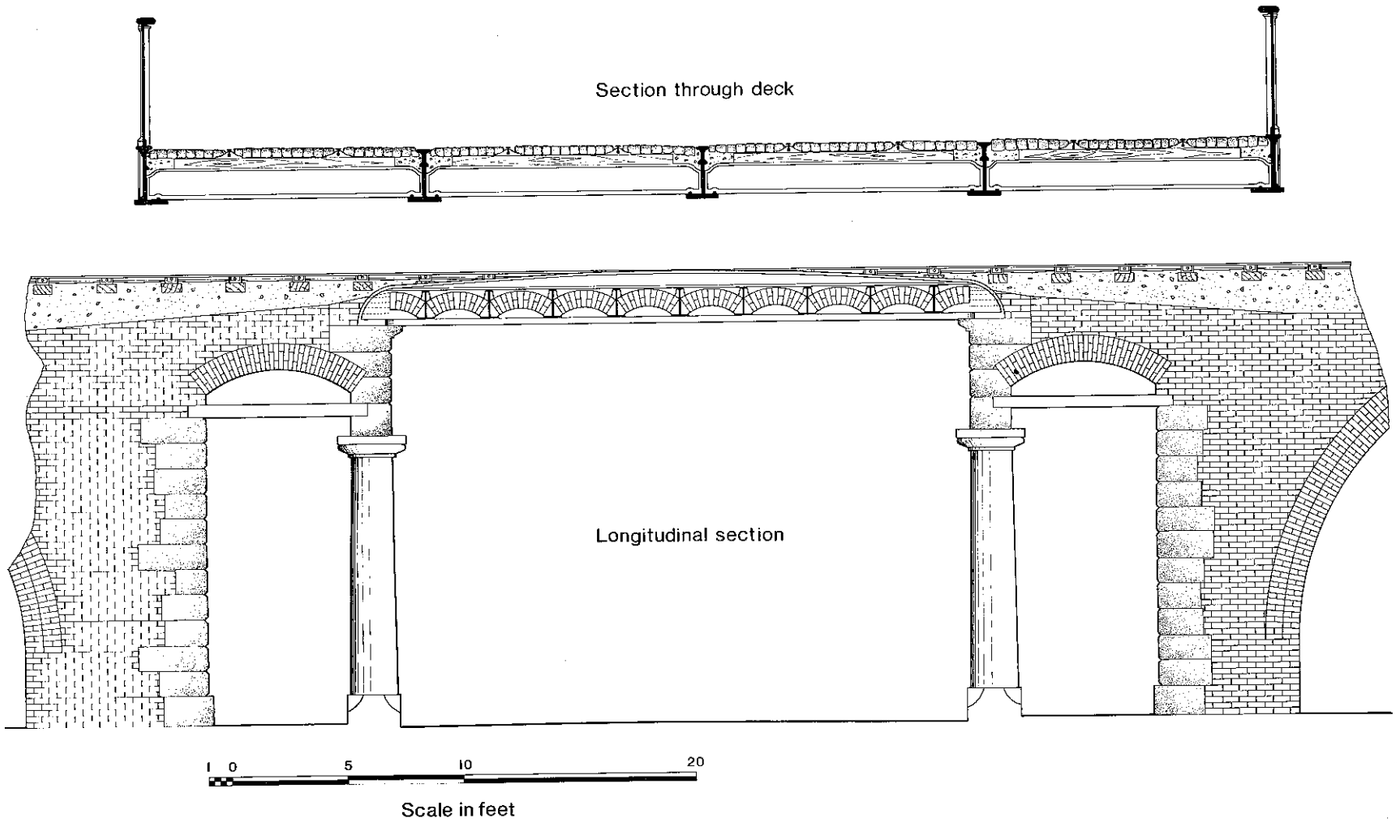
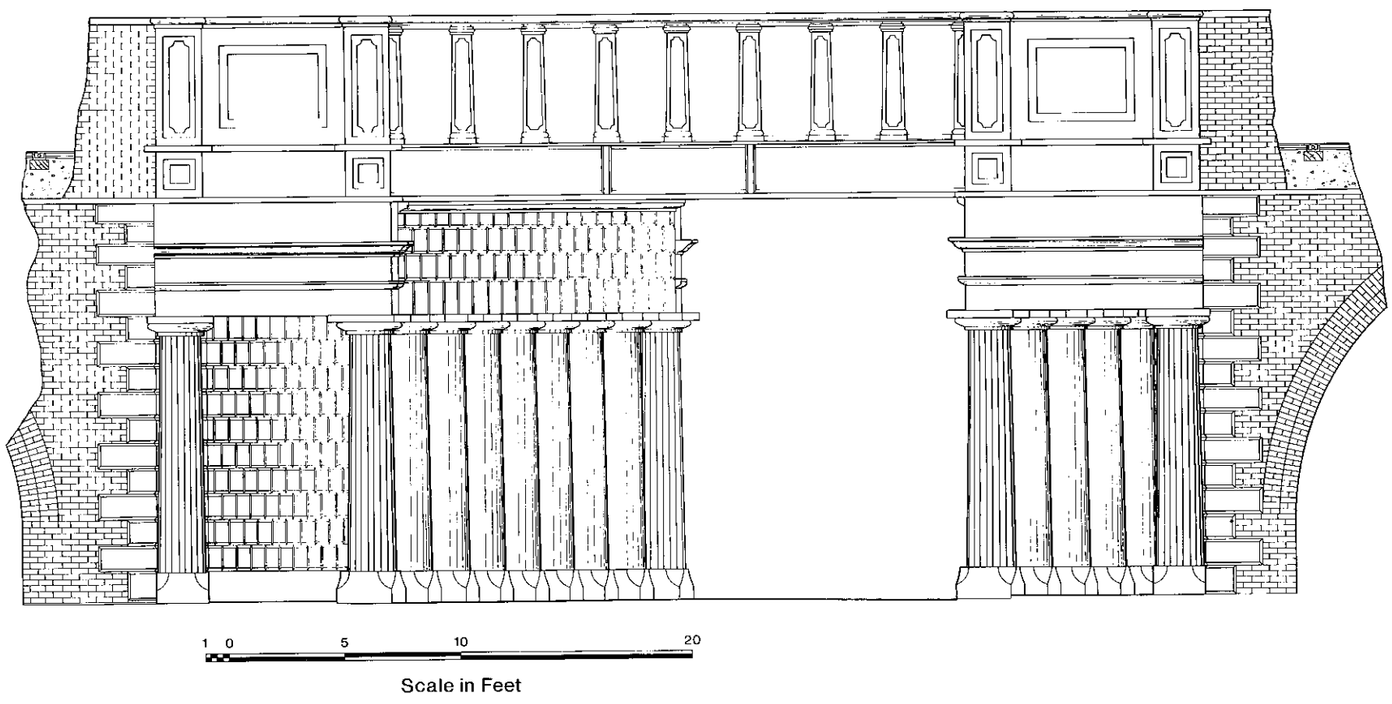


The Water Street Bridge: sections.



The Water Street Bridge: elevation.

Hodgkinson's experiments involved testing to destruction cast-iron specimens of varying cross-section and noting the manner in which they failed. This enabled him to conclude that cast iron underwent tensile failure considerably earlier than compressional failure occurred. To produce a beam proportioned to fail simultaneously from both stresses, the bottom flange required a sectional area six times greater than that of the top flange. To conform with the nature of the load–span relationship, the beam should have a maximum cross-section at a point farthest from the supports and diminish in section towards the supports according to a parabolic curve. In the Hodgkinson beam this involved a web, the upper edge of which was of parabolic profile, and flanges of parabolic plan.

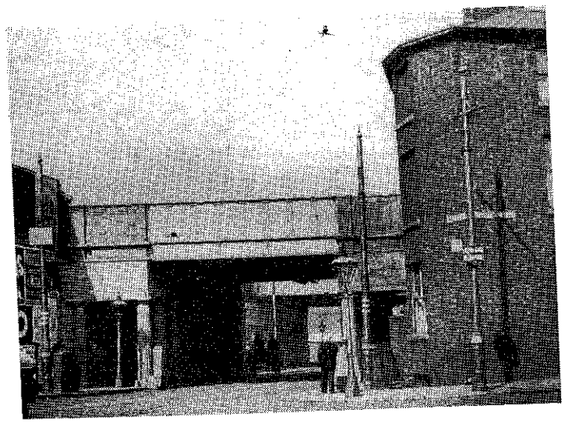
In the printed account of his work[35] Hodgkinson states that Stephenson was present while a number of the experiments were taking place and had expressed his intention to use the new beam form in his Water Street Bridge. On 7 December 1829[36] Stephenson produced for the board a design for the bridge over Water Street but stated that he had an alternative plan which was not quite ready. Almost certainly the latter was that which embodied the results of Hodgkinson's work. It is equally certain that both Hodgkinson and Fairbairn played some part in the design of the structure. Fairbairn's later fame owed much to his advocacy and use of the Hodgkinson beam. The earliest mill by Fairbairn known to have included the new beams was Orrell's Mill, Stockport, of 1834. Prior to that he is said to have designed a mill in Macclesfield using the beams, but the *Manchester Guardian* in May 1830 indicated that construction had not started at that date. The evidence is that the Water Street Bridge was the first application of the new section, for on 12 April 1830 the outer piers were nearly complete.

At first it was intended that the main beams should be supported by a stone wall separating the footways from the road, the footways being arched over in brick.[37] At the request of the Highway Surveyors this plan was abandoned in favour of two rows of columns. Most accounts of the bridge, including one of 1904,[38] describe the columns as being of stone, and masons are known to have worked upon the structure. Wishaw, however, states them to be of cast iron.[39] The superstructure of ironwork was cast by Fairbairn and Lillie. The writings of both Fairbairn[40] and Hodgkinson[41] illustrate a section of one of the main beams which had been tested to an ultimate load of 110 tons.[42]

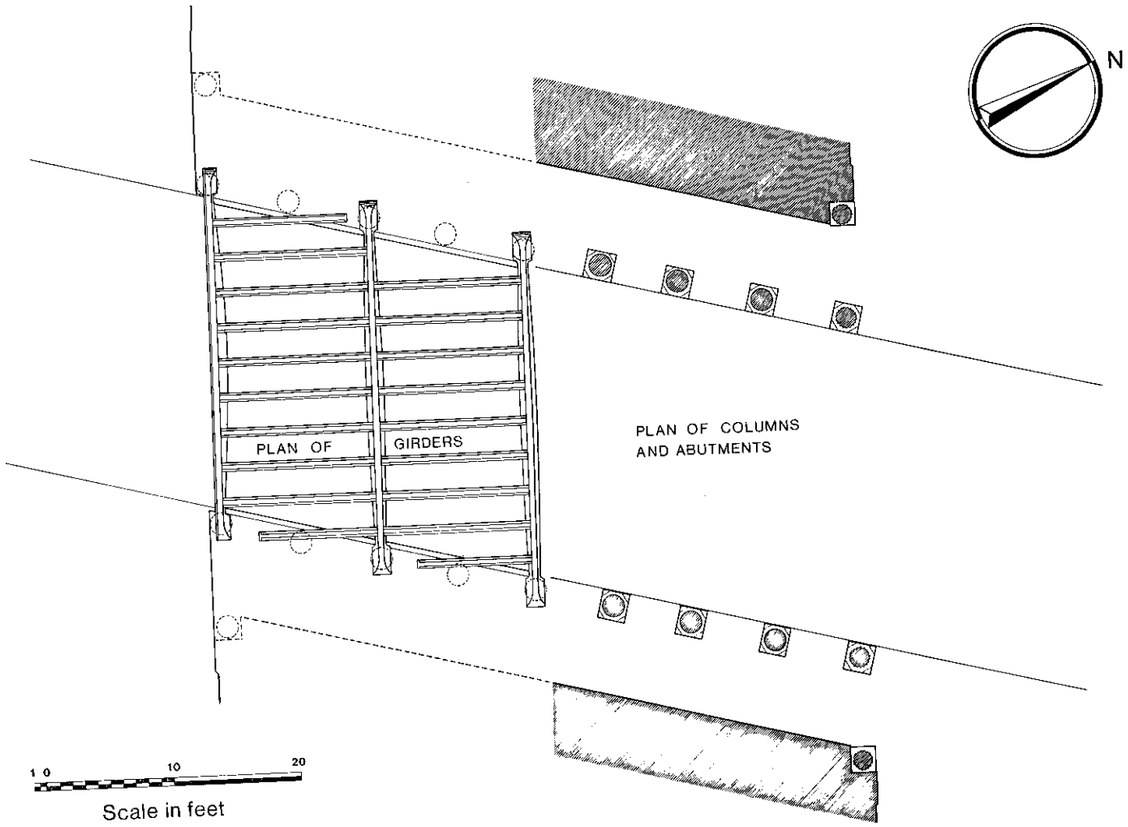
In 1893, as part of a programme of cast girder bridge replacement following the failure of two such structures in 1882 and 1891, plans were drawn up for the replacement of the Water Street Bridge. These plans, showing both the earlier bridge and its replacement, survive and have been used along with photographs taken at the time of demolition in 1905 for the reconstruction drawing.[43] The following description is based upon the drawings.

The road span of the bridge was 24 ft. 6 in., while the footpath spans were 6 ft. The square length was 50 ft. and the angle of skew 39°. At the crown of the road the clearance was 16 ft. 10 in. Between the parapets at rail level the width of the way was 48 ft. The five main beams had a

South elevation of the Water Street Bridge prior to demolition in 1905. *Chris Makepeace*



Demolition about to commence on the Water Street Bridge in 1905. *Chris Makepeace*



The Water Street Bridge: plan.

clear span of 24 ft. 9 in. and were placed at 13 ft. 5 in. centres. Both the flange plans and longitudinal profile were parabolic, with a mid-span section of 2 ft. 3 in. total depth over flanges. The bottom flange was 3 in. × 9 in. and the top flange 6 in. × $1\frac{3}{4}$ in., a ratio of just over five to one. The web appears to have been constant thickness at 2 in. A narrow rib positioned 1 ft. above the bottom flange ran parallel to it for the length of the beam, whilst the upper surface of the bottom flange had lugs cast in. These located the secondary beams, spanning between the main beams at 2 ft. 9 in. intervals. The cross-sectional profile accords with Hodgkinson's form, but the plan and the elevation were of parallel profile. The overall depth was 1 ft. 3 in. with a bottom flange 9 in. × $1\frac{1}{4}$ in. and the top flange about 4 in. × $\frac{3}{4}$ in. The secondary beams carried brick arches with a rise of 4 in. There is no evidence of tie-bars between either the secondary beams or the principals. The footways were brick-arched, concealed behind a false ceiling.

The girder superstructure was supported by two rows of nine columns which tapered from 1 ft. 9 in. below the echinus to 2 ft. at the base, rising from a plinth. The total height over plinth and capital was 12 ft. 6 in. The entablature separating the columns from the girders appears to have been of stone. It performed no structural role with respect to the main spans, the girders being located over alternate columns. The terminal jack arches of the main span abutted the spandrel masonry of the side arches.

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R. S. Fitzgerald

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R. S. Fitzgerald is Keeper at the Leeds Museum of Science and Industry.

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