(*Paper No. 2994.*)

"The Wagga Wagga Timber Bridge, N.S.W."

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To replace the timber bridge over the Murrumbidgee River at Wagga Wagga, Fig. 1, Plate 5, which, after a life of thirty-three years, was found to be beyond repair, it was decided in 1892 to erect a new bridge, with larger river spans, to avoid the rafting of timber which occurred in time of flood with the small 70-foot spans in the old structure. Tenders were invited for an iron bridge, but, the cost proving excessive, the Engineer-in-Chief for Public Works, Mr. Hickson, M. Inst. C.E., determined to erect a timber structure, and approved the Author's design for a truss bridge, with a larger floor space per span, 3,165 square feet, than any other timber structure erected in the Australian Colonies. In this bridge full advantage has been taken of the abundant supply of good hardwood which the colony possesses. The flooring is of tallowwood, an even-grained timber, free from gum veins, and the best colonial hardwood for the purpose, having a life, under similar conditions to those at Wagga Wagga, of about thirteen years. The floor beams, stringers and truss-work are of ironbark, the truss members being sawn free from heart and sapwood, to ensure mature and sound timber. The average of a number of tests shows this most favoured of Australian hardwoods (for structures exposed to the weather) to have a tensile strength of 8 tons per square inch, a crushing strength of $4\frac{3}{4}$ tons per square inch, and a shearing strength along the grain of 1 ton per square inch; whilst its durability may be inferred from the fact that some roughly constructed bridges have in some cases attained a life of over fifty years, many over thirty-five years, and but few less than twenty-five years. A prolonged life may, therefore, be anticipated for bridges of more mature design, in which greater attention is paid to the inspection of timber, and more care taken in construction.

The truss spans are designed to carry a distributed live load of 1·2 ton per lineal foot, or a concentrated load of 16 tons, with

9½ tons on a pair of wheels. The wind-pressure allowed for is 56 lbs. per square foot on the exposed surfaces of curbs, stringers, and ends of planking, and on twice the area of the handrails, ends of transverse girders, top and bottom chords, braces and verticals, the whole being regarded as a uniform moving live load. The colony is subject to violent gales, a remarkable one being the Dandenong gale in September, 1876, during which a velocity of 153 miles per hour, equal to a pressure of 117 lbs. per square foot, was recorded at the Sydney Government Observatory; but such phenomenal pressures extend only over small areas. Many of the existing structures throughout the colony would not now be standing had they ever been subjected to pressures approaching that allowed for in the Wagga Wagga bridge, which may be regarded as somewhat in excess of actual requirements.

The bridge was opened for traffic on the 11th November, 1895, and consists, Figs. 2, of six timber trusses resting on cylindrical iron piers and a concrete abutment, forming three spans, each 110 feet 3 inches long, and nine approach spans each 35 feet long. The carriageway is 24 feet 4 inches wide, whilst one 4-foot 6-inch footway is arranged for on the up-stream side of the bridge. The comparatively large carriageway is necessitated by the requirements of the wool traffic which crosses the structure, a loaded wool-wagon measuring 11 feet 6 inches over all. The trusses, Figs. 3, stand 27 feet 1 inch apart from centre to centre, and are connected at the top and bottom by a system of lateral bracing, consisting of timber transverse struts and wrought-iron diagonal tie-rods; angle- and portal-brackets being provided in the top lateral system. Each truss is formed of wrought-iron vertical suspension rods, diagonal timber struts and timber top and bottom chords, arranged in seven panels. The trusses are 21 feet deep between the centres of triangulations, fully providing for a loaded wool-wagon, which requires 17 feet 6 inches head room.

To prevent the lodgment of water, open top and bottom chords, consisting each of two timbers cut free from heart, and spaced 6 inches apart, were adopted, thus permitting of the easy renewal of these important members, which are also always accessible to the brush. The joint in each flitch in the bottom chord is effected by means of two 14-inch by ½-inch wrought-iron plates placed on each side of the flitch stick. On each of these plates, four wrought-iron strips, 14 inches deep by 3 inches wide and 1½ inch deep, are riveted and are let tightly into the timber, being designed to take the whole of the stress. The stress in each flitch is

50 tons, and as the four strips have a total bearing area of 84 square inches, a factor of 8 is provided against crushing; whilst for shearing along the grain a minimum factor of 13 is provided, irrespective of any assistance obtained from the bolts passing through the plates and flitch. The diagonal braces are formed each of two sawn timbers free of heart, bowed to prevent warping and twisting, and connected together by bolts and hardwood distance-pieces. The horizontal thrust from the braces is taken by castings, having lugs 1½ inch deep let into the chords.

In most of the American Howe trusses, counterbraces are introduced, to give lateral stiffness to the main braces. The great strength of ironbark, however, rendered this unnecessary in the Wagga Wagga bridge, and counters have been provided only in the centre bay, where the analysis showed them to be required. The deck consists of sawn transverse planking spiked to longitudinal stringers, seated on the lower lateral wind-struts. The lower lateral struts are adzed down on their upper surfaces to give a 2-inch camber in cross-section of the deck, whilst the centre line of the strut is placed in the same plane as the centre line of the bottom chord. The ends of the lateral strut are secured to the bottom chords by wrought-iron brackets; to these are attached the lower lateral diagonal tie-rods, the centre-lines of which—if produced—would intersect at the centre of bottom chord. The triangulation lines of the wind-bracing and truss-members thus intersect at a common point, avoiding all bending stress in the bottom chord. The lateral struts are tightly dapped 1 inch over nine sawn packing-blocks resting on the floor beams; these blocks not only raise the lateral struts to the same plane as the centre line of the chord, but also equally distribute the whole load over the pair of floor beams at each apex. As the width of the two floor beams at each apex is 2 feet 5 inches, it was impracticable, without fouling the braces and suspension-rods, to support them on the upper edge of the bottom chord; they are therefore suspended from the chords, each pair by sixteen beam-hangers, 1⅜ inch in diameter, passing on each side of flitches of the bottom chords.

By the adoption of this floor system, the shock from passing loads was reduced by the lateral strut and distributing-blocks acting as a cushion; whilst the shortness of the beam-hangers permitted of a large allowance being economically made for dynamic action. Again, as only direct stresses had to be provided for, an appreciable saving in material was effected.

Any member of the bridge can be renewed separately. The top and bottom chords, consisting of two pieces, the suspension-rods and beam-hangers can be removed and re-arranged to throw the whole weight on one flitch, there being no stress on the remaining flitch; any member of the top and bottom chords can be replaced with sound timber. By loosening the suspension-rods and inserting temporary struts, the braces can be renewed; whilst the removal of the floor beams, stringers and decking is obviously a simple matter. The minimum factor adopted in the trusses is 7 for the stresses due to combined dead and live loads. This may appear somewhat liberal, but the ultimate strength of ironbark having been taken from tests of small specimens of picked timber, less relative strength is to be anticipated in large scantlings. Again, as the flitches were sawn, the grain will run more or less across the line of the stick; and, as defects in timber are liable to escape even the closest inspection, it is necessary to make a wide allowance to cover such contingencies.

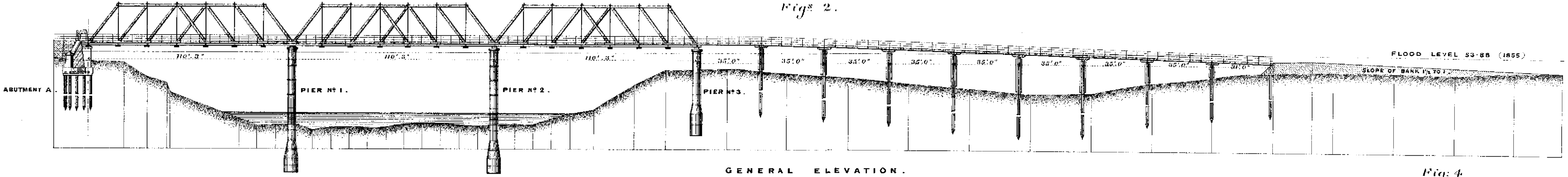
The cylinders, Figs. 4 and 5, were sunk under air-pressure to a gravel foundation, and, after the material within them was excavated, were filled with cement concrete. The maximum pressure on the foundation when the bridge is fully loaded is 5½ tons per square foot, neglecting any supporting-power derived from buoyancy or skin-friction. The piles in the platform forming the foundation for the concrete abutment were "blunt pointed" and driven without shoes to a depth of 20 feet; the set, for the last three blows of a 20-cwt. ram falling 10 feet, being 1 inch. The maximum load carried on a pile-head is 25 tons when the bridge is fully loaded. With the exception of the cylinder plates and a few sections of L-bar, all the wrought-iron bars were rolled from scrap at the Lithgow Ironworks, 97 miles distant by rail from the Atlas Company's works in Sydney, where all the ironwork was manufactured, being then forwarded by rail to Wagga Wagga, a distance of 310 miles. The whole of the timber was brought from the northern rivers of the Colony to Sydney, 150 miles by sea, and thence by rail, 310 miles, to Wagga Wagga.

The cost of the superstructure of one 110-foot truss span, erected complete in position, was £1,300, whilst the total cost of the bridge and earthwork approaches was £14,200.

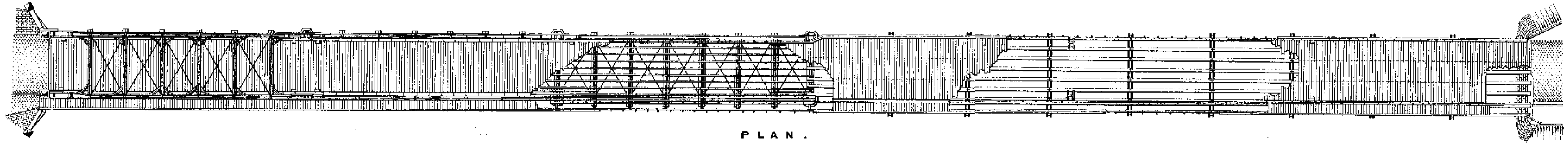
The Paper is accompanied by six drawings from which Plate 5 has been prepared.

WAGGA WAGGA TIMBER BRIDGE N.S.W.

Figs 2.



GENERAL ELEVATION.

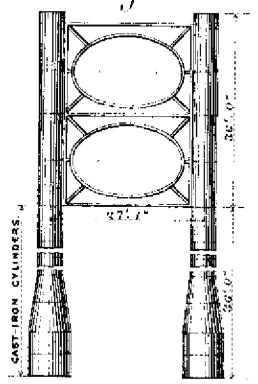


PLAN.

Scale for Fig: 1, 1 Inch = 500 Feet.
" " Figs 2, 1 Inch = 50 Feet.
" " Figs 3, 1 Inch = 16 Feet.

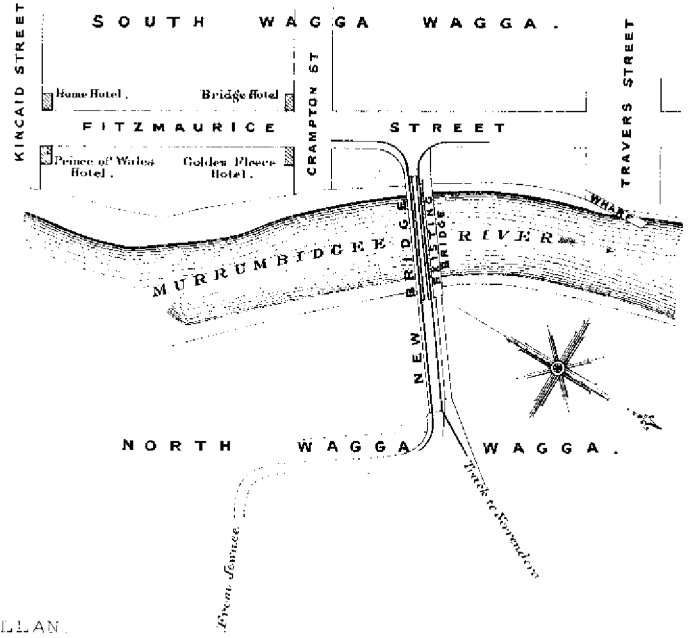
Scale for Fig: 4, 1 Inch = 36 Feet.
" " Fig: 5, 1 Inch = 8 Feet.

Fig: 4.

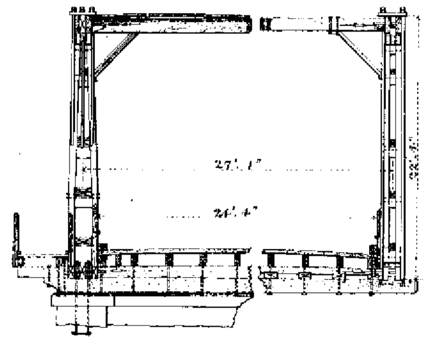


RIVER PIERS.

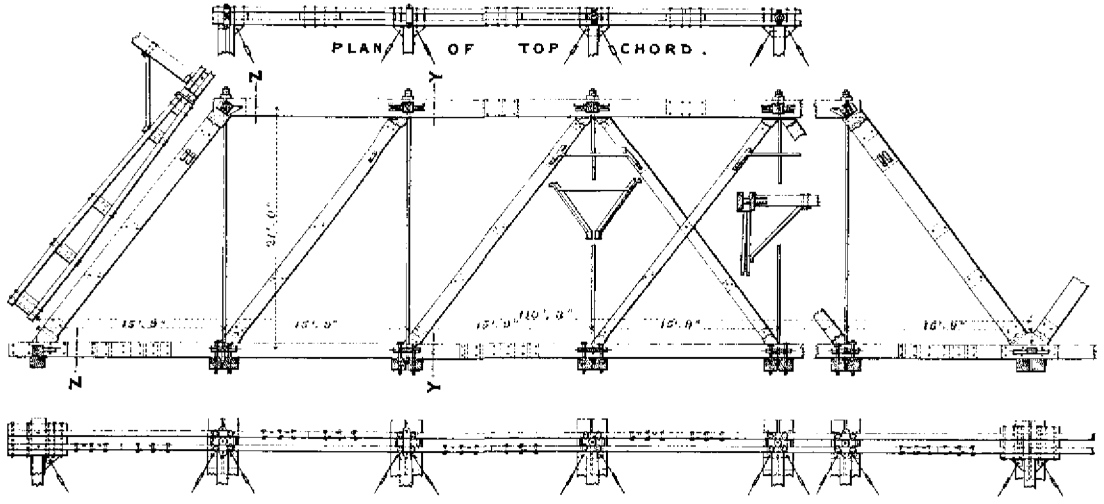
Fig: 1.



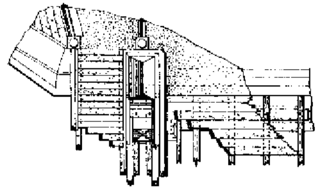
Figs 3.



CROSS SECTION AT Z Z. CROSS SECTION AT Y Y.

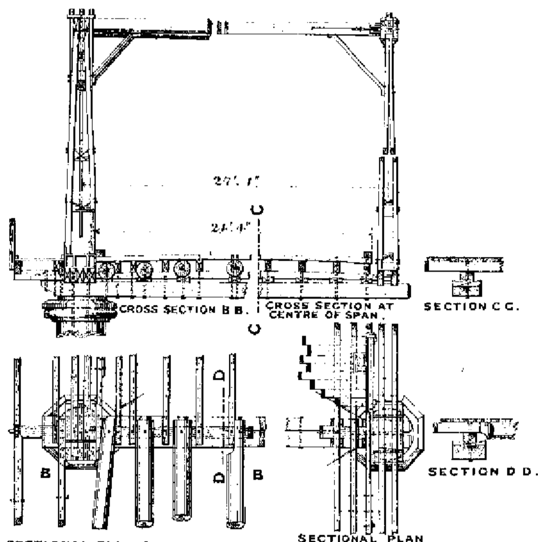


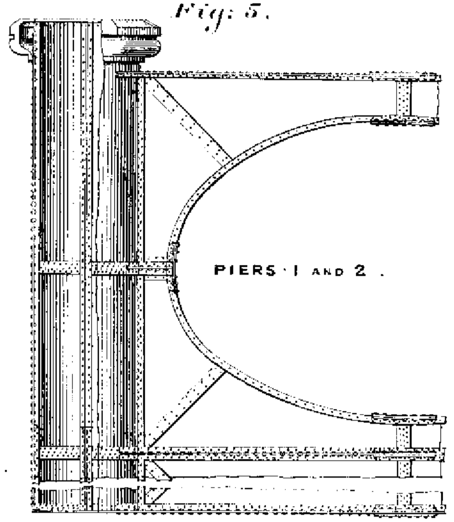
DETAILS OF TRUSSES.



PLAN AT ABUTMENT.

Fig: 5.





DETAILS OF CYLINDER PIERS.

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