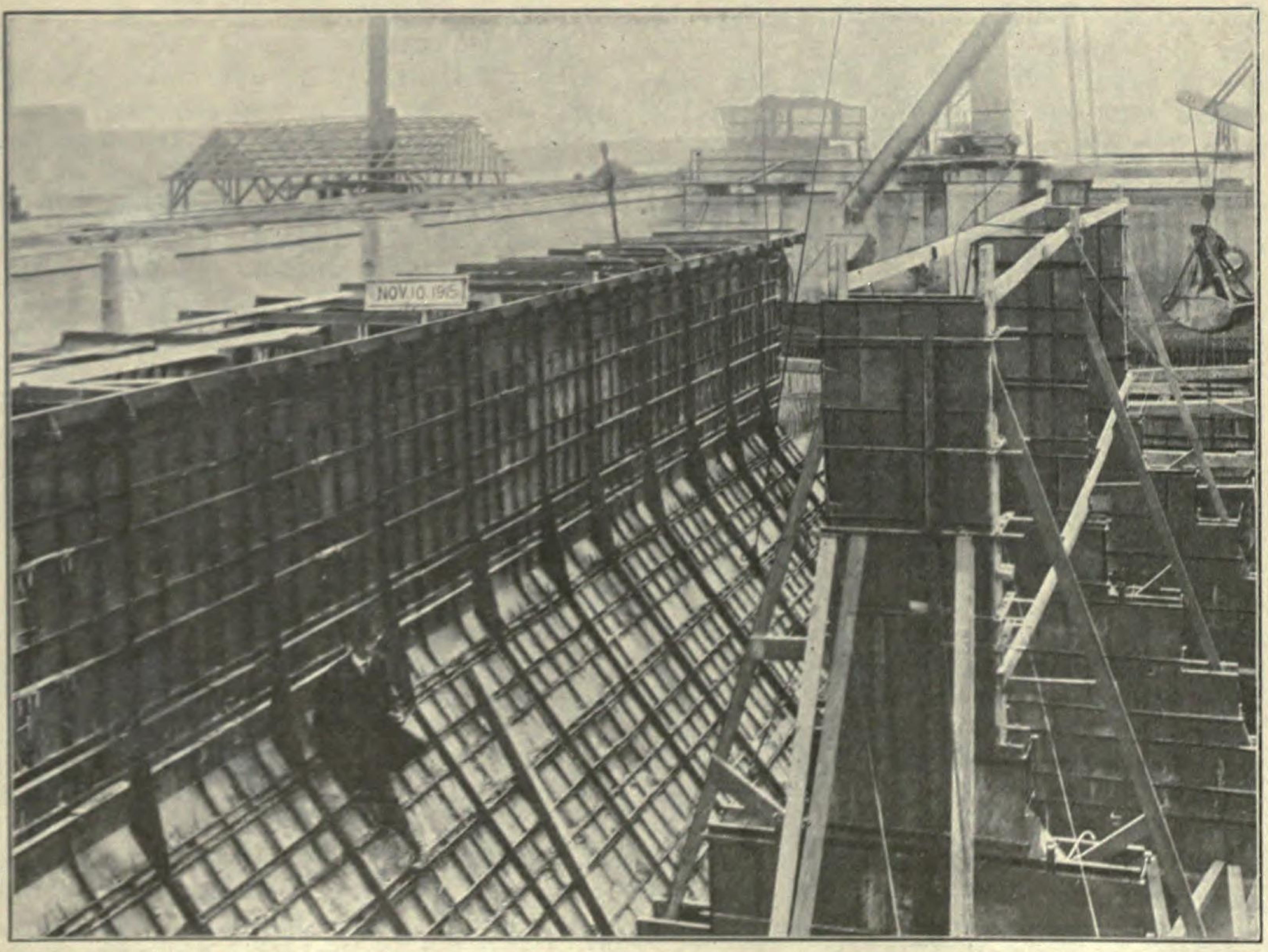
fill on such a steep slope in a manner sufficiently secure to make it practical to dispose the concrete direct upon the earth fill. To secure additional strength, provision was made for cross walls through this earth fill at intervals as shown. The wooden forms, of course, are left in place.

In Photo 3 the steel forms are erected ready to receive the concrete for the dividing walls and the upper portion of the cross walls between the sumps. The picture illustrates how each part of the work is duplicated and how the form is stiffened by the liners and special splice plates at the intercepting angles. In this case, also, the form was provided with a bracket at the top so that a platform or walk was cast at the top of the wall at the same time the wall was cast. In placing concrete in this wall the form was first set up to an elevation about on a level with the shoulder of the man shown in the picture, and filled with concrete to that level, after which the rest of the form was set up to the top of the wall and filled.

How Forms Are Handled

The forms used on this work are, with the exception of the specials provided for the intersections, strictly standard light wall forms, adjustable for use on all plain wall work, where the height poured at any one time does not exceed 10 ft. These forms are attached to the liners before they are erected, and may be shifted either in units 2 ft. wide and 10 ft., 12 ft. or 14 ft. long, as desired, with the horizontal liners attached, or in larger units with the vertical liners attached, in which case it is necessary to employ a derrick to handle the form on account of the weight. The form weighs about the same per square foot of surface as a well made wooden form, but occupies less space and has much greater stiffness.

On this particular job the forms used in the sumps were shifted by the derrick in units 12 ft. wide by 8 ft. high or 96 sq. ft. to a unit, similar units being used on the upper sections. In shifting these large units they are picked up by the derrick and swung around into a new place wherever desired, necessitating little handling.

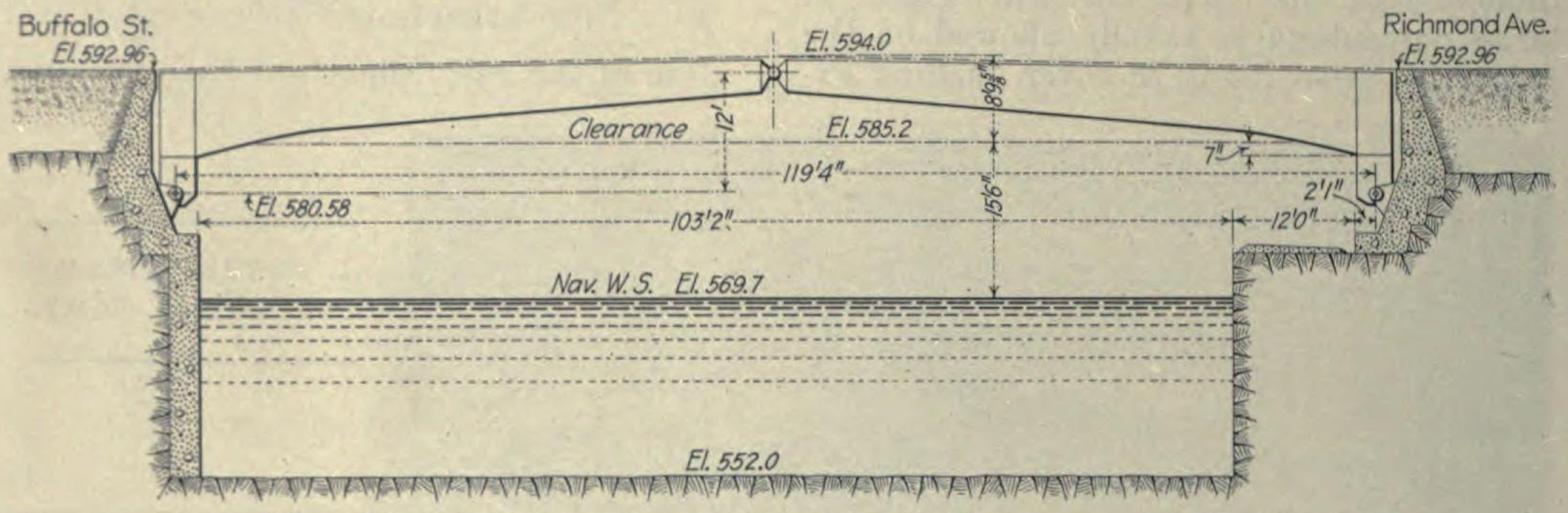


3. FORMS READY TO RECEIVE CONCRETE FOR DIVIDING WALLS

Three-Hinged Arch Girders with Vertical Ends Provide Barge Canal Clearance

Main Street Bridge at Lockport Required Special Design Because of Limited Distance from Underclearance Line to Street Grade

UNUSUALLY limited vertical distance from street grade to clearance line resulted in the adoption of a special type of three-hinged arch girder span over the New York Barge Canal locks at Lockport, N. Y. Fortunately the profile of the rock formation at the site was exceptionally favorable to an arch type of structure, because inexpensive abutments to resist the thrusts could easily be constructed. The general method of design of the arch girders and the details of the shop splice at the end joints between the vertical posts and the main girder will be given.



ROCK FOUNDATION WAS VERY FAVORABLE TO ARCH TYPE OF STRUCTURE

Location and General Dimensions

The bridge is located at the intersection of Main Street with Richmond Avenue on one side of the canal and Buffalo Street on the other, the double-track street car line on Main Street running diagonally across the structure. This location is in the center of the business section, and as other streets intersect at this point it was decided to make the bridge unusually wide and use it as a public square. The total width in plan at one end is 307 ft. 6 in., including a triangular corner approach carried by plate girders. A 10½-ft. sidewalk is used on either side of the principal street crossing the bridge, the balance of the floor being finished with 4-in. creosoted planking and 3-in. creosoted paving blocks supported on I-beams connecting the main arch ribs.

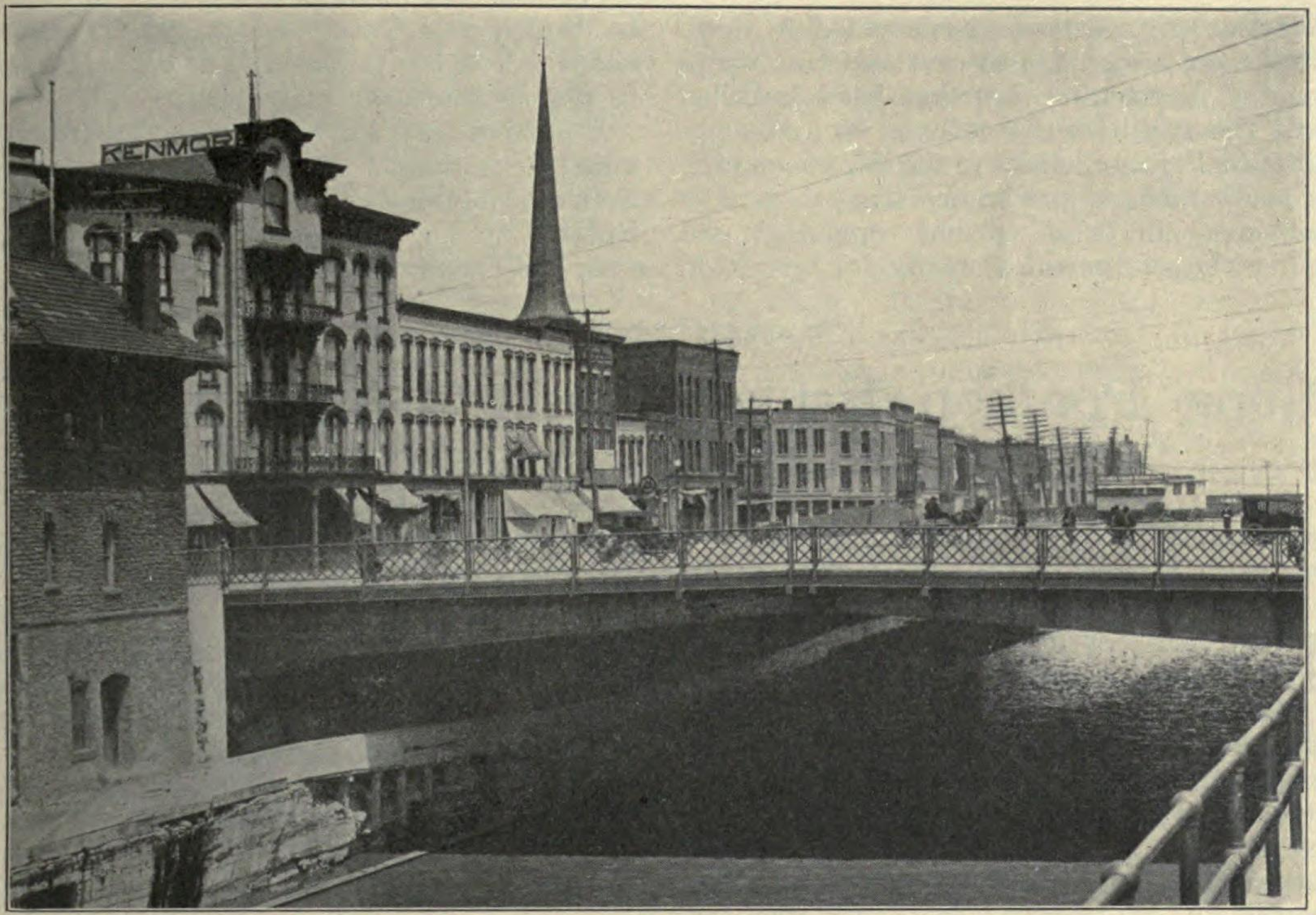
The arch girder ribs are spaced at various distances from 7 ft. 6 in. to 13 ft. 6 in. on centers. Span lengths varying from 116 ft. 10 in. to 124 ft. 2 in. between centers of end pins are used, as the width of the canal prism is changing at this point. The clearance of 15 ft. 6 in. above maximum navigable water level required by the State Barge Canal Commission for all overhead bridges on the canal combined with the fixed location of street grades to limit the available distance for total depth of bridge to only 7 ft. 9 in. for these long spans. The unusual form of three-hinged arch girder with vertical ends, as shown in the accompanying typical elevation, was adopted. A slight grade of about 1 ft. up to the center line of the bridge made possible a greater rise of arch to the center hinge.

Assumed Loads and Allowable Stresses

The design of the floor and arch rib was based on assumed live loads on the trolley tracks as follows: A train composed of cars of 50 tons capacity on either track, each weighing 74 tons when fully loaded, giving axle loads of 37,000 lb. spaced 5 ft. 6 in. apart in trucks 21 ft. 6 in. on centers, the cars assumed 34 ft. on centers; on the second track a train of electric cars weighing 100,000 lb. when fully loaded, and axle loads of 25,000 lb. spaced 5 ft. 6 in. apart in trucks 22 ft. on centers, the cars assumed 40 ft. on centers. The car loads cover 11 ft. in width, and the two tracks are spaced 11 ft. on centers. The balance of the roadway is loaded with 80 lb. per square foot of load.

The allowable stresses used in the design were 20,000 lb. per square inch for tension, and $20{,}000/[1 + (l/r)^2/18{,}000]$ for compression. To allow for deterioration due to corrosion of the steel, the sections in the arch girders were increased in thickness about 1/16 in. above the section theoretically required, and 20 per cent was added to the required section modulus of the I-beams in the floor. Impact allowances of about 50 per cent for uniform loads and 95 per cent for train loads were made.

As the span length of the arches varied in the four groups and the position of the tracks loaded with cars varied in relation to



SPECIAL THREE-HINGED ARCH BRIDGE REQUIRED BY SMALL OVERHEAD CLEARANCE

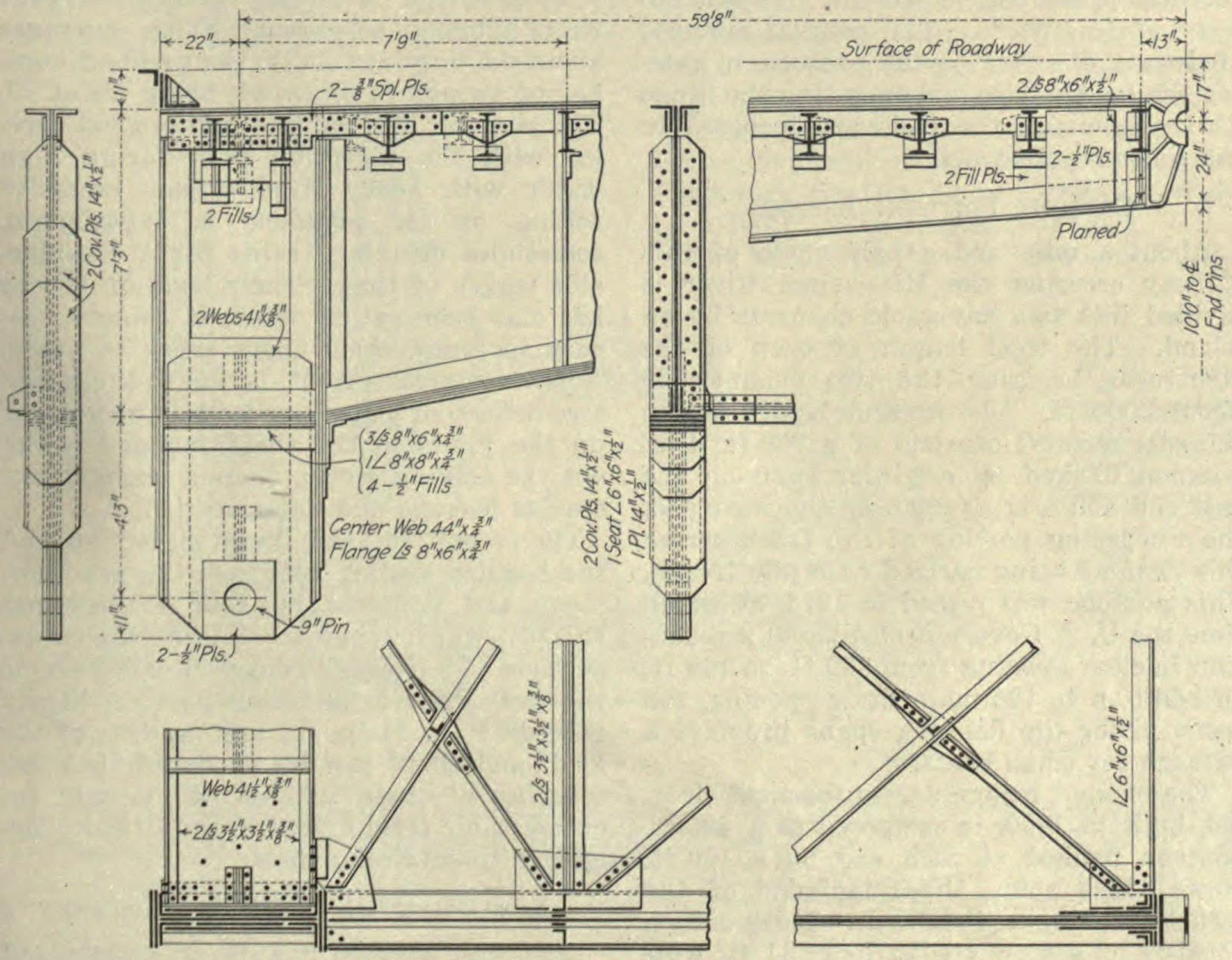
the different arch ribs, it was deemed advisable to construct unit-load influence lines for the stresses in each flange of the arch girders for each of the four groups of the arch spans. This was done by a tabular computation of sections spaced 5 ft. apart. Positions of wheels giving maximum stresses and maximum horizontal thrusts were determined. For uniform loading the area of the influence diagram was used to make the computation of the stress comparatively simple.

Design of Flanges—Details

In general one-sixth of the web plate area was counted as flange area when in compression and one-eighth when in tension. If the stresses in the two flanges were of opposite kind, and one stress was over 50 per cent less than the other, these proportions were increased to one-fourth for the compression flange and three-sixteenths for the tension flange, and if the stresses in both flanges were of the same kind, one-third was used for compression and one-fourth for tension. In all cases the flange stress was computed by moments about the center of gravity of the opposite flange, assumed at 0.15 ft. from the back of the flange angles.

The accompanying detail drawing of the end hinge and shop splice between the vertical end and the main girders shows the material used for the transfer of bending, direct stress and shear. The splice between the web plates is vertical and the heavy compression in the bottom flange of the main girder is transmitted into the end web, reinforced by two 41 x 3/8-in. plates, through the heavy horizontal stiffeners. The end girder strut and lateral bracing in the plane of the bottom flange are indicated in the part sectional plan.

The bridge was designed in the office of the State engineer of New York, under the supervision of W. B. Landreth, special deputy State engineer, by W. R. Davis, chief bridge designer and inspector. The contractor was Larkin & Sangster of Seneca Falls, N. Y., and the total cost was about $1,027,000.



DETAILS OF END HINGE, VERTICAL SHOP SPLICE AND CENTER HINGE

Wayne County Roads Preserved by Maintenance

Repair Crew Responsible for Good Condition of 125 Miles of Concrete Highway, According to Annual Report

"WE have over 125 miles of concrete road in Wayne County, Michigan, some of it in its seventh year of service. All of it is in good condition and we have never taken up and replaced a 25-ft. section since we have been building and developing this type of road. This, we think, speaks volumes for our low annual maintenance costs."

This statement is from the ninth annual report of the Board of County Road Commissioners of Wayne County, Michigan, covering the period from Oct. 1, 1914, to Sept. 30, 1915. It would be natural to assume that it would be reinforced with detail figures indicating what the maintenance costs have been, but the reader will search for them in vain. This year's report, like its predecessors, dodges the issue of costs, although a number of pages of lump sum figures are given which are of no practical use, for they are in a form which precludes comparison on a unit basis. The report, however, describes the methods of maintenance used last year, and extracts from this portion of the document are given below.

Tar Treatment for Cracks

A crew of seven men, a team and a tar kettle are used for the maintenance work. The foreman is paid $5 a day, the team and driver $5 a day, tar man $3 a day, two laborers, $2.50 a day each, and two laborers, $2.25 a day each. The tools used consist of several wire bristle brooms, a wheelbarrow, a couple of shovels, a tar bucket and sprinkling cans. Two men are utilized to sweep all cracks or spalled joints clean with the wire brooms, after which the man with the tar can fills the cracks with tar which is heated to about 225 deg. Fahr., allowing it to stand for a few moments to prevent it from bubbling. It is then covered with a clean, coarse, dry sand, spread from a shovel.

Pit holes are similarly treated. An excess of tar and sand is used and traffic is allowed to iron it out. The Wayne County officials use a special tar mixture graded between Tarvia A and X. Where an imperfection exists that does not extend through the road but is over an inch in depth, the practice is to clean it out and dry it carefully, paint it with hot tar, after which it is filled with stone of a suitable size graded to fill the voids as nearly as possible, tamped down or rolled into place. Hot tar is then poured over the patch, the quantity being gaged so that the tar will be taken up by the remaining voids without any large excess being left on the surface, and coarse, dry sand is then spread with a shovel over the surface. Holes of a lesser depth and any joints from which the filler has wholly or partly disappeared come in for the class of treatment already described for cracks and joints.

A maintenance crew will cover from 1 to 3½ miles of road in a day and one trip over