# THE RECONSTRUCTION OF THE PORTAGE VIADUCT.

An Explanation of the Method of Reconstruction Without Interrupting Traffic.

The Portage viaduct is officially known as bridge No. 16 of the Buffalo Division of the Erie R. R. It is a single-track structure 819 ft. long and about 235 ft. high from the bottom of the river to the base of rail. It consists of six towers supporting plate-girder and truss spans of from about 50 to 118 ft. long. Originally it was built of timber, and for a long time after its completion in 1852, was famous for its height and imposing appearance where it crosses a rocky chasm a short distance above a beautiful waterfall. It was replaced in 1875 by a light pin-connected wrought-iron structure carrying a single track on long and deep ties laid across the top chords of the trusses, which were spaced about 20 ft. apart and were supported directly by the battered columns of the towers. It was originally intended to add at some time a second set of trusses close to the original ones, and from the four lines thus secured support a double track. This plan was never carried out, and when it became necessary to provide for heavier traffic, it was found feasible to support modern trusses and girders on the existing towers and masonry which were in good condition. New spans were, therefore, designed with special care to provide for their erection and the maintenance of traffic without interruption, and the reconstruction was successfully accomplished in 1903.

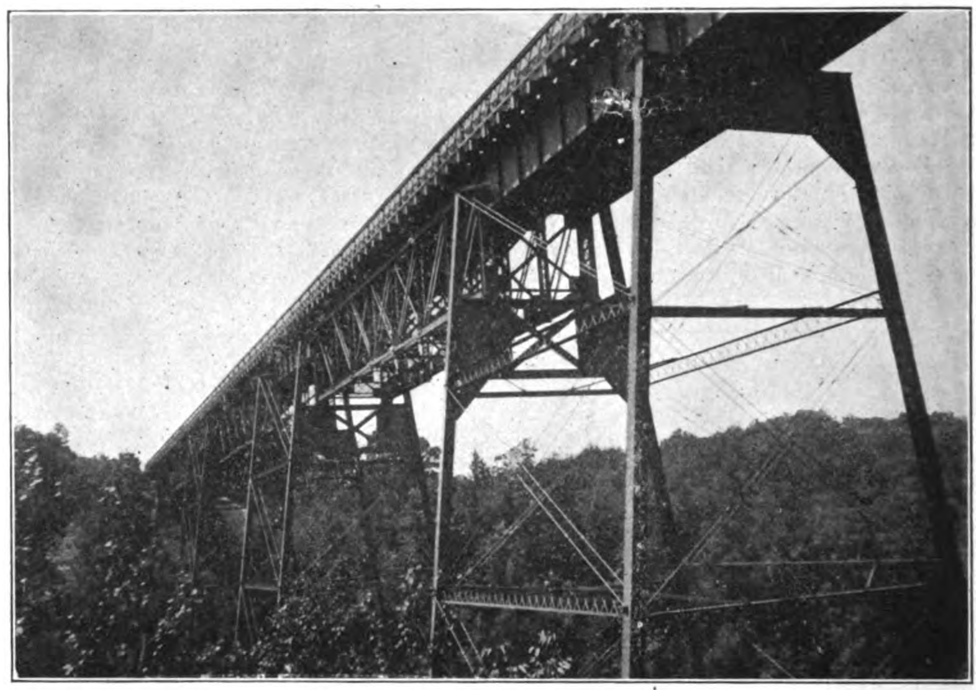
The new work was illustrated and its principal features were described in The Engineering Record of February 4, and consist essentially of 50-ft. deck plate-girders in the tops of the towers and between the shorter towers with two 100-ft. and one 118-ft. pin-connected deck Pratt truss spans between towers over the deepest part of the gorge. All of the spans are carried by new transverse girders riveted to the inner faces of the columns in the upper stories of the towers.

The old spans were all pin-connected trusses with their top chords seated on the column caps 19 ft. 10 in. apart on centers. In order to clear them, the new trusses and girders were made 14 ft. apart on centers, so as to have transverse clearance between the tower columns inside the old trusses. The panel points and transverse bracing were made different from those in the old spans, so that the members of the new structure would clear those of the old structure, as indicated by the accompanying diagram of one tower span and part of the 118-ft. span, which are typical of the whole viaduct. A general plan and elevation of the complete viaduct was published in The Engineering Record of February 4.

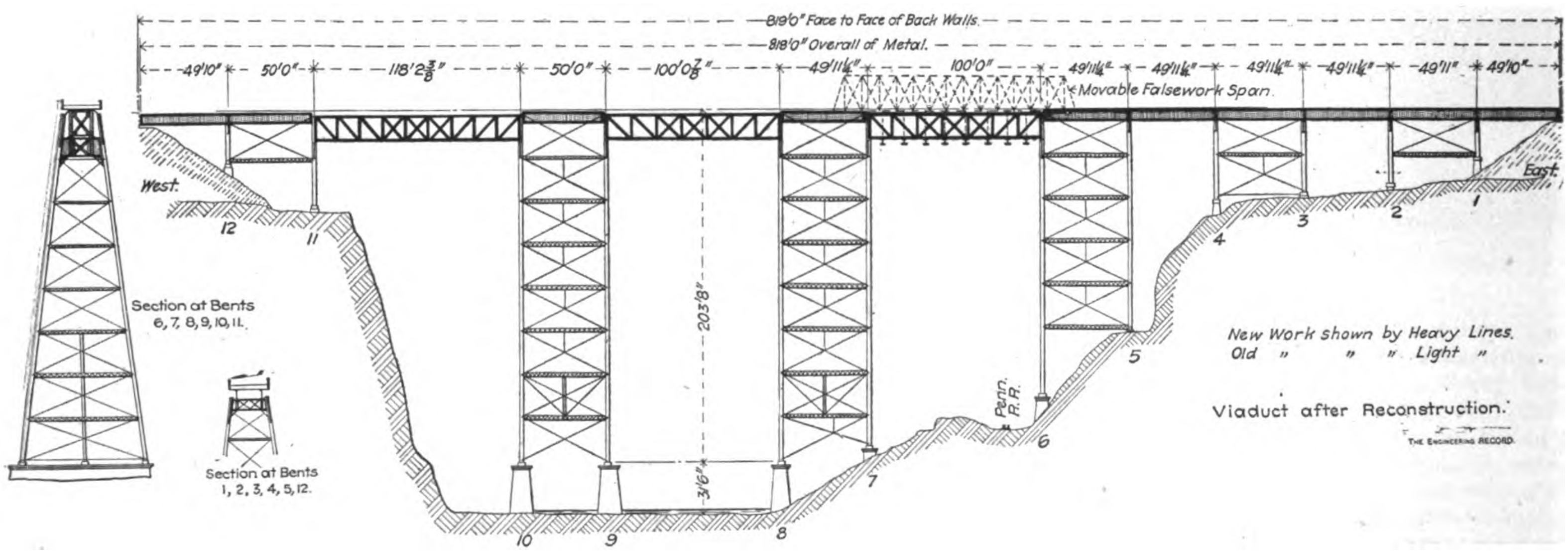
The sequence of operations and the details of the work were carefully determined in advance before the erection was commenced, and the erection was executed in exact conformity to these plans. The principal operations were connecting the new transverse girders to the tops of the tower columns; assembling on them the 50-ft. plate-girder spans and replacing the old track on them; assembling the truss spans above their required position on a platform suspended from falsework trusses; suspending the old track from the new trusses; removing the old trusses; lowering the new trusses to final position and laying the permanent track on them.

Operations were commenced by installing at the end of the viaduct an air compressor driven by a 22-h.p. Fairbanks-Morse gasoline engine. This was equipped with a receiving tank adjacent and an auxiliary tank in the middle of the viaduct, and distributed compressed air to all parts of the structure through a 1½-in. pipe with outlets about 50 ft. apart for flexible connections or manifolds.

Light working platforms in the tops of the towers were suspended from the track ties by 1-in. vertical rods with welded loops at both ends; and workmen on them cut away the lattice-bars on the inner sides of the battered posts and drilled holes for the connections of the new transverse girders. These holes were scribed from cast-iron templates through which the holes in the girders had previously been drilled. The holes in the columns, except in inaccessible positions where they were ratcheted by hand, were drilled by pneumatic tools manufactured by the Chicago Pneumatic Tool Co. There were about 2,200 holes 15/16-in. in diameter, and they were drilled at the rate of ten per hour by the pneumatic tools and four per hour by hand. While this work was in progress a 20-ton derrick was erected in the storage yard for unloading materials. It had a 42-ft. boom and was provided with one stiff-leg and two guys. With it the materials were piled up indiscriminately as received and sorted as delivered for use in the structure. A two-bent wooden gantry traveler was also built to run on rails laid outside of the track on the regular ties of the old bridge. It had sufficient clearance for the train traffic to pass through it, and it could be left in any position where it was required without interrupting trains. It was made with very deep overhead transverse bracing and had two cantilever jigger beams, from which tackles were suspended about 3 ft. clear of the front bent. The rear end of each jigger beam was anchored by



Tops of Old Towers with New Girders and Spans.

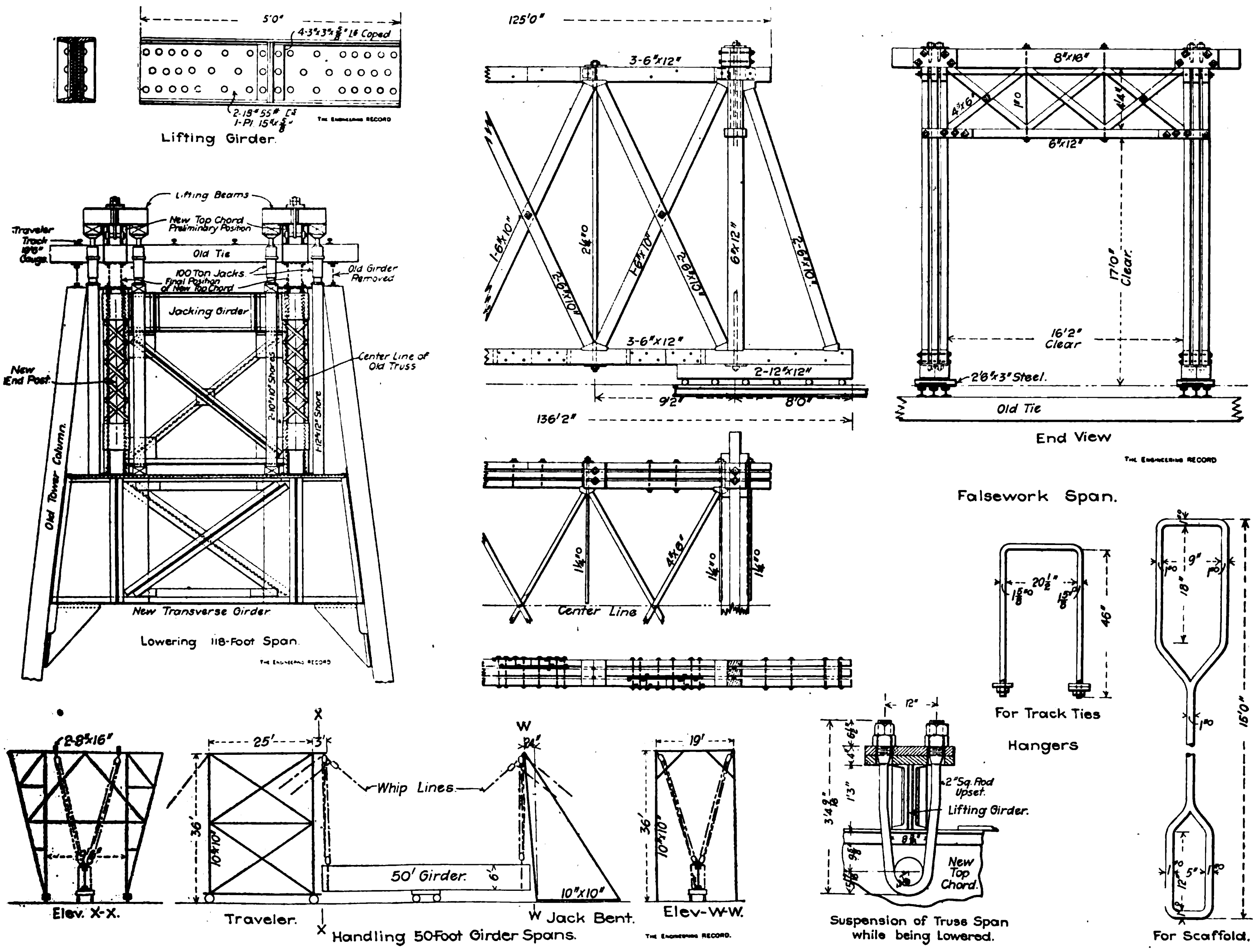



Reconstructed Portage Viaduct, Erection Traveler Shown Dotted.

a ¾-in. steel wire cable made fast to the old trusses.

The 10-ton transverse girders were delivered on trucks to the traveler, which lifted them by a single tackle hitched near one end of the girders and lowered them vertically between the ties of the old bridge floor. When they were clear underneath, a tackle from the other jigger beam was hitched to the opposite end of the girder and both tackles were operated to hoist the girder into a horizontal position and swing it to place between the tower columns, to which it was immediately connected by assembling bolts through all of the field-rivet holes. Riveting gangs closely followed the erectors and replaced the bolts by rivets, most of which were driven by pneumatic hammers. A girder was put in position and bolted up without obstructing the track more than about one hour, ties were removed from the old tower span by two whip lines attached to the traveler, and two attached to the jack bent, and were loaded on trucks and carried a short distance away. The top laterals and sway-bracing were then removed from the old span, leaving the bottom struts and laterals in position. The two new girders were then simultaneously lowered to their seats on the new transverse girders, their sway frames were bolted in place and their lateral rods were put in with the aid of the whip lines, which afterwards replaced the old ties and track on the new girders. The whole operation required about 2½ hr. from the time the old span was out of service until the new span was in service. Afterwards the old trusses and bottom lateral and transverse struts were removed piecemeal by the whip lines and the traveler and jack bent were advanced another were first moved over the 118-ft. span and wedged up at the ends to release the rollers and take bearing over the tops of the tower posts. Thus there was no extra dead load on the old light spans on account of erection. Vertical suspenders were then attached to the lower chords of the trusses and transverse I-beams were connected to them just above the lower chords of the old viaduct trusses.

On them was laid a working platform and the lower chords of the new trusses were assembled on it, supported in the usual manner by blocking and camber wedges. The vertical and diagonal members of the trusses were then put in position and connected to the lower chords, and finally the top-chord pieces were set on the vertical posts completing the trusses. The pins were driven and the trusses were swung from blocking over the new transverse girders, which




**Apparatus for Lowering New Spans and Details of Travelers and Movable Falsework Span.**

and the work was done at intervals between trains when it occasioned no interruption to traffic.

A sort of braced gallows-frame with longitudinal sills and inclined stiff-legs and having an overhang of 24 in. was built and equipped with two four-part Manila tackles corresponding to those on the traveler. This was called a jack-bent and was seated on one side of the tower, while the traveler was seated on the opposite side of the tower. A sufficient interval between trains was selected and the girders for the tower span were separately delivered and unloaded by the traveler and jack-bent main tackles which landed them alongside the track without releasing them from the tackles. The rails and cross-span and so on. All of the tackles and the whip lines were operated by a two-drum-four-spool Lidgerwood hoisting engine located most of the time near the center of the viaduct, but occasionally moved for convenience.

While the 50-ft. spans were being erected, the falsework Howe trusses were framed in the storage yards, and after the 50-ft. spans were erected they were assembled on the cross-ties outside of the track at the west end of the viaduct. After they were braced together by the overhead struts which afforded clearance for trains to pass between them, each truss was seated on six solid steel rollers at each end and rolled forward on tracks made with three lines of rails spiked to the old ties. The trusses raised them about 3 ft. above their final position. All of the bracing except the top laterals was connected to the trusses and the working platform was removed, the suspenders extended and the platform replaced below the lower chords of the old trusses, where it served to support them during their removal. Before the old trusses were removed, the 8x16-in. cross-ties 22 ft. long, which had rested on their top chords, were suspended from the new top chords which just cleared them, by pairs of U-bolts, and the spans being thus shortened, their strength was increased to carry the traffic from the new trusses and release the old trusses. After the old trusses were removed, transverse lifting girders were connected to the ends of the new trusses by U-bolts engaging the end top-chord pins and passing between the chord webs where short sections of the cover-plate had been temporarily omitted to give them clearance. The girders were short enough to clear trains on the main track, and were supported at each end clear of the new trusses by 100-ton hydraulic jacks. The two inside jacks were theoretically carried by the plate-girder connecting the tops of the end posts of the new trusses, which were erected independently of the trusses and were braced together so as to virtually form temporary tower bents. The top flanges of the jacking girders were thought to afford too narrow bases for the jacks and 10x10-in. vertical shores were therefore set under the jacks on both sides of the girder to prevent any danger of tipping or displacement and transmit any eccentric load directly to the main transverse girders. Single 12x12-in. vertical shores at the ends of the transverse girders supported the jacks under the outer ends of the lifting girders. By these eight jacks the span was lifted slightly to release the blocking which had supported its top chords on the new transverse girders, and was then gradually lowered to its final position with the ends of the top chords seated on the cap plates of the vertical end posts.

The total displacement was about 3 ft. and the rails were blocked up to maintain the original elevation as the trusses descended. After they had been lowered about 15 in., temporary ties and stringers were connected to them providing for the heaviest traffic, while the original ties were removed and the truss lowering was completed at convenience during intervals between trains, care being taken, of course, to always provide blocking to support the truss in case of any failure of the jacks. When the old ties were removed, the top-lateral system was assembled and the field rivets were driven as soon as possible after connections were made. One new span was put in, riveted up complete and the old span removed in 15 days. The entire work of reconstruction was done by an average party of sixteen men, who were employed for a total period of eleven months, although less than seven months were required to put the new spans in service; but a long time was necessary to complete the bracing in the readjusted upper panels of the towers, to cut off the upper ends of part of the tower columns and to finish various tedious operations. A 6-in. water main in service was carried on the bridge, and its maintenance during the renewal work was rather troublesome. Work was commenced May 25, 1903, and all of the new spans were in service Dec. 15, 1903.

The work was concluded without accident and at a cost materially less than the original estimate. The work was designed and the erection methods planned by Mr. Mason R. Strong, engineer of bridges under the direction of Mr. C. W. Buchholz, then chief engineer of the Erie R. R., and his successor, Mr. W. L. Derr. The 500 tons of steel work were built by the McClintic-Marshall Bridge Co., and were erected by the railroad company's regular erection force in charge of Mr. W. H. Wilkinson, inspector of bridges.

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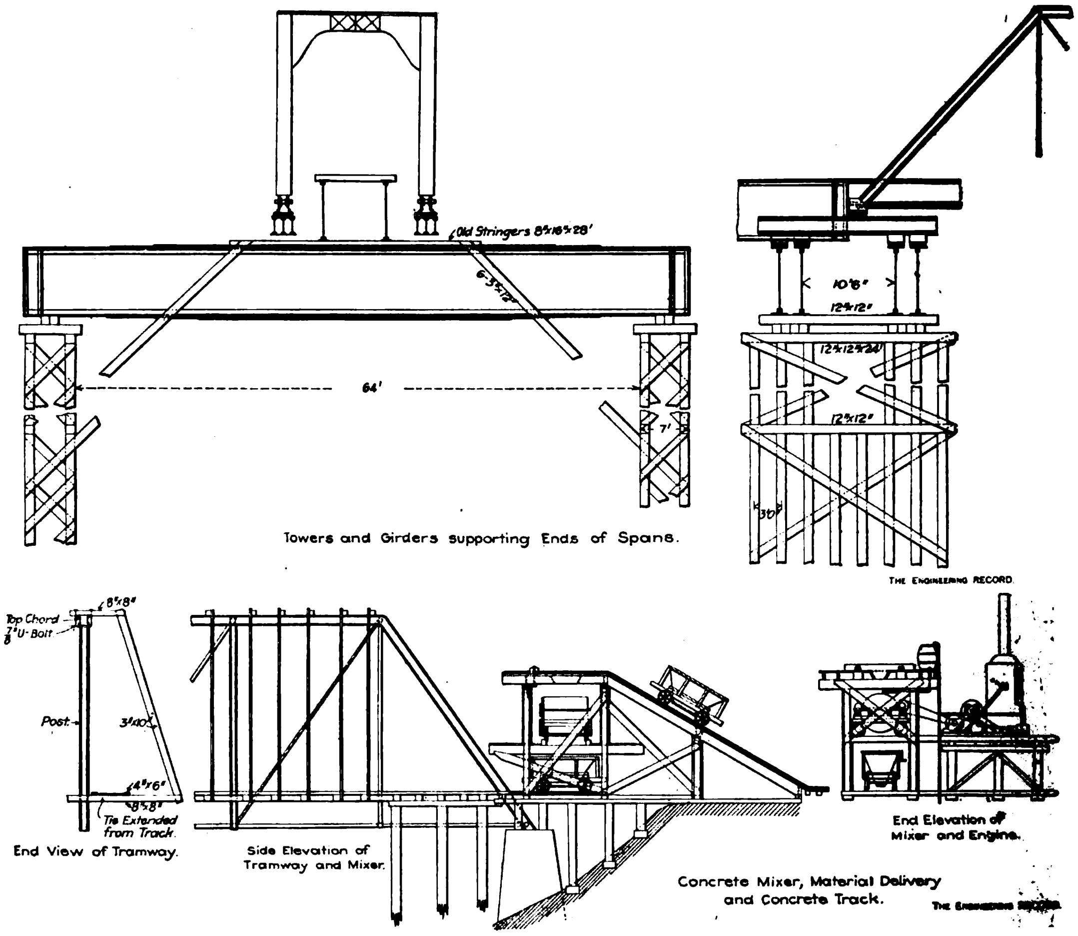
An Unusual Pier Foundation was prepared some years ago by Sir Guilford Molesworth for a Ceylon bridge. The rock bottom was about 8 ft. below the water surface. He made a small islet of broken rock on this bottom and carried it up about a foot over the water line. The upper surface was then pounded with a heavy ram, after which a shallow pit was excavated in its center. Grout was filled into this pit and penetrated all the interstices of the heap of stone, consolidating it effectively.

## Reconstructing Piers of a Railroad Bridge in Service.

A rather unusual piece of substructure work has recently been successfully accomplished in replacing two piers and repairing one abutment of a railroad bridge under traffic where exceptional difficulties were encountered. The bottom of the river was very much obstructed, the river was subject to sudden high floods and to dangerous ice gorges, and one new pier had to be built in the same position as the old one. The work was executed with ordinary plant and involved interesting features in the method of supporting the spans over the replaced pier, and novel devices for supporting the service track, driving the concrete mixer, and handling concrete buckets where there was not sufficient clearance to operate a derrick.

The Wabash River bridge, of the Cleveland, Cincinnati, Chicago & St. Louis Ry., at Terre Haute, Ind., consisted of one curved-chord, 230-ft. span, one 78-ft. girder span, and three 125-ft. Pratt truss spans, resting on limestone masonry piers. From the base of rail to low water is about 40 ft. The old piers were built in 1865, when the road was constructed. They were 22 ft. in length by 6 ft. in width under the coping, and were square ended, with a batter on both ends and sides of ½ in. to a foot. There seems to be no record of the foundations of these piers, but they were supposed to rest simply on timber grillage some distance below low water. The three 125-ft. spans were on the east side of the river and were very much too light for the increased weight of the heavy rolling stock of the Big Four System. It was first decided to replace the three spans with five 74-ft. girders supported on four new concrete piers.



**Temporary Erection Structures.**

An attempt was made early last spring to build a pier by the open cofferdam process, but after working at it for some months it was found, on account of the quantity of rip-rap stone in the river that this process was practically impossible. The contractor made several attempts to drive sheet piling, and finally did succeed in getting in what appeared to be a fairly tight sheet pile cofferdam, but when he undertook to pump the water out he found that he could not lower it more than a fraction of an inch with one 10-in. and one 6-in. centrifugal pumps. On further investigation it was found that the whole river bottom was filled with riprap of sizes running from one-man stones up to 3-ton stones, and, in addition to this, there were two old bridge spans, a locomotive and 40 old freight cars, the remnants of three wrecks on the bridge, besides old falsework piles that had been cut off below low water.

On account of so much debris in the river, and also because the range between high and low water in the Wabash at this point is about 27 ft., and the ice gorges in the spring are very severe, the first plan for replacing the three east spans was abandoned and it was decided to put in two piers resting on pneumatic caisson foundations and two 184-ft. Warren truss spans, thus giving a greater waterway between the piers, and less chance for the ice to gorge than by the other plan.

The Foundation Company, 35 Nassau St., New York, was called in consultation and given a contract to construct these new piers and rebuild the east abutment. They designed the caissons, which were approved by the chief engineer. The caissons were built of 12x12-in. yellow-pine timber, the walls being 24 in. thick and the deck 36 in. thick, with a 4-in. oak shoe on the cutting edge. They were 38 ft. 6 in. in length by 16 ft. 6 in. in width, with a working chamber 6 ft. 4 in. high, with 35 ft. of 12x12-in. beech cribbing on the deck, in which 1:2½:5 concrete was deposited during the process of sinking the caisson. The first caisson was built on shore about 200 ft. below the bridge. Owing to the shallowness of the water in the river it was found necessary to build a false bottom on it in order to successfully launch it. The caisson was launched Oct. 22, 1904, and was