

Postage Department Board of Trade
Whitchurch 22nd November
1859.

Sir. I have the honor to acquaint you for the information of the Lords of the Committee of Privy Council for Trade, that I have re-inspected the Permanent Bridge for carrying the Worcester and Hereford Railway over the River Severn at Worcester.

In reference to the short description of this Bridge given in my report of the 29th ulto, I should explain, that the Cast Iron arched ribs, which each support a line of rails, are cast in four pieces of the length of somewhat over 31 feet, and these pieces are bolted together at the Haunches and Crown of each arch. The depth of each rib is 24 inches and the sectional area is 79.2 inches. The Gender over each arched rib is cast in three pieces, which are bolted together, and it rests on and is screwed down to the top flanges of the arched rib and spandrels. Its depth is 20 inches and the sectional area is 34.₃ inches.

I tested this Bridge with similar weights to those used on the last occasion - but as the results then obtained differed considerably for the two arches - the weight was slightly changed. Three Heavy Locomotive Engines and Tenders were used for the South Road and a

Train of Ballast Waggons with a small Locomotive
for the North Road - Both Trains are stated to
weigh as much as $1\frac{1}{4}$ ^{Ton} per foot lineal - and
it is possible that the Locomotives exceed that weight.

The approximate weight of the iron work in one
span, is stated to be about 160 Tons; and the Total weight
of the Iron work and Permanent way in the Bridge is said
to be 330 Tons. The height of the springing of the arches
in the drawings forwarded to the Board of Trade, is
represented as about 30 feet above the Level of the Water.

In consequence of the scaffolding used for the erection
of the Bridge having been removed, the deflections of the
arches were observed by means of a Spirit Level and
Levelling Staff - and, when I made my former inspection
the Staff was placed on the transverse ^{which is} Deck Planking
secured to the Top Flange of the Girders, and carrying the
^{midway between the two Lines.}
Ballast and Permanent Way. On this occasion, holes
were made through the planking, and the Levelling Staff
was held on the tops of iron rods passed down through these
holes, and resting on the flanges of the arched ribs.

The deflections of the North Rib of the South Road
only were observed, the Levelling staff being successively
held over the Haunches and at the crown of each arch.

The Rolling Loads for both Lines of Railway were
simultaneously brought from the West side of the Severn

up to the west Haunch of the Western or Hemwick arch of the Bridge, and a series of readings of the Levelling staff observed. The load was then brought farther on the arch up to its centre, and another series of readings noted - proceeding in this manner, from the west towards the East, until the effect of placing the load on different parts of each Arch had been observed.

The longitudinal position of the Girders was also noted from time to time as the load was shifted.

The observations with the Spirit-Level, placed in the 6 foot space on the East side of the River, were read by Mr. Richard, Brother of the Resident Engineer, and verified by myself - checked also by the independent readings of another observer with a different Spirit Level placed close to the other - so that I have every confidence that no material error exists in the readings of the Levelling Staff. The deflections would undoubtedly have been more satisfactorily determined by a different class of observation, if the Scaffolding had remained up.

I annex an abstract of the results obtained from these observations - but without enumerating them ⁱⁿ detail, I should state, that when the Rolling load was placed at rest on the Western or Hemwick Arch, the deflection at each of its Haunches amounted to 1.08 inch, and to 1.56^{nd.} at the Centre - the Eastern or Worcester Arch being at the same time raised up, at its west Haunch 0.36 inch, at its centre 1.26 inch, and at its East Haunch 0.84 inch.

Again, when the Rolling Load was placed on the Eastern or Worcester Arch, the deflection on its western Haunch was .96 inch - on the centre arch, was 1.74 inches and on the eastern Haunch 1.20 inches - while the Western or Henwick Arch was raised up 0.40 inch at its west haunch, 1.32 ^{inch} at the centre and 0.72 inch at the east haunch - thus a total vertical movement of 2.88 inches took place at the crown of the western arch, and of 3.0 inches at the crown of the eastern arch.

The vertical movements of the cast iron arched ribs are accompanied by a longitudinal horizontal swaying to and fro of the riders, resting on the crowns of the arched ribs and on the spandrels of the two arches, the guides moving simultaneously with the arches, to the extent of about $\frac{3}{4}$ inch.

I also ascertained by observations made with a theodolite ^{placed} ~~for~~ on a quarry a short distance from the Bridge that the pier swayed and ~~for~~, according to the position of the Rolling Load, but I had no means at hand, available for measuring the exact quantity.

It is possible and likely that these quantities would be sensibly increased by the passage of trains at speed over the Bridge.

On examining the arch ribs when the rolling load was on the arch, it was apparent that the whole of the sectional area of the rib (79.2 inches) was no longer in a state of compression at the crown of the arch, as light could be seen through it, nearly halfway up the depth of the arched rib - and this occurred when the load was evenly distributed over the arches, and when the deflections were respectively 1.56 and 1.74 inches - there was no apparent change at the haunches.

It is also manifest from the measurements recorded in the abstract of the observations, that even a small load is sufficient to produce

distortion in the form of the arch on which it rests - but
this is far more apparent when the load is fully placed on one
Arch and not on the other.

This distortion is the unavoidable and necessary result
of an insufficient depth and insufficient sectional area
of the arched ribs for so large a span (120 feet) and so heavy
a load - although that was not greater than might at any
time be brought upon ^{them}. The results obtained, would be very
suspicious and probably ^{dangerous}.
Scarcely admissible for a simple wrought iron beam bridge,
and ^{they} are altogether beyond what should be found
in an arched bridge.

Under these circumstances, I have only to report, that
as constructed, the Bridge is too weak, and that the opening
of this Permanent Bridge for carrying the Worcester and
Bewdley Railway over the River Severn at
~~Gloucester~~^{Worcester}, would, by reason of the incompleteness
of the works, be attended with danger to the
Public using the same.

I have the honor to be,

Yours truly,

Your most obedient Servt.

J. Holland Colcl
Royal Engineers

Abstract of the Results of the Observations made on the 16th November 1859
 for determining the deflections and elevations of the Haunches and Crowns
 of the Cast Iron Arched Railway Bridge over the Severn at Worcester,
 and also of the longitudinal movements of the ends of the Girders - compared
 with the state of the Bridge without any load upon it.

The deflections are marked +

" Elevations " -

A movement of the Girder Eastwards is marked E.

.. Westwards .. W

Weight brought up
 from the Midspan
 up to and beyond
 immediately over
 the

	Western Arch Deflections &c			Eastern Arch Deflections &c			Movement of the Girders						
	West Haunch	Centre	East Haunch	West Haunch	Centre	East Haunch	West End of Bridge	South Girder	South Girder	Space between Girders diminished - increased +	West Girders	South Girders	East End of Bridge
West-Haunch of the Western Arch	+0.12	+0.0	-0.06		not observed		not observed	not observed	not observed	not observed	not observed	not observed	
Centre	+0.72	+0.60	+0.12		not observed		inch	inch	inch	0.37 E	0.75 E	-0.14	-0.08
East-Haunch	+0.96	+1.32	+0.72	-0.48	-0.96	-0.66	0.50 E	0.25 E	-0.03	-0.02	0.37 E	0.30 E	
Edge of Pier.	+1.08	+1.56	+1.08	-0.36	-1.26	-0.84	0.50 E	0.37 E	0.0	+0.04	0.50 E	0.30 E	
West-Haunch of Eastern Arch.	+1.08	+1.44	+0.96	-0.36	-1.08	-0.90	0.12 E	0.37 E	+0.05	+0.08	0.50 E	0.30 E	
Centre.	+0.42	+0.84	+0.72	+0.24	-0.30	-0.60	not observed	not observed	not observed	not observed	not observed	not observed	
East-Haunch	-0.36	-0.66	-0.06	+0.84	+1.32	+0.48	0.12 W	0.25 W	not observed	0.12 W	0.42 W		
Edge of East Butment	-0.48	-1.32	-0.72	+0.96	+1.74	+1.20	0.25 W	0.37 W	+0.02	+0.02	0.50 W	0.40 W	

J. Holland C. J. G. J.