Union Chain Bridge

River Tweed

PROPOSED CONSERVATION & STRUCTURAL REPAIRS

Heritage, Design & Access Statement

For replacement deck surface material

by

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CONSERVATION OVERVIEW OF THE PROJECT

1) HISTORIC AND ENGINEERING SIGNIFICANCE OF THE UNION CHAIN BRIDGE

The Grade I Listed Union Chain Bridge over the River Tweed, is internationally and nationally significant as a unique engineering structure and locally as a vital bridge connecting two close communities in Scotland and England, crossing the border at its mid-span.

Not only did the Union Chain Bridge span two countries but its construction period of only one year, spanned the reign of two Kings, George III and George IV.

Opened in July 1820, the Union Chain Bridge was Europe's first iron suspension bridge designed to carry vehicular traffic and is the earliest surviving iron suspension bridge in the World that is still in vehicular use.

When completed, it also had the longest clear span deck in the World for more than six years, until Telford's Menai Suspension Bridge opened in 1826.

The Union Chain Bridge was designed by Samuel Brown (1776-1852), an entrepreneurial naval captain and innovative self-taught engineer, and contains the earliest and only remaining examples of his patented eye-bar wrought iron Chains, forged with a circular cross-section.

The Scottish Pylon is the earliest standing road suspension bridge masonry pylon in the World.

In 1817, when the design competition was launched for the Union Chain Bridge, Samuel Brown saw his chance to demonstrate that these chains could be assembled as catenary chains to support a bridge deck beneath, which could be erected far quicker and at a fraction of the cost of a conventional masonry bridge.

From 1817 until 1844, following his joint design with Thomas Telford on the Runcorn Chain bridge and his first built design, the Union Chain Bridge, Samuel Brown was in great demand and he built over 23 known chain bridges and chain piers and designed a further 30 that were never built.
One other of his chain road bridges still exists, the Wellington Suspension Bridge, 1831, on the River Dee, but is now closed to traffic and two of his chain footbridges at Gattonside, 1826, and Kalemouth, 1835, on the Rivers Tweed and Teviot, are also still standing.

It's influences on the design of future suspension bridges internationally, can be seen in the iconic 1849 Chain Bridge over the Danube in Budapest, by William Tierney Clark and the 1864 Clifton Suspension Bridge over the Avon in Bristol, by Isambard Kingdom Brunel.

However, due to dwindling resources for maintenance over the past 45 years since its last major overhaul in 1974, various individual structural failures have occurred which have led to the Union Chain Bridge being entered into Historic England's and Historic Environment Scotland's '*Heritage at Risk*' Registers, classified as 'Condition: Poor' and 'Priority Category: C'.

2) THE BRIDGE, ITS SETTING AND PROTECTED STATUS

Status: English part
Structure Name: UNION CHAIN BRIDGE (Formerly known as UNION BRIDGE)
Structure Type: Road Bridge, Suspension Bridge, Toll Bridge, Border Crossing
Listed: Grade I
List entry No: 1042214
Date first listed: 11 Feb 1988
UID: 237916
Date first scheduled: Pre-1965
Schedule No. ND/329
Date de-scheduled: 20 December 1999

County: Northumberland
District Type: Unitary Authority
Parish: Horncliffe

Historic England *Heritage at Risk Register*
First registered August 2013
List Entry No: 1042214
Condition: Poor
Priority Category: C

National Record of Industrial Monuments No. ND88
Northumberland HER Record No: N2408
ICE Ref. No. HEW 143
Within River Tweed SSSI and SAC

National Grid Reference: NT 93416 51034

Sustrans Route 1
Pennine Cycleway Route 68.

Status: Scottish part
Historic Environment Scotland: Canmore
ID 60103

Listed: Category A
Council: Scottish Borders
Parish: Hutton

Buildings at Risk Register
Register Number: DP 158884
Within River Tweed SSSI and SAC

National Grid Reference: NT 93391 51025

Sustrans Scotland Route 1

Union Bridge Toll House.
Historic Environment Scotland: Canmore ID 278483

3) SIGNIFICANCE VALUES

3.1 International Historical Value • Very High

The Union Chain Bridge is internationally significant as Europe's first iron suspension bridge, designed in 1817, to carry vehicular traffic and is the earliest surviving example in the World that is still in vehicular use.

When completed in 1820, it had the longest clear span deck in the World until Telford's Menai Suspension Bridge opened in 1826.

It contains the earliest and only remaining examples of Samuel Brown's patented eye-bar wrought iron chains, forged with a circular cross-section.

The Scottish Pylon is the earliest standing road suspension bridge pylon in the World.

3.2 International Historical Engineering & Technological Value • Very High

The new iron chain suspension bridge technology pioneered on the Union Chain Bridge and further developed by Thomas Telford with Brown's patented flat eye bar design, allowed bridges to span large widths at a fraction of the cost of more traditional construction techniques and was soon taken up across the World.

In 1817 two designs were prepared for a suspension bridge of 245ft (74.7m) span, one by Capt. Brown and the other by Robert Flinn of North Shields. In January 1818, eminent Engineer and Architect, John Rennie became the consulting engineer for the project when he was requested by William Molle, Chairman of the Berwick Turnpike Trustees, to give his opinion on the designs they had received.
Rennie preferred Capt. Brown's proposal, finding his bar link chains "very superior" to the common links proposed by Flinn.

Rennie advised Samuel Brown that the design of the masonry abutments should be strengthened, the span reduced by 22ft (6.7m), and the Pylons should be taller with rollers for the chains to pass over (this was only taken up in the Scottish Pylon). He suggested the battered sides to the freestanding Scottish Pylon and probably the Egyptian Revival design and classical motifs instead of the 'clumsy, ill-arranged and over-loaded with ornament' of Brown's Pylons. Rennie also suggested the raising of the deck at mid-span, to about 3ft above the roadway level at each Pylon to avoid high seasonal river levels.

Other eminent British Engineers known to have visited the Union Chain Bridge were Robert Stevenson (1772 -1850) who had been invited to the Opening Ceremony on 26th July 1820 and had written his widely published description of the bridge in *The Edinburgh Philosophical Journal,* in October 1821.

Stevenson's article was also published in 1824 in German, French and Polish and in 1832 Charles Drewry published the first book in English, devoted solely to suspension bridges; his '*A Memoir on Suspension Bridges*'.

Captain Samuel Brown was the most prolific suspension bridge engineer that Britain has ever seen and following completion of the Union chain Bridge in 1820, he

designed over 50 chain suspension bridges and chain piers, building 23, ushering in the era of long span bridges.
He was one of a number of pioneer engineers who have been overshadowed by their more eminent contemporaries and largely forgotten, even though he was the only engineer of his contemporaries to be knighted.

The Union Chain Bridge attracted attention from leading French engineers of the time, Joseph Dutens (1765-1848), Baron Charles Dupin (1784-1873) in 1825, Claude-Louis Navier (1785-1836) in 1821. In 1823, another eminent French Engineer, Sir Marc Isambard Brunel, visited The Union Chain Bridge with his English born son, Isambard Kingdom Brunel (1806-1859), who later incorporated wrought iron eye-bar chains in his 1831 Clifton Suspension Bridge design and his 1845 Hungerford Bridge.

It is currently on Historic England's '*Heritage at Risk Register*' as a Priority Category: C structure and Condition: Poor.

International Recognition
There is significant public concern about its crisis of condition at home and abroad from American, Scandinavian and Japanese engineers, such as Professor Hiroshi Isohata, who visited in 2014. Professor Hiroshi Isohata teaches engineering at the College of Industrial Technology at Nihon University, Tokyo and was involved in the design of the Akashi Straits Bridge, which currently has the longest central span of any suspension bridge in the world.

The Institution of Civil Engineers (ICE) through its Panel for Historical Engineering Works and publications, encourage the conservation of outstanding historical engineering works and is supportive of an authentic refurbishment of this bridge.

Following the proposed refurbishment of the Union Chain Bridge, the ICE (the Institute of Civil Engineers) intends, together with the American Society of Civil Engineers and the support of Northumberland County and Scottish Borders Councils, to recognise the bridge's significance more widely by designating it an '*International Historic Civil Engineering Landmark*' at a joint presidential plaque unveiling following its successful and appropriate refurbishment.

It also supports the *Friends of the Union Chain Bridge* and the aims of Northumberland County Council, stated in a letter of 27 January 2014, '*that together with our colleagues from Scottish Borders Council we remain committed to securing the future of the structure with the ultimate goal of completing most of its refurbishment during the bicentennial celebration year of 2020*'.

Captain Sir Samuel Brown, RN KH KB FSA FRSE (1776-1852)
Captain Brown RN and his Welsh chain-making company Brown, Lenox & Co would play a vital part in the development of chain bridge design in the UK.
His company Brown Lenox & Co. also went on to produce the launch chains for Isambard Kingdom Brunel's Great Eastern steamship in 1858, which were immortalised in the backdrop to Robert Howlett's well-known 1857 photograph of Brunel. The company was also the sole supplier of Admiralty chain from 1808 to 1916.

The Union Chain Bridge was built at the height of the Industrial Revolution in Britain using Welsh iron and it exemplifies the high quality of Brown's wrought iron chains, having survived the past 197 years without requiring replacements.

Samuel Brown became a member of the Society of Arts in 1820, was elected a member of the Royal Society of Edinburgh in 1831 and was the only British Engineer out of his contemporaries of Rennie(1761-1821), Telford(1757-1834), Tierney Clark (1783-1852), Stevenson(1772 -1850), Brunel(1806-1859) & Page(1803-1877), to be recognised for his pioneering engineering achievements, by being made a Knight of the Royal Guelphic Order by the Prince Regent (later King William IV) in 1835 and in 1838 a Knight Bachelor by Queen Victoria, taking the title, Captain Sir Samuel Brown, RN KH KB FSA FRSE of Netherbyres.

Besides registering patents for Chain making and suspension bridges, Brown also registered patents for the propulsion of vehicles and railway locomotives, improvements to breakwaters, the construction of iron lighthouses and refinements to the marine compass.
In the early decades of the C19th, Brown was one of the most eager promoters of suspension bridges in Great Britain because of their lightness and low cost.
What was not understood then, was wind-induced oscillations and problems of unstiffened bridge decks. Damage was sustained by deck oscillations to several of his early bridges. The Brighton Chain Pier was partially destroyed in 1833 and 1836, which caused the hangers to fracture. A similar event at Brown's chain bridge at Montrose in 1837, resulted in it being strengthened by longitudinal trusses, as too was the Union Chain Bridge in 1871.

There is only one known portrait of Samuel Brown himself, which is by an unknown artist from the British School, with the Royal Chain Pier, Brighton in the background, painted around 1824.

3.3 Architectural Value • Very High

The masonry Pylons are particularly significant as they were an early use of the Egyptian style of Tower, influencing many suspension bridge designers throughout the world in the C19th, such as Telford on the Menai Bridge, Brunel at Clifton, Tierney Clark at Budapest and Roebling on the Brooklyn Bridge, New York.
It was John Rennie, Architect, who advised Brown on the design of the Union Bridge Pylons, in particular, suggesting the battered sides in rusticated masonry.

The Scottish Pylon is the earliest standing road suspension bridge pylon in the World.

The whole structure is Listed Grade I (English half) and Category A (Scottish half) and its urgent need of repair is evident in Historic England's '*Heritage at Risk Register*' as being in Priority Category: C, Condition: Poor.

3.4 Communal and Social Value • Very High

During its early years, the bridge was principally used for carting lime and coal from North Northumberland to Berwickshire, saving an 11-mile detour to the next nearest crossing at Berwick-upon-Tweed.
In 1821, a contemporary described it as:

'The new iron suspension-bridge over the Tweed at this point is one of the greatest acquisitions the country possesses, and at the same time, one of the finest specimens in existence of modern invention employed as a medium of social and commercial intercourse. The daily inconvenience - besides serious accidents and

loss of life - to which the inhabitants were so long subjected, has thus been completely remedied; it admits two carriages abreast, affords the usual accommodation for foot passengers, and has proved of incalculable benefit to the public.'

In the first half of the C19th, the Scottish Toll House, 1820, currently in private hands and therefore not part of this Project, had been an important community resource as it held a liquor licence for the sale of whisky until 1854 and was a Marriage House until 1857. Toll charges ended in 1883 when Tweed Bridges Trust took over the upkeep of the bridge.

Nowadays, the Bridge is still used by residents on both sides of the River, as well as tourists, cyclists and horse riders.

It is the River Tweed crossing point for Sustrans Routes 1 and 68, as well as the North Sea Cycle Route, the Pennine Cycleway and the Coast and Castles Cycle Route.

The *Flying Scotsman Vintage Car Rally* from Belvoir Castle to Gleneagles also crosses the Union Chain Bridge.

The Bridge is within River Tweed SSSI and SAC.

Union Chain Bridge has become an international tourist and engineering attraction.

3.5 Aesthetic Value • Very High

The Union Chain Bridge is in a magnificent picturesque setting, gracefully spanning the River Tweed hanging by the seemingly delicate rods from the sweeping curve of the chain, which is held firmly in the vertical rock face of the English bank to the strong freestanding masonry Pylon in Scotland.

Apparently, Samuel Brown's original inspiration for a chain suspension bridge came from a spider's web in his garden.
In 1821 Samuel Brown had informed Mr. Walker, the first President of the Society of Arts in Edinburgh that he –
'..took one dewy morning, the first idea of a suspension bridge from observing the construction of a spider's web thrown across a garden walk…….'

This lightness of design and the emphasis of the curve of the chain is complemented by the reducing height of the parapet railings towards the centre of the bridge.

From the down and up-stream river banks, the views of the River Tweed are uninterrupted beneath the bridge with its deck floating 9 metres above the water, with no piers spoiling the vista.

3.6 Artistic Value • High

The elegance of this bridge and its setting was first recorded by leading British artist Alexander Nasmyth (1758-1840), in his 1819 oil on canvas of the bridge. This painting (2163 x1434) was commissioned by George Home with the viewpoint from his country seat of Paxton House, a few miles downstream on the Scottish side. This has

recently returned to Paxton House, purchased with the assistance of the Heritage Lottery Fund, the National Art Collections Fund and other donors in 2003.
Various engravings and aquatints were published between 1820 and 1822, based upon drawings by George Buchanan (1800-1864), T.S. Good (1789-1872) and engravings by Robert Scott (1777-1841) and William Read, which appeared in national and international publications at the time.

Brown's Royal Chain Pier, Brighton was painted by both JM Turner in 1824 and John Constable in 1826.

3.7 Evidential Value • High

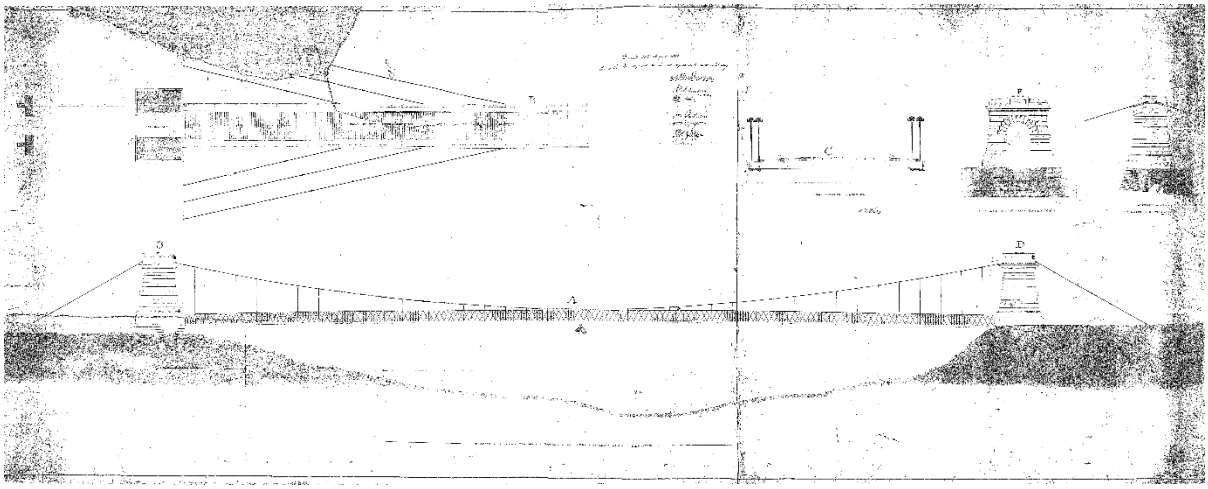
Understanding the design developments, technological developments, repairs and engineering improvements over the past 198 years.

Understanding the performance of the various iron components produced by casting and forging, compared with the materials in production today.

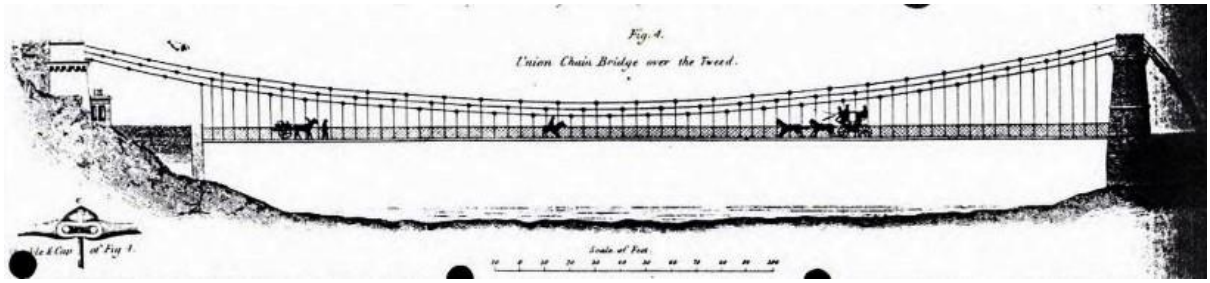
Understanding the Georgian and Victorian paint palettes used on the bridge in 1820 and 1871.

Archaeology of Scottish anchorages (visible above ground from 1820 to 1902).

Further research into Samuel Brown and his pioneering engineering work and his collaboration with his contemporary engineers and architects.



Samuel Brown's signed Contract drawing, 21 August 1819, showing a freestanding English Pylon



Robert Stevenson's illustration, October 1821

4) SUMMARY OF THE CURRENT CONDITION

Conservation and repair works have been granted permission - 19/03927/VARYCO (NCC) and 18/01789/LBC (SBC). Works are currently underway to conserve the bridge but the modern deck was always due for replacement with new material ,and it is a change to the specification of material for this replacement decking that is the subject of this consent.

This work came under Item 5 Replacement of deck, support timbers, and deck boards. Alteration of carriageway width, kerbs & walkway widths.

5) PLANNING HISTORY

Current permissions reference 19/03927/VARYCO (NCC) and 18/01789/LBC (SBC).

Reference Number: N/07/B/0512
Description: Replacement of two missing hangers and one fractured hanger.
Status: Permitted: 07 August 2007

Reference Number: UID: 237916
Schedule No. ND/329
Date de-scheduled: 20 December 1999

Reference Number: 1042214
Description: UNION SUSPENSION BRIDGE (THAT PART IN ENGLAND),
Status: Listed Building - Grade I
Date first listed: 11 Feb 1988

Reference Number: PKT 0348
Description: The County of Northumberland (Union Bridge, Berwick)
Tree Preservation Order 1976
Status: Confirmed

6) ORIGINAL PROPOSALS FOR ITEM 5 - DECK

6.1 Historic and engineering significance of the Deck Timbers

The deck construction consists of large section cross beams attached to the Hangars, which support the longitudinal support timbers beneath the transverse deck boards that form the sub-base for the asphalt covered roadway boards. This basic construction has been maintained over the past 200 years but the timbers themselves have been replaced many times during that period due to rot, wear and tear.

The 1820 deck support timbers and boards were altered in 1837 when the raised walkways were first introduced. Up until this time, the road and walkway were the same level longitudinal boards, only separated by the longitudinal cast-iron cart kerbs and cast-iron rails as guides for the wagon wheels and the central cast-iron cross-rails for the horse and cattle hoofs. This arrangement left a walkway width of three feet (914mm). The raised walkway width was changed a further three times until its current width of 736mm, introduced in 1974.

The 1820 15" x 7" timber support beams are known to have been replaced in 1871, along with the 12" x 3" deck boards, probably following a major failure of the hangers. Also, in 1871, steel deck bracing was added beneath the deck.
The cast-iron cart rails and kerbs were removed in 1837 and the cast-iron deck-edge decorative cornice was also either removed then or had fallen off in storms.
Because of the constant replacement of all of the timber components forming the deck, it is the whole form of construction that is more significant than the actual timber members and the strong demarcation of the roadway over the past two centuries with either cast-iron edges or timber kerbs that is more significant.

6.2 Condition prior to dismantling and proposals (as included in the original submission)

The existing timber deck timbers generally were in a deteriorated state with varying degrees of rot and decay, depending on their location. The asphalt coated deck boards forming the road surface was also in a very poor condition having been patched and re-fixed numerous times since the boards themselves were last replaced in 1992.
These 'Acme' panels were first used in 1974 as an additional layer to the asphalt covered lateral planks used between 1871 and 1974.
To prolong the lifespan of the bridge and to comply with modern design codes, the proposed timber deck is also to be revised by narrowing the carriageway width whilst widening the walkways, to the original 1820 widths which were not altered until 1903. The benefit of the reduced carriageway width will improve the durability of the bridge by restricting the number of cars which can cross, as it reduces the possibility of cars entering from each end and crossing somewhere on the bridge.
Furthermore, by restricting vehicles to travel only along the longitudinal centre of the deck, reduces the fatigue the hangers will be subjected to and the speed at which vehicles can safely travel.

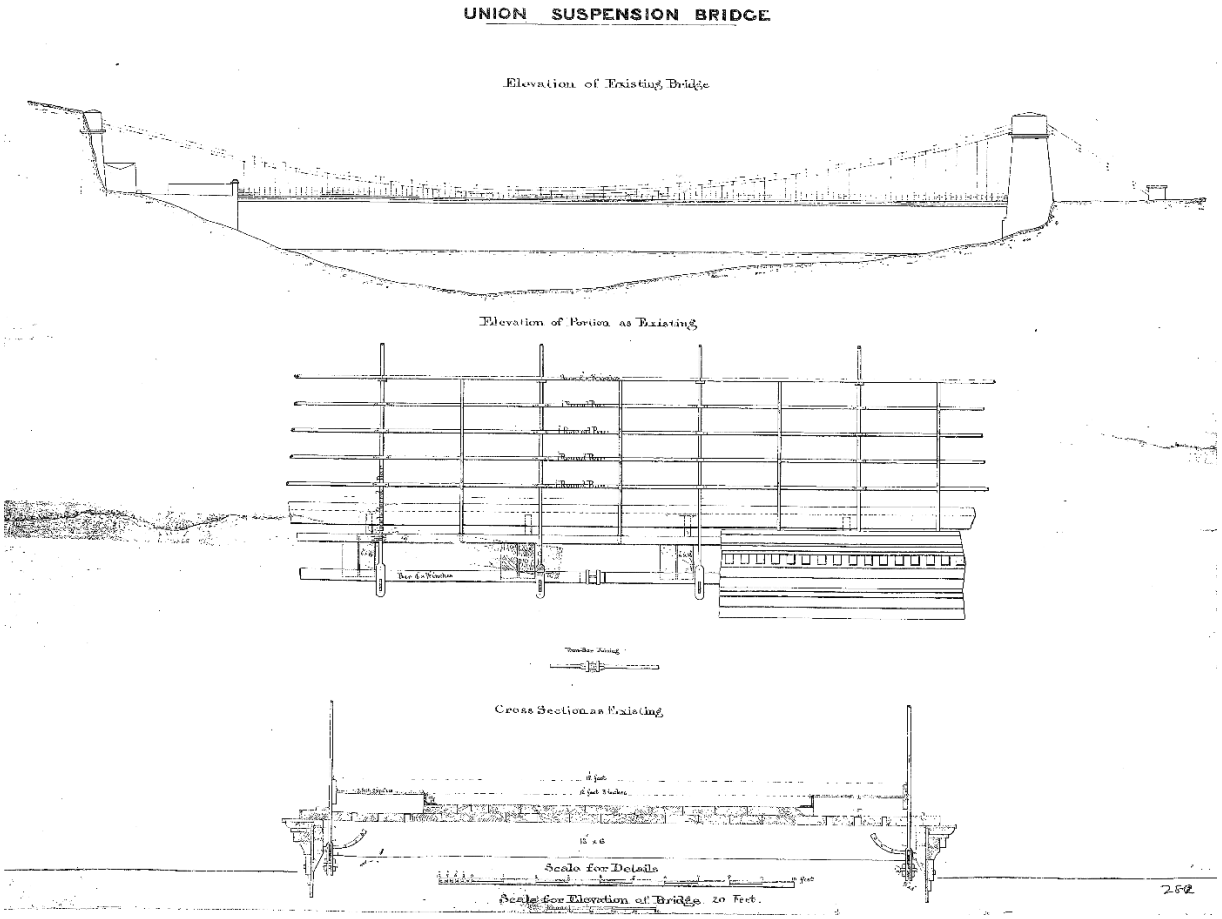
The original approved proposal for the replacement decking for the reinstated bridge was for Acme Panels, which are marine plywood panels encapsulated in resin with an abrasive grit surface.

6.3 Heritage and visual impact of replacement road surface, walkways & timbers

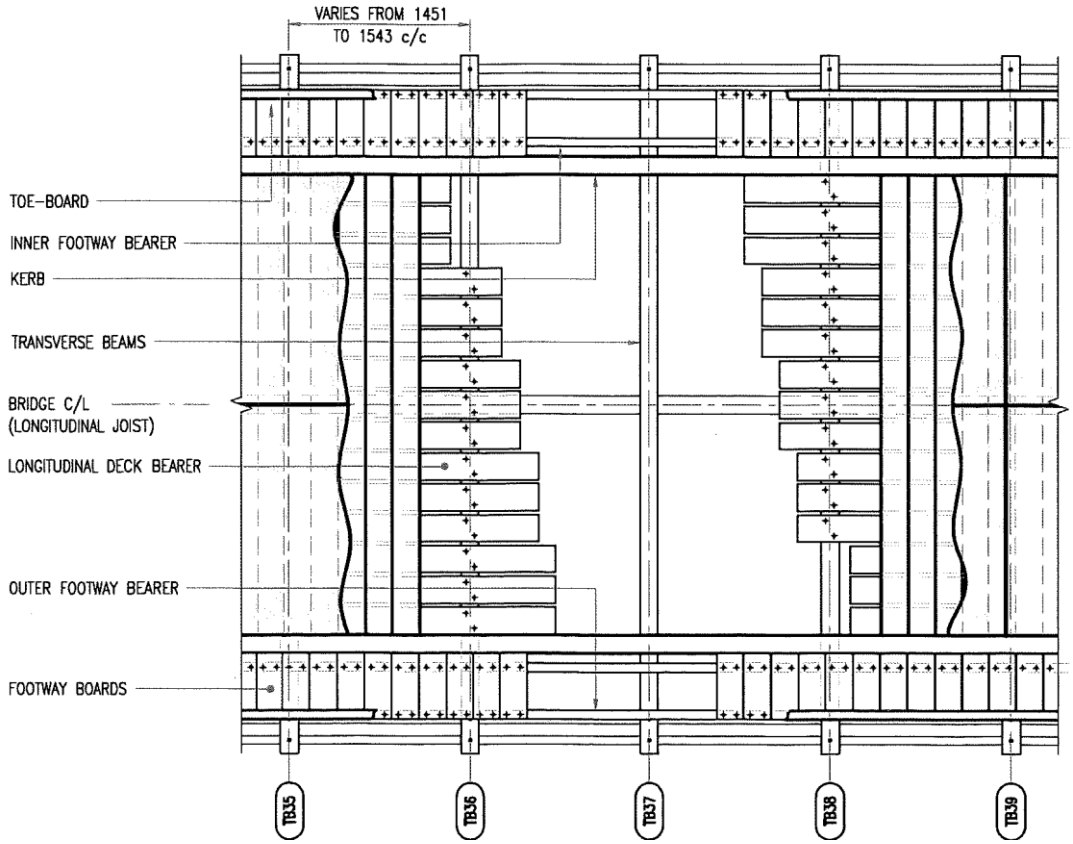
Because of the constant replacement of all of the timber components forming the deck, it is the whole form of construction that is more significant than the actual timber members and the strong demarcation of the roadway over the past two centuries with either cast-iron edges or timber kerbs that is more significant visually.
If the cast-iron rails and kerbs had survived, they would be just as viable today as a surface for vehicles and also helping to keep crossing speeds low.
The low significance value of the timber deck components will therefore not be affected by a 'like for like' replacement of decaying components and visually will be minimally different. Any colour and textural treatments to the surfaces of the carriageway and walkways will be considered and presented at a later stage in conjunction with the proposed colour scheme for the bridge metalwork and the hard surfaces in the landscaping proposals in Item 11.

IMAGES OF THE TIMBER DECK CONSTRUCTION & CONDITION

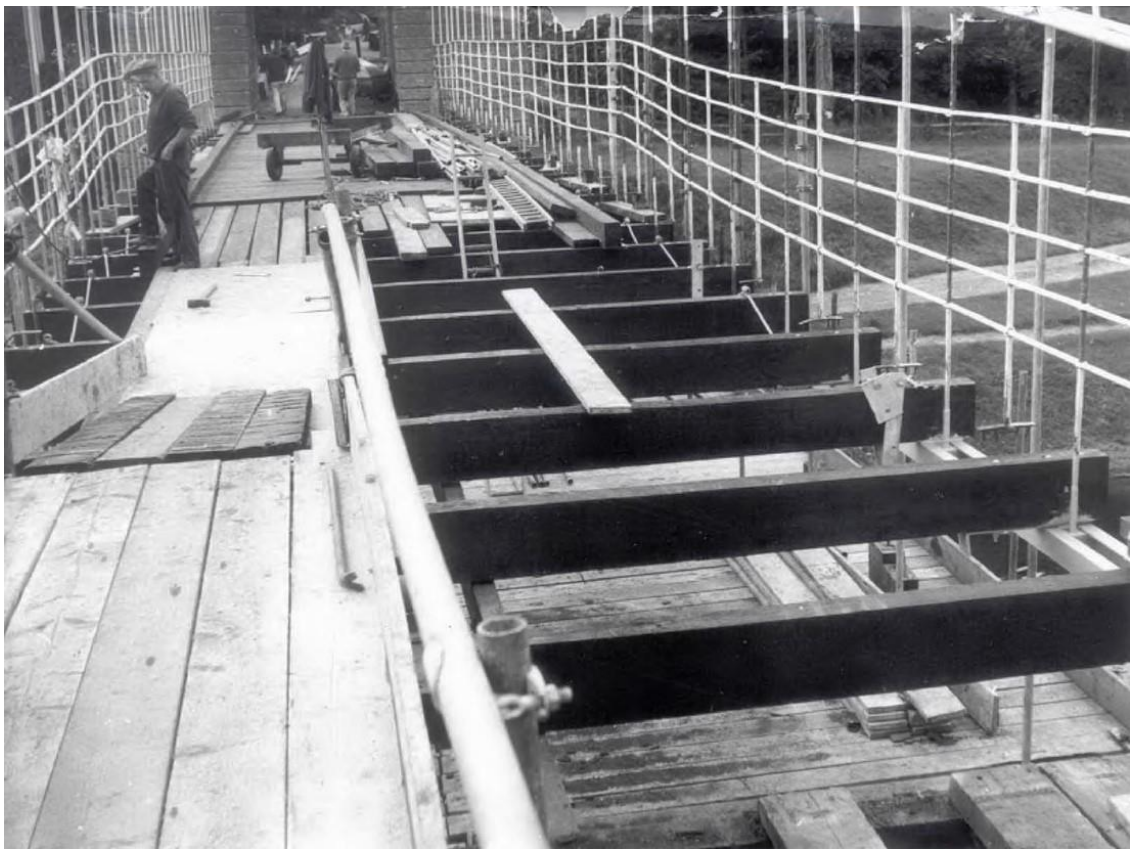
Before dismantling



1838 - 1871



1974 – 2018



1974 MAJOR DECK REPAIRS

2018 DECAY TO LONGITUDINAL TIMBERS

2018 DECAY & DAMAGE TO TOEBOARDS

7. CURRENT PROPOSALS FOR THE REPLACEMENT DECKING MATERIAL

The revised proposals for the deck surface are for the use of Evergrip Panels which are GRP Panels, glass fibre construction encapsulated in resin with an abrasive grit surface. Outwardly there is very little difference in appearance between the two panels. These are shown on drawing HB157290-B-C02-TBT-02-0508-C Item 5 - Revised Deck Panels - Layout

Original approved proposal for ACME PANELS for the new decking

New decking proposal With Evergrip Panels

This alternative approach was suggested by the main bridge contractor The Spencer Group due to their previous experiences:

- ACME panels will deteriorate around the edges first where adjoining panels abrade each other - particularly on a flexible structure such as UCB - when this happens the plywood core eventually becomes exposed and the deterioration accelerates.
- The GRP panels should have a service of many decades outlasting ACME panels 3-5 times. This reduces the future maintenance burden allowing funds to be concentrated on other aspects of the structure.

Edges of the ACME panels become more prominent as they become damaged

We set out below our view on the Significance of this alteration to the original proposals.

International Historical Value • Very High

The Union Chain Bridge is internationally significant as Europe's first iron suspension bridge, designed in 1817, to carry vehicular traffic and is the earliest surviving example in the World that is still in vehicular use.
The decking on this bridge has been replaced on many occasions and therefore this amendment will have no effect on the Historical Value. The finish is very similar to previous surfacing but the enhanced longevity of the Evergrip panels will be beneficial from a maintenance perspective and avoid the slow deterioration that has been visible with previous decking.

International Historical Engineering & Technological Value • Very High

The Engineering and Technological Value is concerned with the new iron chain suspension bridge technology allowing bridges to span large widths at a fraction of the cost of more traditional constructions. It is not directly related to the decking. Whilst the Institution of Civil Engineers (ICE) through its Panel for Historical Engineering

Works and publications, encourage the conservation of outstanding historical engineering works and is supportive of an authentic refurbishment of this bridge, the decking in place was not the original decking.

It is more important that a sound, hard wearing material is used for the part of the bridge which will get the most wear and tear in order that further repair disruption does not need to be undertaken for many years. The previous decking was not original and as technology has progressed, it is prudent and appropriate to utilise a similar looking product with greater robustness in this location as such is available.

Architectural Value • Very High

This in in relation to the pylons and the decking does not form a part of this.

Communal and Social Value • Very High

During its early years, the bridge was principally used for carting lime and coal from North Northumberland to Berwickshire, saving an 11-mile detour to the next nearest crossing at Berwick-upon-Tweed. Nowadays, the Bridge is still used by residents on both sides of the River, as well as tourists, cyclists and horse riders. It is the River Tweed crossing point for Sustrans Routes 1 and 68, as well as the North Sea Cycle Route, the Pennine Cycleway and the Coast and Castles Cycle Route.

It is important that the decking material installed is as repair free as possible in order that disruption, that the current closure of the bridge is causing to the public use of the bridge as a significant crossing of the river by its current closure between England and Scotland, is minimised for many years to come.

Aesthetic Value • Very High

The lightness of design and the emphasis of the curve of the chain is complemented by the reducing height of the parapet railings towards the centre of the bridge.

Asphalt coated deck boards forming the road surface have been in place since 1974. The proposals will not change the overall appearance and will have no impact on the reason for Very High aesthetic value.

Artistic Value • High

As for Aesthetic Value.

Evidential Value • High

Understanding the design developments, technological developments, repairs and engineering improvements over the past 198 years.

The repairs required to the timber deck over many years has been to improve the surface for more onerous and intense use by motor vehicles. The proposed deck with its more assured long-term performance will add to the history of repair and technological improvement.

Summary

Taken as a whole, the change of material being proposed for the decking forms a part of ensuring Union Chain Bridge's future integrity and structural capability of continuing to carry a vehicular route for a further 120 years, now a requirement for all vehicular bridges

The conservation proposals for the repair of the Grade I Union Chain Bridge are a balancing of the bridge's historic authenticity and aesthetic significance, with the necessary structural improvements and modern materials to ensure its future as a vital vehicular crossing between Scotland and England.

The proposals follow the principle 'Where a development proposal will lead to less than substantial harm to the significance of a designated heritage asset, this harm should be weighed against the public benefits of the proposal including, where appropriate, securing its optimum viable use'.

As stated in the approved Heritage Statement, because of the constant replacement over many years of all of the timber components forming the deck, it is the whole form of construction that is more significant than the actual timber members, and it is the strong demarcation of the roadway over the past two centuries with either cast-iron edges or timber kerbs that is more significant visually.

The low significance value of the timber deck components will therefore not be affected by a 'like for like' replacement of decaying components. The proposal now presented will not be visually different.

C) ACCESS STATEMENT

The proposed change to the decking material does not affect access