Input 6 Stephenson's failed Dee bridge

One of the grandest railway projects was conceived by Robert Stephenson in 1838, to strike northwest from London to Holyhead in Anglesey. While it would require giant bridges across the Menai Strait, the tidal river Dee at Chester would also need bridging. Following approval by Parliament in an act of 1845, cast-iron beams were laid across the river near the city and the bridge finished by the end of 1846. It was inspected and approved for traffic shortly after.

Less than a year later, on 24 May 1847, disaster struck. A passenger train had almost crossed the structure when the final span suddenly collapsed. The driver felt it give way under the locomotive, and increasing speed, just reached solid land at the far side of the bridge. Unfortunately, the tender and train did not make it, and fell about 30 feet to the river below. Five people were killed and many injured. Independent investigation by the railway inspectors showed the outer beam had fractured at its centre, on the tension side of the structure (**Figure C9**).

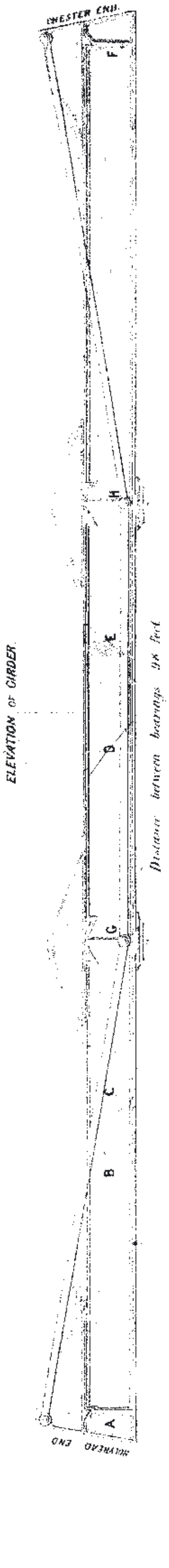

Figure C9 Section of the Dee bridge

The design of the beam had been used in smaller spans in previous bridges without failure, so what caused failure on the Dee? The beam had an I shape in cross-section and was bolted together from three beams. It was reinforced with longitudinal wrought iron straps, which were attached at either end to the cast-iron beam. However, the beam was not strong in tension and fractured in a brittle way near the centre of the span.

The rails were fixed to planks laid on oak joists, which sat on the lower flanges of the cast-iron beam (**Figure C10**). As a precaution against fire, 18 tons of ballast had been deposited over the planks just before the accident.

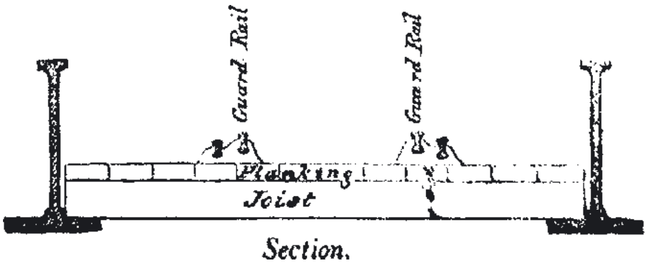

Figure C10 Broken south beam from Dee bridge

Six trains had passed without problem just before the stone was laid. One of masonry abutments had also broken in the accident, but the investigators saw it as an effect of the beam fracture, not its cause.

Lateral movement was supposed to be restricted by lateral wrought iron tie bars, but Captain Simmons of the Royal Engineers noted that they could move 0.75 inch in their dovetailed sockets. In addition, the failed girders were not exactly straight when cast.

Although fatigue was not appreciated at this period, the investigators hinted that 'repeated use' could have weakened the beam. No hollows were found in the metal, however. The estimated load at failure was much lower than the maximum design load.

In anticipation of the Tay bridge disaster later in the century, Stephenson and others alleged that the tender left the rails and struck the bridge, so initiating the failure. This was disproved, and the jury in the subsequent inquest agreed with the investigators.

All bridges of similar design were strengthened, and the Board of Trade initiated a series of tests to provide more realistic design rules in using cast-iron. Stephenson never used cast-iron again, starting his own experiments on wrought iron, which he used successfully in the hollow tube monocoque structure of the Britannia and Conway bridges. The extra material costs were large, compensated by the greater margin of safety.