SECRETARY.

Chicago, Milwaukee and Puget Sound Railway

RECORD OF CONSTRUCTION

— OF THE —

MISSOURI RIVER BRIDGE

MOBRIDGE, S. D.

C. F. LOWETH, ENGINEER AND SUPT. B. & B.

Record Cons. Mo. River bridge, Mobridge.

Chicago, Milwaukee & St. Paul Railway Co.

Office of Engr. and Supt. Bridges and Buildings.

Room 1359 Railway Exchange.

C. F. LOWETH,
Engineer and Supt. B. & B.

Chicago, May 27,1910

Mr.E.W.Adams,
Secretary,
Milwaukee,Wis

Dear Sir:-

I am sending you by separate mail a bound copy of Record of Construction of the bridge over the Missouri River Bridge at Mobridge on the line of the CM&PSRY. It appears to me it would be desirable to have this in your records.

Yours truly,

C. Loweth

Engr.&Supt.B&B

L:

CHICAGO, MILWAUKEE AND PUGET SOUND RAILWAY

MISSOURI RIVER BRIDGE, MOBRIDGE, SO. DAK.

THE MISSOURI RIVER BRIDGE
AT
MOBRIDGE, SOUTH DAKOTA.

I N D E X.

A P P E N D I C E S.

P L A T E S.

and the Engineers' dwelling house and office were left for use by the watchmen and pumpmen located there. With these exceptions, the buildings were wrecked.

II.

TEMPORARY BRIDGE.

A temporary bridge was necessary for use in the bridge construction, and for getting construction supplies and contractors' grading outfits to the front. It was also used by the Operating Department for freight traffic, and at times when out of commission, due to damage from ice or high water, the material for the front was transferred by ferry boats to the west bank.

Work started in July was completed in August,1906, and the track laid to Pontis September 21st,1907. 1823 lineal feet of bridge was built, consisting of 117 bents, 4 piles per bent, having 12"x12" caps, three 8"x16" stringers under each rail, and 6"x8"x10' ties. When first built, in 1906, two spans which could be readily removed were put in between Piers I and II, to be used in case any boats required passage. No boats passed until the following year (1907), and upon the renewal in 1907 no provision was made for the passage of boats, but, instead, a pile bent and two spans of flooring were removed when a passage was required.

Beginning at the east end, 642 feet was built on a 11 degree 30 minute curve to the left, and the remaining 1181 feet on tangent, parallel to and 90 feet north of the center line of track of permanent structure. A boom of heavy timbers, for protecting the cofferdam at Pier I and the east part of the temporary bridge from floating ice and drift, was built at a slight angle with the current, at a point 368 feet from the east end, extending to the shore 600 feet north of the center line of permanent track, and 60 feet south of the temporary bridge.

The bridge built in 1906 remained in service until March 9th, 1907. At this time, on account of the raise of water in theMissouri River, which was the forerunner of the breakup, the bridge was partly torn out and the material saved.

The river opened on March 20th,1907, and on March 31st, as there was no running ice, the work of renewal was begun, but was stopped on April 1st on account of running ice. On April 11th,1907 when the renewal was completed with the exception of 15 bents, the ice started running again, and with a heavy wind blowing from the west ran along the east bank and boom, taking out 34 bents which had been driven from the boom west. No material damage was done to that portion driven from the west side, as the wind kept the ice along the east shore and boom. 49 four, five and a few six-pile bents were driven and the bridge completed April 21st,1907. This remained in service about five weeks. During this time the falsework piles, on which the caisson for Pier III was to be built, were driven and the caisson partially completed. The water raised five feet from May 19th to May 30th, and the drift so increased in amount and size, lodging so thickly along the bridge, that a large crew of men working continuously could not keep it clear. On May 30th 45 bents were washed out; the caisson falsework at Pier III undermined, and the partially completed caisson sliding into the water was washed down stream at 6:30 P.M. May 30th.

Work of renewing the 45 bents was begun June 8th and the bridge completed June 16th,1907. This was in service ten days when the high water and collected drift washed out 72 bents next to the west shore. The drift and high water continued for about ten days, and on July 5th the work of renewal was begun and finished July 18th,1907. This bridge remained in service until the permanent structure was completed,-March 18th, 1908, after which it was torn up, and the piles between the boom and Pier III broken off or pulled, so as to have as great and unobstructed opening as possible when the river broke up and the ice started running. The river opened April 5th,1908.

III.

SUBSTRUCTURE.

The substructure consists of east abutment, four river piers and eight viaduct piers.

The east abutment is of concrete and of gravity design. The footing is on hard shale.

Pier I has a concrete footing, bearing on hard shale. Sandstone masonry with granite nosing was used from a point 2 feet below low water surface to a point 5 feet above high water. The neat work is of concrete, reinforced with corrugated steel bars.

Piers I, II and III are of the same general design as Pier I. The footings of Piers I and II were carried down to solid bearings by the use of pneumatic caissons. Owing to the great depth to shale, Pier IV was founded on piles.

There are eight concrete viaduct piers on pile foundations. The concrete in the footings was placed under water.

A list of plans and drawings on file is given in Appendix I.

East Abutment.

The east abutment is located on the east bank of the river. At this location the ground surface is at Elevation 1304.0.

Work was started in the Fall of 1906, but was abandoned and preference given to the caisson work at Pier II. The bottom of the footing was planned at Elevation 1293.5, but at this depth rotten shale was encountered and the excavation was carried down to Elevation 1285.8, which was well into hard shale. At this elevation a small triangular pocket of soft shale was encountered, located north of the center line of track, extending across the footing, and bearing slightly north of west. This material was removed leaving a V shaped trench 3-1/4 feet deep. Three test pits were put down: one 4'x3½' at about the center of the excavation north of center line of track, to Elevation 1283.8; one 4'x3½' at the west edge of excavation, on the center line of track, to Elevation 1282.8; and one 3¾'x2¾' five feet east of west edge of excavation, and 13½ feet north of the center line of track, to Elevation 1282.7.

No work was done onthe east abutment from October 12th,1906 to March 6th,1907. At this time the high water and breakup of the Missouri River made impossible any work on Piers I and II, and the east abutment was pushed to completion.

On March 22nd the first concrete was deposited in the footing and the abutment completed April 22nd,1907.

There was a bulge of 2" at center line of track 8 feet above the bridge seat, caused by insufficient form bracing. The steep bank just west of west edge of excavation made proper backwall bracing impossible. Accurate measurements were taken to ascertain if any shortening would have to be made in deck span. No change was required.

Plate II shows plan, elevation and section of the east abutment.

Pier I.

Pier I is located at the east edge of the river at low water stage. Borings made at this location showed hard shale at Elevation 1251.5 which is but 7 feet below low water, making it feasible to use a cofferdam. Work was started driving the United States steel sheet piling August 11th,1906. The size of the cofferdam was 17½'x50', and was driven so that the excavation was begun August 23rd, but on account of favorable condition for working at Pier II, the excavation at Pier I was not rushed.

The bottom of the footing, as designed, was at Elevation 1250.5, but when the excavation reached this point, eight cracks were found in the shale, bearing slightly north of west, and one bearing northeast and southwest, crossing the others and extending from a point 6 feet west of the southeast corner to a point 6 feet south of the northeast corner. A test pit was put down, and a 2" layer of soapstone being found at Elev. 1245.0, the footing was carried to Elev. 1242.0, and, in addition, a test pit, 8'x4' on top reduced to 4'x4', and finally to 4'x1', was excavated on center line of track to Elev. 1225.0. This test pit was filled with concrete, and fifteen 60-pound rails, 28 feet long, spaced 8 inches in the clear, were imbedded vertically, and ten 60-pound rails, 12 feet long, imbedded horizontally.

The excavation was completed November 28th,1906, and the work on Pier I abandoned until February 21st,1907, at which time work was begun placing concrete. The footing was completed February 27th,1907, and the work again abandoned until April 6th,1907, where being unable to continue work at Pier II, on account of high water, work at Pier I was renewed. On May 2nd the stone masonry was started,and finished June 4th, 1907. Forms for neat work were then built, the concreting started on June 16th was finished June 22nd, and the forms removed July 7th, 1907. The sheet piling was not removed until July, 1908.

Plate III shows two elevations and plan of Pier I.

Pier II.

Pier II, located 423 feet west of Pier I, is founded on a pneumatic caisson. The caisson was built of 12"x12" western fir timber, sheathed on the outside with 3"x12" pine planks, caulked on the outside 15 feet high and sheathed on the inside with two rows of 3"x12" pine planks; one row horizontal and one row diagonal. The ceiling of the caisson consists of 3"x12" plank. Oak timber was used on the cutting edge. The outside dimensions of the caisson was 65'6"x26'6", and from cutting edge to ceiling 7'. The deck was constructed of two rows of 12"x12" and one of 12"x18" timbers, making a depth of 3'6". 12"x12" struts spaced 12-ft. centers were placed against 8"x12" horizontal timbers, which were spaced 2'8¾" above cutting edge. 12"x12" knee braces, bearing against the side of caisson and top of 8"x12" horizontal pieces, and against the ceiling and 8"x12" pieces bolted through the deck, were put in and tied with 1¼" diameter rods.

Two 24" diameter material shafts, each section 12'3½" long, were put in on center line of caisson; one 18' from each end. The air lock for the supply shaft was 42" in diameter and 11'5" long; the 42" section was 9'8" long, and tapered to fit the supply shaft. On a line with the two material shafts and 31 feet from the south end of the caisson was located the 42" diameter entrance shaft, each section of which was 10 feet long. These sections were so designed that any of them could be used as a lock by changing the doors.

Owing to the low stage of water in the Missouri River at certain seasons of the year, which made it impossible to build the caisson ashore and tow it into position, it was necessary to drive falsework piles on which to construct it. The pile driving, started September 2nd, was completed September 25th, and the work of building the caisson begun September 30th,1906. Two months were required to construct it, and on December 4th,1906 the work of lowering began. Forty-eight 12-ton screw jacks were used to lower it, and the first concrete was put in on January 5th,1907, the caisson still resting on jacks and lowered fast enough so that the top of the concrete remained above the surface of the water. Air was turned on and pressure men entered the caisson on January 10th. On January 12th the excavation was in sand and gravel, so compact that a water jet having a nozzle pressure of 50 pounds was put into use, and the coarser material, which would not pass through the 4" diameter blow pipes, was put into cement sacks and taken out through the entrance shaft. At Elevation 1232.0 sand and clay were encountered to Elevation 1212.5, the cutting edge reaching Elevation 1232.0 February 5th,1907. The caisson was lowered through this 19.5 feet of sand and clay at an average rate of 1.95 feet per day, the only delay occurring on February 16th, which was due to a drop in the caisson of 2.91 feet during the night of the 15th and 16th, which brought the surface of the concrete so near the water surface that another drop was not advisable until more concrete was added. On February 15th,1907 the change in working time of the pressure men was made from eight to six-hour shifts. At this time, the cutting edge was in hard clay and shale. This material was easily worked from Elevation 1232.0 to 1210.5, and at this elevation, the clay and shale became extremely tough. So much so in fact, that mattocks were used to cut the material, and the jet with a nozzle pressure of 120 pounds was used in excavation. The cold water jet caused considerable trouble, for soon after it was brought into use the pressure men complained of aches which they thought were bends. The water pipe was then tapped and steam fed into it so that the water forced into the caisson was at a temperature of about 50 degrees. The progress of sinking the caisson was very slow from February 16th to March 3d, 1907, it being lowered only 8½ feet in seventeen days. On March 3d the pressure men were taken from the caisson on account of the raise in

the river. A timber protection was built March 5th to keep the floating ice from the material and entrance shafts at Pier II. On March 6th, the machinery barge, derrick barge and scow pile driver were moved to the east shore behind the boom, which had been constructed to protect Pier I and the east end of temporary bridge from floating ice and drift. The machinery barge was moved back into place behind Pier II and air turned on April 26th,1907.

On or about April 28th, C.F.Loweth, Engineer and Superintendent of Bridges and Buildings, and J.J.Harding, Engineer of Masonry Construction, entered the caisson, cutting edge at Elevation 1201, to examine the material being taken from the test pits, and decided to land it at Elevation 1189.15, in the material then being excavated. In order to land the caisson as soon as possible, the upper footing course of sandstone was omitted, and concrete put in with granite nosing. The lower footing course was, as per plan, of concrete with granite nosing.

From April 26th to May 7th,1907 test pits were dug and borings made in the caisson to determine the character of material. These borings, made with the cutting edge at Elevation 1200.2 showed clay to Elevation 1186.7, and harder clay from Elevation 1186.7 to 1182.7. The stone masonry was started May 4th,1907 and on May 24th the caisson was landed at Elevation 1189.11. Five test pits were put down which showed hard shale at Elevation 1184.0.

The northeast and southwest corners of the caisson rest on solid banks of shale. Work of sealing was finished June 1st,1907. The stone masonry was finished June 17th,1907, and work begun on the 18th building forms for neat work, but all work on Pier II was abandoned June 27th, on account of high water, accompanied by heavy flow of drift, which washed out the temporary pile bridge. Work on the forms was renewed July 16th,1907 and completed August 8th,1907. The concreting of the neat work, which was started August 12th,1907, was completed August 19th,1907.

A water gauge is anchored to the south end of the pier.

The caisson at Pier II contains 148,133 feet,board measure, of lumber.

The maximum skin friction, which is the average weight in pounds per square foot of friction surface, was 2200 pounds, and the minimum 683 pounds. The indicated air pressure varied from 6.5 to 31 pounds, while the calculated air pressure varied from 6.65 to 32.6 pounds.

Plate IV shows two elevations and plan of Pier II.

Pier III.

Pier III, located 425 feet west of Pier II, and 848 feet from Pier I, is founded on a pneumatic caisson, of the same size and design as the caisson at Pier II, except that one 36" material shaft was used in place of one of the 24". The 36" material shaft was used here on account of the large stones encountered at Pier II, which had to be broken up to get into the 20" bucket. With the 36" shaft a 30" bucket was used.

As at Pier II, the caisson was built on falsework at its exact location and lowered with jacks. Work, which was begun on the falsework May 11th,1907, was finished May 20th, and the construction of thencaisson started and rushed so as to have it well grounded before the June raise in the river.

When the caisson was partially completed, the river rose rapidly, and the drift, coming lightly at first, increased in quantity and size and lodged against the temporary bridge from Pier II to the west shore. On May 30th, after all efforts to keep the drift cleared away from in front of the temporary bridge at Pier III had failed, the falsework upon which the caisson was built was undermined to such an extent that it gave away, and the caisson, sliding into the river, was washed downstream and grounded on a sand bar about one mile below the bridge. An attempt was made to anchor it, which was futile, but it was held long enough so that the material and entrance shafts were removed. No effort was made to recover the caisson, as it was not only considered very questionable whether the ferry boats in use in that vicinity would be able to tow it back to the bridge, but also the length of time and necessary equipment needed was such that the plan of recovering was abandoned.

Work on Pier III was not renewed until July 25th,1907, on account of the high water, which made it impossible to rebuild the temporary bridge. On July 30th the falsework on which to build the caisson, which was begun July 25th, was completed, and the new caisson, finished August 22nd, was ready

to lower the same day. Concrete was first put on the deck August 24th and the air turned on August 28th,1907.

The average drop of the caisson from August 28th to October 16th was 1.07 feet per day, going through 17½ feet of sand from Elevation 1249.5 to 1232.0; 23½ feet of gravel, sand and loose shale from Elevation 1232.0 to 1208.5; and 11½ feet of quicksand and gravel from Elevation 1208.5 to 1197.0. At this elevation, stone, coarse gravel and shale were found; and the average drop from October 16th to December 2nd was reduced to 0.6 feet per day. During this time there were several delays, due to leaky flues in boilers, disorder or compressor and pump; and these, in addition to the material encounteredbeing more difficult to work, caused less daily settlement in the caisson. The material encountered at Elevation 1197.0 was stone, coarse gravel and shale, which extended 13 feet, or to Elevation 1184.0; then gravel, sand and shale for 9 feet to Elevation 1175.0. At Elevation 1175.0, gravel, sand, boulders and shale were found, the largest of which was taken out by buckets.

The stone masonry, started November 16th, was finished December 17th,1907.

The caisson was landed on shale at Elevation 1168.04. December 2nd the test pits were put down to guard against any layer of soapstone.The work of sealing was finished December 7th,1907.

Work on the forms was begun December 18th,1907, and the concreting finished January 1st,1908.

167,452 feet, board measure, of lumber is contained in the caisson of Pier III.

The maximum skin friction was 3060 pounds, and the minimum 486 pounds.

The indicated air pressure varied from 5 to 40 pounds, while the calculated pressure was from 5.6 to 39.25 pounds.

Plate V shows two elevations and plan of Pier III.

Pier IV.

Pier IV, located 422.5 feet west of Pier III, is of the same general design as Pier I. The depth of the shale at this point was found to be 125 feet below low water, and a pile foundation was decided upon. An attempt was made to use a cofferdam and excavate with an orange peel bucket, and later with an 8" sand pump, but the character of the material was such that it flowed or boiled up under the sheet piling and no progress was made. It was then decided to use a light caisson, and the falsework piles on which to build it were driven. The outside dimensions of the caisson were 60'0"x 32'2", with an 8'0" ceiling, the size being governed by the dimensions of the cofferdam. 8"x16" timbers were used horizontally and vertically on the sides, sheathed on the inside with vertical 2"x10" planks, and thoroughly caulked. The deck consisted of two rows of 12"x12" timbers, and the outside sheathing above the deck was of 2"x10" plank. This caisson was constructed on rollers, with the east edge over the west edge of the cofferdam, and when completed was skidded into position and lowered over the foundation piles, which were cut off as the caisson was lowered. Eight cuts were made on the 267 piles. The cutting edge was landed at Elevation 1232.79.

The foundation piles were driven from November 6th to December 10th, 1907, and the caisson was ready to lower January 8th,1908. Concrete was first put on the deck on January 10th, and the stone masonry work done between January 22nd and February 8th. Sealing the caisson took from February 1st to February 4th, and the entire pier was completed February 18th,1908.

The calculated air pressure varied from 2.7 pounds to 12.15 pounds, but the indicated air pressure was very variable. When the caisson was being sealed, the indicated air pressure at the compressors was 25 pounds, while at Pier IV the test showed but 16 pounds.

The pier is surrounded by a willow mattress, 110'x100', extending 60 feet on the channel side and weighted down with riprap. A permeable pile dike for the advancement of the right shore bank upstream approach to the bridge was put in.

The caisson as constructed contains 100,831 feet,board measure,of lumber.

Plate III shows two elevations and plan of Pier IV.

Viaduct Piers.

There are eight reinforced concrete viaduct piers, supporting the steel columns for the viaduct west of Pier IV, which are founded on piles.

Work was begun driving the foundation piles December 12th,1907. Cofferdams 10'6"x11'3" were put in at each pier. The concreting, started February 9th,1908, was finished February 24th. At all of these piers, the piles (16 at each pier) were sawed off under water, and the concrete for footings was deposited under water by means of a 10" diameter pipe. A willow mattress, 70 feet wide, extending 35 feet each side of the center line of track and from Pier IV to 35 feet west of west viaduct piers, was woven and weighted down with riprap.

Plate VI shows plan and elevation of pedestal piers.

Caisson Levels and Alignment.

In order to keep a daily record of the alignment of piers during the sinking of the caissons, the following methods were used:

For Pier II, two points, one on each bank, were put in on the north side, so that the line connecting them was parallel to the center line of track of permanent structure, and a point set in the ice about 18" east of the east side of caisson. The point in the ice was continually checked to ascertain if there had been any movement of the ice.Each morning the transit was set over the point on the parallel line in the ice, and a backsight taken to the point on the west shore about 1100 feet distant. A right angle was turned and measurements from this line to the northeast and southeast corners of the caisson recorded. Measurements to determine the exact stationing of the west base line were made, using a 500-foot tape, standardized at 60 degrees Fahrenheit, with a 12-pound pull. The expansion or contraction was computed at .0000065 per foot for each degree, and the amount recorded. After repeatedly checking the stationing of the west shore base line, all measurements were made to piersfrom this point along the temporary bridge. This was advisable, not only on account of the very steep slope of the east bank making the checking of measurements from the east base line very difficult, but also on account of the east end of the temporary bridge being on a curve, which made it very difficult to get any direct measurement to the east shore. The caisson for Pier II was located by measurement from the east shore, and this point checked by using three transits set up on east base line,- one on center line of bridge, one 750.46 feet north and one 655.8 feet south of center line of track. Foresights were taken to points on west base line, the distancesof which from the center line of track on bridge were computed and measurements checked. The intersection of these three lines was a point 3/8 of an inch east of the center line of Pier II, as measured from east shore. During this triangulation work, it was found that the base lines on the east and west shores were not at exact right angles to the center line of track. This fact, on account of which the computations for triangulation would become complicated, and the fact that the temporary bridge which was in service during the construction could be used for direct measurements, were the reasons for abandoning triangulation methods. Occasionally, the center line of the working chamber in the caisson was carried up through the entrance shaft with a 6-pound plumb bob, so as to determine the amount the vertical center line of the structure, as lowered, varied from the true vertical line.

The center line of caisson, Pier II, was landed with the north end 1¾" too far east,and south end 5/8" too far west. The center line of the pier for stonework was set 1/2" east of the correct line to allow for the pier shifting west when lowered 7 feet. This was due to the center line of the caisson making a slight angle with the vertical, which was impossible to correct, although continual attempts were made. The center of the caisson as landed is about 4-3/8" too far west.

Points were set at each corner of the caisson, the distance above the cutting edge being recorded, and,as the caisson was lowered,the points were raised. Levels were taken each day on these points from which the elevation of the cutting edge was determined. Any variations in elevation of cutting edge at corners would be taken into consideration during the excavation for its lowering, in order to correct any inequality as much as possible.

The center line of Pier I was determined by measurement from the east base line. This measurement was checked by the closing of a parallelogram.

At Piers III and IV the same method was used, except that the point which was put in the ice at Pier II was established on the temporary bridge at Piers III and IV. These points required repeated checking for line and distance, as the temporary bridge was found to move to some extent.

The center line of caisson of Pier III was not lowered in a true vertical plane. At a depth of 77 feet below low water surface, it was 1¾" too far east, which error still remained when landed.

At Pier IV the center line of caisson was landed 3" east at the north end, and 1" east at the south end.

IV.
RIVER PROTECTION.

To protect Pier IV from the ravages of the Missouri River, a pile dike was put in, extending from the north end of Pier IV along the produced center line of the pier for 495 feet; thence, 610.5 feet on a five-degree 44' curve left; thence, tangent 149.5 feet to the shore. The dike was more feasible here, inasmuch as the channel of the Missouri River is straight for a distance of about one mile north, at which point there is an angle of about 45 degrees towards the west.

A woven willow mattress, extending 55 feet toward the channel from the outer row of piles of dike, and 30 feet towards the shore, weighted with riprap, protects the piles from being undermined. The mattress extends the full length of the dike, and well up onto the shore bank, where it is heavily riprapped.

The piles driven have a mimimum penetration of 16 feet in the river bed, with the elevation of top of piles 4.5 feet above ordinary high water. There are four intermediate cross dikes extending from the main dike to the shore. To secure against undermining, a willow mattress was woven, having five 3/8" diameter wire cables woven into it, extending 55 feet from the outer row of piles toward the river and 30 feet on the shore side. The weaving of the mattress was done on barges and sufficient one-man riprap, which was approximately 0.71 tons per lineal foot, put on to sink it. The riprap was unloaded on the west side of the river and a narrow gauge track put in on the west bank to the upstream shore end of the dike and to the shore arms. Peteler cars drawn by one horse were used for conveying the stone. The track was laid on the main dike and on shore arms, over which the loaded cars were pushed by hand. The piles were driven by a steam hammer fed by a hoisting engine fitted up on two 10'x40' barges. The barges were connected to pile clusters with a line by which they could be pulled into position.

Upright or screening poles, forced well into mattress and fastened with 40 and 60d Wire nails, were placed 4" to 16" centers along the main dike and shore arms, to catch the small drift and retard the current, so that a deposit would be made between the dike and shore. Willows for the mattress, were obtained partly from points east of the Missouri River and shipped in. Owing to the difficulty in obtaining willows from points east, a crew was sent up the river by boat and a camp established near Fort Yates, where the willow brush was cut, loaded on barges andtowed down to the bridge by the ferry boat in use at the bridge site.

The result obtained to date by the construction of the dike has been satisfactory, the deposit back of the dike reaching an elevation, at some points, of 1269.2, which is 1.7 feet above ordinary high water. For a distance of several hundred feet south of the center line of track, a deposit has been made, although it may not be as permanent as that north of the bridge, inasmuch as the dike ends at the pier. From all indications, it might be said that, by the construction of the dike, the west shore line has been advanced from its old position to a point about 300 feet into the river.

In the construction of this work, there was used 32,437 lineal feet of piling; 122,040 feet board measure of lumber; 47, 136 lineal feet of screening poles, 23,000 pounds of hardware; 203 cords of riprap, and 1460 cords of willows.

Mr.S.Waters Fox, Consulting Engineer, Kansas City, Mo., made a personal examination of the vicinity of the proposed dike, and prepared the design and specifications.

V.
SUPERSTRUCTURE.

The permanent superstructure comprises the following in the order named, beginning at the east end:

One 125' riveted deck truss span, 125' center to center of bearings, with trusses 12' center to center. The fixed end is at the east abutment.

Three 420' pin connected through truss spans, 419'10¼" center to center of end pins, with trusses 23' center to center, and the depth from center of lower chord to center of upper chord 65'. The fixed end of each span is at the east end. Through an error in the shop, the top chords for the 420' spans were made too short to allow milling. This was remedied, as shown in File F-31 of the B&B Department records; at splice at U-5 a 5/8" plug was made for the entire cross section of the chord. Chord section U-5, U-6, U-7 were milled 1/8" short; adjoining chord sections were lengthened 1/16", and pin at U-5 moved 1/16". The total length of the top chord was not changed, and the camber of the bridge only slightly affected.

283.5 lineal feet of steel viaduct, consisting of five deck girder spans, supported by latticed steel columns 43'1" long, which are supported by viaduct piers on pile foundation. The east end has a bearing on Pier IV, while the west end is supported by a temporary pile pier. The distance from the center line of bearing at Pier IV to the center line of bearing at the pile pier is 281'6". The girders are spaced 7'6" center to center, and the depth, bottom to bottom of angles, is 8'0".

These structures were designed in the Chicago office of the Chicago, Milwaukee & St. Paul Railway Company, Cooper's Class E-55 loading being used in the design.

The following table shows the weight, painting, contractors, date contracts were awarded, and shop and mill inspectors. All material and workmanship conforming to the "Specifications for Steel Bridge Work, Bridge & Building Dept., C.M.&STP.RY.CO.," dated October 15th,1906.

Span	Weight (pounds)	Paint: Shop	Paint: Field	Contract Awarded to:	Steel from	Inspectors: Shop	Inspectors: Mill
125' deck truss	271,860	1 coat #25 paint.	1 Coat Carbonizing Coating.	Minneapolis Steel & Machinery Co.Mnpls. July 2,1907.	Inland Steel Co., Chicago	R.M. Doyle, Chicago-	J.N. Ostro Pitts burgh.
3-420' through spans	7,990,114	1 coat Carbonizing Coating	"	Pa.Steel Co.,Steelton, Pa.Sep.4,1906.	Pa.Steel Co.,Steelton,Pa.	J.A.Colby, Philadelphia,Pa.	
283.5' viaduct	444,987	"	"	Amer.Br.Co. New York, N.Y. May 29-07.	Ambridge Shops,Pa.	J.N.Ostrom Pittsburgh Pa.	
Guard rails.	97,206	1 coat oil.		Kenwood Br.Co. Chicago May 2, 1908	Kenwood Shop.	R.M.Doyle, Chicago, Ill.	

For the deck on the permanent bridge 8"x12"x10' ties were used, spaced 1'0" center to center. The 6"x4"x1/2" guard rail angles are backed up with 4"x8" pine guard rails. The outer guard rail is 6"x8" pine.

With the exception of the east or shore span, the erection falsework was built on pile foundation. The piles were all driven with a scow driver, except those in Span 1, in which the piles adjacent to the track of the temporary bridge and between this track and pier I were driven with a track driver. The foundation piles were capped with 12"x12" caps, on which rested frame bents built of 12"x12" timber, which supported the 8"x16" stringers carrying the ties and track for the traveller. The falsework of the east or shore span, with the exception of three bents, was built on mud sills; one of these three bents was put on the piles used in placing the

cofferdam around Pier I, and the other two bents of falsework were put on piles which were driven to shale by hand.

The traveller designed for use in steel erection was 57'4"x66'6", outside measurements on top, and 86'4½" from top of traveller rail to the extreme top. The inside frames of traveller were plumb, and the outside frames of the leg were battered 1" per foot. The vertical clearance from top of traveller rail was 72'11½", and the distance from center line of track to the center of inside leg frame was 16'4", which was 4'10" from the center line of truss. The traveller ran on four rails, two under each leg, spaced 4'10½" center to center. Each leg was supported by five pairs of rollers. The traveller track ran from Pier I to Pier IV on erection falsework, though not at one time, as the erection falsework of Spans 1 and 2 was being removed and used in erecting Span 3. Erection of the traveller was begun October 21st,1907, and work of tearing it down finished March 6, 1908. The spans were erected in the following order: Span 1, Span 2, Span 3, east shore span, Viaduct.

VI.
TIMBER TRESTLE.

(West Approach.)

The west approach extends from the temporary pile pier, at the west end of the permanent structure, 1289', and is built on a 1°-58' spiral curve. It is of timber construction on piles, with 12"x14" caps, on which are placed the five-post frame bents, which carry 8"x18" stringers, with 8"x8"-10' ties, spaced 1' centers. The 6"x4"x1/2" inner guard rail angles are backed up with 4"x6" guard rails. The entire timber approach between the rails is covered with galvanized sheet iron for protection against fire.

A sidewalk 2'6" wide is built on the north side and extends the entire length of the permanent and timber bridge. Retreats were built on the north side of west approach, spaced 94' centers.

VII.
GENERAL.

The work of constructing the bridge, from the time actual work began on the first temporary bridge until the permanent structure was opened for traffic, was 1 year and 8½ months.

A working force, however, was in the field on preliminary work, construction and cleaning up for three years and one month.

The elevations of the cutting edge at the several corners of the caissons are given on Plates III, IV and V, which show the elevations and plans of the piers.

Piers I, II, III and IV, from top of stone masonry to bridge seat, were reinforced transversely and longitudinally with 3/4" corrugated bars. The transverse bars were spaced about 6" centers under each bearing; 2' centers at the center and ends of piers, and rested directly on the longitudinal bars, which were uniformly spaced 2' centers. The vertical spacing of the bars was 2 feet.

Four 20-pound rails were placed vertically under each bridge seat, extending from the top of the stone masonry to within a foot of the bridge seat. The top end of these rails were placed 6" in from the edges of the castings, and battered two ways, 1/2" per foot.

The air pipe, water pipe and discharge pipes for all caissons were 4" in diameter. The electric light wires were carried down into the caisson through two inch iron pipes.

Permanent combination bench marks and transit points were put in on the east and west side of the river, and lines and levels, taken on all permanent structures, referred to these monuments, so that tests for movement or settlement of the structures could be made. There are four monuments in all,- two on each side of the river, built of concrete, reinforced, and the details of construction and location are shown on Drawing No.C-3266 Case No.4-1.

For lowering the caissons, two side stringers, each 8"x16", were bolted horizontally, one directly over the other, at a point a few feet above the deck, to the upright posts along each side. 8"x16" transverse, horizontal stringers, projecting 3 feet on each side of the caisson, were bolted to the upright side posts. One 8"x16" stringer was bolted on each side, flatwise and parallel, to the side stringers, to the projecting transverse stringers. These rested on the 48 twelve-ton screw jacks, which rested on cribbing built up from the falsework. As the caisson was lowered, the cribbing was removed from under alternate jacks.

During the sinking of the caissons and while the working force was large, a Doctor, carried on the Bridge & Building Department payroll, was stationed at the camp, with an office in the hospital building, in which there was also a room containing two hospital beds to be used in emergency cases. Medicines and medial supplies were kept on hand. With the exception of two or three emergency calls from the front, the doctor's presence at the camp was demanded continually, to be in readiness to administer to the needs of the laborers and caisson men attacked with the bends. Before entering the caisson, the men were given a physical examination, which, if satisfactory, was so stated in writing and signed by the doctor. This paper was required before the caisson men were put to work.

The freight on material used at the Missouri River Bridge over the C.M.&ST.P.RY Co's lines was $83,394.86.

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APPENDIX. 1.

List of Drawings.

A-9147) A-9148) A-8563)	Case 4-1	Profiles on proposed lines over the Missouri River.
C-3644	Case 4-1	Engineering Dept's profile from Mobridge to therive
A-7804) C-3276)	Case 4-1	Profiles of West Approach.
A-7866	Album 104B Page 45	Plan of bridge submitted to and approved by the Secretary of War.
C-2364	Album 152B Page 16	Property between Mobridge and River owned by the Railway Company.
C-3266	Case 4-1	Location and elevations of monuments; points on piers, abutment and viaduct piers.
C-3523	Album 130B Page 48.	Plat of Pontis, S.D., showing camp buildings, temporary tracks and storage yards.
C-4709) C-4711)	Case 4-1	Soundings at Pier I.
		Substructure.
A-7415	Album 150 Page 2.	Details of east abutment.
A-7416	150-21	Details of Pier I.
A-7417	150-22	Granite courses Piers I and IV (CM&STP)
A-9780	152-30	" " " " (Kettle River (Quarries Co.)
A-8356	152-14	Location of line of pressure, Stability Pier I.
A-9242	152-15	" " " " " II.
A-7418	150-23	Details of Piers II and III.
A-7419	150-24	Granite Courses Piers II and III. (CM&STP)
A-9781	152-31	" " " " (Kettle River Quarri (Company.
A-7420	150-25	General plan (explanatory sheet) Piers II and III.
A-7421	150B-7	Details of Pier IV.
C-997	150A-13	Pile plan, Pier IV.
C-783	131B-118	Pile plan (and caisson) Pier IV.
A-7422	152A-16	Cofferdam, Pier IV.
A-7423	123B-174	Bill of material, cofferdam Pier IV.
A-9963	157A-31	Details of viaduct piers.
		CAISSONS.
A-8298	152-1	Caisson Pier II, general plan.
A-8296	152-2	" Piers II and III, details.
A-8297	152-3	" " " falsework.
A-8299	152-4	" " " metalwork.
C-784	152B-25	" Pier IV, details.
A-8299A	123A-180	Ladders for caissons.
A-8299B	123B-20	Goose neck and lock for caissons.
A-9122	123B-74	" " flange and unions for caissons.
A-8891	152-5	Air lock for supply shaft.
A-7435	123B-178	Leather gasket for 3-foot supply shaft.
C-501	123B-186	Air lock for supply shaft.
A-7424	152-23	Details bottom sections of supply shaft.
A-7425	152-34	Details top " 2 " "
A-7426	123B-176	Steel bucket.
C-2078	152-B-6	Pier II, graphical record of sinking caisson.
C-3287	166-2	Pier II, Record of sinking caisson.
C-3288	166-2	Pier II, Progress of work and material passed thro
C-2079	152B-7	Pier III, Graphical record of sinking caisson.
C-3289	166-3	Pier III, Record of sinking caisson.
C-3285)		(Pier I, platted core borings, cracks in shale.
C-3286)	166-1	(
C-3290	166-4	Pier IV, record of sinking caisson.

SUBSTRUCTURE, Miscellaneous.

A-8077	104B-24	12'x48' barges designed for bridge construction.
A-8384	152-6	Machinery barges.
A-8385	152-7	Details of tank for air receiver.
A-8386	152-8	Machinery house.
A-9145	150-26	Details of forms. (All piers.)
Temporary	128B-40	Steel frames for bracing forms and reinforced concrete piers.
A-6919	104B-23	Volumes of piers.
A-8327	123A-172	Rollers for concrete dump cars.
A-7427	152-B-17	Location of bearings on piers.
C-2121	152B-18	Flood levels.
C-1437	Case 4-1	Deflection polygon, Spans 1 and 2.

Masonry reports, showing masonry as built.

A-8298	167-5	Pier II and III.
C-674	167-6	Camber and deflection polygon.
C-784	167-7	Details of Caisson, Pier IV.
A-7415	167-8	East abutment.
A-9663	167-9	Masonry for steel viaduct.
	167-10	Falsework for 125-foot deck truss span.

SUPERSTRUCTURE.

East Span- 125-foot Riveted deck truss approach.

A-9788	151A-44	Erection diagram and bill of material.
A-9789	151A-45	General plan.
A-9793	151A-46	Top chord, U0, U1, U2.
A-9794	151a-46	" U2, U3, U2.
A-9795	151A-47	Bottom chord.
A-9796	151A-47	Diagonals U0, L1 and L1 U2.
A-9797	151A-48	Bottom laterals and Int. diagonals.
A-9798	151A-48	Floor beams and stringers.
A-9799	151A-49	Sway braces and top laterals.
A-9800	151A-50	Shoes, rocker nests, castings, etc.
C-758	151A-45	Bill of field rivets.
C-1488	131B-38	Match marking diagram.

Main Spans, Three 420-foot Riveted Through Trusses.

A-8150	151-1	Strain sheet.
A-8151	151-2	Erection diagram.
A-8152	151-3	General plan.
A-8153	151-4	Bottom chord L0, L1 L3.
A-8154	151-5	Bottom Chord L2 L3.
A-8156	151-7	Top chord U1U2 U3.
A-8155	151-6	End post L0 U1
A-8157	151-8	Top chord U3 U4 U5.
A-8158	151-9	" " U5 U6 U7.
A-8159	151-10	" " U5 U6 U7.
A-8160	151-11	Post L3 U3.
A-8161	151-12	Post U5 L5 R and U5 L5R.
A-8162	151-13	Diagonal L7 U5 and Post L6 U6.
A-8163	151-14	" L1 M2 Ls M4 and L5M6.
A-8164	151-15	Intermediate floor beams.
A-8165	151-16	End floor beams (E.F.B.)
A-8166	151-17	Stringers.
A-8167	151-18	Laterals BL1 BL2 BL3 BL4 BL5 BL6.
A-8168	151-19	Bottom laterals BL 7-8-9-10-11-12.
A-8169	151-20	" " BL 13-14-15-16-17-18.
A-8170	151-21	" " BL 19-20-21 Struts M3-4-5-6-7.
A-8171	151-22	Hangers L4 M4 R&L U2 M2 Struts M4 U4 M2 U2 R&L.
A-8172	151-23	Top laterals TL 1 and TL 2.
A-8173	151-24	Portal.
A-8174	151-25	"
A-8175	151-26	Top laterals U2 U3.
A-8176	151-27	Posts L7 U7 and L1 U1.
A-8177	151-28	Struts and bracing.
A-8178	151-29	Eyebars, pins, nuts, etc.
A-8179	151-30	Bill of material
A-8220	151-31	Profile of spans.
A-9243	151-32	Alternate sections of top chord.
A-9235	151-34	Portal general drawing.
A-9236	151-35	X Section L5 U5

A-9237	151-36	List of field rivets.
A-8918	151-37	Shoes, rollers, etc.

Steel Viaduct.

C-141	157-A-32	Erection diagram and bill of material.
C-143	157A-33	70-ft. deck girder.
C-144	157A-34	70'9" deck girder.
C-145	157A-35	35' deck plate girder.
C-146	157A-36	Columns CR and CL.
C-147	157A-37	Braces LB 1-2-3.
C-148	157A-38	Transverse bracing.
C-149	157A-39	Bill of rivets and bolts.
A-9200	98-28	Castings.

Floor plans.

A-9297	151-33	Floor plan.
C-1867	153-36	Approach guards.
C-1621	152B-4	Sidewalk.

Falsework.

A-7440	158-10	Bill of material.
A-9777	158-1	125' span, details.
A-9721	158-2	General plan.
A-9722	158-3	Details.
A-9723	158-4	"
A-7428	158-5	Bents A,o,p, F&H.
A-7429	158-6	" D E K.
A-7430	158-7	" d e f l m n.
A-7431	158-8	" L & G.
A-7432	158-9	" C and location of bents at intersection with temporary bridge.

Traveller.

A-7434	152A-15	Details.
C-944	152B-26	Additions to Traveller.

Timber-West Approach.

A-9566	152A-38	Bill and elevation.
C-936	152B-9	Details of bents.

River Protection.

A-7442	152-16	Cross dike.
A-7443	152-16	Pile dike.
A-7444	152-17	West shore line showing long dike
C-2483	131B-18	Soundings along dike, etc.

Temporary Bridge, etc.

A-7971	150-1	Profile of temporary bridge drawspan.
A-7971	150-1	Details " " drawspan.
C-2486	152B-23	Telphone wire fastening.

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A P P E N D I X 2.

INDEX TO ALL PAPERS AND CORRESPONDENCE ON FILE IN THE BRIDGE & BUILDING DEPARTMENT.

File No.

D-716:

Act of Congress, dated April 2nd, 1906, authorizing construction of the bridge.

B&B 301, B&B 312, B&B 313:

Samples of core borings taken from vicinity of Piers I, II and III.

D-357:

Core drilling outfit rented from the C&NWRY.

F-31½:

War Department, approval.
Original estimate.
Right of Way Purchase.
Camp and Organization.
Test Pit and Soundings.
Caissons and Pneumatic Foundations.
Cofferdams and Sheet Piling.
Concrete Mixer.
Stone
Boat Service.
Sidewalk, Railing and Hand Car retreats.
Miscellaneous.
Breaking up of River.
Telegraph and telephone service.
Falsework and temporary bridge.
Loading and speed of trains across bridge.
Grand River channel fill.
Bench marks.
Watchman.
Handling material.

F-49:

Progress Reports.

D-242:

Orders, vouchers and correspondence for steel sheet piling used for Pier I.

F-39:

Correspondence and orders for steelwork for 125-foot span.

F-31:

Three 420' through spans:
Miscellaneous information in regard to manufacture, tests, shipment, etc. and erection of steel.
Correspondence re. iron and bridge men.
Vouchers in payment of steel.

F-40:

Correspondence and orders for steelwork for viaduct.

F-62:

Correspondence and orders for guard angles.

D-591:

Brackets and telegraph wire supports and correspondence with Mr.U.J.Fry, Supt. of Telegraph.

D-641:

Voucher for one disc, marked P.D., Drawing A-8178,
and two laterals marked S12R, " A-8166.

D-690:

Miscellaneous information given out for publication.

A P P E N D I X 3.

ENGINEERS, ASSISTANT ENGINEERS, FOREMENA
and SUB-FOREMEN, and their LENGTH OF SERVICE.

C. F. LOWETH,
Engineer and Superintendent of Bridges and Buildings.

J. J. HARDING ,
Engineer of Masonry Construction.

J. H. PRIOR,
Assistant Engineer,
in charge of design and assisted
by

W.E.Pruett,
R.J.Middleton,
H.J.Hansen.

--O--

F. E. RICE,
Resident Engineer,
May,1906 to October, 1908.

J.F.Pinson,
Assistant Engineer,
Preliminary Surveys
and Soundings,
Jan.1906 to June,1906.

W.E.Duckett,
Instrument Man
and
Assistant Engineer,
June,1906 to Mar.1908.

J.H.Neef,
Instrument Man
and
Assistant Engineer,
Jan.1907 to Oct.1908.

H.R.Armeling,
Instrument Man,
Jan.1907-June,1907.

--O--

EDWARD HOWELL,
General Foreman,
May,1906- March,1908.

Robt. Irwin,
Master Mechanic,
Jan.1907-May,1908.

Herbert Long,
Assistant General Foreman,
Nov.1907- January,1908.

R.S.Veach,
Quarry MasonryInspecto
August,1906-June,1907.

E.T.Auld,
Mattress Inspector,
May,1907-Sept.1907.

--O--

Dr. W. E. Stewart,
Camp Physician,
Feb.1907-May,1908.

--O--

E. GREENWALD,
General Iron Bridge Foreman,

H.Du Shane,
Steel Erection Foreman,
October,1907-March,1908.

C.A.Nordeen,
Steel Erection Sub-foreman,
and
Steel Erection Foreman,
November,1907-March,1908.

Wm.Cullen,
Steel Erec.Sub-foreme
and
Steel Erect.Foreman,
Nov.1907 to Mar.1908.

--O--

Carpenter Foremen.

John Anderson, July,1906-July-07

Cyrus Towner, Oct.06-Jan.08.

Mike Hurley, Sub-foreman and Foreman, May,06-Jan.08

J.M.Gonsolus, Oct.06-June,1907.

Pneumatic Caisson Foremen.

M.B.Cahill, Pressure Foreman, Nov.1906-Nov.1907.

James Ryan, Ass't Pressure Foreman, Jan.1907-November,1907; Foreman Nov.1907-February,1908.

Maurice Welch, Ass't Pressure Foreman, November,1907-Dec.1908.

Pressure Gang Foremen.

Dan Ashley, May,1907-Jan.1908

Rollie Collins, May,1907-Dec.1907

B.Williams, May,1907-Dec.08

Wm.Hunt, May,1907-Nov.07

Frank McCarty, Oct.1907-Jan.1908

J.Rawlingson, Oct.1907-March,1908

Jesse Mullins, Feb.1907-June-07

G.Johnson, Oct.1907-Feb.1908

T.Sullivan Feb.07-April,1907

Jesse Gaither, Jan.07-March,1907.

Pile Driver Foremen.

W.Fitzgerald, June,1906-Apr.07

O.Larson, March,07-Jan.08

Ed. Donahue, April 07-March 08

John Ossowski, Subforeman, May,1906-July,1906.

Herbert Jones, April 1907-Jan.1908

Wm. Embody, Sub-foreman and foreman, April,1907-Feb.1908

Geo.B.Getty, Jan.1908-March,1908.

Bridge Carpenter Foremen.

W.J.Ripley, Aug.07-March,1908

John Schrader, Sept.1907-March,1908

Gust.Peterson, Dec.1907-Oct.1908

Robt. McLain, Nov.1907-March,1908

Al.Holmes, Dec.1907-June,1908.

Concrete Foremen.

Charles Luther, Preliminary Soundings and Concrete Foreman, May,1906-Dec.1907

R.T.English, January,1908-March,1908

River Protection Foremen.

W.W.Russell

October,1907-Dec.1907.

Andrew Warren, Weaver Foreman, Nov.1907-Sept.1908.

Labor Foremen:

John Rice, June,06-Dec.06

Ole Iverson, July,06-Feb.08

Knut Simmons, Sept.07-Jan.08

Geo. Null, March-07-Oct.08

C.A.Rice, Painter Foreman, May,1908-Sept.1908.

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Chronological Summary.

TEMPORARY BRIDGE.

5/21/06	Boat "J.H.Keene" began towing material from Evarts, S.D.
7/1/06	Started driving piles for bridge.
9/21/06	Track laid to Pontis and bridge ready one month previous.
1907	
3/9	Began to take out bridge on account of approaching break-up.
3/31	Began to drive piles for renewal.
4/1	Stopped driving piles, on account of running ice.
4/11	Fifteen bents remaining to be driven to close temporary bridge. Running ice took out 34 bents driven.
4/21	Bridge completed.
5/29	Bridge washed out.
5/30	Caisson Pier III, partially completed, washed away.
6/8	Started driving piles to renew bridge.
6/16	Bridge finished.
6/25	Bridge went out.
7/5	Started to redrive bridge.
7/18	Bridge completed.
7/28	This bridge remained in service until after the completion of permanent bridge, 3/18/08, after which it was torn out between Piers I and II and II & III, giving an unobstructe flow to ice.

EAST ABUTMENT:

10/12/06	Quit excavating after going 3' below proposed bottom of footing and finding only loose shale.
1907:	
3/6	Began excavating again.
3/20	Excavation completed.
3/22	Started concreting.
4/17	Finished concreting.
4/22	Finished cleaning up around abutment.

PIER I:

1906.	
8/11	Began driving sheet piling for cofferdam.
8/19	Finished " " "
8/23	Started excavation.
11/28	Excavation completed.
2/21/07	Began concreting footing.
1907.	
2/27	Finsihed " " up to level of stonework.
4/6	Cleaned out cofferdam.
5/2	Started stone masonry.
6/4	Finished stone masonry.
6/16	Began concreting above stonework.
6/22	Finished " " "
7/7	Forms removed.
1908.	
Aug.1	Sheet piling removed.

PIER II:

1906.	
Sept.2	Began driving piles for caisson falsework.
9/25	Falsework completed.
9/30	Started building caisson.
12/4	Caisson completed and began lowering.
1907.	
1/5	Began concreting. Caisson still on jacks and lowered as concrete is put in.
1/12	Had to use water jet and sack out coarser material.
4/28	An examination of material being excavated made by C.F.Loweth and J.J.Harding, who entered the caisson at 57.5' depth.
5/4	Started stone masonry.
5/27	Caisson landed.
6/8	Finished sealing caisson.
6/17	Stone masonry completed.
6/18	Began building forms for neat work.
6/27	Abandoned work on Pier II, on account of temporary bridge washing out.
7/16	Resumed work on forms.
8/8	Forms completed.
8/12	Started concreting.

1907.
8/19 Finished concreting

PIER III.

1907.
5/11 Started driving falsework piles.
5/20 Falsework completed.
5/30 Caisson (partially completed) undermined and washed away.
7/25 Started driving falsework.
7/30 Finished " "
8/22 Caisson completed and began to lower.
8/24 Started concreting.
9/4 Fire in caisson - let air off to flood caisson and put fire out.
11/16 Started on stone masonry.
12/1 Caisson landed.
12/3 Work sealing caisson.
12/7 Finished sealing caisson.
12/17 Finished stone masonry.
1/6/08 Finished concreting pier.

PIER IV.

1907.
8/1 Started driving falsework.
8/28 Started driving sheet piling.
10/15 Using clam shell bucket for excavating.
10/22 Sand ran under sheet piling, filling up 8 feet.
10/31 Decided to use light caisson.
11/6 Day and night crew driving foundation piles.
12/10 Finished " "
1908.
1/8 Caisson completed and started to lower.
1/10 Began concreting.
1/22 Stone masonry started.
2/1 Started to seal caisson,
2/4 Finished sealing caisson.
2/8 Finished stone masonry.
2/14 Began concreting neat work.
2/18 Finished " "
5/15 Started weaving mattress around Pier 4.
5/30 Finsihed " " " "

VIADUCT PIERS.

12/12/07 Started driving foundation piles.
1908
1/24 Finished " " "
2/9 Began concreting.
2/24 Finished "

WEST APPROACH.

8/2/07 Began driving piles.
2/21/08 Finished " except pile pier.
3/11/08 Pile pier completed.

DIKE AND PROTECTION WORK.

1907.
6/22 Began driving piles with steam hammer.
6/26 Abandoned driving on account of high water.
7/19 Began again to drive piles.
7/30 Boat Keene took crew up to Ft.Yates to cut willows.
8/19 Began weaving mattress.
10/20 Began laying riprap.
7/28/08 Finished all mattress work.

FALSEWORK- STEEL ERECTION AND RIVETING.

East Shore-Deck Span.
6/27/07 Started falsework.
8/18/07 Finished "
4/5/08 Started steel erection.
5/23/08 falsework removed.

SPAN 1, PIER I to II:

1907
8/12 Started driving piles for falsework.
8/13 " erecting frame bents.

1907.

10/7	Finished driving falsework piles.
10/20	Falsework almost completed.
10/21	Began building traveller.
12/11	Completed steel erection.
12/12	Began riveting.
12/17	Began to remove falsework.
3/14/09	Finished removing piles from boom to Pier II.

SPAN 2, PIER II to III.

1907.

8/11	Began driving piles for falsework.
1/2/08	Finished falsework.

1908.

1/4	Started steel erection.
1/24	Finished " " and began to remove falsework.
3/7	Finished removing falsework.
4/17	Riveting completed.

SPAN 3, PIER III to IV.

10/20/07	Started driving piles for falsework.

1908.

1/26	Started steel erection.
2/9	Finished erecting falsework.
2/26	Finished iron erection and began to remove falsework.
3/6	Traveller taken down.

VIADUCT.

1908.

3/11	Started steel erection.
3/18	Finished steel erection.
3/19	A C-1 engine, hauling 16 cars loaded with steel rails, was run across the bridge, and passenger Train No.3 of March 19th,1908 passed over the bridge.
4/28	All riveting on bridge completed.

PAINTING.

4/17/08	Painting begun.
8/18/08	Painting finished.

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APPENDIX 5.

BORINGS AND SOUNDINGS.

Boring No.1, made April 15th, 1906, at Station 620 plus 93, on center line of track:
Elevation of shale 1257.0; drilled 28' to Elev. 1229.0.

Boring No.2,made April 16th, at Station 620 plus 93, 50 feet south of center line of track:
Elevation of shale 1257.0; drilled 9' to Elev. 1248.0.

Boring No.3, made April 16th, at Station 621 plus 04, 50' north of center line of track:
Elevation of shale 1257.0; drilled 11' to Elev. 1246.0.

Boring No. 4, made April 16th, at Station 621 plus 48, 50 ' north of center line of track:
Elevation of sand 1252.5 to 1254.5; hard shale 1254.5; drilled 22' to Elev. 1232.5.

Boring No.5, made April 17th, at Station 621 plus 40, 50' south of center line of track:
Elevation of shale 1254.5; drilled 9' to Elev. 1245.5.

Sounding No.6, made April 17th, at Station 620 plus 50, on center line of track:
Elevation of shale 1266.0, test pit 4'x6'.

Boring No.7, made April 18th, at Station 621 plus 90, 50' south of center line of track:
Elevation of shale 1254.0; drilled 10' to Elev. 1244.0.

Boring No.8, made April 18th, at Station 621 plus 90, on center line of track:
Elevation of shale 1254.0; drilled 31' to Elev. 1223.0.

Boring No.9, made April 18th, at Station 621 plus 90, 50' north of center line of track:
Elevation of shale 1254.0; drilled 10' to Elev. 1244.0.

Boring No.10, made April 24th, at Station 625 plus 02, 48' south of center line of track:
Gravel from Elev.1243.0 to 1232.0; blue clay 1232.0 to 1206.0; hard shale at Elev. 1206; drilled 11' to Elev. 1195.0.

Boring No.11, made April 24th, at Sta.626 plus 30, 50' south of center line of track:
Gravel from Elev. 1235.0 to 1230.0; sand and mud Elev. 1230.0 to 1208.0; gravel Elev. 1208.0 to 1205.0; quicksand, gravel and loose shale Elev. 1205.0 to 1198.0; soft shale 1198.0 to 1191.0; hard shale at Elev. 1191.0; drilled 5' to Elev. 1186.0.

Boring No.12, made May 2nd, Station 626, plus 15, on center line of track:
Gravel from Elev. 1245.0 to 1231.0; sand and mud Elev. 1231 to 1201; soft shale 1201.0 to 1195.0; hard shale at Elev. 1195.0; drilled 30' to Elev. 1165.0.

Boring No.13, Made May 3d, at Station 623 plus 02, on center line of track:
Elevation of shale 1251.0; drilled 8' to Elev. 1243.0; very hard shale 1243.0.

Sounding No.14, made May 3d, at Station 619, plus 14, on center line of track:
Elevation of shale 1289.0; test pit 4'x4' showed clay from Elev.1307.0 to 1297.0.

Sounding No.15, made May 5th, at Sta. 618 plus 72, on center line of track:
Elevation of shale 1291.5; test pit 4'x4'.

Boring No.16, made May 5th, at Sta. 623 plus 90, on center line of track;
Elevation of shale 1237.0; drilled 1' into hard shale and lost 8' of casing, on account of high wind. Mixture of loose gravel and loose shale over hard shale, Elev. 1261.0 to 1248.0.

Boring No. 17, made May 6th,1906, at Sta. 626 plus 15, 50' north of center line of track:

Gravel from Elev. 1243.0 to 1233.0; loose shale, sandand lignite 1233.0 to 1198.00; soft shale Elev. 1198.0 to 1183.0; hard shale at Elev. 1183.0, drilled 12' to Elev. 1171.0.

Boring No. 18, made May 8th, at Sta. 625 plus 80, on center line of track:

Gravel from Elev. 1240.0 to 1232.0; loose shale, sand and lignite from 1232.0 to 1188.0; hard shale 1188.0; drilled 28' to Elev.1160.0.

Boring No.19, made May 10th, at Sta. 1011 plus 08.3, 50' north of center line of track:

Gravel,sand,loose shale and lignite from Elev. 1239.0 to 1166.0; hard shale at Elev. 1166.0; drilled 17'to Elev. 1149.0.

Boring No. 20, made May 19th, at Sta. 1010, plus 26.3, 60' south of center line of track:

Gravel, sand, loose shale and lignite from Elev. 1238.0 to 1168.0; hard shale 1168.0; drilled 7' to Elev. 1161.0.

Boring No. 21, made June 23d, at Sta. 625 plus 50, on center line of track:

Gravel from Elev.1243.6 to 1234.0; sand, lignite and blue clay 1234.0 to 1183.0; soft shale 1183.0 to 1176.0; hard shale at 1176.0; drilled 1' to Elev. 1175.0.

Boring No. 22, made June 24th, at Sta. 625 plus 50, 25' north of center line of track:

Gravel from Elev. 1243.4 to 1234.0; sand,lignite and blue clay 1234.0 to 1186.0; soft shale 1186.0 to 1178.0; hard shale 1178.0; drilled 1' to Elevation 1177.0.

Boring No. 23, made June 25th, at Sta. 625 plus 25, on center line of track:

Gravel from Elev. 1243.4 to 1234.; sand and lignite 1234.0 to 1230.0, gravel 1230.0 to 1226.0; sand and blue clay 1226.0 to 1186.0; soft shale 1186.0 to 1183.0; hard shale at Elev. 1183.0; drilled 1' to 1182.0.

Boring No. 24, made June 28th, at Sta. 625 plus 30, on center line of track:

Gravel from Elev. 1243.8 to 1234; sand, lignite and blue clay 1234.0 to 1185.0; soft shale 1185.0 to 1183.0; hard shale at Elev. 1183.0; drilled 1' to Elev. 1282.0.

Boring No. 25, made July 18th, at Stat. 625 plus 12, 35' north of center line of track:

Gravel from Elev. 1242.6 to 1236.6; clay and sand 1236.6 to 1201.6; soft shale 1201.6 to 1191.6; hard shale at Elev. 1191.6; drilled 2' to Elev. 1189.6.

Boring No. 26, made July 19th, at Stat. 625 plus 20, 40' south of center line of track:

Gravel from Elev. 1242.6 to 1236.6; clay and sand 1236.6 to 1193.6; loose shale 1193.6 to 1181.6; hard shale at Elev. 1181.6; drilled 1' to 1180.6.

Boring No. 27, made July 20th, at Stat. 625 plus 10, 40' south of center line of track:

Gravel from Elev. 1242.6 to 1236.6; clay and sand 1236.6 to 1193.6; loose shale 1193.6 to 1185.6; hard shale at Elev. 1185.6; drilled 1' to Elev. 1184.6.

Boring No. 28, made July 23rd, at Sta. 625 plus 10, on center line of track:

Gravel from Elev. 1242.6 to 1236.6; clay and sand 1236.6 to 1200.6; loose shale 1200.6 to 1184.6; hard shale at Elev. 1184.6.

Boring No. 29, made July 23rd, at Stat. 625 plus 20, on center line of track:

Gravel from Elev. 1242.6 to 1236.6; clay and sand 1236.6 to 1200.6; loose shale and sand 120066 to 1183.6; hard shale at Elev. 1183.6; drilled 1' to Elev. 1182.6.

Boring No. 30, made July 26th, at Sta. 1012 plus 02.3, on center line of track; Sand from Elev. 1261.3 to 1228.0; gravel 1228.0 to 1212.0; lignite and sand 1212.0 to 1156.0; soft shale 1156.0 to 1148.0; harder shale 1148.0 to 1133.0; hard shale at Elev. 1133.0.

Boring No. 31, made July 31st,1906, at Station 1013 plus 02.3, on center line of track:
Same results as Sounding No.30.

Boring No.32, made in July, date unknown, at Station 625 plus 25, 25' north of center line of track:
Gravel from Elev. 1244.1 to 1234.0; sand, blue clay and loose shale 1234.0 to 1187.0; soft shale 1187.0 to 1185.0; hard shale at Elev. 1185.0; drilled 1' to Elev. 1184.0.

Boring No.33, made August 3d, at Station 1014 plus 02.3, on center line of track:
Same as boring No.30, except soft shale from Elev. 1159.0 to 1152.0.

Boring No.34, made Aug.11th, at Station 1014 plus 77.3, 25' north of center line of track:
Sand with a small mixture of clay from Elev. 1258.8 to 1217.0; gravel 1217.0 to 1215.0; sand and lignite from 1215.0 to 1188.0; gravel 1188.0 to 1186.0; lignite and sand 1186.0 to 1162.0; gravel 1162.0 to 1155.0; soft shale 1155.0 to 1147.0; hard shale at 1147.0; drilled 3' to 1144.0.

Boring No.35, made in August, date unknown, at Station 1014 plus 77.3, 25' south of center line of track:
Sand and lignite 1258.7 to 1222.0; gravel 1222.0 to 1219.6; sand, gravel, lignite and loose shale 1219.6 to 1166.0; gravel 1166.0 to 1157.0; soft shale 1157.0 to 1147.0; hard shale at 1147.0; drilled 1' to Elev. 1146.0.

Boring No. 36, made in August, date unknown, at Station 1015 plus 02.3, 25' south of center line of track:
Sand and lignite 1258.5 to 1421.0; blue clay 1241.0 to 1229.0; loose shale and lignite 1229.0 to 1169.0; gravel 1169.0 to 1156.0; soft shale 1156.0 to 1146.0; hard shale 1146.0; drilled 1' to Elevation 1145.0.

CORE DRILL BORINGS.

Boring No. 37, made Aug. 27th at Station 621 plus 05, 10' south of center line of track:
Casing lowered to hard shale, and boring made as follows:
Hard shale 1252.0 to 1200.0; hard lime stone layer 1200.0 to 1199.92; hard shale 1199.92 to 1185.16; softer shale 1185.16 to 1182.16; hard shale 1182.16 to 1145.66; hard lime stone 1145.66 to 1145.58; soft soapstone 1145.58 to 1145.56; hard shale 1145.56 to 1145.0.

Boring No. 38, made Sept. 6th, at Station 621 plus 17.8, 14'5" south of center line of track:
Casing lowered to hard shale, and borings made as follows:
Hard shale 1251.5 to 1248.5; limestone 1248.5 to 1248.3; hard shale 1248.3 to 1225.0; harder shale 1225.0 to 1215.0; soapstone 1215.0 to 1241.88; hard shale 1214.88 to 1214.5; soapstone 1214.5 to 1214.44; hard shale 1214.44 to 1184.0; soapstone 1184.0 to 1183.92; hard shale 1183.92 to 1181.0; limestone 1181.0 to 1180.78; hard shale 1180.78 to 1179.6; limestone 1179.6 to 1179.1; hard shale 1179.1 to 1172.6; soapstone 1172.6 to 1172.58; hard shale 1172.58 to 1172.5; hard limestone 1172.5 to 1172.42; hard shale 1172.42 to 1170.3; hard limestone 1170.3 to 1170.22; hard shale 1170.22 to 1169.4; hard rock 1169.4 to 1169.2; hard shale 1169.2 to 1160.0.

Boring No.39, made Sept. 18th, at Stat. 621 plus 17.8, 20' north of center line of track:
Casing lowered to hard shale and borings made as follows:
Hard shale 1251.5 to 1248.2;limestone 1248.2 to 1248.14; hard shale 1248.14 to 1245.0; soapstone 1245.0 to 1244.94; hard shale 1244.94 to 1207.0; soapstone 1207.0 to 1206.96; hard whitish rock 1206.96 to 1206.88; hard shale 1206.88 to 1191.0; soapstone 1191.0 to 1190.92; hard shale 1190.92 to 1190.6; Soapstone 1190.6 to 1190.52; hard shale 1190.52 to 1189.0; hard soapstone 1189.0 to 1188.84; hard shale 1188.84 to 1186.6; soapstone 1186.6 to 1186.52; hard shale 1186.52 to 1183.0; hard limestone 1183.0 to 1182.75; hard shale 1182.75 to 1182.7; soapstone 1182.7 to 1182.68; hard shale 1182.68 to 1181.0; hard whitish rock 1181.0 to 1180.84; hard shale 1180.84 to 1175;50; soapstone 1175.50 to 1175.42; hard shale 1175.42 to 1169.0; hard whitish rock 1169.0 to 1168.92; hard shale 1168.92 to 1163.0; hard limestone 1163.0 to 1162.75; hard shale 1162.75 to 1159.20.

Boring No.40, made Sppt. 25th, at Sta. 621 plus 05, 25' north of center line of track:

Casing lowered to hard shale and borings made as follows:

Hard shale 1251.5 to 1214.6; soapstone 1214.6 to 1214.58; hard shale 1214.58 to 1195.7; hard limestone 1195.7 to 1195.54; hard shale 1195.54 to 1193.3; soapstone 1193.3 to 1193.28; hard shale 1193.28 to 1190.5; soapstone 1190.5 to 1190.46; hard shale 1190.46 to 1178.0; limestone 1178.0 to 1177.92; hard shale 1177.92 to 1177.3; soapstone 1177.3 to 1177.18; hard shale 1177.18 to 1170.7; hard limestone 1170.7 to 1170.62; hard shale 1170.62 to 1166.7; soapstone 1166.7 to 1166.68; hard shale 1166.68 to 1166.40; limestone 1166.4 to 1166.32; hard shale 1166.32 to 1165.0; limestone 1165.0 to 1164.98; hard shale 1164.98 to 1164.5; hard limestone 1164.5 to 1164.42.

Boring No. 41, made Oct. 1st, at Sta. 625 plus 54, 46' north of center line of track:

Casing lowered to hard shale and borings made as follows:

Hard shale 1185.25 to 1182.7; extra hard shale 1182.7 to 1182.54; hard shale 1182.54 to 1176.0; softer shale 1176.0 to 1174.5; hard shale 1174.5 to 1171.0; softer shale 1171.0 to 1170.75; hard shale 1170.75 to 1169.67; softer shale 1169.67 to 1165.59; hard shale 1165.59 to 1162.4; hard limestone 1162.4 to 1162.32; hard shale 1162.32 to 1159.0; hard shale 1159.0 to 1158.0; hard rock 1158.0 to 1157.92; hard shale 1157.92 to 1155.63; hard shale 1155.63 to 1141.0. At 1141.0 a diagonal crack in the core was found. Hard shale 1141.0 to 1128.7; softer shale 1128.7 to 1121.47; hard broken shale 1121.47 to 1104.77; hard shale streaked with whitish hard rock 1104.77 to 1100.77. Core lost from 1100.77 to 1093.1; soapstone 1093.1 to 1092.94; hard broken shale 1092.94 to 1084.67; soapstone 1084.67 to 1084.59.

Boring No.42: made Oct. 14th, at Station 625 plus 54, 30' south of center line of track:

Gravel from 1244.3 to 1234.0; traces of lignite and sand 1234.0 to 1226.0; sand and blue clay 1226.0 to 1190.0; soft shale 1190.0 to 1183.0; hard shale 1183.0 to 1180.0; soft shale 1180.0 to 1177.0; hard shale at Elevation 1177.0; drilled 7' to Elevation 1170.0.

Boring No.43, made Oct. 15th, at Station 625 plus 54, 30' south of center line of track:

Casing lowered to hard shale and borings made as follows:

Hard shale 1200.8 to 1196.8; hard loose shale 1196.0 to 1191.8; broken hard shale 1191.8 to 1188.1; sand and clay 1188.1 to 1178.0; hard shale 1178.0 to 1177.0; hard limestone 1177.0 to 1176.92; hard shale 1176.92 to 1174.0; soapstone 1174.0 to 1173.98; hard shale 1173.98 to 1150.0; soft soapstone 1150.0 to 1149.98; hard shale 1149.98 to 1145.67; soft shale 1145.67 to 1144.07; hard shale 1144.07 to 1143.6; limestone 1143.6 to 1143.48; hard shale 1143.48 to 1138.67; medium soft 1138.67 to 1138.6; soapstone 1138.6 to 1138.56; hard shale 1138.56 to 1138.5; soapstone 1138.5 to 1138.48; hard shale 1138.48 to 1137.3, soapstone 1137.3 to 1137.22.

Boring No.44, made Oct. 24th, at southeast corner of Pier II:

Casing lowered to hard shale and borings made as follows:

Broken hard shale from Elev. 1180.0 to 1178.51; hard limestone 1178.51 to 1178.43; hard shale 1178.43 to 1175.0; softer shale 1175.0 to 1174.98; a diagonal crack in shale found at 1177.0; hard shale 1174.98 to 1168 soft shale 1168.8 to 1168.76; hard shale 1168.76 to 1164.7; hard limestone 1164.7 to 1164.64; hard shale 1164.64 to 1164.6; hard limestone 1164.6 to 1164.56; hard shale 1164.56 to 1160.0; extra hard shale 1160.0 to 1159.75; hard shale 1159.75 to 1151.1; hard limestone 1151.1 to 1151.04; hard shale 1151.04 to 1148.6.

Boring No.45, made Oct. 29th, at Station 1010 plus 50, 41' north of center line oftrack:

Casing lowered to hard shale and borings made as follows:

Hard shale 1167.15 to 1152.5; limestone 1152.5 to 1152.46; hard shale 1152.46 to 1147.0; harder shale 1147.0 to 1145.5; soapstone 1145.5 to 1145.46; hard shale 1145.46 to 1103.3; soft shale 1103.3 to 1103.14; hard shale 1103.14 to 1099.6, streaked with whitish limestone; hard shale 1099.6 to 1089.0; limestone 1089.0 to 1088.84; hard shale 1088.84 to 1075.5; soapstone 1075.5 to 1075.42; hard shale 1075.42 to 1075.0; soapstone 1075.0 to 1074.92; hard shale 1074.92 to 1064.0. From Elevation 1075.0 to 1074.0 shale streaked with whitish hard rock.

Boring No.46, made Nov. 9th, at Station 1010 plus 74, 25' south of center line of track:

Casing lowered to hard shale and borings made as follows:

Hard shale from Elev. 1166.5 to 1157.6; limestone 1157.6 to 1157.52; hard shale 1157.52 to 1154.0; limestone 1154.0 to 1153.92; hard shale 1153.92

Boring No.47, made Nov. 16th, at Station 1010 plus 50, 25' south of center line of track:

Casing lowered to hard shale and borings made as follows:

Hard shale at 1166.6; drilled 1' in hard shale to Elevation 1165.6, and discontinued the diamond drill borings.

NOTE: Borings Nos. 1 to 37, except Nos. 6, 14 and 15, were made by the wash boring method. Nos. 6, 14 and 15 were made by test pits.

Borings Nos. 37 to 47 were made with a Sullivan Core drill, which was rented from the Chicago & Northwestern Ry.Co.

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TABLE "A"

SACKS OF CEMENT USED, AND CONCRETE VOLUMES

STRUCTURE	Where Used	Volumes Concrete Cu.Yds	Universal	Atlas	Wolverine	Marquette	Meduso	ChicagoAA	Alpha	Peerless	Total	
East Abutment	Footing	1053	850								850	
	Neat	4244	1880								1880	
		5297									2730	
Pier I	Footing	453.0	1012	1607	50						2669	
	Backing Stone M'sy	95.0	156		9		8				173	Mortar only
	Neat	557.7	3021								3021	
		1105.7									5863	
Pier II	Footing	3812.1	8041	11061				1080			20182	
	Backing Stone M'sy	131.4	118								118	Mortar only
	Neat	772.1	4103								4103	
		4715.6									24403	
Pier III	Footing	4677.0	6211		10502				3491	3656	23860	
	Backing Stone M'sy	191.4	187		75						262	Mortar only
	Neat	761.0	4125								4125	
		5629.4									28247	
Pier IV	Footing	1075.0	4778		720	105	600				6203	
	Backing Stone M'sy	98.7	133								133	Mortar only
	Neat	541.3	2502			915					3417	
		1715.0									9753	
Pedestals	Footing	164.4				450					450	
	Neat	180.0				1325					1325	
		344.4	10								1775	
Monuments		4.									10	
Totals		14043.8	37127	12668	11356	2795	608	1080	3491	3656	72781	

TABLE-"B"

STRUCTURE	CU.YDS. CRUSHED STONE							Cu.Yds. Sand	Cu.Yds. Cut Stone	
	Minneapolis	Kasota	Mankato	Sioux Falls	Ortonville	Mendota	Total	Olivia	Granite Ortonville	Sand Stone Kettle River
East Abutment			325.37				325.37	150.0		
Pier I	100.00	70.00	400.00	50.00	220.00		840.00	412.3	49.60	150.85
Pier II	431.00	71.00	1746.00	100.00	1103.00		3451.00	1658.0	79.57	187.74
Pier III	300.00	70.00	2556.00	50.00	1050.00		4026.00	1941.0	41.27	227.73
Pier IV	862.24	67.88		51.20	239.02	82.66	1303.00	628.0	50.24	154.72
Pedestals			261.00				261.00	102.0		
Monuments		2.20					2.20	1.1		
	169324	281.08	5288.37	251.20	2612.02	82.66	1020857	489.24	276.68	721.04

Note:—
The use of so many kinds of Stone was due to the inability of any of the Stone Companies to furnish the stone as needed either through lack of cars to load or the capacity of their plants.

APPENDIX 7.

BRIEF COST REPORT.

In making up the cost report, a brief of which is given in Tables I,II,III and IV, Sheets 3,4,5 and 6 of this Appendix, the general buildings referred to comprise:

Camp buildings, boarding camp and equipment, carpenter and blacksmith shop, engineers' office and dwelling, rope, tool, nail, cold storage and ice houses, oil platforms, housing engines and sidetracks.

The concrete masonry buildings comprise:

Cement houses, cement, sand and stone chutes, heating plant and sand platform.

The structures not included in the above comprise:

Dynamo house and lighting plant, machinery barge, hospital and furnishings, scow derrick, push car track, side tracks at Piers II and III, soundings, skids and traveller.

The Report includes:

Credit for all material shipped away, as shown on bills sent to the Chicago office;

Credit for material left at Pontis, as shown on inventory, and

Credit for cash collections and board deductions.

THE TOTAL COST OF GENERAL BUILDINGS, MATERIAL, LABOR AND FREIGHT was charged as follows:

1/4%	Foundation east abutment.
1/4%	" pedestal piers.
1 %	" Pier I.
8 %	" Pier II.
11 %	" Pier III.
3 %	" Pier IV.
2%	Concrete masonry Pier I.
7%	" " Pier II.
9%	" " Pier III.
3%	" " Pier IV.
1%	" " East abutment.
1%	" " Pedestal piers.
1%	Stone " Pier 1.
1%	Stone " Pier II.
1%	Stone " PiermIII.
1%	Stone " Pier IV.
5%	Dike.
1/2%	Falsework east approach.
3%	" Span 1.
3%	" Span 2.
3%	" Span 3.
1/2%	Iron erection east approach.
3%	" Span 1.
3%	" Span 2.
3%	" Span 3.
1/2%	" Viaduct.
10%	West Approach.
15%	Temporary Bridge.
100%	

THE TOTAL COST OF CONCRETE MASONRY BUILDINGS, MATERIAL, LABOR AND FREIGHT, was charged as follows:

3%	Concrete masonry east abutment.
7%	" " Pier I.
34%	" " Pier II.
42%	" " Pier III.
12%	" " Pier IV.
2%	" " Pedestal Piers.
100%	

THE COST OF STRUCTURES MATERIAL LABOR AND FREIGHT, not included in GENERAL BUILDINGS OR CONCRETE MASONRY BUILDINGS, was charged as follows:

Dynamo House and Lighting Plant.

30%	Foundation Pier II
45%	" " III
20%	" " IV
5%	camp

(Sheet 1.)

Machinery, Barge and Hospital:

40% Foundation Pier II.
50% " " III.
10% " " IV.

Scow Derrick:

30% Concrete masonry Pier II.
10% Foundation Pier II.
10% Foundation " III.
30% Concrete " " III.
10% Stone " " II.
10% Stone " " III.
100%

Push Car Track along Temporary Bridge.

20% Concrete masonry Pier II.
30% Concrete masonry Pier III.
50% Concrete masonry Pier IV.

Side Track, Pier II (Built twice)

45% Foundation Pier II.
5% Stone masonry Pier II.
50% Concrete " Pier II.

Side Track, Pier III, (Built twice.)

45% Foundation Pier III.
5% Stone masonry Pier III.
50% Concrete " Pier III.

Borings and Soundings.
4 % Foundation east abutment.
24% " Pier I.
24% " Pier II.
24% " Pier III
24% " Pier IV.
100%

Skids and Traveller:
33-1/3% steel erection span 1.
33-1/3% steel erection span 2.
33-1/3% steel erection span 3.

BRIEF COST REPORT TABLE I

APPENDIX 7
Sheet #3

CLASSIFICATION		COST EXCLUSIVE OF FREIGHT				FREIGHT	COST INCLUDING FREIGHT		
MAIN	SUB.	MATERIAL	LABOR	TOTAL	Cost Per Unit		TOTAL	TOTAL Cost Per Unit	% of total Cost of Bridge
GENERAL BUILDING ACCT.	Camp Buildings	$ 3138 85	$ 3885 81	$ 7024 66		$ 502 10	$ 7526 76		
	Boarding Camp & Eq.	2375 55		2375 55			2375 55		
	Carp. & Blacksmith	82 88	55 00	137 88		12 54	150 42		
	Office Building	193 01	218 94	411 95		34 95	446 90		
	Dwelling Engineers	440 26	516 09	956 35		72 39	1028 74		
	Rope House	35 83	20 20	56 03		6 02	62 05		
	Tool House	46 04	23 00	69 04		8 15	77 19		
	Nail House	34 12	33 50	67 62		5 54	73 16		
	Cold Storage & Ice Hse	424 51	277 68	702 19		74 95	777 14		
	Oil Platform	19 19	6 75	25 94		3 69	29 63		
	Housing Engines	182 64		182 64		22 72	205 36		
	Side Tracks	54 20	1604 95	1659 15			1659 15		
		$ 7027 08	$ 6641 92	$ 13669 00		$ 743 05	$ 14412 05		
CONCRETE MASONRY BUILDINGS ACC'T.	Cement House	$ 405 69	$ 252 45	$ 658 14		$ 59 78	$ 717 92		
	Cement Chute	46 76	49 30	96 06		7 00	103 06		
	Sand & Stone Chute	245 37	474 97	720 34		71 70	792 04		
	Heating Plant	131 20	354 78	485 98		11 96	497 94		
	Sand Platform	64 80		64 80		18 85	83 65		
		$ 893 82	$ 1131 50	$ 2025 32		$ 169 29	$ 2194 61		
Dynamo House & Lighting Plant		$ 903 08	$ 41 93	$ 945 01		$ 12 18	$ 957 19		
Machinery Barge		664 72	1341 94	2006 66		79 72	2086 38		
Hospital & Furnishings		214 05	120 87	334 92		11 21	346 13		
Scow Derrick		38 36	759 23	797 59		6 12	803 71		
Push Car Track		2039 52	438 27	2477 79		905 70	3383 49		
Side Car Track (Pier II)		2131 92	606 42	2738 34		729 35	3467 69		
Side Car Track (Pier III)		2171 92	516 13	2688 05		746 85	3434 90		
Soundings and Borings		5853 29	7925 15	13778 44		366	14137 10		
Skids		621 74	2400 00	861 74		154	1023 28		
Traveler		2202 13	3117 88	5320 01		140	5541 41		
Total-		$ 24761 63	$ 22881 24	$ 47642 87	3.167 Cu. Yd. Masonry	$ 4145 07	$ 51787 94	3.44	5.65% Cu. Yd. of Masonry

29.

BRIEF COST REPORT—TABLE II

APPENDIX 7
Sheet 4

CLASSIFICATION	COST EXCLUSIVE OF FREIGHT.							COST INCLUDING FREIGHT.				
			LABOR			LABOR&MATRL			TOTAL			% of total cost of Bridge.
SUBSTRUCTURE.	Material.	Labor.	Cost per Unit.			Total.	Cost per Unit.		Freight.	Total.	Cost per unit.		
Foundation:													
Monument.		$ 7 20	.288			$ 7 20	.288			$ 7 20	.288		
E.Abutment.	$ 269 58	893 16	2.007			1162 74	2.61		$ 16 21	1178 95	2.649		
Pier I	3298 97	6124 60	13.98			9423 57	21.515		319 81	9743 38	22.245		
Pier II	2315 91 7	2955 7 15	8.21			5271 632	14.64		3125 12	5584 1 44	15.511		
Pier III	2937 496	3149 043	6.091			6086 539	11.77		3983 21	6484 8 60	12.543		
Pier IV	1669 365	2145 8 58	13.712			3815 223	24.38		3178 84	4133 1 07	26.41		
Pedestal Piers	205 28	488 364	46.511			693 392	66.037		70 077	763 469	66.74		
										$ 18058 533			19.7%
Concrete Forms.													
Monuments	4 70	11 00	1.294			15 70	1.847		58	16 28	1.915		
E.Abutment	213 44	438 91	1.058			652 35	1.571		35 22	687 57	1.656		
Pier I	482 42	1024 04	2.547			1506 46	3.747		346 2	1541 08	3.833		
Pier II	707 35	2161 28	4.879			2868 63	6.475		67 33	2935 96	6.627		
Pier III	785 61	2161 26	4.879			2946 87	6.652		77 69	3024 56	6.827		
Pier IV	681 45	1257 38	3.128			1938 83	4.822		63 60	2002 43	4.981		
Pedestal Piers	139 48	864 10	3.154			1003 58	3.662		23 90	1027 48	4.10		
										$ 11235 36			1.23%
Concrete Masonry													
Monuments	11 72	11 80	2.95			23 52	5.880		6 85	30 37	7.593		
E.Abutment.	2013 05	1710 1 1	3.230			3723 16	7.029		1319 78	5042 94	9.520		
Pier I	4805 90	3063 16	2.770			7869 06	7.117		2842 92	1071 1 98	9.688		
Pier II	2136 053	9998 12	2.120			3135 865	6.65		1218 1 04	4353 969	9.169		
Pier III	2439 581	1136 807	2.019			3576 388	6.353		1450 430	5026 818	8.929		
Pier IV	994 404	618 630	3.607			1613 034	9.405		512 933	2125 967	12.396		
Pedestal Piers	1263 58	2775 88	8.060			4039 46	11.729		928 62	4968 08	14.425		
										$ 13582 091			14.8%
Stone Masonry													
Pier I	3284 99	782 85	3.905			4067 84	20.293		563 01	4630 85	23.102		
Pier II	6945 63	1001 90	3.748			7947 53	29.732		837 01	8784 54	32.862		
Pier III	7288 31	1500 57	4.617			8788 88	27.042		909 90	9698 78	29.842		
Pier IV	4976 75	1136 64	5.558			6113 39	29.827		564 39	6677 78	32.581		
										$ 29791 95			3.25%
Dike	18683 45	17864 68	14.64	Lin.Ft.		36548 13	29.96	Lin.Ft.	2868 38	39416 51	32.308	Lin.Ft.	4.30%
Pile Pier	594 08	264 76				858 84			132 41	991 25		Cu.Yds. of Masonry	0.11%
Engineering.		11507 68		Cu.Yds. of Masonry		11507 68		Cu.Yds. of Masonry		11507 68	0.823		
Engr'g. Monuments	88	60 68				61 65				61 65			1.26%
Total.	$ 18342 978	$ 17156 593	11.46			$ 35499 571	23.60		$ 5441 484	$ 409410 55	27.22	"	44.66%

BRIEF COST REPORT—TABLE III

CLASSIFICATION	COST EXCLUSIVE OF FREIGHT.						COST INCLUDING FREIGHT.			
			LABOR.		LABOR & MATR'L			TOTAL.		% of total Cost of Bridge
SUPERSTRUCTURE	Material.	Labor.	Cost per Unit	Total.	Cost per Unit.	Freight	Total.	Cost per Unit.		
Falsework.										
E. Approach	$ 1032.35	$ 935.76	7.486 Lin. Ft. of span.	$ 1968.11	15.745 Lin. Ft. of span	$ 247.99	$ 2216.10	17.729 Lin. Ft. Spans		
Span I	6237.37	8376.16	19.948	14613.53	34.794	1938.57	16552.10	39.409		
Span II	6301.37	8845.88	21.062	15147.25	36.064	2061.07	17208.32	40.972		
Span III	5906.79	7341.33	17.479	13248.12	31.543	968.37	14216.49	33.849		
							50193.01			5.47%
Steel Erecting										
E. Approach	905.82	58.44	4.307 Ton of Steel	964.26	72.9209 Ton of Steel	18.53	982.79	72.3077 Ton of Steel		
Span I	9088.44	5276.85	3.963	9616.29	72.2106	3918.37	10008.66	75.1531		
Span II	9081.13	4465.00	3.353	9527.13	71.5460	3918.36	9919.549	74.4884		
Span III	9088.47	4030.36	3.026	9491.583	71.2747	3918.37	9883.420	74.2171		
Viaduct	1256.24	69.246	3.112	1325.570	59.5806	62.872	1388.442	62.4047		
							32182.356			35.11%
Steel Riveting										
E. Approach	44.25	528.77	0.105 Rivet	573.02	0.1143 Rivet.		573.02	0.1143 Rivet.		
Span I	670.86	1902.95	0.1325 "	2573.81	0.1793 "		2573.81	0.1793 "		
Span II	670.86	2246.76	0.1565 "	2917.62	0.2033 "		2917.62	0.2033 "		
Span III	670.87	1929.14	0.1351 "	2600.01	0.1811 "		2600.01	0.1811 "		
Viaduct	54.43	346.58	0.0834 "	401.01	0.0964 "		401.01	0.0964 "		
							9065.47			0.99%
Steel Painting.										
E. Approach	94.30	139.35	1.7189 Ton of Steel	233.65	1.7445 Ton of Steel		233.65	1.7445 Ton of Steel		
Span I	523.67	2127.83	1.9911	2651.50	1.9910		2651.50	1.9910		
Span II	523.66	2107.37	1.9757	2631.03	1.9757		2631.03	1.9757		
Span III	523.67	2123.69	1.9879	2647.36	1.9872		2647.36	1.9872		
Viaduct	72.50	164.00	0.7371	236.50	1.0629		236.50	1.0629		
							8400.04			0.92%
Floor.										
E. Approach	355.97	252.48	1.9496 Lin. Ft. of Floor	608.45	4.698 Lin. Ft. of Floor.	46.72	655.17	5.059 Lin. Ft. of Floor		
Span I	1179.33	813.98	1.9364	1993.31	4.742	155.43	2148.74	5.111		
Span II	1179.33	797.97	1.8788	1977.30	4.655	155.43	2132.73	5.021		
Span III	1179.33	830.71	1.9530	2010.04	4.490	155.43	2165.47	5.088		
Viaduct	792.71	355.82	1.2573	1148.53	4.058	104.43	1252.96	4.428		
							8355.07			0.91%
Engineering		7095.91					7095.91			0.77%
			Lin. Ft. of total Spans.		Lin. Ft. of total Spans.				Lin. Ft. of total Spans.	
Total.	$ 32221.472	$ 64312.55	38.5686	$ 3865272.7	231.725	$ 18405.79	$ 4049330.6	242.166		44.17%

BRIEF COST REPORT—TABLE IV

APPENDIX 7
Sheet 6

CLASSIFICATION. TEMPORARY BRIDGE. WEST APPROACH.	COST, EXCLUSIVE OF FREIGHT. Material.	Labor.	LABOR. Cost per Unit.	Total.	LABOR & MATRL Cost per Unit.	Freight.	COST INCLUDING FREIGHT. Total.	TOTAL Cost per Unit.	% of total Cost of Bridge
TEMPORARY BR.	$ 2994034	$ 3118505	5.67 (Lin. ft. of Bridge Built.*)	$ 6112539	11.113 (Lin. ft. of Bridge Built.*)	$ 61854	$ 6730393	12.237 (Lin. ft. of Bridge Built.*)	
Amount charged to Permanent Bridge.							450000		
							6280393		6.85%
WEST APPROACH.	$ 2304748	1203178	9.334 Lin. Ft.	3507926	27.21 Lin. Ft.	43956 9	3947495	Lin. Ft.	4.31%
CONDENSED COST REPORT.									
SUBSTRUCTURE PERMANENT BR.	$ 1834297 8	$ 1715659 3	11.41 Cu. Yds. of Masonry	$ 3549957 1	23.60 Cu. Yds. of Masonry	$ 5441484	$ 4094105 5	27.22 Cu. Yds. of Masonry	44.67%
SUPERSTRUCTURE PERMANENT BR.	$ 3222147 2	643125 5	12.018 Ton of Steel.	3865277	72.229 Ton of Steel.	184057 9	4049330 6	75.668 Ton of Steel	44.17%
TOTAL COST	$ 5056445 0	2358784 8	14.027 Lin. ft. of Perm. Br.	7415229 8	441.041 Lin. ft. of Perm. Br.	728206 3	8143436 1	484.294 Lin. ft. of Perm. Br.	
TEMPORARY BR.	$ Proportioned 277463 5	Proportioned 288789 5	5.251 (Lin. ft. of Bridge Built.*)	566253 9	10.295 (Lin. ft. of Bridge Built.*)	61854	6280393	11.419 (Lin. ft. of Bridge Built.*)	6.85%
WEST APPROACH	$ 2304748	1203178	9.334 Lin. Ft.	3507926	27.21 Lin. Ft.	439569	3947495	30.62 Lin. Ft.	4.31%
TOTAL	$ 5564833	$ 2767892 1	18.42 Cu. Yds. of Masonry	$ 8332276	55.39 Cu. Yds. of Masonry.	$ 833948 6	$ 9166224 9	60.94 Cu. Yds. of Masonry	100.00%

*Lineal ft. of Bridge built includes all renewals, due to high water, ice, and drift.

A P P E N D I X 8.

LIST OF FIELD AND NOTE BOOKS, AND SUMMARY OF CONTENTS OF EACH.

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BOOK I.

Borings by J. F.Pinson.
Triangulation sketches and base lines.
Foundation notes for Pier I.
Profile notes for west approach.
Sand and stone track notes.

BOOK II.

Borings by J.F.Pinson.

BOOK III.

Temporary bridge notes; drawspan; notes on curve.
Samples of water taken from springs near Mobridge.
Borings and soundings at Pier I.
Soundings at Sta. 625 plus 30 to Sta. 632.
Sand and stone track notes.
Water level records.
Miscellaneous volumes.

BOOK IV.

Borings and Piers I,II and III.
Foundation notes for Pier I and east abutment.
Dimensions of icehouse and barge derrick.
Caisson notes and daily record for Pier II.
Miscellaneous volumes and water level notes.
Base line measurements and triangulation notes.

BOOK V.

Triangulation notes.
Side track and falsework for Pier III.
Stonework, forms and concrete for Pier II.
Notes on pull necessary to move caisson.
Falsework notes and notes on Pier IV.
West approach and temporary bridge.

BOOK VI.

Notes on barge levels and water line; water level notes.
Base line measurements and angles, and triangulation "
Stationing of abutments and piers.
Form lumber for Piers II and III.
Miscellaneous volumes.
Rails in foundation Pier I.
West approach.

BOOK VII:

Daily notes on caisson for Pier II.

BOOK VIII.

Notes for steel track.
Falsework.
Caisson notes for Pier III.
West approach.
Alignment of Pier II.
Bearings.
Backwall for east abutment.
Span 3.
Estimate for Piers III and IV.
Camber.

BOOK IX. Daily notes on caisson for Pier III.

BOOK X. Daily notes on Caisson for Pier III.
Setting stone for Pier III.

BOOK XI. Steel viaduct notes; traveller for steel erection.
Notes on Piers III and IV.
Falsework.
Bench mark notes.
West approach.

Pedestals for Steel Viaduct.
Willows for river protection.
Camber for Span 2.
Floor beamsfor Spans 2 and 3.
Pile Driver X-221.

BOOK XII.

West approach- pile pier.
Pedestals for steel viaduct.
Floor beams.
Falsework.
Spiral for curve.
Notes on Pier IV.
Base line measurements.
Camber.
Water level notes.
Bench mark notes.

BOOK XIII.

Daily notes for caisson for Pier IV, and record of placing concrete and setting stone.
Miscellaneous volumes.

BOOK XIV.

Borings.
Length of piles and material used in temporary bridge.

BOOKsXV and XX.

River protection work.

BOOK XVI.

Measurements of crushed stone. and granite.
Form lumber and miscellaneous volumes.

BOOK XVII.

Measurements of crushed and cutstone.

BOOK XVIII.

Alignment notes for sidings.
Dimensions of bunk houses.
Water level notes.

BOOK XIX.

Record of cement used.

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A P P E N D I X 9.

SPECIFICATIONS FOR CUT GRANITE FOR MISSOURI RIVER BRIDGE.

May, 1906.

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Material to be furnished under these specifications will consist of the cut granite face stones for that portion of the upstream nose from a little below low water level to a little above extreme high water level for four river piers for proposed bridge over the Missouri River for the Chicago, Milwaukee & St. Paul Railway Co., near Evarts, S.D.

The material is to be furnished F.O.B. cars at the quarry.

The dimensions for each course, the thickness of the several courses and the number of stones in each course shall be as indicated on detailed plans to be furnished by the Railway Company from time to time as the work progresses.

The starlings for two of the piers, Nos. I and Iv, will be battered about one-half inch per foot, and for the intermediate piers, Nos. II and III, will have a batter of 8" to the foot.

All stones must be sound, durable, free from seams, cracks and other defects which, in the judgment of the Engineer and Superintendent of Bridges & Buildings, may impair its strength or durability, and shall be of the best quality of Ortonville granite.

All stones shall be well proportioned, and shall be so arranged in each course as to form a proper bond with the stones of the course next beneath it, and in no case shall the bond be less than 15". There shall be no vertical joint closer to the nose of the pier than 2 feet.

All stones shall have their beds well dressed, so as to lay easily to a 5/8" thick joint, with their top and bottom beds parallel.

The vertical joints shall be dressed back at least 15" from the face, and at right angles to it, and the beds must be dressed to the full size of the stone. No overhang whatever will be allowed.

There shall be no depression in the bed within 6" of the edge of stone, and at no place is the depression to exceed 1/2" in bottom bed, and 1" in top bed, nor can this depression in the bottom bed amount to more than 1/4 of the area of the bed, nor more than 1/2 for the top bed.

The exposed face of all curved surfaces of the stone shall be fine pointed, with no projections exceeding 1/2" . All shoulder and nose lines shall be marked with a 1½" chisel draft, and the place surfaces back of the shoulder lines shall be rock faced, with no projections exceeding 2½".

All cutting shall be carefully and accurately done, so that the courses will build up with the surfaces true to the lines called for by the plans.

Each stone, at the point of the nose of the piers, shall have two 1¾" holes drilled entirely through it, located so as to properly dowel the stone to the underlying stones, and all other stones shall have one 1¾" hole each.

The stone is to be shipped at the Contractor's risk.

The stone will be inspected at the Contractor's cutting yard, unless the inspection is otherwise provided for with the consent of the Engineer. In any case, the Contractor shall furnish the inspector with full facilities for examination of the stone.

The right is reserved to the Engineer to reject any or all of the stone for want of conformity with these specifications, at any time previous to its being paidfor in full by the Railway Company, notwithstanding that it may have been previouslypassed upon by the inspector, and in case of such rejection, the title to the stone shall be in the contractor, and he shall be charged freight on the same on this Company's lines at regular traffic rates.

The stone will be paid for on the basis of its net cubical contents, exclusive of face projections and by taking the average superficial area of the two beds into the actual thickness of the stone.

Payments will be made monthly, on the basis of 85% for all stone furnished or cut ready for delivery during the previous calendar month, provided that the stone cut and delivered is in the order necessary to permit o continuous laying in the field.

A P P E N D I X 10.

SPECIFICATIONS FOR CUT SANDSTONE FOR MISSOURI RIVER BRIDGE. May,1906.

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Material to be furnished under these specifications will consist of the cut face stones for the sides and downstream ends, from the top of intermediate belt course to top of footing, for four river piers for proposed bridge over the Missouri River, for the Chicago, Milwaukee & St.Paul Ry.Co, near Evarts, S.D.

The upstream nose of these piers below the intermediate coping will be of granite.

The material is to be furnished F.O.B. this Company's tracks, Minneapolis.

All stone must be sound, durable, free from seams, powder or other incipient cracks, and other defects, which, in the judgment of the Engineer and Superintendent of Bridges & Buildings, may impair its strength or durability, and shall be of best quality of Kettle River sandstone.

No course of stone shall be less than 24", nor more than 28" in thickness, excepting the intermediate belting course, which will be 30" in thickness; each course shall be uniform in thickness and shall decrease in thickness from the bottom of the pier upward.

No stone shall be less than 5 feet nor more than 8' long, nor less than three, nor more than 6' wide, but in no case shall its length be less than 2½ times its thickness, nor its width less than 1½ times its thickness.

Headers at least five feet long shall be put in frequently to bond the wall, and they shall be so arranged that the headers of any course shall fall between the headers of the course next below it. There shall be at least one header to every two stretchers, and they shall at no point be less than 3/4ths their full width.

The stone in each course shall be so arranged as to form a proper bond with the stones of the course next beneath it, and in no case shall the bond be less than 15".

The Contractor shall furnish a sketch to scale of each course showing the full dimensions of each stone for approval before cutting begins, and no deviation from the approved plans will be allowed except by consent of the Engineer.

All face stones, except intermediate beltings, shall be rock faced. The edges shall be brought to lines corresponding with the finished dimensions of the masonry, and there shall be no projections beyond these lines exceeding one-eighth of the thickness of the course. No hollow faced stone will be accepted.

All stones shall have their beds well dressed, so as to lay easily to a 5/8" thick joint, with their top and bottom beds parallel to the natural quarry beds.

The vertical joints shall be dressed back at least 15" from the face and at right angles to it, and the beds must be dressed to the full size of the stone.. No overhang whatever will be allowed.

There shall be no depression in the bed within 6" of the edge of the stone, and at no place is the depression to exceed 1/2" in bottom bed, and 1" in top bed, nor can this depression in the bottom bed amount to more than 1/4 of the area of the bed, nor more than 1/2 for the top bed.

The intermediate belting is to have its beveled edge bush hammered, and is to have 1½" chisel draft around it just above the bottom edge and just below the beveled part.

The stone will be inspected at the Contractor's cutting yard, unless the inspection is otherwise provided for with the consent of the Engineer. In any case, the Contractor shall furnish the Inspector with full facilities for examination of the stone.

The stone will be paid for on the basis of its net cubical contents, exclusive of face projections, and by taking the average superficial area of the two beds into the actual thickness of the stone.

Payments will be made monthly on the basis of 85% for all stone furnished or cut ready for delivery during the previous calendar month, provide that the stone cut and delivered is in the order necessary to permit of continuous laying in the field.

The right is reserved to the Engineer to reject any or all of the stone for want of conformity with these specifications at any time previous to its being paid for in full by the Railway Company, notwithstanding that it may have been previously passed upon by the inspector, and in case of such rejection the title to the stone shall be in the Contractor and he shall be charged freight on same on this Company's lines at regular tariff rates.

The Railway Company will furnish from time to time, plans showing the dimensions of that part of courses which will be of granite, and the sandstone must be cut so as to lap the granite by at least 3".

APPENDIX 11.

SPECIFICATIONS

of

Permeable Pile Dike Work for Advancement of right bank upstream approach to bridge Over Missouri River, on C.M.&St.P.Ry Co's Coast Line Extension at Mobridge, S.D.

by
S.W.Fox, Consulting Engineer, Kansas City, Mo.

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The work herein specified contemplates the construction of a longitudinal dike and three cross dikes, located as shown on the accompanying map, marked Pl.1, and described as follows:

LONGITUDINAL DIKE: (See Pl.1., Line A-B)(Plates on file in Drawing Room.)

This structure is to consist of three rows of piles, driven to a water grade having elevation 1274.ft., at point A, Pl. 1., braced for proper transmission of stresses, provided with reinforcement or guard piles for protection against ice and drift, with a foot-mattress to prevent scour of the bed of the river around or in front of the piles, and with gratings of poles to reduce flow through the dikes to whatever extent may be found necessary or advisable to cause deposits; all in accordance with the accompanying drawing, Pl.11, and the following specifications.

PILE WORK: The piles are to be long leaf pine, driven with a Nasmyth steam hammer in three rows, the rows being 10' between centers, and the piles 10' between centers in the rows, being driven to give a diagonal system of bracing as shown on the drawing, Pl.11.

The piles in the outer row will be driven on the line A.B. All piles to be driven plumb, accurately to position, and to a minimum penetration of 25'.

BRACING: An upper and lower system of wales and double diagonal braces with filling blocks, will be attached by screw bolts to the piles, as shown on Pl.11, the upper system being put on in advance of the foot-mattress, and the lower system following closely the weaving of the mattress.

All lumber used in this work will be long leaf pine.

WIRE STRAND TIES: The upper 500' of the dike will be further strengthened with a tie at each bent made of four parts of 3/8" galvanized steel wire strand and extending from the pile in the outer row to the corresponding pile in the inner row, as shown on Pl.11. The ties will be fastened with Crosby Clips and made taut by pin-twisting, the pinbeing left in and anchored1

MATTRESS WEAVING: The foot-mattress will be of the continuous woven type, 12" thick and 85' in width, of which 55' shall lie on the stream side of the outer row of piles. The mattress will be reinforced longitudinally and transversely with 3/8" strand, as shown on the drawing. These strands will be put in under tension, so that, when the mattress is subjected to stress, the strands will take up and transmit the same. At all intersections, the longitudinal and transverse strands will be drawn together and fastened securely with U bolts, to prevent rendering in case of rupture.

The weaving of the mattress will follow closely the attaching of the upper system of bracing.

Temporary pile anchorage will be provided, as directed by the engineer in charge, to safely hold the mattress on the surface during the construction, and to guide it to position on the bottom of the river.

BALLASTING MATTRESS: The foot-mattress will be sunk to place on the bottom of the river after all bracing has been attached, using 1½ tons of one-man riprap stone on each linear foot of mattress. The greater portion of the stone will be placed on the stream side of the piles, only enough being used inside to overcome the buoyancy of the mattress.

SCREENING DIKE: The dike will be screened or curtained with a vertical grating of willow or cottonwood poles, as shown on Pl.11. A continuous curtain will be placed on the middle row, the poles being forced wellthrough the foot-mattress and securely fastened to the stream side of the wales of the upper and lower system of bracing. Cross curtains will be also attached in the same manner to alternate diagonal bents. The spacing of the curtain poles will be from 4" to 16", as directed by the engineer in charge. The engineer will also direct when and where the curtains shall be placed.

CROSS DIKES: These structures, three in number, located as shown by lines Xx, Yy, Zz, on Pl.I, are to consist of two rows of pilesdriven to the same grade as the longituddnal dike, braced for proper transmission of stresses, provided against scour with a foot-mattress, and screened to induce deposit of sediment; all in accordance with the accompanying drawing, Pl.III, and the following specifications:

PILE WORK: The piles are to be of tamarac, driven tom place with a Nasmyth steam hammer, in two rows, the rows being 10.4' between center lines, and the piles 12' between centers in the rows; the position of the piles in one row being such with reference to those in the other row as to form in plan a system of equilateral triangles.

All, piles will be driven plumb, to a minimum penetration of 16' and accurately as to position and grade at top.

BRACING: These structures will be braced with wales and diagonal braces, as shown on Pl. III.

The bracing will be attached in advance of the mattress constructior

The foot-mattress will be of the continuous woven type, 12" thick, 35' in width, of which 20' will be above the upstream row of piles. The mattress will be reinforced longituddnally and transversely with 3/8" wire strands, as shown on Pl. III.

Temporary pile anchorage will be provided, as directed by the enginee in charge, to safely hold the mattress on the water surface during construction, and to guide it to position while being sunk to the bed of the river.

BALLASTING MATTRESS: The foot-mattress will be sunk to place on the bottom of the river after all bracing has been attached, using 50 tons of native boulders on each 100 linear feet of mattress.

SCREENING DIKES:

The dikes will be screened with poles along the upstream row of piles, the poles being forced well through the mattress and fastened to the upstream side of the wales, an additional string of wales being attached for this purpose, to the upstream row of piles as close to the water surface as possible with 40 or 60d wire nails. The spacing of the poles and the time when they are to be placed will be directed by the engineer in charge.

M A T E R I A L S.

PILING: The piling for the longitudinal dike must have been cut during the current year from sound first growth trees of the variety know as long leaf yellow or southern pine. A minimum thickness of sapwood is desired, and no piling will be accepted which shows at its butt a ring of sapwood more than $2\frac{1}{2}$" thick.

All piling must be sound, free from rot, unnatural or deformed growths, ring heart, bad shakes or other defects that would lessen their strength or durability. All piling shall be peeled free from bark and the limb growth shall be trimmed off close to the trunk and smooth.

The piling must measure not less than 9" in diameter at the top, and not less than 14" nor more than 18" in diameter at the butt end, and all piling must have a gradual taper from butt to point. No piling will be accepted the center line of which departs at any point more than the diameter of the piling at that point from a straight line through the centers of the butt and point.

The piling for the cross dikes shall conform to the specifications for those used in the longitudinal dike, except that they may be of tamarac instead of long leaf pine.

All piling will be inspected at the loading point, and any and all piling not fully up to these specifications will be rejected.

All piling must be of the lengths ordered, and any piling measuring three inches or more short of a specified length will be classified as of the next shorter specified length, but no piling three inches or more shorter than the shortest specified length will be received.

LUMBER: The lumber must be yellow pine of the variety known as long leaf southern; each piece shall be 90% heart and no piece will be accepted on which the surface area of the four faces shows more than 10% of sapwood; the lumber must be sound, free from rot, bad heart, cracks, wanes or shakes and bad knots or other defects that would lessen its strength or durability; it must be well manufactured to sizes and lengths as ordered. No stick will be accepted which is two inches or more shorter than the lengths ordered or which measures 1/2" or more scant of the specified cross sectional dimension.

The lumber will be inspected at the loading point, and any lumber not fully up to these specifications will be rejected.

WILLOW BRUSH: The brush must be sound, growing willows, such as are commonly found in thickets on Missouri River bottom lands.

The brush shall average 1-3/4" in diameter at their butt ends, and shall not be more than 2½" nor less than 3/4" of an inch in diameter, except that a small percentage (about 1½% of the entire quantity) of the brush furnished may be from 1/2 to 3/4 of an inch in diameter at the butt for special use in weaving selvage edge.

No dead, deformed or worm eaten brush will be accepted and particular care must be taken to cull out all brush showing black knots or welts due to worms.

To facilitate handling, the brush shall be made up into bundles of such sizes and weight as to be readily raised and carried by one man, each bundle being securely bound near the butts and tops with No.18 annealed wire.

STONE: The stone shall be clean, sound, hard and durable stone, freshly quarried, It shall be in pieces that will average about 100 lbs. each; no piece of stone shall weigh more than 200 lbs. and none less than 10 lbs. All stone must be from strata 3" or more thick.

The stone will be inspected at the quarry or loading point, and any and all stone not fully up to these specifications will be rejected.

Galvanized wire strand: The strand must be 3/8" in diameter and composed of seven wires properly laid; each wire to be No. 11 U.S. standard gauge of the best Bessemer steel, well galvanized, and to have an ultimate tensile strength of 800 lbs. and the strand to have a breaking strength of not less than 5000 lbs.

To facilitate handling, the strand shall be wound on wooden reels, each reel containing ahout 3000 ft. of strand. The exact weight of each reel, gross and tare, shall be plainly marked on the reels.

The strand will be inspected at the point of delivery, and any strand not fully up to these specifications may be rejected.

Bolts (machine): The bolts shall be of the lengths and diameters specified, the length being measured under the head, and have standard square heads and nuts, and three inches of thread.

The material used shall be a good grade of common iron.

U Bolts: These bolts must be made in accordance with the drawing herewith, marked Plate A. The materials used shall be a good grade of common iron.

A P P E N D I X 12.

CONDITIONS OF LABOR AND STATEMENT OF WAGES.

All men were required to conform strictly to the rules which this Company made to safeguard its interests and those of its employes.

Board, bedding and bunks in the Company's camp were furnished to the men at the rate of $4.00 per week, and, when necessary, rubber boots were furnished free.

Transportation was furnished to the job, and, with the exception of the pressuremen, the men were given transportation to the point, on this Company's lines, from which they shipped, provided they had worked one month.

All pressuremen who stayed at work until the caisson was sealed, or who were obliged to quit for some reason satisfactory to the Engineer in charge, were furnished return transportation to any point on this Company's lines.

Straight time at the rate of $2.25 per day was allowed the pressuremen while travelling to the bridge site, provided they worked on the job not less than three weeks.

Scale of wages, per day of ten hours, unless otherwise noted:

Stationary Engineers	$2.50 to	$3.75	per day of 12 hrs
Firemen	2.00 "	2.50	" " "
Pipe Fitters	3.00		" " "
Electricians	2.50 "	2.75	
Machinist	4.00		
Blacksmith	3.00 "	3.25	
Bridge Carpenters	2.50 "	2.75	
Carpenters	2.25 "	3.25	
Stone Masons	3.50		
Concrete Facers	2.50		
Concrete Machine Men	2.50		" " "
Concrete Men	2.25 "	2.50	
Cement Men	2.25 "	2.50	
Steel Erection Men	4.00		
Riggers	2.75 "	3.50	
Rivet Tenders	2.50		
Weavers	2.50		
Caulkers	2.50 "	3.50	
Painters	2.50 "	2.75	
Lock Tenders	2.75		
Watchmen	2.25		" " "
Laborers	2.00 "	2.25	
Steel Erection Foremen	4.50		
Bridge Carpenter Foremen	3.00 "	3.25	
Carpenter Foremen	2.75 "	3.50	
Concrete "	2.75 "	3.25	
Rigger "	3.50		
Caulker "	3.50		
Weaver "	3.00		
Pile driver Foremen	3.00 "	3.25	
Labor Foremen	2.50 "	3.00	

Time and one-half was allowed for overtime and Sundays.

The following rates were paid the pressuremen:

First 50'	below water surface,	8-hr.dy,	$3.00,	4-hr.shifts,
50' to 65'	" "	6-hr.dy.	3.25,	3-hr. "
65' to 75'	" "	4-hr.dy.	3.50,	2-hr. "
75' to 85'	" "	3-hr.dy.	3.75,	1½ hr "
85' to 95'	" "	2-hr.dy.	4.00,	1 hr. "

The Pressure Gang Foremen received $1.00 per day more than the pressure men.

For inside concrete work, sealing the caissons, the men on the inside received 25 cents per day extra. All Sunday work was figured straigh time, no extra time being allowed.

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LIST OF BUILDINGS ERECTED.

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Bunk House #1,	24'x48', gable roof, inside walls ceiled, quarters for men.
" #4,	24'x64', with wing 24'x36', gable roof, inside walls ceiled, quarters for men.
" #2,&5,	24'x72' each, gable roof, inside walls ceiled, quarters for men.
Cook house and Dining hall,	24'x130'-8", wing 48'x34'.
Washroom,	16'x24', inside walls and ceiling ceiled.
Water tank and house,	2 tanks 10'x12', house 12'x24', shed roof, camp water supply.
Roothouse,	16'x28', for storing vegetables.
Carpenter and blacksmith shop,	13'x40'6", shed roof.
Engineer's Office,	20'x32', gable roof, insidewalls and ceiling ceiled.
Engineer's dwelling,	20'x32', gable roof, inside walls ceiled.
Rope house	12'x12', shed roof.
Tool house	14'x16', "
Nail house	20'x20', "
Cold storage and Ice House,	40'x52'.
Dynamo House,	14'6"x18'6", shed roof, electric lighting plant for camp and caisson work.
Hospital	16'x24', gable roof.
Cement house,	20'x120', shed roof.
" chute,	14'x16'3".
Sand chute,	14'x24'4".
Stone chute,	14'x30'.
Heating plant building,	14'x30'6", gable roof, boiler and tank house for heating sand and stone.

Standard cement houses - used to store material.

The track arrangement is shown on the plan of the Missouri River Bridge Crossing, Plate I. This plan also shows the tracks toward the river, which were to the material yard.

The location of the temporary line from the main line across the temporary bridge ran at the foot of a steep bank, and on this bank were built the sand, stone and cement bins. The tops of the sand and stone bins were about level with the top of a gondola car, and sand and stone was unloaded from the cars directly into the bins or the storage pile, as occasion necessitated. Material for timber trestle and protection work was stored on the west side of the river.

LIST OF MACHINERY AND EQUIPMENT.

--O--

2	150 H.P. standard heating boilers, used on machinery barge and caisson work.
1	60 " locomotive heating boiler, used for heating sand and stone in bins.
2	30 " Lidgerwood engines, steel erection.
1	30 " American hoist engine, steel erection.
1	32 " Mundy engine, steel erection.
1	30 " Lidgerwood engine, used on traveller for laying floor in first temporary bridge and also on the scow driver, for driving piles.
1	35 " " " used with steam hammer.
1	25 " Hoisting " double drum, used on scow derrick.
1	15 " " " used for pumping.
1	10 " American hoist rev. engine, used for hoisting concrete.
1	25 " Hoisting engine, fixed on a push car to act as a dinky engine, but not used.
1	Hayward clam shell bucket, 1½ cu.yd. capacity, used on travelling crane to unload crushed stone and sand.
1	" " " 1 cu.yd. capacity(same purpose as above
1	Orange peel bucket, 1 " ", excavation Pier IV.
1	Cyclopean drop bottom bucket, 1 cu.yd. capacity, used to handle concrete from mixer to caisson.
1	8" Morse horizontal belt driven pump, cofferdams at Pier I, and ppdestal piers.
1	8" Vertical belt driven pump, same as above and Pier Iv.
3	#3 Edsom diaphragm pumps, pumping out barges and for smaller work.
2	#22 Chicago Improved cube concrete mixers, with elevating hopper.
2	Guy derricks, with hand slewing device, used for setting stone masonry on Piers I and IV.
6	Wells lights, used whenever night work was required.
2	Ransom concrete hoisting buckets, 20 and 30 cu.ft. capacity, used in concrete elevators.
1	16-12-9 duplex fire pump.
2	16-18-18¼ Ingersoll-Sargent Class "A" straight line steam air compressors, used on machinery barge for caisson work.
1	48" diameter by 24 ft. air receiver, storage tank for painters' sand blast.
1	Attachment for Lidgerwood engine for operating pump.
1	3" Fisher steamp pump governor, steam pressure 100# to 150#, hydraulic, 50# to 125#.
1	220 volt,8 K.W. capacity, belt driven, moderate speed, direct current dynamo, used in electric lighting plant for camp and caissons.
1	15 H.P. gasoline engine, to run dynamo.
36	2½"x24" jack screws, used to lower caisson and for miscellaneous work.
1	Bridge traveller, for steel erection.
1	25' motor boat, used for recovering material and for transferring laboring men to and from work on west side when temporary bridge was out of commission.
4	1-16' and 3-20' row boats, used for transferring men and material.
2	boiler feed pumps.
2	#9 Sellars injectors.
24	Sterling wheelbarrows.
100	pieces, 35# U.S. Steel sheet piling, 18' long, used for cofferdams Pier I.
1	Little Giant boring machine, used for drilling holes in falsework and timber trestle timbers.
8	Boyer long stroke riveting hammers.
1	83# Prentice vise (combined) used in blacksmith shop.
1	set of ice cutting tools.
2	Plain engineers' transits.
2	" " wye levels.
5	iron oil barrels, storing gasoline.
2	Blacksmith forges and outfits.

4800' sq.ft. of S.H. sail cloth- for covering concrete during freez-
weather.
1 steam hammer, used to drive piles in pedestal piers and protection, and Wakefield Steel Sheet Piling at Pier Iv.
1 Float drive drop hammer.
1 Edson jet pump (2-man)
1 5 H.P. combined gasoline engine and pump, used for pumping water for camp supply,to engine tanks and to standard 24x16 water tank on the east side of the river.
1 Air compressor car, used for riveting and boring tools.
1 10-ton locomotive crane, used for all classes of work, part of which is as follows: dinky engine, loading and unloading all classes of material, tearing up temporary bridge, lifting large trees over temporary bridge when trying to keep bridge clear from drift, switch engine.

6 18" guage Petteler dump cars, used to convey riprap to mattress.
24 Standard gauge push cars.

2 Track drivers, X-221, X-225, used on temporary bridge and falsework piles.
4 Derrick cars; X-1, used for erecting steel; also timber bents for falsework and pulling falsework piles.
X-13, used for erecting steel; Strobel #2, used for erecting steel; CM&STP 28867, used for timber trestle erection work, west approach.

The FLOATING EQUIPMENT consisted of the following:

1 Ferry boat, "J.H.Keene," 300 tons displacement.
1 Ferry boat, "Winnie" 275 "
These boats were the property of the Chamberlain Investment Co., of Chamberlain, S.D., and were rented by the day for use at the bridge site and Evarts, S.D.

2 10'x48' barges)
16 10'x40' ") made and shipped from Tomah Shops.

4 20'x40' " constructed at Evarts, S.D.

These barges were fitted up for use as occasion demanded;-scow pile drivers, barge derrick, pile pulling and mattress barge, and were used as follows:

Scow pile drivers, driving piles for temporary bridge; protection work along the west shore; piles for falsework under the three main spans; piles for protected work and platform around Piers II and III.

Barge derrick, used for handling concrete from mixers to caissons; for handling the stone used in masonry; for handling entrance and material shafts and all of the heavy work at Piers II,III&IV

Pile puller, was rigged up on one barge and successfully used for pulling a few piles in the temporary bridge.

Mattress barge, was used toweave mattress for the dike foundation.

Besides these uses, the barges were used for towing material from Evarts to the bridge site; for temporary bridge and buildings erected before the track was laid, and for towing willows from Ft. Yates to the bridge site.

The machinery barge consisted of four 20'x48" barges, which were spliced together, making the combined size, 40'x80'. The machinery barge house, 32'x60', with gable roof, was built on this barge, and contained a compressor room, boiler room and coal locker, pressure men's room and workroom. The pressure room contained the air compressors and Smedley fire pump. The boiler room contained two 150 H.P. boilers and coal lockers. The compressors, pumps and boilers were used during the lowering of the caissons at Piers II,III and IV. The pressure men's room, having lockers, wash troughs, table and benches, was used by the pressure men as a dressing and lunchroom, and was kept at a temperature of about 85 degrees Fahrenheit by steam pipes from the boilers. The workroom contained a bench for pipe cutting and machine work.

The entire barge was moved and anchored behind Piers II and III during the sinking of the caissons, but at Pier IV, on account of the shallow water in that vicinity, the barge was left at Pier III, and the air, water and steam piped to the caisson at Pier Iv.

As far as the machinery and equipment could be spared, it was shipped either to the shops for repairs, or to points where it was needed on the Extension and old lines, and for all shipments made, proper credit was allowed to the bridge.

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Addendum 14.

SPECIFICATIONS
FOR
STEEL BRIDGE WORK

BRIDGE AND BUILDING DEPARTMENT

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY CO.

GENERAL.

The following specifications conform to the "General Specifications for Steel Railroad Bridges," as approved by the American Railway Engineering and Maintenance of Way Association, March 1906, except for certain modifications to which attention is called by foot notes; the same numbering of paragraphs is followed for convenience of reference, and some marginal references are omitted.

All bridge work shall be furnished by the manufacturer in accordance with detail shop plans to be made by the Engineer and Superintendent of Bridges and Buildings of the Chicago, Milwaukee & St. Paul Railway Company, and a sufficient number of blue print copies of these plans will be furnished the manufacturer for his use.

The shop plans shall be changed, or corrected by the manufacturer as the purchaser may direct, as occasion requires.

The bridge work to be furnished under these specifications shall be delivered to the purchaser F. O. B. cars on its tracks nearest the works where manufactured.

Payment will be made within thirty (30) days after each bridge shall have been completely manufactured and delivered, in all respects to the satisfaction of the Engineer and Superintendent of Bridges and Buildings of the Chicago, Milwaukee & St. Paul Railway Company.

The expressions, Purchaser and Railway Company, Engineer, Inspector, and Manufacturer, used in these specifications, are held to mean, respectively, the Chicago, Milwaukee & St. Paul Railway Company, the Engineer and Superintendent of Bridges and Buildings of said railway, the Inspector appointed by said Engineer, and the individual, firm or corporation furnishing the finished material.

MATERIAL.

Steel.

83. Steel shall be made by the open-hearth process.

84. The chemical and physical properties shall conform to the following limits:

Elements Considered.	Structural Steel.	Rivet Steel.	Steel Castings.
Phosphorus, maximum.. { Basic..	0.04 per cent.	0.04 per cent.	0.05 per cent.
Phosphorus, maximum.. { Acid .	0.06 "	0.04 "	0.06 " (a)
Sulphur, maximum	0.05 "	0.04 "	0.05 "
Ultimate tensile strength.	Desired	Desired	Not less than
Pounds, per square inch	63,000 (b)	50,000	65,000
Elong., min. in 8", Fig. 1	1,500,000 *	1,500,000	15 per cent.
" " " 2", " 2	Ult. tensile strength / 22	Ult. tensile strength	
Character of Fracture	Silky	Silky	Silky or fine granular
Cold Bends without Fracture	180° flat †	180° flat ‡	90° $d = 3t$.

* See paragraph 93. † See paragraphs 94, 95 and 96. ‡ See paragraph 97. (a) Changed from 0.08. (b) Changed from 60,000.

The yield point, as indicated by the drop of beam, shall be recorded in the test reports.

Allowable Variations.

85. If the ultimate strength varies more than 4,000 lbs. from that desired, a re-test shall be made on the same gauge, which, to be acceptable, shall be within 5,000 lbs. of the desired ultimate.

Chemical Analyses.

86. Chemical determinations of the percentages of carbon, phosphorus, sulphur and manganese shall be made by the manufacturer from a test ingot taken at the time of the pouring of each melt of steel, and a correct copy of such analysis shall be furnished to the engineer or his inspector. Check analyses shall be made from finished material, if called for by the purchaser, in which case an excess of 25 per cent. above the required limits will be allowed.

Form of Specimens.

87. PLATES, SHAPES AND BARS: Specimens for tensile and bending tests for plates, shapes and bars shall be made by cutting coupons from the finished product, which shall have both faces rolled and both edges milled to the form shown by Fig. 1; or with both edges parallel; or they may be turned to a diameter of $\frac{3}{4}$-in. for a length of at least 9 in., with enlarged ends.

88. RIVETS: Rivet rods shall be tested as rolled.

89. PINS AND ROLLERS: Specimens shall be cut from the finished rolled or forged bar, in such manner that the center of the specimen shall be one inch from the surface of the bar. The specimen for tensile test shall be turned to the form shown by Fig. 2. The specimen for bending test shall be one inch by $\frac{1}{2}$-in. in section.

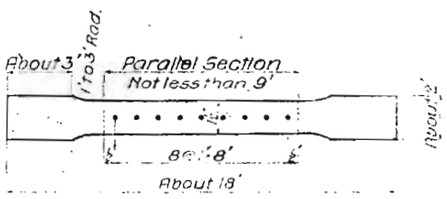


FIG. 1.

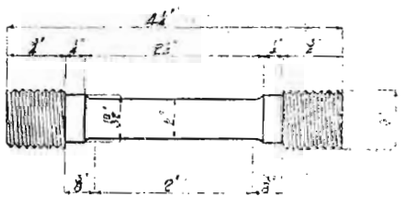


FIG. 2.

90. STEEL CASTINGS: The number of tests will depend on the character and importance of the castings. Specimens shall be cut cold from coupons moulded and cast on some portion of one or more castings from each melt or from the sink heads, if the heads are of sufficient size. The coupon or sink head, so used, shall be annealed with the casting before it is cut off. Test specimens to be of the form prescribed for pins and rollers.

Annealed Specimens.

91. Material which is to be used without annealing or further treatment shall be tested in the condition in which it comes from the rolls. When material is to be annealed, or otherwise treated before use, the specimens for tensile tests representing such material shall be cut from properly annealed or similarly treated short lengths of the full section of the bar.

Number of Tests.

92. At least one tensile and one bending test shall be made from each melt of steel as rolled. In case steel differing $\frac{3}{8}$-in. and more in thickness is rolled from one melt, a test shall be made from the thickest and thinnest material rolled.

Modifications in Elongation.

93. For material less than $\frac{5}{16}$-in. and more than $\frac{3}{4}$-in. in thickness the following modifications will be allowed in the requirements for elongation:

(a) For each $\frac{1}{16}$-in. in thickness below $\frac{5}{16}$-in., a deduction of $2\frac{1}{2}$ will be allowed from the specified percentage.

(b) For each $\frac{1}{8}$-in. in thickness above $\frac{3}{4}$-in., a deduction of 1 will be allowed from the specified percentage.

Bending Tests.

94. Bending tests may be made by pressure or by blows. Plates, shapes and bars less than one inch thick shall bend as called for in paragraph 84.

95. Full-sized material for eye-bars and other steel one inch thick and over, tested as rolled, shall bend cold 180 degrees around a pin, the diameter of which is equal to twice the thickness of the bar, without fracture on the outside of bend.

96. Angles $\frac{3}{4}$-in. and less in thickness shall open flat, and angles $\frac{1}{2}$-in. and less in thickness shall bend shut, cold, under blows of a hammer, without sign of fracture. This test will be made only when required by the inspector.

97. Rivet steel, when nicked and bent around a bar of the same diameter as the rivet rod, shall give a gradual break and a fine, silky uniform fracture.

Finish.

98. Finished material shall be free from injurious seams, flaws, cracks, defective edges or other defects, and have a smooth, uniform and workman-like finish. Plates 36 in. in width and under shall have rolled edges.

Stamping.

99. Every finished piece of steel shall have the melt number and the name of the manufacturer stamped or rolled upon it. Steel for pins and rollers shall be stamped on the end. Rivet and lattice steel and other small parts may be bundled with the above marks on an attached metal tag.

Defective Material.

100. Material which, subsequent to the above tests at the mills, and its acceptance there, develops weak spots, brittleness, cracks or other imperfections, or is found to have injurious defects, will be rejected at the shop and shall be replaced by the manufacturer at his own cost.

Allowable Variation in Weight.

101. A variation in cross-section or weight of each piece of steel of more than $2\frac{1}{2}$ per cent. from that specified will be sufficient cause for rejection, except in case of sheared plates, which will be covered by the following permissible variations, which are to apply to single plates:

102. Plates $12\frac{1}{2}$ lbs. per sq. ft. or heavier:

(a) Up to 100 in. wide, $2\frac{1}{2}$ per cent. above or below the prescribed weight.

(b) One hundred inches wide and over, 5 per cent. above or below.

103. Plates under $12\frac{1}{2}$ lbs. per sq. ft.:

(a) Up to 75 in. wide, $2\frac{1}{2}$ per cent. above or below.

(b) Seventy-five inches and up to 100 in. wide, 5 per cent. above or 3 per cent. below.

(c) One hundred inches wide and over, 10 per cent. above or 3 per cent. below.

104. Plates will be accepted if they measure not more than 0.01 in. below the ordered thickness.

105. An excess over the nominal weight, corresponding to the dimensions on the order, will be allowed for each plate, if not more than that shown in the following table, one cubic in. of rolled steel being assumed to weigh 0.2833 lb.:

Thickness Ordered.	Nominal Weights.	Width of Plate			
		Up to 75"	75" and up to 100"	100" and up to 115"	Over 115"
¼-inch.	10.20 lbs.	10 per cent.	14 per cent.	18 per cent.	--
$\frac{5}{16}$ "	12.75 "	8 "	12 "	16 "	--
⅜ "	15.30 "	7 "	10 "	13 "	17 per cent.
$\frac{7}{16}$ "	17.85 "	6 "	8 "	10 "	13 "
½ "	20.40 "	5 "	7 "	9 "	12 "
$\frac{9}{16}$ "	22.95 "	4½ "	6½ "	8½ "	11 "
⅝ "	25.50 "	4 "	6 "	8 "	10 "
Over ⅝ "	---- ----	3½ "	5 "	6½ "	9 "

SPECIAL METALS.

Cast Iron.

106. Except where chilled iron is specified, castings shall be made of tough gray iron, with sulphur not over 0.10 per cent. They shall be true to pattern, out of wind and free from flaws and excessive shrinkage. If tests are demanded, they shall be made on the "Arbitration Bar" of the American Society for Testing Materials, which is a round bar $1\frac{1}{4}$ in. diameter and 15 in. long. The transverse test shall be made on a supported length of 12 in. with load at middle. The minimum breaking load so applied shall be 2,900 lbs., with a deflection of at least $\frac{1}{10}$-in. before rupture.

Wrought Iron.

107. Wrought iron shall be double-rolled, tough, fibrous and uniform in character. It shall be thoroughly welded in rolling and be free from surface defects. When tested in specimens of the form of Fig. 1, or in full sized pieces of the same length, it shall show an ultimate strength of at least 50,000 lbs. per sq. in., an elongation of at least 18 per cent. in 8 in., with fracture wholly fibrous. Specimens shall bend cold, with the fiber, through 135 degrees, without sign of fracture, around a pin the diameter of which is not over twice the thickness of the piece tested. When nicked and bent, the fracture shall show at least 90 per cent. fibrous.

INSPECTION AND TESTING AT THE MILLS.

Copies of Mill Orders.

108. The purchaser shall be furnished complete copies of mill orders, and no material shall be rolled, nor work done, before the purchaser has been notified where the orders have been placed, so that he may arrange for the inspection.

Facilities for Inspection.

109. The manufacturer shall furnish all facilities for inspecting and testing the weight and quality of all material at the mill where it is manufactured. He shall furnish a suitable testing machine for testing the specimens, as well as prepare the pieces for the machine, free of cost.

110. When an inspector is furnished by the purchaser to inspect material at the mills, he shall have full access, at all times, to all parts of mills where material to be inspected by him is being manufactured.

SHOP MANUFACTURE.

111. The workmanship and finish shall be equal to the best practice in modern bridge works. All material arriving from the mills shall be protected from rust by being stored under cover, or being oiled, and shall have clean surfaces, free from heavy scale or rust, before being worked on in the shops. (*a*).

Straightening Material.

112. Material shall be thoroughly straightened in the shop, by methods that will not injure it, before being laid off or worked in any way. Templets shall be laid flat without distortion while work is being laid out. (*b*).

Finish.

113. Shearing and chipping shall be neatly and accurately done and all portions of the work exposed to view neatly finished. (*d*)

Size of Rivets.

114. The size of rivets, called for on the plans, shall be understood to mean the actual size of the cold rivet before heating.

Rivet Holes.

All parts of the structure shall have sub-punched and reamed rivet holes, except lateral, portal, sway and stringer bracing, batten plates and lacing of members having the lacing connected with one rivet. (*c*).

Punching.

115. Where reaming is not required the diameter of the punch shall not be more than $\frac{1}{16}$-in. greater than the diameter of the rivet; nor the diameter of the die more than $\frac{1}{8}$-in. greater than the diameter of the punch. (*d*).

(*a*) Modified and enlarged. (*b*) Modified by additional clause. (*c*) New paragraph. (*d*) Modified.

116. All punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be cause for rejection. Sub-punching for reamed work shall be so accurately done that after reaming no punched surface shall appear in the periphery of the hole. (*c*)

Sub-punching and Reaming.

117. Where reaming is required, the punch used shall have a diameter not less than $\frac{3}{16}$-in. smaller than the nominal diameter of the rivet. Holes shall then be reamed to a diameter not more than $\frac{1}{16}$-in. larger than the nominal diameter of the rivet. All reaming shall be done with twist drills, held at right angles to the surface. (See 132) (*d*).

118. When general reaming is required it shall be done after the pieces forming one built member are assembled and so firmly bolted together that the surface shall be in close contact. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be allowed. (*e*).

Edge Planing.

119. Sheared edges or ends will generally not be required to be planed. (*f*).

Burrs.

120. The outside burrs on reamed holes shall be removed to the extent of making a $\frac{1}{16}$-in. fillet. (*g*).

Assembling.

121. Riveted members shall have all parts well pinned up and firmly drawn together with bolts, before riveting is commenced. Contact surfaces to be painted. (See 149).

Lattice Bars.

122. Lattice bars shall have neatly rounded ends, unless otherwise called for.

Stiffeners.

123. Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

Splice Plates and Fillers.

124. Web splice plates and fillers under stiffeners shall be cut to fit within $\frac{1}{8}$-in. of flange angles.

Web Plates.

125. Web plates of girders, which have no cover plates, shall be flush with the backs of angles or project above the same not more than $\frac{1}{8}$-in., or as otherwise called for. When web plates are spliced, not more than $\frac{1}{4}$-in. clearance between ends of plates will be allowed.

126. Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder. They shall be milled to exact lengths after being riveted up complete. The removal of more than $\frac{5}{32}$ inches from thickness will be cause for rejection, and the cutting shall extend over the entire face of the connection. (*g*)

Riveting.

127. Rivets shall be driven by pressure tools wherever possible. Pneumatic hammers shall be used in preference to hand driving.

128. Rivets shall look neat and finished, with heads of approved shape, full and of equal size, and shall completely fill the holes. They shall be central on shank and grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary, they shall be drilled out.

Turned Bolts.

129. Wherever bolts are used in place of rivets which transmit shear, the holes shall be reamed parallel and the bolts turned to a driving fit. A washer not less than $\frac{1}{4}$-in. thick shall be used under nut.

Members to be Straight.

130. The several pieces forming one built member shall be straight and fit closely together, and finished members shall be free from twists, bends or open joints.

Finished Joints.

131. Abutting joints shall be cut or dressed true and straight and fitted close together,

(*c*) Last sentence added. (*d*) Last clause added. (*e*) Modified. (*f*) Modified. (*g*) Modified.

especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to have even bearings after they are riveted up complete and when perfectly aligned.

Field Connections.

132. Holes for floor beam and stringer connections shall be sub-punched and reamed according to paragraph 117, to a steel templet one inch thick. All other field connections, except those for laterals and sway bracing, shall be assembled in the shop and the unfair holes reamed; and when so reamed, the pieces shall be match-marked before being taken apart.

Eye-Bars.

133. Eye-bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by upsetting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye-bars are made, if satisfactory to the engineer, and the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of head and neck shall not vary more than $\frac{1}{32}$-in. from that specified. (Sec 160.)

134. Before boring, each eye-bar shall be properly annealed and carefully straightened. Pin-holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins $\frac{1}{32}$-in. smaller in diameter than the pin-holes can be passed through the holes at both ends of the bars at the same time without forcing.

Pin-Holes.

135. Pin-holes shall be bored true to gauges, smooth and straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

136. The distance center to center of pin-holes shall be correct within $\frac{1}{32}$-in., and the diameter of the holes not more than $\frac{1}{50}$-in. larger than that of the pin, for pins up to 5-in. diameter, and $\frac{1}{32}$-in. for larger pins.

Pins and Rollers.

137. Pins and rollers shall be accurately turned to gauges and shall be straight and smooth and entirely free from flaws.

Screw Threads.

138. Screw threads shall make tight fits in the nuts and shall be U. S. standard, except for 1$\frac{1}{8}$-in. diameter and larger when they shall be made with six threads per inch. Upset ends shall have an excess net section at root of threads of 15 per cent. over that of body of bar. (*a*)

Annealing.

139. Steel, except in minor details, which has been partially heated, shall be properly annealed.

140. All steel castings shall be annealed. They shall be free from large or injurious blow holes. (*b*)

Welds.

141. Welds in steel will not be allowed.

Bed Plates.

142. Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed top and bottom. The cut of the planing tool shall make a fine cut corresponding with the direction of expansion. All expansion bearings shall be assembled complete in the shop. (*a*)

Pilot Nuts.

143. Pilot and driving nuts shall be furnished for each size of pin, in such numbers as may be ordered.

Field Rivets.

144. Field rivets shall be furnished to the amount of 15 per cent. plus ten rivets in excess of the nominal number required for each size.

Shipping Details.

145. Pins, nuts, bolts, rivets and other small details shall be boxed or crated.

Weight.

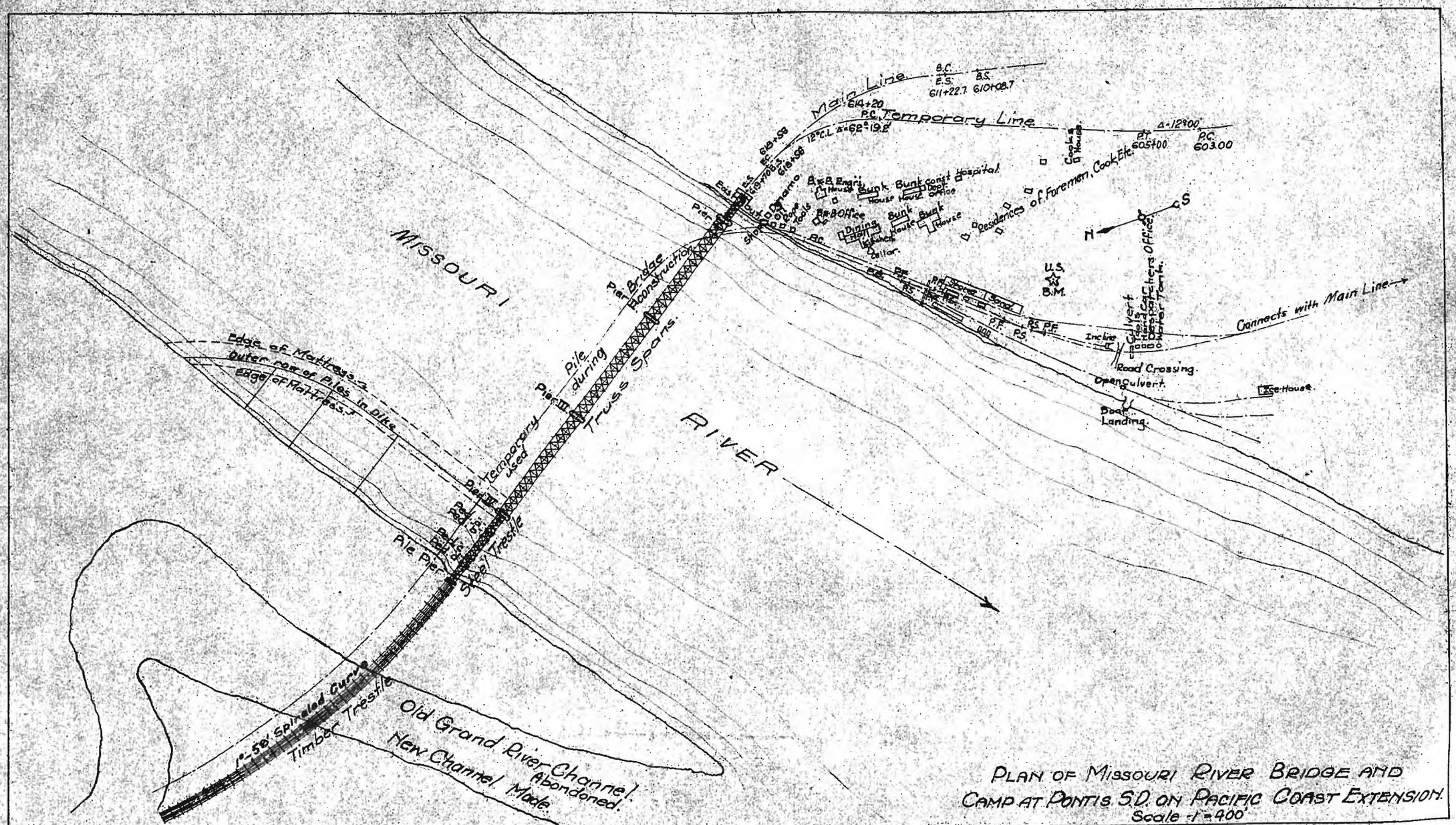
146. The scale weight of every piece and box shall be marked on it in plain figures.

(*a*) Modified. (*b*) Last sentence added.

TESTS OF STEEL EYE-BARS.

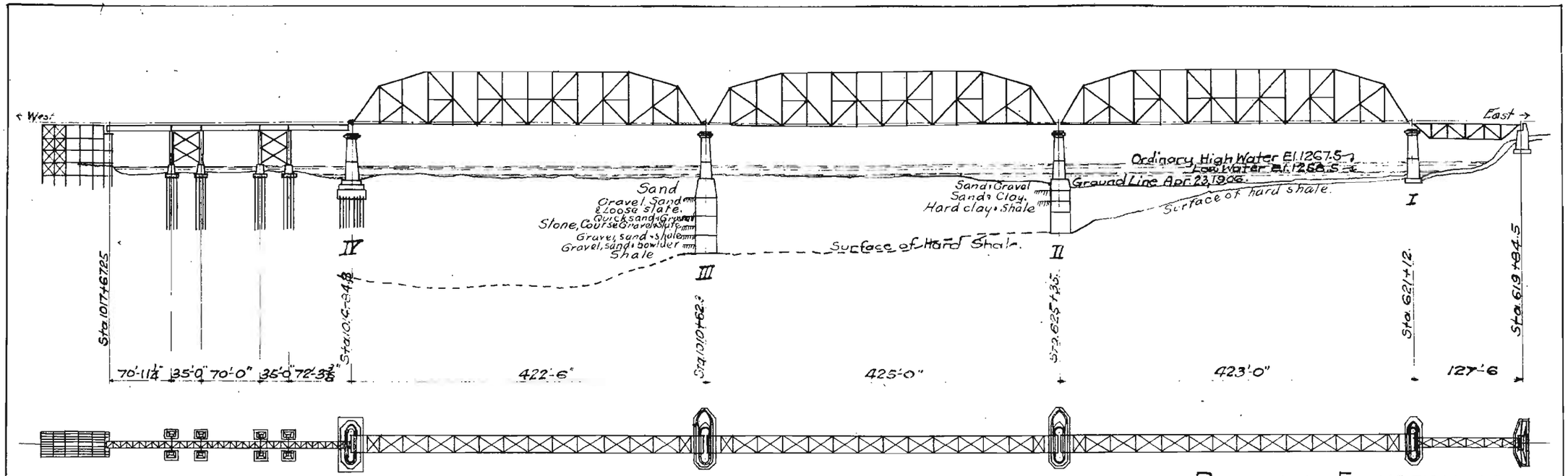
APPENDIX-15

	Mark of Bar	Nominal Size	FULL SIZED EYE-BAR TESTS. Elastic Limit Pounds per Sq inch	Ultimate Strength Pounds per Sq inch	Elongation 10 ft. Per cent	Elongation 12 in. Per cent	Reduction of Area Per cent	SPECIMAN TESTS. Elastic Limit Per Sq. in	Ultimate Strength Per Sq. in	Elongation Per ct.	Reduction of Area Per ct.	Chemical Analysis Carbon	Phosphorus.	Manganese	Sulphur	Kind	Remarks
1	U-1-M-2	16"x2 5/16"	27.720	54620	17.8	41.0	51.2	34760	64360	26.00	50.30	.27	.008	.51	.040	Hearth	
2	U-1-M-2	16"x2 5/16"	28570	54800	25.3	52.0	41.6	35700	66820	25.50	53.00	.29	.011	.55	.037		Granular Tensile test made
3	L-3-L-4	14"x1 3/4"	29.390	58770	14.9	37.0	44.6	34290	63900	26.50	52.10	.27	.008	.37	.040		Same heat as #1
4	L-4-L-5	14"x1 1/2"	32.290	62840	16.2	29.0	27.6	35580	60220	27.50	51.10	.29	.014	.57	.047		Granular break See test-727-5
5	L-4-L-5	14"x1 1/2"	27510	56620	22.2	39.0	46.4	"	"	"	"	"	"	"	"		
6	L-4-L-5	14"x1 1/2"	29290	62140	15.9	40.0	42.7	"	"	"	"	"	"	"	"		
7	L-4-L-5	14"x1 1/2"	28570	57860	17.9	45.0	47.6	36910	63420	26.00	50.80	.26	.015	.48	.038		
8	L-5-L-6	14"x2 5/16"	29370	62070	19.2	38.0	35.5	35090	61420	27.00	56.40	.28	.033	.57	.040		
9	L-5-L-6	14"x2 5/16"	26030	54150	21.2	46.0	49.3	33080	60240	27.00	50.20	.26	.008	.49	.039		
10	L-6-L-7	14"x2"	31290	56870	17.8	39.0	40.4	35270	60500	27.50	50.20	.30	.009	.47	.045	Open	
11	L-6-L-7	14"x2"	32140	66430	3.2	4.0	3.11	34880	62300	26.00	60.50	.39	.028	.61	.024		Bars of this heat field for examination
12	L-6-L-7	14"x2"	26250	56140	23.9	48.0	45.5	"	"	"	"	"	"	"	"		Same as heat #11
13	L-6-L-7	14"x2"	29520	52480				35800	62620	26.50	54.70	.30	.037	.46	.040	Basic	Flow in head Reannealed
14	L-6-L-7	14"x2"	32140	64820	6.0	6.0	5.8	34880	62300	26.00	60.50	.39	.028	.61	.024		Some bars as #11 above, reannealed
15	L-6-L-7	14"x2"	29520	56850	19.9	43.0	37.5	35800	62630	26.50	54.70	.30	.037	.46	.040		Some bars as #13 reannealed
16	L-6-L-7	14"x2"	31290	63000	15.7	42.0	44.6	36800	66230	25.50	52.00	.38	.007	.35	.030		

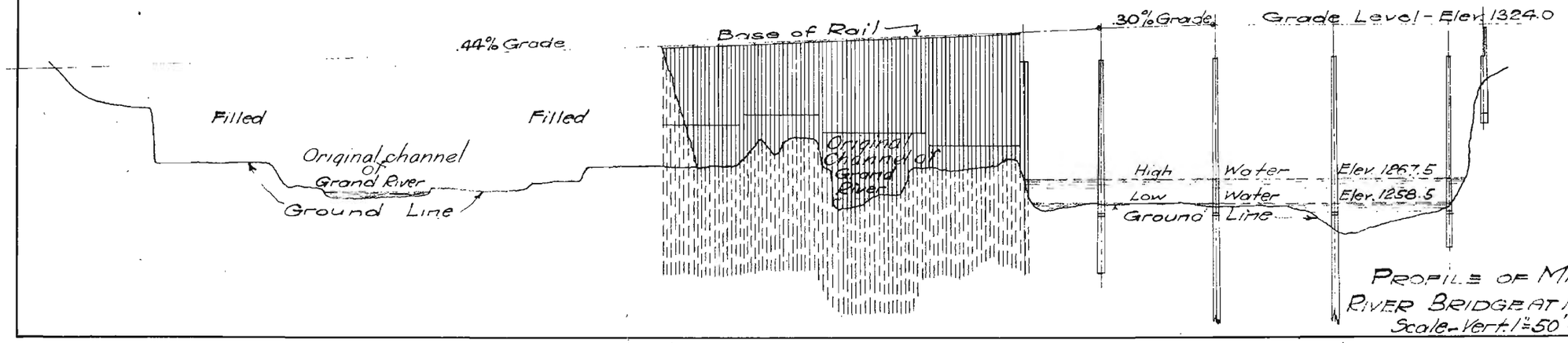


PLAN OF MISSOURI RIVER BRIDGE AND CAMP AT PONTIS S.D. ON PACIFIC COAST EXTENSION.
Scale - 1 - 400'

PLATE II

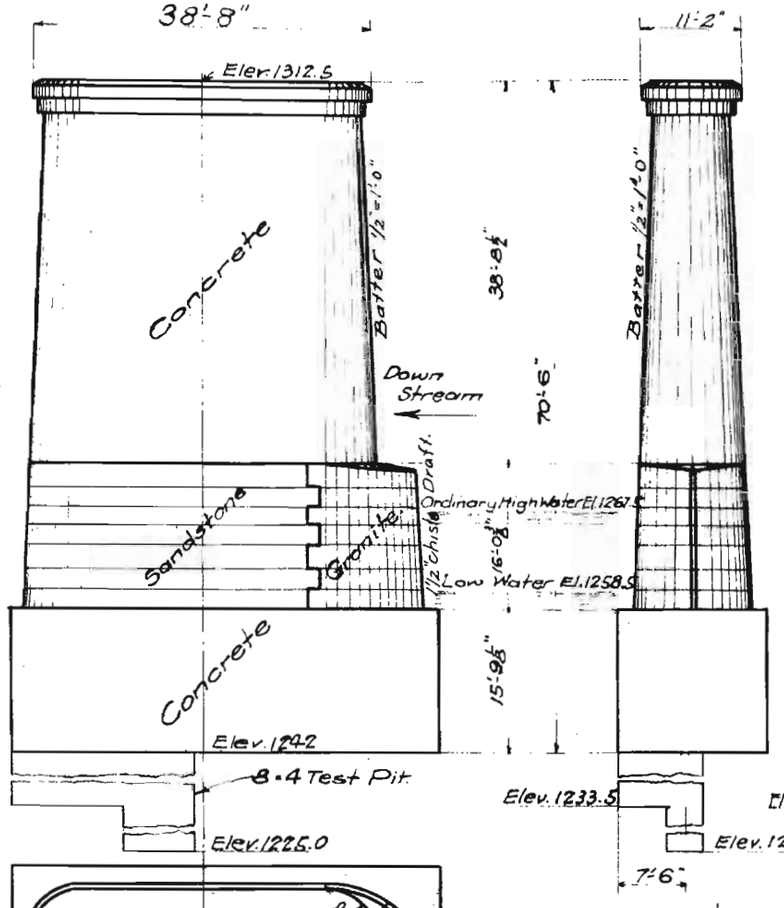


PLAN AND ELEVATION OF MISSOURI RIVER BRIDGE AT MOBRIDGE S.D.
Scale 1"=150'

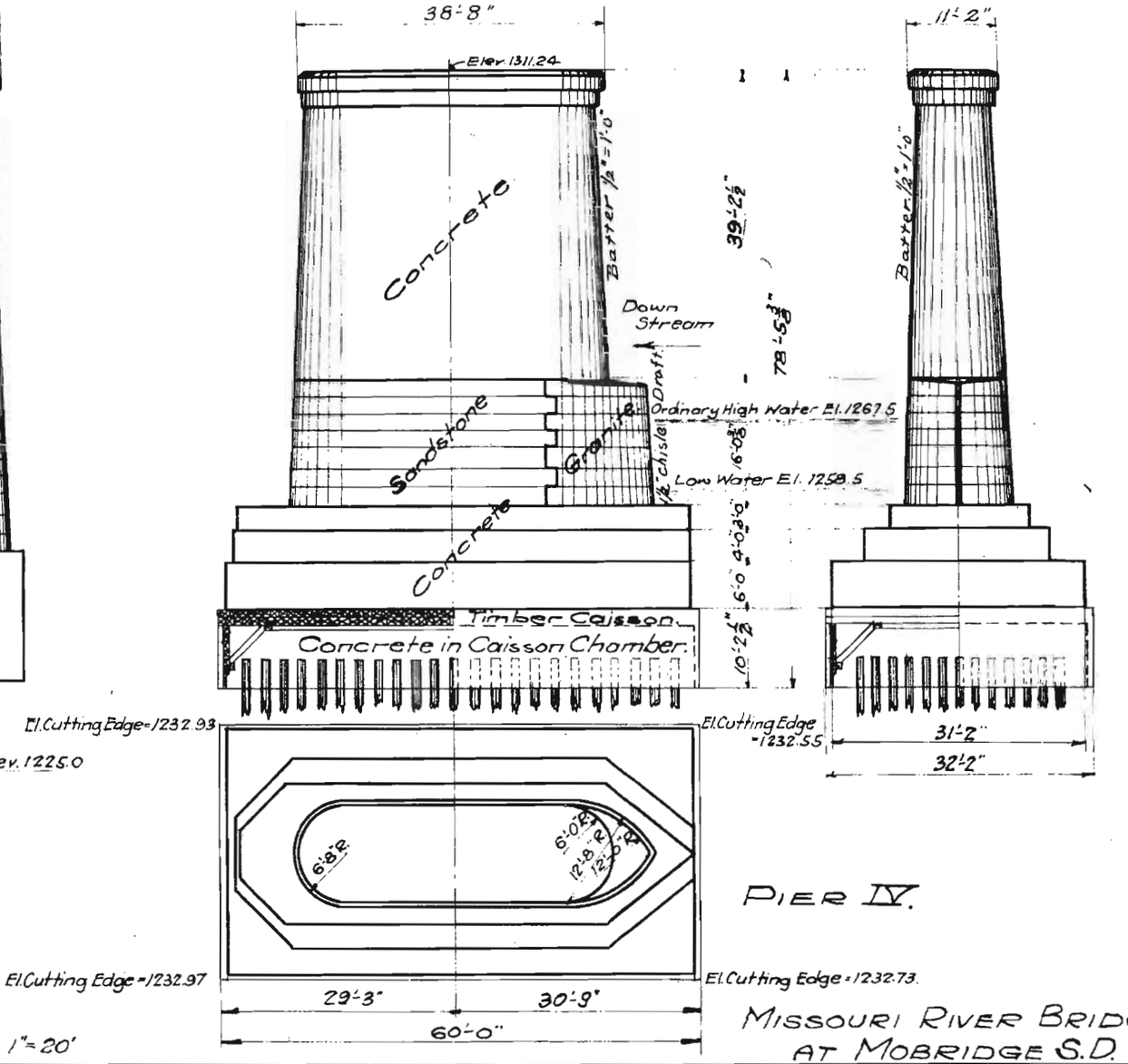


PROFILE OF MISSOURI RIVER BRIDGE AT MOBRIDGE S.D.
Scale-Vert. 1"=50'-Hor. 1"=500'.

PLATE III.



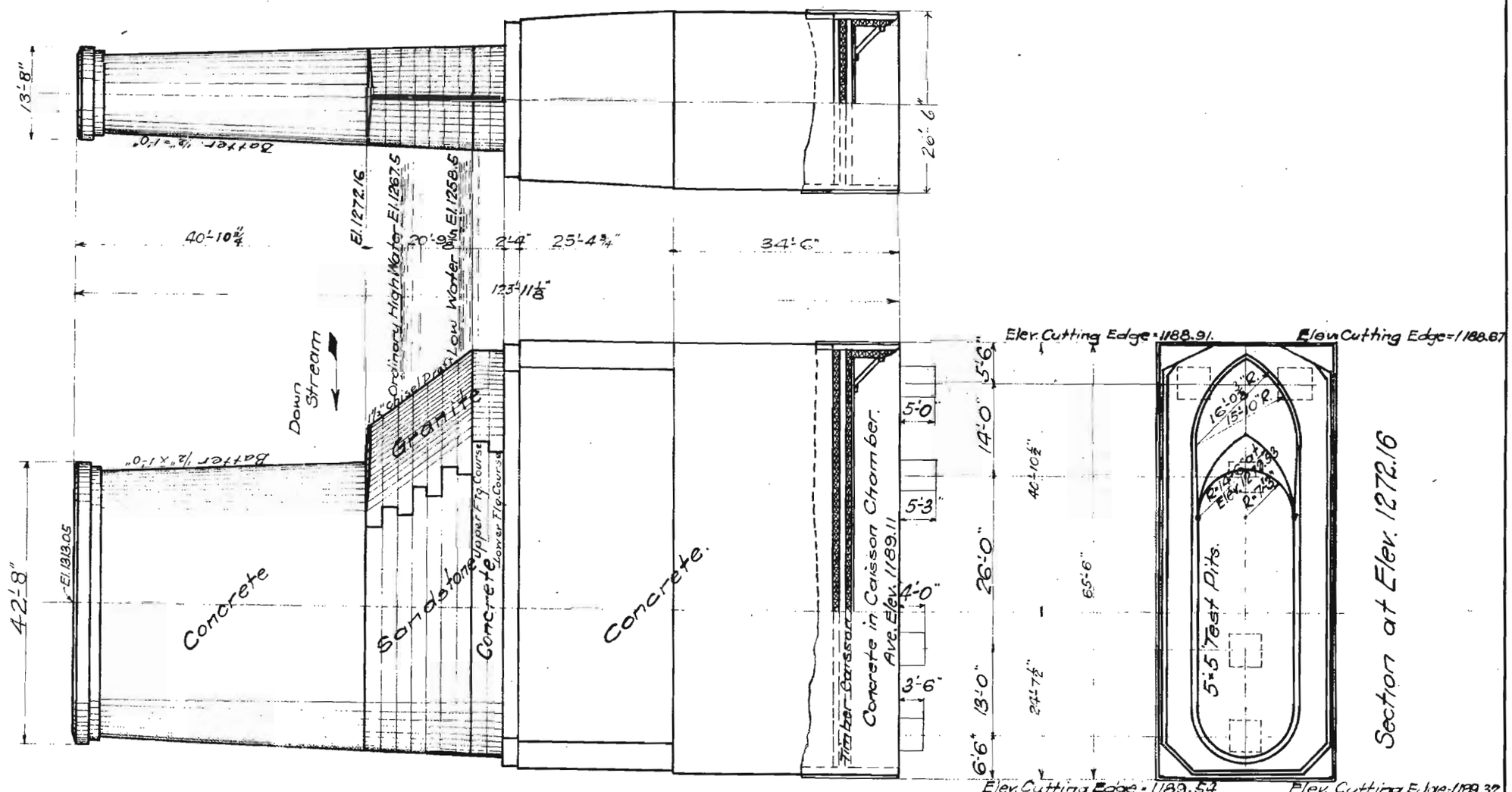
PIER I.



PIER IV.

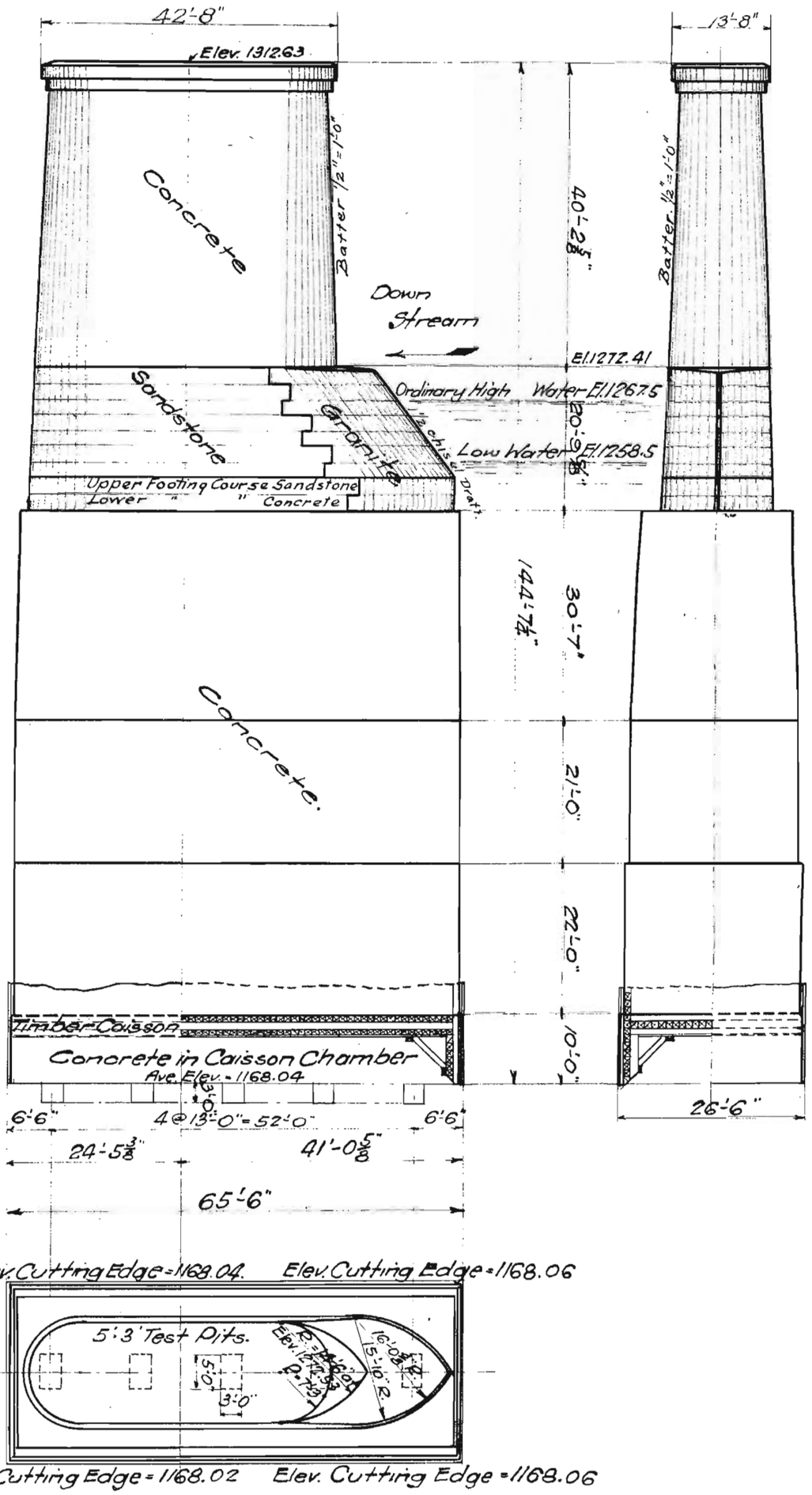
Scale 1"=20'

MISSOURI RIVER BRIDGE AT MOBRIDGE S.D.



PIER II.

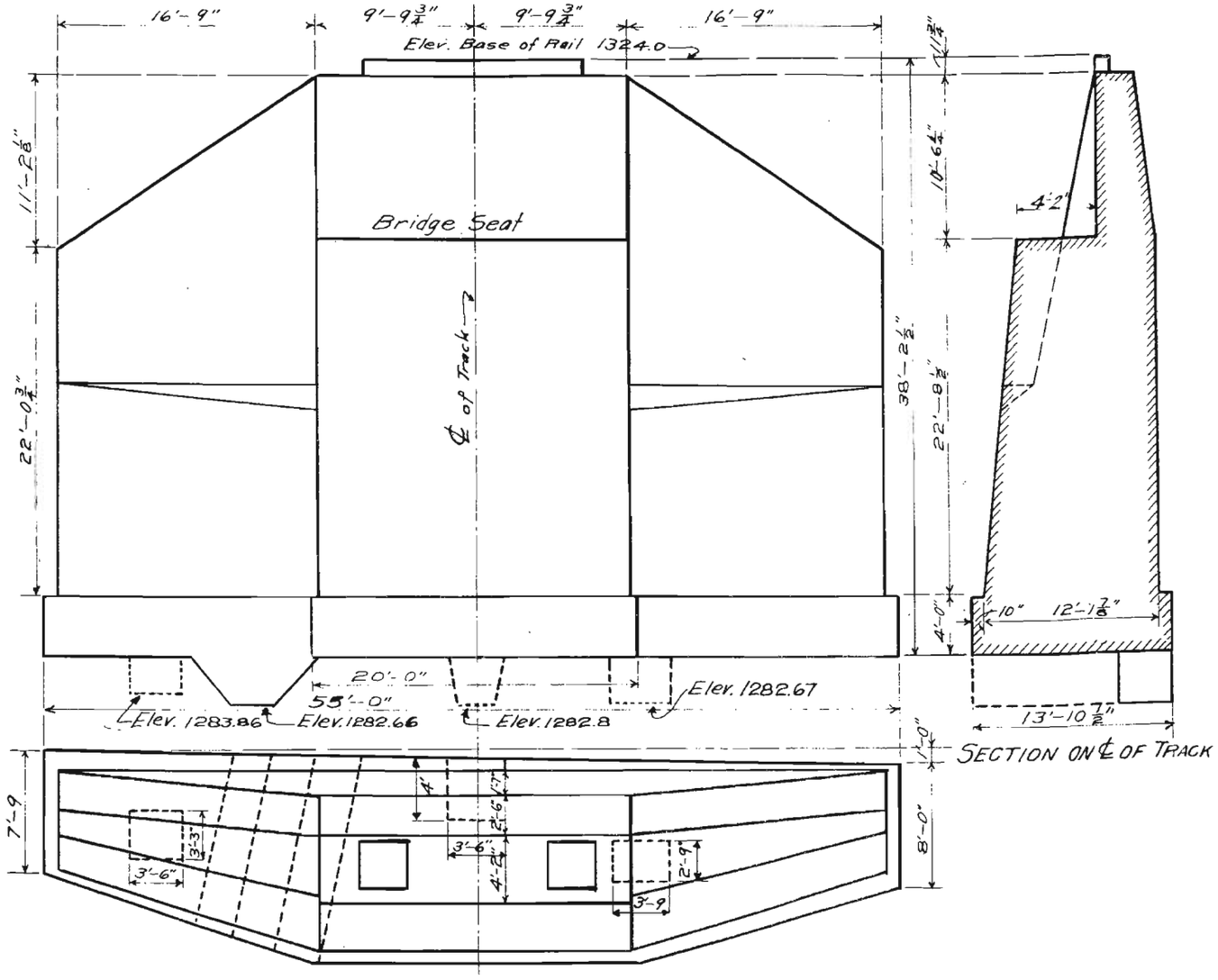
MISSOURI RIVER BRIDGE AT MOBRIDGE S.D.



Section at Elev. 1272.41

PIER III.
MISSOURI RIVER BRIDGE AT MOBRIDGE S.D.
Scale 1" = 20'.

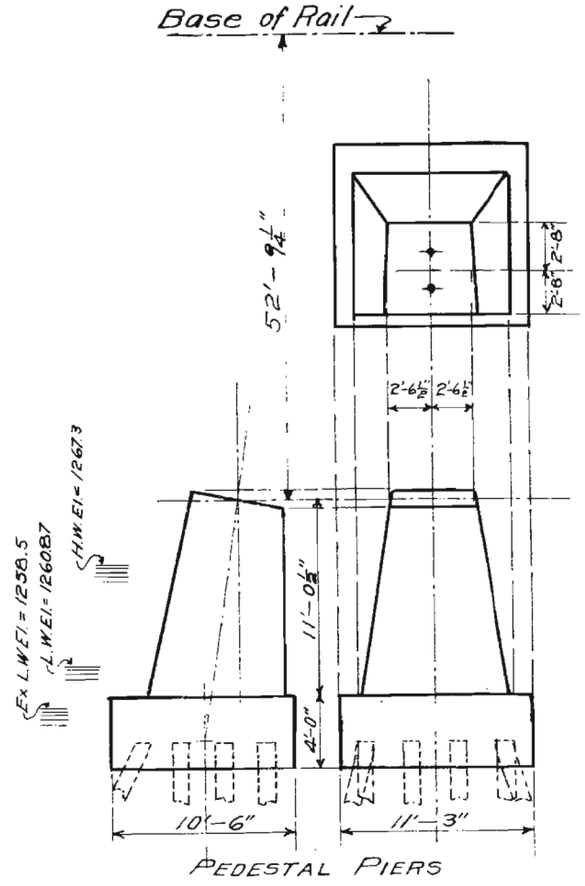
PLATE V.



SECTION ON ℄ OF TRACK

EAST ABUTMENT

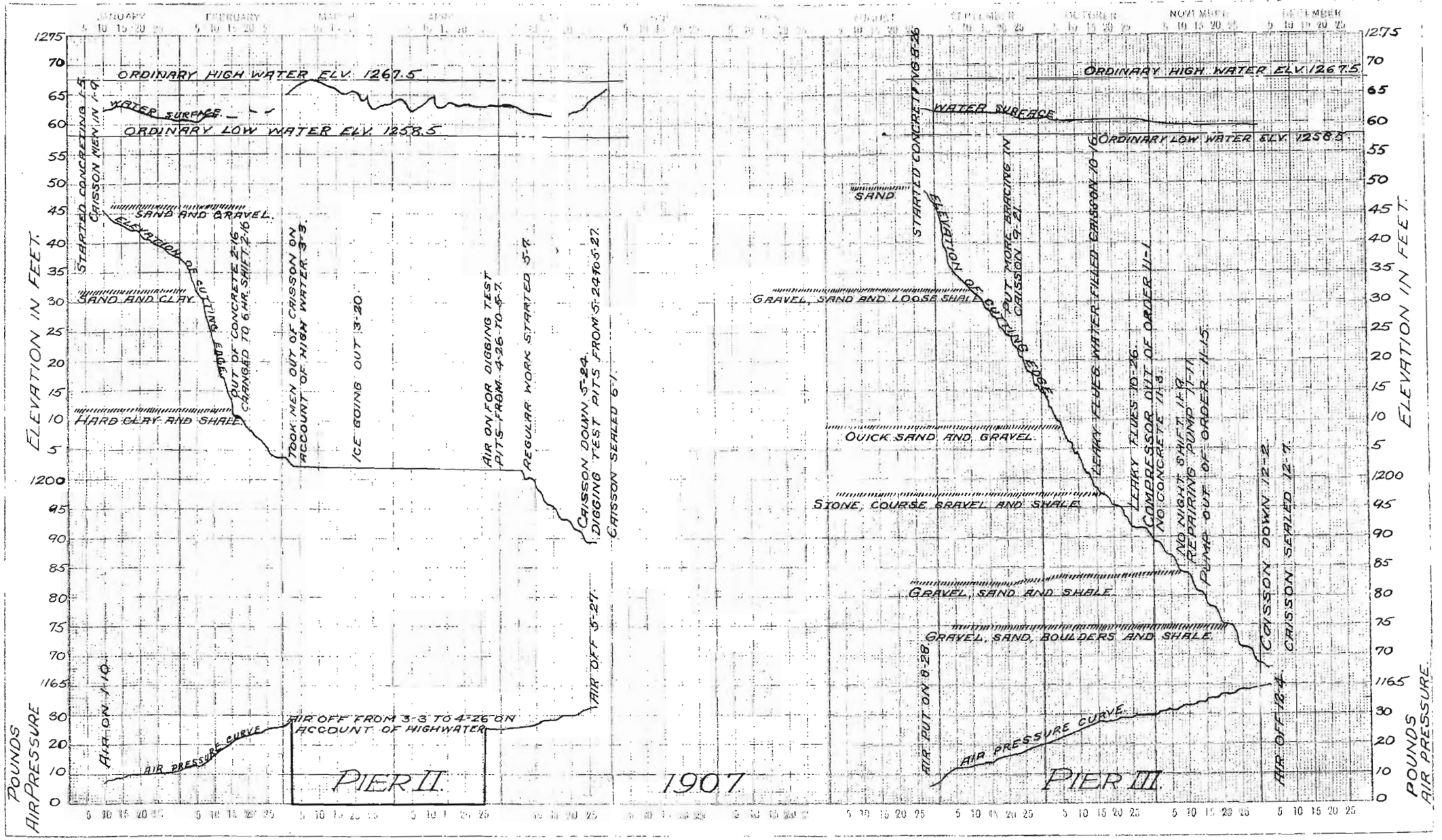
Scale 10'=1"



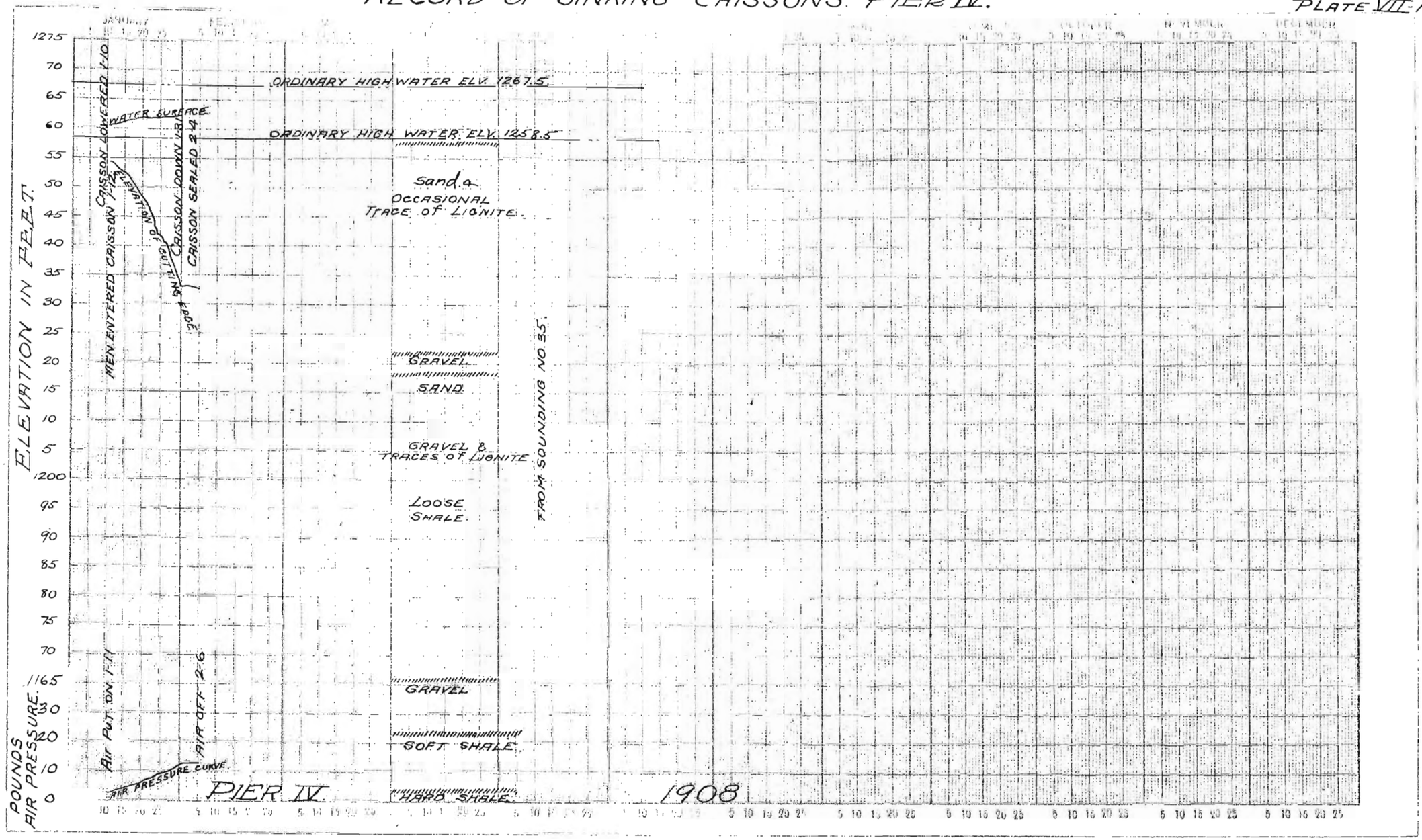
PEDESTAL PIERS

MISSOURI RIVER BRIDGE
AT MOBRIDGE, S.D.

RECORD OF SINKING CAISSONS. PIERS II & III.

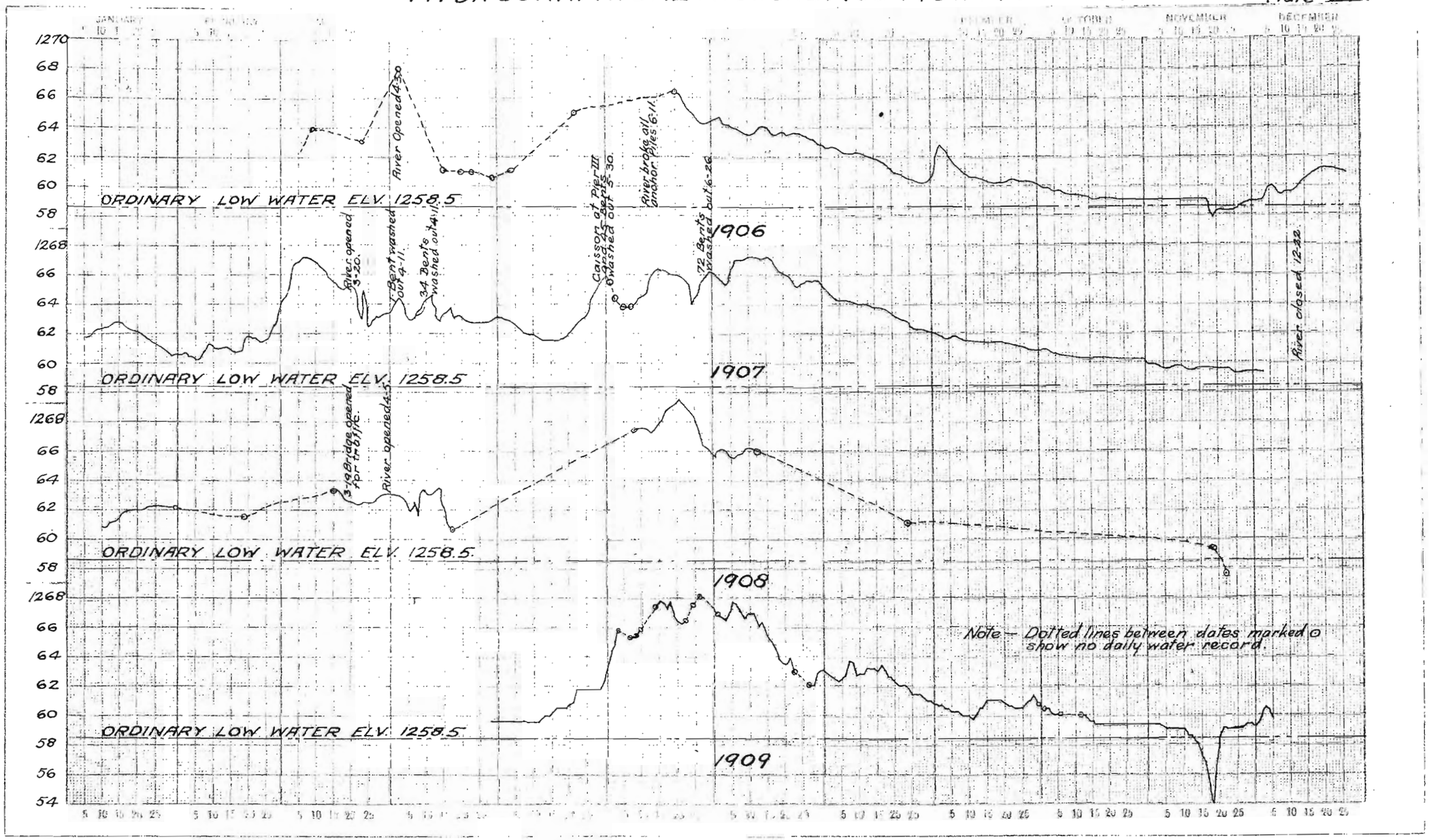


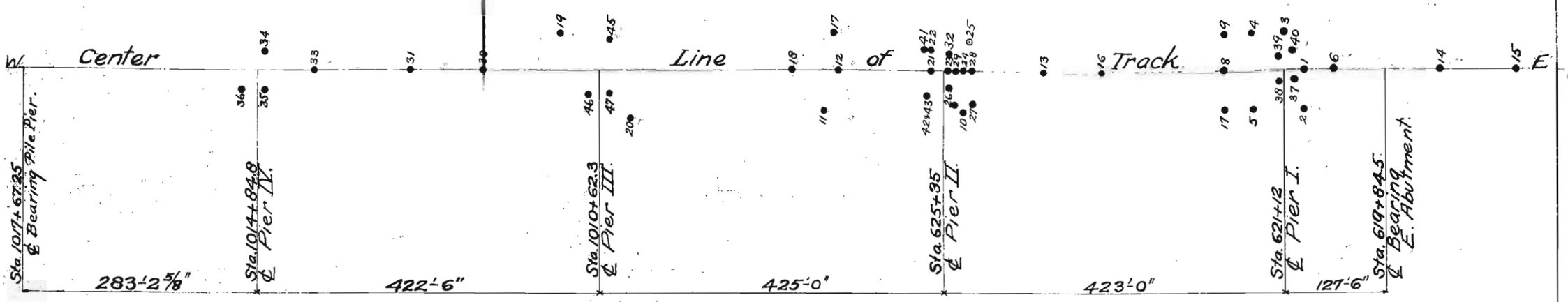
RECORD OF SINKING CAISSONS. PIER IV.



HYDROGRAPHICAL RECORD 1906-1907-1908-1909.

Plate-VIII.





BORINGS FOR MISSOURI
RIVER BRIDGE AT MOBRIDGE, S.D.
Scale - 1" = 150'.