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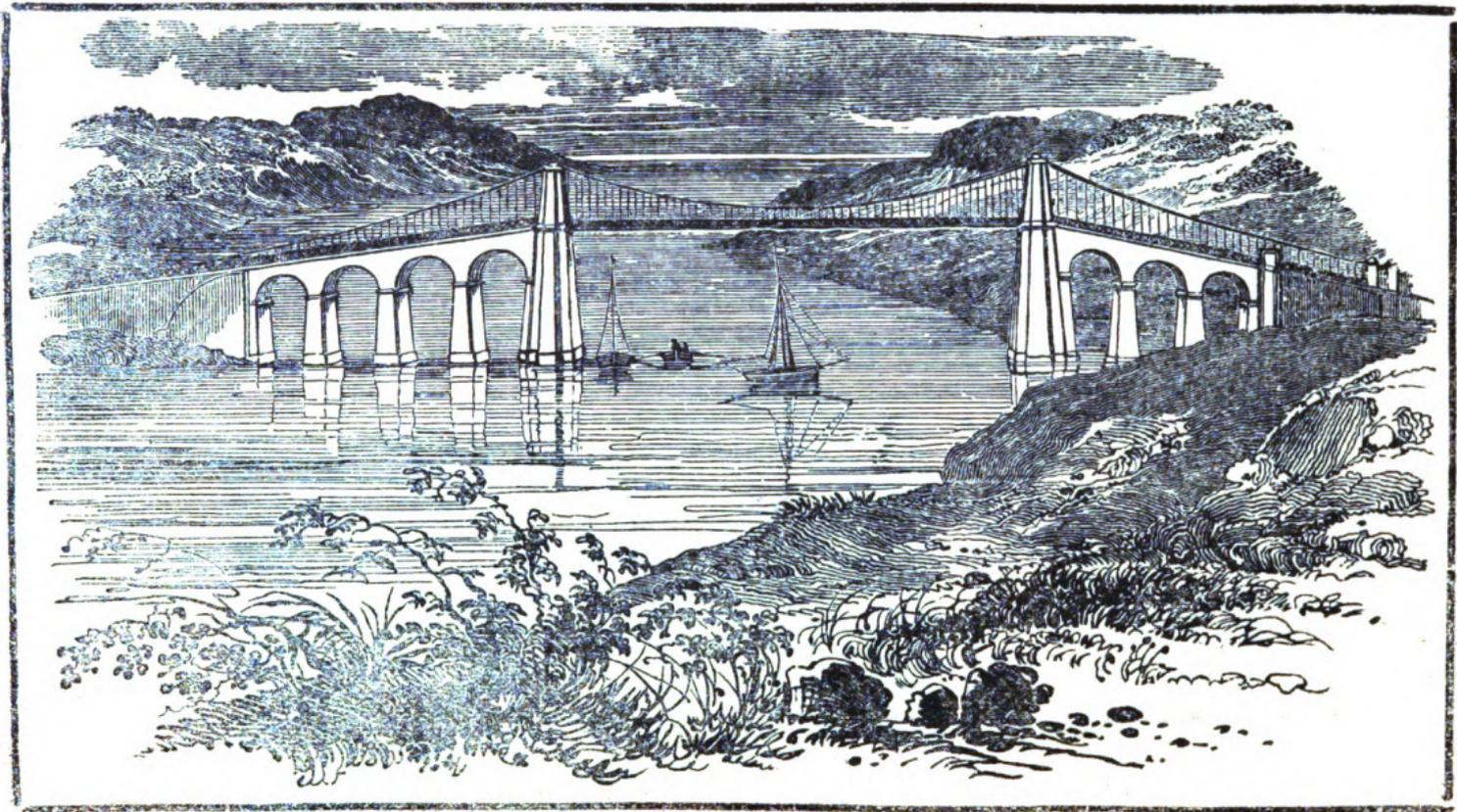
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A DESCRIPTION  
OF THE  
**SUSPENSION BRIDGE,**

ERECTED OVER THE MENAI STRAIT,

Which separates

**ANGLESEY FROM CARNARVONSHIRE**

By Order of Government.

WITH CALCULATIONS OF ITS STRENGTH, AND WEIGHT  
OF MATERIALS.

*Telf*

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DESIGNED BY THOMAS TELFORD, ESQUIRE.

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With some account of different Places

ADJACENT.

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The Fifth Edition.

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PAUL, PRINTER, BANGOR.

1830



AN ACCOUNT  
OF THE  
M E N A I B R I D G E.

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IN the years 1810 and 1811, various plans of bridges were proposed for effecting a regular and safe passage instead of Bangor ferry. all these were to be of cast iron, and of sufficient width of span, and height of elevation not to obstruct the navigation. Among those approved by the Committee of the House of Commons after due investigation, was one of cast iron, of a single arch of 500 feet span, and 100 feet above the level of the high water line in the middle of the arch; projected by Mr. Telford. Although the least expensive of any of these demensions, the estimated cost was upwards of £127 000. But the fixing of proper centring for such a bridge presented great difficulty, which could not be effected by ordinary means from below, owing to the rocky bottom, depth of the channel and rapidity of the tide-way. Mr. Telford was therefore, led to devise a new method of suspending the centring, and furnished a design accordingly.

In the year 1814, Mr. Telford was applied to for the design of a bridge to cross the river Mersey at Runcorn in Cheshire, where it was necessary to preserve an uninterrupted water-way of 1000 feet. When a bridge on the principle of suspension

occurred to him as the only practicable means, and with this view a regular set of experiments were made upon rods of malleable iron, viz. from 30 to 900 feet in length ; and from one twentieth of an inch to two inches in diameter. From the result of these experiments there was reason to conclude that by means of malleable iron properly combined, a substantial hanging bridge, with a clear water-way of one thousand feet might be constructed, and Mr. Telford gave to the Runcorn bridge committee a design for the same.

The facility and economy with which a bridge of this sort might be constructed where the shores are bold and high, led Mr. Telford to consider it as peculiarly well adapted for crossing the Menai strait. He therefore drew a plan upon this principle for the consideration of the commissioners of the Holyhead road, Before they recommended to Parliament the execution of this plan, they called before them several eminent Engineers, also Mr. Brunton of the firm of Brunton and co. iron cable manufacturers, together with Mr. P. Barlow of the Royal Military Academy at Woolwich, who had made experiments and calculations of the strength of materials. It appears says he (in his calculation of the stress and strength of this bridge) that one of the most important data connected with it is the direct cohesion of malleable iron, it appears (he continues,) from various experiments made by Mr Telford and others, that the medium strength of malleable iron is 27 tons to the square inch section ; and that, within certain limits, is proportional to the area. The bars upon which these experiments were made varied from less than an inch to more than two inches in diameter.

In making these experiments more particularly alluded to here, bars of iron were fixed at certain distances, and with certain degrees of curvature and weights hung upon them in the middle, and in different parts till they broke. Some bars of an inch in diameter and a foot long stretched nearly three inches before they broke, and bars of three feet long and one inch square, lengthened as much as eight inches before they gave way.

Iron has this peculiar property, that a certain weight extends the length of the bar, which afterwards remains at that length, and it requires a greater weight to give it an additional stretch, so that although the sectional area of the bar becomes less, yet it bears a greater weight. Hence should any of the bars in this bridge when first placed, bear a greater weight than the next to it, and be exposed to a strain, it would soon accommodate itself to the whole, and in that state be capable of bearing more than it did at first.

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#### COMMENCEMENT OF THE WORK.

In May 1819, preparations were made for laying down the foundation of the main pier on the Anglesey side by blasting and levelling the surface of the small insulated rock called *yynys y moch*, which being accomplished, the channel between the rock and the shore was filled up by an imbankment, surmounted by a railway for the conveyance of stone and other materials used in the building. But when it became necessary to stop the navigation of the main channel while the chains were

in progress of being carried over, this embankment was removed and the space between the rock and the shore made considerably deeper so as to admit coasters to pass as usual. In August the foundation of the main pier was laid down on the rock; and in October preparations were made for laying that on the Carnarvon shore, when after excavating to the depth of between seven and eight feet at low water mark, a proper foundation was obtained, being part of the rock which forms the bed of the channel.

The piers, arches and abutments consist of a species of marble which abounds in Anglesey, and particularly at Penmon near Puffin island, from whence it was supplied for this work. As this marble takes a good polish and is of various colours fragments of it are formed into chimney ornaments, inkstands, &c. and sold at the gate-houses at each end of the bridge.

The abutments consist of four arches on the Anglesey, and three on the Carnarvon shore as represented in the engraving. Each of the main piers is 60 feet by 42 at high water level, and 152 feet in height. These piers, connected with the rest of the masonry, form masses of much greater weight and solidity than is necessary to support a bridge of this span.

The bridge consists of an opening of 560 feet between the points of suspension, and 100 feet from high-water-line to the lower side of the roadway, which being horizontal, this height is uninterrupted throughout; and in addition to these the seven lateral arches, each of 50 feet span, make in all an opening of 910 feet.

Each suspending chain consists of five bars in breadth, with six connecting plates between each set of bars, fastened with bolts eighteen inches in length, and three in diameter, forming the joint between each set of bars. There are four lines of chain in the breadth of the bridge, and four chains in each line, one above the other, which passing over iron saddles placed on the piers are fastened at their extremities to iron frames imbedded in the rock. From these chains the roadway is suspended by iron rods, connected with the framing on which the roadway is laid.

The distance of five feet is kept between the rods that the suspending power may be equally distributed the whole length of the bridge. These rods pass between the bars and are fastened to each two of them alternately, so the general strength of the bridge cannot be affected by taking one away. The chains, flooring, and suspending rods are constructed and united in such a manner that each of the parts may be taken out and replaced separately, so there can be no difficulty in repairing any part when required.

The road-ways consist of two carriage-ways of twelve feet each in breadth, with a foot path of four feet between them. The flooring is composed of three layers of deal plank, the lowest three inches, the others two and a half thick, with a sheathing of felt strongly saturated with pitch, between the upper and middle layers, to prevent the wet and damp from penetrating downward. The outer sides of the carriage-ways are secured with iron trellis work seven feet in height, strongly bound together, and fastened throughout the whole length.

to the suspending rods; and side guards of oak are laid along the road-ways leaving a clear space of eighteen inches on each side, to prevent carriages from getting in contact with the trellis work or suspending rods.

The number of suspending rods in the great opening are 448; along the top of the abutments rods are also attached to the chains, serving as stays to retain them in their proper curvature, and to counteract any inward strain upon the piers.

The main piers are, not as might be supposed, built in the usual solid manner, there being four square openings in each commencing near the base and ending a little below the spring of the arch, these cavities being carefully wrought add much to the strength of the piers, causing them to bear more firmly upon their outward angles, rendering them less liable to strain from the great weight they sustain than if formed in the usual way.

The lateral arches being finished, the arches for the road-ways were then finished and the suspending piers raised to their proper elevation. In these piers each tier of stone is fastened perpendicularly and transversely with bolts and cramps of iron, so that no block can be moved from its place by any strain which might occur during violent gales of wind. The road-way arches in the piers are 9 feet in width, and 15 in height.

The suspending power is calculated at 2000 tons if equally distributed along the bridge, the chains and road-way at 500 tons, so there remains a surplus of suspending power equal to 1500 tons.

As the Anglesey shore afforded a body of rock up to the surface, a secure hold for the fastenings was gained without much difficulty, accordingly circular openings were made in the rock and carried downwards in an inclining direction for about twenty yards, forming passages for the chains to the fastenings.

A horizontal excavation was then made across the bottom of the chain-ways, of such dimensions as to admit the fastening frames, each weighing with its four cross bolts 4016 lb. These frames lie upon the openings of the chain-ways, and are imbedded in the rock; thus forming a hold which no strain can overcome so long as the incumbent mass holds together. These caverns are well worth the inspection of the curious, and may be seen on application to Mr. Fisher, bridge keeper on the Anglesey side.

The chains are fastened in the same manner on the Carnarvon shore, but the rock being at a greater distance from the pier than in Anglesey causes an obvious difference in the chord of the chains from the piers to the shore.

The fastenings in the rock being completed, the first chain-bars were bolted thereto, and successive lengths added thereto till they reached to the saddles on the suspending pier, being supported to that height by strong scaffolding laid down in the same curve in which the chains now appear.

Those parts of the chains which had been carried to the summit of the south pier were afterwards lengthened till they reached down to high

water level; but the Anglesey chains were not carried further than the apex of the pier. A raft was then constructed, and 440 feet of chain laid down upon it, which being attached to the corresponding parts on each side forms one chain.

On the 26th of April 1825, the first chain was thrown over the strait being the uppermost in the eastern line. The raft (before mentioned) six feet in breadth and four hundred and fifty feet in length, lay along shore westward, with one end moored to the main pier as a centre. The day was exceedingly favourable for the occasion, not a breath of wind stirring to ruffle the face of the water, about half past two in the afternoon, the tide flowing slowly to the east, and nearly high water, the end of the raft which lay westward was unmoored and towed round till it came in line across the channel between the main piers, it was then made fast to buoys which had been previously laid down to keep it in a proper position.

As soon as the chain on the raft was bolted to the one suspended from the pier on the Carnarvon shore, two powerful pullys from the summit of the Anglesey pier were then made fast to the other extremity of the chain, when two capstans with 32 men at each commenced working, the strain being nearly forty tons, the chain rose majestically and the attention of the numerous spectators seemed deeply fixed upon the novel and interesting scene. In about two hours it had gained the proper height and was bolted to its fellow on the Anglesey pier.

From this time till the 9th of July following the remaining chains were thrown over, and without any accident attending.

## RECAPITULATION.

The chains, sixteen in number, consist of five bars in each length, and six connecting plates at each joint, secured with two bolts of three inches in diameter, and eighteen inches in length, forming a double joint. The total number of bars in the cross section of the chains is 80; the number of bars in one chain is 935; in the sixteen chains 14660; length of the chain from fastening to fastening in the rock 1714 feet; the number of plates which unite the bars in each chain 1122, in all 17952; the number of vertical rods in each line including the abutments, is 199, in all 796. The suspended part of the road way rests upon 111 sleepers, 222 trussed rods, and 222 king posts.

## WEIGHT OF IRON.

315 Large chain bars 7 feet and a half long 4 inches wide and one inch and a half thick, each 165 lb. makes	lb. 51,075
384 chain plates 18 inches long, 10 broad and one and a half thick, each weigh- ing 75 lb.	28,800
121 large bolts each weighing 126 lb.	16,048
615 chain bars ten feet long, 3 inches and a quarter wide, and one inch thick, each weighing 124 lb.	76,260
738 chain plates 16 inches long, 8 inches broad, and 1 inch thick, each 32 lb.	23,616
246 bolts each 56 lb.	13,776
597 connecting rods and bolts, each 37 lb.	22,089
16 steadying ties, each weighing 1,225 lb.	19,600

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Total weight of one chain 249,229

## WEIGHT of IRON.

	lbs.
The weight of one chain making 249,220, weight of the sixteen chains . . . . .	3,987,664
2 cast iron plates under the saddles, each weighing 46,080 lbs . . . . .	92,160
16 guide plates and brass bushes, each weighing 373 lbs . . . . .	5,968
199 suspension rods, averaging 33 feet and a half in length, by one inch square, each rod weighing 111 lbs multiplied by 4 makes	88,356
111 sleepers, each weighing 334 lbs . . . . .	37,074
222 trussed rods, each weighing 40 lbs . . . . .	8,880
222 king posts, each weighing 7 lbs . . . . .	1,554
Anglesey side } 98 side rails, each weighing 80 lbs . . . . .	7,840
} 98 foot way rails, each weighing 50 lbs . . . . .	4,900
Suspended } 222 side rails, each part         } weighing 101 lbs . . . . .	22,422
Carnarvon- } 74 side rails, each shire side   } weighing 101 lbs . . . . .	7,474
} 74 foot way rails each weighing 50 lbs . . . . .	3,500
6 cast iron frames, for the fastenings in rocks, each weighing 2,240 lbs . . . . .	13,440
24 round bolts, 9 feet by 6 inches, each weighing 444 lbs . . . . .	10,656
Anglesey side } 78 side road rails, each weighing 80 lbs . . . . .	6,240
} 24 centre road rails, each weighing 50 lbs . . . . .	1,200
} 78 cast iron stanchions, to support the rails, each weighing 176 lbs . . . . .	13,626
} 24 short stanchions each weighing 100 lbs . . . . .	2,400
} 39 Hand-rails, each weighing 104 lbs . . . . .	4,056
	4,319,472

WEIGHT OF IRON.		lb.	
Brought forward		4,319,472	
Carnarvon- shire side.	}	38 side rails, each weighing 80 lb. . . . .	3,040
		40 iron stanchions each weighing 176 lb. . . . .	7,040
		38 hand rails, each 404 lb. . . . .	3,952
484 parapet rails, each weighing 31 lb. . . . .		15,004	
3 sets cast iron saddles near the Anglesey gate, each weighing 2,016 lb. . . . .		8,064	
8 gate posts, each weighing 533 lb. . . . .		4,264	
4 toll gates, each weighing 325 lb. . . . .		1,300	
2 lamp posts, each 300 lb. . . . .		600	
12 tie bars in the pier arches, each 533 lb. . . . .		6,396	
32 cast iron saddles over the toll house on the Carnarvonshire side. each 416 lb. . . . .		13,312	
4 plates under the above saddles, each weighing 900 lb. . . . .		3,600	
240 segment saddle bars on the piers near the Anglesey gate, each 200 lb. . . . .		48,000	
8 saddles on the suspending piers, each weighing 3,248 lb. . . . .		25,984	
26 tie bars for the above saddles, each weighing 600 lb. . . . .		12,000	
64 rollers in the saddles on the piers, each weighing 335 lb. . . . .		21,440	
<b>Total weight of iron,</b>		<b>4,493,468</b>	

The suspending chains being completed, the vertical rods were then attached to them, their lower ends having been previously bolted to the transverse sleepers (composed of wood and wrought iron) which support the road way framing. The plank were then laid down upon the sleepers to form the road ways, which were rendered passable to the workmen about the latter end of September, 1825.

The bridge consists of two carriage ways each of twelve feet in breadth, with a footpath of four feet between them, secured on each side with iron trellis-work. From the toll houses to the main piers it makes a rise of one foot in 25, and from the piers to the centre of the platform it rises three feet.

On the 30th of January 1826, it was opened for the use of the public, the London mail coach being the first carriage which passed over it, and on the following day the ship *Melantho* of Carnarvon of 300 tons burthen, with topgallant masts up and all sails set, was the first that sailed under it.

The whole of the expence attending the erection of this bridge was stated to be £120,000.

#### TOLLS.

	s.	d.
For every stage coach.....	2	6
Every post chaise, coach, landau, berlin, barouch, or any such carriag with 4 wheels and 4 horses .....	3	4
Ditto with 4 wheels and 2 horses .....	2	0
Every cart or other carriage and 2 wheels..	0	6
Waggon, wain, or other such carriage and 4 wheels.....	1	0
Horse, mule, or, ass not drawing any carriage	2	
Oxen, cows, or neat cattle the score.....	1	0
Hogs, calves, sheep or lambs the score....	0	6
Foot passenger .....	0	1

A ticket clears for the day.

## BANGOR, &c.

BANGOR has, for several years past, been a place of considerable resort, being conveniently situated for sea bathing, and well furnished with good Inns and lodging houses. And from it as a centre the various surrounding scenery and other objects of curiosity may be visited with facility.

A few of the most interesting objects may be noticed here, viz. About 6 miles from Bangor on the Capel Curig road, is the Penrhyn Slate quarry which is particularly deserving of a visit, it presents an uncommon display of enterprise and industry, upwards of 1500 men being constantly employed in it. The vast excavations which have been made in the bowels of the mountain forms a scene truly grand and interesting.

Three miles above the quarry are two fine lakes, the Ogwen, and Idwal, they afford excellent sport to the Angler, as they abound with very fine trout. And being environed with lofty and precipitous mountains exhibit a wild and romantic scenery.

At the distance of ten miles on the way to Snowdon are the beautiful lakes of Llanberris, where there are two Inns for the accommodation of those who wish to ascend that mountain.

Plasnewydd, a fine seat of the Marquis of Anglesey lies on the north side of the Menai, with fine woods on three sides, the lawn in front sloping to the edge of the water. Near the house are two Druidical altars, this having been one of the last retreats of the Druids in ancient times.

**ABER.** Six miles distant from Bangor on the Conway road is the much admired village of Aber, interesting as having been the residence of Llwelyn the last native prince of Wales, the scite of whose Castle, an artificial mound, is yet to be seen. About two miles from the village, amid grand mountain scenery, is one of the finest water-falls in the Principality, Four miles south of the waterfall is Garnedd Llwelyn whose altitude is 3516 feet. The river affords excellent Trout fishing, and Salmon are found in the deeper parts. There is good Grouse shooting on the neighbouring mountains, and several parts of the Crown lands are free. The Botanist, and Geologist will find ample scope for their researches in the district around. Aber affords a fine beach for sea bathing, and the accommodations at the Bulkeley arms Inn, kept by Mrs. Lewis will be found very superior, combining the comfortable retiredness of a private house and the conveniences of an Inn.

Conway, nine miles from Aber, is an object of curiosity as presenting the most perfect specimen of ancient fortification in Britain. The town is of a triangular form surrounded with high walls surmounted with 24 towers: its Castle is said to be the finest built by Edward the 1st. upon his subjugation of the country. The suspension bridge over the river Conway of 300 feet span is a work of great beauty.

Carnarvon 9 miles from Bangor, is celebrated for its ancient castle where the unfortunate King Edward the II. was born. The scenery between Bangor and Carnarvon is considered very picturesque.

Parties wishing to make excursions by water to Carnarvon, Plasnewydd, Beaumaris, Puffin Island or any intermediate place, may hire Boats at a moderate rate of Thomas Jones, Hiraef Bangor.