Menai Suspension Bridge
The First 200 Years

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TREFTADAETH MENAI HERITAGE

To Rosemary,
Sonya, Anita and Colin
With thanks for your support and patience.

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Front cover image: *The Menai Suspension Bridge*, G. Arnold, 1828.
Courtesy of the Institution of Civil Engineers.

Back cover image: by Warren Kovach

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Chapter 1 – Introduction

The Menai Strait was formed along deep geological fault lines first created millions of years ago. Rivers washed out the softer rocks, and following the last ice age gradual sea level rise meant the Strait was initially flooded during high tides, and then about 5,200 years ago the lowest tides were sufficient to keep it flooded along its full length. For centuries people crossed the Menai Strait by means of ferries and other small vessels. Tacitus describes the Romans' arrival on the south bank of the waterway c60AD and their initial reluctance to cross it to tangle with the fearsome hordes arrayed on the Anglesey shore! Eventually, led by Suetonius Paulinus, the infantry crossed in flat-bottomed barges and the cavalry swam across. They then slew the Druids and, according to Tacitus, demolished *"the groves devoted to Mona's barbarous superstitions".*

In 1282, Edward I commissioned Luke de Tany to occupy Anglesey and build a bridge across the Strait and he brought expertise from the south of England to Chester to supervise the construction of about 40 flat bottomed boats to be joined together for the purpose. Edward's plan was that de Tany's force would cross the strait and attack the Welsh forces led by Dafydd and Llywelyn from the rear, while Edward's force would attack them from the Conwy valley. On 6 November, rather than wait for Edward's instructions, Luke de Tany crossed the strait at low tide with a force of cavalry and infantry, but the Welsh were prepared and attacked them on the mainland. The fighting was so intense that de Tany's force retreated to the bridge to find it now under the tide. To escape the battle many of the English jumped into the strait, and drowned due to the heavy armour and clothing they wore. The significant losses of soldiers and mounted knights included de Tany himself. The bridge was eventually demolished to allow navigation along the strait and the timber was taken to Caernarfon Castle.

From the end of the 16th century, apart from a few months in the mid-17th century, Holyhead was the "packet" port for Ireland (i.e. the port from which Royal or Government correspondence – "Packets" – were transported across the Irish Sea in "Packet Boats"). In order to reach Holyhead travellers from other parts of Britain had to cross the Menai Strait from mainland Wales to the island of Anglesey.

The Menai Strait is a very complex tidal waterway with strong currents and tides and variable water depths. There were up to eight ferry crossing points from the mainland to Anglesey, at various locations along the 11 mile (17 km) waterway. The crossing from Penmaenmawr via Lavan sands (only possible at low tide) and a ferry shuttle across the main channel into Beaumaris is shown on the Ogilby map of the London to Holyhead road in 1675 (Figure 1). Sometime later, and certainly by 1718, the Post traffic was using the Bangor, or Porthaethwy, ferry route just to the east of the present bridge site. Bangor was the nearest settlement to the ferry site on the south shore, and Porthae-

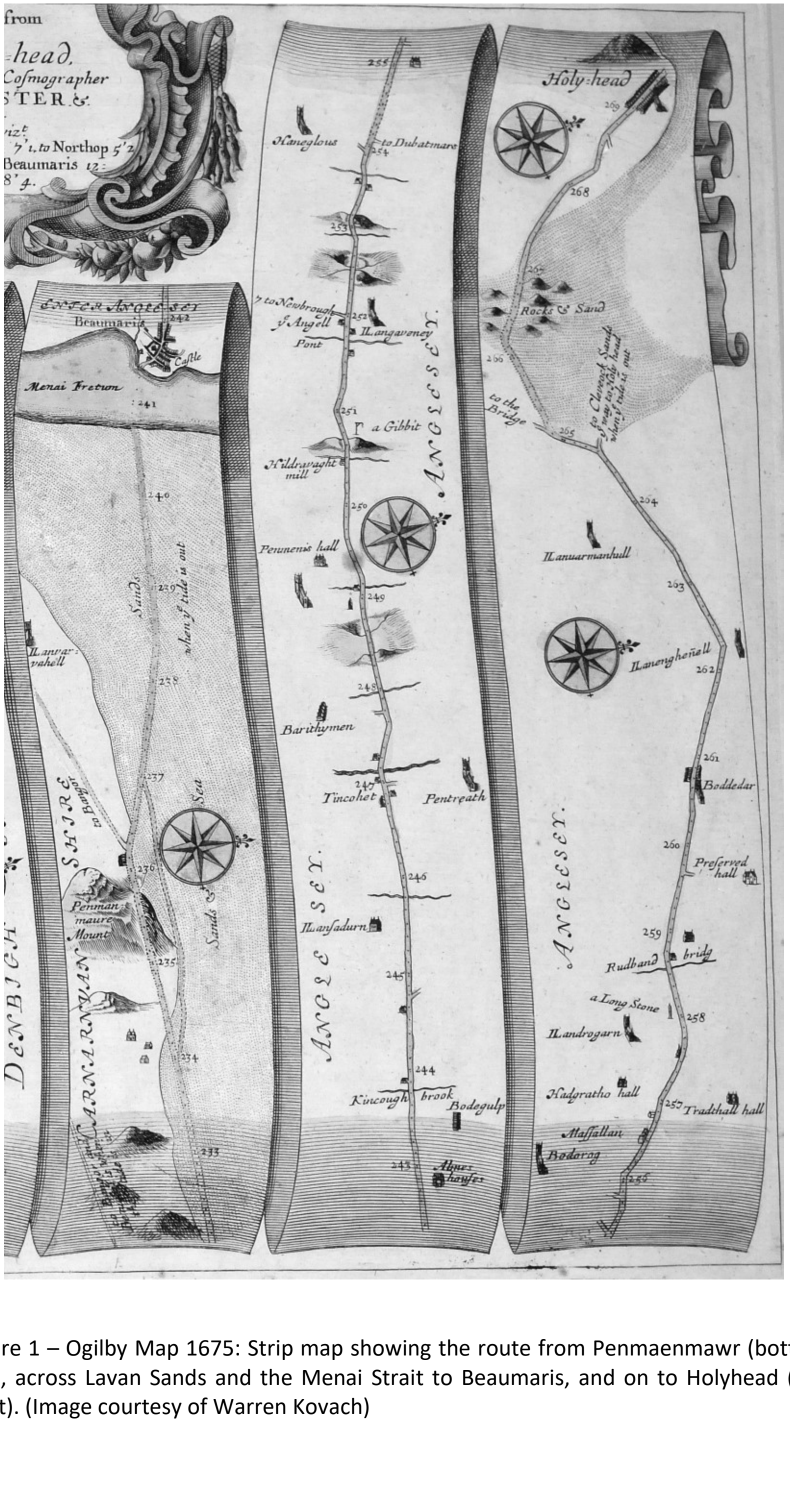

Figure 1 – Ogilby Map 1675: Strip map showing the route from Penmaenmawr (bottom left), across Lavan Sands and the Menai Strait to Beaumaris, and on to Holyhead (top right). (Image courtesy of Warren Kovach)

changing to the same arrangement of outside masonry walls, cross walls and rubble infill described for the lower part of the Anglesey main tower.

Masonry work started on the Anglesey abutment, the end structure of the viaduct, on 6th October, but supplies of stone were still being disrupted by the weather, and Provis reports that two of the boats had been sunk and a number damaged, and that some had left the project rather than risk the same fate!

By the end of 1820, the Anglesey main tower and small pier next to it had reached 51 ft (15.5 m) and 43 ft (13.1 m) above high water level respectively; the middle pier was at low water level; the third small pier and abutment were 36 ft (11 m) and 14 ft (4.3 m) above high water. On the Caernarfon side the main tower had reached high water level; both the small piers were 45 ft (13.7 m) above high water and the abutment had not been commenced.

Developing the Design

While proceeding with the masonry work, thought was being given to the practicalities of the ironwork and how it would be attached to the masonry substructure. The original suspension bridge design submitted to the Commissioners in 1817 (Figure 8) showed the main span suspended from solid cables made of bundles of wrought iron rods welded together and passing over iron pyramids on top of the main masonry towers. In the back spans at either end of the bridge, the cables were divided into a fan arrangement carried through the masonry of the approach viaducts and In the later drawing (Figure 9) these are shown anchored to cast iron plates incorporated into the masonry above the arches.

During further discussions it was decided to carry the chains beyond the masonry and through tunnels in the ground to be anchored in the good solid rock which existed either side of the strait. This removed the risk of the loading on the chains tending to pull the chains out of the masonry, creating forces that masonry is not usually expected to resist. By extending the overall length of the chains, this decision increased the cost of the bridge, but it allowed the angles of the chains either side of the pyramids to be more balanced. Furthermore, the elevation of the masonry could be modified, to reduce the mass of masonry in the approaches by increasing the height of the arches with taller tapered intermediate piers giving slightly wider arch spans. These changes gave the bridge a much more graceful appearance, as can be appreciated by comparing the original design in Figure 9 with the revised design in Figure 13 or with pictures of the finished bridge. It also reduced the quantity of stone required in the approach viaducts.

The revised design, shown in Figure 13, involved carrying the intermediate piers up a further 15 ft (4.6 m) to 65 ft (19.8 m) above high water at the same batter (i.e. slope angle) in both faces as had been planned originally so that they now tapered to 7½ ft (2.3 m) thick at the level of springing (i.e. starting the circular arch) rather than the 10 ft (3 m) at the original springing point. The span of each arch was therefore increased from 50 ft (15.2 m) to 52½ ft (16 m). To keep the line of the arch crowns parallel to the gradient in the approach roads, the arch next to the main tower was a semicircle, but the other arches were segments of circles of successively greater radius.

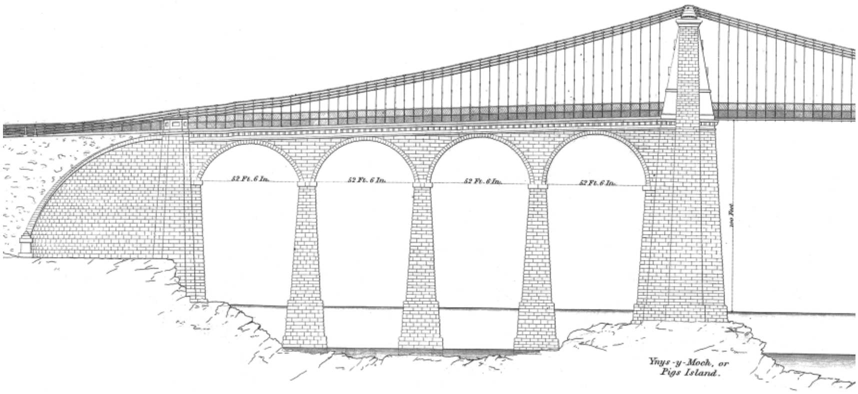

Figure 13 – Elevation of the Anglesey end of the bridge after design changes to chains and higher arches on the approach. (Provis, Plate 5)

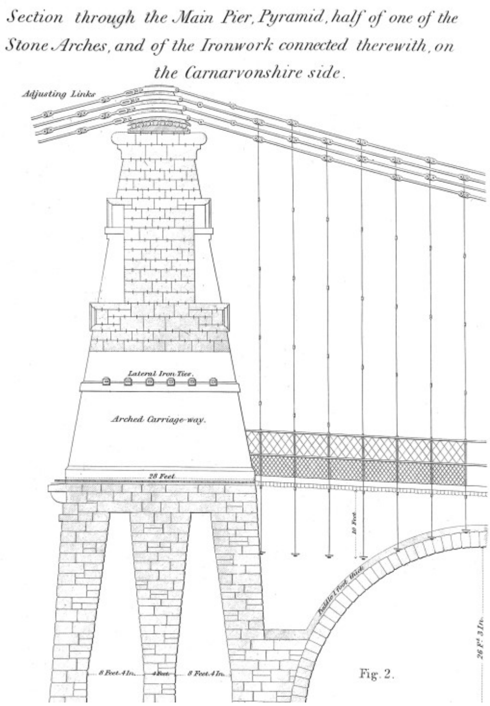

Figure 14 – *Section through the Main Pier, Pyramid, half of one of the Stone Arches and of the Ironwork connected therewith on the Carnarvonshire side*. Upper part only. (Provis, Plate 6)

Appendix 9 is a reprint of a paper presented to the Royal Society in March, 1826 by its President, Davies Gilbert, entitled “On the Mathematical Theory of Suspension Bridges, with Tables for Facilitating their Construction”. Appendix 10 is a letter from Davies Gilbert to Telford dated 22nd December, 1827, thanking him for wishing to include the paper in the book:

> *...I shall be highly gratified by finding it annexed to the account about to be published by Mr. Provis, of one of the greatest undertakings ever executed.*

The Folio volume book was published in 1828, the text on each page fitting roughly into A4 size, but the plates were full size. Provis’ final words on the subject are:

> *The Bridge has now stood two years, uninjured and unchanged, and there is reason to believe that with ordinary care and attention it will stand the test of ages.*

As will be seen, however, this was not William’s last involvement with Menai Suspension Bridge.

His final two plates of Menai Bridge are magnificent engravings of the bridge and the strait drawn from either side (Figures 59 & 60).

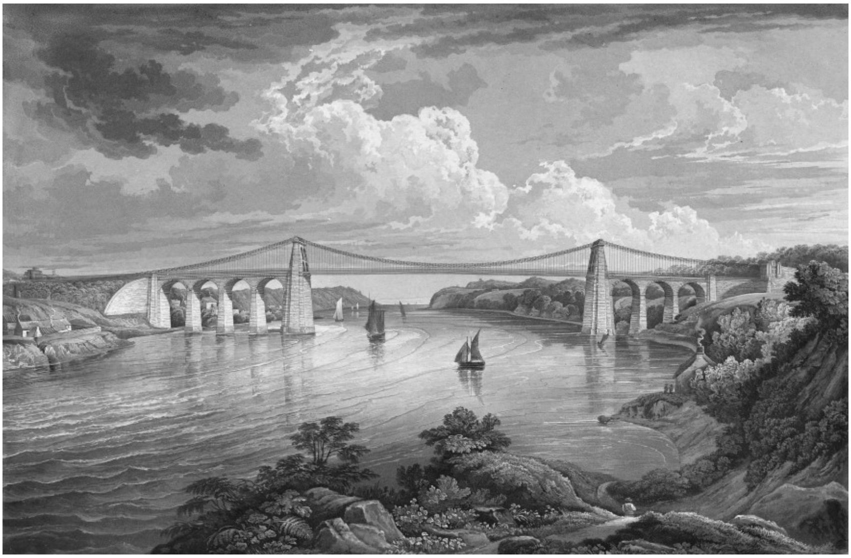

Figure 59 – *View of the Suspension Bridge erected over the Menai Strait in North Wales – Looking towards Beaumaris.* (Provis, Plate 15)

John Provis, nine years younger than his brother, was then appointed Assistant Engineer to the Commissioners under Telford, at a salary of £150 per annum. He took over his brother’s previous responsibilities for the roads from Shrewsbury and Chester to Holyhead and both the Menai and Conwy crossings. In 1829 he also took responsibility for Holyhead harbour, and his salary was increased to £250 p.a. His responsibilities later, after Telford's death, were extended even further.

Interestingly, the brothers subsequently married two sisters; William marrying Harriot Stanton on 18th July 1825, and John marrying Emily Stanton in 1833. The sisters were both daughters of Thomas Stanton, a civil engineer originally from Shrewsbury, who was first employed by Telford in 1798 on the Ellesmere canal. He eventually became that company's Agent and Engineer, and was also Deputy County Surveyor as Telford was mostly absent from Shropshire and unable to directly undertake the functions of County Surveyor.

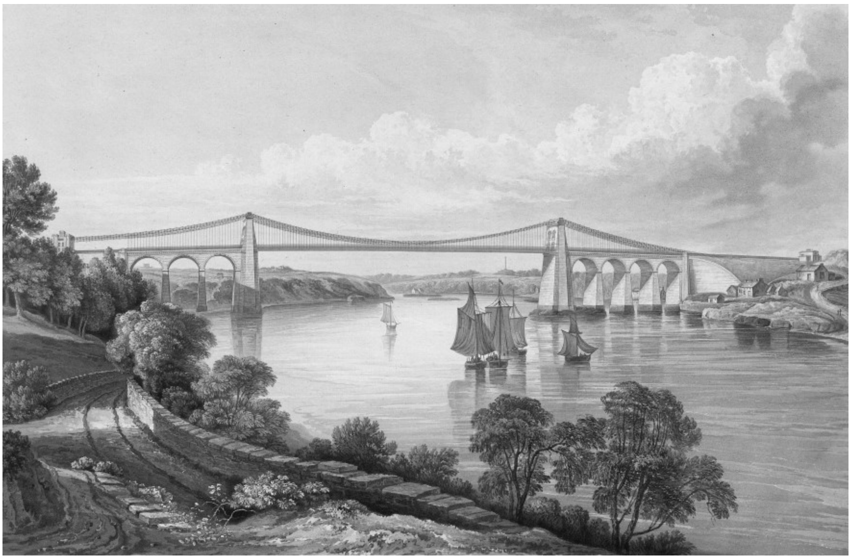

Figure 60 – *View of the Suspension Bridge erected over the Menai Strait in North Wales – Looking towards Plas Newydd and Carnarvon.* (Provis, Plate 16)

The Institution of Civil Engineers

In Kendal's coffee shop in Fleet Street, London, the Institution's inaugural meeting was held on 2nd January 1818. H.R. Palmer was the instigator of the meeting and he was joined by seven other young civil engineers. The Provis brothers were both elected to the new professional body in 1819. In March 1820 Thomas Telford was invited to become its first President, an invitation he accepted, commenting that the object and rules of the Institution drafted by Palmer closely mirrored his own aims for such a body. He took a keen interest in the activities of the Institution, attending meetings whenever he could, and it was largely thanks to Telford that the Royal Charter was granted in 1828.

Figure 121 – *Showing chain after lowering to deck.* (RE)

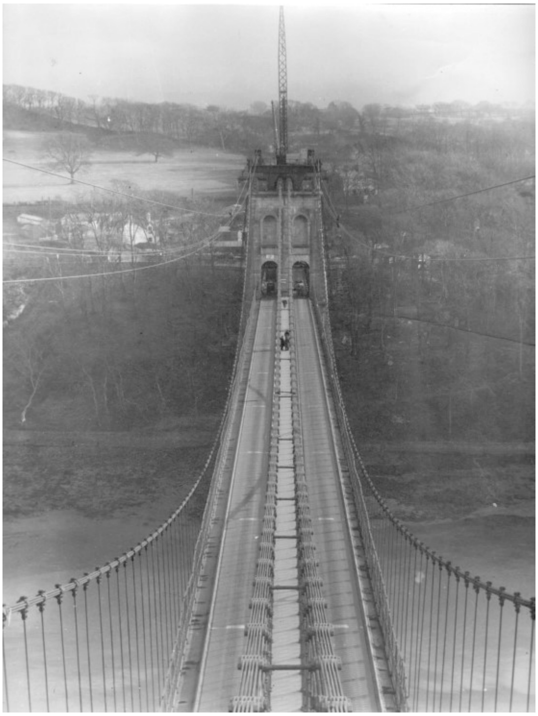

Figure 122 – Main span, view from Caernarfon tower, outer chains removed, deck supported by temporary cables, central chains still in place. (DC Owen)

Figure 123 – *Showing progress on the dismantling of the Bridgemaster's house.* (RE)

Meanwhile, the chains on the approaches were also being demolished, with the Bridgemaster's house being partially demolished to enable removal, Figure 123. The chains on the scaffold were cut up in situ and loaded for removal, and the saddles in the front wall of the Bridgemaster's house were extracted, Figure 124. In the tunnels it was more uncomfortable, working in confined space, burning through layers of paint to cut the bars which were then hauled up to the mouth of the tunnel for removal.

Figure 124 – *View of intermediate saddles removed from Bridgemaster's House.* (RE)

When the chains and anchorage castings had all been removed from the outer tunnels, the anchorage chambers had to be enlarged. Care was taken not to disturb the central anchorages as the central chains were still carrying the majority of the main span load. The rock spoil from the chambers was removed, with some difficulty, through the small original drainage tunnels, shown in Figure 95, and tipped on the bank below the exit. After the chambers had been enlarged, the joists and channels for the new anchorages were then brought down into the chambers ready for erection.