

Renewing the Moorabool Viaduct.

A Great Undertaking by the Victorian Railways

By A. Goudy.*

The viaduct over the Moorabool River valley, on the Geelong to Ballarat line, was built about the year 1860, and was a double track bridge consisting of ten 130 ft. continuous spans, with two wrought iron pin-connected Warren girders 10 ft. deep on 8 ft. centres under each track resting on masonry piers about 90 ft. high. At this time Mr. G. C. Darbyshire was engineer-in-chief of the Victorian railways.

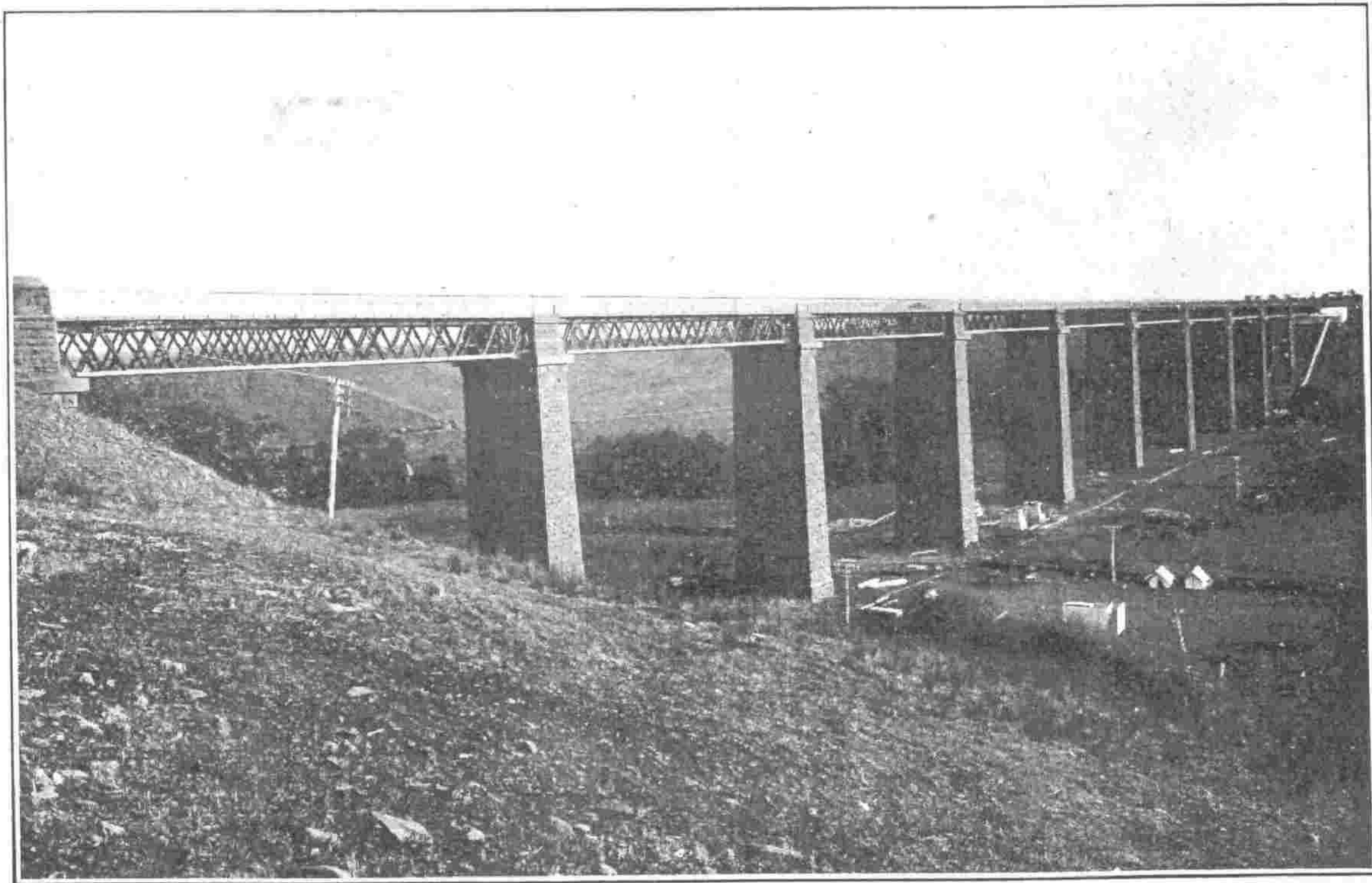
followed by loaded trucks the maximum stresses were:—

Compression, $6\frac{3}{4}$ tons per sq. in.

Bearing on pins, 21.6 tons per sq. in.

Bending on pins, 20 tons per sq. in.

This was endorsed by Mr. J. H. Fraser (formerly chief engineer of ways and works), who investigated the stresses, but it was not till 1893, when it was proposed to run heavier engines (the "A"



Original Viaduct.

This viaduct was designed by Mr. Isambard Kingdom Brunel, the famous engineer, who designed the Great Eastern railway, London, and was erected by Messrs. Evans and Merry, contractors for the Geelong to Ballarat line. In 1885 the late Professor Kernot, of the Melbourne university, wrote to the railways department stating that the girders were highly stressed with the engines then running (X class, 45 ft. long, 56 tons weight) and recommended that the bridge be reduced to single track. An exhaustive analysis of the stresses was made by engineers of the department, showing that with "X" engines then running

class, 50 ft. long, 74 tons weight), that Professor Kernot again protested, when after repeated tests it was decided to remove one track from the bridge and place the remaining track centrally so as to distribute the load over the four girders.

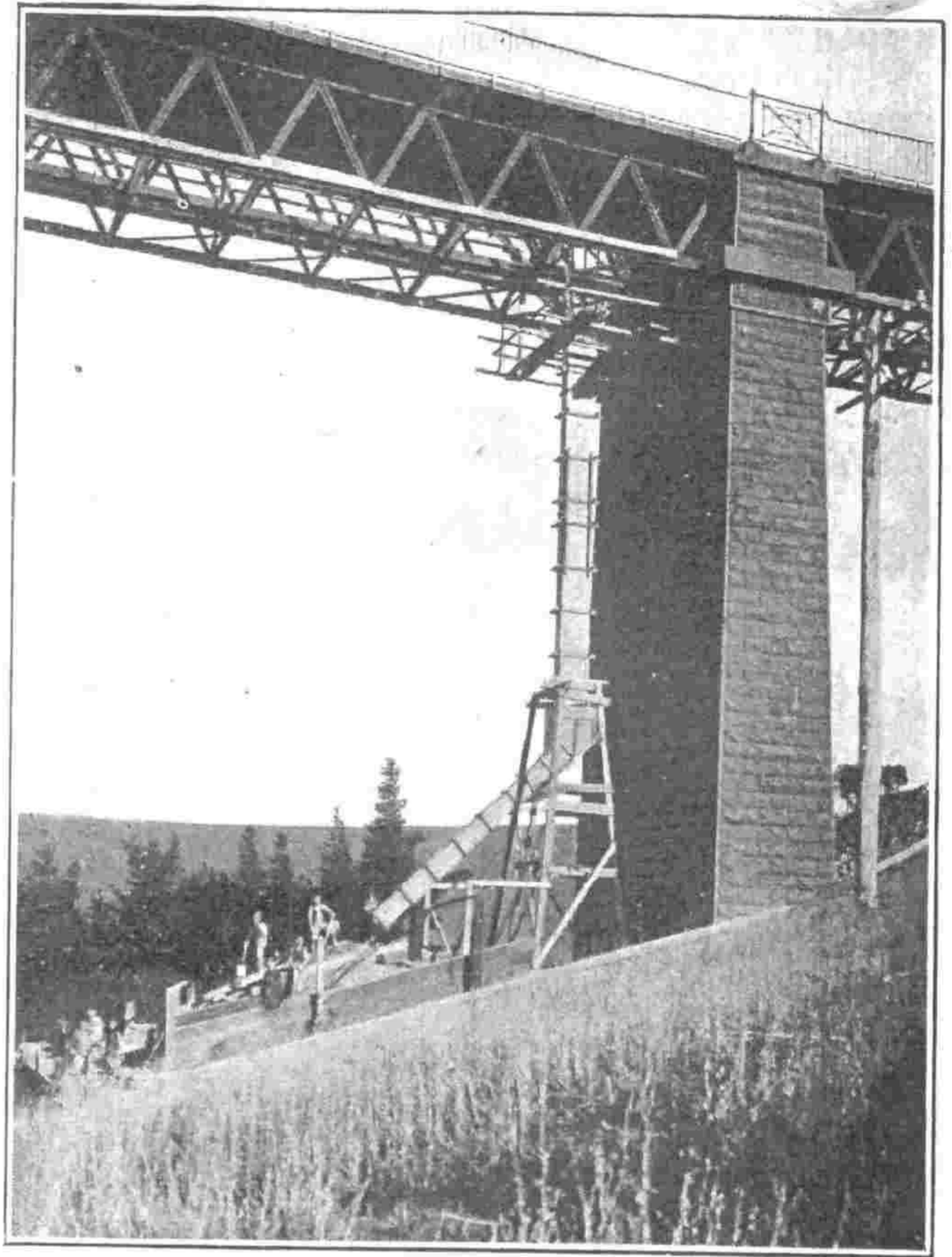
In 1910 further tests were carried out to determine the distribution of stress on the girders under the Dd engines (57 ft. long, 94 tons weight) then running, and on account of the high stresses noted and the fact that heavier engines were contemplated, it was decided by the commissioners to renew it as there were no practicable means of strengthening it. After full investigation, taking into account cost, difficulties of erection and inter-

*Engineer, Victorian railways.

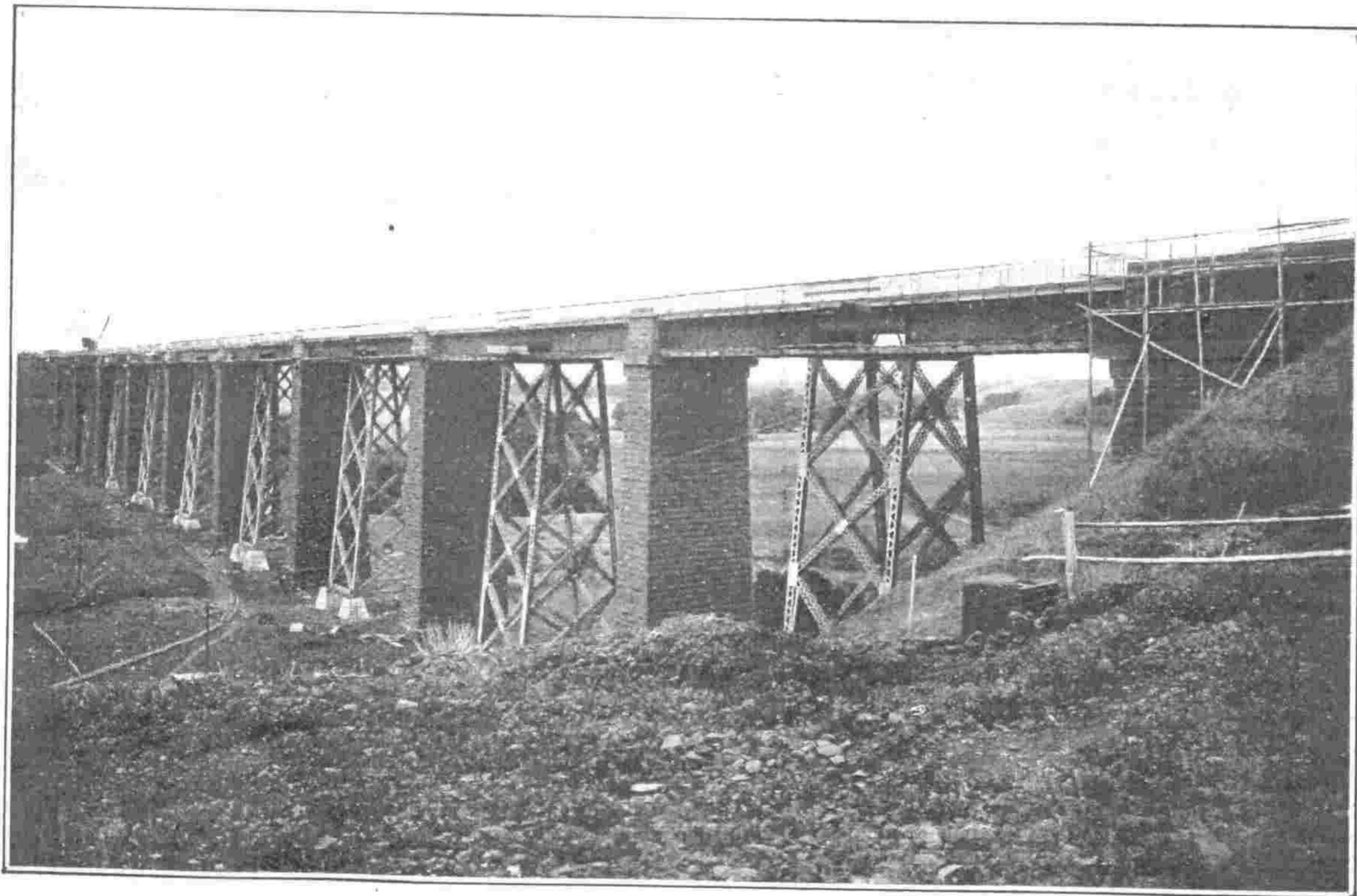
ference with traffic, the present design of placing intermediate steel piers in the centre of each existing span on which would rest a double track plate girder deck bridge, was agreed to by the commissioners.

The new bridge is designed for Cooper's American standard "E 50" loading (in which the engine provided is 56 ft. long and approximately 160 tons weight), and also for two axle loads of 25 tons on 7 ft. centres. The bridge consists of two lines of plate girders, 15 ft. centres, 5 ft. 6 in. deep in intermediate and 2 ft. 6 in. deep in tower spans.

On the upper flanges of these girders are rolled steel joist cross girders, 5 ft. centres, carrying a 7 in. longitudinal timber deck and ballasted tracks. Each original span of 130 ft. is divided into three—a tower span of 25 ft. and two intermediate spans of 50 ft.—with a space of 5 ft. between bearings on the existing masonry piers. The steel tower bents are in vertical planes, but the posts in each bent are battered, 1 in 10 being 15 ft. centres at the top and 32 ft. centres at the base in all except the end towers. Each of the four posts of each tower is carried on a concrete pedestal 5 ft. 6 in. square on top and 10 ft. square on the base, each resting on nine piles driven to refusal. Each leg of tower consists of two rolled steel joists 16 x 6 x 62 lbs., 16 in. centre to centre, reinforced with $\frac{3}{8}$ in. plates in the lowest section and latticed together in the three upper sections. The bracing of the towers in both longitudinal and transverse planes consist of box form latticed members each



Shoot for Concrete Materials.



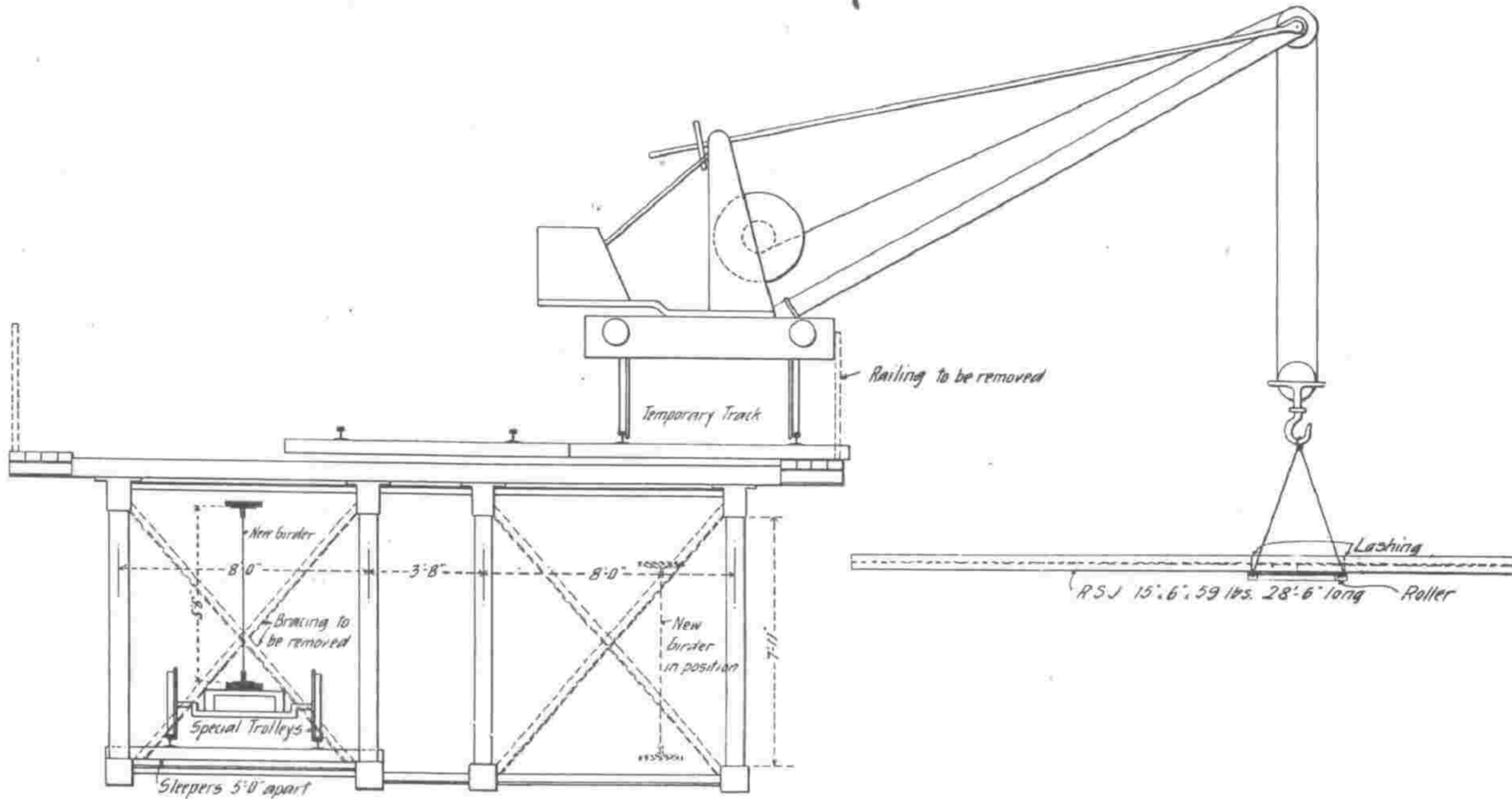
Renewed Viaduct.

consisting of four angles. The towers were designed for a combination of stresses due to dead and live load (plus allowance for impact), brake force and wind. The wind force provided for was 30 lbs. per sq. ft. on the exposed surface of train,

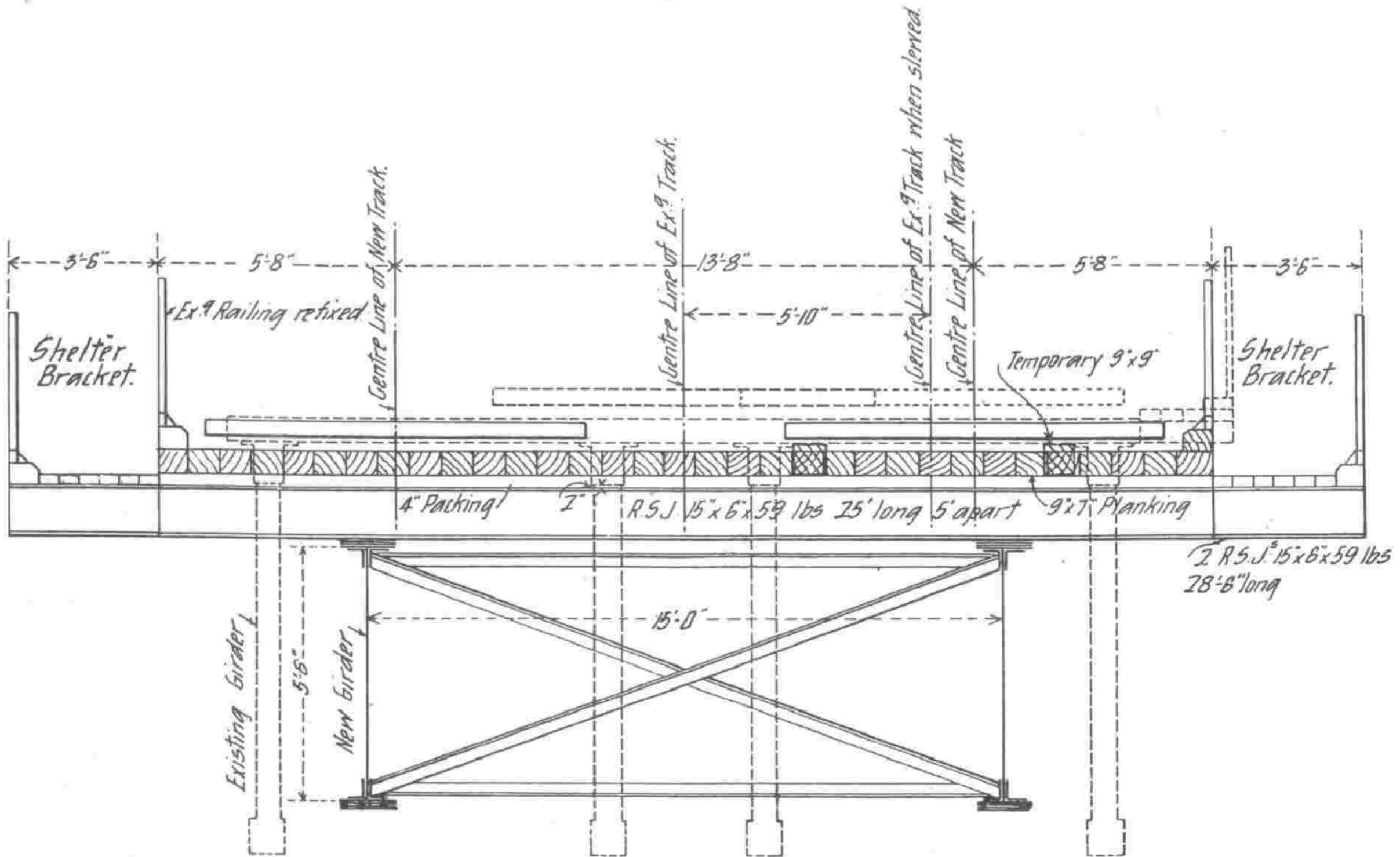
load, live load and impact; and 8 tons per sq. in. when brake and wind stresses were added.

The height from rail level to ground level in the central spans is 102 ft.

Contracts were let to Messrs. Dorman, Long and



Method of Placing Girders and Cross Girders.



Cross Section of Superstructure.

girder, etc., and 250 lbs. per ft. of height on each bent of a tower. Brake force was taken 1-5th of a vertical live load on the span. The combined loads gave a compression of 350 tons in the lowest section of tower posts. The maximum stresses allowed were 6½ tons per sq. in. for combined dead

Co. Ltd. for the manufacture of the steelwork, and while their shops were at work, the departmental forces constructed the concrete bases for the towers. The steelwork was also erected by the department.

For the erection of the towers, wire ropes from

steam winches on the ground were run through pulley blocks attached to the old girders. The various sections were thus lifted into position and temporarily bolted up. Scaffolding was built round each tower as it progressed, and when erection was complete the contractors' riveters proceeded to rivet the various members together. Some delay and anxiety was caused by an unusually high flood which deposited some of the scaffolding in the neighboring tree tops and caused considerable scour around some of the bases. No damage, however, resulted to the structure.

When the towers were completed, the girders were, one by one, lowered into pits below the tracks just beyond the end of the bridge. Openings had been broken through the abutment walls at the ends of the old girders and a tramway laid on sleepers resting on the lower chords of the old girders, sufficient of the sway bracing being removed to allow a clear passage. On this tramway the girders were run out on shallow trolleys and successively placed in position on their bearings on piers and towers.

When the girders were in position the cross girders were swung from the jib of a crane on the bridge deck and threaded into position between the members of the old trusses, the spacing of cross girders being so arranged as to make this possible.

When the cross girders were fixed, longitudinal beams were placed on them under the final positions of the rails of one track and packing wedged between the beams and the deck. The running track was then slewed to its final position on the down side of the bridge, thus bringing the load on to the new superstructure. The decking on the up side of the centre line could now be removed and the old girders taken to pieces and removed. The new (longitudinal) decking could now be laid on that side of the bridge and the track slewed to that side. The old structure on the down side is thus free for dismantling in a similar manner.

The total weight of iron in the old superstructure was approx. 1410 tons. The new shed superstructure contains 690 tons (510 tons in girders and 180 tons in cross girders) and the towers 550 tons. Thus the old ironwork is replaced by a new structure 12 per cent. lighter and yet carrying double track providing for heavier loading and greater factor of safety than the old structure had even with single track loading.

The estimated cost of renewal is approximately £60,000. The contracts for construction and riveting of steelwork (not including erection) amount to £30,160.

The old structure complete, including the blue-stone piers and abutments, cost about £180,000, of which the part now being removed accounted for £75,000.

The new structure was designed in the office of

Mr. A. Goudy, under the direction of Mr. J. H. Fraser, who recently retired from the position of chief engineer of way and works. The construction work was at first in charge of Mr. F. K. Esling, who developed the details for construction, Mr. G. S. Luttrell being in immediate control of the work.

Later stages of the work have been in charge of Mr. C. H. Fethney, who has erected all the steel and completed the work. The whole of the work has been carried out without accident or hindrance to the traffic.

THE ENORMOUS COST OF NIAGARA AS A SPECTACLE.

Progressive men on both sides of the Niagara frontier are agreed, says the "Electrical World," that even before the war a greater diversion of water from the Niagara river was justifiable and that the present emergency merely changes the word justifiable into obligatory. Sir Adam Beck in his recent testimony at Washington presented an official Canadian viewpoint with reference to Niagara, and an American viewpoint has since been published. It is possible, however, to present the situation very clearly, so that any layman may grasp it. In round numbers the flow of water and the head at Niagara Falls represent 5,000,000 continuous horsepower. Even at the low price of \$10 a horsepower year, the spectacle has a potential value of \$50,000,000 per annum. Can any nature lover contend that the view is worth any such sum, and would any government be justified in appropriating \$50,000,000 yearly to reproduce the attraction? With these self-evident facts in mind, it is difficult to understand why this profligacy continues, especially when there is such urgent need of the power, a willingness to use more water on both sides of the border, and apparently nothing to stop it except the inertia of governmental bodies. Certainly this inertia is extremely costly; it even borders on the criminal and should be overcome at once.

The royal commission appointed by the N.S.W. government to inquire into the cost of production and distribution of gas sold by the Australian Gaslight Co. and the North Shore Gas Co., who serve the Sydney metropolitan area, recommended that the price be fixed at 4/8 per 1000 cub. feet, an increase of 1/2 on the ruling price. The companies have agreed after consultation with the government, not to charge a higher rate than 4/5. If it is found that this price does not enable the companies to earn the dividend prescribed under the Act, in order that the capital which is so much required for necessary extension of mains and works may be raised, the position must, of course, be reviewed.