PROJECT SUMMARY

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Whortlon Bridge Update January 2021

1 Structure Overview

Whorlton Suspension Bridge is a Georgian 55m (180ft) single span, wrought iron chain suspension bridge which spans the River Tees to the south of Whorlton Village, County Durham. The bridge is the UK's earliest surviving example of a wrought iron chain suspension bridge with twin battered masonry pylons to each end, designed by John and Benjamin Green and opened on the 7th July 1831.

The superstructure is constructed from two wrought iron suspension chains to each elevation. The timber deck is connected to the chains with wrought iron vertical hangers. Steel angle plan bracing to the underside of the deck was a later addition to give greater resilience to wind loading. The suspension chains span between cast iron saddles located at the top of the sandstone masonry towers. The structure is founded and anchored to bedrock foundations.

The bridge was constructed in 1831 and is a Grade II* listed building (listed 19th January 1952) and a Scheduled Ancient Monument.

The bridge carries a 3.6-meter-wide single lane carriageway, with footways on the east and west sides. The bridge has a vertical clearance of 5.1-meter over the River Tees.

The bridge has had a 3-tonne weight restriction imposed since the early Twentieth Century.

Following identification of a failed hanger to chain connection in summer 2019 the bridge was closed to vehicles. A detailed inspection and assessment process commenced that concluded that until further investigation and testing the bridge should be closed to all users. The bridge therefore closed completely in winter 2020.

2 Structure Condition

A Principal Inspection was carried out in October 2019. The inspection found the structure to be in a fair/poor condition overall. The specific findings of the report are summarised as follows: -

2.1 Timber Deck

Loss of section was noted to the main longitudinal timber at the interface with the abutments. Multiple loose bolts were noted to the longitudinal timber scarf joints together with minor displacement of the joints. Facia boards were found to be loose, with one board missing on the west elevation.

Image 1 - Typical condition of longitudinal timber and loose bolts

2.2 Hangers

Corrosion and rust staining were noted throughout the structure hangers. Where the rod is attached to the upper chain, loss of section of the rods was noted where it passes through the lower chain.

Hanger number 34 on the west chain has failed where the hanger connects to the chain. This defect does not appear to be unique with elongation or pin wear occurring at many other hanger/chain connections across the bridge.

Image 2 - Broken hanger to west elevation

Image 3 -Typical indication of wear to other hanger/chain connections

Image 4 – Typical indication of wear to other hanger/chain connections

Other defects noted included deformation of hangers and missing wedges used to secure the longitudinal beams to the hangers.

Image 5 - Missing securing wedges

2.3 Chains

Generally, the chains were found to be in fair condition with sporadic corrosion noted throughout, predominantly to the chain pin connections. Contact between the chain and the tower coping was noted to all four towers on the anchor side of the tower. There are higher levels of surface corrosion within the anchor chambers. Deformation to a link pin on the south east back stay was noted.

Image 6 - Deformation to chain link pin

2.4 Chain Saddles

The chain saddles were found to be in fair condition with only sporadic isolated corrosion noted.

2.5 Deck Bracing System

The deck bracing system was generally in fair condition with isolated corrosion and rust staining at bolted connections and connections to the main longitudinal timbers.

2.6 Abutments

Both north and south abutments were found to be in fair conditions. Wetness was noted throughout with isolated mortar loss and moderate vegetation growth.

2.7 Towers

Generally in fair condition with isolated mortar loss and weathering noted. Rust staining was noted from corrosion of the parapet handrail at the junction with the towers. An isolated vertical fracture was noted to the north west tower under the chain saddle.

3 Assessment Summary

An assessment was carried out to determine if the 3T weight restriction was appropriate.

The age and uniqueness of the bridge meant a number of structural elements could not be tested, so a number of material properties had to be assumed in the assessment based upon the current Codes of Practice (published by the Overseeing Organisations for the Design Manual for Roads and Bridges).

The structure was subject to the following loading conditions:

a) Self-weight (dead loading)
b) Pedestrian Loading
c) Live loading (limited to 3 tonne single vehicle or convoy)

The assessment was carried out assuming that all the structural elements were in a good condition (Condition Factor =1) in order to determine the full carrying capability of the bridge (this would be the case when all the defects discussed in Section 2 have been repaired).

The assessment concluded that the structure could not withstand the effects of the load combinations above, as summarised in Table 1 below.

Table 1 - Main Structural Elements Summary: Load Combination 1

Load Combination 1 (Ref: CS454) – Dead Load + Assessment Live Loading 3T Single Vehicle + Pedestrian

Element	Effect	Dead Load S_D*	Live Load S_{FL}*	Total Effects S_A*	Assessment Resistance R_A*	Reserve Factor $\frac{(R_A^* - S_D^*)}{S_{FL}^*}$	Pass/Fail
Main Chains	Axial (kN)	421	342	762	685	0.77	FAIL
Hangers (Rods)	Axial (kN)	16	94	110	84	0.73	FAIL
Main Longitudinal Timbers	Bending (kNm)	5	66	71	20	0.23	FAIL
Main Longitudinal Timbers	Bearing (kN)	16	94	110	8	-0.09	FAIL DL*
Transverse Timber Beams	Bending (kNm)	14.0	60	74	20	0.10	FAIL

*(DL – denotes dead loading)

In addition to the assessment, a sensitivity analysis was undertaken to determine whether the structure could withstand pedestrian loading in isolation as this would potentially allow the structure to remain open to pedestrians. The pedestrian loading was applied over a 2m wide strip along the total length of the structure. This analysis concluded that the structure could not withstand the pedestrian load effects generated.

The assessments undertaken have identified the failure of the main chains and link pins under loading. Improving the assessed capacity of the main chain links will require gathering further information from the bridge such as obtaining detailed pin and link geometry and actual material strengths/properties. The additional information will allow further analysis of the connections.

As the assessment considered the bridge in good condition, the extent of defects noted in the summary of the visual inspection discussed in Section 2 need to be identified. The condition, type and arrangement of the anchorages must also be confirmed.

4 Next Stages

To progress the scheme there are two main aspects that need to be addressed prior to any repair or strengthening works:

4.1 Investigation and Testing

A procurement exercise is currently underway to appoint a steelwork contractor competent in assessment and inspection of historical wrought iron structures. The contract will require the contractor to design a series of temporary works systems to allow separation of the chain links and hangers in various locations for further inspection and assessment. A programme and methodology of in-situ non-destructive testing will also be developed. It is a critical requirement of this phase to understand how fatigue has compromised aspects of the structure over the 190-year life.

The investigation and testing contract will be developed alongside an accredited Conservation Engineer who will assist in ensuring the methods proposed are acceptable to Historic England. Before the works can commence on site, Scheduled Ancient Monument consent will be required.

4.2 Assessment Validation

Following completion of the investigation and testing contract, the assessment will need to be revisited using the information obtained. it is this phase of the project that will determine the outlook for the bridge and its future capacity restrictions.

Following the completion of the above, a scheme of works will be developed to carry out any repairs required. This will require further Scheduled Monument Consent applications and identification of a funding source.

5 Programme

The following is the anticipated forward-looking programme. This assumes no delays throughout the process and that the scheme progresses as intended:

Task	Timescales
Develop Investigation and Testing Design Contract and appoint a Contractor	December 2020 to February 2021
Complete design of temporary works and Investigation and Testing scope	February to April 2021
Submit a Scheduled Ancient Monument consent application	April 2021
Procure a testing Contractor to execute the works	May to June 2021
Scheduled Monument Consent granted	July 2021
Carry out Investigation and Testing Contract	July & August 2021
Revisit the assessment following completion of the site works	September & October 2021
Design the required strengthening and refurbishment works and apply for Scheduled Monument Consent	October 2021 to June 2022
Tender, plan and execute repair works	July 2022 to March 2023