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ITHACA, NEW YORK
MAY, 1903

Illinois Side

THE THEBES BRIDGE.*

BY RALPH MOJESKI.

The subject of my lecture to you to-day will be the location, design and construction of the Thebes Bridge. To treat it fully and in detail in an hour or two would be impossible, and therefore, I can only attempt to give you a somewhat general idea of this work.

Thebes is situated in that part of Illinois which is sometimes called Egypt. It is about 26 miles northwest from Cairo, Ill., and 36 miles north of the mouth of the Ohio River. On the west bank of the Mississippi River, in Missouri, two miles above Thebes is the town of Gray's Point. On the east bank one and one-half miles above Thebes, and practically opposite Gray's Point, is the town of Gale. Between Thebes and Gray's Point, and Gale and Gray's Point, transfer boats are used to transfer trains between the Illinois Central, the Chicago & Eastern Illinois and the St. Louis Southwestern railroads on the east bank to the Frisco System, Iron Mountain and St. Louis Southwestern railroads on the west bank. It is to dispense with this transfer boat service, which at best is unreliable and of a very limited capacity, that the construction of the bridge was undertaken.

The Mississippi River at Thebes on the bridge line is about 2700 feet wide between high banks and only about 2400 between low water banks. A rise in the Ohio River checks the flow of the Mississippi and causes it to rise for some distance above the mouth of the Ohio. Thus the floods in the Ohio, the Missouri and in the upper Mississippi, all influence the river stage at Thebes. The result of this condition is a considerable irregularity from year to year in oscillations of the water gauge. At this point the Mississippi but rarely freezes over from shore to shore, but during the winter months it carries very large quantities of floating ice, which sometimes seriously interfere with the transfer boat service. The uncertainty of the water stage and the floating ice were not the least difficulties which had to be overcome in building the foundations, as will be explained later.

At Thebes the river is confined between banks bearing a great resemblance to each other. At the bridge line each shore is formed by a low water bank with a general elevation of about 10 to 15 feet above low water. Each low bank rises with a sharp step and forms what we might term the high water bank which has a general eleva-

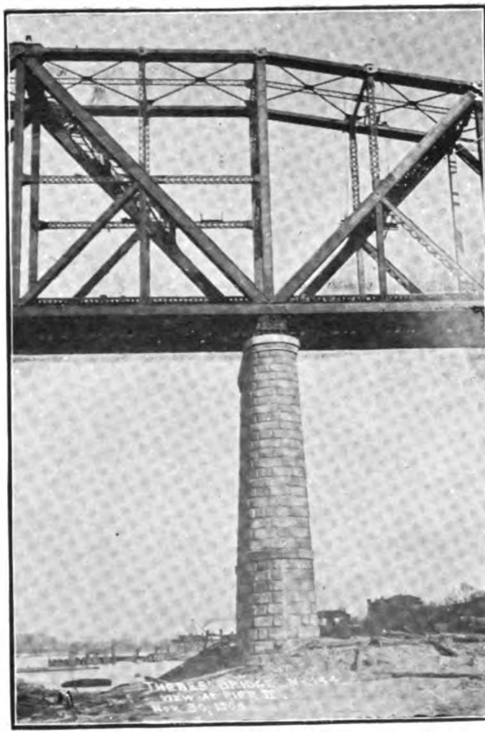
*A lecture given before the Cornell Society of C. E., March, 1905.

tion of about 35 to 40 feet above low water and is practically level for 500 to 600 feet, at which distance from the river it strikes the foot of the bluffs. It is quite unusual on the lower Mississippi to find bluffs so near the river on both shores. Generally when they are near on one side, they are either absent or far away on the other.

The above brief description of the general conditions will assist you in understanding more fully some of the remarks which are to follow throughout this paper.

The entire work can be subdivided into the bridge proper, comprising six river piers and the steel superstructure, the concrete approaches, consisting of five arches at the east and seven at the west end of the bridge proper and the grade approaches consisting of 2.1 miles of double track railroad forming the Illinois approach and 1.9 miles of double track railroad forming the Missouri approach. In order not to make this paper too long, nothing further will be said about the grade approaches. The piers supporting the steel superstructure of the bridge proper are numbered from I to VI, pier I being on the Illinois shore. The foundations of piers I to V have all been sunk by the pneumatic process and are built on rock. The foundation for pier VI is also on rock but was built in open excavation. This was possible because at the site of pier VI the surface rock is about 10 feet above low water. A cofferdam was built to protect the excavation from a possible rise in the river and the excavation of surface rock excavated inside of this cofferdam down to solid limestone 50 feet below the surface. At pier I, where the surface of the surrounding ground is more than 35 feet above low water, an attempt to reach bed rock in open excavation was made but abandoned because a water-bearing stratum, principally quicksand, was encountered when still 18 feet from bed rock. A pneumatic caisson was therefore resorted to at pier I.

The piers themselves are built of ashlar stone facing, backed with concrete except three last courses under the coping which are backed with stone. The stone used was the Oolitic limestone of the Romona quarries near Indianapolis. The upstream nose stones below the starling coping and the bridge seats are of granite. Piers I and VI are 10 feet thick and piers II, III, IV and V are 12 feet thick under the belting course. The coping, the starling coping and the upstream starling are bush hammered ; all other stones have a quarry face. As in all Indiana Oolitic limestone the quarry face is obtained with a channeling machine and therefore is quite smooth. The edges of each stone were scabbled off so as to present the appearance of rock face.



Pier II

Erection View—Span 2-3

This gives the pier a much more pleasing appearance than could be obtained with a smooth bush hammered or channeled face.

The double track steel superstructure is composed of five spans of the following lengths measured between end bearings:

The central or channel span 671 ft. 6 ins.
The two adjoining spans 521 ft. 2 ins. and the
Two shore spans 518 ft. 6 ins.

They are of the cantilever type and arranged so that the two fixed spans between piers II and III and between piers IV and V are alike; the three suspended spans are alike, and the four cantilever arms are alike, except that for purposes of erection the top and bottom chords of cantilever arms of the channel span have been made slightly heavier. The structure has been designed to carry the heaviest modern loading. It is built of medium steel having an elastic limit of not less than 37,000 pounds and an ultimate strength of 62,000 to 70,000 pounds per square inch. The heaviest eyebars used have a section of 14″ x 2⅝″. The pins range from 9 inches to 14 inches in diameter in the trusses. The pins at the main bearings over piers II, III, IV and V, are 18 inches in diameter. The top chords of the fixed spans are 42 inches deep and about 5 feet wide. The panel of top chord of the cantilever arm next to the pier is composed of 8 bars 14″ x 2½″ and 2 bars 14″ x 1⅝″, making the total section 325½ square inches, which represents a solid bar of steel a foot and one-half square. The gross section of the stiff top chord of the fixed span near the first panel point is 762 square inches, or 2 feet 3½ inches square.

The fixed spans are 75 feet high between centers of chords. The distance from the top of the truss to the lowest point of the foundation of pier is 231 feet. The trusses are spaced 32 feet between centers, leaving 27 feet 8½ inches for net clearance for passage of trains. The clear height is 22 feet 6 inches from base of rail.

The total weight of the superstructure is 26,880,000 pounds divided as follows:

Two fixed spans 12,050,000 lbs., or 11,560 lbs. per lin. ft. of span.
Three suspended spans 7,720,000 lbs., or 7,030 lbs. per lin. ft.
Four cantilever arms 7,110,000 lbs., or 11,650 lbs per lin. ft.

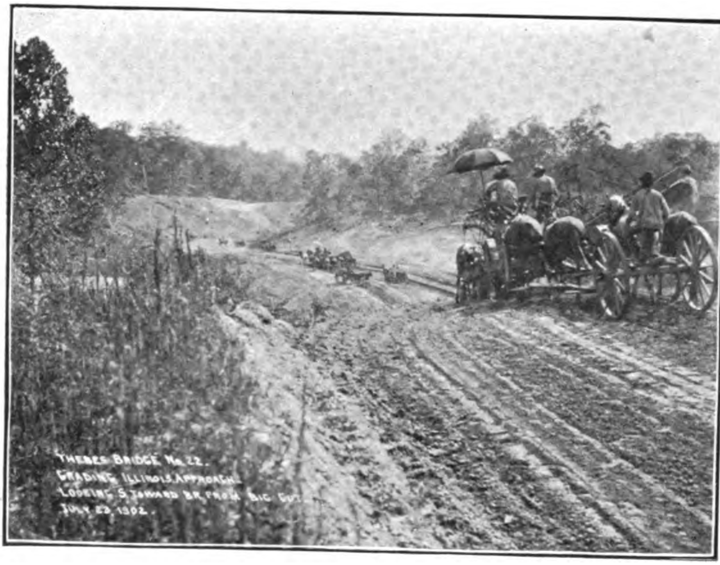
The series of arches forming approaches to each end of the bridge proper are built of solid concrete. All surfaces exposed to view have a 2 inch mortar facing which was placed simultaneously with the body of the concrete mass and allowed to set and bind together. All of the arches, except one, have a clear opening of 65 feet, the one exception being the 100 ft. arch adjoining pier VI. This arrangement is not as symmetrical as we should have liked to have it. The reason for this lack of symmetry will be given later on in connection with the discussion of the conditions which governed the design.

There are five 65 ft. arches in the Illinois approach and six 65 ft. and one 100 ft. in the Missouri. The distance face to face of arch rings is 28 feet. The space between spandrel walls is filled with permeable material, principally earth and gravel. A layer of clay crowns this fill and forms the subgrade. The ballasted track is laid on this layer of clay. An 8 inch drain pipe is placed vertically in the center of each pier; the water from the subgrade is taken to these 8 inch pipes by a series of smaller clay pipes laid on the clay surface. The water which is not caught at the subgrade but filters through the permeable filling on to the extrados of the arches is admitted to the same 8 inch vertical drain pipes by means of special grate castings placed at the lowest point of the interior concrete surface. You will notice that some of the intermediate piers in these approaches are wider than the remainder. These are buttress piers and are wide enough to resist the thrust of an arch applied on one side only. This divides the approaches into groups of not over three arches, each group being entirely independent from the adjoining one. This has its advantage in the construction. As soon as a group of arches comprised between one of the abutments and a buttress pier or between two buttress piers is completed the centers may be entirely removed and used elsewhere.

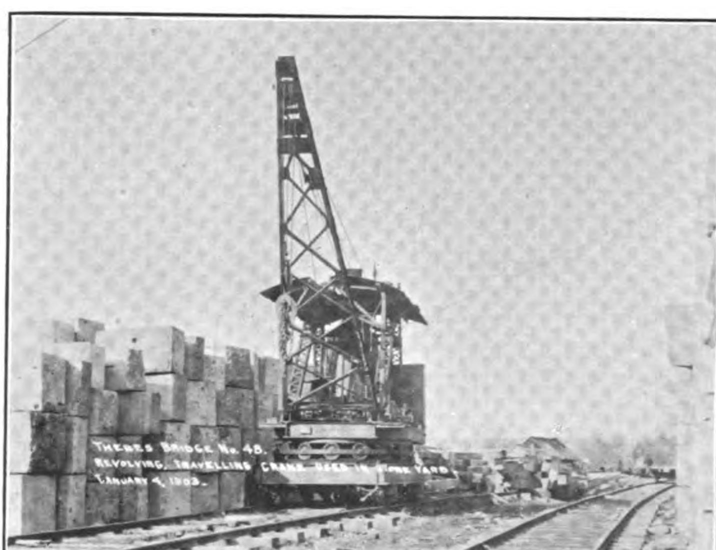
These buttress piers would also prove their utility in case anything should happen to one of the arches; in such an event the arches of one group only would be endangered instead of the whole approach. In Europe this feature is given much importance in consequence of probable necessity at some time or other of purposely blowing up bridges in times of war. In such cases the destruction is limited by the buttress piers.

Expansion joints have been provided in the spandrel walls over the piers. They are covered by the pilasters which at each pier project beyond the face of the arch. These projections have been utilized in providing recesses in the parapet intended to serve as places of refuge from passing trains.

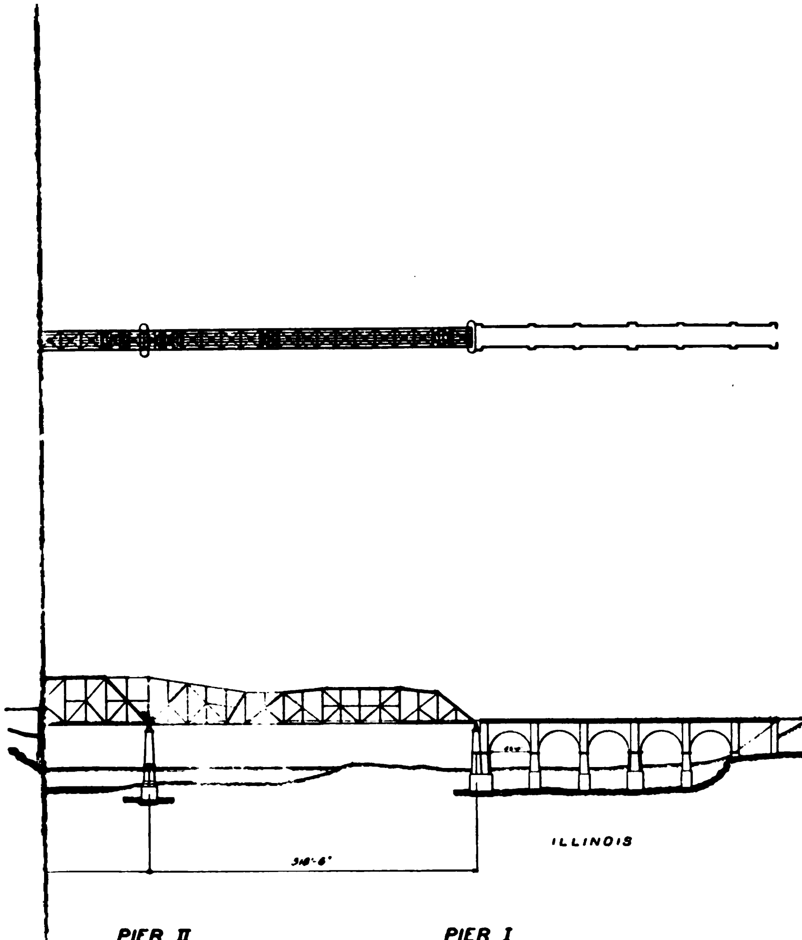
Eight 1¼" square corrugated steel rods have been used in each arch, disposed as follows: two near each face of the arch curved and running parallel with the intrados, and two near the top of each spandrel wall running horizontally. These rods are not intended as reinforcement, but merely to prevent surface cracks and to ascertain that the expansion and contraction will occnr at the expansion joints and

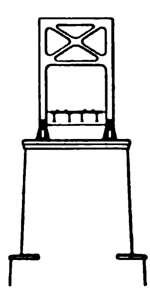


Grading Illinois Approach



Revolving Travelling Crane





ELEVATION AT PIERS I & VI

SOUTHERN ILLINOIS
AND
MISSOURI BRIDGE CO

GENERAL ELEVATION & PLAN
OF
THEBES BRIDGE

not elsewhere. The section of the concrete arch ring, without considering the rods, is amply sufficient to resist all stresses. No attempt has been made at elaborate ornamentation of these arches, although concrete construction lends itself very well to architectural effects. Such ornamentation would have been entirely out of place in that locality. In order, however, to relieve the design from excessive severity, the parapet walls with their cornices have been somewhat ornamented.

Having thus described the work in its general outlines, I shall now discuss the various considerations which led to the design as adopted and built. During the progress of this discussion I shall avoid theory which you readily acquire in your regular course and point out to you in a broad manner the practical side of things, trusting that it will be more instructive and interesting than the mere description of details.

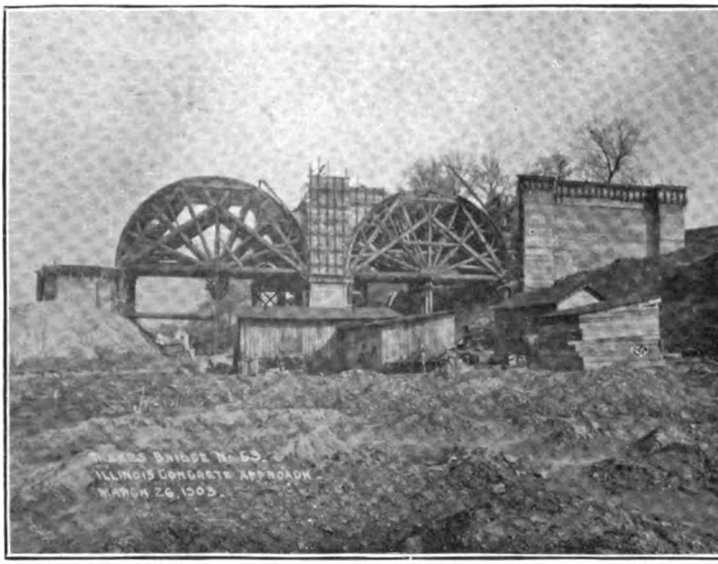
Before my partner, Mr. Alfred Noble, and I had taken charge of this work, a commission of engineers of the various railroads concerned in the bridge had made surveys of several possible crossings in the vicinity of Thebes and Gray's Point. A number of borings had also been made. The presence of high hills on both sides of the river and the comparatively small distance between them, the presence of solid bed rock at a reasonable depth as revealed by the borings, the possibility of approaching each end of the bridge with a maximum compensated grade of 0.5% and at a reasonable cost, were all considerations pointing clearly to the advantage of adopting the present location. An act of Congress dated January 26th, 1901, limits the location in the following language :

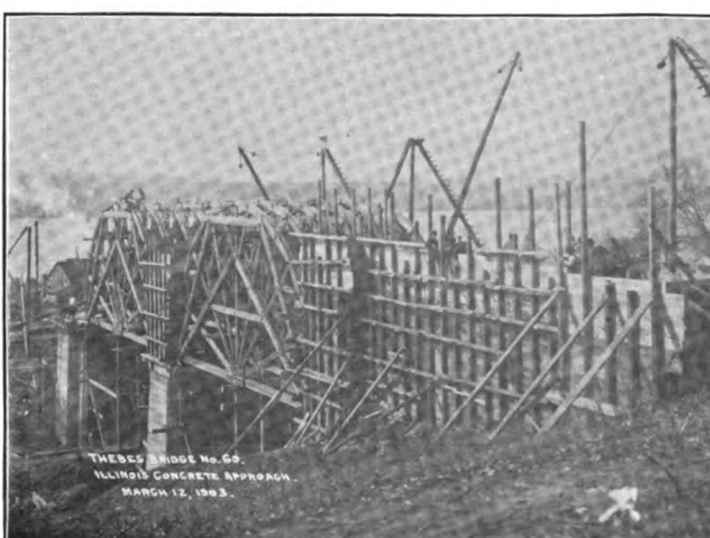
"That the Southern Illinois and Missouri Bridge Company, a corporation created and organized under and by virtue of the laws of the State of Illinois, its successors and assigns, be, and the same is hereby authorized and empowered to erect, construct, maintain, and operate a bridge and approaches thereto over the Mississippi River from a point on the Mississippi River in Alexander County, in the state of Illinois, opposite the terminus of the Saint Louis Southwestern Railway, at or near Gray's Point, in Scott County, in the State of Missouri, or from some other convenient point on said river in said Alexander County, Illinois, to some opposite point on said river in the State of Missouri, within the distance of three miles above or below the terminus of said railway ;" the length and clear height of spans, as follows ;

"That any bridge built under this Act shall be a high bridge with unbroken and continuous spans, and shall have at least one channel span, with a clear channel way at low water of not less than six hundred and fifty feet, and all other spans over the waterway, at a bank full stage, shall each have a clear channel way at low water of not less than five hundred feet, and all said spans shall have a clear headroom of not less than sixty-five feet, measured from extreme high water as determined at the location of the bridge, to the lowest part of the superstructure of the bridge or anything attached thereto."

After deciding on the location a careful study was made as to economy of various designs of superstructure, piers, foundations and approaches. The steel superstructure being by far the most important item of expense, about two and a half times greater than the substructure, was the subject of several comparative estimates. Two designs suggested themselves naturally. One composed of five independent spans, the other consisting of continuous cantilever trusses. In the later design the simplest arrangement and the one adopted was to make three cantilever spans and two fixed spans. The shore spans are each composed of a suspended span resting on the shore pier at one end and suspended from a cantilever arm at the other; the channel span is composed of a span suspended at both ends from cantilever arms. The two spans next to the channel span are fixed, with cantilever arms projecting at each end. By making the cantilever arms all of the same length and by making this length equal to the difference between the total length of the channel span and of the shore span, the length of all three suspended spans is made equal. By further adjusting the distance between centers of piers we succeeded not only in making all suspended spans and cantilever arms and both fixed spans virtually identical among each other, but also in reducing the panels to two lengths, one of 30′ 6″ for suspended spans and cantilever arms, and one of 32′ 6⅞″ for fixed spans. This has its importance in the cost of the work because it reduces the number of varieties of members to be manufactured. The greater the variety of component members, or in other words the less duplication of parts occurring in a structure, the greater will be the shop cost of manufacture. In all designs preference was given to single intersection system of trusses with subdivided panels. The double intersection Warren truss has been used in several large cantilever structures; it has the advantage of reducing the deflection and consequently the vibration but it does not afford good connections for the floorbeams such as are obtained when vertical posts are used. The single system has further the advantage of making the stresses perfectly well defined.

The design based on five independent or simple spans was estimated and studied. The weight of steel work of such a design figures out to be about the same as that of a continuous cantilever superstructure.



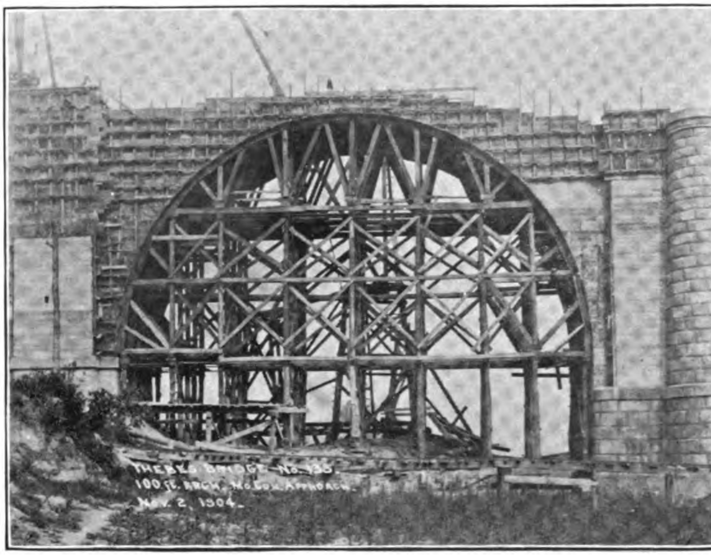


Falsework Illinois Concrete Approach

The four middle piers, however, would have to be wider to accommodate two end pin bearings of the adjoining simple spans instead of one of the cantilever construction, and this would result in a slight increase of cost of the independent span design. On the other hand, the fixed spans would be more rigid and perhaps make a handsomer structure. Concerning the latter quality I am somewhat in doubt if the two 500 ft. spans flanking the 650 ft. span would not, by comparison, look smaller than the two 500 ft. shore spans, thus marring the esthetic merit of the design. But the most serious objection to the independent span design was the question of erection. You all know that a cantilever span can be erected without falsework. The erection of a double track fixed span of about 670 feet between centers of bearings, on falsework, in forty or fifty feet of water and a strong current, is a serious matter. Besides, it would have necessitated the closing of that span for navigation during one summer and fall, and it could not have been erected in any other season because of either high water and danger from driftwood or from floating ice. It would have been impossible, therefore, to erect the entire superstructure in one year, as the channel span would have consumed practically an entire low water season. It might occur to some of you that the channel span could be designed in a manner to provide for erecting it as a cantilever and without falsework and to disconnect it from the adjoining spans after its erection is completed, thus transforming it finally into a simple span. A second thought will dismiss that solution as impracticable in this particular case. In the present design of the channel span the overhead traveler when near the center will handle comparatively light pieces, such as form part of the center top chord sections of the suspended span which is only 366 feet long. In the case under discussion it would have to handle center chord sections of a 670 ft. span weighing probably three or four times as much. In the cantilever design the natural distribution of material is such as to require very little or no addition of section to take care of erection stresses. The contrary would occur if it were proposed to erect a 670 ft. fixed span as a cantilever, because the moments over the piers due to erection stresses would be enormous. Not only that, but the effect of the erection stresses on the adjoining spans to which the cantilever would have to be anchored by special device, would modify their design very extensively. The permanent cantilever construction was therefore preferable, and was finally adopted. Another design was also possible and was considered. It consisted of a cantilever center or channel span flanked by two anchor spans, and of two simple shore spans. This solution, which was intermediate between the continuous cantilever and the five simple spans, was not adopted for the reason of the great number of different parts it would require and because it would be uneconomical while offering no particular advantages. It can readily be seen that the trusses of the anchor spans would necessitate twice the number of varieties of members that our present fixed spans require, as these anchor spans, being subjected to cantilever stresses on one end only, would not be symmetrical about their center. Also, that the shore spans would be entirely different from the channel span, thus calling for a further greater variety of component parts, while in the adopted design the shore spans are composed of members which are exact duplicates of those in the channel span.

Simultaneously with these considerations the general outlines of the steel work were studied. Some economy in the amount of metal might have been obtained by building very high towers at the ends of each fixed span to carry the cantilever arms. Although such construction is quite common, it was deemed preferable to make the chords of the fixed spans horizontal and thereby to reduce the inclination of the cantilever top chord to that which admits of the use of an overhead traveler for the erection of the channel span. By doing this we obtain a structure with quiet and simple outlines which it is almost impossible to obtain where, for the sake of economy, very high towers are used. You will easily notice a difference in the inclination of the diagonal post in the extreme panel of the cantilever arm adjoining the suspended span. A little study will show that with the present arrangement of equal panels mentioned before, this difference in inclination was unavoidable. As anticipated, however, it is not as conspicuous in the actual construction as it is on the plans, in fact it defines better the place where the cantilever arm ends and the suspended span begins, and points out to the observer the existence of the suspended spans, a desirable circumstance from an esthetic point of view. Carrying this idea further the end top chord sections of the suspended spans were made inclined, dropping at the hip. This was done first in order to incline the post just mentioned at a greater angle from the vertical and by that to admit of a better floorbeam connection at its foot, and, second, in order to reduce the severity of the top chord line taken as a whole, while at the same time defining the suspended span.

After deciding on the form of the skeleton for the superstructure, the design of the piers was determined upon. The width of the piers was determined by the area required for carrying the bearings of the



Falsework 100 ft Concrete Arch

Illinois Concrete Approach

superstructure; the four intermediate piers were therefore made 12 feet wide or two feet wider than the shore piers, as the latter have less load to carry. The usual batter of ½ inch to the foot was given the shafts. The starlings were made pointed both up and down stream for the usual reasons, namely, the up-stream ones to act as ice cutters and both to diminish the disturbance which is produced in the current by an obstruction.

Ashlar masonry was used for conservative reasons as well as for greater rapidity and facility of construction, especially in connection with pneumatic foundations.

It became at once apparent from the boring records that pneumatic foundations would be necessary for all river piers and probably also for pier I. The material overlying the limestone bedrock is composed of shale, hard and soft clay, flint, sandstone, gravel, quicksand, etc. The rock, where it occurs, is fissured and the fissures are filled with the softer materials. In view of these pockets and layers of soft material and of the fissured character of rock, it was not considered safe to place the foundations on the shale or sand rock, but it was absolutely necessary to go down to the limestone below. A cofferdam could not have been depended on to hold water under such conditions, besides offering many dangers from floods, ice and drift.

After the general design for the bridge proper was determined upon, attention was given to the approaches. Of the various possible designs only two seemed practicable, one consisting of a steel viaduct with towers and plate girders, and one consisting of concrete arches. Careful estimates indicated that under the prices for steel which were then prevailing, a steel viaduct would cost from $10,000 to $20,000 less than the concrete arches. The advantages in favor of the concrete arches were so important, however, that it was deemed preferable to adopt the concrete construction. These advantages are:

1st. Low cost of maintenance. The steel needs frequent painting which can be estimated at 15 to 20 cents per ton per year. Both approaches are subjected to gases from locomotives passing underneath them; in case steel were used it would tend to deteriorate rapidly unless painted every year or two which adds of course to the cost of maintenance.

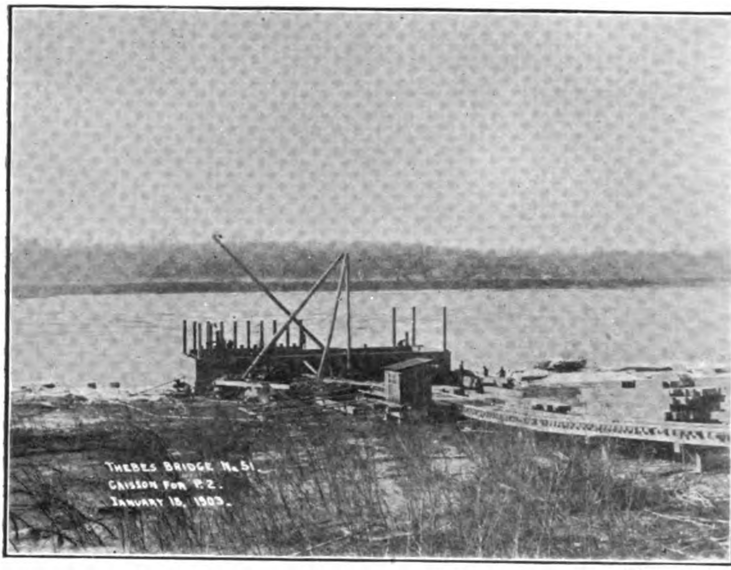
2nd. Greater capacity. The live loads are only a small part of the total loads in a concrete arch and, therefore, doubling or trebling the live loads for which the bridge proper was designed would not have much effect on the concrete structure, while it would overstrain or even endanger a steel viaduct.

3rd. Solid roadbed. This advantage hardly needs explanation. As far as the passengers and train crew are concerned the concrete approaches will be solid ground to them just like an embankment and the length of the bridge will be virtually reduced to the bridge proper between piers I and VI.

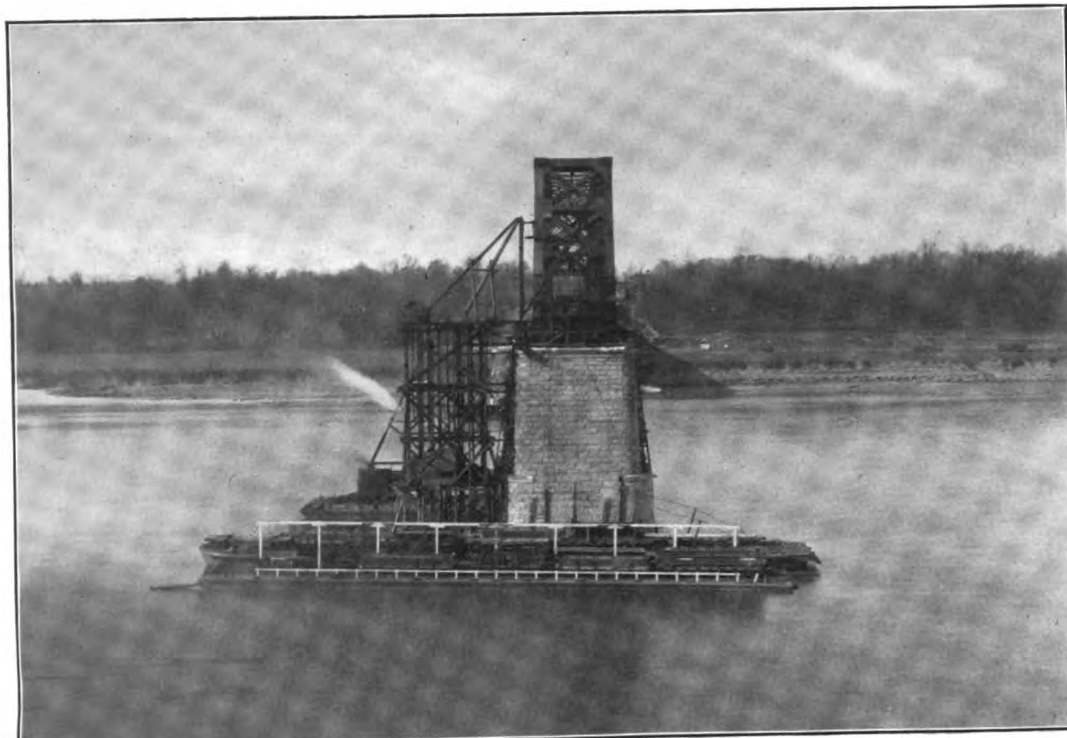
4th. Safety. The concrete structure is absolutely safe from severe injury by derailment. The worst that could happen would be the scarring of the parapet wall. It is also fireproof.

5th. The arch openings afford better room for locating tracks and yards underneath. A steel viaduct economically designed would occupy about one-half of its length by towers and the other half by plate girder spans. These towers, unless expensively and unusually designed would be braced in such a manner as to preclude the laying of tracks in the space they occupy, leaving only about one-half of the total length available for yards and tracks. In the concrete approach approximately three-quarters of the length is available for that purpose.

After deciding on the design of the superstructure, substructure and approaches, a general plan was prepared showing a central or channel span of 650 feet in the clear and four spans, two on each side of the central span of 500 feet in the clear. Pier I was placed on the high bank in Illinois and pier VI on the high bank in Missouri, both close to the river channel. Both concrete approaches were at that time designed with uniform arch openings. The whole structure was quite symmetrical. Unfortunately the navigable channel, or I should preferably say, the channel used by the river pilots, does not always coincide with the deep water channel nor with the center of the stream. To comply with the demand of the pilot association we were obliged to move our channel span 150 feet to the east in order to place it centrally over the course they generally take. This not only spoiled the symmetry of the structure, but required more study on a new arrangement of spans. As pier VI would now come on the low bank which is submerged by high water, the construction of a 100 ft. arch was authorized by the government to span that part of the river left between pier VI and the west shore. Thus piers II, III, IV, V and VI were definitely fixed by the location of the channel span and by the clear span lengths required by the act of Congress. Pier I was left in doubt. We were given the option to leave pier I where it was originally contemplated to place it. This would have made the span between piers I and II only 350 feet long in the clear. The following design, therefore, was estimated and considered—a 350 foot simple span between piers I and II, a 500 foot simple span between piers V and VI, a 650 foot canti-



Caisson, Pier 2



Looking West from Pier III. Nov. 30, '04.

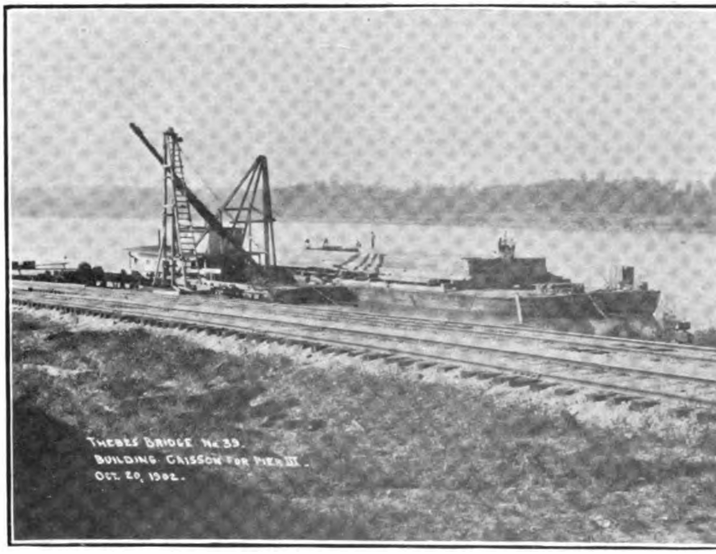
lever channel span, and two 500 foot anchorage spans, one on each side of the channel span. This design was compared with one in which pier I was moved east 150 feet, together with the other piers, thus shortening the east concrete approach and preserving the continuous cantilever design. A comparative estimate of cost revealed a slight difference in favor of the latter, but the chief reasons for adopting it were the better yard room it afforded the C. & E. I. R. R. between the shore and pier I, the greater multiplicity of parts in the steel superstructure and the greater symmetry of the work as a whole.

Let us now pass to the description of the main features of the execution of the work. As already mentioned, the foundations for all piers but one were placed by pneumatic process. The caissons were built of timber; the walls of the caissons were made of 12″ x 12″ sticks laid horizontally and tied by other 12″ x 12″ timbers or posts running vertically. They were braced by the same sized timbers in both directions horizontally. Two layers of 3″ x 12″ planking were spiked on the outside of the walls, the inside layer being placed diagonally and the outside vertically, the object of the diagonal planking being to give the caisson greater stiffness in all directions. The joints in the outside layer of vertical planking were caulked with oakum. The roof of the working chamber was made of two solid layers of 12″ x 12″ planking, one placed longitudinally and one transversely, and two layers of 3″ x 12″ planking placed between the two layers of 12″ x 12″ timbers. The ceiling and sides of the working chamber were covered with 3 inch planking thoroughly caulked. The cutting edge was made of wood. It is not unusual to make this cutting edge of iron. To this, however, there were two objections, the greater time required to secure the iron or steel cutting edges, and the fact that it is very much more difficult to repair a steel cutting edge than a wooden one. In the case of the Thebes foundations, where blasting had to be resorted to, this question of repair to the cutting edge was quite an important one. It is very easy to replace a timber which may become shattered by the dynamite while it would not be practicable to repair a bent or broken steel cutting edge.

The caisson for pier I was the largest one of all, being 66 feet long and 40 feet wide and 40 feet 4 inches high. It covered the foundation of pier one and the adjoining buttress and therefore had to be made wider than the other caissons. It was built in place and sunk without any difficulty to bed rock. The caisson for pier II was smaller, being 76 feet long by 28 feet wide and only 16 feet high. It was built in place on the river bank, its construction being begun at low water. Before the construction of the caisson was finished the water came up and covered the lower part of it so that the spikes attaching the outer plank had to be partly driven under water. The broken rock overlying the limestone bed rock at pier II was extremely hard and required constant blasting. This blasting was carried on while the men remained in the working chamber. It had to be resorted to constantly in all intermediate piers. I am glad to say that no serious accident due to blasting occurred during the entire construction of the foundations.

Caissons for piers III, IV and V were built on barges, two barges being used for each caisson for that purpose. They were launched by admitting water inside the barges and then towed to place and anchored. After adjusting their location as nearly as practicable they were loaded by concreting above the working chamber roof until they landed on the bottom of the river. After sufficient weight was thus obtained the air pressure was applied and the sinking continued as usual. As the sinking progressed, the masonry was gradually built on top of the caisson previously filled with concrete. For the purpose of reducing weight the concrete backing was not generally placed until the caisson reached the final depth and the working chamber was filled with concrete, or using the usual expression, not until the caisson was sealed.

As already mentioned the foundation for pier VI was made in open excavation. It was originally planned to found this pier on surface rock by excavating this rock to a depth of only six or seven feet. In ordinary stages of water this could have been very easily done without any cofferdam, but during the time of construction the water was unusually high at practically all seasons and we were obliged to construct the cofferdam around the proposed excavation. To make sure that the foundation would be satisfactory and that the rock is perfectly solid, we made some additional borings which, to our surprise, disclosed some clay at various elevations above the limestone bed rock. It is impossible to determine from borings, unless they are extremely numerous, whether the material encountered is in layers or in pockets. As there was no time to lose in preparatory work of additional borings it was decided to carry the open excavation clear down to bed rock, which was done. This was all the more necessary because pier VI not only carries the weight of the superstructure, but also the thrust of the 100′ concrete arch, and any settlement in this pier would have been a very serious matter. The excavated area was approximately 70′ long by 40′ wide and 50′ deep. Fortunately no water-bearing



Caisson for Pier 3

strata were encountered, the material being all solid sand rock with a small amount of clay.

The masonry of each pier in the river, after the sealing of the caisson, was built with a traveling crane set on tracks on top of the pier. This crane was used by the contractors and was quite successful. After the completion of each pier a small derrick was built and hoisted up on the pier with the traveling crane; the traveling crane was then lowered with this derrick. The masonry of pier I was built with stationary derricks, and the masonry of pier VI was built with a high derrick barge.

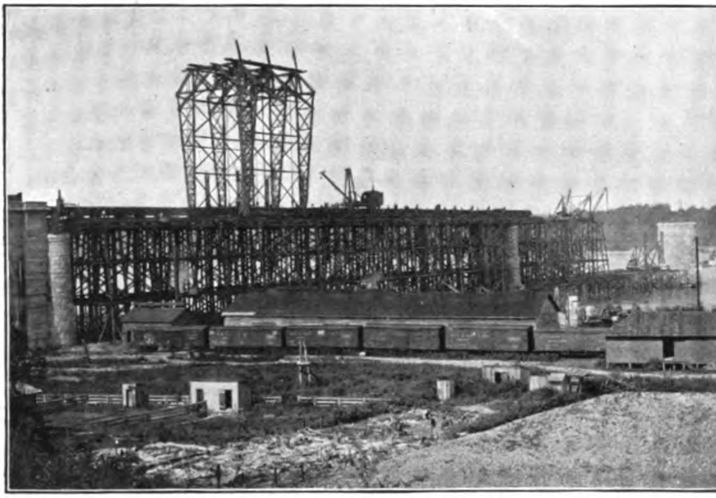
The foundations for the concrete approaches were principally made in open excavation, some difficulty being experienced in keeping the excavation in good condition due to leakage of water and to the great pressure of the clay on the sheet piling and bracing. An experiment was tried successfully in the foundation of one of the concrete piers in the east approach of building and sinking a reinforced concrete caisson without compressed air. This was done, the evcavation being carried on in the atmospheric pressure and the caisson gradually sinking to the strata of shale and rock on which all the approach piers were founded, being pushed down by the weight of the increasing volume of concrete above the concrete roof. The same process was used in two piers in the west approach. Although this method proved successful in all three cases, for some reason known to the contractor he preferred not to use it on all the piers.

The concrete for the piers and arches above the ground was laid in carefully built forms; three sets of centers were necessary and were provided so that each series of arches between an abutment of a pier and a buttress pier, or between two buttress piers could be built continuously. The centering for the 100′ arch was special. The concrete was mixed by machinery, the contractor using principally a Smith mixer for that purpose.

In view of the very short time allowed for the completion of this bridge, it was arranged to erect the steel superstructure working from both ends simultaneously. To this end four spans of falsework, two travelers and two complete erecting plants were provided. The falsework contained approximately 2,000,000 feet B.M. of timber. The spans between piers I and III were erected by bringing the material over the finished concrete approach. On the west side, however, the concrete approach was not finished in time for the erection, and we were obliged to make a different arrangement by which the material was loaded on cars, these cars switched and loaded on transfer barges which were obtained for that purpose, and these transfer barges towed to pier IV, where a special fifty-ton derrick was installed on a large timber tower to take this material from the barges and deposit it on push cars on the bridge grade.

For reasons explained before, the channel span was designed to be erected without falsework. This work is now going on and for the purpose of expediting it two overhead travelers have been provided, one working westward from pier III and one eastward from pier IV. It is hoped that in a few weeks the two travellers will meet at the center of the span, when the final connection will be obtained by driving the center pin of the bottom chord. To insure the two arms connecting accurately together, wedge adjustments have been provided in the top and bottom chords at the end of each cantilever arm. The wedges will be placed in such a position that by withdrawing them by means of heavy screws we will be able to control the position of each half of the suspended span with great economy.

The river has now been frozen over for two weeks and a break up may be expected as soon as the weather moderates. We are, however, working on the channel span and expect to have it completed within six weeks. This would have been impossible had we planned to erect it on falsework.



Erection View. Spans 1 to 3. Aug. 1, '04

Looking West from the Illinois Approach. April 8, '05