Hanover Courier, Tuesday 6 January 1880, Morning edition, number 10113, page 5

"The Tay Bridge and the probable cause of its collapse"

The following message has been sent to us by the Director of the Technical College, Professor Launhardt:

The estuary mouth of the Tay Bridge forms a long bay, one of many found in Scotland and known as a firth. The Tay, near the city of Dundee on the north bank of the river, is 3¼ kilometres wide, has a water surface of 14 metres and a usual tidal change of 5.2m. Before completion of the bridge, which began in July 1871 and opened to traffic in February 1878, trains of the North British Railway would be carried over the Tay by a steam ferry. The associated inconvenience and loss of time prompted the company to build the bridge, for which the engineer Sir Thomas Bouch produced a design. The bridge, most of which is in a straight line, connects to both banks with curve of 402 metres radius, so that it forms an elongated S-line. The total length of the bridge is 3155m, divided into 85 openings, the spans of which are arranged in different sizes depending on the nature of the subsoil. The bridge is 26.8 meters above the high-water mark so that high-masted ships can pass underneath. The bridge was constructed only for a single rail track, with a narrow width of 4½ meters. On the smaller side openings, the rail track lies above girders and is bordered only by low ground. In the middle there are 13 large openings, which collapsed in the accident. Of those, 11 have a 74m span and two a span of 69m; there, the track lies instead below, between the approximately 8-metre-high load-bearing walls. This was done in order to keep the full height underneath the rail track free for the passage of ships. The columns of these openings were thus about 5m higher than those at the sides. The span of the individual openings, even the larger ones, is modest, as double-span bridges of are constructed in many cases, and suspension bridges might be even more than five or six times the width. The bridge attracted the attention of engineers from the outset of construction, partly because of its considerable length, which few other bridges even remotely match, but particularly because of the extraordinarily slender form of the pillars and their foundations. During construction, the method of creating the foundation repeatedly changed based on experience. Foundation work was carried out in an entirely solid manner. According to the reports available so far, the foundations and the parts of the column that reached above the high-water mark remained completely intact. Similarly, the construction of the bridge girders, which run from pillar to pillar, was competently carried out, such that a rupture of these girders under the load of the train carriages was not to be suspected in the least. The fault in the structural disorder of the bridge, which has undoubtedly become the cause of this terrible misfortune, lies in the form of the columns, which are too slim and afford too little resilience to withstand the lateral attack of a storm. According to the original design, all column parts above water should be made of brickwork, as was the case for the side openings that did not collapse. These pillars consist of two circular, brick-lined columns with a 2.6m diameter, connected by a wall of a thickness of only 76cm, so that at the considerable height of 22m, on the outside these pillars look like two factory chimneys standing side by side. For the larger openings in the middle with a height of about 27m above water, the columns should have a diameter of 4.1m at their base and 3m at the top. Even with such bold and daring measurements, the central pillars would probably have remained standing, as was the case with the bricked-up columns of the openings at the sides. When the works were transferred to a new contractor in 1876, however, the construction of these central pillars was changed. Although the type of foundation was improved, the pillars were arranged in a fatal manner. According to the new plans reported in English technical journals in 1876, masonry of the pillars was to extend only to 1.5m above the high-water mark. On top were six cast-iron columns of 46cm and 38cm diameter, respectively; attached to these delicate columns of approximately 25-metre height, were the bridge girders. The cast-iron pillars are admittedly of the type used, in similar disorder, in viaducts in England, France and Austria, even at greater heights - though almost always with broader bases. Here, the iron pillars were clearly unable to offer sufficient steadfastness against the fierce storms, which often rage along the Firth of Tay with terrible violence.

If the windthrow in a violent storm is calculated at 150 kilograms per square metre - as has been observed in individual cases even in Central Europe – then girders with an open width of 74m, which offer wind an area of attack of at least 300m², would receive a windbreak of 45,000kg or 45 tons. Such a windthrow would already topple the girders from the columns - although the columns could remain intact - if this is not prevented, as may be expected, by the way the girders are borne by the pillars. The foot of the pillar lies 1.5m above high water; there, the windthrow hits a lever arm of 28m, reaching a moment of toppling of 28.45 = 1260 metric tons. This increases to at least 1300 metric tons including the windthrow hitting the pillar itself. The weight for one opening is a maximum of 200 tons; the weight of one pillar is a maximum of 110 tons, thus with a pillar width of 7m in the direction of the river the steadfastness of the column is ½. 7. 310 = 1085 metric tons. At the moment of the wind's attack, the excess on the pillar resilience (1300-1085 = 215 metric tons) must be absorbed by the lower studs, by means of which the cast-iron columns are attached to the brick plinth. As a result, these lower studs received an acute tension of 30,700kg; this must have pulled out the bolts along with the blocks in which they were affixed. Even with a windthrow lower than the assumed 150kg/m2, the bridge could therefore already be toppled over. If the bridge did hold its position, the crossing of the train would pose even more danger. The train, consisting of 7 carriages and with a weight that can be estimated at a maximum of 140 tons, offers the wind an enlarged surface area of attack, calculated to be at least 180m2. This means that the moment of the wind's attack increases to 2036 metric tons, while the steadfastness of the pillar increases to 1575 metric tons. With the train on the bridge, even a windthrow of 120kg/m2 could cause the collapse of the bridge. With the collapse of the span carrying the train, the neighbouring spans had to follow, partly because the train kept moving while it overturned; and partly because every four spans were built to join together, and even the remaining spans were connected by the lines of the track.

For the reconstruction of the bridge, in the first instance the pillars will need to be made stronger. It is advisable to reduce the number of openings, thereby increasing the width of the individual spans and increasing their weight, on which their steadfastness depends.

Had the bridge had been built as a twin-track, instead of the narrow width of one track, the resulting doubled width and doubled weight would have had four times the steadfastness, and the bridge would have been adequately secured against the assault of the storm. Among the many important iron bridges of Germany there is fortunately not one which would be exposed to similar dangers during storms. However, this terrible accident may be cause enough to carefully examine the smaller and therefore lighter iron bridges concerning their safety in the face of storms.