



for the Friends of the Union Chain Bridge

December 2019

*A Christmas Message
from our Chairman*

2019 has been a wonderful year for the preservation of the Bridge. The highlight undoubtedly, was the news in September that the second round submission to the National Lottery Heritage Fund had been successful. This has secured over £3m for the project and means that we can start the restoration in February. Other highlights included a visit by HRH The Duke of Gloucester, also in September, and a ceremony to mark the bicentenary of the laying of the foundation stone in July.



It really will be fascinating to see the work start to dismantle the Bridge and then put it all back together again. The period that the Bridge is closed will also reinforce to the local community how much we rely on it as a necessary piece of infrastructure.

In July of next year we will mark the 200th anniversary of the opening of the Bridge and the Friends with our project partners are working on ways to mark this celebration. This will be an opportunity for the local communities on both sides of the Tweed together with a group of eminent engineers from around the world to celebrate the extraordinary feat in building this Bridge and the impact it has had on the development of suspension bridges around the world.

Further details of our plans will be announced shortly.

May I take this opportunity to thank you for your continued support and wish you all a very Happy Christmas and New Year.

Robert Hunter

An Open Meeting

to explain the Bridge restoration works,

and their effect on local communities, with representatives of Northumberland

County and Scottish Borders Councils

Horncliffe Memorial Hall

on Tuesday January 21st at 7pm

Refreshments will be served

Critical Restoration Dates

These are the critical dates in the restoration plan for the next 18 months.

2019

- 6th December** Last date for submission of tenders
- 9th – 20th December** Evaluation of tenders
- 23rd December** Award of contract

2020

- 21st January** Open Meeting in Horncliffe
- 1st February** Bridge closes (see below)
- 10th February** Contract starts
- 26th July** BICENTENARY CELEBRATIONS

2021

- April** Works completed
- Late Spring** OFFICIAL RE-OPENING

Bridge Closure – Advance Notice

Northumberland County Council have pre-published a Notice of a Road Traffic Order to be made on the 19th December 2019, providing for the Closure of the Bridge from 1st February 2020 until the 7th June 2021, with the usual diversions in place for vehicular traffic via the A698, the A1 and the B6461. It is expected that a similar order will be made by Scottish Borders Council and that further details of the closure and the alternative arrangements which will be put in place will be available at the Open Meeting on the 21st January.

Farewell to the 1903 Rope

The final ten years of the nineteenth century were *anni horribili* for the Union Bridge and its guardians, the Tweed Bridges Trustee, with continuing worries about the Bridge's load-bearing capacity and stability, culminating in an extraordinary report by their Surveyor, Joseph Bean (Northumberland County Surveyor) in June 1902 giving the Trustees the starkest of options – to spend £850 (the equivalent of £73044 today) to carry out essential works or to demolish the Bridge and build a new one at an estimated cost of £10,000 (£859,000).

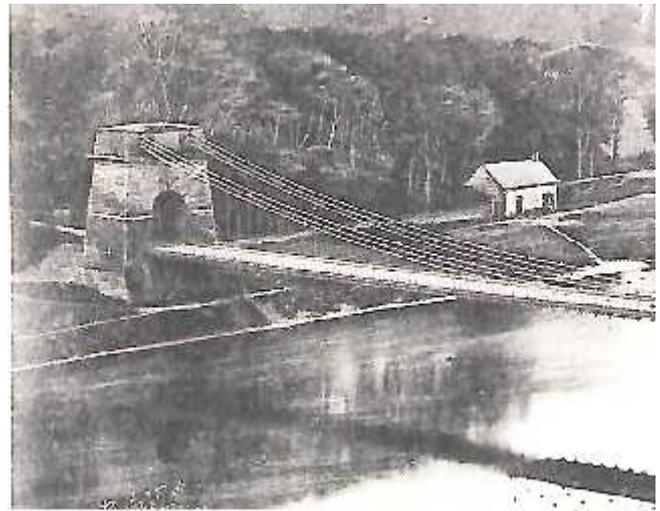
Some ten years previously, Joseph Bean's predecessor as Surveyor, H F Sneyd-Kinnersley (also the County Surveyor, as all Trust surveyors were, throughout its life) had reported that the maximum loads on the Bridge were frequently exceeded..."I should recommend that the maximum load should now be fixed at four loaded carts instead of six, not because I consider the bridge weaker than it was formerly but in consequence of the peculiarity of the traffic. I find that the rule is for 8 loaded carts to leave Velvet Hall station together (the contents of one railway truck) – at present (either all or six) go on the bridge together. It would cause less wear and tear if this cavalcade was equally divided and I don't think that any appreciable loss of time or obstruction to the traffic would be caused by this alteration in the regulations." He therefore requested permission to erect two "short and clear notices in more prominent positions on each end of the bridge".

This amended and more restrictive regulation replaced the following one made and advertised in 1887, following earlier doubts about the structural integrity of the Bridge:

UNION BRIDGE NOTICE
No Vehicle shall pass over this Bridge except at a walking pace. All Bodies of Troops or other persons walking in procession shall break step in crossing and no crowd of persons shall stand on the Bridge. Not more than 4 Carriages or Carts shall pass over at one time. Drivers and others in charge of Cattle or Sheep are directed not to allow any large number of animals to be on the Bridge together.
By order of the Trustees

Just three years later, in 1890, Mr Sneyd-Kinnersley reported to the Trustees that he had found very serious deterioration on the condition of the chains over the English tower; and he quite obviously regarded this discovery as a dereliction of his duty to inspect and maintain the Bridge in proper repair as he offered the Trustees his resignation. However, they decided that the bearing-chain repairs constituted "new works" rather than routine maintenance and engaged Robertson & Co of Sunderland to carry out the work at a cost of £200 (2019: £18,000).

Which brings us back to Joseph Bean's alarming report of 1902, giving the Trustees the option of demolishing and rebuilding the Bridge. The Bridge chains, he said, were one-third of the strength required by the Board of Trade; they had always been under excessive strain and "when such is the case, no surprise should be felt if the Bridge collapsed under certain conditions which may arise, such as a gale of wind with a snowstorm or a rolling load passing over at a considerable velocity or a crowd of people on the Bridge. You have notices upon the Bridge providing against the latter."



The Scottish tower in 1900, before the addition of the wire rope. In airing these alarming prognostications, the Surveyor may well have had in mind the recent disastrous collapses of Brown's chain piers at Brighton (in 1896) and at Newhaven, Edinburgh (in 1898). But they had the desired effect and at their meeting in November 1902 the Trustees accepted their Surveyor's proposal to strengthen the Bridge structure – by new and additional steel wire cables, the effect of which, in the Surveyor's opinion, would be to strengthen the Bridge to such a degree as to provide an equivalent to a new Bridge.

The Cleveland Bridge and Engineering Company's tender for £1000 (2019: £85,000) was accepted and the work was carried out without the need to close the Bridge to traffic. So the extra wire cable suspension system has survived in place for 117 years.



View from the top of the English tower showing the wire rope entering the anchor block over roller bearings.

....the 1903 calculations confounded

However, when engineers surveyed the Bridge in connection with the recent Heritage Lottery bid preparations, they concluded that Joseph Bean's assumption that the wire rope would provide an additional factor of safety in the event of a catastrophic failure of the chains was incorrect. The rope, which is believed to comprise 7 strands, spiral-bound with each strand containing 26 individual wires, made of crucible-cast steel, is highly susceptible to corrosion and introduces a significant indeterminacy in the structure, complicating the Bridge's structural behaviour and shewing the accuracy of any model analysis. The analysis showed that the axial stiffness of the wire rope is significantly lower than that of the chains, resulting in the wire rope taking very little load beyond its own weight; as a result of which, the rope's own hangers are under minimal tension which results in lateral instability causing mechanical damage to the original hangers and handrail elements. This is compounded by a lack of information as to the anchoring arrangements of the rope

and of the tensioning the rope hangers underwent which further reduces its reliability as a load carrier.

Engineers created a three-dimensional nonlinear model to replicate the behaviour of the rope in relation to the chains, as the rope and chains behave non-linearly. The outcome of the modelling has shown that the only way for the rope to attract substantial load would be if a significant change to the Bridge occurred such as a catastrophic failure of the majority of the chains. As this is deemed highly unlikely, the rope is regarded as a redundant part of the structure.

...so the rope goes after 117 years

Although the proposed removal of the rope and its hangers was initially controversial and is regretted by some local residents who have known it all their lives (it has, after all, been in place for well over half of the life of the Bridge) the restoration of the Bridge to its original state will improve the aesthetic value and visual understanding of Samuel Brown's suspension system's lightness of design and will enhance the sweeping catenary curve of the chains which was compromised by the complication of the added rope (unnecessarily, as it now appears). The height of the catenary curve has been increased by the presence of the rope and the additional hangers at completely different spacings from Brown's hangers, have confused the aesthetic of the original elegant structure. **It is intended that a section of the rope will be incorporated in the rebuilt pilaster on the Scottish side, as a heritage asset.**

Sources: *Samuel Brown and Union Chain Bridge* by Gordon Miller and Stephen K Jones (2018); *Northumberland County Council's Design Specification* (February 2019)

Plans for the Bicentenary on 26 July 2020

The Friends are in active discussion with their restoration Project partners, Northumberland County Council, Scottish Borders Council and Museums Northumberland, as well as The Paxton Trust, about arrangements to celebrate the bicentenary of the opening of the Bridge on 26th July 1820. We know that several members of the American Society of Civil Engineers and of the Japan Society of Civil Engineers are planning to be with us, as well as members of the UK Institute of Civil Engineers, to present a plaque recognising the Bridge as an **International Historic Engineering Landmark** a rarely-bestowed and significant accolade, acknowledging the achievement of Capt Sir Samuel Brown and the Bridge's status as the oldest suspension bridge in the world still carrying vehicular traffic.

Our next Newsletter will carry full details of the activities planned for what will be a very special day. Keep it free in your diary!

The Bicentenary Foundation Stone

The Bicentenary Foundation Stone, unveiled on the 26th July 2019, to mark the bicentenary of the laying of the original



Stone, is on temporary display in the independent Berwick Visitor Centre, pending its permanent placement in the immediate vicinity of the Bridge on completion of the restoration works. The Visitor Centre, in the former Methodist Church in Walkergate, opened earlier this year and houses a fascinating collection of items, as well as a specially commissioned 15 minute film, to introduce visitors (and

locals!) to the unique attractions of the border town. There's a café too.

Heriot-Watt University supports Union Chain Bridge's Conservation

At a recent Heriot-Watt University School of Energy, Geoscience, Infrastructure and Society Seminar, Professor Roland Paxton, our patron, and radar specialist Dr Colin Stove, of Adrok Ltd, outlined their joint University/Adrok research contribution to **'Supporting conservation of Union Chain Bridge of 1820 near Berwick-upon-Tweed, including use of a new radar imaging spectrometer to locate its Scottish anchorages'**.

Their presentation concentrated on the bridge's historical engineering aspects from original research, its international significance, present state on the eve of a start on its £8m conservation. Also on the use of newly developed non-invasive maser scanning to locate its inaccessible anchorages for which no drawings are known and of which Prof Paxton showed a notional model he had made.

The audience was particularly fascinated by the detailed account of the maser scanning in May 2018 and its revelations of ballast plates and ground conditions. Prof Omar Lagrouche, Director of the School's *Institute for Infrastructure and Environment*, commented that the audience had enjoyed the talk and were impressed by all the authors' activities. He hoped this would lead to more interaction with Heriot-Watt colleagues and further research opportunities.

After an informal discussion, Dr Benny Suryanto, organiser of the seminar, showed the speakers samples from old reinforced concrete structures under laboratory examination in which the pre-stressed steel was corroding. Reinforcement and concrete deterioration, which is difficult to remedy, is now of universal concern as there are many structures of this type. Adrok's new spectroscopy technique may be capable of facilitating the non-destructive monitoring of the extent of internal damage (cracks/corrosion) in reinforced concrete.

Since the presentation, this application, and another relating to the passage of masers through water at the School's reinforced concrete wave tank, are now under active discussion as possible joint research exercises.



Dr Colin Stove (left) and Prof Roland Paxton (r) at the Seminar with our leaflets!

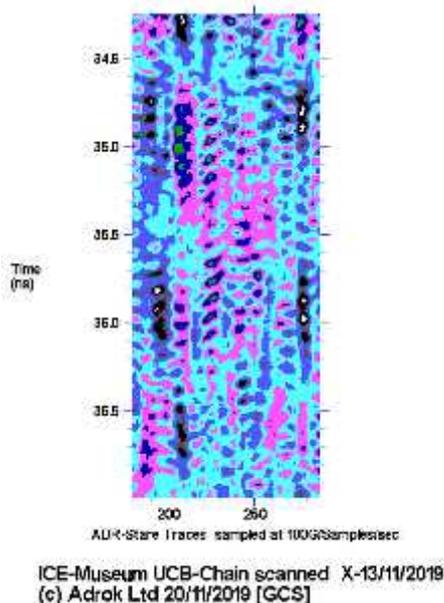
Capt Samuel Brown's Trinity Chain Pier at Newhaven

by Prof/Dr Roland Paxton, MBE FRSE FICE Co-Patron of the Friends



Chain Pier, Newhaven (c1845?) Calotype Album Vol 2; Reproduced with acknowledgement to the Trustees of the National Library of Scotland

Recently, Ted Cawthorn (Friends' Trustee), Prof David McGuigan (ICE Scotland Museum) and I took up an invitation to visit the Leith laboratories of Adrok Ltd [who in a joint radar research exercise with Heriot-Watt University last year located inaccessible anchorages at Union Chain Bridge]. Dr Colin Stove provided a fascinating account of the firm's facilities and work, including determination of hidden geological detail at great depths below the earth's surface. He then passed a maser through a Union Chain Bridge wrought iron link of 1820 using his latest spectroscopic procedure and determined the image below and a mean value for its Dielectric Constant of 1.7578751 as measured against the speed of light (0.2997925m/ns), a value of the same order as that identified by underground scanning at the bridge allowing for other factors. This means that the link had slowed down the speed of light by a factor of 1.325848822x [Dr. Stove].



Adrok scan of Union Chain Bridge link

Afterwards, we visited the site of the Trinity Chain Pier at Newhaven, near Leith. This little-known pier, another innovative icon of Capt. Brown, erected in 1821 just 13 months after the opening of Union Chain Bridge, attracted the attention of leading

British and French engineers, including Baron Charles Dupin and C.L.M.H. Navier. The pier facilitated passenger transport, mainly between ports on the Firth of Forth, at the dawn of the rapidly developing paddle-steam-boat era. In mid-1830 the *Royal George* carried 8,168 passengers to Dysart, Leven and Largo in a two-month period, as well as 1,181 pleasure trippers who did not land in Fife. In 1831 the *Victory* and *Lady of the Lake* made daily sailings from the Chain Pier to the same destinations [Wikipedia]. A decline in this usage gathered pace in the 1840s as the railways and larger boats and ports developed. Later it had a fascinating extension of use as a popular sea-bathing facility. The pier was demolished by a storm in 1898. Although inadequately designed by modern standards, the pier deserves to be remembered as a triumph of the experimental technology of its time and a landmark in iron pier development.



Plaque at the Old Chain Pier pub; for "Anchorage" read "Land pier"

The 700ft(213m) overall length pier with its 4ft(1.2m) wide deck at about 10ft(3m) above High Water provided a safe and convenient way of crossing the foreshore to a steam-boat landing in deep water. It was proposed by Lt. George Crichton R.N., Chief Agent of the London and Edinburgh Steam Navigation Co. and commissioned by the Trinity Pier Company, which included proprietors of steam vessels employed in the Firth of Forth. The Company contracted for the pier to be made and erected by Capt. Brown which he did in less than 12 months at a cost of about £4,000, much less than if it had been constructed in stone.

The pier's catenaries differed from that of Union Bridge in having 3 spans of 209ft(64m) with a central dip of about 1/16.8 span [Drewry/Navier], and in having just one chain at each side of the deck, both of which Capt. Brown proved with a load of 39.3 tons[39.9t]. It had inclined eye-bar stays of 1in(25mm) dia. above and, from 1822, beneath the walkway [see Drewry/Navier figure]. The main chain eye-bolt links were 10ft(3m) long, diminishing in diameter from 2in(51mm) at the supports to 1.875in(48mm) near ¼ span and 1.75in(44mm) near and at mid-span which, although on a correct principle in achieving a modest economy were, as Capt Brown appreciated, not accurately proportioned to a catenary of uniform strength which was, and still is, impracticable. The pier, although of light construction and vibrating sensibly with the passage of a single person, had not shown any signs of failure by 1832 [Drewry]. It satisfactorily accommodated a walkway test

load of 21tons(21.3t) of pig-iron placed between the various points of suspension whilst passengers crossed. Although inadequately designed by modern standards, the pier deserves to be remembered as a triumph of the experimental technology of its time and as a landmark in iron pier development.

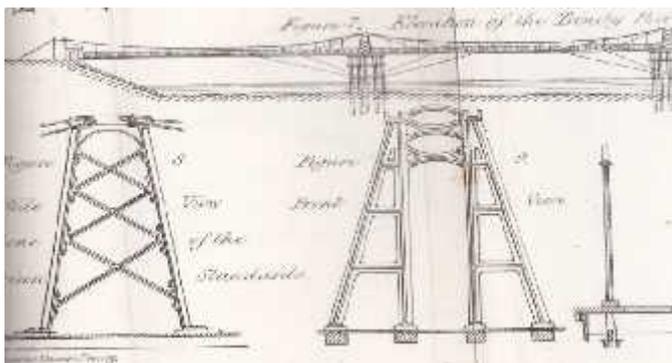


View of 'Land pier' tower building and first 209ft (64m) span; from Capt Brown's specification enrolled in the Court of Chancery, Edinburgh: [Edin.Phil.J VI 1821]

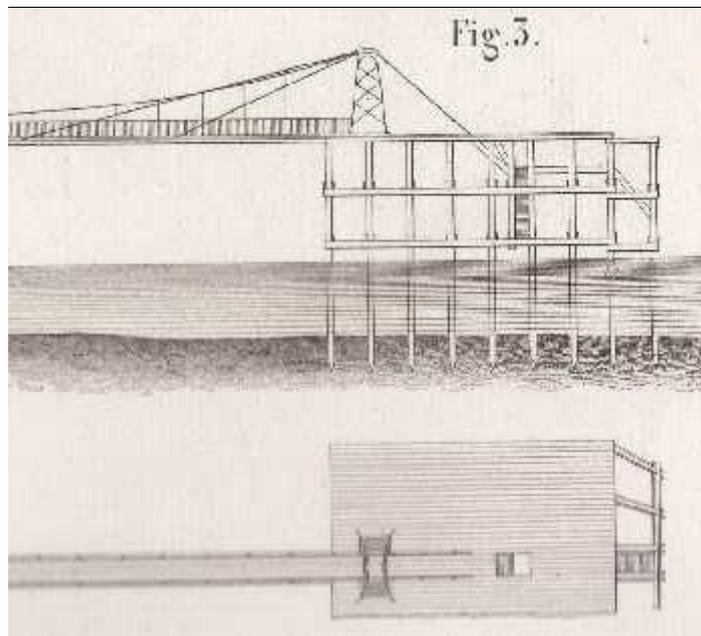
An abridgment of *The Scotsman* coverage of 25th August 1821 reporting the opening of the Pier:

'The advantages that have been derived by the public since the introduction of steam navigation in the Firth of Forth, have been in no small degree counter-balanced by the difficulty and danger encountered in the communication between the steam vessels and the shore, hitherto principally by means of small boats, rendered particularly unsafe from their being generally crowded or overloaded. This unpleasant part of the voyage is now at an end; for at all times of the tide the steam-boats can now approach close to the new chain pier to receive and land passengers.'

This novel and elegant structure has been some time in progress under the superintendence of Captain Brown, R.N., whose ingenuity and ability require no comment. It was on Tuesday last [21st August] opened to the public in the presence of a numerous party of gentlemen. The pier was decorated with flags. Soon after eleven o'clock, the Lord Provost and Magistrates and other gentlemen, accompanied by Mr Scott of Trinity, Mr Crichton, Mr Stevenson, Mr Ramsay, and other proprietors, walked in procession from the Trinity Hotel along the pier, from whence they embarked in two steam-boats attended by a band of music, two vessels on each side of the pier firing a salute and, after an excursion to the Roads, returned and partook of an elegant cold collation provided by Mr Maclaren of the Trinity Hotel, under a tent erected on the platform at the extremity of the pier, to which upwards of 500 sat down. The scientific gentlemen present expressed themselves completely satisfied with the design and execution of the pier, which reflects the highest credit on the skill and ingenuity of Captain Brown and the spirited individuals at whose risk and expense this undertaking has been carried through'



Braced iron supports with saddles for main chains lay. Back chains from the 20ft (6m) tower at 45 degrees were stopped into iron plates 'on the principle of a mushroom anchor' [Drewry 1832, after Navier 1823]



Pier platform with Steps to landings [Dupin 1821/5]



Masonry of shore terminal incorporated into the Old Chain Pier pub. Chains in niche not part of pier. See fig 2 for plaque wording at niche crown. [© D McGuigan]

Main sources: **Brown Capt S**, 'Description of the Trinity Pier...' *Edin.Phil.J.VI 22-28*; **Drewry, C S** *A Memoir on Suspension Bridges*; **Navier, C M L H**, *Memoire sur la Ponts Suspendus*, 1823; **Dupin, C** *Voyages dans la Grande Bretagne*, 1825. *Planches. Pt iii, Pl Vi*; **Paxton, R** *Historic Berwick on Tweed Bridges* H-WU, IIE. 2018

Institute for Infrastructure and Environment, Heriot-Watt University, Edinburgh 28.11.2019



The Old Chain Pier Pub and Restaurant at Newhaven, Edinburgh

Friends receive £129,137 Grant Funding

We are delighted to report that, since the last Newsletter, we have received a further £129,137 in grant funding towards our contribution to the Project's heritage and outreach targets. A grant of £50,000 from the Tyneside-based Catherine Cookson Charitable Trust was quickly followed by one of £79,137 from SSE's Scottish Borders Sustainable Development Fund.

Dame Catherine Cookson became a multi-millionaire following the success of her 100+ books and films and the royalties from them facilitate her Trust's charitable donations, particularly within the North East of England

SSE is one of the largest energy companies in the UK, with a substantial portfolio of energy projects. They contribute large sums of money to local communities, particularly in the areas of their onshore wind farms.

Our Treasurer, Robert Bulling, moves on

We will shortly bid farewell to our Treasurer of the past four years, Robert Bulling of Horncliffe. Robert, who also retires as a Trustee, is moving on, to become Chairman of the Friends of Norham Castle (left), formed recently to mark its forthcoming 900th anniversary in 2022, which rather puts our bicentenary into perspective! Until about 25 years ago, Norham Castle was one – the Union Bridge being the other – of two Grade 1 listed buildings in the parish of Horncliffe. When



the Norham community objected to the proximity of the Horncliffe parish boundary to the village, especially as it annexed 'their' Castle, the Boundary Commission agreed and Norham regained their border fortress after a long absence. The Union Bridge's Tweed Bridges Trust sister bridge at Norham- the Ladykirk and Norham Bridge - is a mere 132 years old, which is some sort of inter-parish consolation; and Union is now the only Grade 1 listed building in Horncliffe parish.

We will miss Robert's care of the Trust's finances and his wise counsel in constitutional and other matters, and we wish him well.

The 10-Stage Restoration Process

As the countdown towards the start of the restoration begins, Friends may wish to refer again to the 10 stages of the extraordinary dismantling and re-assembly process set out in the centre pages of our April 2019 Newsletter. This may be found on the Newsletters page of the Friends' website at www.unionbridgefriends.com

Friends' Trustees and Patrons 2019/20

Trustees: Robert Hunter (Horncliffe) (Chairman) , Martha Andrews (Chirside) Robert Bulling (Horncliffe)(to31.12.19) Edward Cawthorn (Union Bridge) Thomas Cockburn (Horncliffe) Georgina Home Robertson (Paxton) John Home Robertson (Paxton) Stephen K Jones (Cardiff) Alex McGregor (Paxton) David Osman (Fishwick) David Walker (Velvet Hall)
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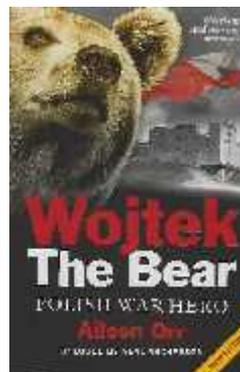
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And finally, a Seasonal Diversion...

Wojtek the Bear, at the Bridge

While Friends living in Berwickshire and the parish of Horncliffe will need no introduction to Wojtek the bear, other readers may be less familiar with him and his association with the Bridge.

In early 1942, Polish soldiers in Iran bought a young orphaned bear cub from a boy who had rescued him after his mother was shot by



hunters. He was adopted by the 2nd Transport Company (later reorganised as the 22nd Artillery Supply Company) and named Wojtek ("Voy-tek") or "Happy Little Warrior". Quickly integrating with the troops and becoming their mascot, he enjoyed wrestling with them, was taught to salute when greeted and even marched alongside them on his hind legs. He moved with his Company to Iraq, Syria, Palestine and Egypt, from where the Polish II Corps was attached to the British Eighth Army in the Italian

campaign. As regulations prohibited mascots and pets on British

transport ships, Wojtek was officially enlisted unto the Polish Army as a private within 22nd Artillery Supply Company. **He was present at the Battle of Monte Casino**, during which he helped his unit to transport ammunition by carrying 100lb crates of artillery shells, emulating other soldiers. Following Monte Casino, Wojtek was promoted to Lance Corporal and was depicted carrying an artillery shell



on the official insignia of the Supply Company (left).

After the war, Wojtek came to Berwickshire with the 22nd Company and was stationed at Winfield Camp on Sunwick Farm, just two miles from the Union Bridge. He soon became popular amongst locals and, with his minders, attended social functions in Hutton, Paxton, Foulden and Chirside. He was made an honorary member of the Polish-Scottish Association.

Wojtek's great passion was swimming at the Union Bridge and he was regularly brought by army truck to the River, accompanied by a

section of soldiers. The late James Scott of Chain Bridge recalled watching him plunge gleefully into the water under the Bridge, attached to a long chain, often spending upwards of an hour in the River before being coaxed reluctantly out.

When the Polish Army was demobilised in 1947, Wojtek was retired to Edinburgh Zoo where he spent the rest of his life, dying in December 1963 at the age of 21. There are statue memorials to Wojtek in Duns Market Square and in Princes Street Gardens in Edinburgh, as well as in several Polish towns.

So, in the spirit of the Season let's make Wojtek the Bear posthumously an Honorary Friend of the Union Chain Bridge.

Wesołych wi t!

Wojtek the Bear by Aileen Orr (Birlinn 2019) is one of several books about Wojtek available from booksellers.

