be lined with zinc or brass for the same reason. The hood is to be 22 ft. diameter and this distributes the area of inflow of each of the 28 intakes to a large area of lake bottom. Around each of the intakes concrete is to be deposited (by means of a tremie or chute) to a thickness of about 6 in. for a radius of 30 ft. The lower edge of hood would be about 30 in. above the concrete.

Heavy materials dropped from the surface would simply fall on the hood and roll away to one side. Lighter materials stand very slight chance of being carried under the hood by the inflow current. To prevent the formation of anchor ice in the hood and intake (in the event of such disturbance as to cause water to be drawn from near the surface), there would be a 2-in. pipe led along the intaake pipe for gravity flow from a hot-water tank on the crib to the hood. For any intake thus choked, the intake gate would be closed and hot water allowed to flow to the hood.

Buoys would be placed around the crib to warn vessels from anchoring within the area occupied by the intakes. In regard to the submerged intakes, it may be noted that practically all such intakes now in use have no protection or means of preventing the surface water from flowing directly into the intake. And all sunken intakes as now built are troubled at times with the formation of anchor ice.

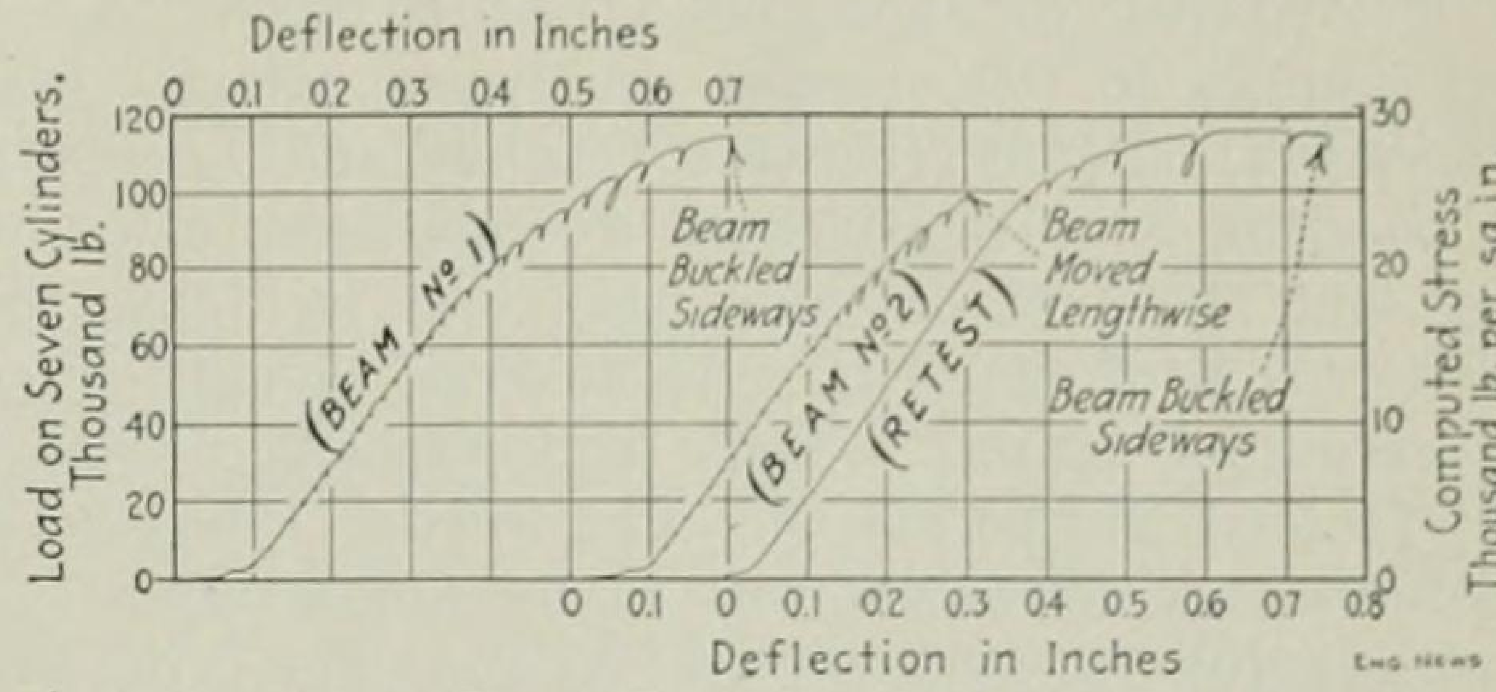
The intake well being partly covered by the floor of the crib, the well room in the superstructure would be only about 20 or 24 ft. square, leaving only sufficient space to operate a hoist or crane for use in making repairs on the well, shaft or tunnel. This would extend up through the two-story superstructure, and above it would be the light tower. With this design, the building necessary for housing the operating force, well room, store rooms, etc., would occupy only half the space now usually devoted to this purpose, and half the surface area of the crib might be utilized as a garden for the use and pleasure of those living on the crib.

The elimination of trouble from anchor ice at the crib means that one crib keeper and his two assistants could handle the work throughout the year, instead of having to hire a much larger force during the winter. The staff is needed to place lights and meet other government requirements, and also attend to the cleaning of screens and other work. The cost of this 400,000,000 gal. intake crib would be practically the same as that of the Edward F. Dunne crib (300,000,000 gal.), as the submerged intakes and outside piping would about balance the difference in cost of the crib proper.

The author has been in the employ of the city for some 17 years and has had charge of the construction of several of the intake tunnels. He realizes that little investigation has been made along the line eliminating the numerous defects and difficulties encountered at the present cribs, but has sought to devise a new and better structure for the purpose.

Through Train Service between New York City and points in eastern New Hampshire and Maine and the North Station in Boston will be inaugurated on June 23, through the completion of the new Hampden R.R., extending from Springfield, Mass., to Bondsville, 16 miles. Through trains over the New Haven system will connect with the Boston & Maine system at Bondsville, so that passengers from New York City and farther South can travel to Maine and New Hampshire summer-resort points without change of cars. The distance from New York to the North Station in Boston by this route will be 234 miles, as compared with 232 miles by the Shore line.

Bending Tests of Two I-Beams were made recently by the Iron City Testing Laboratory, Pittsburgh, for Hindman-Henderson Co., of the same city. A uniform-load testing machine was used, having seven hydraulic plungers applying equal loads at the eighth-points. The I-beam section was somewhat unusual, being 20 in. deep and weighing 59 lb. per lin.ft. (nominally.) Deflections were measured at all stages of loading, and autographic curves of deflection taken. These show complete straightness up to an extreme-fiber stress of 31,000 lb. At 49,000 to 51,000 lb., the two beams (which had deflected laterally throughout the tests) failed, by jumping out of the machine sideways. The curves (see cut) in-



AUTOGRAPHIC LOAD-DEFLECTION CURVES FOR TWO 20-IN. BETHLEHEM I-BEAMS, SHOWING HIGH FLEXURAL ELASTIC LIMIT

dicate, however, that this failure point was close to the normal ultimate. The deflections of the two beams differed slightly, which result is attributed to differences in manufacture. Moduli of elasticity of 28,000,000 and 25,000,000, for the two beams respectively, are reported. The following table of weights and properties of the section, and their departures from nominal values, may be of interest:

	Nominal	Beam 1	Beam 2	Mean Departure
Depth, in.	20	19.54	19.64	2% low
Weight, lb. per ft.	59	54.3	54.3	8% low
Flange width, in.	8.0	8.1	8.1	1% high
Web thickness, in.	0.375	0.389	0.389	3% high
Area, sq.in.	17.36	15.79	15.91	9% low
Moment of Inertia, in.⁴	1172.2	1023	1011	13% low

The tests show that I-beams may have perfectly elastic and normal character practically up to the tensile elastic-limit value of the metal, in spite of the existence of irregularities, internal stresses, etc., evidenced by irregular or inconsistent deflections. The test thus tends to set at rest some of the doubts raised by the tests of Prof. E. Marburg ("Engineering News," Aug. 12, 1909, p. 168) when very low values of elastic limit were found in bending tests of I-beams. However, published tests of I-beams are too few in number to allow of very positive conclusions.

A Temporary Rolling Drawbridge of the retractile type, moving in a horizontal line across the river, is to be built over the Chicago River at Madison St. to accommodate foot traffic during the removal of the present swing bridge and the construction of the new bascule bridge. A pile trestle south of the present bridge will extend from the west bank to the line of the old center pier, and the rolling draw will form the east connection, providing a 70-ft. opening for navigation.

The construction will be very similar to that of the Milwaukee River drawbridge described in our issue of Jan. 30, 1913. The drawspan will have steel trusses 70 ft. long, with a walk 11 ft. wide between them, and one end of the span will be mounted on a pair of car trucks traveling on two standard-gage tracks on a trestle parallel with the present east approach to the bridge. The city owns a large yard south of the approach which is used to store material for the Bridge Department, and this yard provides a convenient site for the trestle carrying the tracks on which the draw will run. The span will be balanced by a counterweight on the short arm, behind the trucks. The operating mechanism will consist of a hoisting engine and cable connected to the trucks, and it is expected that the bridge can be operated in about one minute.

The plans for this temporary drawbridge have been prepared under the direction of Alonzo J. Hammond, Engineer of Bridges and Harbor. The removal of the present bridge has been ordered by the War Department in furtherance of its policy for the improvement of the Chicago River channel by taking out all center piers and similar obstructions.

Instruction in Methods for the Prevention of Accidents must be given by the teachers of the public schools of New Jersey, 30 minutes during each month hereafter, according to a bill passed by the legislature of 1913.

INDEX

Engineering World
A Journal of Engineering and Construction

Volume 20

January—June, 1922

PUBLISHED MONTHLY BY THE

INTERNATIONAL TRADE PRESS, Inc.
MONADNOCK BLOCK
CHICAGO

CLEVELAND OFFICE: 500-501 The Arcade

NEW YORK OFFICE: Room 1736—15 Park Row

DENVER OFFICE: 401 Interstate Bldg.

LONDON OFFICE 42 Old Broad St., E. C.

CINCINNATI: 448 Main St.

PORTLAND: 617 Railway Exchange Bldg.

Substructure for Madison Street Viaduct

Unusual Methods of Construction Employed to Construct Heavily Reinforced Concrete Bents Without Traffic Interference

By R. F. IMLER

Among the many improvements comprising the Chicago Union Station project is the construction of a new viaduct over the terminal tracks at Madison street. The new viaduct will extend from the east side of Canal street to the west abutment of the bridge over the Chicago river and will replace the old structure now in use.

The present structure occupying the site of the proposed viaduct consists of an approach and a short steel span. The approach pavement rests upon an earth fill retained by masonry walls at the sides, a concrete retaining wall at the Canal street end and a concrete and masonry abutment at the river end. The present steel span is supported at one end by this abutment and at the other end by steel columns resting upon concrete piers.

This span bridges three railroad tracks, one of them the main line of the C., M. & St. P. railway. It was designed to carry much lighter vehicular and street car traffic than that passing over it at present, so that it has been necessary to reinforce it and place additional supports under the end nearest the river. An old center pier, steel, swing bridge forms the present river crossing.

Replacement of both these antiquated structures was fast becoming necessary at the time the Chicago Union Station project was formulated so that viaduct and bridge were planned simultaneously. Upon completion of both projects the immense volume of traffic over this thoroughfare will travel from Canal street to the east bank of the river over adequately designed modern structures. The new double-leaf, trunnion bascule bridge is rapidly nearing completion and the construction of the substructure for the viaduct is now in progress.

Building of the viaduct at Madison street, as a part of the Chicago Union Station Co.'s project, is in charge of J. D'Esposito, chief engineer of the company, and A. J. Hammond, assistant chief engineer. Contract for the substructure was awarded to the Underground Construction Co., 106 North La Salle street, a prominent Chicago firm specializing in foundation and tunnel work. Work performed by this company is supervised by J. J. Casey, president, and R. W. Emmert, secretary. Wm. O'Donnell, possessing extensive experience in tunnel construction, is general superintendent and is in charge of the work at Madison street as well as other work being performed by his company for the Chicago Union Station Co.

Superstructure of the Madison street viaduct is to be of steel and concrete construction. It is designed to permit the passage of 13 railroad tracks beneath it, greatly extending the railroad facilities at this section of the terminal. The space at present occupied by the earth fill supporting the approach pavement will be utilized for railroad tracks.

Superstructure girders supporting the street car

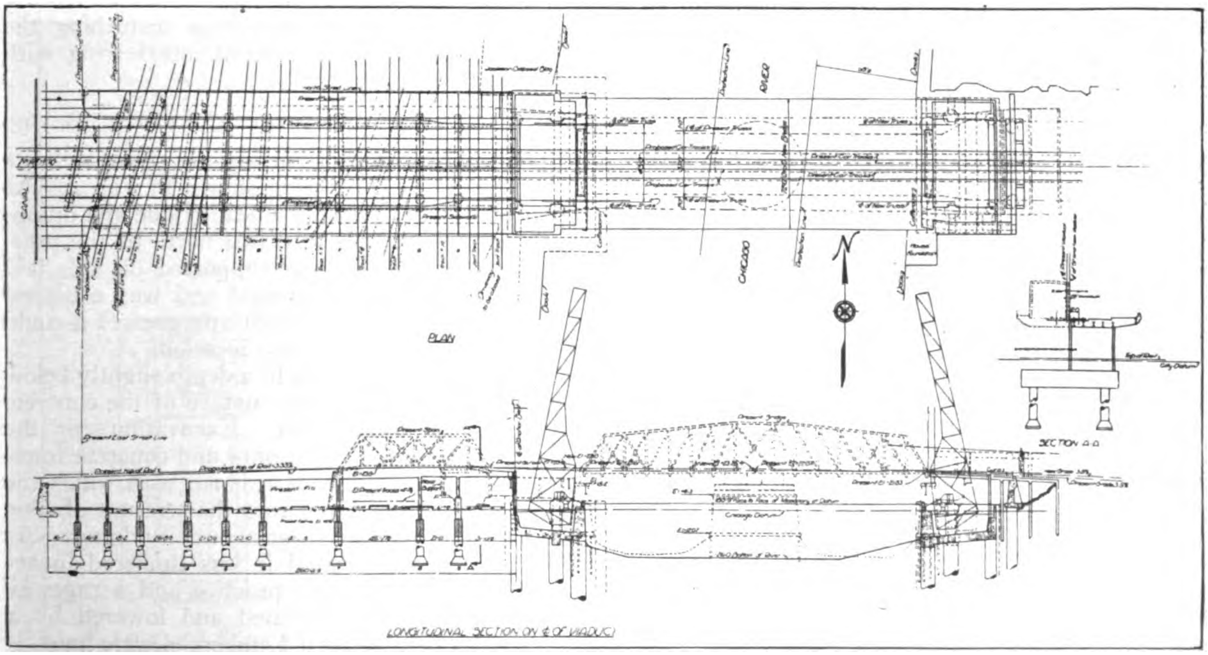


Fig. 1.—General Elevation and Plan of Madison Street Improvement Showing Location of Viaduct Substructure.

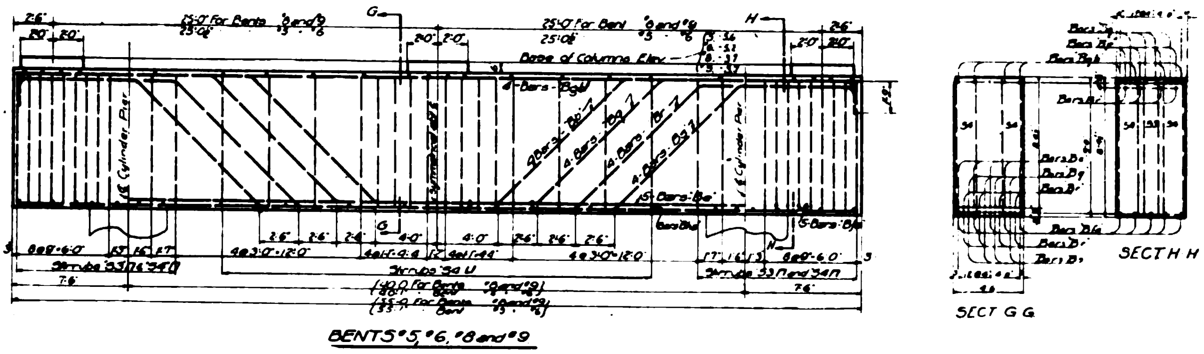


Fig. 2.—Drawing Showing Arrangement of Reinforcement in Typical Substructure Girder.

tracks, pavement and sidewalks will be supported by steel and concrete columns resting upon the reinforced concrete substructure. Columns at the Canal street end of the viaduct will be supported by the substructure of the Canal street improvement and those at the river end will rest upon the west abutment of the new bridge.

Design of the viaduct is in conformity to the proposed track layout. The columns of the superstructure are located between the tracks with ample clearance. There are three rows of supporting columns. Those of the central row are located on the center line of the viaduct and the outer rows are upon lines parallel to the center line and nearly coincident with the proposed curb line. Location of the columns, the substructure supporting them and the track layout necessitating the unusual location of the supporting members of the viaduct are shown in Fig. 1.

Description of Substructure.

Substructure consists of nine reinforced concrete bents similar in general design but slightly differentiated in detail. Each bent consists of two cylindrical concrete piers and one heavily reinforced concrete girder.

Necessity for allowing clearance for a proposed subway beneath the cross girders and between the supporting piers is the controlling factor in the design of these bents. The concrete piers in all bents are spaced 40 ft. from center to center and when a subway is constructed it will pass between them.

Shafts of piers are from 4 ft. to 4 ft. 9 in. dia. All piers are belled at the base to afford greater bearing surface upon the hardpan beneath. The diameter of the bearing surface of the bells ranges from 9 to 11 ft. Piers in bent 1 have bases 9 ft. dia.; in bents 2, 3, 4 and 5 the bases are 10 ft. dia.; in bents 6 and 7 they are 11 ft. dia., and in bents 8 and 9 they are 10 ft. 6 in. dia. All piers rest upon hardpan which is encountered at from 50 to 55 ft. below Chicago datum.

Concrete girders surmounting the piers range in length from 55 to 57 ft. Girders in bents 1, 2 and 3 are 7 ft. 6 ins. in depth, and in bents 4, 5 6, 7, 8 and 9 are 9 ft. in depth. In bent 1 the girder is 4 ft. 2 ins. in width, in bents 2, 3, 4, 5, 6, 8 and 9 the girders are 4 ft. 6 ins. in width, and in bent 7 the girder has a width of 5 ft. 10 ins.

Arrangement of the reinforcement in girders for bents 5, 6, 8 and 9, which is very similar to that in the other girders, is shown in Fig. 2. This drawing also shows the bearing of the superstructure columns upon the girder. The load is applied at three points. A column is located on the center line and the two side columns are outside the supporting piers. To a certain extent the side loading compensates the central load. Arrangement of the reinforcement in these girders is an interesting example of reinforced concrete beam

BENTS 5, 6, 8, 9	Bb	16	1¼"φ	60'0"	14'6¾"	11'5¼"	8'0"	8'1"					⌴
	Bq	16	"	-	12'0¾"	"	13'0"	"					"
	Br	16	"	44'0"	1'6¾"	"	18'0"	"					"
	Be	16	"	60'0"	7'0¾"	"	23'0"	"					"
	Bgb	16	"	58'0"							1'9"	54'6"	⊓
	Bfa	20	"	54'6"									Straight
	Be	20	"	40'0"									"
	Bha	176	¾"φ	4'3"									"
	54	304	"	18'6"	8'7"	1'3"							⊓
	53	88	"	18'2"	8'7	0'11"							⊓

Fig. 3.—Table of Reinforcement Bars Used in Typical Girder.

design. Fig. 3 is a table showing the number, size and shapes of reinforcement placed in girders 5, 6, 8 and 9. It will be noted that some of the shapes have an over-all length of nearly 55 ft. which greatly complicated their being placed in position.

Madison street is one of the most important thoroughfares connecting the central business district with the populous west side of the city. It is highly essential that the new bridge and viaduct be built with as little interference with traffic as possible. Substructure for the viaduct is being constructed without in any way disturbing the present structures and without interferring with railroad traffic.

Method of Constructing Concrete Bents.

The method of constructing the concrete bents is illustrated by the sketch shown in Fig. 4. As illustrated in the drawing a head frame and dumping platform were erected just north of the present approach. This was supported on sills laid on the surface of the ground and was equipped with rollers so that as the work progressed it could readily be moved to the next location.

A shaft was then sunk to a depth slightly below the elevation of the lower surface of the concrete girder to be constructed. Excavation for the shaft was through old masonry and concrete foundations, various strata of rubbish with which the land had been filled and into the stratum of blue clay usually encountered at about city datum. As the shaft was excavated it was timbered in accordance with the usual practice and a cageway framed. Cage was elevated and lowered by a steel cable operated by a Lambert electric hoist.

When the shaft was complete, excavation of a tunnel under the approach was begun. Excavation was made by clay knives through blue clay. As the excavation progressed the tunnel was timbered. For a tunnel, in which a girder 9 ft. in depth and 4 ft. 6 ins. in thickness was to be placed, a sill 6 by 12 ins. by 5 ft. 6 ins. long was first placed with a 3 by 12-in. spreader 4 ft. 6 ins. in length upon it. The elevation of the upper surface of the spreader was the same as that of the lower surface of the girder to be placed in the tunnel. Upon this sill was placed two 6 by 12-in. uprights 13 ft. in height, and upon them a 6 by 12-in. cap similar to the sill beneath the uprights. Similar sets of timbers completely lined the tunnel.

At the elevation of the upper surface of the girder 6 by 8-in. horizontal stringers were placed along the sides of the tunnel and 8 by 8-in. jack braces placed between them. These braces served the double purpose of sustaining the earth pressure on the sides of the tunnel and supporting the track from which the concrete was poured. Braces were spaced on 3-ft. centers. In the space below these braces, eventually to be occupied by the reinforced concrete girder, additional braces were placed as it was thought advisable. These temporary braces were removed before the girder was concreted. The timbering of the tunnel and the arrangement of excavating and concreting tracks in the tunnel are interesting and unique features of this construction.

As the excavation for the tunnel further progressed, a light 14½-in. gage track was laid on the spreaders over the sills. Excavated material from the tunnel and the wells was moved to the shaft in small dump cars operating over this track. Dump cars were rolled upon the cage, hoisted and rolled out upon the dumping platform where the excavated material was chuted into motor trucks and hauled to the lake front where a fill is being made.

Construction of Piers.

When the excavation and lining of the tunnel was complete, sinking of wells for the piers was begun. For hoisting the material excavated from the wells to the floor of the tunnel, a 1½-hp. electric hoist, manufactured especially for this purpose by the Sasgen Derrick Co., was used. This hoist was set up in the tunnel, a head block and pulley set directly over the well and a cable passed from the hoist over the pulley and into the well. The extreme compactness of this hoist made it a

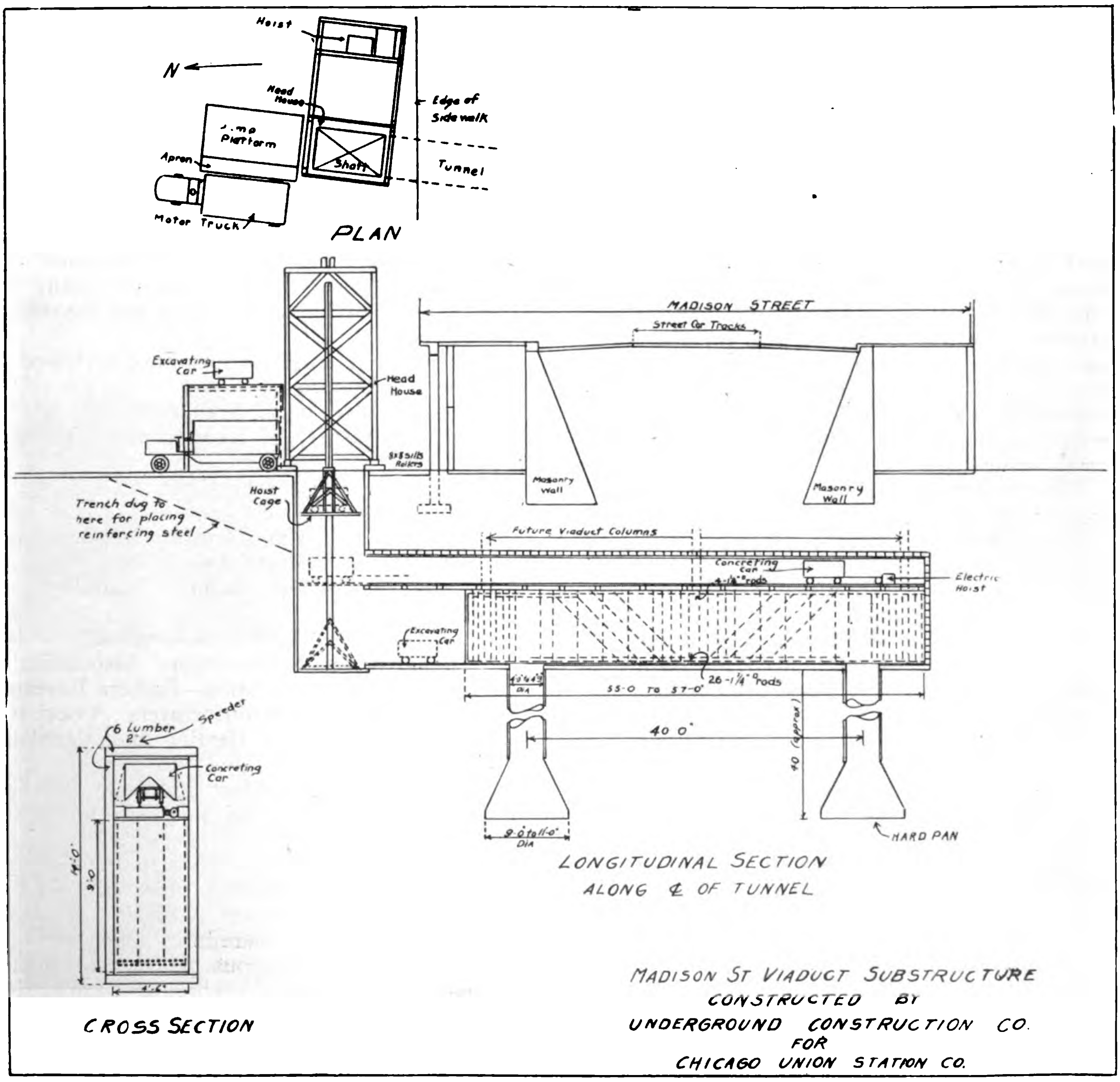


Fig. 4.—Sketch Showing Method of Constructing Viaduct Substructure.

most useful and valuable piece of equipment for this work and for placing concrete in the girder.

Excavation for the piers was through several strata of clay and about 2½ ft. into the stratum of underlying hardpan. Spades were used to excavate the upper strata. In the lower, stiffer strata grubbing hoes were required. To excavate the hardpan railroad picks were used.

Wells were lined with 2-in. maple tongue and groove lagging retained by ½ by 3-in. iron bands.

Concrete used in piers and girders consisted of 1 part Universal portland cement, 2 parts sand and 4 parts pebbles. Aggregate and cement were furnished by the Consumers Co. of Chicago. Concrete for the piers was mixed in a portable concrete mixer operated by a gasoline engine. This equipment was manufactured by the Standard Scale & Supply Co. Mixed concrete for the piers was hauled in specially designed side-dump cars over the tracks used for excavation. Piers were concreted to the floor of the tunnel and reinforcement placed for the girder.

Part of the reinforcement was formed of square bars 60 ft. in length which, after bending, had an over-all length of 54 ft. 6 ins. To place these long bars in the tunnel it was necessary to cut a trench outside the tunnel 13 ft. long. The bottom of this trench sloped from the surface of the ground to a depth of 9 ft. at the edge of the shaft. Reinforcement bars were handled by a gin pole rig and entered the tunnel at about 45-deg. angle. At the time of placing the reinforcement the anchor bolts to which the column bases are to be fastened were set.

When the reinforcement was in position, mixed concrete was placed in the special side-dumping steel cars and pulled through the tunnel over the tracks laid on the jack braces above the girder. Cars were pulled in by the 1½-hp. electric hoist previously mentioned. Concrete for the girder was mixed in a steam operated concrete mixer manufactured by the Milwaukee Chain Belt Co. Starting at the end farthest from the shaft, concrete was poured continuously until the girder was complete.

The foregoing description and the accompanying sketch apply to the methods used in constructing bents 1 to 7 inclusive. Excavation for the girder in bent 9, located under the old steel span, did not require a tunnel as nothing interfered with the open cut method of excavation. Although bent 8 is likewise located beyond the present earth fill, it passes under the present main line of the C., M. & St. P. railway so that tunnelling was necessary. There was not sufficient clearance, however, for a head frame and it was necessary to complete excavation and construct this bent through two working shafts sunk on each side of the track. It was a noteworthy achievement to have constructed this bent without delaying railroad traffic. Bent 7 remains to be built. It is located under the old abutment and it is planned to use 12 by 12-in. timber in the tunnel for this girder instead of the 6 by 12-in. timber used in the construction of the other bents.

Building of this substructure presented a unique problem in tunnel timbering and performing intricate construction in extremely close quarters. It has been solved in a most ingenious and workmanlike manner by the contractor.

National Board of Underwriters Recommend an Ordinance on Chimney Construction

The average annual loss due to defective chimneys in the United States for the year 1916-1919, inclusive, and reported by the Actuarial Bureau to the National Board of Fire Underwriters, was $11,898,000. All losses were not reported and it is conservatively estimated that the complete actual loss was 25% larger, thus making an approximate total loss per year of $14,872,000. The number of lives sacrificed in the average 23,000 fires which produced this annual property loss is not known, but is unquestionably large.

Since fires from this cause are classed as "strictly preventable," it should need no further argument to justify the promulgation of an ordinance, suitable for adoption by a town of any size, or for enactment as a state law. The latter form would be the most effective.

Conservation of our national resources is the demand of the hour. It is, therefore, the duty of all state and municipal authorities to use their best endeavors to stop this great needless waste. The enforcement of a law requiring safe, smoke-tight construction of chimneys of ample size and height would be a sure means of accomplishing an immense saving in life and property as well as materially increasing home comforts.

Defective chimney fires would practically disappear if such an ordinance were generally enforced, and since the additional cost of the construction as compared with ordinary practice would seldom exceed $10 to $15 per chimney, the requirement would not be burdensome. The increased expense would be returned many fold due to saving of life and property and the efficient use of fuel.

The following organizations have reviewed the ordinance and approved it:

American Institute of Architects.
American Society of Heating and Ventilating Engineers.
Associated Tile Manufacturers.
Clay Products Association.
Common Brick Manufacturers' Association.
Eastern Clay Products Association.
National Boiler and Radiator Manufacturers' Association.
National Fire Protection Association.
National Brick Manufacturers' Association.
National Lime Association—Eastern Bureau.
National Lumber Manufacturers' Association.
National Warm Air Heating and Ventilating Association.

Also various independent architects and heating engineers having wide experience in the subject.

This broad endorsement gives the requirements a reputation for correctness which has not been accorded to any similar set of specifications hitherto prepared. It is, therefore, hoped the ordinance may receive generous public approval and become a construction standard in states, cities and towns throughout the country.

Copies of the ordinance may be had by writing to Ira H. Woolson, 76 William street, New York City.