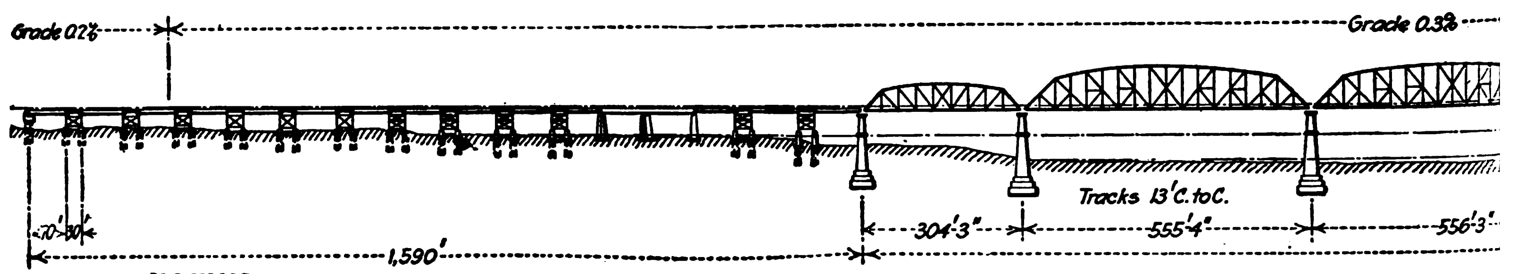
Ohio River Bridge for the C., B. & Q. R. R.

SYNOPSIS—This great bridge, now under construction, is notable for the use of silicon steel and for having the largest plain truss span ever built (723 ft.). It is a double-track bridge, designed for exceptionally heavy live loads. The article outlines the requirements of the steel and the loading.

The new Ohio River bridge at Metropolis, Ill., now under construction by the Chicago, Burlington & Quincy R.R., will have as three special features: The longest fixed truss span yet built, 722 ft. 11 in. c. to c. of piers (with four others of about 556 ft.); the use of silicon steel for the truss members; and provision for very heavy loading. A general drawing and description of the bridge were given in *Engineering News,* July 30, 1914, and the drawing is reproduced herewith. Preliminary work was started about that time, but was stopped very soon after, owing to financial conditions resulting from the war in Europe. The railway connections are nearly completed, however, and a car ferry is being established across the river. In June, 1915, it was decided to proceed with the bridge, and work is now in progress on the pier foundations and the fabrication of the steel.



CHICAGO, BURLINGTON & QUINCY R.R. BRIDGE OVER THE OHIO
C. H. Cartlidge, Chief Engineer;

The bridge was designed by C. H. Cartlidge, Bridge Engineer of the Chicago, Burlington & Quincy R.R. (and Chief Engineer of the auxiliary Paducah & Illinois R.R., which is building the bridge and its connections). All detail drawings were prepared in the Bridge Department, these being submitted for the approval of Ralph Modjeski, consulting engineer for the bridge. The Union Bridge & Construction Co., of Kansas City, Mo., has the contract for the substructure. The American Bridge Co. has the contract for the fabrication and erection of the superstructure, and is building the steelwork at its shops at Gary, Ind.

The structural design of the main trusses is very heavy. The top chords and end posts are of H-section, with two built-up channels for the sides and a continuous diaphragm. The top and bottom lacing is of angles and bars respectively. Some of the plates will have a thickness as great as $1\frac{3}{4}$ in. The largest pins are 15-in. diameter. The top chords are riveted throughout, and very large gussets are used.

An ordinary open-floor deck will be used on the truss spans, while the approach viaduct will have a solid deck of reinforced-concrete slabs for ballasted track.

The river piers will be of reinforced concrete, sunk by the pneumatic process to about 85 ft. below high water, and resting in a deep bed of gravel. Concrete piles will be used under the footings of the viaduct approaches in some cases, while in others these foundations will be on a bed of cemented gravel.

Character of the Steel Used

In the trusses, all main members except the eye-bars will be of silicon steel, the eye-bars and pins of nickel steel and all other material (including lacing) of medium steel. The material in the deck plate-girders and towers of the viaduct approaches will be of medium steel. This is the first use of silicon steel for heavy bridge work in this country. The purpose of using it is to combine high strength with a low increase of weight, in view of the high loading which the bridge is designed to carry. The cost is not very much in excess of that of medium steel and less than for nickel steel. It requires rather more care in the mills and the shops and will be rather slower for drilling. All the material will be openhearth steel.

All rivet holes in silicon steel (which will be $\frac{7}{8}$ to $1\frac{1}{2}$ in. thick) will be drilled from the solid to $\frac{1}{16}$ in. excess diameter, and this will apply also to medium structural steel 1 in. thick and upward. For medium steel less than 1 in. thick the holes will be subpunched and reamed. Any sheared plates or shapes in the trusses will have the edges planed or faced.

The rivet steel is similar in composition to the structural steel except that its sulphur limit is 0.04% and its maximum ultimate strength is 55,000 lb. with a yield point 55% of this. In unit stress the shear and bearing are 11,200 and 19,000 lb. respectively for shop rivets, and 9400 and 16,000 lb. for field rivets.

The nickel-steel eye-bars tested to destruction must show a minimum of 80,000 lb. ultimate tensile strength and 48,000 lb. yield point by drop of beam, also 10% elongation in 18 ft., with 25% reduction in area and a silky fracture. Full-sized material for these eye-bars, 1 in. thick and over, must bend cold 180° around a pin three times the thickness of the bar, without a sign of fracture.

The requirements for the three grades of steel are given in the accompanying table, and in regard to the chemical requirements it is specified that the material must be uniform or of approximately the same composition throughout.

CHARACTER OF STEEL FOR THE OHIO RIVER BRIDGE OF THE CHICAGO, BURLINGTON & QUINCY R.R.

	Structural Steel	Nickel Steel	Silicon Steel
Phosphorus, max. (basic)	0.05%	0.04%	0.04%
Phosphorus, max. (acid)	0.08%	0.05%	0.06%
Sulphur, max.	0.05%	0.04%	0.05%
Nickel, min.	.....	3.25%	.....
Carbon, max.	.....	0.45%	0.40%
Manganese, max.	.....	0.80%	1.00%
Manganese, min.	.....	0.50%	.....
Silicon, min.	.....	.....	0.25%
Ult. strength, min.	55,000	95,000	80,000
Ult. strength, max.	65,000	110,000	95,000
Yield point	30,000	55,000	45,000
Elongation in 8 in.*	$\frac{1,500,000}{\text{Ult.}}$	$\frac{1,500,000}{\text{Ult.}}$	$\frac{1,600,000}{\text{Ult.}}$
Reduction of area, min.†	40%	25%	35%
Fracture desired	silky	silky	silky
Cold bend without fracture: ¾-in. thick	flat	d = 2t	d = t
Cold bend without fracture: ¾ to 1½ in.	d = t	d = 3t	d = 1½t
Cold bend without fracture: over 1½ in.	d = 1½t	d = 3t	d = 2½t

*Elongation in 8 in.—For silicon and nickel steel a deduction of 1% will be allowed from the specified elongation percentage for each increase of ¼ in. (or fraction thereof) in thickness above 1 in., but the elongation must not be less than 14%. In structural steel, a similar deduction will be allowed for a similar increase in thickness above ¾ in. †Reduction of Area—For material ¾ in. and less in thickness a reduction of 1% will be allowed for each increase of ⅛ in. above ¾ in., with a minimum allowable reduction of 24% for silicon steel.

Load and Stress Requirements

The very high live load for which the bridge is designed is a striking feature. The live load assumed for the truss design is as follows: On the near track, two engines of the 2 : 8 : 0 class of Cooper's E-90 loading, followed by a train load of 7500 lb. per ft. of track; on the far track, the train load only. For hangers and subdiagonals, however, two engines are assumed for each track. For the approaches the assumed live load for each track consists of two Cooper's E-90 engines followed by the train load mentioned.

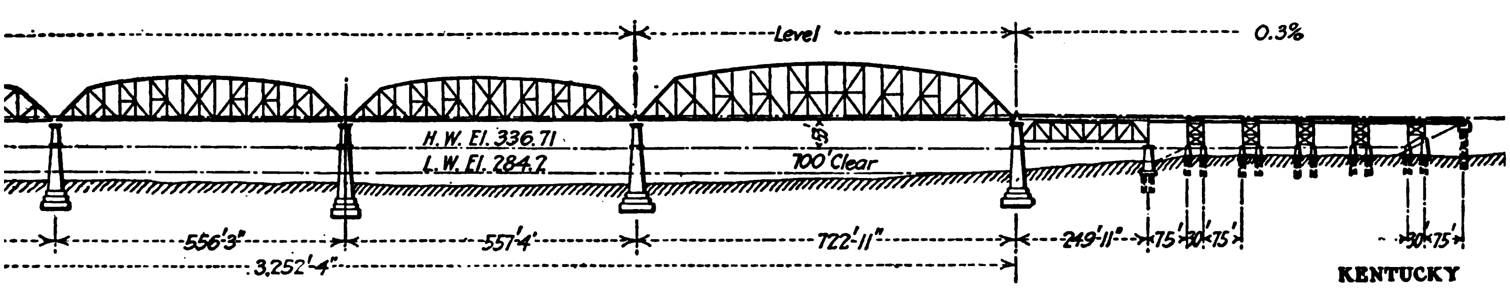
It was the engineer's opinion that the bridge should be designed and built for the ultimate probable load. The reason was that, with spans of varying lengths and with loads nearly equal to (or perhaps a little above) the present existing equipment, the resultant design would not provide the same percentage of strength after the loads should have reached the maximum allowable. This is due, of course, to the fact that the dead load of a long span is a much larger proportion of the total load on that span than it is of the total load on a shorter span. By proportioning the spans for the ultimate probable load a uniform relation between the dead and live loads is maintained, and when the loads for which the bridge is designed are finally realized the spans will be stressed throughout to the amounts decided upon in designing.

This applies particularly to the engines, and it was considered that 45-ton axle loads might reasonably be regarded as a maximum. For the train load, however, the same figure was used as for previous large bridges, since there is little indication of increase in weight per foot of track, in spite of heavier car loads and axle loads. Thus solid coal trains on the Chicago, Burlington & Quincy R.R. do not run higher than 4000 lb. per ft. of track, and with merchandise freight in solid trains it is only about 3000 lb. per ft. of track.

The dead load of track and deck is taken at 500 lb. per ft. of each track for the truss spans (with open floor construction), and 3350 lb. per ft. of each track for the ballasted concrete deck on the approaches.

Impact is provided for in the trusses by adding 10% to the live-load stress in all members, except that for floor hangers and subdiagonals 50% of the live load for one track is to be added on the near track. The 10% addition is increased to 20% for the 246-ft. deck-truss and 300-ft. through-truss spans. For impact on the approaches 22,500 lb. is added to each of the four drivers on one rail of each track for the engine which will cause the greatest stress.

Wind load on the trusses is taken at 30 lb. per sq.ft. of area of train and floor in elevation, for 20 ft. in height; also the same load for the area of truss members of two trusses not covered by this height. All are treated as moving loads. For the top laterals on through spans and the bottom laterals on the deck span, the wind load is taken at 50 lb. per sq.ft. on the exposed area of truss members for two trusses. This also is treated as moving load.



RIVER AT METROPOLIS, ILL., CONTAINING THE LONGEST PLAIN TRUSS IN EXISTENCE
Ralph Modjeski, Consulting Engineer.

For the approaches the viaduct towers are designed for a wind load of 50 lb. per sq.ft. on 1½ times the vertical projection of the structure unloaded; or 30 lb. on the same surface plus 400 lb. per lin.ft. of structure applied 7 ft. above the rail for assumed wind force on a train when the structure is either fully loaded or loaded on either track with empty cars assumed to weigh 1200 lb. per lin.ft., whichever gives the larger strain.

The traction, or longitudinal force, is provided for in the viaduct towers by an allowance for a longitudinal force of 20% of the live load applied at the top of the rail, on one track only. Only a short section of the land end of one approach is on a curve, but the specifications provide an allowance for centrifugal force of the live load applied at the top of the high rail. This force is considered as live load and is derived from the formula $60 - 2\frac{1}{2} D$, in which 60 is the speed in miles per hour and D the degree of curve.

The following unit stresses are allowed for the total dead load, live load and wind load:

	Silicon Steel	Medium Steel	Nickel Steel
Tension and compression*	30,000	20,000	35,000†
Tension and compression for wind	30,000	24,000	35,000
Shear, webs	.....	11,200	.....
Shear, pins	.....	.....	20,000
Bearing, pins	30,000	20,000	35,000
Bending, plates and shapes	30,000	20,000	.....
Bending, pins	.....	.....	35,000

*Compression as reduced by Gordon's formula. †Tension only for nickel steel (eye-bars).

For members having alternate stress, the gross and net sections required for compression and tension stresses respectively are determined and half the smaller section is added to the larger section. The net sections and gross sections are used where tension and compression respectively are the governing stresses. Pin plates are proportioned for the sum of both stresses, except where governed by the section required at pin holes. Members subject to both axial and bending stresses are so proportioned that the combined fiber stresses will not exceed the allowed axial stress.

Garbage-Disposal Propositions at San Francisco

The City Engineer of San Francisco, M. M. O'Shaughnessy, made a report to the Board of Supervisors of the city, on July 2, summarizing various propositions which have been made to the city for the disposal of its garbage and refuse. E. G. Borden offered to erect, at his own cost, a 50-ton experimental hydro-incinerator under the Heslewood patents. The incinerator may be briefly described as a modified gas producer. Mr. Borden claimed that the plant would produce low-grade fuel gas and clinker, both salable articles, and estimated the cost of a 50-ton plant at $8650. After the plant's success had been demonstrated he would sell it to the city at cost, the city to pay in addition $50,000 for the use of the patents covering its construction, with the right to erect such additional plants as it might require.

Collins & Pellett offered to install garbage incinerators with a capacity of 512 tons per day of 24 hr. for $340,000, guaranteeing them to be odorless and practically smokeless.

Fred T. Smith offered to reconstruct the old Thackeray incinerator plant belonging to the city for $255,000, so that it would have a capacity of 720 tons per day of 16 hr. As an alternate proposition he would rebuild the plant for $85,000 and operate it for ten years for 60c. per ton of garbage delivered, the city to guarantee an average of 500 tons or more per day. He also offered to construct a new plant of 720 tons' capacity per day of 16 hr. for $510,000, or for $175,000 with a ten-year operating contract. This proposition was accompanied by detailed specifications as to the operation of the incinerator without dust, smoke, odor or other nuisance.

T. J. Lacey, of San Antonio, Tex., offered a scheme for utilizing garbage in the manufacture of fuel briquettes. J. E. Briggs offered the De Carie incinerator. H. B. Harris, of Nashville, Tenn., offered a garbage incinerator of his own design. Charles Turner, Vice-President and General Manager of the San Francisco Disposal Co., proposed a separate collection of garbage and refuse, the latter to be disposed of in the Islais Creek incinerator and the former to be treated by the reduction method in a plant that his company has built and would enlarge to provide sufficient capacity for the city. J. M. Hirsch, of Chicago, offered a chemical treatment for garbage claimed to produce valuable byproducts.

Richard Schmidt asked for a 35-year franchise to dispose of all the garbage, refuse and waste matter collected in the city by dumping it on waste land and covering it with layers of earth, at a price of 60c. per ton delivered, including that delivered by private scavengers as well as by the city. For such a franchise he offered to pay to the city the sum of 3c. per ton during the first year of operation and 4c. per ton thereafter.

Mr. O'Shaughnessy has investigated the method of garbage disposal proposed by Mr. Schmidt, which is in use at Seattle, Wash., and submitted statements from the President of the Board of Health, the City Engineer and the head of the refuse-disposal department of Seattle, expressing satisfaction with this method as used in that city. Mr. O'Shaughnessy recommended that before entering into any negotiations for the disposal of San Francisco refuse by incineration or reduction, a thorough trial should be made of the method proposed by Mr. Schmidt.

Water Pollution Enjoined at Niagara Falls

The Supreme Court of New York issued an injunction on July 5 restraining the City of Niagara Falls from discharging the effluent of the municipal water-works filter plant in such a manner as to pollute the water taken from the Niagara River by the Western New York Water Co. The city and the company are competitors in furnishing water to the people of Niagara Falls. The municipal water-works, located about two miles above the city, takes water from the river through an intake extending some 2000 ft. beyond the shore, carrying it to a filter plant built in 1912. There is discharged into the river from this filter plant annually about 550 tons of suspended matter from the sedimentation basins, an equal amount of solids in effluents from the filter beds, and about 300 tons of chemicals used in treating the water at the filtration plant.

About two miles down the river from this municipal water-works filter plant is the intake of the Niagara Falls Power Co., from which the Western New York Water Co. draws its supply for domestic use. The water company claimed that the discharge from the municipal filter plant above materially increased the amount of suspended matter in its water supply, as well as the percentage of bacteria, thereby subjecting the company to greater expense in filtering the supply before delivering it to consumers. The river, however, carries a large amount of pollution anyway, and the attorneys for the city contended that, this being the case, it was immaterial that the effluent from the municipal filter beds was discharged into the river. The attorneys for the company, however, showed that there was a trunk sewer near the municipal filtration plant into which the effluent from that plant could be discharged as conveniently as into the river, and with little more expense, and which would deliver the effluent below the falls.

Under these conditions the court decided that it was reasonable to require the city to discharge the effluent from its filtration plant into the sewer instead of into the river itself. Issuance of the injunction was delayed for six months to give the city time to make this change. The case was notable for the conflicting evidence of the chemists testifying on opposite sides of the case. The court decided in favor of the testimony presented by the plaintiff on the ground that the tests made by its chemists were the more reliable, in that they tested the acidity of the gelatine used in their examinations. The experts for the plaintiff were H. F. Huy, of Buffalo, and James M. Caird and F. J. Longley, of Troy.