strong, director, and Mr. N. S. Sprague, superintendent. Mr. Emil Swensson was consulting engineer for the bridge, and the American Bridge Co. was the general contractor for the superstructure of the truss spans.

Bridge Work in Connection with the Elimination of the Grade Crossings of the Nickel-Plate at Cleveland, Ohio.

The New York, Chicago & St. Louis R. R., commonly called the "Nickel Plate," traverses the city of Cleveland and its suburbs for a distance of 16.94 miles. Its course is intersected by 120 highways, 20 of which either did not cross at grade, when the road was constructed in 1882, or had been separated from the grade of the railroad prior to 1909. In the latter year operations were begun to eliminate the grade crossings, and this article treats of the bridge work required for the elimination of these crossings. The ornamental features of the bridges are of special interest. The data contained in the article were taken from a paper by Mr. A. J. Himes, engineer of grade elimination, in Vol. 15, No. 160, Bulletin of the American Railway Engineering Association.

GENERAL.

In Cleveland it was arranged that all street work and highway bridges should be constructed by the city through its engineering department. In East Cleveland all work was done by the railroad company. The ordinances requiring the work provided for the elimination of all grade crossings between East Ninety-third St., Cleveland, and Ivanhoe Road, East Cleveland, a distance of 4.97 miles. Of this distance the four-track roadbed covers 2.4 miles and a double-track roadbed was built the remaining distance. The work required 63,000 cu. yds. of concrete, 5,500 tons of steel for the bridges, and 7,500 lin. ft. of temporary and permanent wooden trestles. In general the concrete was a 1:3:6 mixture. For the bridge floors and for reinforced concrete work a 1:2:4 mixture was used. The steel bridge work was performed entirely by contract.

Very strong opposition to the ordinances developed among the residents of the territory where the road was to be built, which resulted in the final adoption of some very unusual bridge designs to make the structures less unsightly than the usual steel construction.

STEELWORK OF BRIDGES.

The bridges were all designed according to the New York Central Lines' specifications of 1910. The Cleveland bridges were the first to be constructed under these specifications, and a large part of the writer's work, as a member of the New York Central Lines Bridge Committee, was to secure the adoption of a joint specification in order that it might be available for these bridges.

The traffic of the Short Line promised to be as heavy as any in America, while that of the Nickel Plate is lighter. The Nickel Plate is operated wholly independently of the New York Central Lines, but its relations with the latter are so close that to build any portion of the four-track bridges for less than the maximum requirement seemed very short-sighted. Joint specifications seemed the easiest means of securing authority for proper bridges.

The live load in these specifications is Cooper's E-60, with an alternate load of 144,000 lbs. equally distributed on two axles spaced 7 ft. center to center.

The unit stresses are: Tension, 18,000 lbs. per square inch; compression, 16,000—70 l/r, but not to exceed 15,000 lbs. per square inch; and the impact $I = S\left(\frac{300}{L+300}\right)$. The use of unit stresses somewhat higher than common is in recognition of the apparent impossibility of any material increase of live load without a general reconstruction of all roadway structures.

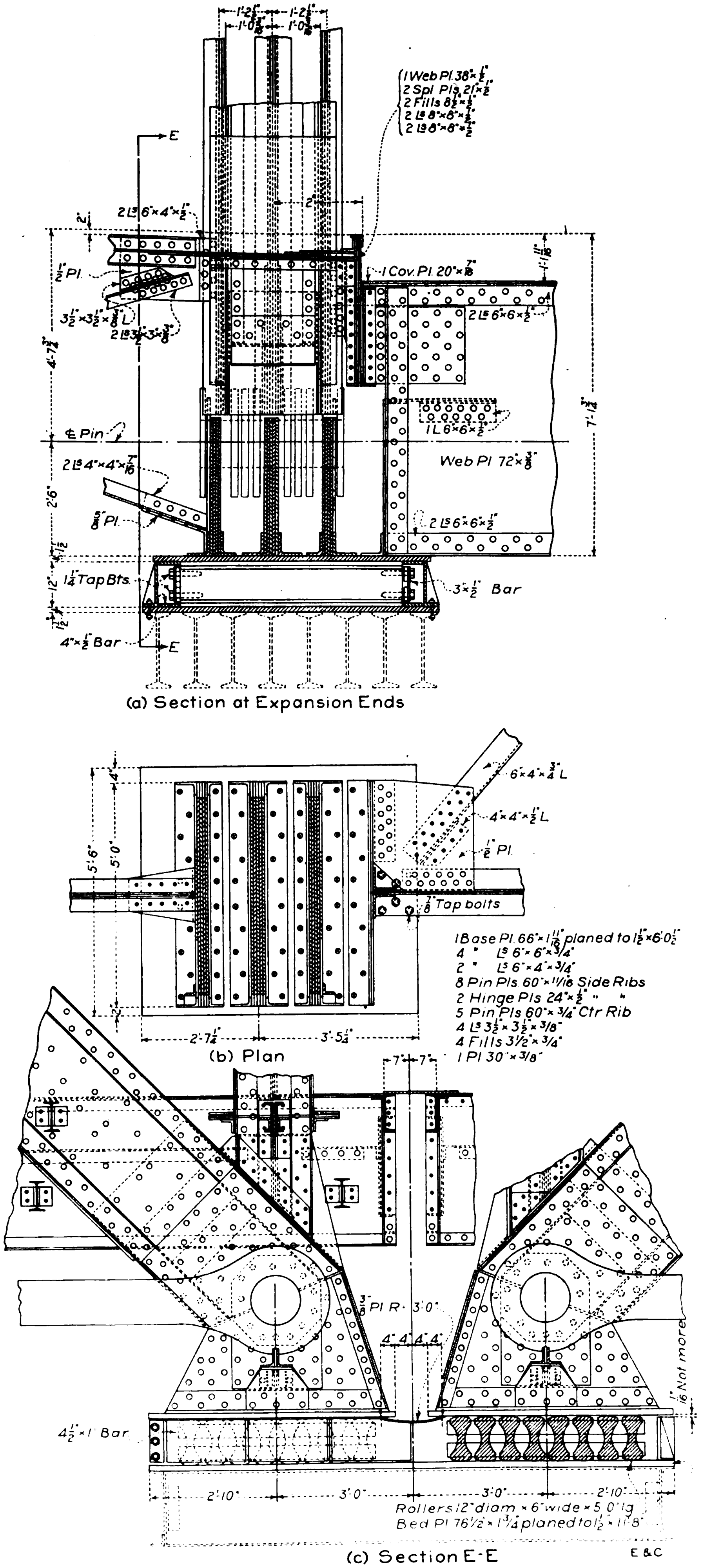

Fig. 3. Cross-Section, Plan and Elevation of Expansion End of North Side Point Bridge, Pittsburgh.

The bridge floors are of I-beams, either encased in concrete or bearing a concrete slab above the beams.

The steelwork of the highway bridges consisted mainly of lattice columns and longitudinal beams, the whole being encased in concrete. The tonnage of the railroad bridges was 4,870, and that of the highway bridges 630—a total of 5,500.

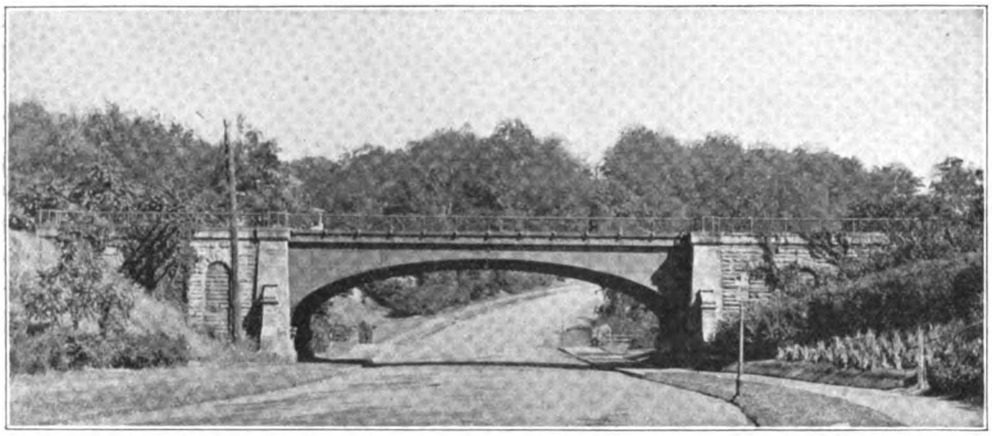

Fig. 1. Old East Boulevard Three-Hinged Steel Arch, Cleveland, O.

Fifteen of the bridges were plate girders; seven of them were three-hinged arches.

The former East Boulevard Bridge of the Nickel Plate (Fig. 1) was considered a very handsome structure, and the people of East Cleveland, in the hope of beautifying their city, demanded the construction of similar arch bridges. To this the company objected strongly, but it was finally arranged to build such bridges on a few particular streets. There was no material difference in weight between the plate girder and arch bridges. There was a considerable difference, however, in the volume of masonry in the foundations. The rock surface was about 12 to 16 ft. below the surface of the streets, and the foundations of the arch bridges were designed to carry the arch thrust to the rock. This increased the volume of concrete materially above what was needed for the plate girder bridges.

No lateral bracing was used in any of the bridges, it being left for the floor slabs to furnish lateral rigidity. Before the construction of the floor slabs temporary wooden stringers were laid on the I-beams to support the track to grade, and the trains caused considerable motion in the arch bridges and the girders having curb supports. In all such cases temporary wooden bracing was used to check the motion.

At Euclid Ave. a combination of long span, sharp skew, curve and heavy loading made it necessary to use curb supports. Curb supports were likewise used at the Mayfield Road.

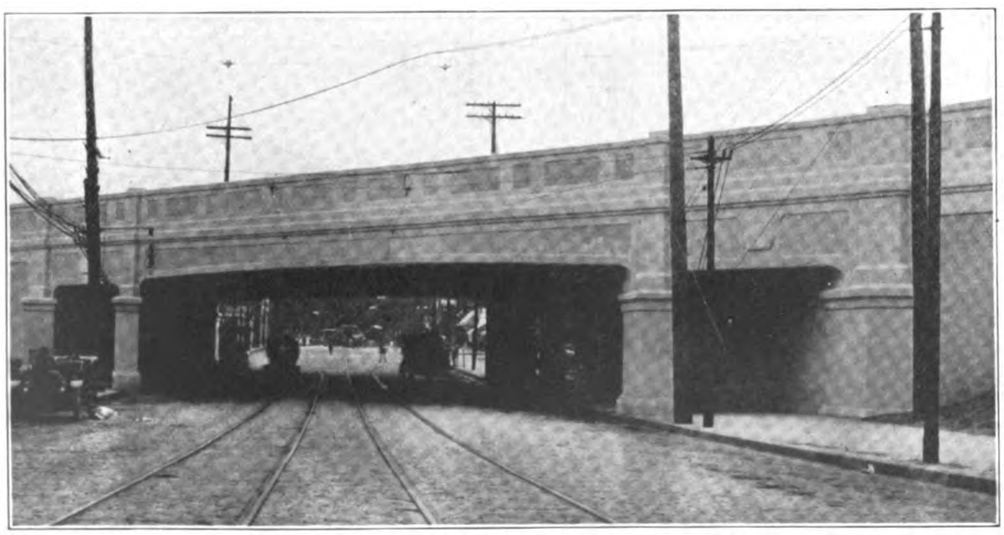

Fig. 3. Euclid Ave. Bridge—Plate Girders with Concrete Fascias—Steel Columns Encased in Concrete.

The old bridges at Cedar Ave. and East Boulevard were dismantled, and all new bridges were erected with derrick cars. All bridge work was done by contract.

DESCRIPTION OF EAST BOULEVARD AND EUCLID AVE. BRIDGES.

East Boulevard Bridge.—The original East Boulevard Bridge was a three-hinged plate girder arch with ornamental stone abutments. It was built for two tracks and had a clear span of 57 ft. 4 ins. The floor consisted of I-beams with a deck plate to which the rails were fastened directly by clips and bolts.

The revised grade of the railroad contemplated a lowering of the Nickel Plate track over the boulevard of 6.39 ft. The grades of the two roads separate just east of Cedar Ave., the Nickel Plate descending sharply to the westward on a 0.5 per cent grade, and the Short Line ascending westward on a 0.3 per cent grade. The effect of this divergence at the boulevard is to produce a difference in the elevation of grade lines of 3.72 ft.

The city ordinance provided for a plate girder bridge with concrete abutments, but when the time came to detail the work the park department entered a protest. It desired that the bridge be rebuilt on lines exactly similar to those of the former bridge. It was impossible to do this, as was reluctantly admitted after a careful study. A stone arch was then proposed, with abutments similar to those of the old bridge. This was impracticable because of insufficient space from top of rail to soffit on the Nickel Plate side. The negotiations continued a whole year without results. It was finally proposed by Mr. Hoffman, chief engineer of the Board of Public Service, that a composite bridge be built; that a reinforced concrete arch be built for the Short Line tracks where there was plenty of room, and that plate girders be used for the Nickel Plate tracks. The present bridge

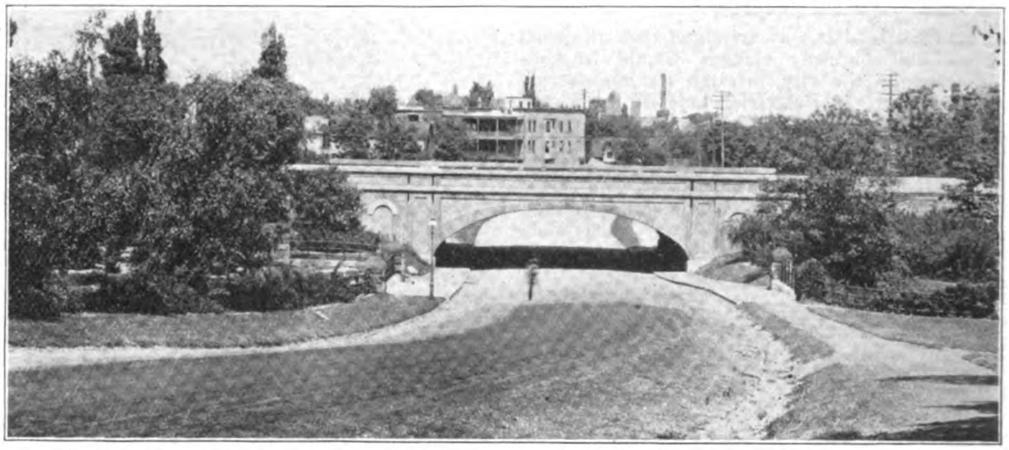

Fig. 2. New East Boulevard Bridge, Cleveland— Combination of Arch and Plate Girders with False Parapet and Soffit.

(see Fig. 2) is the outcome of that suggestion. It was designed to meet the requirement that it have something of the appearance of the old structure, except that the arch should be concrete instead of steel. To carry out the idea as well as possible the writer offered to surround the plate girder with a parapet and false soffit, so as to present the appearance of a simple arch structure and to face it with a matrix of red granite. Later it was decided to color the mortar with iron oxide—not a fortunate proceeding, for the color is much inferior to that of the granite. The granite is now exposed in the rough panels and along the moldings, pilasters and bases where it is bush-hammered. The smooth surfaces are weathering gradually and after a time the difference of color will be less pronounced.

The design of the structure is of interest. The arch is solid and perfect in condition, except for a fine vertical crack in the parapet over the haunches. This is a shrinkage crack and it occurred soon after construction. Its position could have been predetermined by a joint. The whole arch was formed continuously without any intermission night or day, and has thus far been wholly impervious to water, although no waterproofing was used.

Because of the deflection and vibration of the plate girder, a longitudinal joint was constructed along the face of the arch and adjacent to the plate girder to avoid cracking. The joint was filled with oakum and an asphalt mixture, but it will not stay in place. The motion of the steel span causes it to work upward out of the joint.

The false soffit under the plate girder is divided into three sections. The center is a part of the concrete floor slab. There is a transverse joint 10 ft. 8 ins. each side of the center. From the joint to the springing line the soffit is a sheet of mortar 3 ins. thick, plastered on woven wire. The wire is supported by a framework of light channels. Provision is made for motion at the transverse joints. The concrete parapet or face of the false arch is separated from the concrete floor slab by a vertical joint. This joint has thus far prevented any damage to the concrete due the the vibrations from passing trains.

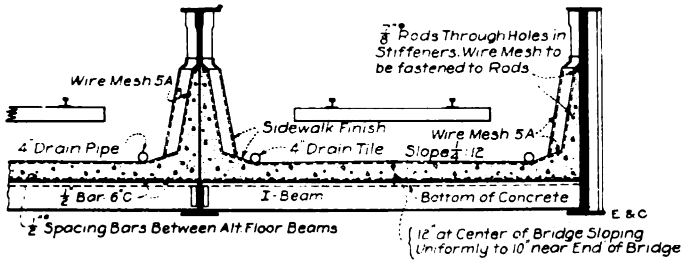

Fig. 4. Section of Typical Bridge Floor—Concrete Slab and I-Beams.

Euclid Ave. Bridge.—At Euclid Ave. the tracks cross the street on a 4° curve, the tangent making an angle of 37° 29′ with the center line of the street. The street was depressed 3 ft. 6 ins., and the railroad grade was elevated 14 ft. 4 ins. This street was made a controlling point in the grade line, the prime object being to avoid as far as possible any obstruction to the view along the avenue. In this respect the result is quite satisfactory as may be seen in Fig. 3.

Preliminary studies indicated that a plate girder bridge with curb supports was the only feasible design. Sketches were made for trusses spanning the whole street, but they were objected to as unsightly. The clear span measured on the skew is 140 ft. 3 ins. Because of the curve it was necessary to space the girders 19 ft. center to center. The heavy live load and the enormous dead load, together with the lateral clearance needed because of the curve, made the use of curb supports imperative. Solid shale was found 27 ft. below the old street surface. It was overlaid with water-bearing sand, the depth of water varying with the season—generally being about 6 ft. A concrete pier was constructed under each of the girders on the curb line, ten piers in all being provided. The inside piers are 6½x6 ft. in plan, and carry an estimated maximum load of 17 tons per square foot. The sidewalk spans are so short that the abutments are little more than retaining walls. Their load is small, but to insure against any settlement which might damage the concrete superstructure they are founded on piles.

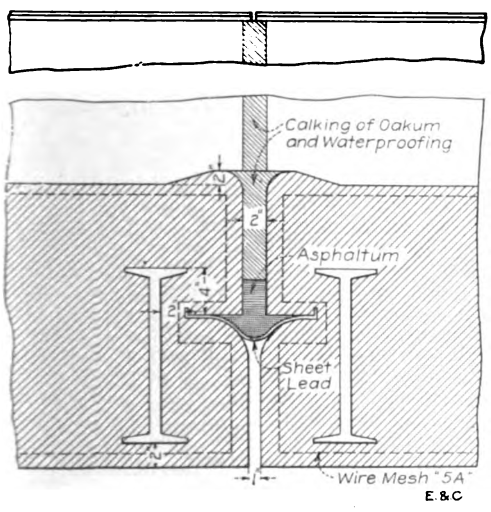

Fig. 5. Detail of Joint in Floor Slab for Arch Bridge.

The thickness of the floor, 3 ft. 6 ins. from top of rail to the underside, was agreed to by the city officials a long time before the passage of the ordinance, even before the live load and unit stresses were determined, and before the type of bridge had been selected. When the design of the structure came up for consideration it was soon found that the depth of floor allowed was very scant. A minimum thickness of ballast of 8 ins. had been agreed to as necessary to prevent noise and avoid damage to the concrete. The summit of the grade had been located on the bridge so it was not desirable to raise the grade. These conditions are stated in detail because, even though investigations had indicated that the waterproofing of the floor slabs was in ordinary cases unnecessary, there was no fall to take water away from the bridge in this case, and cracks in the floor were bound to occur over the curb supports. Had there been sufficient depth of floor available to waterproof the slab and give it a protective covering, such a course might have been followed. Under existing conditions the leakage at the curb line is considerable.

The bridge was constructed without at any time closing the street, only one street car track and one side of the roadway being abandoned at a time while depressing the roadway. The inside girders weighed 79 tons, and measured 91 ft. 3¾ ins. over all. They were placed with a derrick car from above.

The form of the bridge in plan is a rhombus, the diagonals being respectively 83½ ft. and 245½ ft. Both ends of the structure were left free on the abutments. The tops of the abutments were finished smooth and were well painted with heavy asphalt paint. The floor slab was then extended over the abutments. Some trouble was expected from temperature changes, and trouble did later develop. There has been a little motion on the top of each abutment—just enough to crack the mortar in the angle between the floor and the abutment face. The greatest motion has occurred at the extreme apices of the rhombus. At the northerly apex the motion has resulted thus far in a few cracks that are hardly noticeable. At the southerly apex, in February, 1912, a crack appeared in the face of the pilaster extending from the upper right-hand corner to the lower left-hand corner, although two expansion joints had been constructed in the abutment. One of the joints did not appear to work, and it was naturally assumed that the crack was occasioned by the tendency of the wing walls to part from the head wall in the angle, which is a common occurrence in abutment masonry. To remedy this the wing wall was cut loose from the head wall during the following summer by drilling entirely through the abutment, and the crack in the pilaster was filled to a depth of 2 or 3 ins. In the winter of 1912-13 the crack again opened, and further repairs were required. The portion of the pilaster below the bridge seat and between the crack and the joint near the end of the abutment has been removed and rebuilt, using reinforcing bars and dowels in the old concrete. At the bridge seat two grillages made of rails have been placed, one bearing upon the other, the rail heads being in contact with each other. In this way we have endeavored to provide a sliding surface of less resistance, it being thought that the pull of the bridge in cold weather was the cause of the crack. The portion of concrete which was removed from the pilaster showed a projection from the face of about 1/16 in. in extreme cold weather.

Another crack, and one which should have been avoided, occurred in the outside columns. The bridge proper is carried on steel columns encased in concrete. These rest on concrete piers, carried to the rock foundation. The concrete fascias which conceal the bridge rest on the outside columns, but the columns were sufficiently elongated in cross-section with concrete to carry the load. In each of the four outside columns the concrete has parted from the steel, although the crack is, as yet, barely visible. It is now evident that steel reinforcement should have bound the concrete under the fascia to the steel column under the girder, even though the composite column does have a solid rock foundation.

Fig. 6. Cedar Ave. Bridge—Plate Girders Masked by Concrete.

BRIDGE FLOORS.

It was required that the railroad bridge floors be relatively noiseless and waterproof. In former years every effort has been put forth to build shallow floors so as to minimize the change of grade. Such floors have always permitted the muddy water to seep through upon people passing below and have operated as drums in accentuating every sound from the passing trains. To overcome these defects the floors were made of I-beams and concrete slabs, upon which tracks were laid and ballasted as upon the ground. Such a design requires a greater depth of floor, which means a greater change of grade, and more steel to carry the added weight of concrete. The bridge is therefore more expensive. But in cities where the noise is troublesome the ballasted floor is a great improvement. Trains passing over such floor are noticed but little more than when passing over the solid ground.

A concrete floor slab can also be made reasonably water-tight. Both observation and experience indicated that water-tightness could be secured either by concrete alone or in combination with waterproofing. The requisite seemed to be that the material and workmanship should be the very best. If poor waterproofing were placed over poor concrete the

Fig. 7. Mayfield Road Bridge—Plate Girders Masked by Concrete.

structure would leak. If the concrete were good it would hold water, either with or without the waterproofing.

In order to confirm these opinions before construction an investigation of concrete practice on other roads and in building work was undertaken by Mr. G. H. Tinker, bridge engineer, New York, Chicago & St. Louis R. R. Later as chairman of the Committee on Masonry of the American Railway Engineering Association he had exceptional opportunities for continuing the study. The result of this work was in harmony with the above-stated views, and the bridge floors were accordingly designed without waterproofing. A paper by Mr. Tinker, setting forth briefly the information he has accumulated, appeared in Vol. 5, No. 3, of the Journal of the Cleveland Engineering Society. The following extract is quoted therefrom:

In the bridges recently built in Cleveland by the Nickel Plate no foreign waterproofing substance has been used. An attempt has been made to construct a concrete slab which would be in itself as nearly waterproof as is practicable or desirable to make. This has proved satisfactory. When the Cedar Ave. bridge floor was built, the ends of the bridge were dammed up, and the trough so formed was filled with water and allowed to stand for several days. No water whatever came through at any point of the slab. A little water ran through the dam and down over the back wall and seeped through the joint between the bridge seat and floor slab. At the center bent there is a drainage system provided to carry what water might percolate through at that point down to the gutters. Through some slight defect in the formation of this drainage some water seeped through there and dampened the concrete, but at no point of the bridge did any water drip.

Special efforts were made to avoid the en-

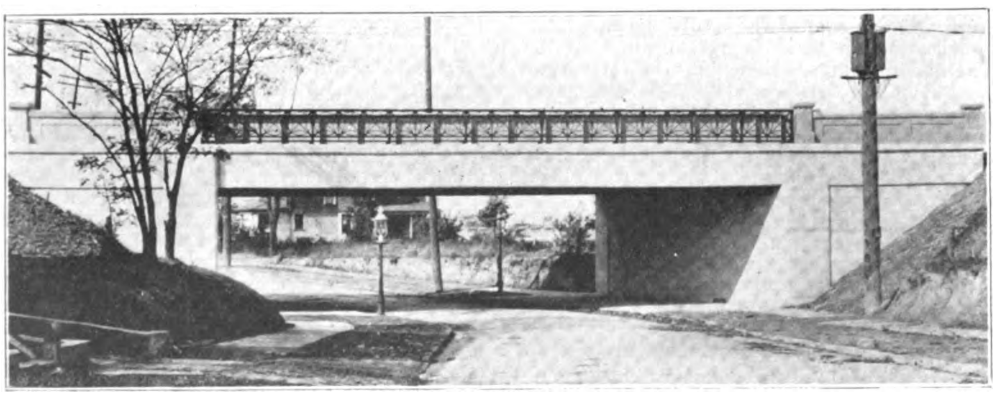

Fig. 9. Shaw Ave. Bridge, East Cleveland—Flat Beam Fascia with Crnamental Iron Railing.

trance of water between the steel and concrete and at points of contraflexure and where cracks might develop from temperature changes. Bevel flashings of steel were riveted to the girder webs and malleable cast flashings were fitted around the stiffeners to cover and seal the edge of the concrete (see Fig. 4). This design was very successful. At points of contraflexure over curb supports and at Cedar Ave. over the center columns it was realized that cracks would develop, and an attempt was made to forestall their appearance by the construction of joints. The joints were carefully provided with gutters and drainage pipes, and it was hoped that no trouble would be experienced with the water. The cracks were successfully forestalled, but

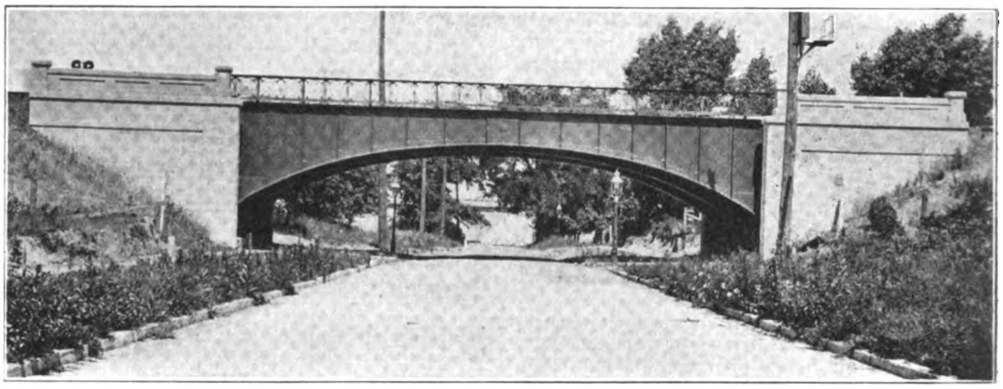

Fig. 8. Three-Hinged Steel Arch at Eddy Road, Cleveland.

the drainage was unsuccessful. The channels soon became clogged with cinders, and the details of the steelwork in the cross-girders did not leave room for a sufficient body of concrete, and in some instances the concrete proved imperfect. Therefore, while the slabs proved generally tight, there has been some leakage at points of contraflexure.

Much reliance has been placed on the use of direct labor and carefully selected foremen, but there came a great rush of work at a critical time and the floors suffered. In East Cleveland at a later date it became necessary to build waterproof joints at the hinges of the arch bridges. This was successfully accomplished in the manner shown in Fig. 5.

The concrete in the floor slabs cost about $12 per cubic yard in place.

Now that the bridges are completed and have been two or more winters in service, the conclusions are as follows:

(1) Concrete can be made water-tight, under low heads, for all practical purposes.

(2) The mixing, placing and ingredients of concrete are subject to such a great number and variety of defects that only the keenest attention will secure an impervious structure.

(3) Contraflexture, temperature changes and settlements will produce cracks.

(4) It is best to forestall cracks with predetermined joints.

(5) Joints can be sealed against water if well designed.

The highway bridges were paved with brick. The gutters have a good fall, and the water runs off quickly. On the under side of the bridge floors the concrete is protected from locomotive blasts by cast-iron plates ½ in. thick and 36 ins. wide. They weigh 71 lbs. per linear foot, and cost $5.23 per foot in place.

ORNAMENTATION OF BRIDGES.

Both cities insisted that the bridges be of an ornamental character. In Cleveland that idea seemed to mean that the structures must be masked with concrete. Steel was held to be unsightly, but concrete was in high favor. The bridges over East Boulevard and Cedar Ave. were surrounded by park land of considerable beauty. In East Cleveland the municipal artist pinned his faith to a steel arch.

A study of the bridges shown in Figs. 1, 2, 3, 6, 7, 8 and 9 furnishes sufficient evidence that bridges can be constructed which are artistic and which do not detract from the beauty of the surroundings. The bridges at East Boulevard and Euclid Ave. are shown in Figs. 2 and 3 respectively, both of which have already been described somewhat in detail. The Cedar Ave. Bridge (see Fig. 6) was first designed and planned as a type. It consists of a set of plate girders masked in concrete. The aim in its design was to secure a pleasing effect from general lines and without fineness of detail. The restrictions of space for the roadway prevented that freedom of treatment which is necessary to secure the best results.

The writer has always felt a strong repugnance to the use of stone as a beam. Such a beam is not self-supporting and can never be more than a symbol of deception. Accordingly he tried to relieve the "curse" by giving the fascia the form of an arch, but, while the curve of the soffit is somewhat pleasing, the required clearance of the roadway prevented a rise that would afford much resemblance to an arch.

The reddish color of the East Boulevard Bridge, designed about a year later, resulted from some criticism of the glaring whiteness of concrete.

The elevation of the concrete fascia of the Mayfield Road Bridge (see Fig. 7) was designed in the office of Robert Hoffman, chief engineer, Department of Public Service. In this case the concrete fascia is built directly upon the outer girder, and it was desired to cover the stiffener angles and to secure a pleasing effect without the use of too large a mass of concrete.

In East Cleveland the artists were not so active. The attitude was rather a stubborn opposition to everything proposed by the company. Steel arches were demanded because of the one formerly used at East Boulevard, and a type of iron railing was designed and adopted by the council. The company was finally able to avoid all but seven of the arches. It had little interest in the railings.

Figure 8 shows a view of the Eddy Road Bridge, which consists of a three-hinged steel arch with an ornamental iron railing.

A band of concrete—a concrete beam—was used to conceal the plate girder spans of the Shaw Ave. Bridge shown in Fig. 9. This bridge also has an ornamental iron railing.

Since the bridges have been completed the consensus of opinion locally is in favor of the plate girders, and it is admitted that the lines of the railings are too fine.

Railways

Principles and Methods for the Valuation of Railroad Property and Other Public Utilities.

(Continued from Page 346.)

OVERHEAD CHARGES.

When the items contained in the inventory are multiplied by the corresponding unit prices and the products are added, the result is only a part of the cost of creating the physical property, for the reason that the unit prices used are generally based upon the direct cost of similar works, and do not include the indirect or incidental expenses. For instance, in fixing a price for a building, the unit price under most circumstances would be the amount for which a contractor would undertake to build and complete the building, or it might be the estimated cost of supplying the labor and materials for the building, with a due allowance for the profit and expenses of the contractor and sub-contractors. In order to obtain the full cost of a building, it would be necessary to include the fees of architects, the amount paid inspectors, the cost of grading the grounds, the amounts expended for interest, taxes, insurance, and legal expenses, and a fair sum for the value of the time devoted by the owner to the planning and construction of the building.

If the person making the valuation had information as to the cost of a similar building which included all these items there would be little, if anything, to be added to obtain the reproduction cost of the building, but if, as is usually the case, the unit cost does not include such items, material additions must be made in order to determine the true reproduction cost.

The amount of the overhead charges applicable to any property should be determined on the basis of the prices prevailing at or near the time of the valuation, but under the conditions existing when the plant was created. The accurate determination of the amount of the overhead charges presents such difficulty that reasonable actual costs should be used as a basis in the case of fairly new properties where such costs can be determined.

The allowance for overhead charges has generally been substantially underestimated by commissions and the courts, as well as by engineers of limited practical experience in construction work. The latter are prone to assume that unit prices bid by contractors or determined during the progress of the work by the inspector are fair measures of its final cost to the owner, but such is rarely the case.

The character and amount of overhead charges are discussed in the following sections:

PRELIMINARY EXPENSES.

Before a public service property can be brought into existence or even its construction begun, a considerable amount of money is necessarily expended for promoting, investigating, organizing and financing, and this expense, together with the value of the services of those promoting and organizing the work, should be included in the valuation. The promotion of projects, public and private, has so often been accomplished by improper or fraudulent methods that the word "promoter" carries with it unpleasant suggestions. It must be recognized, however, that without some man or body of men to promote public service projects they would not exist except under public ownership, and that the services of the promoter are therefore valuable.

The preliminary stage of important developments is often long continued and expensive. For instance, in the case of a large hydro-electric development it is necessary, first, that someone should discover a situation favorable for the development of power and near enough to a market to warrant the consideration of the project. With such a project several steps are usually taken.

First, there is the preliminary study, which must be carried to the extent necessary to warrant expenditures for a further investigation and for obtaining a charter or franchise. Next there is usually a further investigation, with engineering and legal assistance, options are obtained upon the land required for reservoirs and other purposes, reports are prepared, and in general the project is put in shape for presentation to those who may be willing to finance such an undertaking.

At this stage of the proceedings experts are frequently employed to make investigations of the various features of the project, and if their reports are sufficiently favorable, the organization of the corporation is perfected, the bonds are offered for sale, all necessary permits from public authorities are obtained, the acquisition of land and rights is begun, the final surveys and investigations are made, and the preparation of plans and specifications for the construction of the work is carried forward.

If the reports of the experts are unfavorable, the project is usually abandoned, with a considerable loss to those promoting the project. Promotion is a hazardous undertaking, and this feature should be considered in determining the value of the services of the promoter.

The issuing and marketing of bonds involves the payment of a commission to brokers as well as various other expenses, all of which should be included in the valuation, but the discount on bonds due to fixing the interest rate so low that the bonds will not sell at par, should not be so included.

The amount of the preliminary expenses for different projects varies both with the character of the works to be built and the degree of care and skill used in the preparatory work.

The preliminary expenses in connection with ordinary additions and extensions are generally much less than those incurred in connection with the original plant, but they still exist, as for instance, for investigations and designs, for issuing and marketing bonds, and for many other things.

The principal incidental expenses during construction may be classified under the heads Engineering, General Expenses, Contingencies, and Interest and Taxes.

Engineering.—Under the head Engineering is usually included not only strictly engineering expenses, but those of other technical employes and of inspectors. It is difficult to draw the line between the preliminary engineering and that during construction, and it is probably best in most cases to include the part of the preliminary engineering expenses connected with the preparation of the final design of the works with those incurred during their construction.

The percentage of the cost of the work represented by engineering differs with the character of the works and with the amount of care and skill exercised in their design and construction. On railroads it is commonly estimated that the engineering cost will amount to 5 per cent of the physical valuation of the property, exclusive of overhead charges. Statistics of the cost of engineering are available in connection with several municipal and other works, as follows:

Metropolitan Water Works, Massachusetts. This property, costing to the end of 1912, $42,036,000, is to the extent of $15,300,000 made up of old works purchased from the City of Boston and others, on which the engineering charge is not known, leaving $26,736,000, of which the engineering charge was $2,077,000, equal to 7.77 per cent. Based on the total cost, exclusive of engineering, the percentage is 8.42. These amounts include both the preliminary engineering and that during construction.

Boston Subways. Table I has been compiled from official reports.

TABLE I.—BOSTON TRANSIT COMMISSION. (1895-1912.)

	Total cost.	Pctg. of total cost.	Pctg. of construction cost.
Subway:			
Engineering	$ 407,475.48	9.88	11.34
Gen. expense (inc. commission) ...	131,681.57	3.19	3.68
Construction	3,586,002.33	86.93	100.00
Total	$4,125,159.68	100.00	.....
East Boston Tunnel:			
Engineering	$ 191,466.57	5.90	6.62
Gen. expense	161,134.78	4.96	5.57
Construction	2,894,595.01	89.14	100.00
Total	$3,247,196.36	100.00	.....
Boston Tunnel and Subway:			
Engineering	$ 417,866.25	5.05	5.48
Gen. expense	226,441.57	2.73	3.58
Construction	7,623,206.56	92.22	100.00
Total	$8,267,514.38	100.00	.....
Cambridge Connection:			
Engineering	$ 96,575.46	7.10	8.05
Gen. expense	62,355.20	4.59	5.20
Construction	1,199,904.39	88.31	100.00
Total	$1,358,835.65	100.00	......

New York Water Works, now in process of construction. The disbursements upon this work to the end of September, 1913, amounted to $103,178,000. The engineering expense directly attributable to the work under construction amounted to $10,050,000, equal to 9.78 per cent of the total disbursements for this work. In addition, there were engineering expenses relating to investigations of other drainage areas, which are only indirectly attributable to the work under construction, amounting to $394,000 or 0.38 per cent of the total disbursements, making the total for engineering 10.16 per cent. It is to be noted, however, that there is included in this case under the head "engineering" the cost of unusually extensive borings and investigations which were not included as an engineering charge upon the Metropolitan water works. There is not included, however, the cost of expensive investigations by sinking shafts at the Hudson River, which, although originally charged to the engineering account, has been deducted because the shafts afterward became a part of the final construction.

Charles River Basin Commission, Boston.