DOUBLING THE LOAD CAPACITY OF AN OLD IRON RAILROAD VIADUCT.*

In 1888 the Chicago & West Michigan built a wrought iron single track viaduct across the Manistee river about 100 miles north of Grand Rapids, Mich., at a point now known as High Bridge, on the Pere Marquette, which absorbed the old Chicago & West Michigan some years ago. This viaduct is 1,170 ft. long, including 14 tower spans 75 ft. high by 30 ft. long, supporting 45 ft. spans between towers, and one 150 ft. river span across the main channel of the stream. The 30 ft. and the 45 ft. spans were, in the original construction, deck plate girders spaced 8 ft. on centers. The river span consisted of 150 ft. deck trusses spaced 14 ft. on centers. The original structure was designed for a loading about equal to Cooper's E-25. The rolling stock gradually became heavier, so that in later years the bridge was somewhat overloaded. In 1911 it was desired to put E-50 loading on the bridge, which would be unsafe for the old structure. It remained to either replace the structure with a new one, or to reinforce it, and the latter method was elected as being much more economical.

J. F. Deimling, chief engineer of the Pere Marquette, in asking for competitive propositions for the reinforcement, submitted, by way of suggestion, a solution which had been used on the Mill Creek trestle. This consisted of adding a new line of

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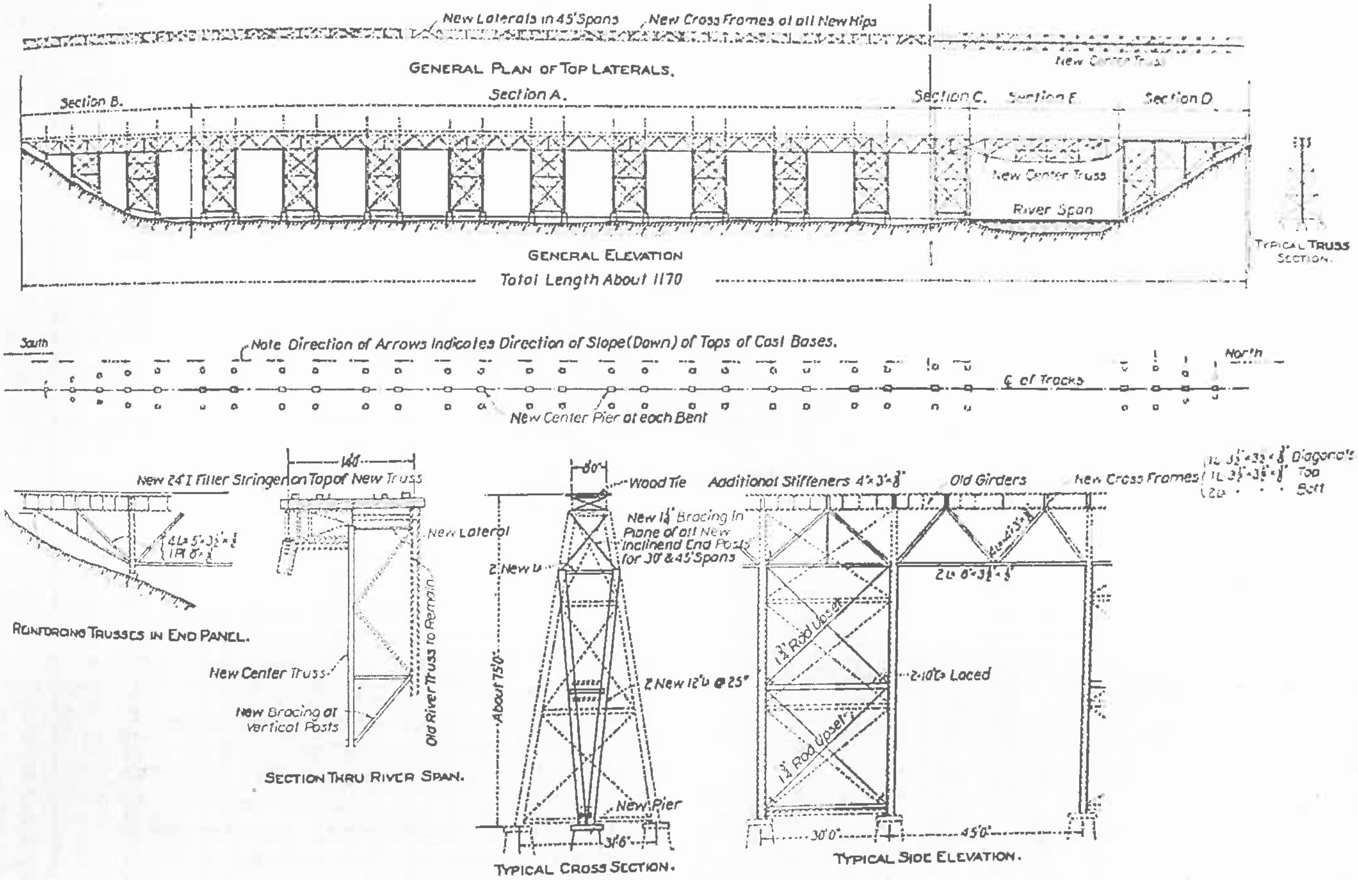
deck plate girders the entire length of the viaduct on the center line of track, these girders being supported on new independent posts at the center of each bent.

This scheme was discarded for the Manistee viaduct, partly on account of greater cost, but chiefly on account of uncertainty of distribution of load among the three girders, as the old girders are only 8 ft. centers, making the ties so short and stiff as to cause a marked degree of indeterminateness of the distribution of the load among the three girders. A further objection was the rocking or tipping effect over the new center girder as a fulcrum under imperfectly adjusted or worn ties, the shortness of the ties magnifying this difficulty. The girders of the old Mill Creek trestle were spaced further apart, which made the new middle girder idea less objectionable in that piece of work. A still further objection to this center girder scheme of reinforcement was the fact that the erection would seriously interfere with traffic during a long period of time.

The scheme finally adopted was proposed by the Wisconsin Bridge & Iron Company, being original with the writer. The fundamental idea of the adopted scheme was to convert the old deck plate girders into deep lattice trusses, of which the old girders would themselves constitute the top chords. This was done by adding a bottom chord about 12 ft. below the girders and introducing a Warren web system between the two chords thus formed. These old deck girders are, of course, stiff enough to resist the bending action of the load, and to deliver these local loads to the panel points of the newly formed truss. In calculation, for safety, the old girders were figured both as single spans between new panel points, and as continuous girders, the worst result being used in all cases. Additional stiffeners were added and cross frames installed.

To carry the excess load from these newly formed trusses to the ground, two new columns are added to each bent, starting at the bottom chord of the new trusses and running on an incline down to a new concrete pier built at the center of each old bent. The two new columns thus form a V and make the remodeled bent consist of two A-frames. This construction has the desired effect of virtually lessening the height of the trestle towers by about 12 ft., for the load is now delivered into the towers at the bottom chord of the newly formed trusses. Furthermore, this system braces the structure longitudinally by virtue of the depth of the new trusses. Also, the new A-frame form of the bents stiffens the structure transversely. The scheme has the further advantage of being capable of field construction with practically no interference with traffic, as the old girders were not disturbed, except for the drilling of holes, etc., in them.



Elevation and Details of Reinforced Viaduct.

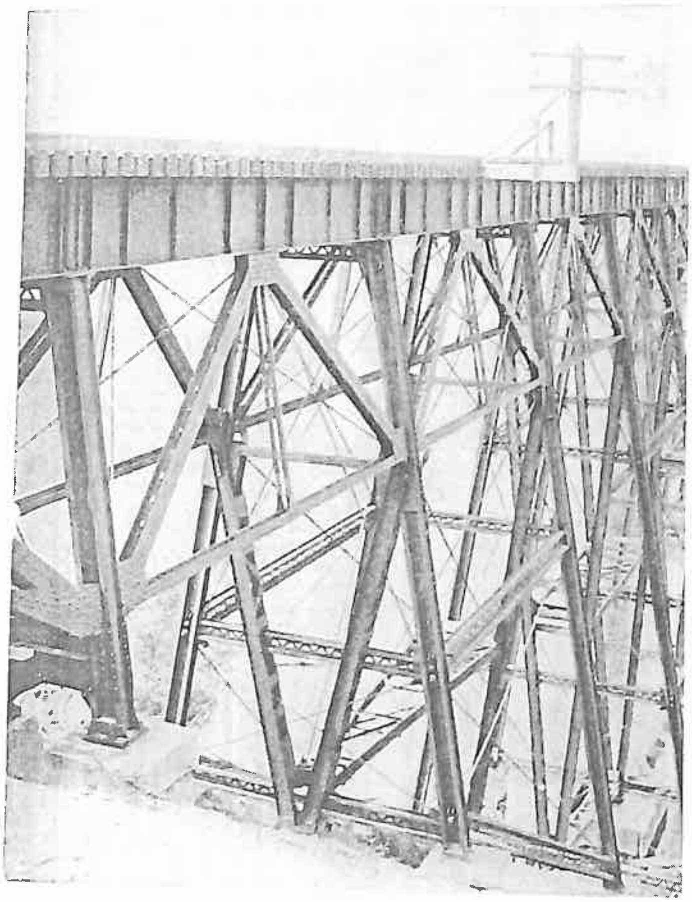
At the river span the system just described could, of course, not be followed, and here a new deck truss 150 ft. long was placed midway between the old trusses. The distance between the old trusses is 14 ft., being thus sufficiently far apart to give longer and consequently more limber ties, permitting of more definite proportioning of loads as delivered from the ties into the two old and the one new truss, and also minimizing the tipping effect of the ties. The load from the new center river truss is carried to the ground by a new independent straight column.

The towers supporting the river span, and the three short spans of the north approach to the river span, were originally built with the deck girders spaced 14 ft. centers, the same as the river span trusses, and we therefore reinforced this small portion of the viaduct by the introduction of a new girder midway between the two old ones, in line with the new river truss and, like the latter, supported by a single new independent straight column at the middle of the old bents.

One source of indeterminateness in both of the schemes seriously considered was the possibility of improper distribution of load between the two old and the one new pier of each bent. This is always true in the case of a continuous three-point-bearing, but there was no alternative in this problem, as there seemed to be no way of getting sufficient bearing in the soil except to introduce the new middle pier. As a partial insurance to a proper distribution of loads on the three piers, the new middle pier was surmounted with an adjustable cast iron base, so simple in its adjustment that a bridge inspector on his annual inspection can, without any assistance whatever, and with no other tools than a good sized wrench, adjust this shoe to take care of any difference in shrinkage or settlement which may appear among the three piers. The sliding surfaces of these adjustable shoes were coated with a cheap and lasting form of lubricant known as "Velvet No. 2." The wedges provide for a vertical movement of ¼ in. for a horizontal movement of 3 in. and are controlled by ordinary machine bolts with double nuts. In erecting the wedges, they were set in pairs with the slopes in opposite directions so as to neutralize each other and prevent the entire structure from tending to drift or slide all in one direction.

The new piers were of concrete construction resting on piles, there being 12 piles to each of the standard bents, and 20 piles for the special piers under the new river truss. The piles were driven 35 ft. The piles were so arranged that they could be driven on either side of the old bent without disturbing the old iron work.

The method of handling the pile driver was quite interesting. It had to be moved many times to drive the small cluster of



Details of Reinforced Viaduct, Pere Marquette.

piles at each of the bents, each cluster being split into two groups as divided by the old iron bents which stood on the center line of each pile cluster. The pile driver was handled from the deck of the structure 75 ft. above, and was placed at the various points of operation without removing any of the old bracing. This not only saved expense, but was better for the structure. The driver was picked up near its center of gravity, tilted over with its legs uppermost and its nose or top thrust between the bracing rods of the structure to the desired point of setting up. In this way it was moved along from point to point. Very little timber bracing was used at the foot of the driver, which was guyed to the old iron columns of which there were plenty near each set-up. The engine was handled separately from the driver, not being mounted on it. This avoided the necessity of moving the engine as frequently as the driver.

The erection of the steel work was somewhat unusual, and while at first appearing somewhat formidable, it worked out satisfactorily and with reasonable economy, barring delays due to foundation trouble. The old work was mostly field bolted, which made the occasional temporary removing of old members less expensive. The new steel was handled by a derrick car at the beginning of the work, but this method did not prove entirely satisfactory, and was later replaced by a locomotive crane which gave better results.

The river span was erected with very little falsework. The new steel columns were first erected at the ends of this span. Then the top chord was raised and suspended from the old structure with steamboat ratchets, the turnbuckles being placed so as not to interfere with railroad traffic. All new top chord bracing was then placed, this being connected to the old trusses, and all bottom chord bracing removed. The balance of the new truss was then placed with falsework consisting of but a single wood post at either end, and the truss was kept suspended and controlled with 24 turnbuckles until completely riveted.

The cost of the reconstruction was, in round numbers, as follows; these figures including all extras on the work proper and a contractor's profit of 10 per cent., the work having been undertaken on a percentage basis with a fixed maximum limit:

Foundations in place (Ry. Co. furnished gravel free)	$10,200.00
New steel, 455 tons delivered at site (free freight)	22,400.00
Erection of steel (free transportation of men and equipment)	11,300.00
Total cost	$43,900.00

which, on a conservative guess, is only about half what a new structure would have cost.

The old structure weighed 496 tons.

AUTOMATIC BLOCK SIGNAL RECORDS.

In our issue of February 21, page 333, we printed the records of automatic block signal performance on eight railroads, but omitting the names of the companies. All of them are prominent lines, doing a large business; but the names had to be omitted because certain collateral information, which it would be necessary to have if one were to make comparisons, one road with another, was not available. For a ninth road, however, we have a more complete record and the performance of signals on that road, the Baltimore & Ohio, is the subject of the sketch now printed, the facts being given by courtesy of President Daniel Willard.

On the Baltimore & Ohio we find carefully kept and well arranged records. The quality of its signal service is to be classed as good. It cannot be said that the performance of its signals is markedly better than that on other roads, but its recording system is well arranged, and the practice of its signal department is to a satisfactory degree typical of American practice. It is by no means certain that instructive comparisons, as between roads, can at present be made at all except in a very general way. The percentage of failures to perfect signal movements is found to vary so much between different roads similarly situated that it is evident that there are in most cases vital differences in the bases on which computations are made. And, as is obvious to the student of the subject, all mathematical comparisons are of secondary value, for the reason that on all of the principal roads the proportions of inefficiency are measured in hundredths or thousandths of 1 per cent., figures so small that the statistician, looking at percentages alone, would be forced to mark every record substantially "perfect." There are imperfections, but the specialist in percentages is not the one to help in curing them.

The Baltimore & Ohio System, with 5,471 miles of line, including the Baltimore & Ohio Southwestern and the Cincinnati, Hamilton & Dayton, of which 4,805 miles is passenger lines, has 431.82 miles, nearly all of which is double track or with more than two tracks, on which the automatic block system is used. The remainder of its passenger lines are operated under the manual block system. A great many of the automatic sig-