

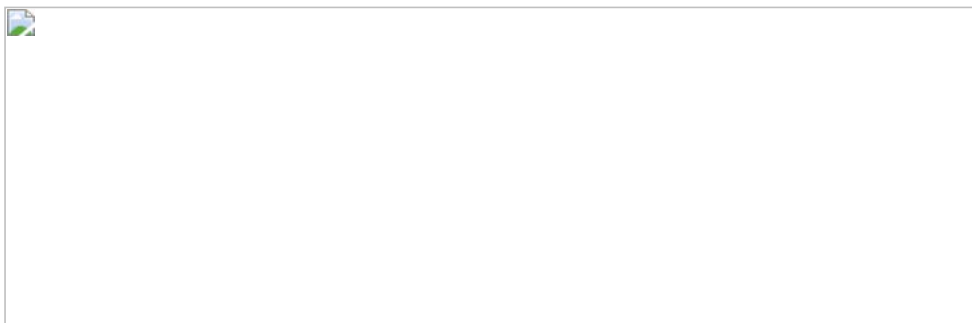
'BRUNEL'S SWIVEL BRIDGE', CUMBERLAND BASIN, BRISTOL**REPORT 01 - AUTHENTICATION OF THE BRIDGE**

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INDEX

| | Page |
|---|------|
| 1 Introduction | 2 |
| 2 Summary of main findings | 2 |
| 3 Background | 2 |
| 4 Design and construction of Brunel's Swivel Bridge | 3 |
| 5 New bridge over Jessop's North Entrance Lock | 4 |
| 6 Brunel's Swivel Bridge moved to Howard's Lock | 5 |
| 7 The 'Replica Bridge' over Brunel's Lock | 5 |
| 8 Subsequent history | 5 |
| 9 Site inspection | 6 |
| 10 Discussion | 6 |
| 11 Conclusions | 7 |
| 12 Notes, references and acknowledgements | 7 |

**1 INTRODUCTION**

At the first meeting of the Brunel Swivel Bridge Group on 15 March 2006, the author agreed to research the history and form of construction of the bridge, and to assess its historical engineering significance. A preliminary study of easily-accessible secondary printed sources highlighted a couple of areas of particular concern. Firstly, Professor Angus Buchanan, the acknowledged authority on the history and development of Bristol Docks, has concluded that there is some uncertainty about whether the bridge alongside the north lock is in fact 'Brunel's Swivel Bridge'. Secondly, previous assessments of the bridge's engineering significance have been founded on its reputed, but as yet unproven, early use of plate girders with tubular flanges, and their uniqueness of survival.

Consequently, the objectives of the investigation became:

- 1 to authenticate the bridge as a Brunel-designed structure, and
- 2 to put the application of tubular flanges into historical context.

The purpose of this first report is to present and discuss evidence from documentary sources and site inspections, with a view to verifying or disproving the authenticity of the 'Brunel Swivel Bridge'. A later report will deal with the historical engineering issues.

2 SUMMARY OF MAIN FINDINGS

- 2.1 In early 1849 staff in I.K. Brunel's Westminster office prepared designs for a 'Swivel Bridge', to carry traffic over the new South Entrance Lock ('Brunel's Lock') which was then under construction; the bridge was operational in October 1849.
- 2.2 Brunel himself was closely involved in both its design and its construction.
- 2.3 In 1872-1873 the bridge was shortened and relocated over the new North Entrance Lock ('Howard's Lock').
- 2.4 Based on a study of documentary and visual evidence, the author has concluded that the extant bridge now fixed parallel to Howard's Lock is indeed Brunel's Swivel Bridge, albeit shortened, repaired and altered in some degree.
- 2.5 At least two later swing bridges were constructed at the Cumberland Basin to the same general design as Brunel's Swivel Bridge; one of these is still extant over Brunel's Lock.

3 BACKGROUND[i]

The port of Bristol was greatly improved by the construction of the Floating Harbour, which was completed in 1809 to the design of William Jessop for the Bristol Dock Company. Included in the project were a pair of locks (North and South Entrance Locks) linking the river and Cumberland Basin; the basin was joined to the Floating Harbour by a Junction Lock.

By the 1830s the growth in the numbers and size of vessels had rendered the harbour facilities inadequate. The Dock Company asked for advice from I.K. Brunel, who had come to Bristol in 1828 to recuperate from serious injuries sustained during the Thames Tunnel work. His recommendations at that time were essentially related to the removal of mud deposited in the dock from silt-laden density currents associated with the operation of the entrance locks. He designed a drag-boat to move mud from the sides of the dock, and sluicing arrangements for emptying parts of the dock and scouring mud into the river.

In 1835 he was called back to advise on repairs to the locks. Despite his recommendation that they be enlarged rather than repaired, the company adopted a short term policy of repair. In 1843 he advised them again that repairing the South Entrance Lock would be extremely expensive, and that it would cost little extra to construct a new, larger lock.

Eventually, in 1844 the company commissioned Brunel to design a replacement South Entrance Lock, and work started in 1845. The main contract was awarded to one Rennie. He sub-contracted the iron-work to George Hennet, who owned substantial engineering and foundry works in Bristol and Bridgwater.[ii]

4 DESIGN AND CONSTRUCTION OF BRUNEL'S SWIVEL BRIDGE[iii]

The lock was to be spanned by a movable bridge. By 1849, when the lock construction had advanced to the stage where fabrication of the bridge must begin, the Dock Company and all its works had been acquired by the City of Bristol, who managed them through a Docks Committee. Brunel initially intended it to be a 'rolling bridge' but, because of foundation difficulties, in January 1849 he reported to the Committee that he now proposed a 'swing bridge'.[iv]

The bridge design was carried out in Brunel's office, 18 Duke Street, Westminster, and drawings and instructions were sent from there to William Bell, Brunel's 'assistant engineer' (resident engineer in all but name) at Bristol docks. The first rough tracing of the proposed 'Swivel Bridge' (so called from then on by Brunel's office) was sent down on 16 February 1849, so that Hennet could order the wrought-iron plates.[v] As the design and fabrication advanced, drawings were sent to amend, clarify and refine the details. A written specification (so far not located) was not produced until 3 April 1849, by which time there were only minor design details still to be decided.[vi]

The earliest drawing so far located is dated 10 March 1849, showing the plan and elevation of a 'Swivel Bridge 76ft Opening'; a copy letter of the same date in Brunel's letterbook refers to this tracing having been sent to Bell that day.[vii] The overall length of the bridge as drawn is 121ft 9ins; 87ft 9ins for the nose plus 34ft for the tail. No drawings or correspondence have been found to suggest there were subsequent alterations to the leading dimensions and general arrangement.

Robert Brereton, Brunel's chief assistant, signed off the drawings and letters, and was probably responsible for the detailed design. However, it is clear that Brunel closely monitored progress both in the design and its execution - for example, in April 1849 Brereton wrote to Bell that one of the detail drawings was ready and that 'as soon as Mr Brunel has looked at it, it shall be sent'. From time-to-time Brunel's opinions and preferences were forwarded to Bell for action. In the same April letter, when it was near time to cast the main bearing wheels Brereton told Bell, 'Mr Brunel likes generally to see these things in the patterns [ie. before casting], you had better get

Jones [probably Hennet's works manager] to ask him to look at them when he is in the yard.'^[viii] In July Brunel himself wrote to Hennet, instructing him to make some alterations; presumably Bell was not authorised to give such instructions.^[ix]

The bridge was sufficiently complete by 8 October 1849 for it to be swung open and shut.^[x] Following some final adjustments, on 29 October the Dock Master reported to the Committee that the bridge had been handed over to him, complete and fit for use.^[xi] The following day Brereton instructed Bell not to apply the final coat of paint 'till Mr Brunel sees the bridge'.^[xii] It is not known when Brunel made his inspection, but Brereton told Bell that he intended to make his own inspection during a proposed visit to Bristol on 10 December.^[xiii]

On 2 February 1850 Brunel's chief clerk, Joseph Bennett, sent Hennet's final account to the Docks Committee's secretary, Edward Hinton, for payment.^[xiv] Three days later Bennett wrote to Hinton asking what form of completion certificate the Dock Directors wished Brunel to provide.^[xv] The bridge construction phase was effectively complete; the lock itself, 'Brunel's Lock', had been operative since April 1849.^[xvi]

5 BRIDGE OVER JESSOP'S NORTH ENTRANCE LOCK

On 8 August 1863 Thomas Howard, the Docks Engineer, reported to the Committee that tenders had been advertised for a new 'swivel' bridge over Jessop's North Entrance Lock. Thomas had 'as far as possible adopted the same general design' as Brunel's bridge, which was performing well.^[xvii] The Docks Committee accepted the tender of Hennet, Spink & Else of the Bridgwater foundry on 24 August 1863.^[xviii] According to the contract drawings, which were signed on 26 August, the bridge was 77ft overall; 59ft plus 18ft.^[xix]

The bridge was ready for use by 24 October 1864. Howard reported that although it was designed on the 'general plan and dimensions' of Brunel's bridge, there were a number of modifications, particularly in the turning mechanism and arrangements. Also he had taken the opportunity to improve the road alignment over the two bridges.^[xx]

Shortly after this, the inadequacies of the remaining Jessop locks, and the threat of competition from Avonmouth Docks, forced the City Council to prepare plans for improving and enlarging shipping accommodation. Tenders were received in October 1866 for a series of measures designed by Howard, including replacements for the North and Junction Locks. The successful tenderer, William Tredwell, soon began work on a new Junction Lock. However, financial constraints delayed a start on the new North Lock until 1868.^[xxi]

During construction of the new North Lock ('Howard's Lock'), the old Jessop North Lock was partly obliterated; the 1863 bridge was removed, and reputedly shortened and re-erected over the entrance to Bathurst Basin.

6 BRUNEL'S BRIDGE MOVED TO HOWARD'S LOCK

The Docks Committee intended to close Brunel's Lock and convert it to a public graving dock, as soon as Howard's Lock was operational. In April 1872 Howard was authorised to adapt Brunel's bridge 'for the purposes of the new works'.^[xxii] The following March the Committee confirmed that Brunel's bridge was to be removed to Howard's Lock and that a temporary wooden bridge be put over Brunel's lock.^[xxiii] There is an undated drawing titled 'Brunel's Bridge - Proposed Shortening', showing preliminary details of how the nose of the bridge could be shortened by 10ft.^[xxiv] No drawing has been found so far that shows how the tail could be shortened, nor how the counterweights could be adjusted to restore the balance.

In July 1872 Howard reported that the new lock was virtually complete and expected to be operational in October 1872. In the event, he later reported that the lock was opened for traffic on 19 July 1873.^[xxv]

7 THE 'REPLICA BRIDGE' OVER BRUNEL'S LOCK

In November 1873 the Masters of Steam Vessels petitioned the Committee to keep Brunel's Lock open as a second means of entrance and exit. It was not until June 1874 that the Committee directed Howard to prepare plans for a new bridge over it.^[xxvi] On 10 August 1874 the Committee accepted the tender of Edward Finch & Co Ltd, of Bridge Works, Chepstow, for a new 'swivel' bridge.^[xxvii]

There is a set of undated drawings which show the overall length as 106ft 6in; 76ft 6ins plus 30ft.^[xxviii] The bridge shown is effectively another shortened version of the Brunel 'Swivel Bridge'. Another set of undated drawings, un-dimensioned but otherwise similar to the above, has been signed contractually on behalf of Finch, and by Howard.^[xxix] In July 1875 Howard reported that the new bridge was just about to be delivered and erected,^[xxx] and in August 1876 he was able to report that the bridge was complete.^[xxxi]

8 SUBSEQUENT HISTORY^[xxxii]

It has not been established whether the bridge over Howard's Lock was converted from manual to hydraulic operation at the time of its repositioning. The hydraulic machinery of the lock was renewed in 1901-1902, when the present bridge machinery manufactured by Sir

W.G. Armstrong, Whitworth & Co Ltd of Newcastle upon Tyne, was fitted. [xxxiii] At that time the bridge was still known as 'Brunel's Bridge'. [xxxiv]

It was taken out of service in about 1968, and now rests parallel to the lock. The 'Replica Bridge' still spans across Brunel's Lock but has been fixed.

9 SITE INSPECTION

The dimensions and structural details of the two extant bridges have been compared to the relevant original drawings.

9.1 'Brunel's Swivel Bridge' at Howard's Lock.

The original 1849 drawings of the Brunel bridge show its overall length as 121ft 9in overall; 87ft 9ins plus 34ft. The extant bridge at Howard's Lock measures 111ft 9in overall; 77ft 9ins plus 34ft. These dimensions would accord with a nose shortening of 10ft, as detailed in the undated drawing titled 'Brunel's Bridge - Proposed Shortening'. It is apparent that at some time during its service life the southern top flange over a considerable length was replaced by a cylindrical steel section of roughly the same diameter; presumably this was to repair impact damage. Otherwise, the details of the remaining structure agree very well with the drawings of 1849. In particular, on both the extant structure and the drawings the web stiffeners comprise a flat plate riveted to the web via angle-irons. Also, the longitudinal 'tie-bars' within the top flanges, which are detailed in the drawings and mentioned in the correspondence between Brereton and Bell, can be clearly seen in the extant bridge.

9.2 The 'Replica Bridge' over Brunel's Lock.

The original contract drawings of the bridge signed by Finch and Howard show its overall length as 106ft 6in; 76ft 6in plus 30ft. The extant bridge measures 95ft overall; 76ft 6in plus 18ft 6in. These dimensions would accord with the case where there was no nose shortening, but where there was a tail shortening of about 11ft 6in, and it is apparent that the tail section which incorporated the counterweights has in fact been removed. Otherwise, the structure agrees very well with the contract drawings. In particular, on both the drawings and the extant structure the web stiffeners comprise a 'bulb-flat' section riveted to the web via angle-irons. There are no longitudinal tie-bars in either the drawings or the extant bridge.

10 DISCUSSION

The question of authenticity was raised by uncertainties expressed in works published around 1970 by Professor Angus Buchanan, who is an acknowledged authority both on I.K. Brunel and on the history and development of Bristol Docks. For example, he states:

There is, however, difficulty in identifying which bridge it is because there are two on the site, virtually the same in design and size. [xxxv]

And again:

We cannot be certain which of two bridges it is ♦ No markings have been found on either bridge to make the identification certain. [xxxvi]

However, points of particular significance in identifying which, if either, of the two bridges is 'Brunel's Swivel Bridge' are not only the striking similarities, in terms of dimensions and structural details, between the extant structures and the bridges portrayed in some of the original drawings, but likewise their evident dissimilarity to each other.

Also, as noted above, the bridge at Howard's Lock was still known as 'Brunel's Bridge' in 1901.

11 CONCLUSIONS

Taken together with the written correspondence and reports, there is sufficient agreement between the general arrangements and structural details, as-drawn, and the actual structures to be able to conclude:

1.

that the bridge by Howard's Lock is 'Brunel's Swivel Bridge', i.e. the same bridge that was originally installed over Brunel's Lock in 1849, and that was adapted for use at Howard's Lock around 1873;

2.

that the bridge currently over Brunel's Lock (the 'Replica Bridge') is the same bridge that was installed there in 1875-1876.

12 NOTES, REFERENCES AND ACKNOWLEDGEMENTS

The author wishes to acknowledge the considerable help and advice given by Mr David Neale, former Bristol City Docks Engineer

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- [i] Based on information supplied by Mr David Neale, and in: Buchanan R.A., 'I.K. Brunel and the Port of Bristol', Trans. Newcomen Society, Vol. 42, 1969-1970, p.41-53.
- [ii] Murless B.J., 'George Hennet', in Biographical Dictionary of Civil Engineers Vol. 2, (in course of publication).
- [iii] Information in this section is based on two primary collections:
Correspondence: BUL PLB 6 and 7 (two of Brunel's private letterbooks held by the Bristol University Library, Special Collections);
Drawings: BRO 42054/C/6 7624-7647 (aperture cards of microfiched drawings held by Bristol Record Office).
- [iv] Buchanan R.A., 'I.K. Brunel and the Port of Bristol', op.cit., p.53.
- [v] Brereton to Bell: BUL PLB 6, 16 February 1849.
- [vi] Ibid., 3 April 1849.
- [vii] Ibid., 10 March 1849; BRO 42054/C/6 7624.
- [viii] Brereton to Bell: BUL PLB 6, 14 April 1849.
- [ix] Brunel to Hennet: BUL PLB 6, 21 July 1849.
- [x] Brereton to Bell: BUL PLB 7, 8 October 1849.
- [xi] Large D. (ed.), 'The Port of Bristol', Bristol Record Society, Vol. 36, 1984, p.10.
- [xii] Brereton to Bell: BUL PLB 7, 30 October 1849.
- [xiii] Ibid., 8 December 1849.
- [xiv] Bennett to Hinton: BUL PLB 7, 2 February 1850.
- [xv] Ibid., 5 February 1850.
- [xvi] Buchanan R.A., 'I.K. Brunel and the Port of Bristol', op.cit., p.52.
- [xvii] BRO PBA/Corp/R/4/3, Engineer's Reports 1862-1868, 8 August 1863.
- [xviii] BRO PBA/Corp/M/2/5, Docks Committee Minutes 1863-1867, 24 August 1863. George Hennet died in 1857; his second son, Follett Charles, took over the Bridgwater foundry, which traded at first as Hennet & Spink, later as Hennet, Spink & Else: Murless B.J., 'George Hennet', op.cit., passim.
- [xix] BRO 42054/C/6 9159-9165.
- [xx] BRO PBA/Corp/R/4/3, op.cit., 24 October 1864.
- [xxi] Large D. (ed.), 'The Port of Bristol', op.cit., passim.
- [xxii] BRO PBA/Corp/M/2/7, Docks Committee Minutes 1871-1874, 15 April 1872.
- [xxiii] BRO PBA/Corp/M/2/7, op.cit., 31 March 1873.
- [xxiv] BRO 42054/C/5/2232.
- [xxv] Large D. (ed.), 'The Port of Bristol', op.cit., passim.
- [xxvi] BRO PBA/Corp/M/2/7, op.cit., 22 June 1874.
- [xxvii] Ibid., 10 August 1874.
- [xxviii] BRO 42054/C/6 7650-7658.
- [xxix] BRO 42054/C/6 9206-9212.
- [xxx] Large D. (ed.), 'The Port of Bristol', op.cit., p.127.
- [xxxi] Ibid., p.132.
- [xxxii] Based on information supplied by Mr David Neale.
- [xxxiii] BRO 42054/C/6 7640-7644.
- [xxxiv] For example: BRO 42054/C/6 7628; 42054/C/7 10513.
- [xxxv] Buchanan R.A., 'The Cumberland Basin, Bristol', Industrial Archaeology, Vol. 6, No. 4, November 1969, p.329.
- [xxxvi] Buchanan R.A., 'I.K. Brunel and the Port of Bristol', op.cit., p.53.