

THE SAYBROOK BRIDGE OVER THE CONNECTICUT RIVER.

By Edward W. Bush, Chief Engineer, Mem. Conn. Soc. C. E.

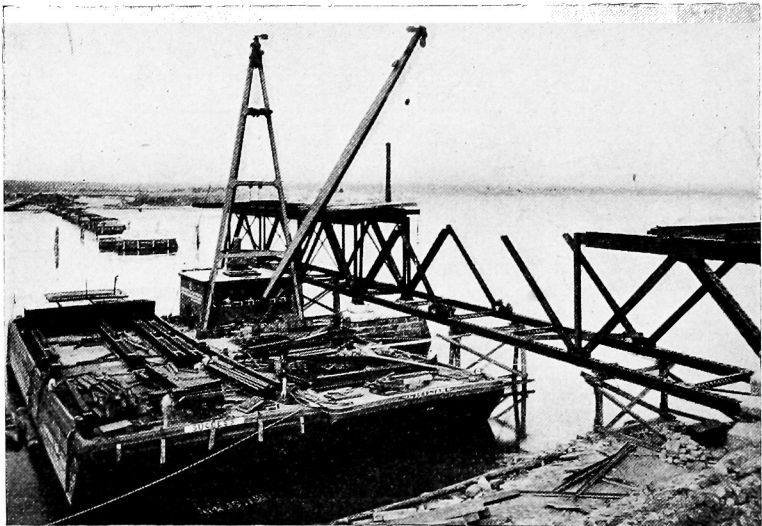
The Saybrook Bridge, which crosses the Connecticut River about three miles from its mouth and connects the towns of Old Lyme and Old Saybrook, was opened on August 24, 1911, by an automobile parade about five miles in length. The bridge is an important part of the highway trunk lines of Connecticut as it is on the main shore route between New York and Boston. It replaces a small steam ferry that the two towns maintained during the time each year that the river permitted navigation, and its construction by the State of Connecticut, in response to the efforts of the ardent automobilists, is an innovation in this State, as this is the first bridge to be built by and for the State. Some few years ago Connecticut bought, by condemnation proceedings, three toll bridges which crossed the Connecticut River farther up in the State. These bridges were made free and turned over to the counties to maintain. About as soon as these matters were settled, and toll bridges in Connecticut abolished, the State appropriated a half million for the Saybrook Bridge and specified that toll should be charged for twenty years.

The bridge has no decided novelty, but is a good example of well-tried methods consistently carried out. It is 1800 feet long and contains a two-arm Scherzer rolling lift draw, affording a 200-foot clear opening. There are eight approach spans of about 159 feet each on one side and two approach spans of 122.5 feet each on the other side of the draw.

The Connecticut River is navigable to Hartford, a distance of fifty miles from its mouth, for vessels drawing about ten feet of water. At the bridge site the river is really a tidal estuary with a mean tidal range of nearly three and one-half feet. The maximum current due to ebb tide is about three and one-half miles per hour, which is increased somewhat during the time the river is discharging freshet water.



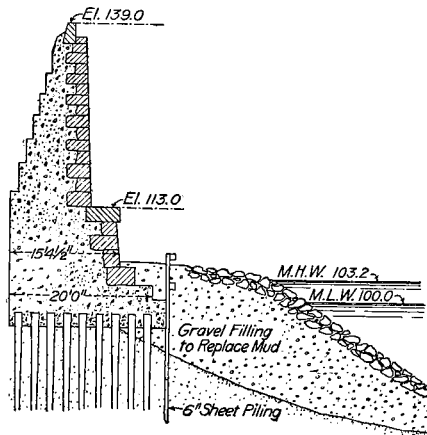
GENERAL VIEW OF SAYBROOK BRIDGE.



ERECTING STEEL AT SAYBROOK BRIDGE.

The twelve piers are founded in from fifteen to forty feet of water on piles supporting timber grillages on which the masonry was laid by the open caisson method. The abutments, thirty-nine feet high, rest on piles, over and around the tops of which was placed, by the cofferdam method, a concrete footing course.

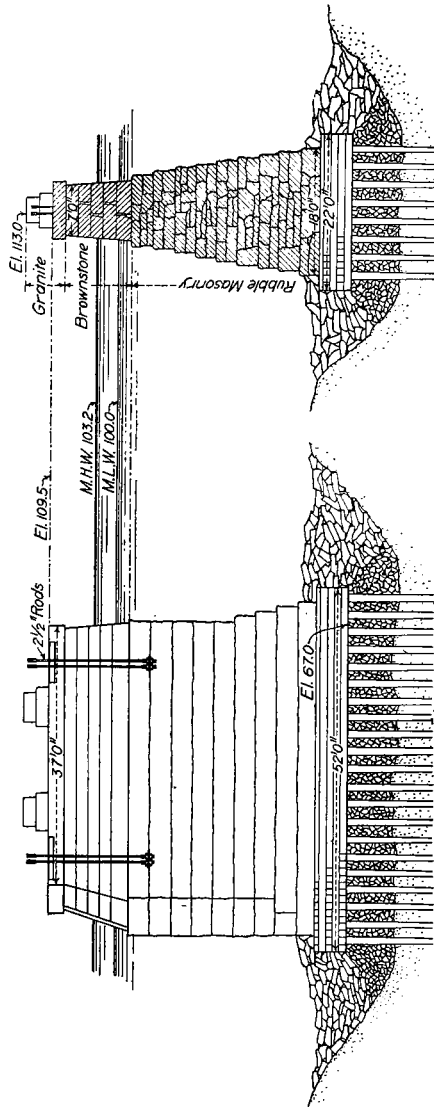
Some doubt existed as to where the draw channels should be located. The method used to fix this was so simple and effective that it may readily be applied to other locations under similar



WEST ABUTMENT, SAYBROOK BRIDGE.

circumstances. Two rowboats carrying red and white flags at day and white lights at night were anchored at the edge of the proposed channel and all tug boat and steamboat captains using the river were asked to observe this channel and suggest to the engineer any changes desired by them in its location. The rowboats were shifted from time to time until the shipping interests using the river were satisfied with the location.

Test borings were taken at frequent intervals across the river at the bridge site during the time of preliminary study. Dry samples were taken every two to five feet and the actual samples removed were preserved in wooden boxes having an inside space of 1 x 1 x 40 inches. The samples, separated by small pieces of zinc in saw-cut slots, were laid off to scale of one inch to a foot and arranged in this way could be very easily studied by persons interested.



PIER NO. II, SAYBROOK BRIDGE.

The borings showed that the river bed varied considerably from place to place, there being all grades of silt, mud, silty sand, sharp sand, etc. A thick bed of good mortar sand was found at one place and later used, and below it were various strata of silty material which included a well defined layer of muck. Such information was of inestimable value in determining the pile lengths and loadings.

Before driving piles at any pier, the site was dredged from 5 to 10 feet in order to clear away the lighter silty top as well as to leave a hole below the general bed of the stream for the riprap protection, which afforded the lateral support to the piling. The piles, mostly chestnut and hemlock, having seven-inch tips and being from twenty-five to forty feet long below the cut-off, were driven by a No. 1 Vulcan steam hammer working in an extension-lead driver by a thirty-foot white oak follower.

By using this equipment the best part of the pile, the butt, was retained in the finished work as the piles were so selected as to length that when fully driven the upper end would be but two feet or so above the elevation of cut-off. At some of the piers the point of cut-off of the piles was about thirty-seven feet below high-tide level. Piles were cut off by a circular saw at the end of a shaft hung in the leads of a driver by a fall line so that the saw could be easily raised or lowered to meet variations of tide, etc. After being cut off the piles were heavily protected by small riprap placed between and around the piles to a depth of from three to seven feet below their tops.

Above the timber grillage to a point a little below mean low water where the ashlar starts, the piers are constructed of Portland brownstone rubble laid in large blocks and well bonded. The ashlar consists of Portland brownstone backed with concrete and capped with granite coping and bridge seat pedestals.

Above the foundation courses the abutments are faced with Portland brownstone ashlar backed with concrete and have granite bridge seats and roadway parapet courses. The brownstone used was the gritty, coarse-grained stone which does not spall or disintegrate when exposed to the weather. An accompanying drawing shows a section of the west abutment. In front of this abutment was a bed of soft mud having a depth of about twenty feet. This mud was removed by dredging and instead of placing the usual riprap stone in front of the abutment

to prevent any forward movement, a much cheaper and it was thought a better substitute was found in a convenient bed of gravel and sand, material from which was deposited in generous quantities immediately in front of the sheet piling cofferdam along the face and wings of the abutment. The outside slope of this backfilling was protected by riprap.

An accompanying drawing shows one of the piers supporting one end of the track girder on which rolls the segmental girder of the Scherzer arm and also supporting one end of an approach span. The eight two and one-half-inch by eighteen-foot anchor rods there shown were necessary to take care of the uplift at this pier due to weight and loading on the channel end of the moving arm of draw, as there is no arch action of the two Scherzer arms when closed. An arch shape was given the draw for æsthetic reasons only.

After the substructure work was completed, quite an elaborate system of soundings to the riprap and river bed were taken along lines easily reproduced. These soundings have been plotted to a scale of twenty feet to an inch and cover all the bottom between the piers as well as a generous area seventy-five feet upstream and downstream from the ends of each pier. This map will be of value in comparing soundings taken at a future date to detect scour at the bridge site.

The superstructure includes about 2200 tons of steel. The trusses are of the deck Warren type with a bottom chord panel length of nearly forty feet and a subpanel length at the top chord of about twenty feet. The floorbeams, spaced about ten feet apart, rest directly on the top chords. They consist of twenty-inch I-beams. The trusses are spaced fifteen feet apart. The roadway is twenty-four feet wide between the wheel guards and a trolley track is laid near one side of the roadway. The bridge is designed for a sixty-ton trolley car.

The floor surface is two-inch spruce plank laid transversely on top of three-inch creosoted yellow pine laid diagonally. In order to permit the trolley rails to be removed, rebonded or otherwise worked upon without tearing up that portion of the wooden floor more generally used for traffic, the three-inch underplanking was only laid at the outer sides of the track, to within one-fourth-inch of the bottom flange of the trolley rail and a two-inch wearing surface plank was placed alongside and in close

contact with the head of the rail. By removing the planking between the rails and these longitudinal planks just outside of the rails, any track work may be done without tearing up other flooring.

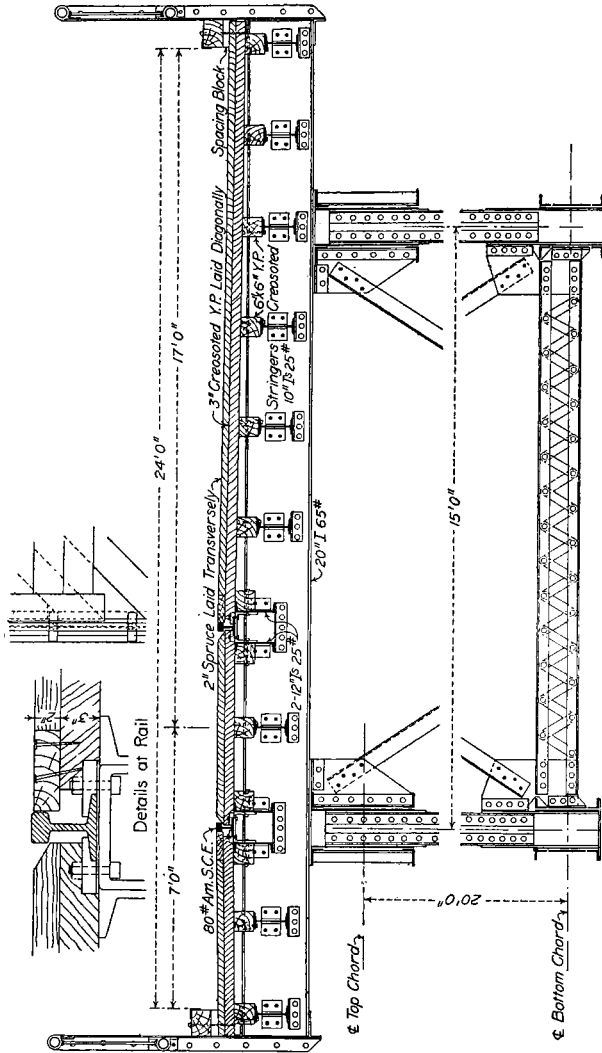
All steel work was erected by derrick barges. It was unloaded directly from cars to barges at Saybrook Point dock and towed to the bridge site. Three bents of falsework were placed under each of the one hundred and fifty-nine spans and two bents under each of the one hundred and twenty-two and one-half-foot spans. Two piles were driven at the end of each bent, about five or six feet apart, the tops were drawn together and capped with a short cap which in turn supported the regular cap of the bent. As the top and bottom chords were fairly stiff members, they were fabricated in long pieces, thus reducing the number of field splices. Some of the parts of the bottom chords were raised in lengths of over seventy-five feet.

The Scherzer arms were erected horizontally without falsework after the concrete counterweights had been placed. A temporary boat channel was provided by omitting one of the fixed spans until after the Scherzer arms had been erected and turned up.

Electricity is used to operate the draw, there being a thirty-seven-horsepower motor on each arm. The draw can be fully opened in seventy seconds. Three men are employed to operate the draw, each man taking an eight-hour shift. The operator also collects the toll charges.

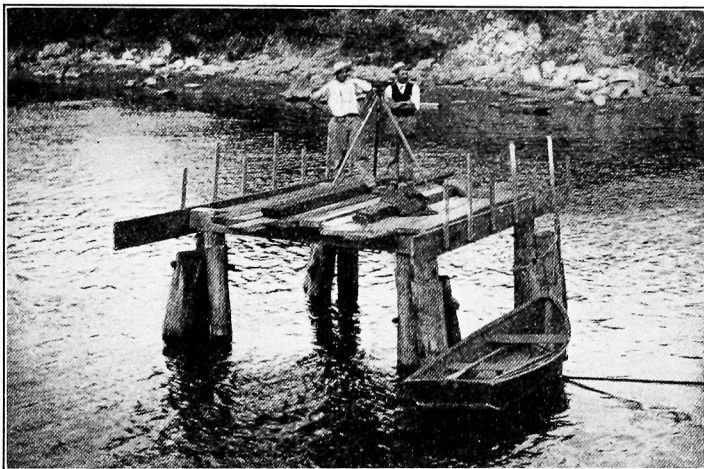
The east and west approaches to the bridge are each one-half mile in length and included considerable excavation and filling. Near the west abutment, at a location commanding a good view of the entire bridge as well as the river for a distance of about two miles up and down stream, there has been erected as an appurtenance to the bridge an eight-room cottage containing all modern conveniences. This cottage will be occupied, rent free, by the head bridge tender, who will thus be within easy call at such times as he is not on his regular shift.

The triangulation system to determine the length of the crossing and the layout of piers was started from a base line along the west bank about 2000 feet long. A check base about nine hundred feet long was established on the east bank at a distance about 2200 feet from the other base line.



TYPICAL CROSS SECTION, SAYBROOK BRIDGE.

The computed and measured length of this nine hundred-foot base line agreed to within an eighth of an inch. The maximum variation in the computed lengths of the bridge crossing, as determined by three out of four different ways in which this length could be independently computed, was also an eighth of an inch.



PLATFORM USED IN LAYING OUT SUBSTRUCTURE.

The bases were measured by ordinary tested steel tapes supported each twenty-five feet, but used with the correct pull, as reported by the tape manufacturers. The angles were read by an ordinary Buff & Berger transit and later were checked by a Berger transit-theodolite, but the first readings were not changed any. The hubs were posts set about three and a half feet into the ground and had the tops project above the ground about twelve inches, for which distance they were hewn to about six inches square and had the sides painted white. The tops were flashed with sheet copper or zinc and care was taken that the mark coincided with the exact center of the post so as to be able to bisect the post, instead of sighting on a lining rod held on the mark, when measuring angles at some distant hub.

Upstream from each of the twelve piers was built a small platform about ten or twelve feet square, from which the survey

work of locating the dredging, pile driving and landing caisson, etc., was done. An accompanying photograph shows such a platform placed in about thirty feet of water, at a time when the level was being used to sight on a target on the saw shaft when piles were being cut off. The slats used in locating the pile rows also appear in the view.

These platforms were somewhat unsteady at times but nevertheless served their purpose most admirably. They were quickly erected and removed and the cost was slight when compared to their many advantages.

The bridge was opened about seventeen months after Congress passed the act permitting its construction. In that time all contracts have been placed and the work constructed. The commission was organized and the first preliminary survey started about two years before the opening. The cost of the work has come within the preliminary estimates and there will be about \$30,000 of the \$500,000 appropriation unexpended.

The substructure was constructed by Holbrook, Cabot & Rollin Corporation, Boston, Mass. The superstructure was built and erected by the Pennsylvania Steel Company, Steelton, Pa. The Bridge Commission consists of Messrs. D. A. Blakeslee of New Haven, A. N. Shepard of Portland, and James H. Day of Saybrook, Conn. The writer was chief engineer. Messrs. Boller & Hodge of New York City designed the superstructure.

DISCUSSION.

MR. BUSH: In taking and plotting the soundings above referred to, it was our aim to leave a permanent record of the condition of the bed of the river as it was when we finished work, so that others coming later may readily detect scour if there is any by running soundings over the same lines used by us.

MR. KELLOGG: What paint was used on the Saybrook Bridge?

MR. BUSH: All paint used on the bridge was made by the Eureka Chemical Co., Brooklyn, N. Y., the shop coat consisting of Metal Red, No. 1. The two field coats were made up of the following specifications:

Pigment; $\frac{2}{3}$ white lead, $\frac{1}{3}$ oxide of zinc with a little lamp black to color.

Vehicle; a pure linseed oil with a small amount of turpentine drier.

The first field coat is a light brown in color. The second and final coat is a very light gray color—almost a white.

Three reasons influenced us largely in selecting this color; something that would look well with the surroundings, a color that would show up well at night time under the rays of a search-light from river boats, and a color that would quickly show rust in the event of the bridge being neglected at some future date as to its upkeep.

The bridge is owned by the State, and as we all know Connecticut has no State organization of technical men who are charged with the care and maintenance of such a structure as this, the bridge may be sadly neglected as to painting at some future date. It will be more apt to receive a coat of paint if the rust shows up strongly against a light color than it would if the same amount of rust was more or less concealed because the structure had been given a dark color.

A MEMBER: Is this commission a permanent commission? Do they receive a salary?

MR. BUSH: The Saybrook and Lyme Connecticut River Bridge Commissioners were appointed in 1909 for five years. Their duty is to construct and maintain this bridge and the Act says they shall receive no salary.

MR. HILL: I would like to inquire about the pile loading. Are those piles driven to rock?

MR. BUSH: No. They were driven until it took from twelve to twenty blows to make the last foot of penetration. A very careful log was recorded of each pile in ten. During the driving of all piles the pile-driver inspector was constantly watching the penetration to see that the pile did not bring up tight and then apparently loosen up later, which would indicate a broken pile. The number of blows per foot of penetration increased gradually and we never got any piles that we suspected were over-driven. The piles were carefully selected, being seven inch tip, and a little bit stockier pile than are usually used in this locality.

MR. JACKSON: What saving was effected, Mr. Bush, in using brownstone in the place of granite?

MR. BUSH: We received alternate bids for using either granite or brownstone as facing. We did not pay as much for

the brownstone as we would have paid if the granite bid had been accepted. The contractors were unable to obtain brownstone already dressed, so organized a stone cutting gang and cut it themselves. They told me they could have bought dressed granite for the same that the dressed brownstone actually cost them.

MR. JACKSON: In placing riprap about the piers, did you put more stone in some places than other places? Where in your opinion do you expect the most scour to occur?

MR. BUSH: It is too soon to tell whether or not there will be much scour at the Saybrook piers, but from experience with other piers, I believe the greatest scour is to be found where there is a strong swirl, which would be at the quarter points of the pier. Just down stream from a pier a sand bar usually forms, but at either side of the bar will occur the greatest scour unless prevented by riprap if the current is strong and the material light. At Saybrook we used a generous amount of riprap at all piers. Especially did we bank up the riprap against the down stream end of the piers near the middle of the river. The piers had to go through one winter without the superstructure loads helping them resist the ice thrust, so we placed more riprap than we would had the substructure and the superstructure been built the same season. On top of the riprap we deposited a small amount of sand and silt to fill up the interstices between the stones and so improve the lateral stability of the mass.

MR. HILL: I would like to ask in regard to the distribution of the load allowed for. You spoke of it being designed for a sixty-ton trolley car.

MR. BUSH: The loading on the roadway was according to the following specifications:

For the floors and its supports a uniform load of 100 pounds per square foot of surface of roadway, or a concentrated load of 20 tons on two axles 12 feet apart, with 6 feet between wheels. On the trolley stringers, a concentrated load of 60 tons on four axles spaced 5 feet 6 inches, 25 feet, and 5 feet 6 inches.

For the trusses or girders, 90 pounds per square foot of floor, with the above specified 60 ton concentrated loading. The uniform loading to be taken as covering the floor up to within two feet of the rails.

I might say that it was our intention to have a bridge which would permit any class of teams to trot in crossing.

MR. HILL: Then you do not need to have any signs up, "No trotting allowed?"

MR. BUSH: No, they can go as fast as they like. I have observed some fairly heavy horses trotting over and there was no discernible swaying of the structure, nothing but slight vibration. The south truss is the same size as the north truss, and the north truss takes seven-eighths, I believe, of the concentrated load of a sixty-ton trolley car. The trusses are strong enough to permit another track to be laid on the bridge if the same is desirable.

MR. JACKSON: There has been some discussion as to the relative merits of the trunnion and roller lift type of bridge. Did you go into that at all in your investigation over there?

MR. BUSH: We considered the trunnion and the rolling lift type, and we thought that the Scherzer Rolling Lift type best fitted our local conditions, and also made a better looking bridge. There are some advantages that each type has over the other type. In regard to using the trunnion type or rolling lift type as against the swing draw, we found that we could have built a bridge of the swing type at this point a little bit cheaper than the type that we did put in. A swing type of draw is not as favorable to the navigation interests as the lift type, which has no long outstanding arms alongside of which the boats must pass in making or leaving the draw opening. The lift type is also much easier for sailing vessels to pass when going against the wind.