Hans I. Seland

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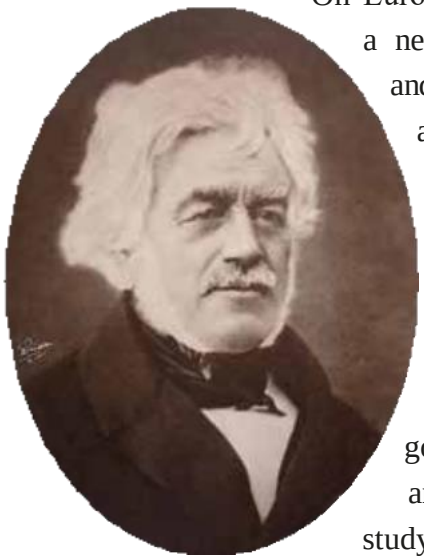
Hans Seland (b. 1943) has known Bakke suspension bridge and the early 19th Century postal road in Flekkefjord, Norway, since boyhood. He is a Civil Engineer, educated at the University of Newcastle uponTyne (UK). He worked with the Norwegian Public Roads Administration from 1972 to 2010. In retirement he has traced road-master Johnson's Norwegian government-sponsored 1838 study tour of North Sea countries. In his travels Seland met academics and knowledgeable amateurs and visited transport improvements on the ground, including Capt. Brown's Kalemouth suspension bridge in Scotland as well as Union Bridge. He has published articles on G.D.B. Johnson and the first Industrial Revolution in *Engineering History and Heritage* (London: 2013) and in Norwegian publications.

7. Capt. Samuel Brown's influence on Norway's iconic first suspension bridge

Hans Seland



On Europe's periphery around 1840 a new generation of politicians and professionals looked abroad for technology to help modernise industry and transport. At a time when British mentors inspired an international technological culture, Norwegian road-master Johnson went on a government mission to Britain and around the North Sea to study the new roads and bridges, harbours and railways.

George Daniel Barth Johnson *(above)* was born in Norway in 1794. His father was a Lutheran clergyman from Iceland and his mother the daughter of a Norwegian public servant of distant German descent. He trained as a military engineer but worked all his life on civilian projects.

Johnson read Robert Stevenson's account of the 1820 opening ceremony of Samuel Brown's Union Chain Bridge [*Edin. Phil. J.* **V.** 1821], possibly a translation in Danish professor Ursin's Polytechnical Magazine. In the 1830s he was charged with the task of building 40 miles of post road for vehicular traffic between Kristiansand and Stavanger. The road would cross several sizable rivers, and Johnson hoped that the new British suspension bridges might offer a reasonable solution to that challenge.

Johnson post road on the Feda Fjord 1836

Johnson left Kristiansand in June 1838. On his journey he stopped at St. Andrews, Edinburgh, Kalemouth, Kelso, Newcastle upon Tyne and London. On Sunday July15th he wrote his wife to tell her that he had seen Queen Victoria in London. The journey took him through the North Sea countries in 100 days. He submitted his report in a practical manual form in 1839 and named it *Handbook for Road Officials*.

Johnson advised the use of Kalemouth Bridge as a suitable prototype for potential Norwegian suspension bridges. The bridge still crosses River Teviot about six miles south west of Kelso in the Scottish Borders. In Handbook Johnson wrote that landowner William Mein had commissioned the bridge in c.1830 in order to supply direct access to his estate.

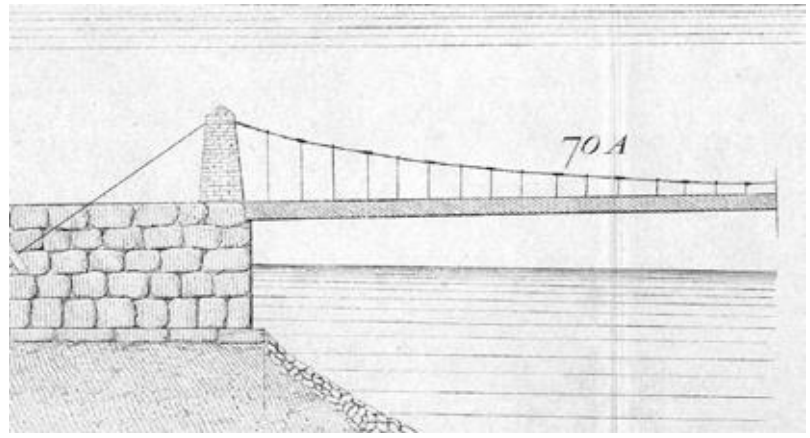
Samuel Brown (1776-1852) designed the Kalemouth Bridge superstructure about 10 years, and as many bridge spans, after he created Union Bridge. He gave Kalemouth Bridge a more

Johnson's UK journey 1838

efficient sag-span curvature ratio than its elder sister spans and also provision against deck oscillation by means of robust timber lattice parapets. In addition to these, Wellington Bridge, Aberdeen still stands.

In September 2010 I travelled to Scotland to see the bridge that Johnson had inspected in 1838 and compare the Handbook notes to the real bridge. I found that his notes were reasonably sound, but not always accurate. My measurements confirmed that the length of the bridge deck is 53.4 m, and the total width is c. 5.4 m. The bridge has one pair of link chains on either side, made of round rods of wrought iron. Thirty-three suspenders on either side of its main span, hold the deck. Every other suspender is attached to the midpoint of one pair of chain links. Johnson wrote in his *Handbook* that the bridge towers were shaped like truncated pyramids with quadratic bases, but they proved to be rectangular. Johnson's observations illustrate the value of little-known foreign reports of the British Industrial Revolution.

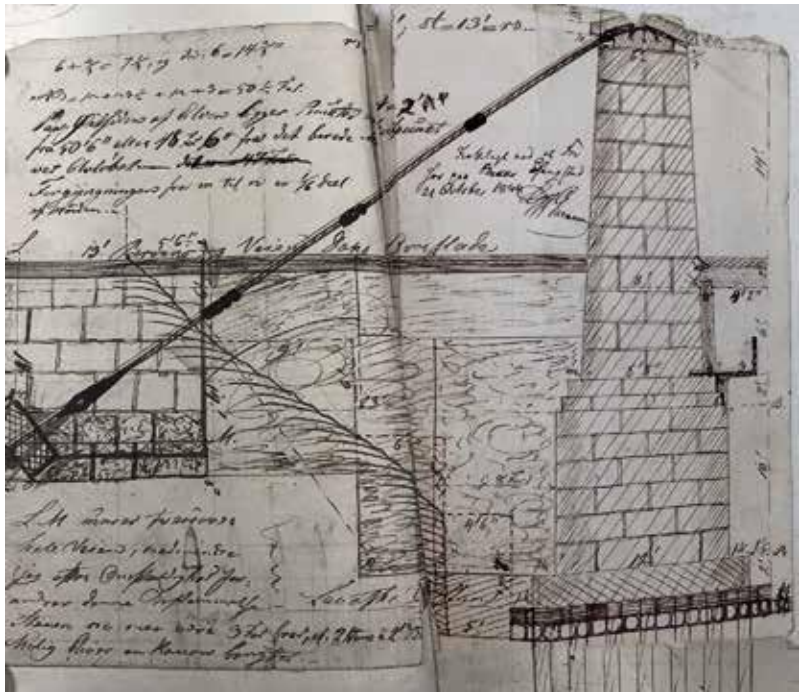
In early 1841 the Norwegian Ministry of Justice approved Johnson's plan for the Bakke river crossing on the West Country Highway. The bridge was a hybrid of Kalemouth and Scotswood (Newcastle upon Tyne) suspension bridges. The wrought iron was to be produced at Aall's Naes Iron Works in Tvedestrand.



Johnson's sketch of Kalemouth Bridge in ***Handbook***

Bakke Bridge was the first major Norwegian and Scandinavian suspension bridge. Its initial design was a direct result of Johnson's tour. He had wanted to build a "no nonsense" copy of the superstructure of Kalemouth Bridge, but some critical measurements proved to be inaccurate:

- Brown's chain links had 2 inch (imperial) diameters which Johnson interpreted as 1¾ inch (Norwegian). That reduced the Bakke chain link cross section by 20%.



Johnson's concept drawing of Bakke Bridge

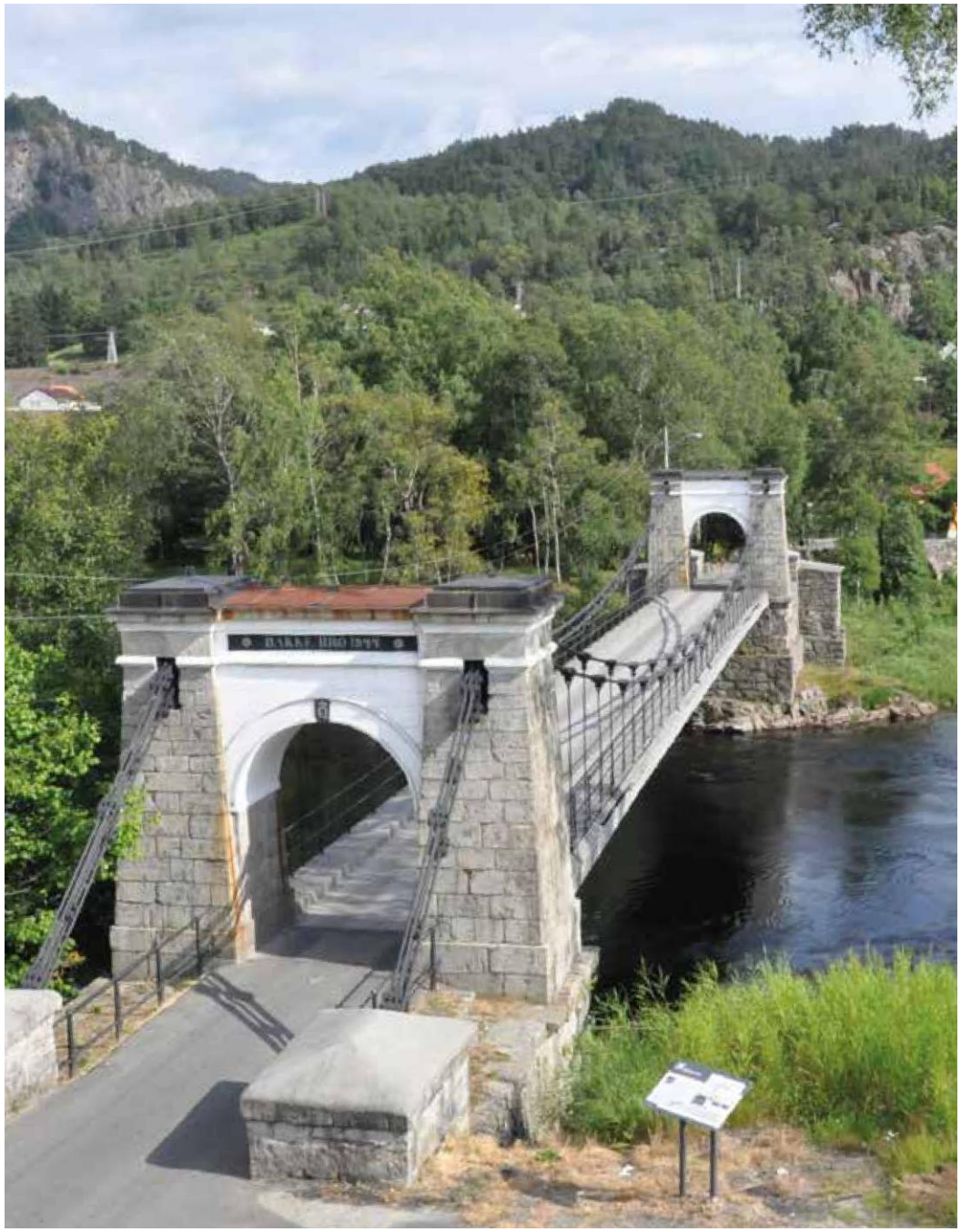
- The Bakke pylons were two feet lower than at Kalemouth inducing an increased stress in the main chains of 17% for the same load.
- The bridge deck at Bakke was two feet wider than its Scottish model and the dead load changed accordingly.
- Best practice live load increased by at least 15% during the intervening years.

In Spring 1842 another military engineer, Christian Vilhelm Bergh *(right)* (1814-1873) was appointed new resident engineer at Bakke. He was Johnson's junior by 20 years, and his engineering education had been more thorough than that of his superior. Bergh's engineering mentor was B. N. Garben of Johnson's generation. Garben had translated Claude Navier's 1823 report on suspension bridge design and applied it to a potential Norwegian case. He published his work in a military journal in 1842, but Johnson dismissed it because he found the design case unreasonably conservative compared to Brown's lighter bridges.

Soon after his arrival, Bergh set out to test his new knowledge on the Bakke design. He found it inferior, and he told Johnson so. Johnson, however, relied on his own intention to copy well-functioning Kalemouth Bridge, and he dismissed Bergh's concern. Bergh then resigned from his position at Bakke and went above Johnson's head to alert central Government. Through the winter of 1842-43 an intense written debate developed involving Johnson, Bergh, Garben, military engineering colleagues and even a professor of astronomy at Oslo University. The documents are buried in the National Archives and probably have not been read since 1843. It took me the better part of one winter to decipher the Gothic handwriting and try to understand the mathematical and other arguments meant to convince the officials of the responsible Government department.

By May 1843 Johnson was relieved of his bridge duties. Bergh was promoted project manager and finished the bridge to his own design influenced by Navier's theoretical design approach in late 1844. Most importantly he doubled the number of main chains from four to eight.

As a young Civil Engineer in the Norwegian Public Roads Administration I was fortunate to be charged with the rehabilitation of Bakke Suspension Bridge. The bridge received listed status in the 1950s and stands proudly to this day. In my retirement I publish articles on the history of transport infrastructure technology and I make Mr Johnson my case study.



Bakke Bridge stands proudly today

The harsh realities of technology transfer hit both Navier and Johnson with full force some 200 years ago. Navier never got another commission to build a bridge after his Pont des Invalides failed, but his theoretical work dominated Continental suspension bridge design for many years to come. Johnson never admitted his failure at Bakke, and in his writings he totally ignored his former assistant. Bergh was recognized as Norwegian expert of suspension bridges and rose to be the country's first Director of the Norwegian Public Roads Administration.

In spite of setbacks and personal cost to some participants, the pioneers of the Industrial Revolution laid the foundations for modern society, as we know it. Samuel Brown and his Union Chain Bridge made notable contributions to that process.

Kalemouth Bridge c1830-33 © R Paxton 2016