction).	

The defects are recorded, including defect category, severity, extent, location, description and dimensions.

This was not a general/principal inspection and so the impact has not been recorded in this example.

Inspector's additional notes/Action to be taken:

No evidence of buried joint sealant throughout.

Joint not inspected from abutment level – cannot comment on leakage.

The lack of sealant is most likely the reason for open cracks forming at buried joint locations. As a result of these cracks/open joints, potholes are starting to form. Action should be taken the next couple of weeks to reinstate the surfacing where potholes are forming – marked as failure above.

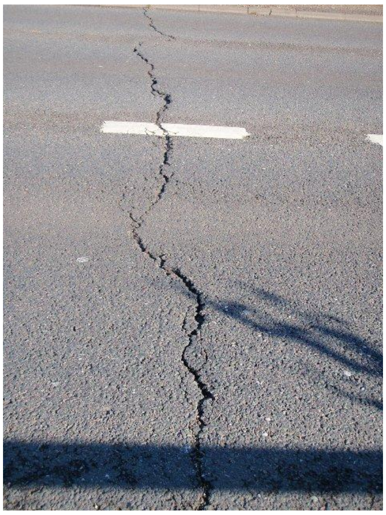
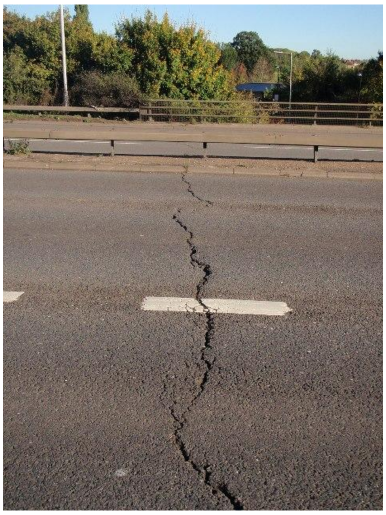
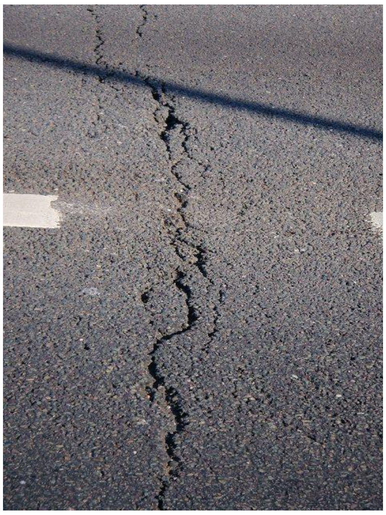
We would recommend installing a sealant in order to increase the movement in the joint system which may prevent major cracks in the surfacing in the future.

Joints inspected from footway on W'Bnd Side of deck and hard shoulder on E'Bnd Side.

The notes include remedial actions to be undertaken, including a timescale for completion.

Limitations of the inspection are also recorded.

Example safety inspection report

The photographs are labelled with location and orientation, which corresponds to the information on the site sketch. There will be cases when annotation of the photograph is useful.		
	2. West joint, WB direction - Lane 2 & 3, looking north	3. West joint, WB direction - Overview, looking north
		
4. East joint, WB direction - Overview, looking north	5. East joint, WB direction - Close-up localised pothole Lane 1/2	6. West joint, EB direction - Overview, looking south
		
7. West joint, EB direction - Close-up localised settlement, Lane 2	8. East joint, EB direction - Overview, looking south	9. East joint, EB direction - Close-up localised crack, Lane 2

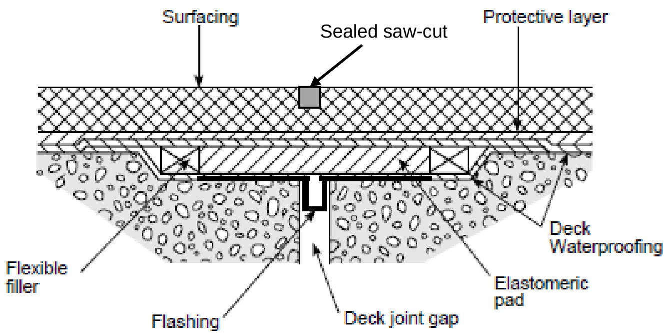
Example inspection photographs, with inspector's comments

Appendix 2 Proposed joint specific inspection pro formas

The pro formas provided prompt the inspector to ensure that they record all necessary information before the inspection from the structure records and previous inspection reports and considers all defects relevant to that particular joint type. By setting out the defects in this manner, the inspector should not miss a defect because he will actively need to indicate that it is not present.

These pro forma should be used whenever a detailed inspection of an expansion joint is required.

Inspection pro forma: HA type 1 - Buried joint



Structure ID/name:					
Inspection type: GI PI SI	Date/time:				
Weather:				Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)
Manufacturer:	Model:				
Previous condition: Defects	Year	Cond	PI/GI		

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:

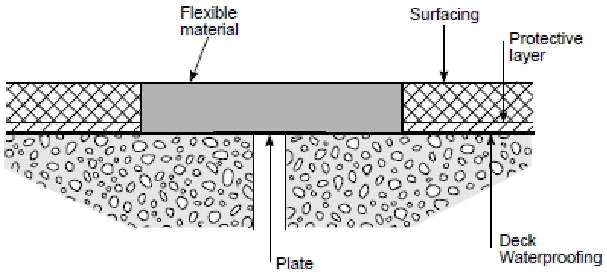
Name *Signature*

Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.6	Surfacing over buried joint is depressed/ cracked/ broken up					
17.7	Seal for induced cracking is cracked/ breached/ raised/ missing					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

Site sketch:	**Joint performance check:**
	The below performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf). Can the joint withstand traffic loading? ☐ Does the joint accommodate movement? ☐ Does the joint offer good ride quality? - Surfacing ☐ - Footway ☐ Does the joint offer skid/slip resistance? - Surfacing ☐ - Footway ☐ Is there excessive noise/vibration? ☐ Is there potential for rapid deterioration? - Cracks ☐ - Potential to form pot-holes ☐ Is the joint watertight? ☐ Is the joint suitably drained? ☐
Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.	

Inspection pro forma: HA type 2 - Asphaltic plug joint

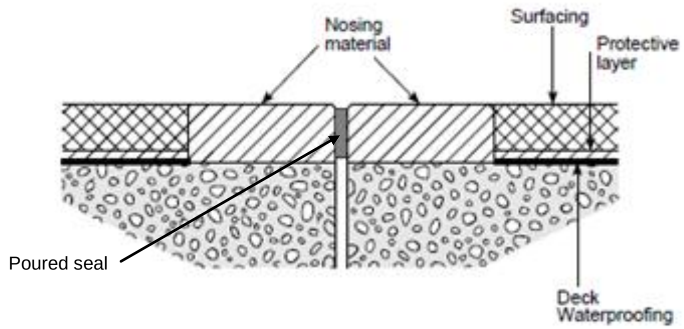


Structure ID/name:						
Inspection type: GI PI SI	Date/time:					
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					
Previous condition: Defects		Year		Cond		PI/GI
Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)						
Inspector: *Name* *Signature*						
Site sketch overleaf						

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.8	Interface between APJ and road is debonded					
17.9	Material is missing from APJ					
17.10	Tracking or flow of binder					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

Site sketch:	**Joint performance check:**
	The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf). Can the joint withstand traffic loading? ☐ Does the joint accommodate movement? ☐ Does the joint offer good ride quality? - Surfacing ☐ - Footway ☐ Does the joint offer skid/slip resistance? - Surfacing ☐ - Footway ☐ Is there excessive noise/vibration? ☐ Is there potential for rapid deterioration? - Cracks ☐ - Potential to form pot-holes ☐ Is the joint watertight? ☐ Is the joint suitably drained? ☐
Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.	

Inspection pro forma: HA type 3 - Nosing joint (poured seal)

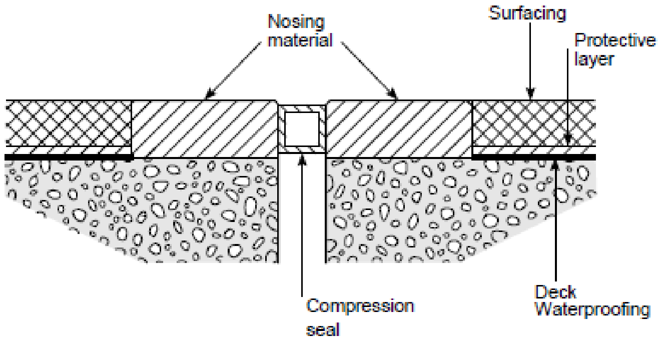


Structure ID/name:						
Inspection type: GI PI SI	Date/time:					
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					
Previous condition: Defects		Year	Cond	PI/GI		
Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)						
Inspector: *Name* *Signature*						
Site sketch overleaf						

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.11	Nosing is cracked or breaking up					
17.13	Seal is breached					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

Site sketch:	**Joint performance check:** The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf). Can the joint withstand traffic loading? ☐ Does the joint accommodate movement? ☐ Does the joint offer good ride quality? - Surfacing ☐ - Footway ☐ Does the joint offer skid/slip resistance? - Surfacing ☐ - Footway ☐ Is there excessive noise/vibration? ☐ Is there potential for rapid deterioration? - Cracks ☐ - Potential to form pot-holes ☐ Is the joint watertight? ☐ Is the joint suitably drained? ☐
Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.	

Inspection pro forma: HA type 4 - Nosing joint (preformed compression seal)



Structure ID/name:				
Inspection type: GI PI SI	Date/time:			
Weather:				Temp:
Joint:	Fixed (✓):		Free (✓):	Installed: (year)
Manufacturer:	Model:			

Previous condition: Defects	Year	Cond	PI/GI

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:

Name *Signature*

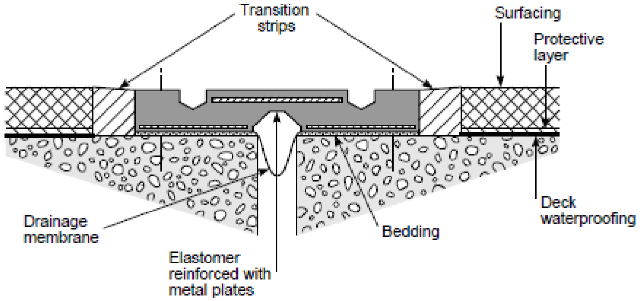
Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.11	Nosing is cracked or breaking up					
17.13	Seal is breached					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

<table>
<tr><td>Site sketch:</td><td rowspan="2">Joint performance check:
The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf).

Can the joint withstand traffic loading? ☐
Does the joint accommodate movement? ☐
Does the joint offer good ride quality?
- Surfacing ☐
- Footway ☐
Does the joint offer skid/slip resistance?
- Surfacing ☐
- Footway ☐
Is there excessive noise/vibration? ☐
Is there potential for rapid deterioration?
- Cracks ☐
- Potential to form pot-holes ☐
Is the joint watertight? ☐
Is the joint suitably drained? ☐</td></tr>
<tr><td>Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.</td></tr>
</table>

Inspection pro forma: HA type 5 - Reinforced elastomeric joint



Structure ID/name:						
Inspection type: GI PI SI	Date/time:					
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					

Previous condition: Defects	Year	Cond	PI/GI

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:

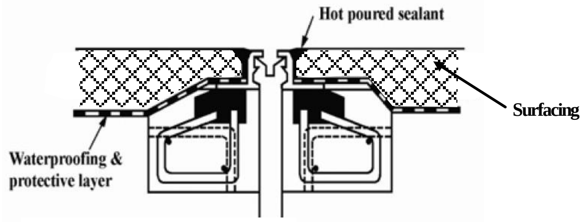
Name *Signature*

Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.11	Transition strip is cracked or breaking up					
17.12	Bolts are missing					
17.14	Preformed units are defective (tears/ cracks/ delaminated)					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

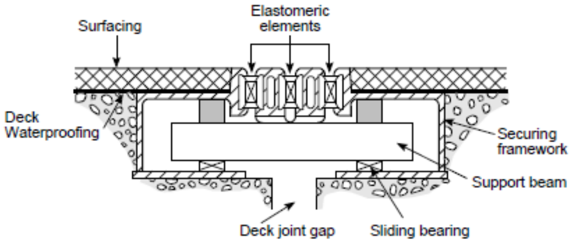
Site sketch:	**Joint performance check:** The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf). Can the joint withstand traffic loading? ☐ Does the joint accommodate movement? ☐ Does the joint offer good ride quality? - Surfacing ☐ - Footway ☐ Does the joint offer skid/slip resistance? - Surfacing ☐ - Footway ☐ Is there excessive noise/vibration? ☐ Is there potential for rapid deterioration? - Cracks ☐ - Potential to form pot-holes ☐ Is the joint watertight? ☐ Is the joint suitably drained? ☐
Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.	

Inspection pro forma: HA type 6 - Elastomeric in metal runners (cast-in)



Single element

Multiple elements



Structure ID/name:						
Inspection type: GI PI SI		Date/time:				
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					
Previous condition: Defects			Year	Cond	PI/GI	

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:

Name *Signature*

Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.13	Seal or seals are breached					
17.14	Rails are defective (bent/ cracked/ twisted)					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

<table>
<tr>
<td>

Site sketch:

</td>
<td rowspan="2">

Joint performance check:
The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf).

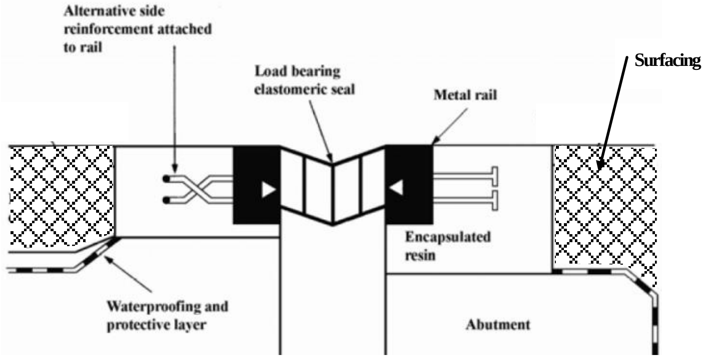
Can the joint withstand traffic loading? ☐
Does the joint accommodate movement? ☐
Does the joint offer good ride quality?
- Surfacing ☐
- Footway ☐
Does the joint offer skid/slip resistance?
- Surfacing ☐
- Footway ☐
Is there excessive noise/vibration? ☐
Is there potential for rapid deterioration?
- Cracks ☐
- Potential to form pot-holes ☐
Is the joint watertight? ☐
Is the joint suitably drained? ☐

</td>
</tr>
<tr>
<td>

Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.

</td>
</tr>
</table>

Inspection pro forma: HA type 6 - Elastomeric in metal runners (resin encapsulated)



Structure ID/name:						
Inspection type: GI PI SI	Date/time:					
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					
Previous condition: Defects	Year		Cond		PI/GI	

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:

Name *Signature*

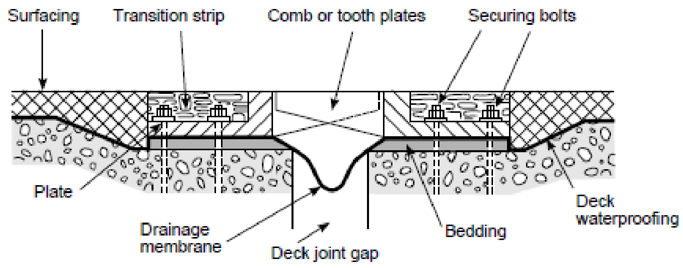
Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.11	Resin strip is cracked/broken/ missing					
17.13	Seal or seals are breached					
17.14	Rails are defective (bent/ cracked/ twisted)					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

<table>
<tr>
<td>Site sketch:</td>
<td rowspan="2">Joint performance check:
The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A ‘Y’ will confirm that the performance requirement has been checked and any defects identified noted overleaf).

Can the joint withstand traffic loading? ☐
Does the joint accommodate movement? ☐
Does the joint offer good ride quality?
- Surfacing ☐
- Footway ☐
Does the joint offer skid/slip resistance?
- Surfacing ☐
- Footway ☐
Is there excessive noise/vibration? ☐
Is there potential for rapid deterioration?
- Cracks ☐
- Potential to form pot-holes ☐
Is the joint watertight? ☐
Is the joint suitably drained? ☐</td>
</tr>
<tr>
<td>Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.</td>
</tr>
</table>

Inspection pro forma: HA type 7 - Metal tooth/comb joint



Structure ID/name:						
Inspection type: GI PI SI	Date/time:					
Weather:					Temp:	
Joint:	Fixed (✓):		Free (✓):		Installed: (year)	
Manufacturer:	Model:					
Previous condition: Defects			Year	Cond	PI/GI	

Additional comments: (eg. Proximity of inspection, restrictions, constraints, etc)

Inspector:
Name *Signature*

Site sketch overleaf

	Defect	Y/N	Comment	Action required	Severity	Extent
17.1	Joint leakage (describe effects of leakage)					
17.2	Joint sub-surface drainage is defective					
17.3	Adjacent surfacing is cracked/ disintegrated					
17.4	Joint fixtures are loose, damaged or missing					
17.5	Vegetation is growing from the joint					
17.12	Bolts are missing					
17.14	Toothed unit is corroded/cracked/ deformed/ broken					
8.x	Highway drainage					
Overall expansion joint condition: *(consider dominant or interacting defects)*						

Site sketch:	**Joint performance check:**
	The above performance requirements should be checked, and where shortfalls are identified the associated defects should be made clear on the other side of this pro forma. (A 'Y' will confirm that the performance requirement has been checked and any defects identified noted overleaf).
	Can the joint withstand traffic loading? ☐ Does the joint accommodate movement? ☐ Does the joint offer good ride quality? - Surfacing ☐ - Footway ☐ Does the joint offer skid/slip resistance? - Surfacing ☐ - Footway ☐ Is there excessive noise/vibration? ☐ Is there potential for rapid deterioration? - Cracks ☐ - Potential to form pot-holes ☐ Is the joint watertight? ☐ Is the joint suitably drained? ☐
Indicate footways, reserves, lane markings, directions, abutment and deck side, location and extent of defects, orientation of photographs.	