MEMO

TO	Gary Peacock – Bath and North East Somerset Council Dale Mynett – Bath and North East Somerset Council	**FROM**	Liam Hennessey - WSP
DATE	**28 March 2022**	**CONFIDENTIALITY**	**Public**
SUBJECT	**Cleveland Bridge – Truss 4 North End – Support Defect – Interim Commentary**		

Background

The replacement deck system of Cleveland bridge was constructed in 1929 and is extremely novel in terms of its design and detailing. Figure 1 illustrates the structural arrangement at one end of the deck. The loads from the reinforced concrete deck slab (1) are carried by 4 reinforced concrete trusses (2) and transferred into the abutments by groups of 11 exposed hanger bars (3), via a transverse beam (4), which is supported on mass concrete piers (5) that protrude from the abutment (6). There are therefore 88 hanger bars in total across the structure.

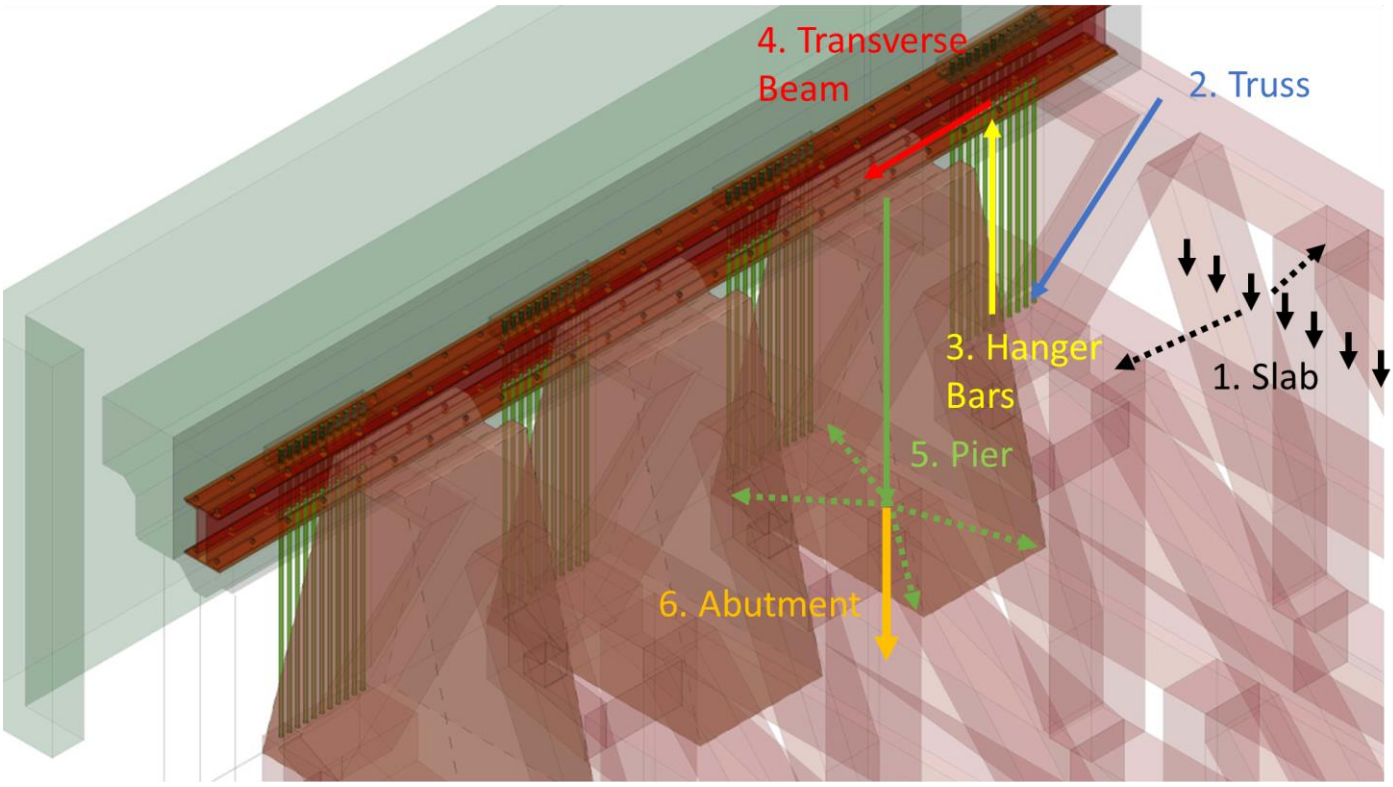

Figure 1 - Generalised load path arrangement.

A series of defects were identified in January 2022 at the lower end of the hanger bars at the north end if Truss No.4 (area circled in Figure 2). These can be attributed to corrosion of the hanger bars within the original cover concrete at their interface with the top of the truss bottom chord, as a result of persistent water leakage over a protracted period of time.

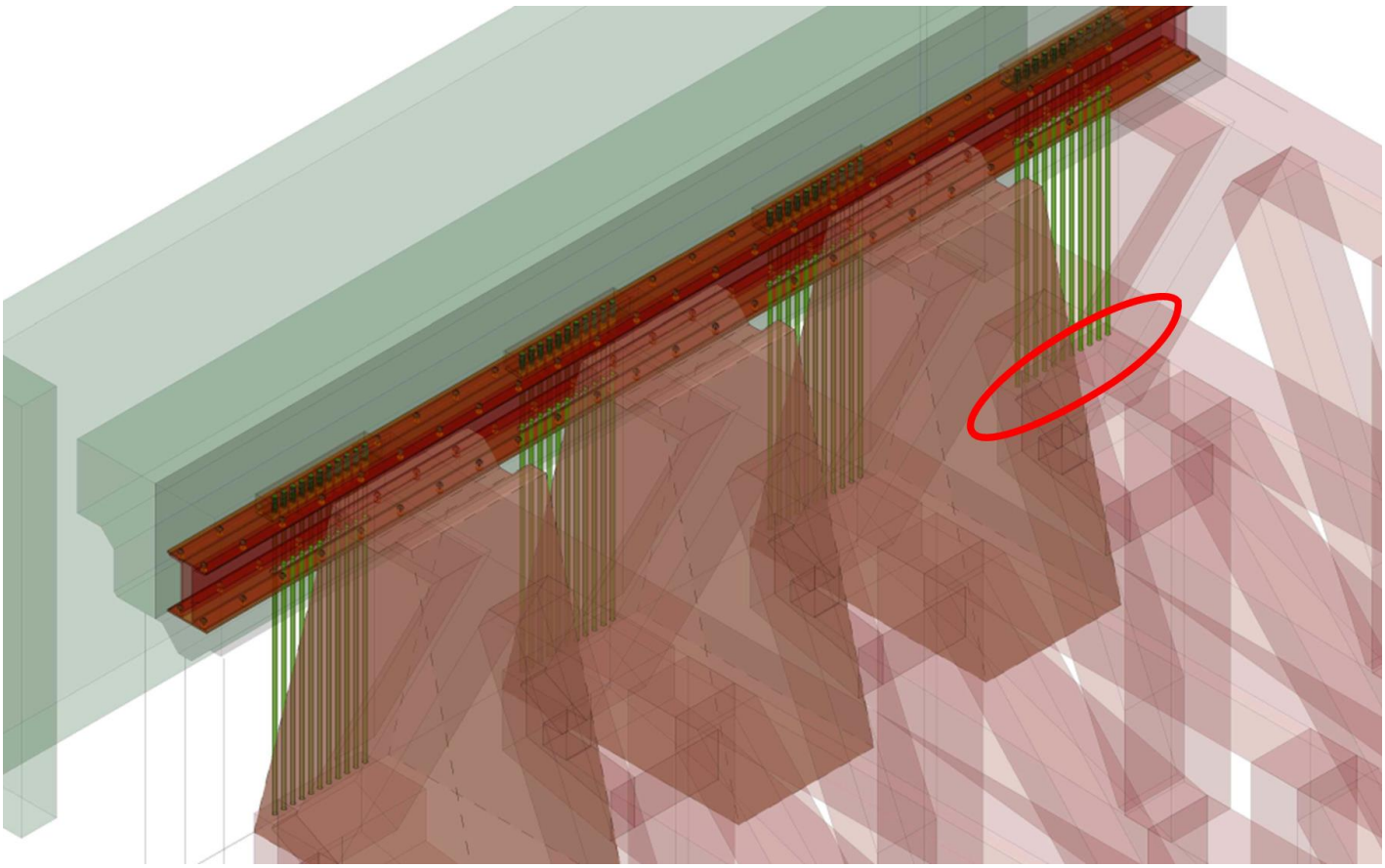

Figure 2 - Defect location.

A Summary of Works to Date

Following the previous memo issued on the 21st February 2022, WSP has considered the implications of the presence of these defects, along with appropriate monitoring and load mitigation plans and explored potential repair and remediation options. Given the complex geometry and historic retrofit to the structure, there are significant challenges associated with any viable repair or retrofit solutions. Alternate load paths into the abutment are being considered and investigations are currently ongoing to determine the viability of such options.

Direct measurements of the corrosion defects have identified significant levels of section loss, as illustrated in Figure 3, but further and more detailed quantification of section loss is proposed in order to refine the assessment work undertaken to date.

Figure 3 - Close up photograph of hanger bars to the north end of Truss No.4.

Following ongoing discussions with Bath and North East Somerset Council (BANES), WSP are considering options for the ongoing management of the Grade II* structure, both in the immediate as well as long term.

Our initial analyses have suggested that the structure is no longer capable of sustaining its current load rating of 18 tonnes, as a result of the section loss to the hanger bars. Quantitative assessment and checks are ongoing to determine the capacity of adjacent elements and what the implications of the defects are on the overall structural integrity of the bridge.

In accordance with normal practice, the structure is being managed in line with the Design Manual for Roads and Bridges (DMRB) standard, *CS 470 - Management of sub-standard highway structures*. On 2nd March 2022 an *Immediate Risk Structure Emergency Action Record of Agreement* was accepted by the Technical Approval Authority and Client, BANES. This document details the measures that are to be implemented on the structure, which includes a lane closure above Truss No.4.

Following liaison with BANES, the Client and Technical Approval Authority, targeted investigations have been agreed, as summarised below:

i. Evaluation of the tensile forces within individual hanger bars based on measurements of their natural frequencies and vibrational mode shapes.

ii. Impressions will be taken of the areas of severe corrosion to the hangers to the north end of Truss No.4 in order to more accurately evaluate the degree of section loss suffered by individual bars.

iii. Non-destructive testing of the corroded areas to the same hangers to identify the presence of any cracking/pitting type defects.

iv. Ground-penetrating radar has been used to determine the existing arrangement of the reinforcement, hanger bars, piles and abutment features.

v. Exploratory drilling and endoscope surveys have been carried out to determine the condition of the transverse hanger beam (see 4 in Figure 1).

vi. Exploratory cores have been taken through the abutment to confirm whether record drawings reflect the in-situ conditions.

vii. Cores for strength testing have been undertaken out to determine the insitu material strength of the abutment.

In conjunction with the above investigations, analysis and structural assessment activities have been undertaken. A variety of potential options have been investigated and an initial feasibility study has been started. A range of methodologies for replacing the effected bars using welded, clamped and coupled connections have been considered and discounted due to their long term reliability and constructability concerns.

Assessment activities to date have been focussed on the superstructure of the bridge and there is limited reliable data available with regards to the make-up of the historic abutment structure and its ability to accommodate any secondary load transfer through any alternative support system beneath the ends of the lower chords. Additionally, there are practical constraints, such as access within the abutment galleries (Figure 4), which will be a key factor in the evaluation of viable mitigation measures that might be installed to ensure the ongoing safety of the structure. Specialist contractor advice has been sought to begin to progress potential option development.

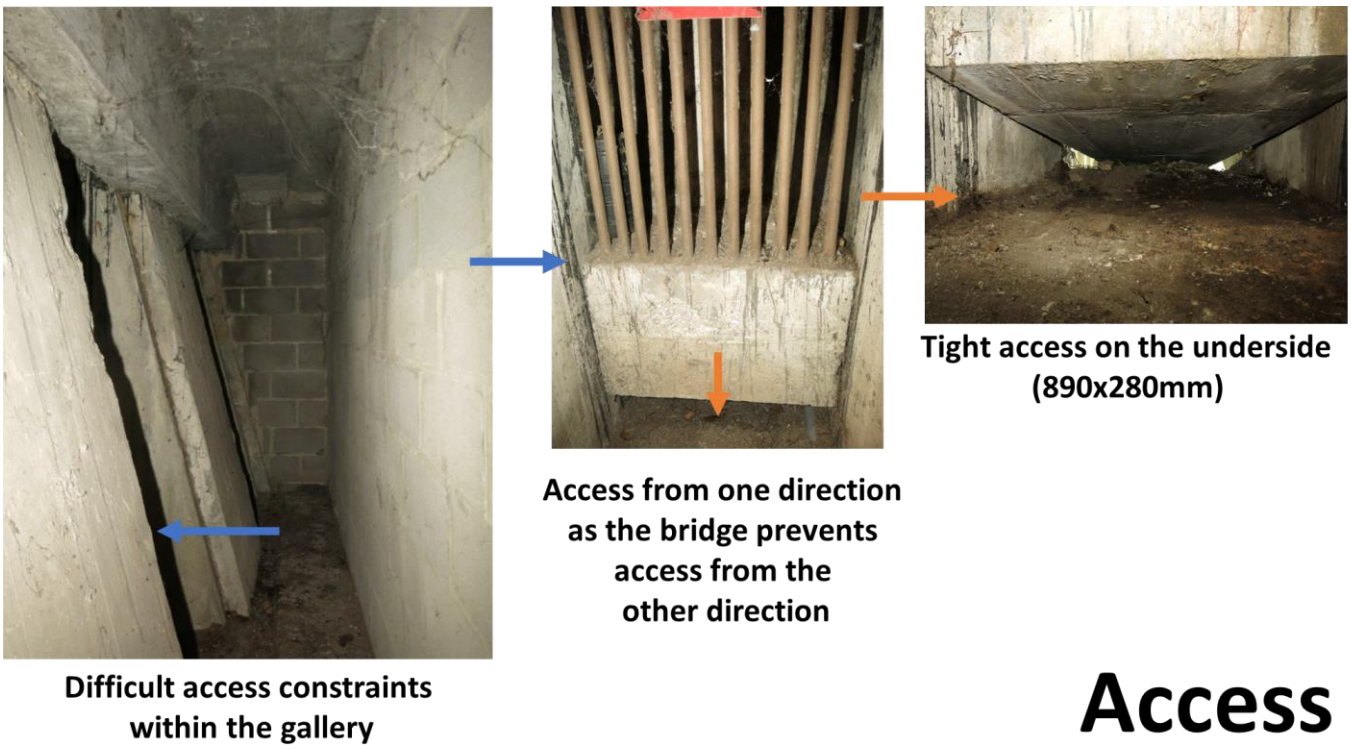

Figure 4 - Access considerations.

Next steps

Our recommendations for the next steps to be taken to ensure the ongoing safety of the structure are as follows:

1. Clearly identify all effects that require monitoring and reporting requirements, in order to develop a detailed specification for a monitoring system. It is anticipated that the structure will need to be monitored throughout its remaining lifespan. A workshop with the Client and TAA would be beneficial in terms of defining the system scope and functionality.
2. Technical notes will be developed that detail the approach and outcomes of the assessment activities undertaken to date in relation to the evaluation of the effect of the section loss to the hanger bars on the performance of the structure. The technical notes could be further developed into a more comprehensive assessment report if deemed appropriate by the TAA.
3. The feasibility study should be further developed to identify viable options for remedial works that will mitigate the risk of failure of the corroded hanger bars. The study will consider and evaluate the merits of installing a passive, failsafe support system in parallel with the ongoing monitoring system against the potential risks associated with the option of providing an active, alternative support system via bearings installed beneath the truss bottom chord. The detailed design of the preferred option will be covered by a separate Approval in Principal process and subject to an appropriate level of checking.

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