THE TAY BRIDGE DISASTER.

Since the cable brought across the Atlantic the terrible account of the destruction of the Tay Bridge and the entire loss, with all the persons on board, of a train crossing the Frith of Tay from the south on its way from Edinburgh to Dundee, much of the mystery attending its sudden failure has been cleared. The technical journals of England, notably *Engineering* and the *Engineer*, have naturally taken up the subject with much earnestness and zeal. In view of the incompleteness of details, and also of the fact that an investigation by eminent experts is being made under the auspices of the Board of Trade, they have wisely abstained from committing themselves to any pet theory, and it would be manifestly unfair to attempt to pass judgment on this side of the Atlantic. We are not inclined to make this sad occasion one of retaliation for many slighting remarks which English engineers have too often ventured unwisely on American engineering skill and practice. The fall of a structure which has been long regarded as a crowning monument of modern engineering is a fearful warning which no one should affect to be able to disregard, and public confidence has suffered a severe shock which has given rise to earnest, though misplaced, expressions of distrust in this country also. We believe that the cry of "what next?" and the wholesale condemnation in which the daily press, notably, indulges so freely, is calculated to do much more harm than good. We shall confine ourselves for the present to as full a representation of the facts brought to light until now in connection with the catastrophe as we are able to obtain, reserving for a future occasion a summary of the conclusions to be drawn from it. For the data and the illustrations we now publish we are mainly indebted to the publications mentioned above. It appears that no complete account of the whole structure as finished has appeared in any of the transactions of technical bodies or in the journals devoted to engineering, because important changes were made both by contractors and engineers to meet unexpected difficulties. This is true not only as regards the position of the piers, and consequently the length of the girders, but also as to many of the details, which appear to have been modified as the expediency of alterations was suggested during the course of erection. As an example, we may state that, instead of the 13 large girders, each 245 feet in length, originally projected, 11 only were put in accordance with the first design, while two were reduced in length to 227 feet. This circumstance naturally introduces into all discussions possible at the present moment an element of uncertainty, which is much to be regretted. How far this deficiency may be met by records in the possession of the engineers and contractors connected with the building of the bridge, it is impossible to state at this juncture. As finally constructed, the bridge was 3,450 yards long, and consisted of eighty-five spans of the following dimensions: Eleven spans of 245 feet each; two spans of 227 feet each, lattice girders; one bowstring girder of 166 feet, one span of 162 feet 10 inches, thirteen spans of 145 feet each, ten spans of 129 feet 3 inches, eleven spans of 129 feet each, two spans of 87 feet each, twenty-four spans of 67 feet 6 inches, three spans of 67 feet, one span of 66 feet 8 inches and six spans of 28 feet 11 inches, all lattice girders—in all, eighty-five spans. In addition to which there are at the north end one span of 100 feet and three of 29 feet, plate girders. In the fifteen spans exceeding 145 feet, and on the 160 feet bowstring girders, wrought-iron cross girders have been used. In the rest of the structure, timber. In the case of the bowstring girders and the thirteen large spans, being those which fell, the roadway was carried on the bottom booms of the girders, while in the case of all the other spans it is carried on the top. Our engraving clearly shows how the juncture between the short and longer spans was effected. The girders were arranged in continuous groups, generally of four or five each. The greatest clear height from high-water mark to the bottom of the lower booms was about 87 feet. "Counting from the south end"—we quote from Major Hutchinson's report to the Board of Trade—"piers 1 to 14 are entirely of brick in cement; piers 15 to 48 are brick for 5 feet above high-water mark, finished with a stone belting, upon which are carried groups of cast-iron columns braced together; piers 49 to 77 consist of groups of cast-iron columns braced together, starting from the cylinders, and encased in brickwork to a height of 5 feet above high-water mark; piers 78 and 79 are cast-iron cylinders throughout, filled with concrete; piers 80 to 84 are cast-iron columns; piers 80 to 89, brick in cement. The permanent way is of double-headed rails fished at the joints in 24 feet lengths, 75 pounds to the yard, secured in chairs 3 feet apart on continuous timbers 17 inches wide, and varying between 7 and 14 inches in depth. Throughout the length of the bridge guard rails are provided. The floor of the bridge is of 3 inch planking." It will be seen that the bridge is an extremely heterogeneous structure—a conglomeration, in fact, of a great many bridges of various spans and types of girders and piers. The eleven 245-foot and the two 227-foot girders stood nearly in the centre of the bridge, and carried the load on the bottom booms. These are the girders which have fallen into the stream, and we may confine our attention entirely to this part of the structure. The girders were about 27 feet deep, and weighed each about 190 tons. The booms each consisted of a trough 15½ inches deep by 15 inches wide inside, the bottom of the trough being a ¾-inch plate 2 feet wide, while the sides were ⅝-inch thick, and were connected to the bottom by 3½ x 3½ x ⅝-inch angle-iron. Similar angle irons were also riveted along the upper edges of the sides. The girders were arranged in continuous groups, the thirteen largest spans forming two groups of four spans each and one group of five spans, roller bearings being provided when necessary to accomodate expansion and contraction. The width of the platform was 15 feet and carried with a single line of track. The piers upon which the large spans rested are placed on a foundation consisting of a caisson 31 feet in diameter and filled with concrete. Upon this was built a brickwork of hexagonal section 27 feet long in the direction of the axis of the river and 16 feet in the line of the bridge. On the top of this hexagonal mass of brickwork was a capping of stone in four courses, of an aggregate depth of 5 feet, while on this again was erected a pier composed of six cast-iron columns braced together, four of these columns being nearly vertical and placed under the girders, while the other two are cut-water columns. The two pairs of nearly vertical columns were 15 inches in diameter, and they were placed 9 feet 10 inches apart from centre to centre through all their length, in a direction transverse to the bridge, while in the other direction they were 12 feet apart at the bottom and 10 feet at the top. The two outer or cut-water columns were 18 inches in diameter, and they were placed singly, one on each side, 21 feet 10 inches apart from centre to centre at their basis, and 19 feet 10 inches at their summits, each of these columns having a rake of 1 foot only. Each column was made in seven 10 foot 10 inch lengths, united by flanges, although in some of the piers a less number of lengths was used. Horizontal bracing was introduced at each joint, and diagonal bracing between the lines of horizontal bracing. Each cut-water column was connected at its top to the adjoining pair of 15-inch columns by short girders, on which the girders of the bridge took their bearing; but there was, we believe, no through transverse girder fixed to the tops of the columns. The columns were filled with Portland cement concrete, and their average thickness appears to have been 1¼ inches, giving a sectional area of 66 square inches.

Adjacent columns were braced together with horizontal bars and diagonals, and there were also cross sets of bars, making altogether eight planes of bracing. The diagonals between two adjacent columns were of flat iron, single, 4½ by ½ inches, with cottered fish plates on their lower ends, and attached to the cast-iron columns close to the flanges by one 1½-inch bolt in a hole 1⅝ inches in diameter. The horizontal double bars were of pairs of channel irons 6½ by 2½ inches by ½ inch, placed back to back 2½ inches apart. In addition to these there were horizontal round bars placed diagonally between the four 15-inch columns, which according to *Engineering*, appear to have been an after thought, and were an attachment which was at least not very well planned. Each column springs from a foundation plate bolted to the masonry, and to which the column itself was fastened by eight bolts, which for the 15-inch columns were 1½ inches in diameter. In the case of the 18-inch outer columns the foundation plates were 4 feet square, while for the 15-inch columns they were 3 feet 10 inches in diameter. Each foundation plate carried a base about 22½ inches high, the base being stiffened by eight radial ribs, four of which were bossed to allow of the passage through them of the 1¾-inch bolts securing the foundation plate to the masonry, while in the case of two others provision was made for the attachment of the bracing. On top of the brickwork of the foundation four courses of heavy stone coping were laid, and to these the foundation plates of the columns were bolted.

It appears that an examination of the wreck shows, in some cases at least, that the bolts securing the foundation plates passed through the top course only, while the dowel bolts, holding together the various layers of stones, tied only the two uppermost layers, so that there was no connection between these and the first and second courses below them beyond that given by the cement.

Such are the brief details of the structure, which in connection with the data gathered by an examination of the wreck, to be