

Notes on the Tay Bridge Disaster of Sunday 28 December 1879

Firstly, I am going to show you 4 short videos by the OU which details various eminent people's views on how the Tay Bridge failed and lives were lost. You would think it quite simply for all the study and modern techniques in analysis for a defined answer but you have to make your own mind up.

Introduction

The 1840s in Britain had a decade of extraordinary expansion of the nation's rail network.

In Scotland the situation was in some ways even worse than in England.

In 1852 the *Railway Times*, writing about the Edinburgh Perth and Dundee line, complained that experience has shown that no railway contract is ever completed for the price for which it is undertaken.

Two railway companies of Caledonian Railway and North British were competing to provide a service from Edinburgh and the east coast to Aberdeen and the north of Scotland.

The Railway Bridge took:

- 600 men and six years to build
- It was the longest bridge at the time in the World

Upon completion in 1878, famous visitors, including the Emperor of Brazil, Prince Leopold of the Belgians and Queen Victoria herself, came to pay homage to the marvel of Victorian engineering.

On the night of 28 December 1879, the unthinkable happened, battered by an apocalyptic storm, the thirteen **high girders** of the rail bridge fell into the River Tay carrying with them a train, and all the passengers and crew. There were no survivors.

Sir Thomas Bouch

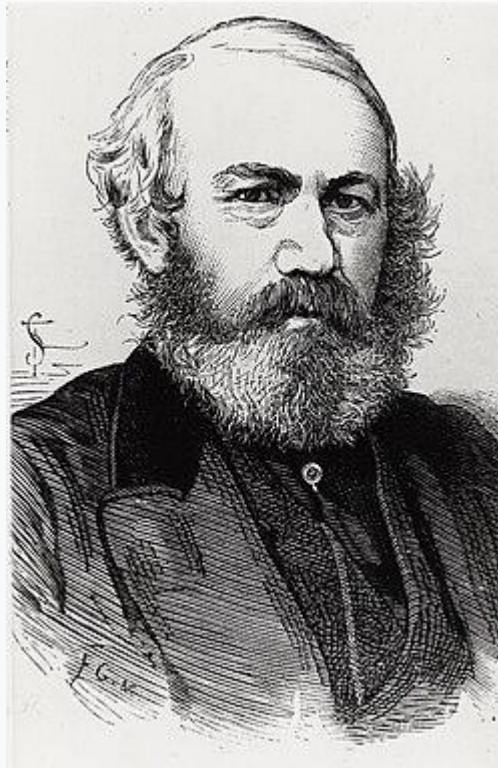
1822 - 1880

Engineer. Born in Cumbria (England), Bouch spent much of his life in Edinburgh. Along with Thomas Grainger (1794 - 1852), he was responsible for designing the world's first train ferry, the paddle-steamer *Leviathan*, which was built by Robert Napier (1791 - 1876) and ran between Granton and Burntisland. Bouch gained a reputation for building railways at minimal cost, which appealed to the railway companies and opened less valuable routes in the years following the initial boom in railway construction. Bouch achieved this by using single-track lines rather than double, timber bridges rather than iron, increasing the spacing between sleepers and using second-hand rails. Although capital costs were reduced, maintenance costs inevitably increased. He designed the first railway crossing from Edinburgh to Fife (which was never built) and, infamously, the railway bridge across the River Tay, which collapsed in a storm in 1879, just months after it opened and Bouch was knighted by Queen Victoria. His design was blamed for this disaster and Bouch was disgraced, although corner-cutting by contractors, in an attempt to save money, sloppy working practices and poor maintenance were significant contributory factors.

He designed the Leven Branch of the North British Railway (1854) and the Penicuik Railway in Midlothian (1872), together with the first viaduct across Bilston Glen in Midlothian (1873), and his Ferryden Viaduct (1879) near Montrose is still used, but the associated South Esk Viaduct (1880) failed extensive testing following the collapse of the Tay Bridge and was immediately redesigned. Bouch also designed a pleasure pier at Portobello, which was demolished in 1917, the Leven Railway in Fife and the South Suburban Railway in Edinburgh.

His reputation destroyed by the Inquiry into the Tay Bridge Disaster, he retired a broken man to his country home near Moffat, where he died. Bouch is buried in Edinburgh's Dean Cemetery.

Sir
Thomas Bouch



Born 25 February 1822
[Thursby](#), Cumberland, England

Died 30 October 1880 (aged 58)
[Moffat](#), Scotland

Engineering career

Discipline Civil engineer
[Structural engineer](#)

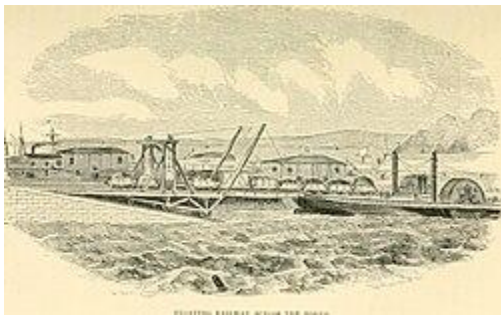
Institutions Institution of Civil Engineers (Associate 1850, Member 1858)

Projects [Waverley Station](#), [Tay Rail Bridge](#)

Sir Thomas Bouch

(22 February 1822 – 30 October 1880) was a British [railway engineer](#). He was born in [Thursby](#), near [Carlisle](#), [Cumberland](#),^[1] and lived in [Edinburgh](#). As manager of the [Edinburgh and Northern Railway](#) he introduced the first [roll-on/roll-off train ferry](#) service in the world. Subsequently as a consulting engineer, he helped develop the [caisson](#) and popularised the use of [lattice girders](#) in railway bridges. He was knighted after the successful completion of the first [Tay Railway Bridge](#), but his reputation was destroyed by the subsequent [Tay Bridge disaster](#), in which 75 people are believed to have died as a result of defects in design, construction and maintenance, for all of which Bouch was held responsible. He died within 18 months of being knighted.

Early career



Bouch's pioneering [ferry ramp](#)

Bouch's father (a retired sea-captain) kept the Ship Inn at Thursby and Thomas was educated locally (Thursby and then Carlisle) before at the age of 17 beginning his [civil engineering](#) career as assistant to one of the engineers constructing the [Lancaster and Carlisle Railway](#). After a short spell working in [Leeds](#) (1844–45) he was for four years one of the Resident Engineers on the [Stockton and Darlington Railway](#), leaving in 1849 to become manager and engineer of the [Edinburgh and Northern Railway](#), one of the precursors of the [North British Railway](#).^[1] He introduced the first roll-on roll-off train ferries in the world, across the [Firth of Forth](#) from [Granton](#) to [Burntisland](#) in Fife (3 February 1850.) Others had had similar ideas, but Bouch put them into effect, and did so with an attention to detail (such as design of the [ferry slip](#)) which led a subsequent President of the [Institution of Civil Engineers](#)^[3] to settle any dispute over priority of invention with the observation that "there was little merit in a simple conception of this kind, compared with a work practically carried out in all its details, and brought to perfection."^[1]

Railway and bridge designer

Bouch then set up on his own as a railway engineer, working chiefly in Scotland and Northern England. Lines he designed include four connecting lines all built by separate companies, which together allowed a direct connection between the West

Cumbrian [haematite](#) mines and the area served by the Stockton and Darlington (which was behind them):

- the [Darlington and Barnard Castle Railway](#) (20 miles, completed 1856)^[4]
- the [South Durham and Lancashire Union Railway](#) (from a junction near [West Auckland](#) via [Barnard Castle](#), over [Stainmore](#) via [Kirkby Stephen](#) to a junction with the [West Coast Main Line](#) at [Tebay](#) (50 miles, completed 1861 (Barnard Castle – Tebay) 1863 (remainder), total cost £666,879^[4]) This included [his viaduct over the Gaunless](#).)
- the [Eden Valley Railway](#) (Kirkby Stephen to Penrith, 22 miles, completed 1862, cost £204,803)^[4]
- the [Cockermouth, Keswick and Penrith Railway](#) (31 miles (including 135 bridges), completed 1864, constructed for £267,000^[5])

His response to a toast at a dinner after the cutting of the first sod on the Eden Railway gave his philosophy on the engineering of those lines:

The works were all of a light and inexpensive character, and if he gave them a first-class railway, - one upon which any speed attainable by a locomotive engine could be run with perfect safety and ease - if he gave it without any extravagance, then he should only have done his duty, but if he failed then he should deserve all the obloquy and discredit attaching to the failure of light works. ... Mr Whitwell had spoken of his character as a maker of cheap railways, but in giving a cheap Eden Valley railway he had relied entirely upon the easy district, and not on inferiority of the works. The line would be carried out in the most permanent and substantial manner possible.^[6]

He made considerable use of lattice girder bridges, both with conventional masonry piers and with iron lattice piers; the most notable examples of the latter being on the Stainmore line: the Deepdale^[7] and [Belah Viaducts](#).^[1] A contemporary treatise on iron bridges^[8] praised the detailed engineering of the Belah viaduct piers (and described the viaduct as one of the lightest and cheapest of the kind that had ever been erected.)

Elsewhere, Bouch's forte was cheapness, and an ability to construct branch lines at a capital cost that might allow them to pay their way, especially if operated frugally (In 1854 Bouch advised the directors of the Peebles Railway that the company should work the line themselves, as they could do so much more economically than a large undertaking.)^[5] Examples included branches to [St Andrews](#), to [Leven](#), and to [Peebles](#), the Peebles line being described in his obituary as "long the pattern for cheap construction".^[1] This could leave over-optimistic clients with a railway designed and built to a price and not making enough money to support proper maintenance (and hence laying up problems for itself as an accident on the St Andrews Railway^[9] showed).

Bouch did the initial survey for the [Edinburgh Suburban and Southside Junction Railway](#), laid out tramway systems in Edinburgh, Glasgow, Dundee and London, and designed the [Redheugh viaduct](#) a road bridge across the Tyne at the same height as and not far upstream of Stephenson's [High Level Bridge](#). He also designed [Hownes Gill Viaduct](#) in [Consett](#), County Durham, which at 700 feet (210 m) long and using a 12-arch

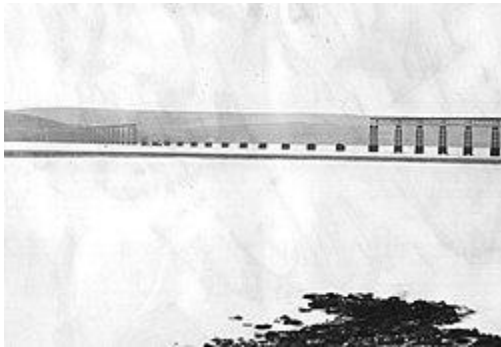
design constructed in brick, carried the [Stanhope and Tyne Railway](#) 175 feet (53 m) above Hownsgill. Today it forms part of the [Sea to Sea Cycle Route](#).

Bouch returned repeatedly to the problem of bridging the two great East Coast firths. Eventually authorisation was given to bridge both the Tay and the Forth; in both cases Bouch was the engineer selected to design the bridge.

Tay Bridge



Original Tay Bridge from the north



Fallen Tay Bridge from the north

Bouch designed the first [Tay Rail Bridge](#) while working for the North British Railway, and the official opening took place in May 1878. [Queen Victoria](#) travelled over it in late June 1879, and she awarded him a [knighthood](#) in recognition of his achievement. The bridge collapsed on 28 December 1879, in the [Tay Bridge disaster](#), when it was hit by strong side winds. A train was travelling over it at the time, and 75 people died.

The subsequent public inquiry revealed that the contractors to the railway company sacrificed safety and durability to save costs. Sloppy work practices, such as poor [casting](#) of the metal, and the re-use of [girders](#) dropped into the estuary during construction, were factors in the bridge's collapse.

The minority report of the inquiry concluded that the bridge was "badly designed, badly built, and badly maintained". The entire "high girders" section, in which trains ran inside the girders rather than on top of them, fell during the accident, taking the train with it. Analysis of the archives has shown that the design, which featured [cast-iron](#) columns with integral lugs holding the tie bars, was a critical mistake, because cast iron is brittle under tension. Many similar bridges had been built using cast-iron columns and [wrought iron](#) tie bars, but none used that particular design detail. [Gustave Eiffel](#) built many such bridges in France in the 1860s, some surviving and still carrying railway traffic.

Being the engineer, Thomas Bouch was blamed for the collapse of the Tay bridge. His assistant, [Charles Meik](#), conveyed the impression that he "was aptly named", implying that he had no real influence over the design and construction.

Sir Thomas Bouch was blamed for the failure of the bridge.

- For the faults in design, he was entirely responsible.
- For the faults in construction, he was principally responsible.
- For the faults in maintenance, he was principally responsible.

Bouch assumed 20 lbs per square foot of wind loading to the bridge. (in an estuary). In France at the same time, they assumed 55 lbs/ square foot and in America they had an allowance of 50 lbs per square foot.

We must remember that there was ***no computers, no British Standards and structural design was in its infancy.***

The river bed site boreholes were wrong and bed rock much deeper than initially thought which changed the brick piers to lighter cast iron columns and wrought iron bracing tie rods.

Using the modern wind loading code (CP3) showed that the true loading on the bridge was 7 times greater than the wind loading used by Bouch. CP3 was published in 1944 and amended in 1972.

Computers for structural analysis started to develop in the 1960s.

Bouch was many decades before these design aids available to engineers.

Even although the bridge was constructed correctly and good materials used the wind would have brought it down without to effect of the train?

Thomas Bouch had many successful bridges to his credit, including two similar in design to the Tay Bridge in the North of England. These bridges carried railway traffic until they were demolished in 1962.

For most of his life Bouch held the view that contemporary structures were over designed, and he introduced considerable refinements of material into both his masonry and iron bridges. No guidance was available to the engineers and design was dominated by rule of thumb and practical experience rather than accurate calculations. Brunel and Stephenson's also had their failures although not to the same scale.

The Tay bridge was inspected and passed by the Board of Trade. The Inspector was Major- General C.S. Hutchison, RE. The bridge was tested by running six coupled good engines over it and measuring the deflection of the girder span.

He was satisfied but added:

I should wish, if possible, to have an opportunity of observing the effects of a high wind, when a train of carriages is running over the bridge.

Troubles Loom

All was not well with the Tay Bridge, however. The cast iron columns had been filled with concrete and were said to be cracking in various places. Contemporary accounts state the concrete was expanding and bursting the columns. The winter of 1978-79 was exceedingly cold and it was also said that the iron was cracking by shrinking onto the concrete.

Further, many of the lugs holding the bracing were snapping off, due it was said to having been burned on afterwards instead of cast integral with the column. The bracing itself was loose in places owing to the cotter connection being vulnerable to vibration. Local enthusiasts timed the trains as they raced the ferry, and found they were travelling at over 40mph.

Bouch had the cracked columns strapped with iron bands, and seemed not to worry since, he claimed, Brunel had had the same trouble at Chepstow. Other repairs were carried out to the bracing by the contractor's foreman, who (it transpired later) had an uneasy conscience about the casting, and did the repairs at his own expense without informing Bouch. The bridge maintenance continued in this haphazard fashion and the railway company seemed unaware of the situation.

Aftermath of the disaster

South Esk Viaduct

After the inquiry, Bouch rapidly removed and reinforced similar lugs on the new bridge he had built, the [South Esk Viaduct](#), at [Montrose](#), but after another inspection, the bridge was demolished and replaced.

Tay Bridge

The remains of the original Tay bridge were demolished and replaced by an entirely new design by [William Henry Barlow](#) and his son Crawford Barlow. Some of the [wrought iron](#) girders were re-used in the new double track bridge by cutting them in half and re-welding to form wider structures for the track. The brick and masonry piers from the old bridge were left as [breakwaters](#) for the new piers, which were [monocoques](#) of wrought iron and steel.

Forth Bridge

Bouch's design for a [suspension bridge](#) to take a railway across the [Firth of Forth](#), had been accepted and the foundation stone laid, but the project was cancelled following the [Tay Bridge disaster](#). One of the piers still remains at the site. A different design,

a [cantilever bridge](#), was drawn up by [Sir Benjamin Baker](#) and [Sir John Fowler](#). The [Forth Bridge](#) was completed in 1890.

Other works

Bouch also seems to have been involved in the design of pleasure piers. He designed [Portobello Pier](#) in 1869, which opened in 1871. The structure rusted badly and by 1917 was uneconomic to repair and was demolished.^[10]



Bouch's tomb in the [Dean Cemetery](#),
Edinburgh

Family

Thomas was a brother of [William Bouch](#), the railway engine designer.^[11] Thomas married Margaret Forrest in Longtown, Cumberland, in early 1856. There were three children: Fanny, born 1854; Elizabeth Ann, born 1856; William, born 1859.^[12]

Death

Thomas Bouch bought a country house in [Moffat](#), "his health", already not good, "more rapidly gave way... under the shock and distress of mind" caused by the disaster. However, he kept offices in Edinburgh, at 111 George Street, his Edinburgh address being 6 Oxford Terrace, near [Dean Bridge](#).^[13]

He died at his house in Moffat on 30 October 1880 a few months after the public inquiry into the disaster finished.^{[1][14]} He is buried very close by, in [Dean Cemetery](#). "In his

death", said the journal of the [Institution of Civil Engineers](#), "the profession has to lament one who, though perhaps carrying his works nearer to the margin of safety than many others would have done, displayed boldness, originality and resource in a high degree, and bore a distinguished part in the later development of the railway system".^[1]

Victims of the Tay Rail Bridge Disaster

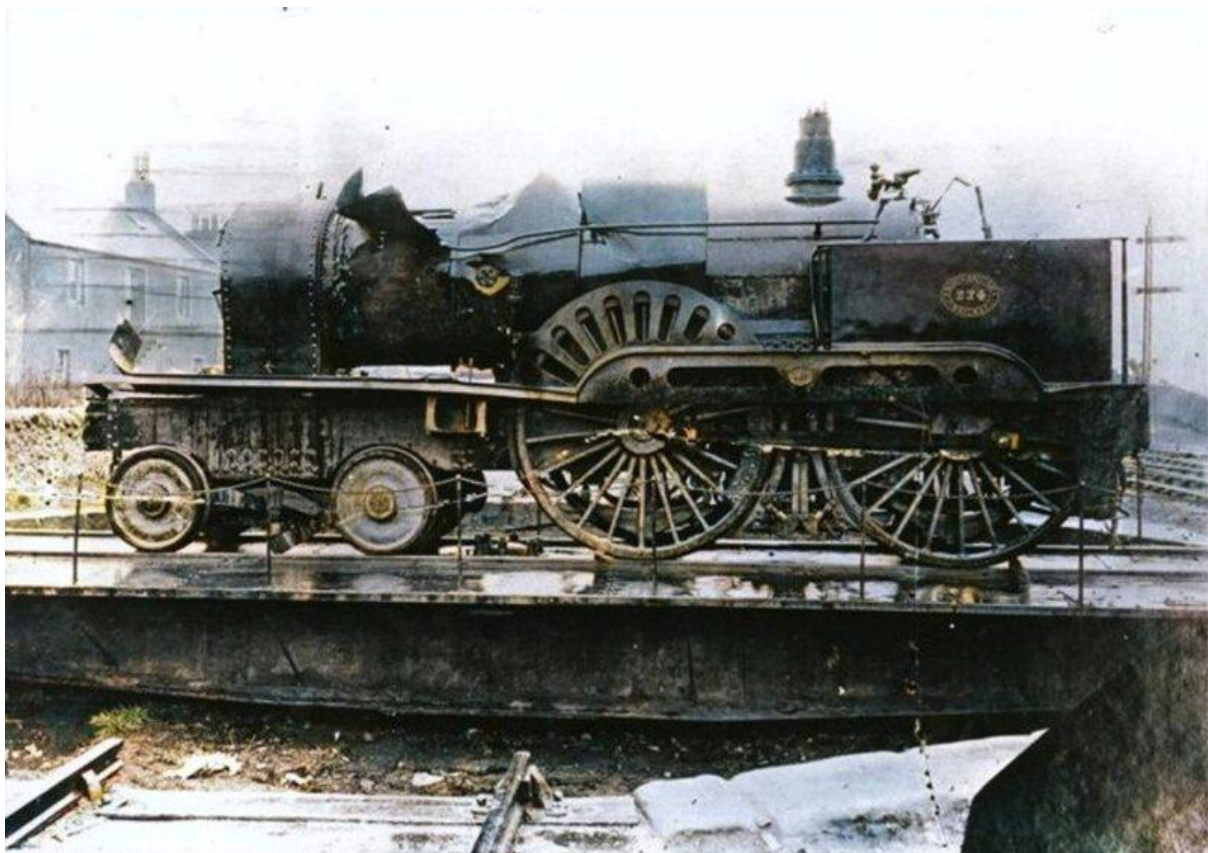
The official records of the enquiry list the 59 victims, 47 male and 12 female.

Many of the victims are buried in Dundee and Fife in unmarked graves mostly in the Eastern Necropolis, in Dundee where many of my family members are buried.

There was a Disaster Fund raised and the victims' dependents made an application for some support.

There may have been those whose body was not recovered and no one came forward to say they were missing after the Disaster?

As late as 1988 there existed a fund of some £4068 held by the local authority and this was passed to the Piper Alpha Oil Rig disasters fund.



Engine 224 was recovered from the river bed, repaired and continued in service for many years. It was nicknamed ***The Diver***.

Lucky People

John Courts

For some, the hand of fate intervened.

Cupar man John Courts was an apprentice at a tobacconist shop in Castle Street.

John, aged 18, was requested by his employer to go to Dundee on the Sunday night.

When he arrived at Cupar Station the train for Dundee had just started moving away from the platform and despite a mad rush he was unable to get aboard.

This was the first time in his apprenticeship that he had missed the train.

John no doubt cursed his luck, but missing the train saved his life.

Peter Pollock

It was a few pints too many that saved well-travelled sailor Peter Pollock.

Peter, a ship's carpenter by trade, wanted to celebrate his forthcoming wedding but you couldn't get a drink on a Sunday unless you were a "bona fide traveller".

He took the ferry across to Newport, sought out a hotel and immediately started to say farewell to his bachelor days.

Needless to say, he got somewhat inebriated in a very short space of time.

Later, he decided to make his merry way back to Dundee, but at Newport pier he found the rising storm had forced the ferry to stop operating.

He made his unsteady way to St Fort to grab the last train home.

Peter bought a ticket for the train and climbed aboard.

Just before it moved off, however, the station master spotted him weaving about and put him off the train. This drinking and the action of the Station Master saved his life!

Recent Bridge design issues

Temple Bridge

A pedestrian only bridge allowing walkers to cross the Thames at Hurley, Berkshire. It was a haunched girder bridge with a wooden deck and at 150 feet 946m) it is the longest hardwood bridge in Britain. It was opened on 24 May 1989 by Lord Hesketh.

In May 2019 the bridge was declared unsafe and closed to pedestrians. It was repaired and reopened in June of that year.

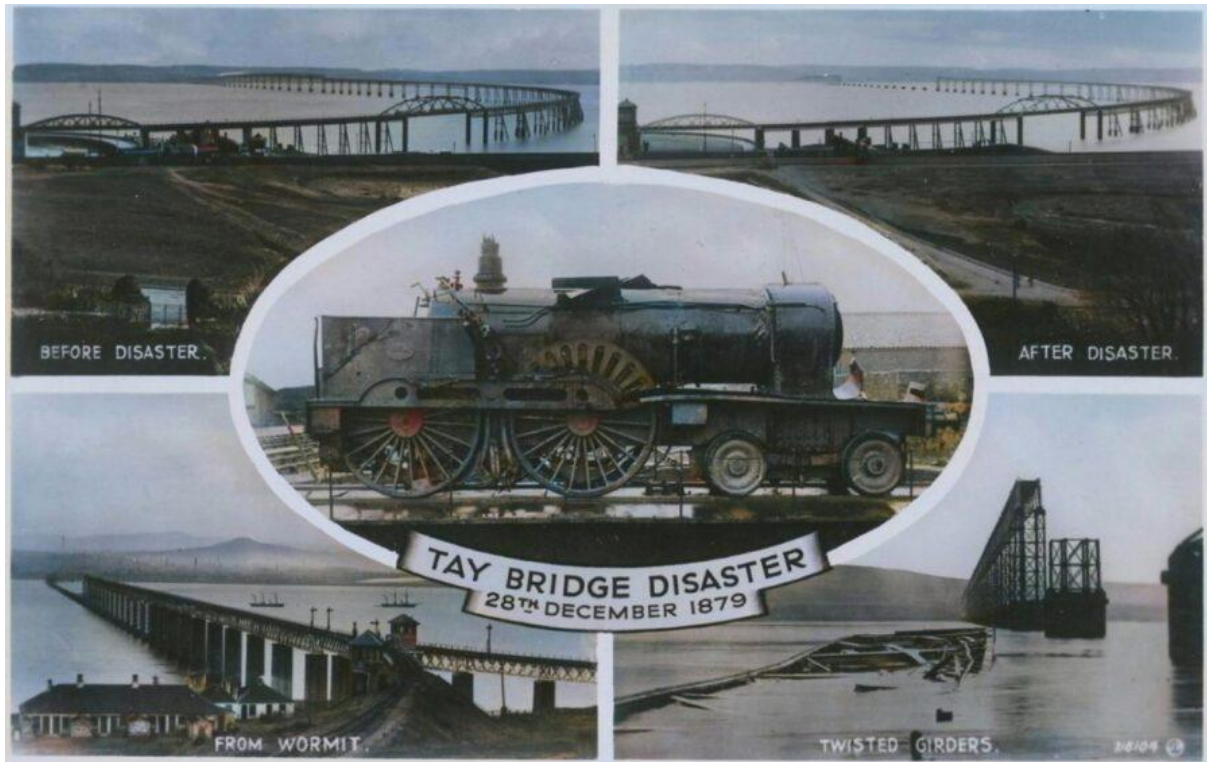
In September 2023 the Environment Agency further repairs are required and large sections of the bridge removed between Nov 2026 and Feb 2026 and it was declared that the components had deteriorated beyond the point of economical repair. The bridge is to remain closed for months.

Millennium Bridge, London

This bridge crosses the Thames around St Paul's Cathedral and Londoners nicknamed it the **Wobbly Bridge**.

After opening in 10 June 2000 unexpected lateral vibration due to resonant structural response caused the bridge to be closed on 12 June for modifications. They tried to limit the number of people crossing the bridge but this led to long queues but it was ineffective to dampen the vibrations. Public Criticism followed. This lateral vibration in light-weight bridges are well known as recent problems occurred on the Auckland Harbour Bridge 1975 and Birmingham NEC Link bridge.

Apparently if the bridge has a lateral frequency of less than 1.3Hz and sufficiently a low mass can experience these Wobbles.



A postcard from Valentine's issued after the Tay Bridge Disaster. Image: Supplied.