Half-Joint Risk Management Report - Brigsteer

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Risk Management and Structural Assessment of Post Tensioned and Half-Joint Bridges SL240 Brigsteer and SL221 Underbarrow
17 July 2024

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Appendices

1. Structure Information

1.1 Structure Name

Brigsteer

1.2 Structure Reference

SL240

1.3 Structure Description

Brigsteer, constructed in 1970 and carries the C5062 single carriageway Brigsteer Road east and west over the A591 Kendal bypass County Road south west of Kendal.

The superstructure is a single span made up of in-situ concrete cantilevers and a precast concrete beam suspended span. The west cantilever is of post-tensioned voided construction, integral with voided abutments. The east cantilever is of post-tensioned solid construction integral with abutments. The suspended span comprises 17No. prestressed pre-tensioned concrete beams and an in-situ reinforced concrete deck slab. The inner beams are inverted T-beams and are transversely post-tensioned. The edge beams are box beams. The suspended span is supported by half-joints at the ends of the cantilevers.

The top side of the structure comprises hardened verges to the north and south, 1.9m and 1.75m wide respectively. The carriageway between verges is 6.1m. Edge protection is provided by painted metallic parapets comprising post and vertical infill railing. The posts are mounted and countersunk into the parapet plinths using holding down bolts. The parapet plinth/ edge beam is 0.45m wide.

The A591 below is a dual carriageway with a grassed central reserve and grassed verges. There are “limestone pitching” revetments in front/above both abutments.

Records state that asphaltic plug type movement joints have been installed above both half-joints. However, the joints appear to have been surfaced over and the surfacing has cracked.

The suspended square span is 18.288m (60’ 0”) between centrelines of bearings.

The bridge is located at OS Grid Ref. SD 503 919.

1.4 Half-Joint Form

The half-joint form is described as ‘solid or box slab with no access to the bearing shelf’ and is classified as ‘Type A’ in accordance with CS 466 (Figure C.3 and Table C.10).

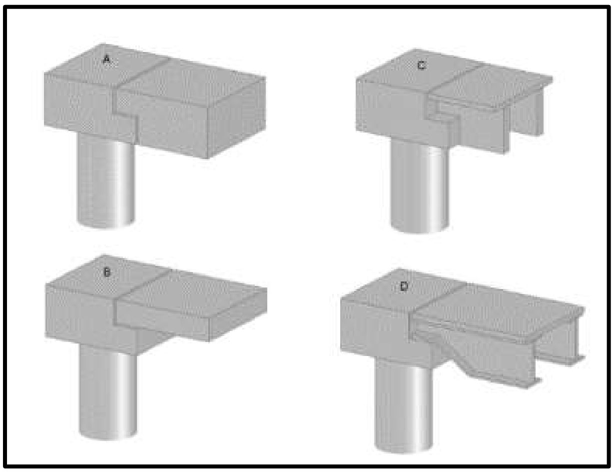

Figure 1 – Visualisation of Half-joint types (CS 466, Figure C.3)

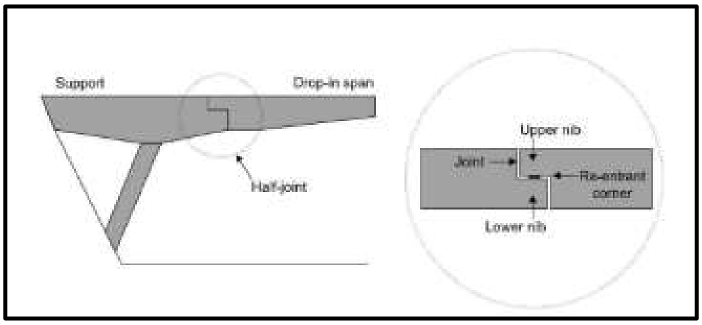

Figure 2 – Terminology used to describe Half-joint elements (CS 466, Figure A.1)

1.5 Current Condition of Structure

1.5.1 Historical Records

Brigsteer bridge is generally in fair condition and has no particular part, area or defect that is causing concern. However, there are some historical cracks to the re-entrant corners of the half-joints. The cracking is noted to be up to a maximum width of 1mm (in many cases hairline), and exhibits leachate in combination with cracking. There is no rust staining or other defect to indicate deterioration of the reinforcement.

An assessment of Brigsteer, undertaken 1991-94 by Cumbria County Council concluded that the structure has a capacity for 40T Assessment Live Loading. Brigsteer was found to have capacity for 22.5 HB units and these ratings are provided on the signed certification. However, a note in the assessment report states that if the HB vehicle travels within 150mm of the kerb, allowing associated HA loading, then the capacity reduces to 14 HB units, limited by the lower nib of the half-joints.

SLS checks concluded that the actual crack width is greater than twice the allowable width. The cracking is therefore attributed to poor detailing of reinforcement as opposed to overloading.

1.5.2 Half-Joint Inspection (July 2022)

The half-Joint Inspection, undertaken 4/5th July 2022 concluded:

Both half-joints are generally in good condition with localised instances of spalling, cracking and staining (mostly on elevation). There are no signs of moisture ingress (i.e. visibly wet/ algal staining).

Previous inspection reports have raised concerns regarding the cracking to the re-entrant corners of the lower nib. By further inspection, it is concluded that the existing cracks are not enlarging and that the condition of the half-joints internally is good.

Recommended condition factor for assessment = 0.9

For further information refer to document BCU00015-JAC-SBR-6330-RP-SL240-CB-004.

2. Initial Review

2.1 Documents used in Initial Review

In accordance with Section 3.2 of CS 466, the initial review shall consider the following record information:

1) the most recent risk assessment;
2) as-built drawings, construction records and other as-built information;
3) principal, general or special inspection reports;
4) recommendations from previous inspections and maintenance records; and,
5) previous structural assessments and recommendations.

Note: there is no current risk assessment for the existing half-joints.

In the absence of a current risk assessment, the initial review considers documents attributable to points 2-5 above. A preliminary risk assessment has been carried out, see section 3, based on the available historical information and shall be verified following the next inspection event.

See Appendix A for a list of available documents utilised as part of the initial review.

2.2 Findings from Initial Review

E 06511 Underbarrow and Brigsteer – Assessment, E 06513 Brigsteer – Structure File:

The assessment carried out 1991-94 by Cumbria County Council is specific to the load carrying capacity of the internal and external beams but also to the capacity of the half-joints.

SLS assessment to BD21/93 and BA39/93 (both withdrawn) concluded that the assessed crack width for the lower nibs of the support spans (0.4mm for HA live load) was more than double the allowable crack width (0.15mm).

ULS assessment calculations concluded that the lower nibs have capacity for 22.5 HB units for Brigsteer, assuming no loss of section or deterioration of reinforcement, and these ratings are provided on the signed assessment certification, dated 14th February 1995. However, a note in the assessment reports states that if the HB vehicle travels within 150mm of the kerb, allowing associated HA loading, then the capacity reduces to **14 HB units, limited by the lower nib of the half-joints**.

The suspended span (upper nib) was found to be uncracked at SLS HA loading and Accidental Wheel Loading. It was also found to be satisfactory for full HA and 30HB units.

The assessment calculations are comprehensive. A signed version is included within the structure file for each structure. Although the cover sheet does not state the name of the Check Engineer, the calculation sheets do have a check date and initial.

Signed assessment certificates are available for both structures, dated 14th February 1995, and provide a rating of 40t ALL. However, there is some ambiguity over the HB rating: 22.5 HB units for Brigsteer. However, a note in the assessment reports states that if the HB vehicle travels within 150mm of the kerb, allowing associated HA loading, then the capacity reduces to **14 HB units, limited by the lower nib of the half-joints**.

The assessment report (summary) is limited to a single page for both Underbarrow and Brigsteer. The report summarises the results of the appended calculations and highlights some assumptions made in the assessment alongside future maintenance recommendations.

The assessment has predominantly been carried out in accordance with BD21/93 but many of the reference documents are dated 1980-90s. As a result, the standards used to assess the structure have since been superseded and so the validity of the assessment cannot be maintained.

The assessment report concludes that the detailing for the half-joints of both Brigsteer and Underbarrow is considered to be poor due to the absence of diagonal reinforcement in the lower nib (in-situ cantilevers) of each half-joint.

The assessment document shows a sketch of reinforcement considered within each section of half-joint. The sketches show all reinforcement to be 19mm in diameter and details the diagonal bar (upper nib) at 49.6 degrees. The bar spacings are generally called off at 152mm although the origin of the spacing and bar sizes is unknown. Available record drawings call off Bar Marks with no associated bar bending schedule.

<u>E 06509 Underbarrow and Brigsteer - Design Calculations:</u>

The design calculations state the following for the half-joint lower nib (in-situ cantilevers):

Bending Moment Design =	7250 lbft	Reinforcement =	12.7mm bars at 152mm centres
Shear Force Design =	114 lb/in2	Reinforcement =	19mm legs at 102mm centres

The design calculations state the following for the half-joint upper nib (suspended span precast internal inverted T beams):

Bending Moment Design =	19720 lbft	Reinforcement =	3 No. 19mm bars per beam
Shear Force Design =	231 lb/in^2	Reinforcement =	3 No. 15.9mm stirrups per beam

The design calculations state the following for the edge box beams:

Bending Moment Design =	264402 lbft	Reinforcement =	3 No. 19mm bars per beam
Shear Force Design =	140 lb/in^2	Reinforcement =	3 No. 15.9mm stirrups per beam

<u>SL240_BRIGSTEER_C5062 PBI 2018 (Principal Bridge Inspection Report):</u>

The 2018 Principal Inspection noted cracks extending from the lower nibs of the north east, north west and south east half-joints, each with associated leachate.

The report noted a short length of exposed rebar (due to insufficient cover) to the north west half-joint.

Brigsteer was found to be in generally fair condition and has no part, area or defect causing concern or inspection of which is beyond the requirements of the Principal Inspection. Consequently, the report considered that a Special Inspection was not required.

<u>Historical Drawings:</u>

Bearings within the half-joints are shown to be elastomeric (Dunlop Metalastik) on record information and are shown as 285.75mm x 146mm x 78.13mm thick @ 604mm centres.

The reinforcement details for the in-situ cantilevers are shown on separate drawings and appear to detail a similar arrangement of reinforcement at each location.

The historical drawings for the cantilevers do not show the size of each bar mark and call off spacings of bar marks sporadically. There are no accompanying bar bending schedules to indicate sizes, shapes and numbers of bars for each bar mark.

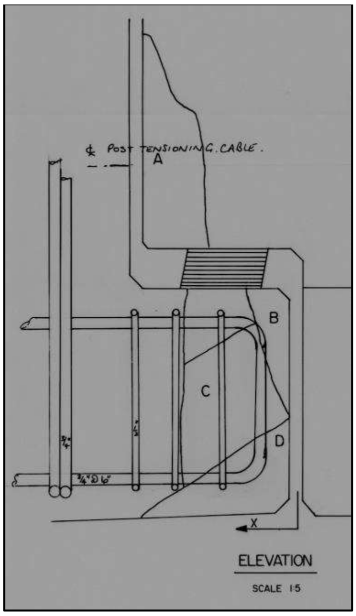

Figure 3 – Brigsteer West Half-Joint Sketch

Showing size of local reinforcement

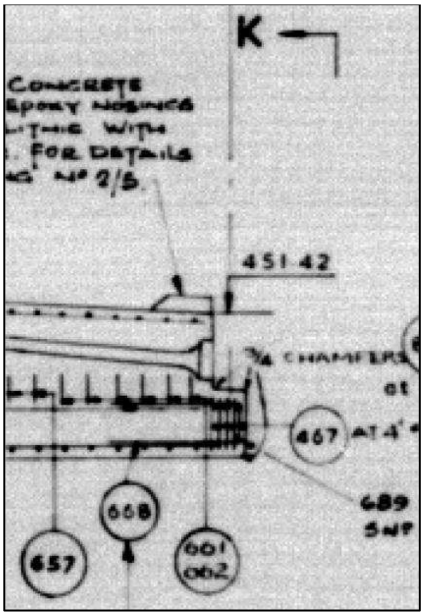

Figure 4 – Brigsteer West Half-Joint

Showing reinforcement layout of lower nib.

Historical drawings show the details for the suspended span to be similar for both structures (detailed on the same drawings). The inner precast concrete beams are inverted T-beams longitudinally pre-tensioned and transversely post-tensioned together. Links protrude from the tops of the inner beams to act compositely with the in-situ deck slab. The outer precast concrete beams are pre-tensioned box beams. They are slightly deeper than the inner beams and bars protrude from inner side of each edge beam at its upper corner to tie into the adjacent in-situ deck slab.

The historical drawings do not show the size of each bar mark and call off spacing of bar marks sporadically. There are no accompanying bar bending schedules to indicate sizes, shapes and numbers of bars for each bar mark.

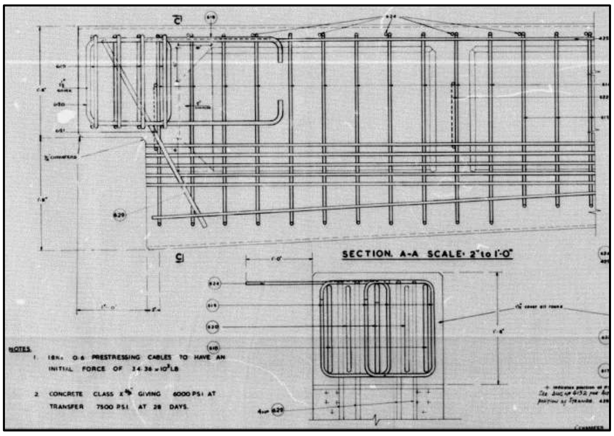

Figure 5 – Suspended Span Details (external beam)

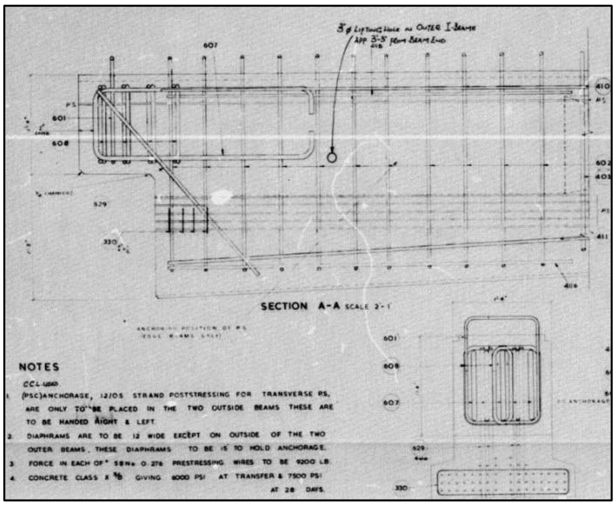

Figure 6 – Suspended Span Details (internal beam)

2.3 Conclusion of Initial Review

Considering the findings of the initial review, it is recommended that a combined Principal Inspection and Inspection for Assessment is undertaken to assess any changes in condition and obtain sufficient parameters to undertake a Structural Assessment of the half-joints so that their capacity can be confirmed in accordance with current codes of practice.

There is some concern regarding the level of detail that can be taken from historical drawings as there are no records of accompanying bar bending schedules to confirm bar sizes and shapes, which are not shown on the drawings. Considering the sketches shown in the 1991 assessment document, the information remains limited (it does not appear that full reinforcement within each section is considered) and its reliability is questionable given the lack of reference to any investigative works. As a result, it is recommended that a "Ferroscan" or similar is undertaken at the next inspection opportunity (where access is available) in order to detail accurately the layout of reinforcement within both nibs of the joints. Otherwise, reasonable assumptions will need to be made within the assessment of the bar sizes, spacings, lap lengths, anchorage lengths, material grade etc., by making reference to the available information on drawings, assessment calculations, design calculations.

The initial review has concluded that there is sufficient information, from the previous 2018 Principal Inspection and historical record drawings, to complete a preliminary Risk Assessment for Structural Assessment (see section 3), however attempts should be made to obtain any further available historical information regarding the reinforcement details.

2.3.1 Recommendations Following Initial Review

- It is recommended that a combined Principal Inspection and Inspection for Assessment is undertaken. Recommendation undertaken 4/5th July 2022. See Half-joint Inspection Report: BCU00015-JAC-SBR-6330-RP-SL240-CB-004.
- It is recommended that a "Ferroscan" or similar non-destructive technique is undertaken at the next inspection opportunity (where access is available). Recommendation undertaken 4/5th July 2022. See Half-joint Inspection Report: BCU00015-JAC-SBR-6330-RP-SL240-CB-004.
- It is recommended that a preliminary Risk Assessment for Structural Assessment is carried out in accordance with CS 466 (see section 3), to be verified following the next inspection opportunity. See revision P01 of this report for the preliminary risk assessment.

2.4 Additional Historical Information Review

2.4.1 Summary

Westmorland & Furness Council provided additional archived files for review, March 2024, which were unavailable during the previously-commissioned activities (including assessment, 2023). Jacobs UK Ltd undertook a review of these additional documents and revisited some which were issued under the original commission with a view to understanding any modifications or alterations which may have occurred during construction and not captured on the previously-provided historical information. Refer to BCU00015-JAC-SBR-6330-RP-SL240-CB-011.

The review of the documents provided found the following key events:

1. The reinforcement layout was altered for the upper nib of the suspended span internal beams.
2. The reinforcement bar sizes were altered from imperial to metric.
3. The size of the upper nib was increased due to the need to accommodate the specified longitudinal fall on the abutment cantilever.
4. The Contractor proposed various alterations to the post-tensioning system.

Although the above points are 'key' findings, the alterations noted would not increase the capacity (i.e. load rating) of the half-joints although it would marginally increase the resistance of some tie components of the strut and tie assessment models.

It was recommended that:

1. The structure be managed under CS 470 as 'sub-standard' with appropriate interim measures established for the half-joints.

2. Investigative works be carried out to ascertain the true construction details and material strengths.

3. Consideration be given to establishing the details and condition of the post-tensioning system through PTSI Site Investigation.

4. A Structural Review be carried out to consider the parameters obtained by the above investigations and whether a reassessment would provide an improved load rating.

2.5 Conclusion of Half-Joint Inspection and Post-Tensioned Inspection

2.5.1 Survey of Half-Joints

The half-joints were surveyed to confirm the size of the upper and lower nibs (on elevation only):

	Design Calculations		Record Drawings		Inspection Measurements	
	(ft / in)	(mm)	(ft / in)	(mm)	(ft / in)	(mm)
Lower nib	5 1/2" x 17 3/8"	140mm x 440mm	12" x 1'5"	305mm x 430mm	-	310mm x 500mm
Upper nib (external)	9" x 20"	228mm x 508mm	1' x 1'8"	305mm x 508mm	-	*305mm x 450mm
Upper nib (internal)	9" x 16"	228mm x 406mm	1' x 1' 4"	305mm x 405mm	-	-

*Note: It is noted that the parapet upstand may mask the vertical extent (450mm / 508mm) of the element.

One of the objectives of the Half-Joint Inspection was to confirm that dimensions on site match those shown on record drawings and hence confidence could be taken that the record drawings are a true representation of the structure. However, the upper and lower nibs of the half-joints appear to have different depths to those shown on the record drawings, and so it has to be concluded that the record drawings aren't wholly reliable.

2.5.2 Ferro-scan of Upper and Lower Nibs

Localised scanning of the half-joints was undertaken using a Ferroscan and GPR, areas of the half-joint which were scanned included; the upper nib, lower nib and cantilever soffit of cantilever. The purpose of the scanning was to confirm the diameter and spacings of reinforcement were scanned to confirm the size of reinforcement shown on available record drawings as to provide confidence in the record drawings.

In general, the spacing of reinforcement observed by scanning does not coincide with the details expected from reviewing record drawings. It is difficult to ascertain the accuracy of the scanned data considering the volume of reinforcement within the half-joints. It is therefore suggested that, since the typical size of bar matches those shown on record drawings, the spacing of bars is determined from the record drawings. Should the Client want a more accurate representation of the reinforcement layout, it is recommended that local breakouts are undertaken.

Inspection and ferro-scanning of the half-joints confirms the following:

- The interior surfaces of the half-joints could not be competently inspected due to the presence of polystyrene filler material. However, as far as can be seen they appear to be in fair condition (via endoscope inspection). The cracking to the re-entrant corners of the lower nibs on the deck elevations does not appear to have worsened since the previous inspections.
- The upper and lower nibs differ significantly in size compared to the dimensions shown on record drawings and as a result casts some doubt against the reliability of the 'record' drawings.
- The ferro-scanning of the upper and lower nib typically confirms the size of the local reinforcement to match that shown on record drawings, the spacing of such bars cannot be accurately determined due to the density of the reinforcement within the nibs.
- There is no indication that the vulnerable details of the structure are different to those noted during the initial review of existing records – it is noted however that there is not significant deterioration of the structure at present.

2.6 Sub-standard Structure Management Documents

A CS 470 Management of Sub-standard Highway Structures has been prepared (doc. ref.: BCU00015-JAC-SBR-6330-RP-SL240-010), dated July 2024, following a 2023 assessment of the half-joints. Refer to section 6.4 for a summary of the CS 470 recommendations.

3. Risk Assessment for Structural Assessment

This Risk Assessment has been revised following a Half-joint Inspection and a Post-tensioned Inspection. The risk assessment is to prioritise half-joint structures for Structural Assessment. The output of this risk assessment process shall assign a risk rating to the structure to enable this prioritisation.

Example risk ratings are as follows:

- Very high;
- High;
- Medium;
- Low

3.1 Primary Risks

The following primary risks shall be included when completing a risk assessment to determine a primary risk rating for prioritising structural assessments:

1. Condition risk, R_C ; and,
2. Structural risk, R_D.

		Structural risk R_D			
		R_D **Very high**	R_D **High**	R_D **Medium**	R_D **Low**
Condition risk R_C	R_C **Very high**	Very high (1)	Very high (1)	High (1)	High (1)
	R_C **High**	Very high (1)	High (1)	High (1)	Medium (1)
	R_C **Medium**	High (1)	High (1)	Medium (1)	Medium (1)
	R_C **Low**	High (1)	Medium (1)	Medium (1)	Low (1)
Note (1) = The primary risk rating determined from the combination of R_C and R_D .					

Figure 7 - Matrix for determining primary risk rating of a half-joint structure

(CS 466 Table C.1)

The primary risks are used to assess the risk of the structural failure of the half-joint based on the following:

1. R_C representing the likelihood of structural failure due to condition risks being realised;
2. R_D representing the likelihood of structural failure due to structural capacity risks being realised; and,
3. The severity of the consequences at this stage is taken as being very high as it involves a half-joint structure failure which could lead to collapse.

The effects from the combination of condition and structural risk should be assessed when assigning a risk rating for the primary risks. It should be noted that this risk rating is to prioritise half-joint structures for assessment and it may not be suitable to use it to prioritise assessment alongside non-half-joint structures within the bridge stock.

3.1.1 Primary Risk Rating

The preliminary primary risk rating for Brigsteer is HIGH in accordance with CS 466 Table C.1, based on the available information relating to the condition risk and structural risk below:

3.1.1.1 Condition Risk, R_C

Condition Risk R_C: Likelihood of structural failure due to condition risks being realised.

The condition risk rating for Brigsteer is considered MEDIUM *(see Note 2)* in accordance with CS 466 Table C.1, based on the combination of defects, their location and damage rating:

Defect Description	Reference	Defect Identification	Zone (see Figure 8)	Damage Rating	Defects in Combination
0.2mm Shear crack to lower nib re-entrant corner	Appendix B, Photograph 1	North east half-joint	3	Slight	Leachate
0.15mm Shear crack to lower nib re-entrant corner	Appendix B, Photograph 2	South east half-joint	3	Slight	Leachate
Shear crack to lower nib re-entrant corner	Appendix B, Photograph 3	North west half-joint	3	Very slight	Leachate
Shear crack to lower nib re-entrant corner	Appendix B, Photograph 4	South west half-joint	3	Very slight	Leachate
Exposed vertical rebar	Appendix B, Photograph 4	South west half-joint	3	Very slight	-

Table 1 Brigsteer, Condition Risk

Note 1: As the risk assessment is preliminary (based on historical information), the 'Zone' has been attributed visually, not in accordance with the measurements of h & c as detailed below.

Note 2: CS 466 states that where poor detailing exists, this can increase the impact of condition defects and thus the risk level. The previous assessment confirmed the poor steel reinforcement detailing and, as such, the risk rating has been increased from Low to Medium.

Note 3: Previous inspections have not been able to inspect the internal hidden surfaces of the half-joints inboard of the elevations and therefore there may be other more significant structural defects not currently known.

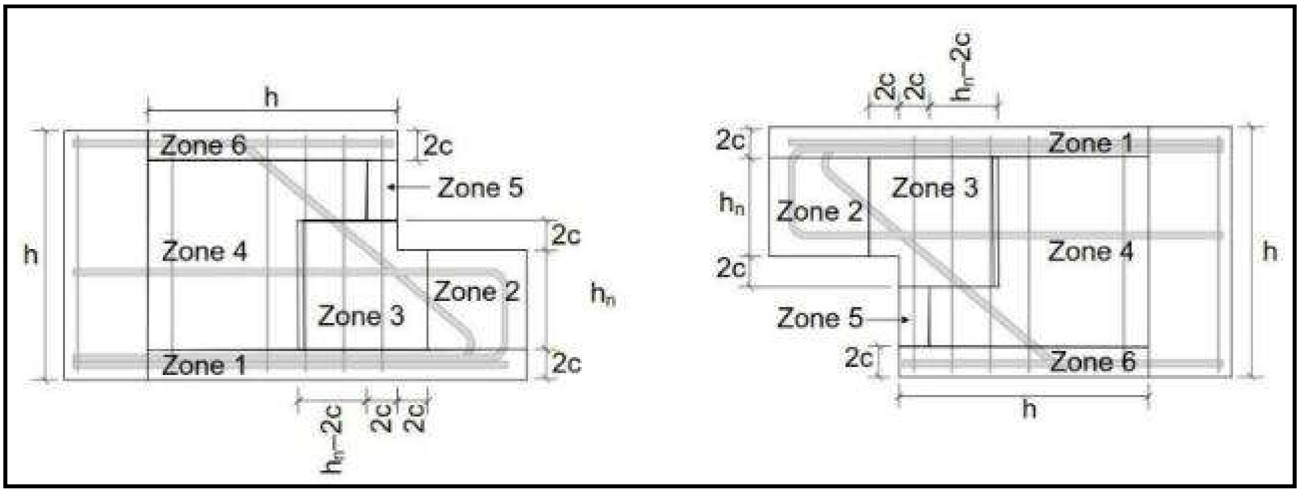

Figure 8 – Zones within the half joint to record locations of condition and detailing defects

(CS 466, Figure C.2)

3.1.1.2 Structural Risk, R_D

Structural Risk R_D: Likelihood of structural failure due to structural capacity risks being realised. Note that R_{D1} has been used.

The structural risk for Brigsteer is considered HIGH *(see Note 4)* in accordance with CS 466 Table C.5, based on the poor reinforcement detailing (as stated by the previous assessment). Historical drawings appear to show that the reinforcement in the lower nib is well anchored and there are full height shear links which appear to be effectively anchored, however there is no diagonal bar. Furthermore, there is no post-tensioning in the lower nib.

The bearings are positioned reasonably close to the edge of the half-joint nibs and the load spread from the bearings is considered likely to be outside of the reinforcement cage. As such there is potential for the breaking-off of the nib corners.

The findings of the half-joint inspection and scanning of reinforcement do not provide sufficient detail to either agree or disagree with the detailing shown on available record drawings. A survey of the upper and lower nib shows the nibs to be significantly larger in size than those shown on record drawings which in turn casts some doubt over the reliability of the record drawings. On this basis, there is no rationale for reducing the structural risk rating. Although the scanned sizes of reinforcement typically match those shown on the historical drawings, the spacing of reinforcement cannot be accurately ascertained without intrusive investigation.

The structural risk for Brigsteer is considered HIGH *(see Note 4)* in accordance with CS 466 Table C.5.

Note 4: CS 466 cl. 4.6.3 notes that a higher rating may be used for R_D where there is a lack of record information. As the bar sizes and spacings used in the design and assessment calculations have not been confirmed, the rating has been increased from Medium to High.

3.2 Secondary Risks

The following secondary risks may be used to refine the primary risk rating of a half-joint structure:

1. consequential risk, R_Q ;
2. vulnerable details risk , R_V ;
3. half-joint form risk, R_F ;
4. other risks, R_O .

As the structure is not part of a package the secondary risks as detailed below should be used to increase the primary risk rating to create a refined primary risk rating.

3.2.1.1 Consequential Risk, R_Q

Consequential Risk, R_Q represents the consequence of structural failure on the routes carried by or below the structure.

The consequential risk for Brigsteer is considered VERY HIGH in accordance with CS 466 Table C.8, based on the consequential scores below from CS 466 Table C.7:

Consequence	Score	Rating
Number of people killed or seriously injured:	10	(very high)
Potential damage vehicles:	10	(very high)
Potential damage to utilities and other public or private services:	3	(high)
Nature of route:	3	(high)
Diversion route:	10	(very high)
Volume of traffic:	1	(medium)
Length of time to restore normal network operation:	10	(very high)
Potential environmental pollution:	0	(low)
Political and reputation damage:	10	(very high)
Financial impact:	3	(high)

3.2.1.2 Vulnerable Details Risk, R_V

Vulnerable Details Risk, R_V represents the risk of structural failure due to additional vulnerable details.

The vulnerable details considered for Brigsteer are associated with the expansion joints above the half-joints. As the joints deteriorate over time, they permit seepage of salt-laden water to access the half-joint bearing shelves. Additionally, as the cantilevers are constructed from in-situ concrete there is a reasonable possibility that there are construction joints at the location of the bottom nib, which would permit the percolation of any water and exacerbate any cracking or other deterioration to the concrete and underlying steel reinforcement.

There are anchorages for the post-tensioning in the in-situ concrete cantilevers situate within the upper area of the half-joint and beneath the expansion joint. The previous assessment also confirmed that the reinforcement detailing of the lower nib is poor. There is no diagonal bar to prevent opening up of the re-entrant corner and this is evidenced in several locations by the presence of historical diagonal cracks. Also, there is no post-tensioning in the lower nib so it acts as a reinforced concrete corbel only.

There are areas of exposed reinforcement, suggesting issues associated with low concrete cover; drawings indicate 38.1mm cover which is relatively low by current standards. The concrete strength of the precast elements is stated as 7500psi (51.7N/mm2) but for the in-situ cantilevers it is stated as Y3/4" (6000psi (41.4N/mm2), 19mm dia. aggregate). The in-situ concrete grade is lower than modern standards for deck construction and may be more susceptible to water percolation into the matrix of the concrete material.

Considering these vulnerabilities, a HIGH rating has been adopted for RV in accordance with CS 466 Table C.9.

The half-joint inspection and post-tension site inspection confirms that the vulnerable details exist as anticipated but that at present there is no ongoing deterioration attributable to the vulnerable details. The cracks to the re-entrant corners of the lower nib are hairline and show no signs of deterioration from previous inspection reports. Typically, the interior of the joint, where visible by endoscope, is in good condition. The spalling of concrete and corrosion of reinforcement remains a local defect and does not appear to have caused widespread deterioration.

3.2.1.3 Half-Joint Form Risk, R_F

Half-Joint Form Risk, R_F represents the risk of structural failure due to the half-joint type which affects the ease of accessibility and visibility for inspections and detecting defects.

The half-joint form risk for Brigsteer is considered VERY HIGH in accordance with CS 466 Table C.12, based on the scores below:

Joint Detail Score: The joint detail score for Brigsteer is 10 *'solid or box slab with no access to the bearing shelf'* in accordance with CS 466 Table C.10. Note that whilst the suspended span is made up of precast beams, they are closely spaced so that their flanges provide a continuous soffit; they are infilled between beams and transversely post-tensioned to form a solid slab.

Ease of Access Score: The ease of access score for Brigsteer is 2 *'Difficult to access more than one joint'* (from below) in accordance with CS 466 Table C.11.

3.2.1.4 Other Risk, R_O

Other Risks, R_O represents a tool to include other risks and considerations that could affect the priority of a half-joint structure.

The other risks rating for Brigsteer is considered LOW in accordance with CS 466 Table C.13, as there are no other factors or issues which have not already been considered that will affect the risk of the structure.

3.3 Refined Primary Risk Rating

The primary risk rating was considered as HIGH based on R_C = MEDIUM and R_D = HIGH in accordance with Table C.1 of CS466. Based on the secondary risks identified in section 3.2 above, it is proposed that the primary risk rating is increased to VERY HIGH due to the fact that the consequential risk is very high and the half-joint form means it is very difficult to gain access for inspections and maintenance and significant structural defects could already exist which have not previously been identified.

Inspection and ferro-scanning of the half-joints confirms the following:

- The interior of the half-joints appears to be in good condition as far as could be seen (via endoscope inspection). The cracking to the re-entrant corners of the lower nibs does not appear to have worsened since previous inspections.

- The upper and lower nibs differ significantly in size compared to the dimensions shown on record drawings and as a result casts some doubt against the reliability of the ‘record’ drawings.
- The ferro-scanning of the upper and lower nib typically confirms the size of the local reinforcement to match that shown on record drawings, the spacing of such bars cannot be accurately determined due to the density of the reinforcement within the nibs.
- There is no indication that the vulnerable details of the structure are different to those noted during the initial review of existing records – it is noted however that there is not significant deterioration of the structure at present.

4. Summary of Structural Review Findings

A CS451 Structural Review of the half-joints was carried out, signed by the TAA on 8th November 2022, and it concluded/recommended the following:

The structure remains in good condition however the available records (design / assessment / record drawings) do not accurately represent the size of the half-joints in reality and as such the available records are not wholly reliable.

It is recommended that the following activities are carried out as a high priority:

1. The half-joints are assessed quantitatively considering;
    - The size of the upper and lower nib are taken as physically measured,
    - In the absence of intrusive investigation to ascertain accurate reinforcement details, that the reinforcement size layout is taken as shown on record drawings.
    - The condition factor for the half-joints = 0.9.
2. Intrusive investigation is taken to ascertain the reinforcement details 'as-built'.

The following maintenance actions are recommended:

- Provide concrete repairs to the east and west cantilever soffits.
- Remove surfacing and waterproofing, re-waterproof, resurface and install expansion joints.

Note, it would be appropriate to undertake the above maintenance actions in combination with any investigation works, particularly investigation into the post-tensioning.

It is further recommended that a post-tensioned special Investigation is undertaken however this is not specific to the half-joints.

Note: A Risk Appraisal to CS 451 (Appendix A) has not been undertaken as an assessment has already been commissioned as part this scheme.

For further information refer to BCU00015-JAC-SBR-6330-RP-SL240-CB-006 P01 & BCU00015-JAC-SBR-6330-RP-SL240-CB-007 P01.

5. Summary of Structural Assessment Findings

Based on the results of a 2023 assessment, the half-joints have been found to be inadequate for dead loads at ULS and SLS. The assessment report recommended that investigative works be carried out to ascertain the true construction details and material strengths and consideration be given to establishing the details and condition of the post-tensioning system through PTSI Site Investigation. The report also recommended monitoring the half-joints in the interim, which has been further considered under CS470 'Management of Sub-Standard Structures', refer to 6.4.

Summary of Results

The half-joints have been assessed to CS 454 and the results are summarised in the table below:

Structural Element	Loading	Capacity
Half-joint (Upper Nib)	Dead load (ULS)	Inadequate
Half-joint (Lower Nib)	Dead load (ULS)	Inadequate
Half-joint (Upper Nib)	Dead load (SLS)	Adequate
Half-joint (Lower Nib)	Dead load (SLS)	Inadequate

Refer to the Brigsteer Assessment Report, BCU00015-JAC-SBR-6330-RP-SL240-CB-009, for further details.

The assessment certification has been prepared based on the above capacities and has been presented to the TAA for acceptance.

6. Risk Assessment for Management

The risk assessment is to prioritise half-joint structures for management and interventions. The output of this risk assessment process shall assign a risk rating to the structure to enable this prioritisation.

Example risk ratings are as follows:

- Very high;
- High;
- Medium;
- Low

6.1 Primary Risks

The following primary risks shall be included when completing a risk assessment to determine a primary risk rating for prioritising structural assessments:

1. Condition risk, R_C; and,
2. Structural risk, R_D.

		Structural risk R_D			
		R_D **Very high**	R_D **High**	R_D **Medium**	R_D **Low**
Condition risk R_C	R_C **Very high**	Very high (1)	Very high (1)	High (1)	High (1)
	R_C **High**	Very high (1)	High (1)	High (1)	Medium (1)
	R_C **Medium**	High (1)	High (1)	Medium (1)	Medium (1)
	R_C **Low**	High (1)	Medium (1)	Medium (1)	Low (1)
Note (1) = The primary risk rating determined from the combination of R_C and R_D.					

Figure 7 - Matrix for determining primary risk rating of a half-joint structure

(CS 466 Table C.1)

The primary risks are used to assess the risk of the structural failure of the half-joint based on the following:

1. R_C representing the likelihood of structural failure due to condition risks being realised;
2. R_D representing the likelihood of structural failure due to structural capacity risks being realised; and,
3. The severity of the consequences at this stage is taken as being very high as it involves a half-joint structure failure which could lead to collapse.

The effects from the combination of condition and structural risk should be assessed when assigning a risk rating for the primary risks. It should be noted that this risk rating is to prioritise half-joint structures for assessment and it may not be suitable to use it to prioritise assessment alongside non-half-joint structures within the bridge stock.

6.1.1 Primary Risk Rating

The preliminary primary risk rating for Brigsteer is HIGH in accordance with CS 466 Table C.1, based on the available information relating to the condition risk and structural risk below:

6.1.1.1 Condition Risk, R_C

Condition Risk R_C: Likelihood of structural failure due to condition risks being realised.

The condition risk rating for Brigsteer is considered MEDIUM *(see Note 2)* in accordance with CS 466 Table C.1, based on the combination of defects, their location and damage rating:

Defect Description	Reference	Defect Identification	Zone (see Figure 8)	Damage Rating	Defects in Combination
0.2mm Shear crack to lower nib re-entrant corner	Appendix B, Photograph 1	North east half-joint	3	Slight	Leachate
0.15mm Shear crack to lower nib re-entrant corner	Appendix B, Photograph 2	South east half-joint	3	Slight	Leachate
Shear crack to lower nib re-entrant corner	Appendix B, Photograph 3	North west half-joint	3	Very slight	Leachate
Shear crack to lower nib re-entrant corner	Appendix B, Photograph 4	South west half-joint	3	Very slight	Leachate
Exposed vertical rebar	Appendix B, Photograph 4	South west half-joint	3	Very slight	-

Table 1 Brigsteer, Condition Risk

Note 1: The 'Zone' has been attributed visually, not in accordance with the measurements of h & c as detailed below.

Note 2: CS 466 states that where poor detailing exists, this can increase the impact of condition defects and thus the risk level. The previous assessment confirmed the poor steel reinforcement detailing and, as such, the risk rating has been increased from Low to Medium.

Note 3: Previous inspections have not been able to inspect the internal hidden surfaces of the half-joints inboard of the elevations and therefore there may be other more significant structural defects not currently known.

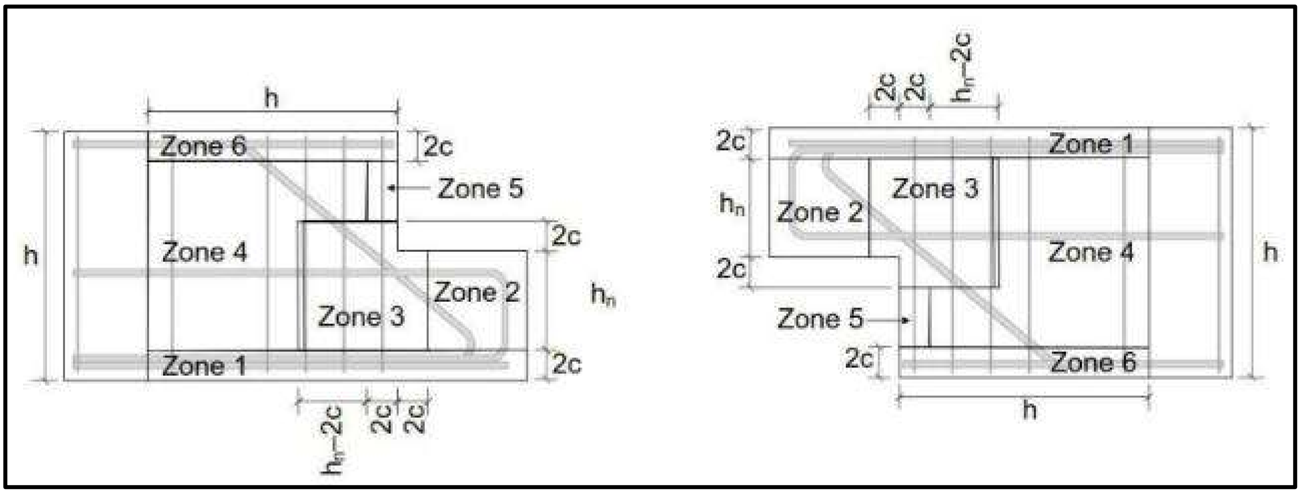

Figure 8 – Zones within the half-joint to record locations of condition and detailing defects (CS 466, Figure C.2)

6.1.1.2 Structural Risk, R_D

Structural Risk R_D: Likelihood of structural failure due to structural capacity risks being realised. Note that R_{D2} (C2.2.2) has been used.

The structural risk for Brigsteer is considered VERY HIGH in accordance with CS 466 Table C.6 based on the conclusion that the half-joints have been assessed as being inadequate for dead load.

6.2 Secondary Risks

The following secondary risks may be used to refine the primary risk rating of a half-joint structure:

1. consequential risk, R_Q ;
2. vulnerable details risk , R_V ;
3. half-joint form risk, R_F ;
4. other risks, R_O .

As the structure is not part of a package the secondary risks as detailed below should be used to increase the primary risk rating to create a refined primary risk rating.

6.2.1.1 Consequential Risk, R_Q

Consequential Risk, R_Q represents the consequence of structural failure on the routes carried by or below the structure.

The consequential risk for Brigsteer is considered VERY HIGH in accordance with CS 466 Table C.8, based on the consequential scores below from CS 466 Table C.7:

Consequence	Score	Rating
Number of people killed or seriously injured:	10	(very high)
Potential damage vehicles:	10	(very high)
Potential damage to utilities and other public or private services:	3	(high)
Nature of route:	3	(high)
Diversion route:	10	(very high)
Volume of traffic:	1	(medium)
Length of time to restore normal network operation:	10	(very high)
Potential environmental pollution:	0	(low)
Political and reputation damage:	10	(very high)
Financial impact:	3	(high)

6.2.1.2 Vulnerable Details Risk, R_v

Vulnerable Details Risk, R_v represents the risk of structural failure due to additional vulnerable details.

The vulnerable details considered for Brigsteer are associated with the expansion joints above the half-joints. As the joints deteriorate over time, they permit seepage of salt-laden water to access the half-joint bearing shelves. Additionally, as the cantilevers are constructed from in-situ concrete there is a reasonable possibility that there are construction joints at the location of the bottom nib, which would permit the percolation of any water and exacerbate any cracking or other deterioration to the concrete and underlying steel reinforcement.

There are anchorages for the post-tensioning in the in-situ concrete cantilevers situate within the upper area of the half-joint and beneath the expansion joint. The record drawings and previous assessment also confirmed that the reinforcement detailing of the lower nib is poor. There is no diagonal bar to prevent opening up of the re-entrant corner and this is evidenced in several locations by the presence of historical diagonal cracks. Also, there is no post-tensioning in the lower nib so it acts as a reinforced concrete corbel only.

There are areas of exposed reinforcement, suggesting issues associated with low concrete cover; drawings indicate 38.1mm cover which is relatively low by current standards. The concrete strength of the precast elements is stated as 7500psi (51.7N/mm2) but for the in-situ cantilevers it is stated as Y3/4" (6000psi (41.4N/mm2), 19mm dia. aggregate). The in-situ concrete grade is lower than modern standards for deck construction and may be more susceptible to water percolation into the matrix of the concrete material.

Considering these vulnerabilities, a HIGH rating has been adopted for RV in accordance with CS 466 Table C.9.

The half-joint inspection and Post-tension inspection confirms that the vulnerable details exist as anticipated but that at present there is no ongoing deterioration attributable to the vulnerable details. The cracks to the re-entrant corners of the lower nib are hairline and show no signs of deterioration from previous inspection reports. Typically the interior of the joint, where visible by endoscope, is in good condition. The spalling of concrete and corrosion of reinforcement remains a local defect and does not appear to have caused widespread deterioration.

6.2.1.3 Half-Joint Form Risk, R_F

Half-Joint Form Risk, R_F represents the risk of structural failure due to the half-joint type which affects the ease of accessibility and visibility for inspections and detecting defects. The half-joint form risk for Brigsteer is considered VERY HIGH in accordance with CS 466 Table C.12, based on the scores below:

Joint Detail Score: The joint detail score for Brigsteer is 10 *'solid or box slab with no access to the bearing shelf'* in accordance with CS 466 Table C.10. Note that whilst the suspended span is made up of precast beams, they are closely spaced so that their flanges provide a continuous soffit; they are infilled between beams and transversely post-tensioned to form a solid slab.

Ease of Access Score: The ease of access score for Brigsteer is 2 *'Difficult to access more than one joint'* (from below) in accordance with CS 466 Table C.11.

6.2.1.4 Other Risk, R_O

Other Risks, R_O represents a tool to include other risks and considerations that could affect the priority of a half-joint structure.

The other risks rating for Brigsteer is considered LOW in accordance with CS 466 Table C.13, as there are no other factors or issues which have not already been considered that will affect the risk of the structure.

6.3 Refined Primary Risk Rating

The primary risk rating was considered as HIGH based on R_C = MEDIUM and R_D = VERY HIGH in accordance with Table C.1 of CS466. Based on the secondary risks identified in section 5.2 above, it is proposed that the primary risk rating is increased to VERY HIGH due to the fact that the consequential risk is very high and the assessment of the half-joints confirms the half-joints are inadequate for dead load. Additionally, the interior surfaces of the half-joints could not be competently inspected due to the presence of polystyrene filler material.

6.4 Sub-standard Structure Management Documents

A CS 470 'Management of Sub-standard Highway Structures' has been completed, BCU00015-JAC-SBR-6330-RP-SL240-CB-010, dated July 2024.

The CS 470 document concludes:

> Brigsteer is categorised as 'immediate' risk in accordance with the code.
>
> Brigsteer is, despite being immediate risk, also considered to be monitoring appropriate under its permanent loading only.

The following interim measures have been proposed and accepted:

Load Mitigation Interim Measures:

- Close Brigsteer to all users.
  - The likelihood of collapse under permanent loading only is considered to be low when considering clause 3.2 of CS470 and as such there are no restrictions recommended to the A591 below.

- Brigsteer is monitoring appropriate in accordance with clause 6.9 of CS470 and having considered its condition (which is fair as far as can be inspected), it is not considered that further load mitigation measures are necessary, i.e. propping or removal of the suspended span.

Monitoring Interim Measures (under permanent loading only):

Monitoring from ground level and deck level

Monitor from ground level using binoculars and from the carriageway above via trial pits.

Frequency: Monthly for the first 3-month period. Frequency of inspections to be reviewed after 3 months.

Tactile Special Inspection Monitoring

Inspection and monitoring of the half joints from within touching distance. All filler material and sealant within the half-joints will need to be removed to facilitate inspection via borescope.

Frequency: 0-months (i.e. first inspection), 3-months, and 6-months and then 6-monthly. All intervals should be reviewed depending on the results of the tactile inspections.

Non-Destructive Testing and Monitoring

Undertake various non-destructive tests to decrease the risk of missing any defects which are present sub-surface and not visible from typical inspections.

Frequency: Intervals of testing should coincide with tactile special inspections.

Alongside the above recommended monitoring, it is further recommended that intrusive investigations and material testing are carried out to establish material condition and strengths to inform further assessment work with a view to improving the assessed capacity and removing the interim measures.

In advance of any intrusive investigations to confirm construction details and material properties, it is considered sensible to carry out sensitivity analysis based on ‘best case’ assessment parameters and material information. This will confirm whether the half-joints may be capable of greater load capacity, if proven through intrusive works that a greater size and strength of reinforcement exists within the half-joints.

Given the differences between the 1995 assessment and the 2023 assessment certifications, it is recommended that a PTSI is carried out to confirm the details of the post tensioning system. On completion of the testing, the post tensioning and cantilever abutments should be assessed.

7. Management Plan

This management plan has been developed in accordance with CS466 considering the conclusions and recommendations from the 2023 structural assessment of the half-joints, which are summarised in section 5 of this report, and the findings of the CS470 Management of Substandard Structures, summarised in 6.4. In summary:

- The half-joints have been found to be inadequate for dead loads at ULS and SLS;
- It is recommended that investigative works are carried out to ascertain the true construction details and material strengths.
- In the interim, the half-joints are considered to be sub-standard as a result of their 2023 assessment.
- It is recommended that the half-joints are monitored (visual inspection and non-destructive testing).
- A CS470 review has been carried and confirms that the structure is 'immediate risk' in accordance with the code, however, Brigsteer is considered to satisfy the criteria listed in clause 6.9 of CS470 and is therefore also considered to be monitoring appropriate. The CS470 recommends the following:
    - Close the bridge to all users,
    - Monitor from ground level and deck level,
    - Tactile Special Inspection monitoring,
    - Non-destructive testing.

Refer to the CS470 for further information on the following sections, BCU00015-JAC-SBR-6330-RP-SL240-CB-010.

7.1 Category of Structure for Management

In accordance with cl. 8.3, Note 3 of CS 466, the structure is 'Sub-standard' on the basis that the half-joints have been assessed to have inadequate capacity for dead load.

7.2 Management Measures

Half-joint structures assessed to be sub-standard may be managed using the following measures:

1. Interim measures;
2. monitoring regime;
3. investigations;
4. repair;
5. strengthen;
6. replace;
7. other measures.

CS 470, Clause 6.1.1, states that load mitigation interim measures should comprise one or more of the following actions:

1. vehicle weight restrictions, calculated in accordance with CS454.
2. lane restrictions, calculated in accordance with CS454.
3. propping of the structure.
4. use of a temporary structure.
5. closure of the structure to all users or classes of vehicles.

Of the actions noted above, it is considered that only 'closure of the structure to all users' is appropriate on the following basis:

- The assessment has found the structure to be overstressed at permanent loads and therefore weight restrictions and lane restrictions are not sufficient – the structure needs to be closed to all users.
- The half-joints are positioned directly above the carriageway of the A591 below and it is therefore not feasible to install props in combination with long-term traffic management that would be required.
- The site does not allow for the opportunity to utilise a temporary structure without significant cost.

The CS 470 concludes that Brigsteer is considered to be monitoring-appropriate under its permanent loading only, despite being immediate risk, in accordance with clause 6.9 of CS470. These elements are reinforced concrete corbels and it is expected that signs of overstress would be visible from within touching distance. More significant measures such as repair / strengthen / replace have not been considered at this time, justified by the above.

The risk of collapse, under permanent loading only, has been risk assessed in accordance with clause 3.2 of CS470, which has determined that the likelihood of local collapse is considered relatively low given that the structure has been in service without any known load restriction for the loads that it has been assessed to since construction and that there are no significant defects attributable to distress. On this basis, there are no restrictions recommended for the A591 (below).

7.2.1 Interim Measures and Monitoring Regime

- Monitoring from ground level and deck level monthly for 3-months (reviewed after 3-months),
- Tactile Special Inspection monitoring at 0-months (i.e. first inspection), 3-months, 6-months and then 6-monthly,
- Non-destructive testing at intervals consistent with Tactile Special Inspection Monitoring.

The intervals for inspection noted above should be reviewed throughout the monitoring period and increased/ decreased according to the findings of the inspections.

7.2.1.1 Monitoring from Ground Level and Deck Level

Summary

Implement monitoring of the deck from ground level using binoculars and from deck level above. This monitoring should include opening up of each expansion joint, initially 2No trial pits per expansion joint, 500mm in length towards the edges of the carriageway, including removal of filler material and formwork from the joint gaps to allow visual inspection of the lower nib re-entrant corner. The excavation should be covered with road plates between inspections along with appropriate measures to minimise flow of rainwater through the joint, such as sealants. Precautions should be taken so as to not load the suspended span with plant, materials, or personnel.

Effectiveness

Monitoring for evidence of crack elongation, rust staining and spalling to the half-joints would provide a clear indication of evidence of the predicted failure mode. These defects could be detectable from ground level with the use of binoculars. However, there is still risk of defects being missed since inspecting from ground level is not as reliable as inspecting from touching distance. It should also be noted that by monitoring from ground level, there is no access or method of viewing the internal faces of the half joints, monitoring from ground level will only allow for inspection of the half joint elevations, most notably the re-entrant corners.

Frequency

It is recommended that the half-joints be monitored monthly for the first 3-months from ground level with binoculars, and from above the expansion joints at deck level. The Intervals between monitoring should be reviewed following the initial 3-month period.

7.2.1.2 Tactile Special Inspection Monitoring

Summary

The Special Inspection and monitoring should include the following items as a minimum:

- presence and extents of expansion joint failure and consequent leakage of water and chlorides on the half joint;
- presence and extent of cracking at re-entrant corners;
- presence and extents of efflorescence or any corrosion deposits;
- presence and extents of concrete delamination or spalling; and,
- bridge temperature at the time of the special inspection.

Measurements and photographs shall be taken and recorded of all defects. It may be more beneficial to install crack 'tell-tales' to ensure readings are taken from a consistent location at each inspection. The purpose of monitoring would be to identify signs of predicted overstress, to react prior to elements leading to a deteriorated state where emergency intervention is required.

Effectiveness

Tactile visual inspection at the intervals outline above would establish any increase in the cracks emanating from the re-entrant corners of the half-joints which have been observed as not increasing in width when compared to available historical inspection reports. The intervals could be reviewed depending on the results from the tactile inspections. All filler material and sealants to the half-joints would need to be removed to facilitate inspection of the internal surfaces using a borescope (note, the effectiveness of a borescope is limited by the presence of debris and lack of light within the half joint). Removal of all filler material within the joints may be difficult and will likely require access from above and below the half-joints, however all efforts shall be made in order to allow thorough inspection of the internal surfaces of the half-joints. Removal of sealant would increase the risk of water ingress and subsequent corrosion and deterioration of the half-joints, and so re-application of sealant would be recommended following each inspection.

Frequency

Inspection and monitoring of the half-joints from touching distance (i.e., MEWP access provided) and hand tools including hammer testing for spall / loose concrete is recommended at 0 months, 3 months, 6-months, and then 6-monthly intervals. The intervals could be reviewed depending on the results from the tactile inspections. Increasing the frequency of inspections will incur additional cost, however, this is justified to reduce the associated risks to sub-standard elements by informing the asset team of the current status and allowing timely intervention.

7.2.1.3 Non-Destructive Testing/Monitoring

Summary

Specialist non-destructive testing (NDT) of the half-joints should be considered further. The following are examples of NDT, applicable to half-joint structures:

- Impact echo testing - non-destructive to the structures under study. It is based on a frequency analysis of the structure's vibrational response when subjected to a shock.

- Radiography - a non-destructive testing method which uses either x-rays or gamma rays to examine the internal structure of manufactured components identifying any flaws or defects.

- Acoustic emission testing - Acoustic emission testing is a non-destructive testing technique that detects and monitors the release of ultrasonic stress waves from localised sources when a material deforms under stress.

- Thermography – Infrared thermography for non-destructive testing and evaluation aims at the detection of subsurface features (i.e. subsurface defects, anomalies, etc.).

The purpose of NDT testing/monitoring would be to identify signs (not visible by Tactile Inspection) of predicted overstress, to react prior to elements leading to a deteriorated state where emergency intervention is required.

It is recommended that a plan and specification for non-destructive testing is sought on the advice of a specialist testing contractor.

Effectiveness

This method would decrease the risk of missing any defects which are present sub-surface and hence not visible at regular tactile inspections. It is suggested that any non-destructive testing should be carried out at intervals concurrent to tactile inspections.

Frequency

It is suggested that any non-destructive testing should be carried out at intervals concurrent to tactile inspections.

7.2.1.4 Trigger Levels

The purpose of visual monitoring is to identify signs of distress to the half-joints and to react prior to elements progressing to a damaged state where emergency intervention is required.

The failure mechanism is anticipated to manifest in the form of significant progressive cracking to the re-entrant corners of the half joints or bearing shelf prior to yielding of the steel within the half-joints which act as corbels.

If monitoring identifies some distress in the half-joints such as further cracking, spalling or corrosion staining, urgent action should be taken to impose the appropriate weight restriction/ closure, install propping or other solution to be agreed with the TAA.

7.2.1.5 Trigger Actions

The following progressive actions should be undertaken when trigger levels indicated in the preceding section are identified by Westmorland and Furness Bridges & Structures Asset Team:

Half-Joints

1. Immediately close the route passing beneath the bridge.
2. Increase frequency of monitoring inspections.
3. Prop the suspended span, if required.
4. Decommission the bridge.

The identification for the need for trigger actions will be made by Westmorland and Furness Council Asset Team based upon a review of inspection information provided by the inspection team.

Westmorland and Furness Council Bridges & Structures Asset Team contacts:

[redacted] Bridges & Structures, For Westmorland and Furness Council. Tel: [redacted]

[redacted] Bridges & Structures, For Westmorland and Furness Council. Tel: [redacted]

Responsibility for implementing trigger actions and the detailed design of safeguarding measures lies with Westmorland and Furness Council Bridges & Structures Asset Team.

If the condition of the structure poses an immediate risk to the health and safety of the public, then police or fire and rescue should be contacted on 999.

7.2.2 Investigations

Based on the results of the 2023 half-joint assessment, the half-joints have been found to be inadequate for dead loads at ULS and SLS. It is recommended that investigative works are carried out to ascertain the true construction details and material strengths.

There is no feasible method of remediating the relatively minor defects of note to the half-joints. Given the critical details in the structure (post-tensioning and half-joints), any investigative work must be carefully considered and carried out in strict accordance with approved method statements. In order to achieve a live load rating for the half-joints (< 40T), material testing and concrete breakout is essential to confirm larger diameter bars (ideally 19mm > 12.7mm) and a higher tensile strength of reinforcement (ideally ~460N/mm2 > 250 N/mm2), which will inform further assessment work.

Any investigations impose a risk of allowing for a route for water/ atmospheric conditions to deteriorate the post-tensioning and half-joints which are critical elements.

Should the properties of materials be found to be as per the desirable properties described above, the structure should be reassessed with a view to achieving a live load rating, although this is likely to be significantly less than 40T.

Investigations should be carried out to confirm the following:

- Physical size of reinforcing steel within the upper and lower nibs,
- Tensile strength of reinforcement bars,
- Compressive strength of concrete,
- Establish the type, arrangement and condition of the reinforcement within each nib,
- Establish the type, arrangement and condition of the post-tensioning system as part of a PTSI.

7.2.3 Maintenance Activities

Efforts should be made to maintain the half-joints watertight to prevent ingress of salt-laden water through the joints and into the concrete, which would lead to accelerated deterioration and eventual loss of strength. The following ongoing activities are recommended with respect to the half-joints:

- Replace expansion joints. Where buried joints are installed, a saw cut and hot-poured bitumen seal crack inducer should be incorporated at carriageway surfacing level.
- Routine inspection of the expansion joints from deck level
- Periodic repairs to expansion joints and adjacent surfacing to ensure watertightness, as advised by the above routine inspections.
- Maintain carriageway surfacing intact and make timely repairs to potholes, cracks etc. in the vicinity of the half-joints and to protect the underlying waterproofing. Consider re-waterproofing and resurfacing the entire bridge at the same time as the expansion joint replacement and include sub-surface drainage to drain sub-surface water away from the half-joints.

Appendix A. Initial Review – Available Documents Used

E 06511 Underbarrow and Brigsteer – Assessment

E 06513 Brigsteer – Structure File

E 06509 Underbarrow and Brigsteer - Design Calculations

SL240_BRIGSTEER_C5062 PBI 2018

70790_Brigsteer Underbarrow Scarf Joint

50803_586 16 3 5A Brigsteer Underbarrow Deck

50799_586 16 3 6A Brigsteer Underbarrow Deck

50796_586 16 2 7A Brigsteer Abut

50798_586 16 2 8B Brigsteer Abut

50804_586 16 2 4C Brigsteer Abut

50797_586 16 2 3C Brigsteer Abut

Appendix B. Reference Photographs

Photograph 1 - Crack on north face

Photograph 2 - East joint south face crack

Photograph 3 - West joint north face crack

Photograph 4 - West joint south side elevation. Note, hairline crack.