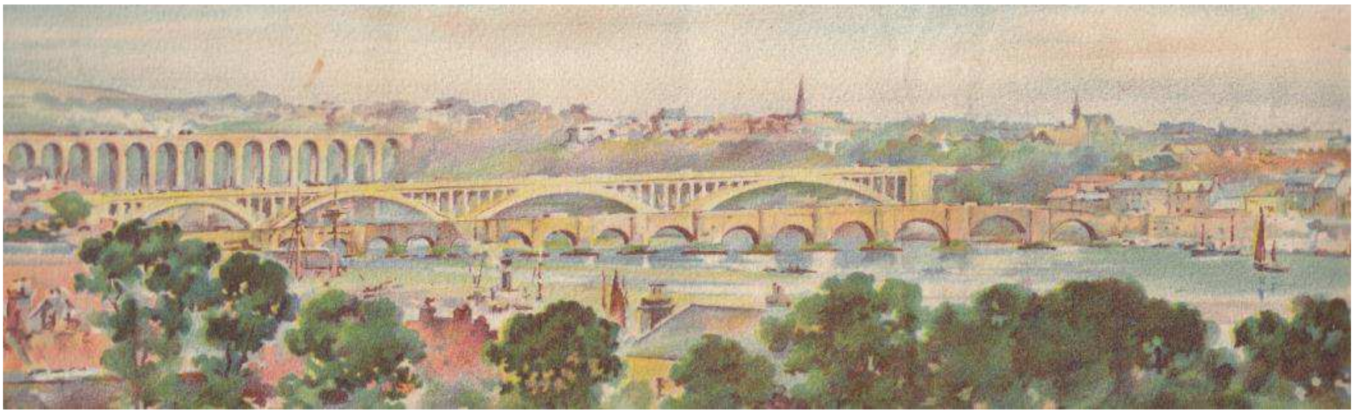

From a watercolour of 'Berwick-on-Tweed' by Frank W Wood 1928 in the possession of the author

Historic Berwick-upon-Tweed Bridges

By Roland Paxton MBE CEng FICE FRSE

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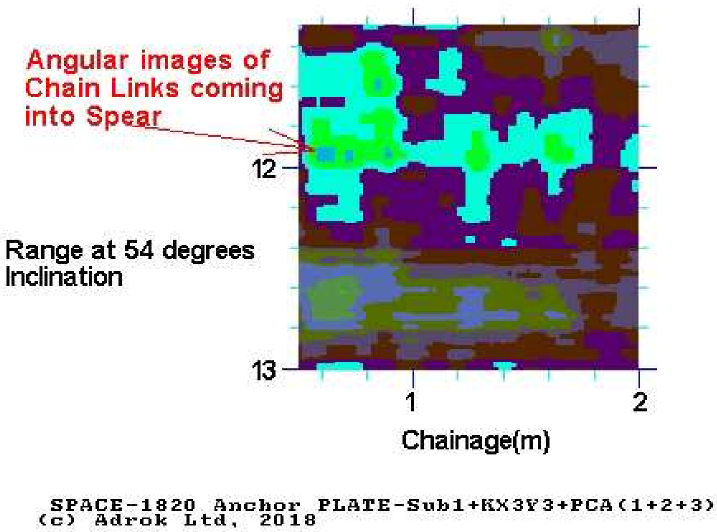
Co-Patron *The Friends of the Union Chain Bridge*



Union Chain Bridge Scottish downstream anchorage revealed
Microwave spectroscopy image of buried iron plate at a vertical depth of c.7.5m intersected at WARR chainage of 12.5m (p.29-30)

The *Institute for Infrastructure and Environment, Heriot-Watt University,* Edinburgh in association with the 600 *Friends of the Union Chain Bridge. 2018*

This monograph based on extracts from the author's writings [with minor additions to January 2023] is dedicated to:

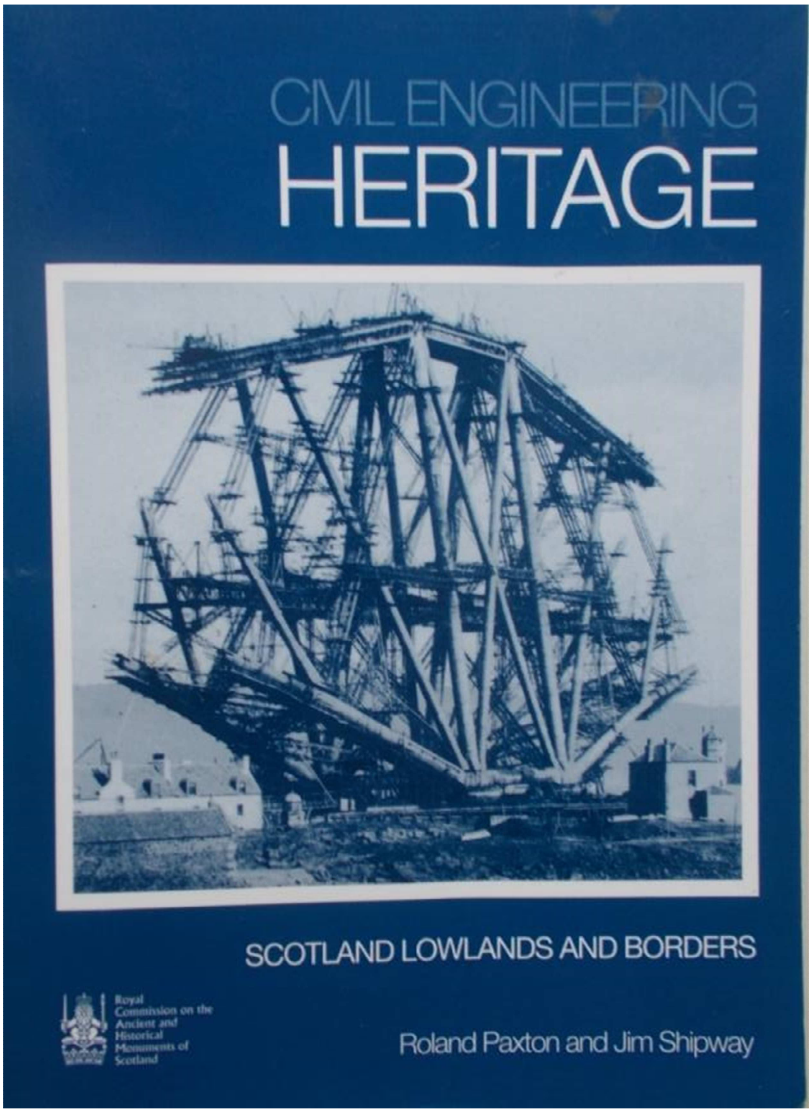
Members of the *American Society of Civil Engineers History and Heritage Committee* on 27 October 2018, to enhance their bridges tour organised by *The Friends of the Union Chain Bridge, and the Institution of Civil Engineers* as a bicentennial tribute to its foresight in 1968 in forming a Monuments Committee, that soon developed into the Panel for Historical Engineering Works [PHEW]. PHEW continues to make an invaluable contribution to society by recording and promoting civil engineering heritage and encouraging excellence in the conservation of its finest examples.

CONTENTS

extracts from

-

Extract from: *Civil Engineering Heritage Scotland Lowlands and Borders 2007*], the Institution of Civil Engineers' national equivalent of *Pevsner* for this subject, in which the five bridge examples featuring below have been deemed worthy of inclusion for their significance. Although not in the tour, Kalemouth Bridge is included as indicative of Capt. Brown's practice post Union Chain Bridge.



27. **Kalemouth Suspension Bridge** HEW 0410 NT 7084 2745

This is a rare operational example of an early wrought-iron chain-bar suspension bridge. It was made and erected over the Teviot in ca.1830 by chain manufacturer Capt. S.Brown, R.N. The span is 186 ft and the timber deck almost 9 ft wide at the suspension pillars.

The bridge has double chains at each side of the deck consisting of 10 ft 2 in diameter rods with hand-forged eyes and short interconnecting links. The chains are suspended from pairs of ashlar pylons at each end of the bridge. With a sag–span ratio of about 1:14 the chains have a marginally less efficient curvature in terms of their load bearing capacity than that Brown adopted at Union Bridge in 1820.

Roland Paxton

A comparison between Union and Kalemouth bridges demonstrates the evolution of Brown's practice. Other improvements on Union Bridge practice at Kalemouth were the cross bolting of each pair of chains and possibly the provision against deck oscillation by means of the robust timber lattice parapets, although these may have been added later. The masonry of the bridge was the work of William Mather, Kalemouth. In 1845 the toll for a pedestrian was a halfpenny, for a horse and cart three pence, and for a chaise one shilling.

In 1987 the bridge was tastefully reconditioned by Borders Regional Council. The timber was renewed, the pylons were refurbished and the pins and short coupling link interconnecting with the main chain links were replaced using spheroidal graphite iron. In 1990 new anchorages were installed. [3]

34. **Union Bridge, nr Paxton** HEW 0143NT 9339 5102

Although projected after Telford's Menai Bridge, which was on a much larger scale, Union Bridge erected over the Tweed four miles west of Berwick in 1819–20 by Capt. Samuel Brown RN was completed first. It has an 18 ft wide deck and for five years was the largest wrought-iron span suspension bridge in the world carrying vehicular traffic, which it still does. It is believed to be the oldest suspension bridge still carrying vehicles and is now subject to a two tonne weight limit.

The bridge was a triumph of the newly-emerging technology made practicable by Cort's improvements in iron manufacture. Brown used his patent wrought-iron chains to achieve a clear span of 361 ft (437 ft between supports), a span several times greater than was practicable by means of a stone arch. The main ironwork consists of 12 individual chains

Union Bridge Roland Paxton

formed of 15 ft 2 in. diameter eye-bar links in three pairs, one above the other, at each side of the deck with a dip of about 26 ft. The bridge has a buried anchorage and supporting tower on the north bank, passing over a tower stump and being anchored into the rock face at its south end [see illustration below from R. Stevenson 1821 via *Scotland's What's On*, Sept. 1991, 38].

Brown's expertise was in chain manufacture rather than bridge design and his original proposals for the 60 ft tall tower and abutments were considerably improved on the advice of John Rennie. Nevertheless, this application of his eye-bar chains, and its development by Telford at Menai Bridge, undoubtedly exercised an important influence in suspension bridge practice.

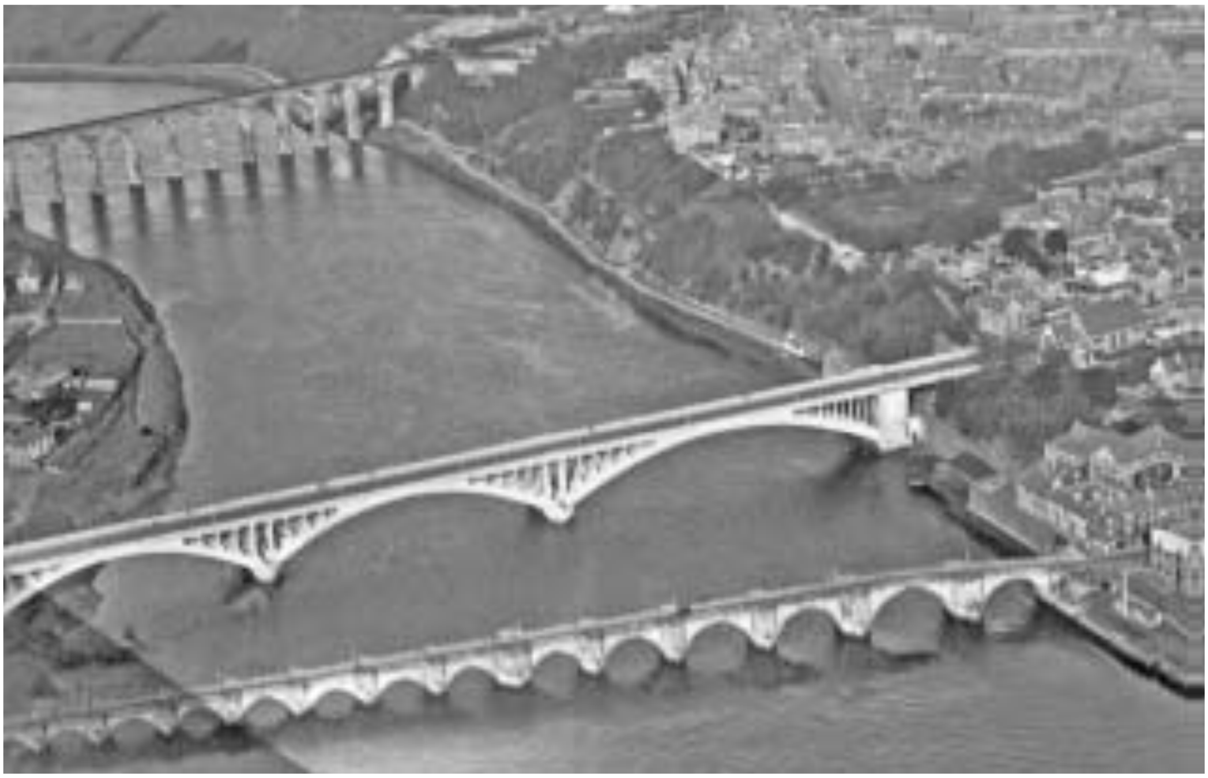
The bridge was erected in the remarkably short time of 12 months and cost approximately £7700 which was compared at the time with the sum of at least £20 000 for a multi-span masonry arch bridge.

Knowledge of Brown's achievement and of other innovative Scottish wrought-iron suspension bridges was widely spread by Robert Stevenson in his authoritative *Edinburgh Philosophical Journal* article in 1821, notable for its early description of deck undulation. By 1824 translations of Stevenson's article had appeared in German, French and Polish publications.

In 1903 the bridge was strengthened by the addition above the chains at each side of a single steel cable and hangers which was intended to come into play and support the deck if an original chain failed. From 1974-81 the bridge was reconditioned including the replacement, in spheroidal graphite iron, of defective short interconnecting coupling links [image on p, 31] between the original main eye-bars which were retained in service.

An original worn link has been preserved in the ICE Scotland Museum at Heriot-Watt University, Edinburgh [see on line catalogue of the Museum's holdings at https://web.sbe.hw.ac.uk/ICE_Museum/ or 'ice Scotland museum' via Google.

Shirley-Smith states in his book that the bridge was blown down six months after its erection but this is untrue and he may have been confusing it with the fate of the first Dryburgh suspension bridge. Although not as influential as Menai Bridge, Union Bridge nevertheless represents a landmark in the development of long span bridges and its custodians through the years are to be congratulated for its tasteful preservation and maintenance. [3, 21, 30–34].NB. This entry was written 12 years ago since when the bridge's maintenance has been neglected pending possible refurbishment.



Berwick-upon-Tweed bridges Postcard 1936

35**. Royal Border Bridge** HEW 0020 NT 9924 5319

Together with the crossing of the Tyne at Newcastle, the Royal Border Bridge over the Tweed removed the last major obstacle in completing the East Coast Main Line railway from London to Edinburgh.

The 2152 ft long viaduct is built on a curve and consists of 28 semi-circular arches of 61 ft 6 in. span, with a stop pier in the middle as a safeguard against progressive collapse. Its greatest height over the bed of the river is 126 ft. Nasmyth's steam pile-driver was used extensively to drive bearing piles into the river bed. The machine is said to have operated at 60 or 70 strokes a minute, in some cases causing the pile heads to burst into flame. American elm was used for many of the piles, some being 100 ft long. Each bearing pile was calculated to carry a load of 70 tons.

The superstructure is mainly ashlar masonry with a hearting of grouted rubble masonry and with brickwork in the piers, arch haunches and arch rings. There are, it is said, 1 437 684 cu ft of masonry in the structure and 1 710 000 bricks in the arches. The greatest numbers of men and horses employed were 2738 and 180 respectively.

The engineers were Robert Stephenson and his assistant T. E. Harrison. The resident engineer was (Sir) George B. Bruce, founder of the firm of Sir Bruce White, Wolfe Barry &

Partners, whose wife laid the foundation stone on 15 May 1847 and placed the keystone in the last arch on 26 March 1850 using a brass mallet. The contractors were James Mackay and J. Blackstock and the work sadly led to Mackay's bankruptcy.

This landmark structure cost the North Eastern Railway Company over £253 000, took three years, three months, three weeks and one day to build and was opened by Queen Victoria on 29 August 1850. [3, 35, 36]

36. **Royal Tweed Bridge** HEW 0695 NT 9951 5278

Royal Tweed Bridge under construction [postcard 1927]

This imposing reinforced concrete bridge is seen to advantage from the adjoining bridges. It illustrates the charm of irregular spans arising from the fact that the bridge is on a gradient of 1 in 51, giving rise to the largest arch at the north end of 361 ft 6 in. span, the longest concrete arch in Britain at the time. Other spans are 285 ft, 248 ft and 167 ft at the south end.

The whole structure, including the four main parallel ribs of rectangular cross-section, was erected in timber staging mounted on timber piles. It was cast in situ using concrete from mixing plants on both sides of the river. An unusual feature is the lack of interruption of the open spandrels columns sequence by any feature at the three piers.

The bridge was designed by L. G. Mouchel & Partners and built by Holloway Bros. (London) Ltd. It was opened on 16 May 1928. The amount of reinforcing steel used in the concrete was 1015 tons and the average labour force on site was 170 men. The cost of the bridge was £160 000. [3, 37, 38]

37. **Berwick Bridge** HEW 0694 NT 9956 5272

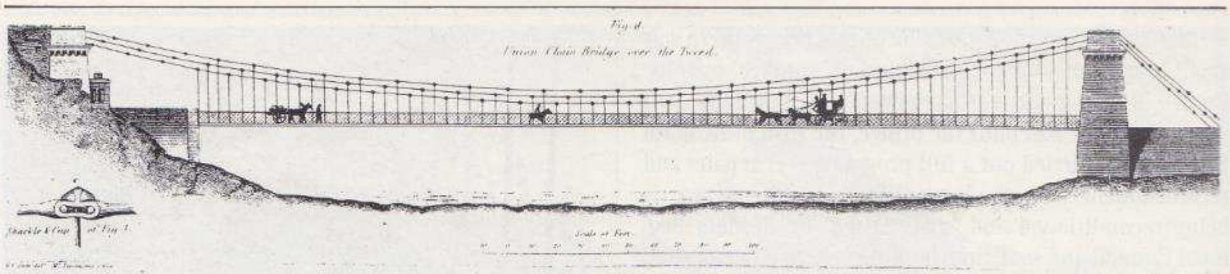
There are records of the destruction of several early wooden bridges over the Tweed at or near this site either by man or nature from 1198 onwards. On 15 February 1607 ice, carried by a strong current, demolished the last timber bridge and a grant was made from the Privy Council to build a new bridge of stone.

The bridge, one of Britain's largest and more important is 1164 ft long of 15 arches, and 17 ft wide between parapets. It was begun in 1610 and took 24 years to complete. The master mason at first was James Burrell who was granted an allowance of 2/6d per day for directing and overseeing. By 1620, seven arches were completed and a contract was entered into with Lancelot, Branxton & Burrell to complete the work within two years. There was serious flood damage in 1621, made worse by the collapse of the old timber bridge, and the contract was cancelled. Work recommenced in 1622 under day labour and eventually the bridge was completed on 24 October 1634 at a total cost of £14 960 1s 6d.
The nearly semi-circular, slightly pointed, arches vary in span, the largest being 74 ft. The bridge is asymmetrical in elevation being higher at the Berwick end. It was built to a high standard with flourishes of ornamentation on some elevations. The piers are founded on oak piles 'properly bound with iron' and each pier is protected against scour by starlings 'or surrounds' 3 ft to 6 ft in width. The bridge now carries local traffic. [3, 36, 39]

References:

[3] PAXTON, R. and RUDDOCK, TED. *A Heritage of Bridges between Edinburgh, Kelso and Berwick*. ICE E&ESA, Edinburgh 1981.
[4] PAXTON, R. 'A bridge not so far'. *Scotland's What's On*. July 1991, 36–37. With an image of Stevenson's 1821 elevation showing the UCB tower base foundations.

OUTINGS AND DISCOVERIES



Designed by Captain Samuel Brown R.N. the Union Chain Bridge, 4 miles upstream from Berwick-on-Tweed is the oldest surviving suspension bridge in Britain still carrying vehicles. For the five years prior to Telford's Menai Bridge (1826) it was the longest bridge span in the western world.

[31] STEVENSON, R. Description of Bridges of Suspension. Edin. Philos. J. 1821, V, 237–56, pl.
[32] PAXTON, R. A. Menai Bridge 1818–26. *Thomas Telford, Engineer* (ed. A. Penfold). Thomas Telford, London, 1980, 102.
[33] ARTHUR, B. 'Reinstatement: Union Chain Bridge'. *Consulting Engineer*, Feb. 1976, 40, 17–28.
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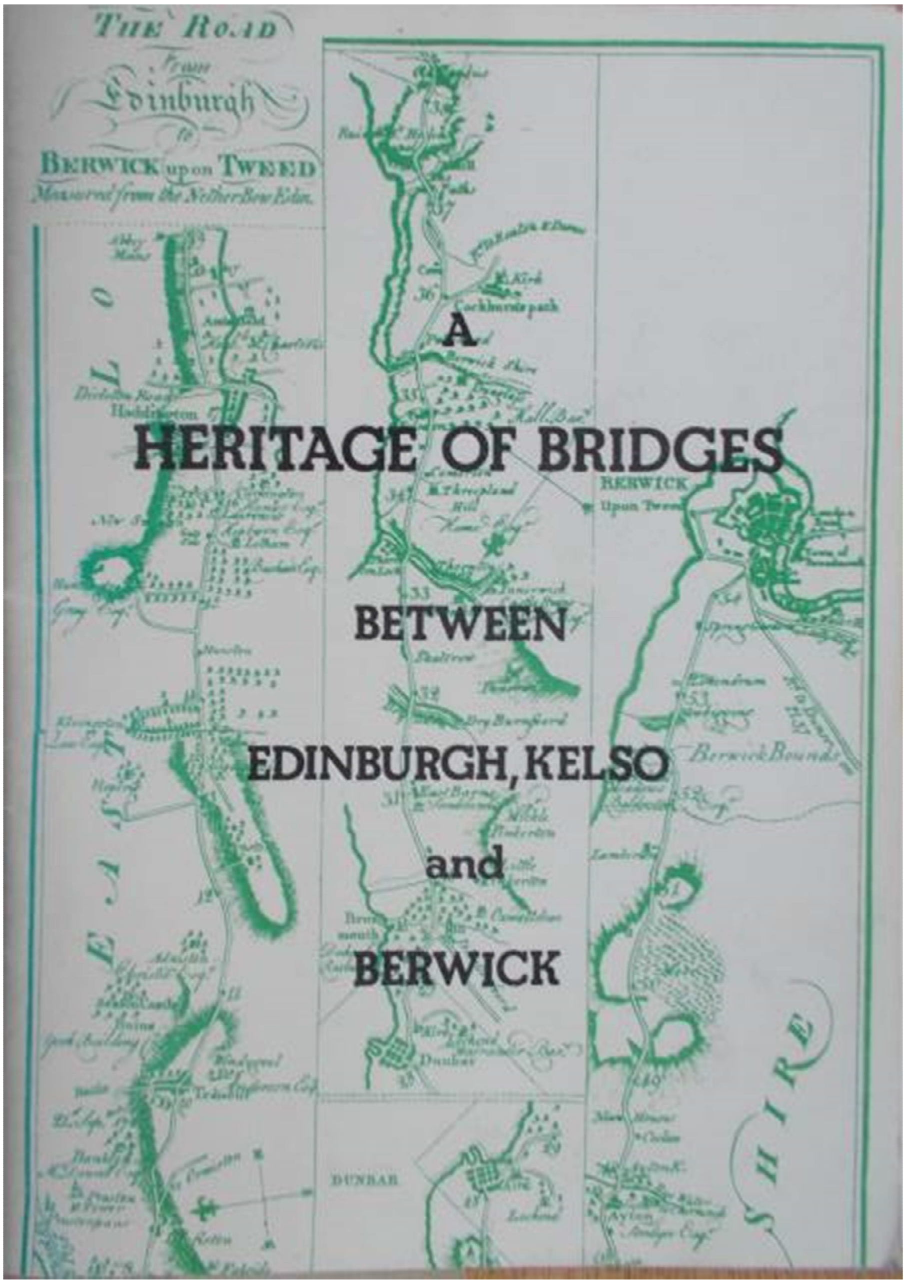
[38] Noble W. (ed.) *Ferro-Concrete Royal Tweed Bridge Souvenir Number*, Twelvetrees, June 1928.
[39] SUMMERSON, Sir J. *The History of the King's Works* (ed. Colvin, H. M. HMSO, London, 1982. 4, pt. 2 (1485–1660), 769–778.

Extract from:



Published for East of Scotland ICE Summer Visit 1981 [With minor revisions]

19. UNION CHAIN BRIDGE NT 934510

The Union Bridge erected over the River Tweed in 1819-20, is the oldest surviving suspension bridge still carrying vehicular traffic. Although started after Telford's Menai Bridge, which was on a much larger scale, Union Bridge was completed first and for five years was the largest span wrought iron suspension bridge of its kind.in the western world. It was a triumph of the newly-emerging bridge technology of its time, utilising wrought iron to achieve a span between points of suspension of 437ft (133.2m) [Stevenson, 1821 - 4], several times that of the largest masonry span previously constructed in the UK and greater than that of any timber or cast iron bridge.

The bridge's success encouraged the building of suspension bridges generally and influenced the use of iron bars rather than iron cables in their catenaries. The bridge was erected in the remarkably short time of about one year and cost approximately £7,700, which was compared at the time with a sum of at least £20,000 for a masonry bridge. The highly developed skills applied in its design and construction were provided by chain manufacturer Capt. Samuel Brown R.N. and eminent civil engineer and bridge builder John Rennie.

In 1817 two designs were prepared for a suspension bridge of 245ft (74.7m) span, one by Capt. Brown and the other by Robert Flynn of North Shields. In January 1818 Rennie became in effect 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 Flynn.

Rennie concluded a letter to Molle, *'I have seen the experimental bridge Captain Brown has at his manufactory at Millwall. It is about 100 feet span and is sustained at each end by a framing of wood fixed in soft clay. These framings are but indifferently done notwithstanding which the bridge is sufficiently supported to sustain the weight of a carriage along the bridge in perfect safely and with very little shake. So I do not entertain the smallest doubt that a bridge of this sort may be made capable of sustaining the weight of loaded carriages passing over it and be also, if properly attended to, a durable structure. The architecture of the stone abutments in Captain Brown's design is clumsy, ill arranged and overloaded with ornament. This part might be much improved both in look and stability …*'[1]

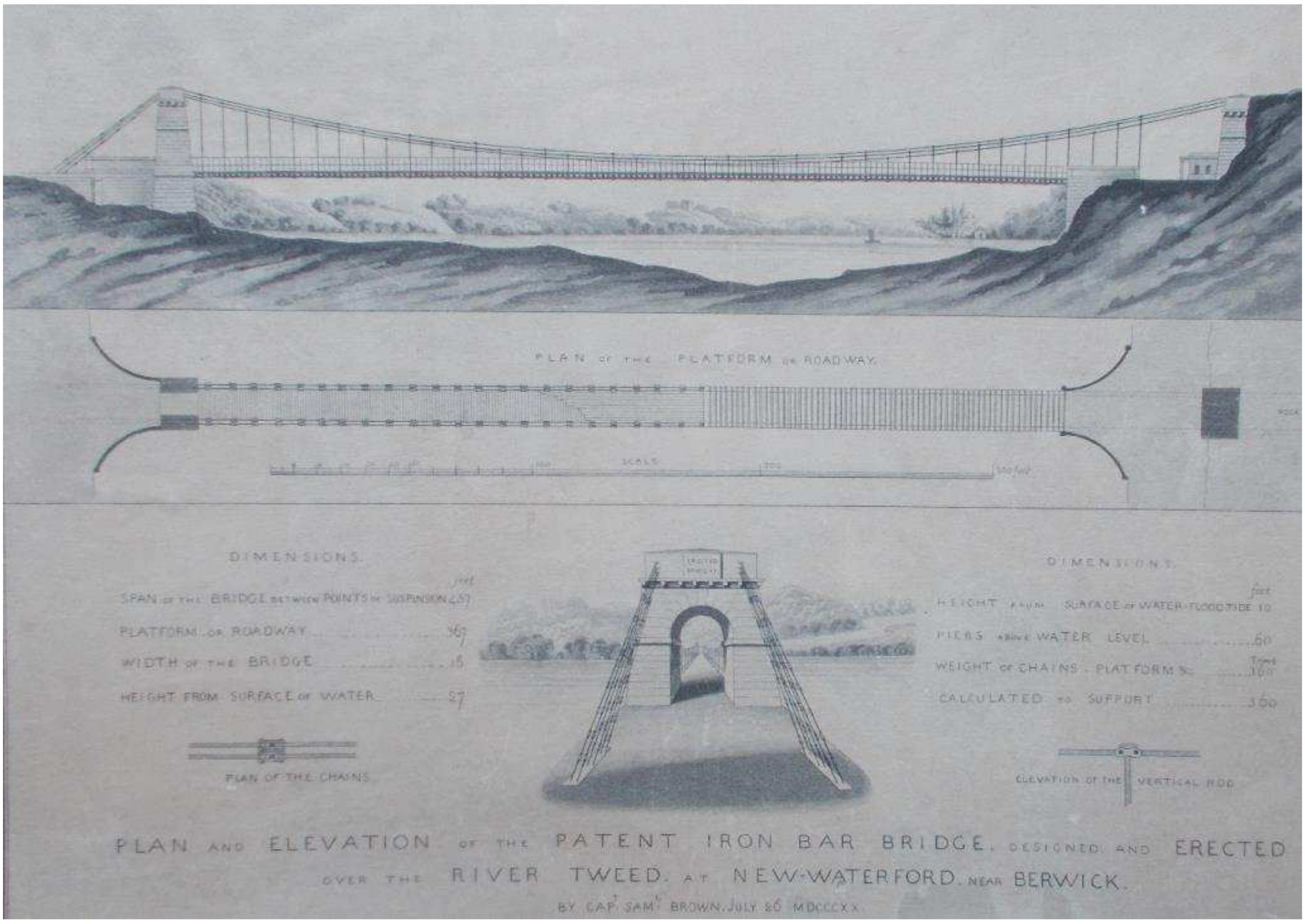
Capt. Brown and Rennie had a meeting late in 1818 to discuss details of the project. Rennie suggested a number of alterations to Brown's design which included strengthening the abutments and towers by increasing their size and introducing tapering faces, reducing the span by 22ft (6.7m), providing rollers for the chains to pass over near the tower tops and raising the deck at mid-span about 3ft above the roadway level at each tower. [2]

In a letter to Molle written in November 1818 Rennie mentions that Capt. Brown had approved of these changes and had made out a new set of plans. Rennie commented on these: *'With respect to the suspending chains and other iron work, they are entirely in Captain Brown's own line, and of course I have not ventured to make any material alterations in them, and moreover, as I am not locally acquainted with the spot where the bridge is to be erected, I can give no opinion as to the nature of the foundation or the manner of fixing the ends of the chains – all I can say is, that if all these matters are properly attended to, my opinion is that the bridge will be a durable and useful structure, and as he takes the responsibility on himself I see no reason why the Trustees should not enter into a contract with him – all the extra expense incurred by the alterations I propose are on the abutments, and if these are approved of by the Trustees, it will be for them to consider what extra allowances should be made for this increase. This extra in my opinion should be liberal as I think he undertakes the work more for the sake of introducing bridges of this sort into general use, than any profit he can derive from the undertaking …'* [3]

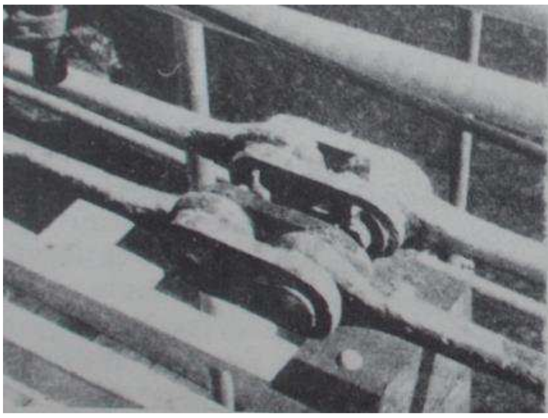
The Trustees seem to have taken the advice of Rennie [FRSE 1788] as after completion of the bridge they presented Capt. Brown with 1000 guineas over and above his estimated price. Even so it seems unlikely that he profited financially from the venture although its success undoubtedly established him nationally as a chain bridge builder.

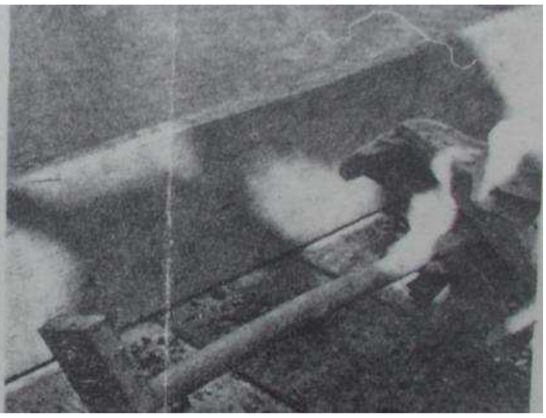
An Act of Parliament was obtained in 1819 and the foundation stone laid on 2 August 1819 by William Molle. A detailed contemporary account of the bridge is provided by Edinburgh civil engineer, Robert Stevenson [FRSE 1815] who was present at the opening ceremony on 26 July 1820. Perhaps he was one of the crowd of about 700 spectators who surged through the toll gates on to the bridge after Capt. Brown [FRSE 1831] had tested its strength by crossing first in a curricle followed by twelve loaded carts. Other technical observers included Prof. John Leslie [FRSE 1807] and George Buchanan [FRSE 1832].

The bridge attracted great public interest, one of the manifestations of which was the publication in London of the aquatint below which included key engineering details .[5]



Bridge features of interest include the 15ft x 2in (4572 x 51mm) diameter eye-bars of South Wales manufacture, the manner they are carried over the towers and the hanger connections, Anchorage details not given. Capt. Brown used individual lines of cable in pairs one above the other at each side of the bridge, that is, about 18ft apart to allow traffic to pass in each direction. The tops of the hangers are secured into cappings each resting on or 'saddling' a pair of chains (see photographs below). [6] This arrangement differs at Kalemouth. [11]


Links with saddle removed

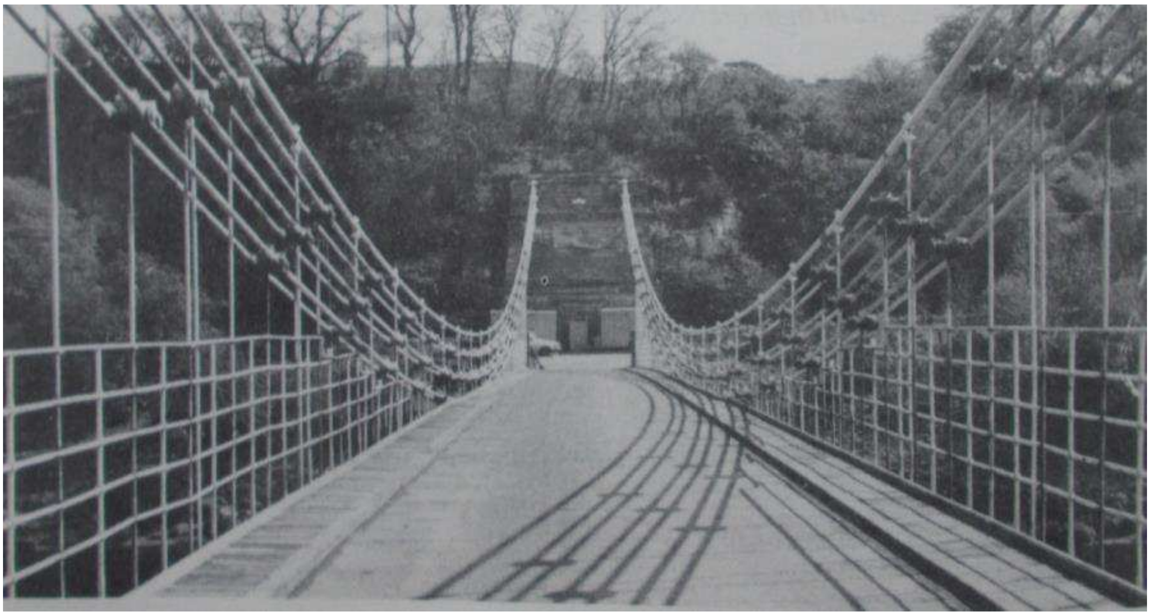

Removed saddle and hanger on deck

The chains, hangers and deck and their arrangement can be readily inspected on site, but not the cast iron ballast plates into which the chains are anchored, which on the Scottish side are buried underground and presumably still exist. Stevenson, who never saw them in-situ, informs us that these plates measure 6ft (1.83m) in length 5ft (1.52m} in breadth and 5in (127mm) thick in the central parts diminishing to 2½ (64mm) at the edge. On the Scottish side of the bridge the ballast plates 'are sunk to the depth of 24ft (7.3m) and loaded with mound-stones and earthy matter to the level of the roadway'. They each weighed about 2¼tons]. On the English side the ballast plates are 'rather above the foundation of the pillar, where they are set nearly perpendicular, with a horizontal arch of masonry which is dovetailed into the rock'. The chains are 'stopped' into the ballast plate 'by a strong iron spear or bolt, of an oval form, measuring 3 x 3½ inches in thickness'. [4]

Over a period of many years a popular misconception has gathered momentum that the bridge was blown down six months after its completion. Although countered to some extent by Cowe, [7] this quite untrue statement appears in at least four books on bridges published between 1911 and 1968.[8] The evidence to the contrary is found in a letter from Capt. Brown to Dr Brewster written about 18 months after the opening of the bridge, 'the fact which is paramount to all others – that ever since it has been opened it has given entire satisfaction and has been in constant use without any restriction'.[9]

The principal details of maintenance on the bridge from 1884-1974 extracted from memoranda and reports of Tweed Bridges Trust are shown in the table [6]

1902	Renewal of timber deck	£650
1903	Addition of steel wire cables and hangers to strengthen bridge	£1531.16
1919	Repairs to timberwork	£240
1925	Replacing wooden sleepers	£372:11:5
1926	Repainting bridge	£130
1933	Renewal of cross beam	£763:2:0
1952	Ironwork cleaned and repainted; repairs to towers	£1,217
1953	Repair of gale damage	£154
1955	Toll cottage demolished and façade erected	£1,015
1957	Repairing bridge; repairs to deck	£800
1963	Repainting bridge; improvements to north anchorage chamber	£550
1964	Replace footpath timbers	£346
1969	Repairing bridge	£900
1974	Renew deck	£37,000



Union Chain Bridge looking from Scotland into England c.1970

In 1974 the Tweed Bridges Trust embarked on an extensive programme of preservation work which is expected to have cost over £100,000 by the time it is completed in 1981. The work being carried out at present includes the removal and replacement of defective links with spheroidal cast iron graphite cast iron links.

Although the original design of this historic bridge would be unacceptable today, being formulated at a time when knowledge of 'strength of materials' and provision against oscillation effects was in its infancy and theoretical design techniques were virtually non-existent. The bridge was nevertheless a remarkable achievement of contemporary technology. [10]. Its survival is not only testimony to the competence of Capt. Brown and Rennie but also to others, particularly the Surveyors of the Tweed Bridges Trust who have been responsible for its subsequent maintenance and tasteful reconditioning [in 1981].

References and Notes

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2. The rollers seem only to have been adopted in the Scottish tower.
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4. Stevenson, R. 'Description of Bridges of Suspension'. *Edin. Phil. Jrnl* 1821. **V.**
5. 'Plan and Elevation of the Patent Iron Bar Bridge, designed and erected over the River Tweed at New-Waterford near Berwick by Capt. Sam Brown. July 26 1820'. London, J. Taylor at the Architectural Library 1822.
6. Arthur, B. 'Union Chain Bridge', *The Consulting Engineer*, Feb. 1976.
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9. Brown, Capt. S. 'Description of the Trinity Pier'. *Edin. Phil. Jrnl* 1822, **VI**
10. Ever since the bridge was opened the stresses in the main chains have been at times too high to allow what most engineers, including Telford nad Rennie in 1819, would accept as having a sufficiently generous safety margin. Apart from being somewhat underpowered the bridge, unlike Kalemouth [11], also lacks any substantial provision against the effects of deck oscillation and it is fortunate that the site is in a fairly sheltered location.
    For further information on early suspension bridges, the original strength of Union and the comparative practice of designers, see, Paxton, R.A. 'Menai Bridge and its influence on Suspension Bridge Development'. *Trans Newcomen Soc.* **49** 1977-8, 87-110.
    For more information on the history of bridge, the reader is referred the late Gordon Miller's new book *Samuel Brown and Union Chain Bridge* [Dec. 2017], with its chapter by Stephen Jones ICE PHEW Member shedding new light on the bridge's Welsh ironwork. Published by *The Friends of the Union Chain Bridge,* from whom copies are available.

[From *History of the Berwickshire Naturalists' Club*. Vol. 53, Pt 2, 2015 147-161]

UNION CHAIN BRIDGE'S HISTORICAL ENGINEERING SIGNIFICANCE

Roland Paxton. School of Energy, Geoscience, Infrastructure and
Society Heriot - Watt University, Edinburgh, Scotland

Fig. 1. Union Bridge (Good, 1822)

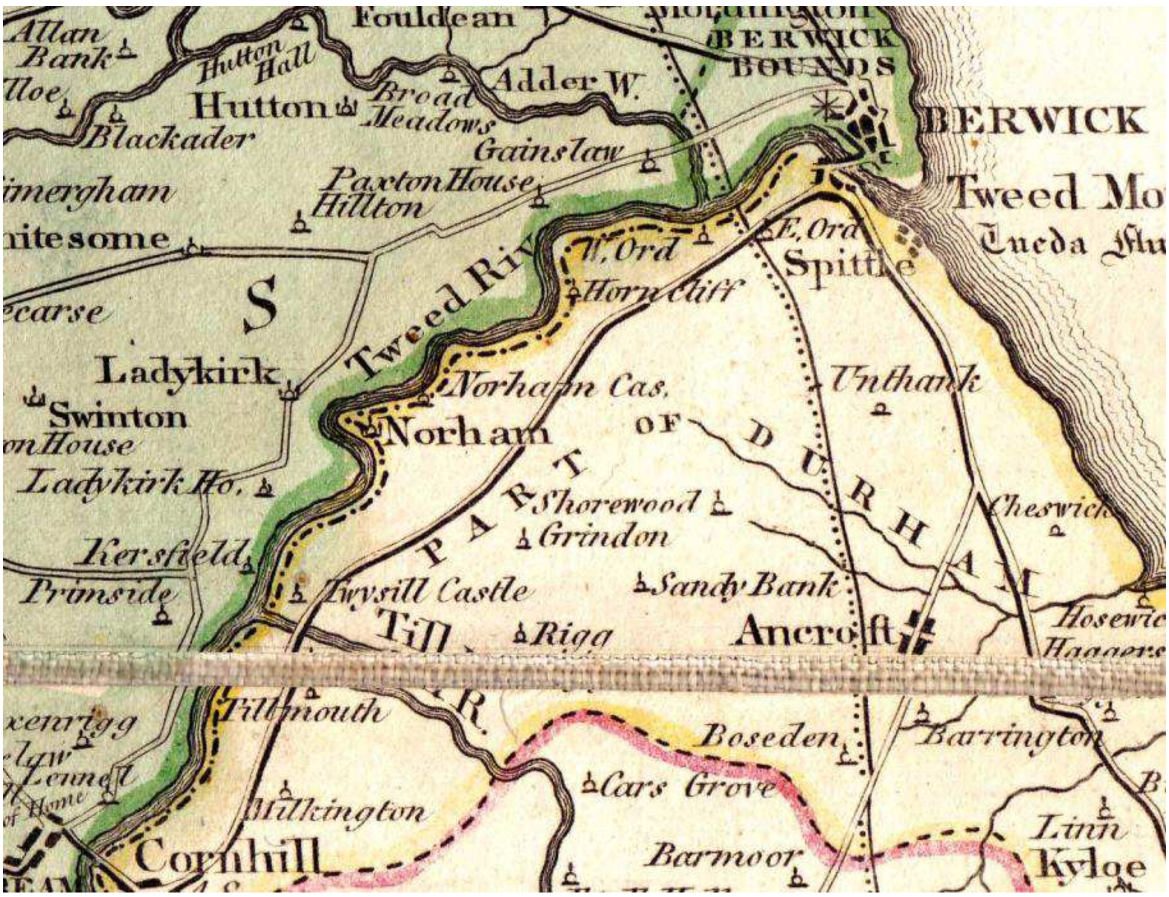

Fig 2. Map – Berwick to Coldstream (Ainslie, 1789)

Introduction

Union Bridge connecting Scotland and England, is jointly owned by Northumberland County and Scottish Borders Councils. When erected in 1819-20 between Paxton in Hutton parish and Horncliffe it was the only road bridge crossing the River Tweed between Berwick and Coldstream. It was commissioned by the Berwick and North Durham Turnpike Trust under the enterprising chairmanship of William Molle. [Fig. 2]

When opened, Union chain bridge at 18 feet wide, was almost certainly the world's longest bridge span carrying road traffic and is now also the longest in service at 195 years. So on two counts it is **a landmark in the development of suspension bridges on an international scale**, as can be seen in the table below:

Name of Bridge, Engineer, Main Cables, Dates	Cable Span (ft/m)
Newburyport, MA, USA (Templeman 1810, to Finley's patent modified), bar chain, replaced 1909	244/74
Union, UK (Capt. Brown & Rennie 1820, bar chain, 2t limit	**437/133**
Menai, UK (Telford 1826), bar chain, renewed in steel 1940	580/177
Fribourg, Switzerland (Chaley 1835, iron wire, replaced)	c.870/265
Wheeling, Ohio USA (Ellet 1849 – iron wire)	1010/308
Queenston-Lewiston, USA (Serrell 1851-64 wrecked, wire)	1040/317
Cincinatti-Covington, USA (Roebling 1867 – wire cable)	1057/322
Niagara-Clifton, USA-Canada (1869-89 wrecked, wire)	1268/387
Brooklyn, USA (Roebling 1883, steel wire; bar chain anchorages)	1596/486
Forth, UK (Fowler/Baker/Arrol 1890, steel cantilever type)	1710/521
Quebec (Vautelet et al 1917, zenith span steel cantilever type)	1800/549
Ambassador, USA-Canada (McClintic & Co.1929, steel wire)	1850/564
George Washington, USA (Ammann/Gilbert 1931, steel wire)	3500/1067
Golden Gate, USA (Strauss et al 1937, steel wire)	4200/1280
Verrazano Narrows, USA (Ammann/Brumer 1964, steel wire)	4260/1298
Humber, UK (Freeman Fox & Partners 1978, steel wire)	4526/1380
Akashi Straits, Japan (Satoshi Kashima 1998, steel wire)	6532/1991

Chronological list of the world's longest road/railway bridge spans >200ft/61m 1810-2019

(All are operational suspension bridges unless otherwise indicated)

The bridge's status and crisis of survival

The historical importance of Union Bridge is recognised in the UK by its highest governmental grades of 'Class 1' by *Historic England* and 'Category A' under the auspices of *Historic Environment Scotland*. It is however more than just an historic monument, being also a useful local crossing facility and an elegant environmental and tourist attraction.

In the past decade the protective paintwork of the bridge has deteriorated and several broken hangers have been temporarily replaced to keep it operational at its low, but much preferable to closure, weight limit of 2 tonnes [Fig. 3]. It is on Historic England's *Heritage at*

Risk register. There is significant public concern about its crisis of condition at home and abroad from American, Scandinavian and Japanese engineers (Isohata, 2015).

Fig 3. Prof Isohata from Tokyo viewing temporary hanger, 2014

Fig. 4. Kalemouth Bridge in 2016

Successful refurbishment of historic transport works

The authentic refurbishment of the bridge will require funding additional to normal maintenance, a challenge which can and should be met. Successful precedents include, restoration of the Scottish Lowland Canals 1994-2002, refurbishment of the historic railway infrastructure, involving 1,483 *Railway Heritage Trust* grants in the past 30 years; Conwy Bridge, now National Trust; Laigh Milton Viaduct 1811 Kilmarnock, the world's oldest of type on a public railway, which attracted funding from seven sources (Paxton, 2007); bridges at Aberchalder (suspension-stay) by Historic Scotland; Linlathen East (cast iron c.1804) by Dundee Council; and later Capt. Brown bridges at Kalemouth c.1835 by Scottish Borders Council [Fig. 4] and Wellington Bridge 1831 by Aberdeen Council (Paxton & Shipway, 2007).

Apart from its already mentioned attributes, Union Bridge is worthy of refurbishment as a masterpiece of entrepreneur, chain manufacturer and bridge engineer, Capt. Samuel Brown R.N. (1774-1852), introducer of the iron chain cable to the Navy, mercantile marine and suspension bridges and, his consultant on its masonry design, the eminent civil engineer John Rennie (1761-1821). Their achievement is best appreciated on a site visit – an experience with valuable educational and tourist potential.

Early development of the iron suspension bridge concept

The use of wrought iron in chain bridges became practicable following late 18th century improvements in manufacture that made it available at an affordable cost for larger applications. This was not a new concept, the Chinese having erected such bridges, using iron chains, for more than a thousand years. In Europe Verantius designed a bridge using eye-bar rod chains in 1595 (Needham, 1971). But the first significant application of wrought iron to improved chain bridge practice in modern times began in the USA around 1796 (Drewry, 1932) by an ingenious judge, James Finley, who showed a commendable appreciation of chain curvature efficiency and deck stiffening for his time. He erected eight bridges by 1811, the most noteworthy being Merrimack, Newburyport, of 244 feet span with elongated chain links about 10 feet long (Finley, 1811; Stevenson, 1821; Drewry, 1832).

Development of the long wrought iron eye-bar chain

From c.1811, Brown and Telford thought that Finley's practice could be improved on by British skill and technology. It was, but in the event neither provided adequately against severe storm-induced vibration at exposed locations, a phenomenon little understood even as late as 1940 in the USA when Tacoma Narrows Bridge failed in a moderate wind soon after opening.

From 1813 shallow catenaries were proposed by Brown and Telford, Brown's with a mid-span deflection from the horizontal chord line of 1/25th span for a Runcorn Bridge proposal, believing this curvature and the high chain tension required to achieve it, with side railings, would minimise vibration. But, all considered, it is as well the bridge was not erected. Modern practice would dictate a deflection of about 1/9th span and strong longitudinal and transverse deck stiffening. These early designs were largely based on experiment before a theoretical approach began to be developed by Davies Gilbert at Menai Bridge from 1821 (Provis, 1828).

In 1813, at his Millwall works, Brown erected a working model of a bridge of about 100 feet span, with a view to extending his chain cable enterprise to suspension bridges. This was probably the model inspected by Rennie that bore carts and carriages *'with very little vibration'* (Rennie, 1819). It was the earliest suspension bridge with eye-bar chains, stronger than small link chains of the same weight, and the prototype for Brown's chain and bridge patents (Brown, 1816-17). This innovation attracted visits from leading French engineers one of whom provided posterity with a detailed drawing indicating a mid-span deflection from the horizontal chord line of about 1/30th span and links about 5 feet long. [Fig. 5]. (Dutens 1819, Drewry 1832).

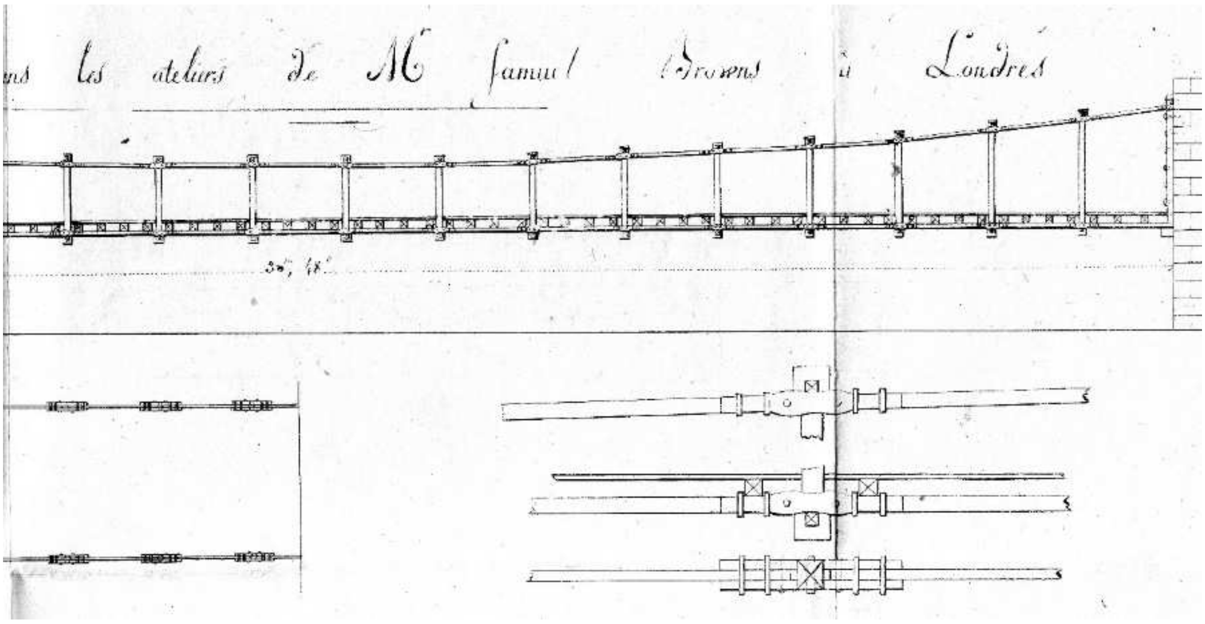

Fig. 5. Dutens's drawing of model chain bridge at Brown's Works

Erection of Union Bridge

The main ironwork comprises single lines of round-bar chain cables weighing about 3 tons, six at each side, formed of 15 feet long by 2 inch diameter, Welsh-made, wrought iron eye-bar links deployed in three pairs, not cross-bolted. They are anchored behind the masonry façade at the English side and into two large cast iron ballast plates 24 feet below ground at the Scottish side, of which a unexecuted plan signed by Brown [see page 27] has survived (Stevenson, 1821; Paxton, 1999).

The bridge's erection had begun by 2nd August 1819 (or a week earlier?) when Molle laid its foundation stone. Its chains were probably pulled into place using large, man-powered, capstans. The opening was on 26th July 1820 after a construction period of only one year. It was preceded by a 'bridge proving' recorded by civil engineer George Buchanan whose published drawing shows loaded stone carts, a chaise and gig, in all weighing about 40 tons (Buchanan c.1820).

The weight of the suspended part of the bridge was about 100 tons. At its opening the bridge survived a surprise live loading when **about 700 people broke through barriers and surged on to the platform**. The civil engineer Robert Stevenson, of Bell Rock Lighthouse fame, who was present and published an account of the bridge, estimated their weight at about 47 tons and that the total suspended weight of 147 tons induced about 370 tons of chain tension (c. 9.8 tons sq. in}. A link tested at Brown's works (Barlow, 1817), sustained a force of 92 tons (29 tons sq. in), Stevenson used this stress to calculate the strength of the bridge at 1104 tons, *'a surplus of say 700 tons'* (Stevenson, 1821). In all, the bridge cost £7000-£8,000 (*NSA*, 1845), much less than one in masonry, including a present of 1,000 guineas from the trustees.

Knowledge promotion

Technical details of the bridge are given in numerous other publications (Dupin, 1825; Taylor, 1822; Drewry, 1832; Paxton & Ruddock, 1981; McCreath & Arthur, 1985; Miller, 1999; Paxton & Shipway, 2007). Particularly influential at the time in promoting knowledge of Brown's work were those of Stevenson, published by 1824 in German, French and Polish, Dupin and Drewry, author of the first book in English devoted solely to suspension bridges.

More popularly the bridge's achievement attracted considerable press coverage for example in 1820 in the *Kelso Mail* and *The Scotsman*, the latter commending its '*superiority over a stone bridge, that, having no support in the middle of the water, it will not be liable to be swept away by floods. To this quarter the advantages are incalculable; in particular, it will save to an extensive district of country seven or eight miles in going for their coal and lime, and will render these articles accessible to them at all times of the year and in all states of the river…*'

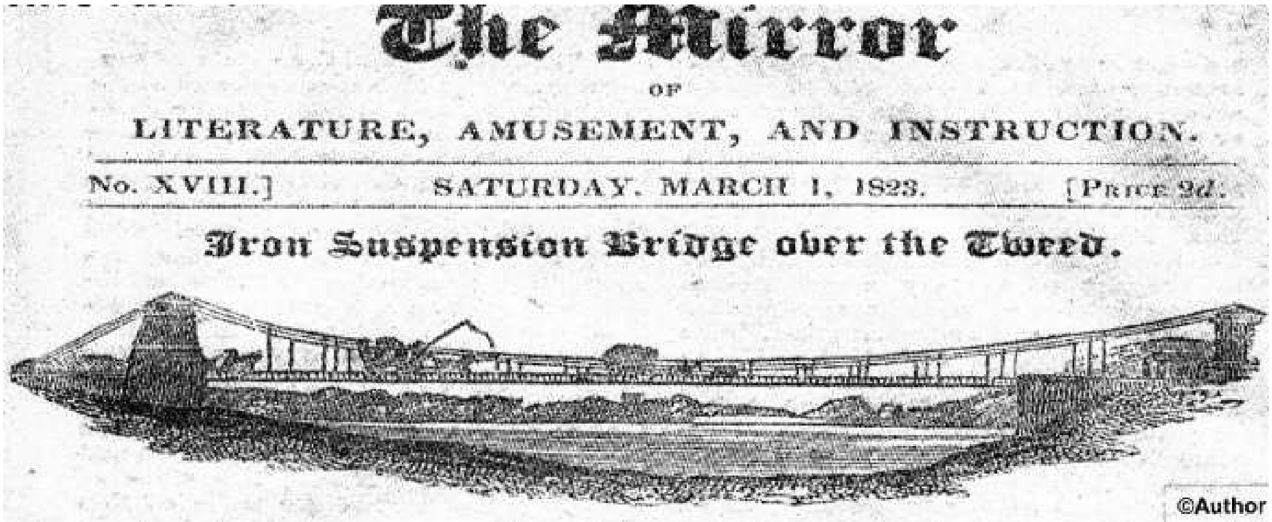
The Mirror
OF
LITERATURE, AMUSEMENT, AND INSTRUCTION.
No. XVIII.] SATURDAY. MARCH 1, 1823. [PRICE 2d.
Iron Suspension Bridge over the Tweed.

Fig. 6. Popular press coverage in *The Mirror* in 1823

In 1823 *The Mirror* [Fig. 6] refers to the bridge as *'one of those extraordinary results of mechanical science which particularly distinguish the age in which we live … the whole works of the Union-bridge were undertaken by Capt. Brown for about £5,000 – a stone bridge must have cost at least four times that sum'*.

Brown's later bridge work

From 1813 to c.1840, Brown had manufactured and erected at least 22 large iron spans, mostly to his own design, more than any of his contemporaries. These included chain piers at Trinity (Leith, 3-span], Hammersmith 1827, Marlow 1829, Montrose 1829, Stockton (railway) 1830, Fochabers 1831, Forres 1831, Aberdeen 1831, Kalemouth c.1830, Kenmare 1838 and 100 Foot River in the Fens. Brighton 1821-1898 (4-span) 1823-1896, and bridges at Warden 1826, and Welney 1826, His many unexecuted bridge designs included three approaching the zenith of practicability for bar chains with spans of 780-1000 feet at Runcorn 1817, North and South Shields 1825 and Clifton 1829, placed in the top three of many considered by the bridge competition committee (Drewry, 1832). Brown also erected a bridge at his new home, Netherbyres, Eyemouth in 1834. (*NSA*, 1845).

Netherbyres Bridge over the Eye Water had a span of about 142 feet. It was exceptional in that it avoided the need for towers at its ends by resting a timber deck on, rather than hanging from, a pair of 1½ inch diameter eye-bar chains 12 feet apart anchored into abutments. (These dimensions were measured from its remains by the author and Colonel Simon Furness of Netherbyres, whose father had dismantled the bridge in c.1930 when its deck had become unsafe).

Each chain would have had a breaking strength of about 25 tons and a working load of about 10 tons, much of which would have been used in achieving a shallow mid-catenary deflection to obtain user gradients at each end convenient for pedestrians and light carriages. No image of the bridge has been found but, for an idea of its form and possible deck connection, see Fig. 5.

Vibration and oscillation damage

From time to time several of Brown's coastal structures, for example his prestigious Brighton Pier (Weale, 1843) [Fig. 7], erected three years after Union Bridge, also bridges of Telford, Brunel and other engineers, sustained wrecked decks from storm-induced severe vibration and oscillation. Although a relatively minor and resolvable drawback to the advantages of suspension bridges it nevertheless led to a public over-reaction against the bridge type in the UK. This was even though by 1840 Brighton pier had been restored, the deck of Menai Bridge had been strengthened at modest cost and Rendel, at Brown's Montrose Bridge, had introduced longitudinal timber stiffening trusses acting independently of the hangers, a landmark in suspension bridge development (Paxton, 1980 & 1999). Public confidence was partly restored by the completion of Clifton Bridge in 1864 with state-of-the-art iron truss stiffening in place of Brunel's proposal. But by 1850 the impetus in long span bridge development had already returned to the USA. A smaller version of the Montrose type of timber trussing is still in useful service at Kalemouth Bridge [Fig. 4] but no record has been found of its date of installation.

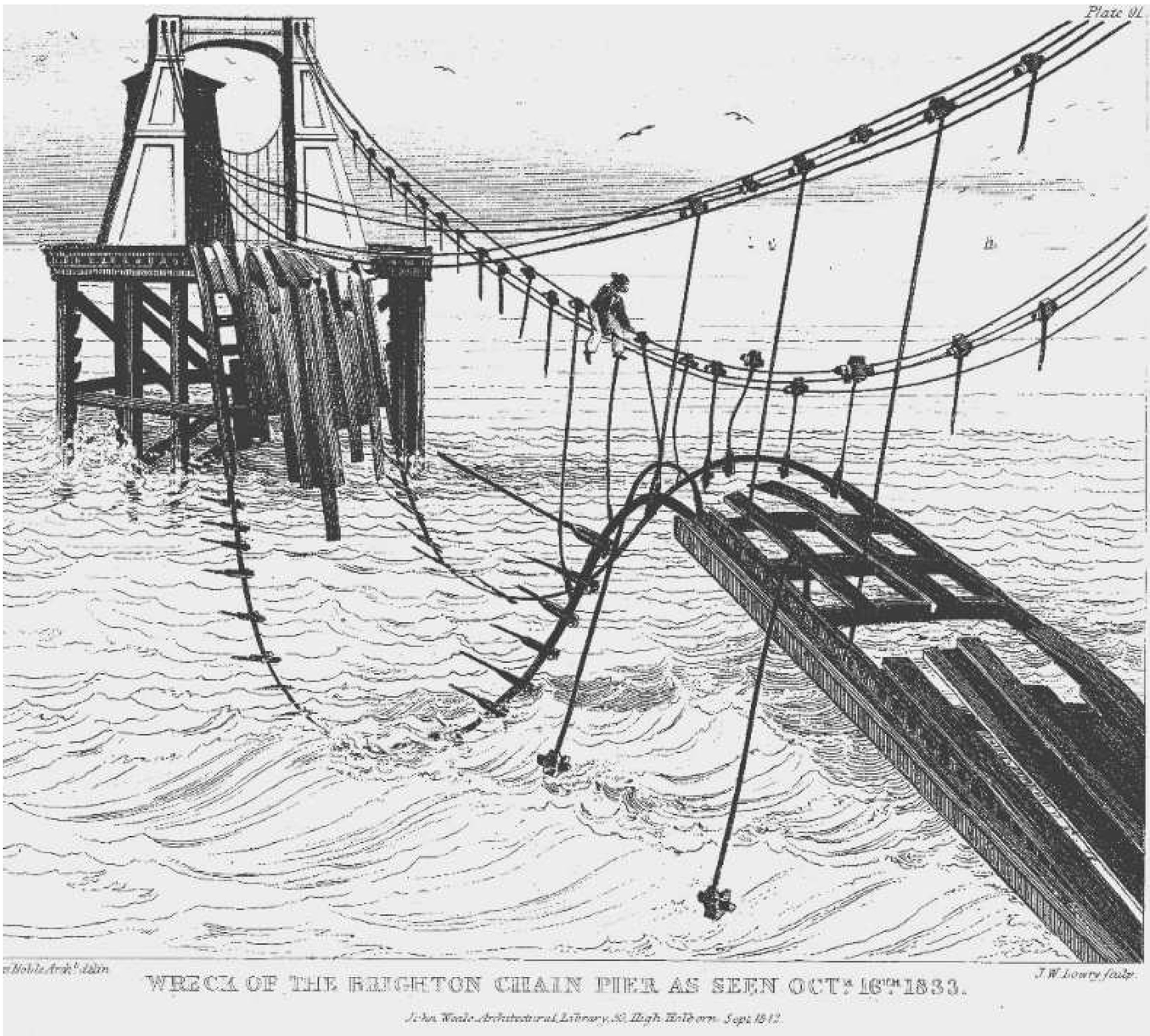

Fig. 7. Brighton Pier. Inspection of storm damage in 1833

No provision against severe deck vibration was made or, as far as the author is aware, has proved necessary, at Union Bridge which, fortunately, is in a fairly sheltered location. A notable bridge engineer published the canard in 1953 that Union Bridge was blown down six months after erection, probably meaning Dryburgh Abbey footbridge! (Shirley Smith, 1963). But in 1823 Brown stated of Union Bridge, *'ever since it has been opened the bridge has given entire satisfaction and has been in constant use without any restriction'* (Brown, 1823).

The leading French engineer, Baron Charles Dupin, an earlier visitor to Brown's model bridge at Millwall, when at Union Bridge, noted that the *'oscillations are very inconsiderable and the vibrations, although perceivable produce no inconvenience … the system of masonry is the work of Mr. J. Rennie'* (Dupin, 1825; Paxton & Ruddock, 1980). Other eminent visitors to the bridge included Navier, and the Brunels, both father and son.

Present state

Some details of the history and maintenance of the bridge over the past 195 years have been published already (Miller, 2006; McCreath & Arthur, 1985; Paxton & Ruddock, 1981), Suffice it to say here that most of the original ironwork is still present and that the bridge's most significant strengthening was made in 1903 by the Tweed Bridges Trust. This was by the addition above the chains of a steel cable and hangers capable of wholly supporting the deck. This arrangement and the present state of the paintwork is shown in Fig. 8.

Fig. 8. Union Bridge's 1820 chains with 1903 strengthening cable

International significance of the bridge

Union Bridge, the most important of the enterprising Capt. Brown's many creations, when erected, was almost certainly the world's longest bridge span carrying road traffic. It is now also the longest serving in this capacity at 195 years. By example and through widespread promotion, by word of mouth and in publications, it encouraged the erection of suspension bridges for the economical crossing of wide water. It also acted as a catalyst in establishing the UK at the forefront of a new era in bridge-building, overtaking the USA for several decades in providing the main impetus in this activity [see Table]. The table also shows that the UK bridges holding the world's longest span record in the past 206 years were Union, Menai, Forth Rail, and Humber, and universally, with 13 other great bridges.

The prime movers in this impetus in the UK, which began with Brown's introduction into the genre in 1813 of the long iron eye-bar chain, were Telford and himself, acting independently. It was the successful use of this chain at Union Bridge that almost certainly influenced Telford, then finalising the design of Menai Bridge (Paxton, 1980), to adopt eye-bars for its main chains in preference to cables of bundled iron wire or small cross-section bars unproven in use by road traffic and more susceptible to corrosion. Today Union Bridge exemplifies the high quality and longevity of Brown's ironwork. Also, Telford was aware of the high quality and strength of Brown's iron from published strength tests that helped to establish 27 tons sq. in. as the average ultimate tensile strength of wrought iron (Barlow, 1817).

But at Menai, Telford did not apply the chains in single lines using round bar links with suspender caps resting on them as at Union Bridge, or as on Brown's patent drawing, but in a stronger form using five parallel, rectangular-section, plate links nearly 10 feet long cross-bolted to short interconnecting links into which the suspender tops were bolted (Provis, 1828; Telford, 1838).

It was this Menai basic form of chain that was used in many large bridges at home and abroad for the next 70 years. For example by I.K. Brunel (Hungerford), Von Mitis (Danube Canal Vienna), Navier (Paris Bridge), Clark (Budapest), Barlow & Hawkshaw (Clifton, Bristol, 1864), Bouch (Forth Bridge 1877, abandoned 1880), Roebling (Brooklyn, New York, anchorages, 1883) and Wolfe Barry's (Tower Bridge London, side spans, 1894), although by then the use of wire cables had for some time become the norm for long spans.

The success of Union Bridge encouraged Brown to extend the concept to railway use which he did at Stockton Bridge in 1830. Although the bridge proved inadequate for its applied loadings, required deck propping and lasted only just over a decade, it did provide an instructive example at the start of the railway era that suspension bridges were then inappropriate for railway use.

Roebling, Brooklyn Bridge's celebrated engineer wrote in 1867, *'Telford's successful accomplishment of the old Menai suspension bridge was the great feat of those days … his great achievement was mistakenly left unappreciated and greatly undervalued'*. Union Bridge's key role in this feat deserves some appreciation too, which is why it is so important to preserve this precious piece of international heritage.

Fig. 9. Union Bridge in 2015

International Recognition

The Institution of Civil Engineers (ICE) through its Panel for Historical Engineering Works and publications (Paxton & Ruddock 1980; Paxton & Shipway 2007) encourages the conservation of outstanding historical engineering works and is supportive of an authentic refurbishment of this bridge. It also supports the *Friends of the Union Chain Bridge* and the aims of Northumberland County Council, stated in a letter to the author 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 its refurbishment prior to the bicentennial celebration in 2020'*.

This process has begun and for the celebration the ICE plans, 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.

Readers interested in the bridge's preservation are encouraged to join the *Friends of the Union Chain Bridge*, and to do everything within their power to support the Councils towards its successful and appropriate refurbishment.

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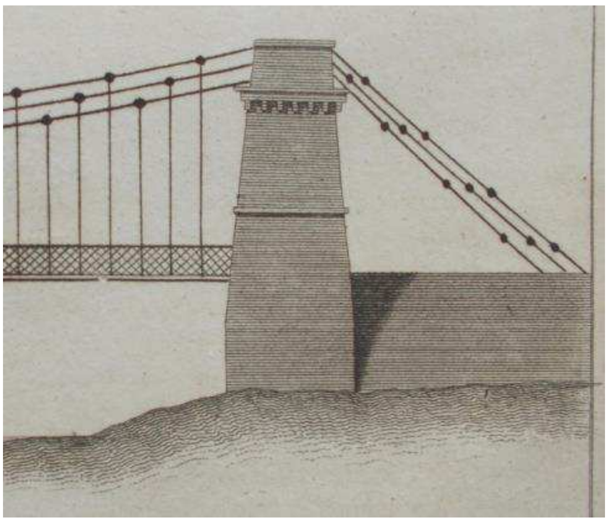
.Article in *ICE PHEW Newsletter* 158 June 2018

Union Chain Suspension Bridge 1820 – Radar Site Investigation of Scottish Anchorages. By Roland Paxton

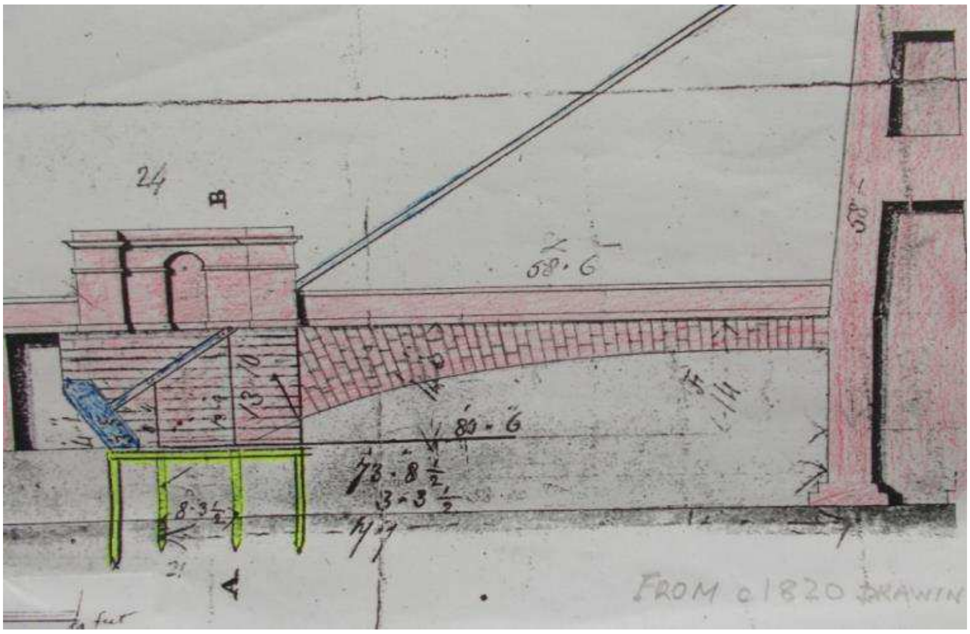
Readers may be aware that this historically significant structure, now the world's earliest road suspension bridge still in use [see table], is undergoing an £8m. refurbishment by Northumberland County Council, with support from Borders Council, the Heritage Lottery Fund*,* The Friends of the Chain Bridge, and others*.*

On becoming aware of a shortage of reliable contemporary data relating to the bridge's 1820 Scottish anchorages, Dr Colin Stove, Chief Scientist of Adrok, and I set up this pro-bono project with the aim of remedying this deficiency using state-of-the-art radar technology to scan the anchorage ground and hidden chains to a depth of 12m below road level. This process is a development of Dr. Stove's novel site investigation practice on our former projects at **Laigh Milton Viaduct** near Kilmarnock, **Brunel's Thames Tunnel**, **Lord Elgin's flooded quarry**, seeking the 1816 'Duke' Stephenson locomotive, and **Loch-nan-Uamh mass concrete Viaduct** near Arisaig, seeking the entombed remains of a McAlpine horse and cart. Our anchorage investigation venture has the potential to inform decision-making on the bridge's refurbishment and conservation, and to provide educational and promotional opportunities for a better understanding of the role of this historic international landmark in suspension bridge development. Contemporary images expected to provide anchorage details comprised drawings and plates by its engineer, Capt. Brown (1819 - Taylor 1822), Robert Stevenson (1821), Dupin (1824) and Drewry (1832}. **None show any detail below roadway**. The undated drawing below shows the ballast plate bottom **13ft 10in below the roadway**.

As to written accounts. Brown wrote to Stevenson on 30 July 1820 (four days after the bridge opening) that the anchor plates 'are **40 feet under the road'** [Miller, 2017, 181]. But Stevenson wrote in the *Edin. Phil. J.* **X.** Oct. 1821, 250, that the chains 'are **sunk to a depth of 24 feet** where they pass through great *ballast plates of* cast iron … [then] loaded with mound-stones and earthy matters to the level of the roadway'.



Stevenson's Scottish Approach *EPJ.* **X.** Oct. 1821. Pl. VIII.



Union Bridge Scottish Anchorage. Drawing signed by Brown c.1820 [unexecuted]. Fewer chains, masonry not as built, shallow ballast plate depth. NLS Ms.Acc.10706

Survey crew led by Dr. Stove engaged on WARR scanning on line of bridge chains 17 May 2018 Note: Adrok designed transmitter and receiver on frame. High quality data was obtained which is being analysed and a report with findings is in preparation [see next Newsletter for results]

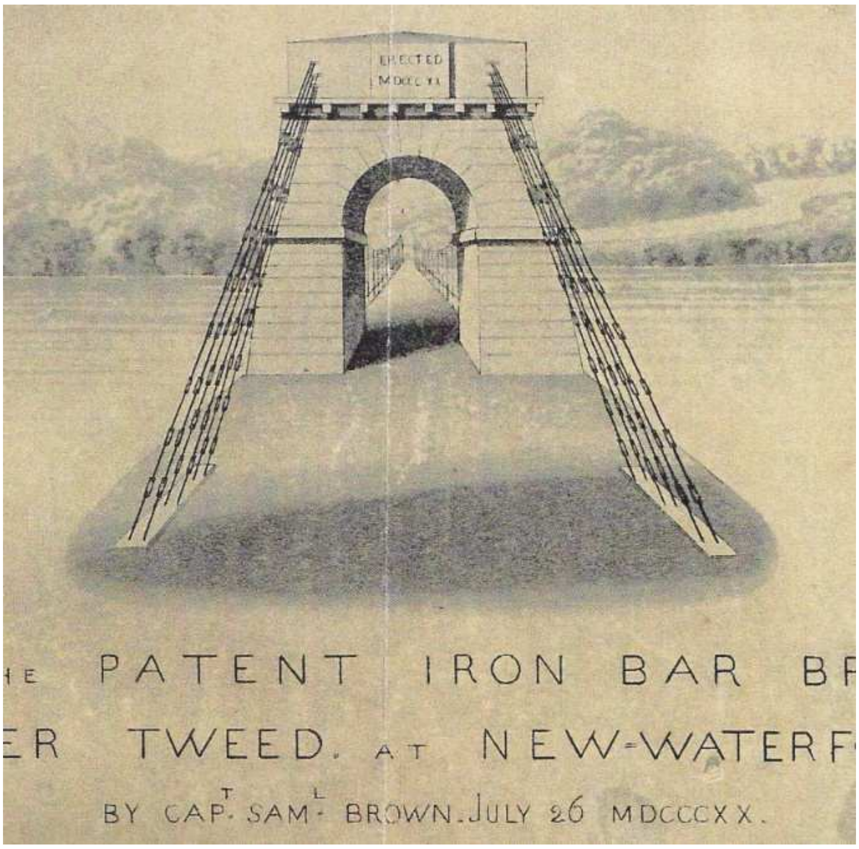
The writer thanks Northumberland County Council for arranging bridge access and providing recent drawings and borehole data. Also, Adrok, without whose expertise, enthusiasm and generosity the venture would not have been possible, and Edward Cawthorn , Secretary of *The Friends of the Union Chain Bridge* for his interest and hospitality.

Institute for Infrastructure and Environment, Heriot-Watt University, Edinburgh. *11 June 2018*

Article for Institution of Civil Engineers PHEW Newsletter, September 2018

Union Chain Bridge 1820 – Scottish Anchorages Revealed by Radar

By Roland Paxton



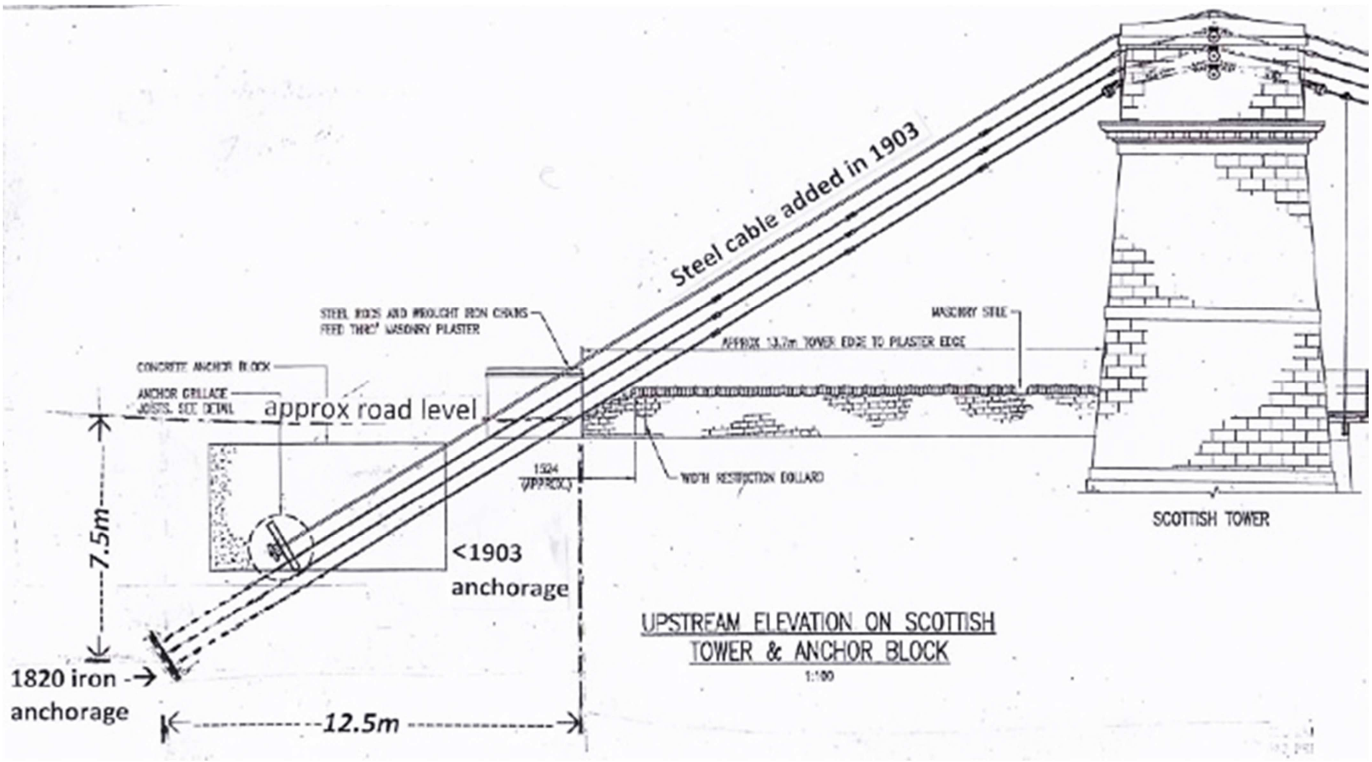
Scottish tower from a plate of details by Brown. [London, J. Taylor 1822] . No anchorages shown

Preliminary findings of the joint research radar investigation outlined in **Newsletter 158** to facilitate decision-making on the historic bridge's ongoing £8m refurbishment and promotion, to which the HLF has given valuable first stage support of £360,000, have now been presented to leading *Friends of the Chain Bridge*, and Northumberland County Council [representatives Greg Simpson, Bridge engineer and Jane Miller, Museums], appropriately at Chain Bridge House, courtesy of Ted and Livvy Cawthorn.

Drs Stove, Robinson and I confirmed that of the three differing Scottish side anchor plate positions given in 1820/1 [no as-built drawings are known] at depths below ground of 40ft (12.2m) or 24ft (7.3m) or 13ft 10in (4.2m), Stevenson's 24ft figure [*Edin. Phil J.* **X.** Oct. 1821] was closest to our finding **of the anchor plate at about 7.5m depth below the road top in wet ground with possible saline effects and corrosion.**

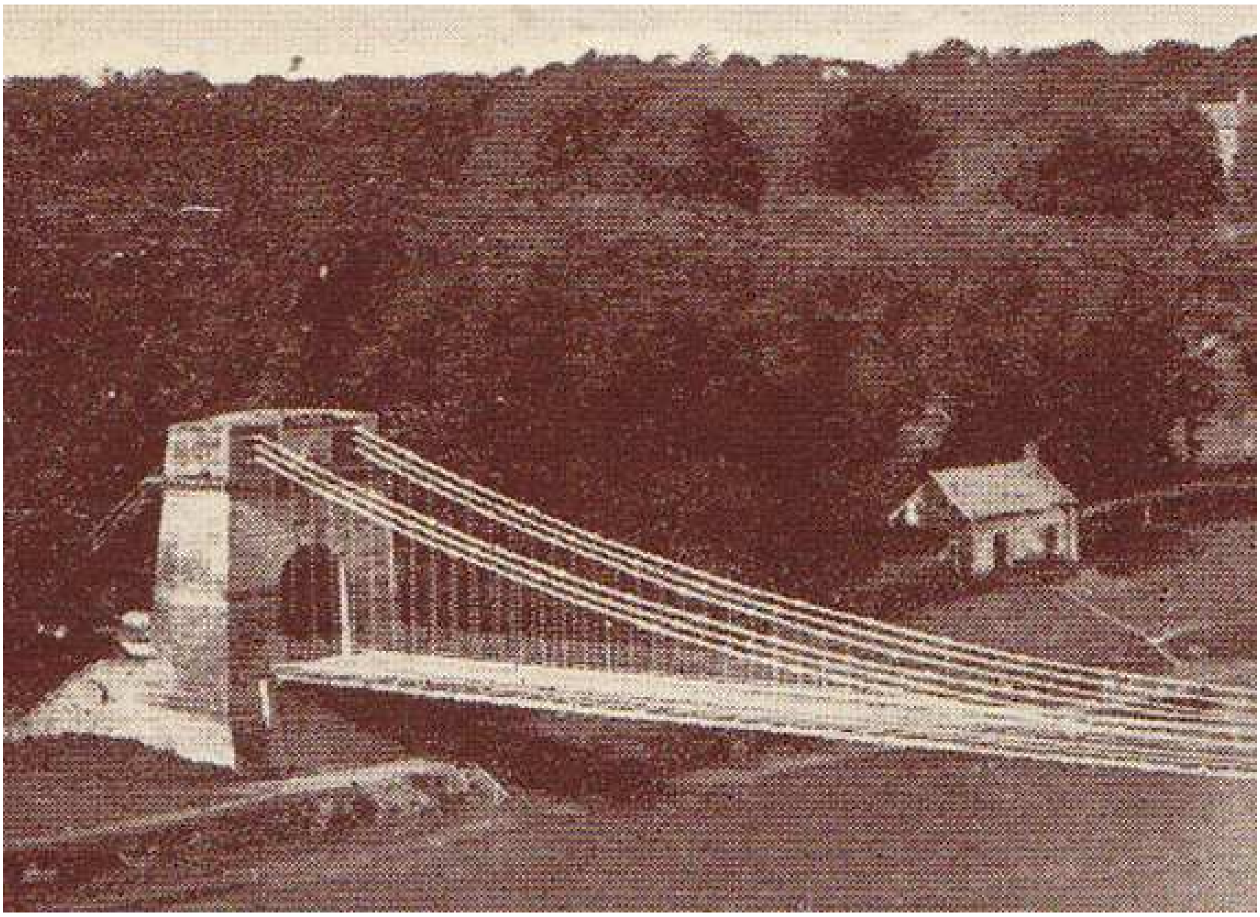
If Captain Brown's statement that the plates 'are 40 feet under the road' [Miller, 2017, 181] refers to the length of the buried chains on their c. 30° inclination, this would be close to the radar-indicated position. It is understood that Northumberland County Council plans to provide new anchorages and to remove and display the present ones.

Scottish downstream ‘pilaster’ 1903? - note chains and cable entry at right edge [zero chainage on WARR line] ©Adrok



The iron anchorage above has been added to NCC drawing [HB157290/B/C02/TBT/02/138 based on a 1902 blueprint for the then bridge strengthening]. Its position was determined by Wide Angle Reflection & Refraction [WARR] radar soundings to be about **12.5m from our zero chainage point** [see ‘pilaster’ photograph] **on the main chains line.** Although this is the most likely result, the complexity of data interpretation dictates mention of the caveat that the X scaling should be accurate to the uncertainty of a few centimetres and the Y (depth) scaling to a few decimetres at best and a few metres at worst. The figure also shows the concrete anchorage for the steel cable added in 1903 enveloping parts of the original chains. The scans showed the 1903 anchor at about the same position as that in the figure, giving confidence to our 1820 anchorage position prediction.

Stevenson, who corresponded with Capt. Brown, described the end of the chains as passing through 'great anchor plates of cast iron into which they are stopped by a strong iron spear or bolt, of an oval form, of 3 x 3½in in thickness. The plates measure 6ft in length, 5ft in breadth and 5in in thickness in the central parts; but towards the edge diminish in thickness to 2½in … thus fixed [they] are loaded with mound stones and earthy matters to the level of the roadway.' [Stevenson *EPJ* 1821]



Scottish tower end of bridge pre 1902/3 strengthening – looking North ©Paxton

The radar scan data plots of the anchor plates were not sufficiently definitive to indicate their precise form and dimensions, but significant variations in the dielectric constants between the likely iron plate and adjoining ground, determined from the WARR scan [shown in progress in Newsletter 158] was indicative of the position of the plate. An independent spectroscopic scan indicated a significant mass of iron at this position, the character of which corresponded with that of an 1820 inter-connecting wrought iron coupling between main links, kindly loaned for testing [see below] by Ted Cawthorn. Another sample is displayed in the ICE Scotland Museum, Heriot-Watt University. Details of the Museum and its holdings can be viewed at web site https://web.sbe.hw.ac.uk/ICE_Museum/ or 'ice museum via google.

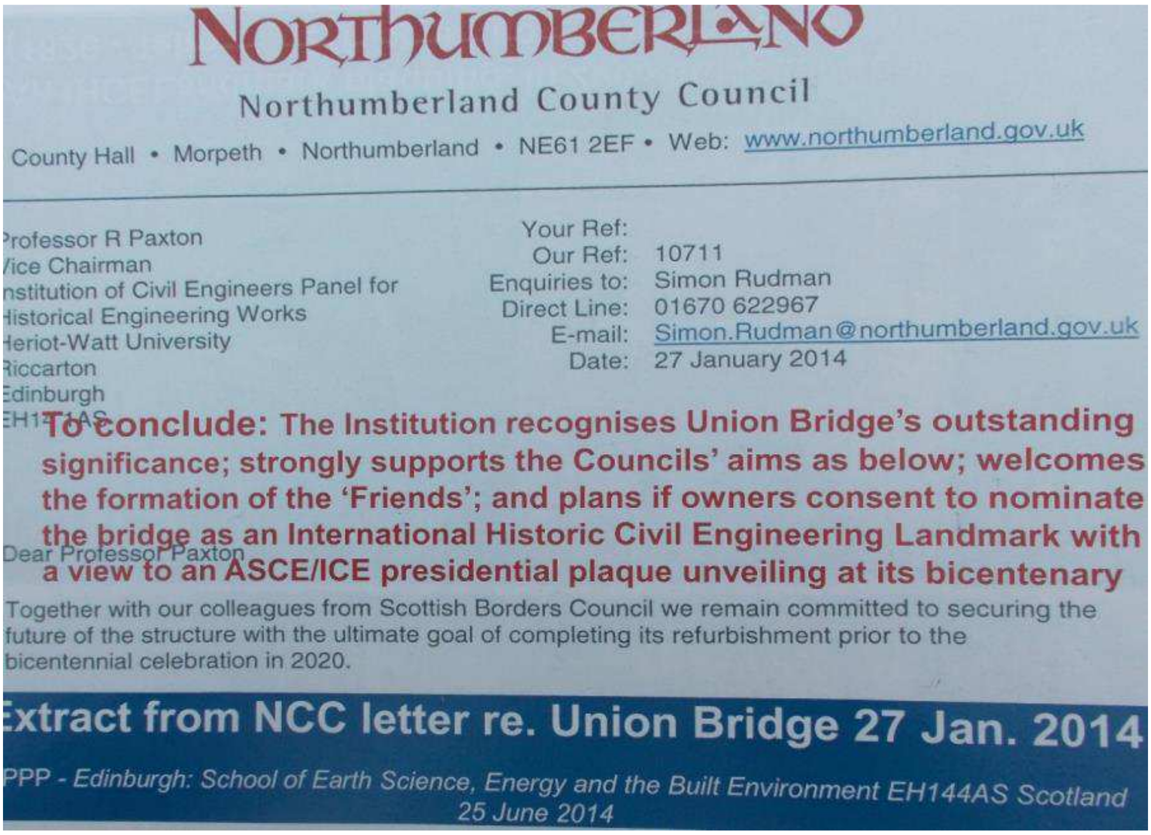
Microwave Spectroscopy Testing at Adrok's laboratory of an 1820 UCB iron coupling positioned in centre of the ADR 16 Channel Polarisation Test Chamber ©Adrok

The writer on behalf of the bridge's *'Friends'* thanks all who have supported this venture, Heriot-Watt University; Northumberland County Council, lead authority with the Scottish Borders Council for the ongoing refurbishment; ICE PHEW; and Adrok for its state-of-the-art radar contribution, enthusiasm, dedication and generosity. Dr Stove and I plan to follow up this account with more comprehensive joint articles on the *modus operandi* of determining hidden structural detail on this and other historic bridge applications for *The International Journal of Remote Sensing* [ed. Prof Arthur Cracknell].

Institute for Infrastructure and Environment, Heriot-Watt University, Edinburgh. 7 October 2018

Postscript

Overleaf is the last image of the author's public lecture on the bridge's historical engineering significance delivered at the inaugural meeting of the *Friends of Union Chain Bridge* in 2014. and subsequently at Hutton, Paxton House and Edinburgh. Support by the world's leading engineering bodies for recognition of the bridge's historical importance by designating it an International Historic Civil Engineering Landmark is now being actively progressed. The bridge has been nominated to the American Society of Civil Engineers for this distinction [ASCE] by the Institution of Civil Engineers [ICE]. They have now been joined by the Japan Society of Civil Engineers. The latest draft [October 2018] of the plaque, which is intended to inform the public about the bridge and its significance, is given below by courtesy of Dr Jerry Rogers of ASCE.



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Direct Line: 01670 622967
E-mail: Simon.Rudman@northumberland.gov.uk
Date: 27 January 2014

To conclude: The Institution recognises Union Bridge's outstanding significance; strongly supports the Councils' aims as below; welcomes the formation of the 'Friends'; and plans if owners consent to nominate the bridge as an International Historic Civil Engineering Landmark with a view to an ASCE/ICE presidential plaque unveiling at its bicentenary

Dear Professor Paxton

Together with our colleagues from Scottish Borders Council we remain committed to securing the future of the structure with the ultimate goal of completing its refurbishment prior to the bicentennial celebration in 2020.

Extract from NCC letter re. Union Bridge 27 Jan. 2014

PPP - Edinburgh: School of Earth Science, Energy and the Built Environment EH144AS Scotland 25 June 2014

DESCRIPTIVE WORDING FOR THE IHCEL PLAQUE

INTERNATIONAL HISTORIC CIVIL ENGINEERING LANDMARK
UNION CHAIN SUSPENSION BRIDGE 1820

UNITES ENGLAND [HORNCLIFFE] AND SCOTLAND [HUTTON] OVER THE RIVER TWEED USING WELSH IRONWORK MADE BY BROWN LENOX & CO., NEWBRIDGE, SOUTH WALES. RECOGNISING THE ACHIEVEMENT AT UNION BRIDGE OF THE WORLD'S THEN LONGEST ROAD-CARRYING BRIDGE SPAN; IN PROMOTING AND DEVELOPING SUSPENSION BRIDGES; AND NOW, AS THE WORLD'S LONGEST-SERVING ROAD SUSPENSION BRIDGE

COMPETENCE AND DRIVE ENABLED THE BRIDGE TO BE BUILT IN ONE YEAR FOR ABOUT £7700 (LESS THAN 40% OF THE COST OF A STONE BRIDGE)

ENGINEER: CAPT. SAMUEL BROWN R.N. (1774-1852). CONSULTANT: JOHN RENNIE C.E. (1761-1821)

SPAN 437ft(133m) overall, deck 367ft(112m);
WIDTH 18ft(5.6m); WROUGHT IRON CHAIN LINKS 15ftx2in dia.(4572x51mm dia.)

OPENED BY WILLIAM MOLLE WS, CHAIRMAN OF THE BERWICK & NORTH DURHAM TURNPIKE TRUST 26 JULY 1820

PRESENTED TO NORTHUMBERLAND COUNTY COUNCIL & SCOTTISH BORDERS COUNCIL BY

ASCE logo **ICE logo** **JSCE logo**

DEDICATED 26 JULY 2020

[revised Nov. 2018]

PS [January 2023]. This wording was shortened to meet cost constraints and now reads as below: Because of various delays in executing the bridge's conservation, the formal plaque dedication is now planned to take place in July 2023.