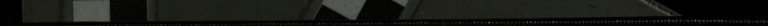

"METHODS OF CONSTRUCTION AND COSTS ON CAISSON FOUNDATIONS"

Thesis for degree of C.E.

Charles H. Dickinson

1918.

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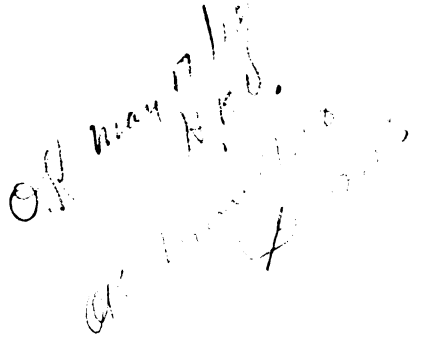


THESIS

-INDEX-

-FINAL UNIT COSTS-

-FOREWORD-

How many times we find that after some job has been completed,we wish some accurate costs had been kept at the time the work was going on so that we might feel that they were not the result of poorly kept notes with items here and there approximate. It is too often the case.

There are always miscellaneous charges which are bound to come sooner or later and these are,in many instances,regarded in a hit or miss method.

The following thesis is based upon records which were kept each day as the work progressed.

Experience has taught us that it is almost impossible to determine any definite data of cost of this work.

The materials may cost the same,labor cost can be proportioned,but the conditions under which the jobs are done are not the same and this is the determining factor.

In keeping the costs of the work recorded on the following pages,the time for every man was checked daily and the distribution made for the same every night after hours. It was with the idea of accuracy in mind that we began these records and kept them up until the work was completed. Nothing was considered as belonging to the miscellaneous work orders and everything and every charge was properly made against its respective work order.

DESIGN

Discussion of formula-

From what I say in the following pages about the design and the changes made,apparently without checking up on the same,I hope no engineer will belittle the importance of design.

The foundation piers were designed by a prominent foundation company which ranks very highly in engineering circles. As the original drawings were not the work of our own office,I cannot do better than accept the word of the "Engineer" for the formula used. I have the word of our office engineer that my supposition as to which formula was used is fairly accurate.

I am not permitted to say whose or what formula it was,but in general,it was the column formula for fixed ends,which takes into consideration lateral deflection. The piers were designed as columns with provision against lateral deflection tho entirely surrounded by solid clay with a bearing capacity of 3000 lbs. per sq.ft. The total load in taken care of by spread footings,nothing being allowed for the skin friction of the pier. This sure must amount to quite a bit as the inside of the caissons was very rough and irregular.

The original design called for shafts 3'-0" square with 1"longitudinal reinforcing bars and ¼" stay bars. To dig a hole 3'-0" square,lag it and have room for a man to work in it to-gether with a hoisting bucket, which will hold anything at all,we decided,was out of the question. We had a line on some old equipment and some new ideas,which we used as an argument for changing the design;of these more will be mentioned later.

Changes and reasons-

The design was then changed,due to the fact that we felt that 3'-0" square holes couldn't be excavated economically or with any speed. We had equipment if the design was made to suit it,so why not change it and make use of what we had on hand.

The contractor had some iron rings 4'-6" in diameter and this was accepted as a good working size for the piers with the lighter loads,the others to have a diameter of 5'-6". The matter was taken up with the Consulting Engineer and finally agreed to,the reinforcing to remain as before; 8 1" longitudinal bars and ¼" stay bars every 12". As we were unable to obtain 1" bars in a reasonable length of time we were allowed to substitute a

DESIGN.

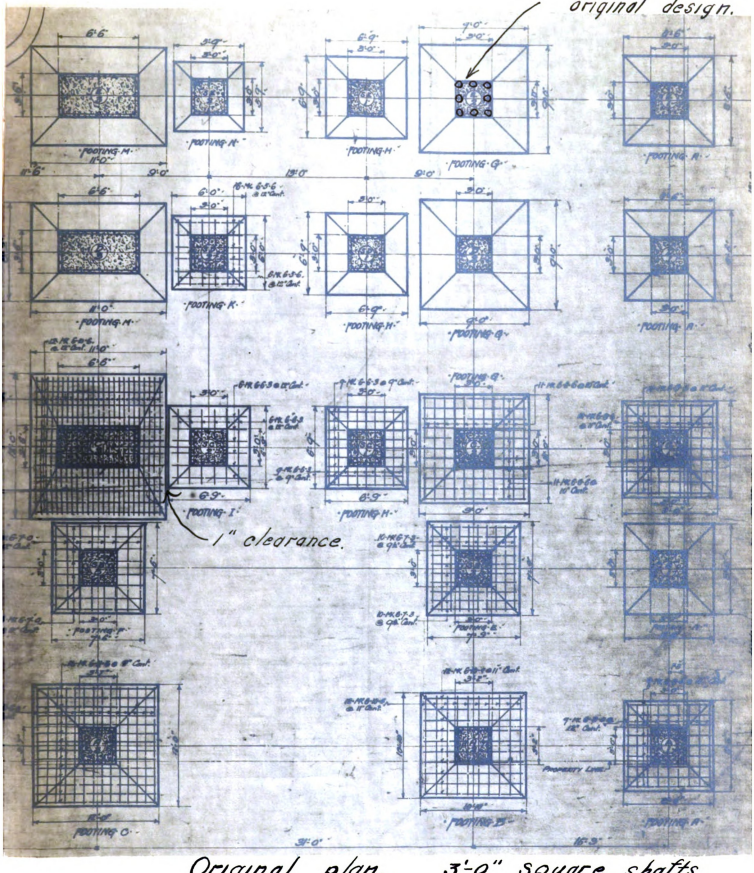
Changes and Reasons:--

7/8" bar,the stay bars being reduced one half by spacing them every 24" instead of 12" apart. The number of 7/8" bars was then reduced to six from eight. In changing from square piers to round ones the area of the shafts increased from 9 sq. ft. to 12.5 sq.ft. These last mentioned changes in the reinforcing steel were made by the Engineer on the job and I am sure without checking up by figures. It may have been possible that the factor of safety was such that these could be made with safety without verifying by figures.

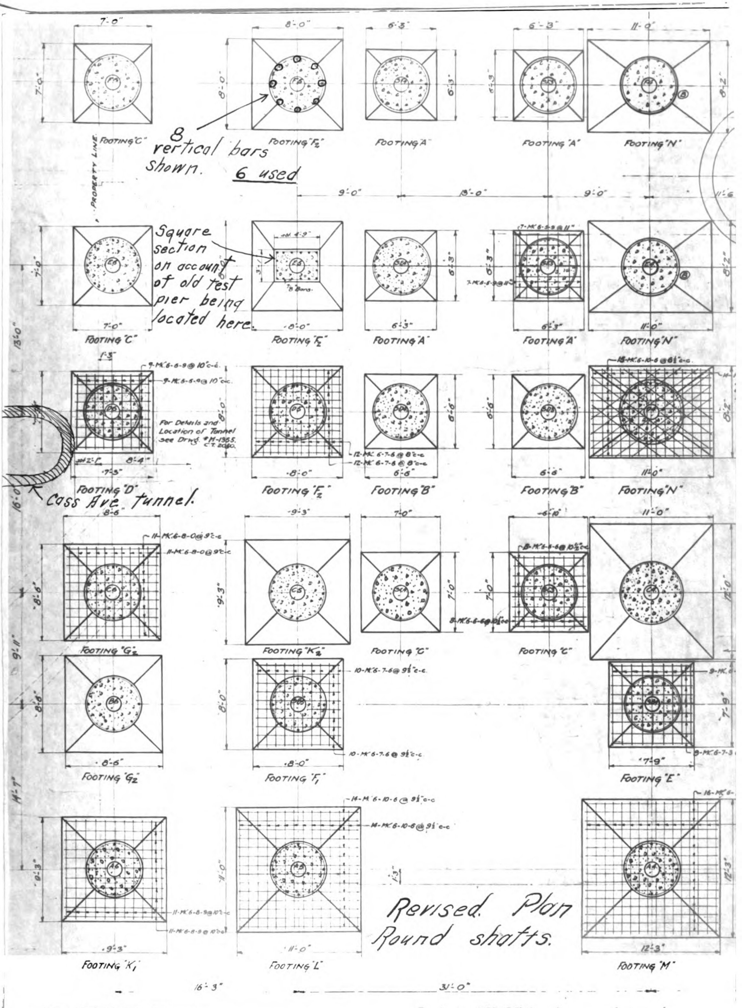
Drawings and Bills of Material:--

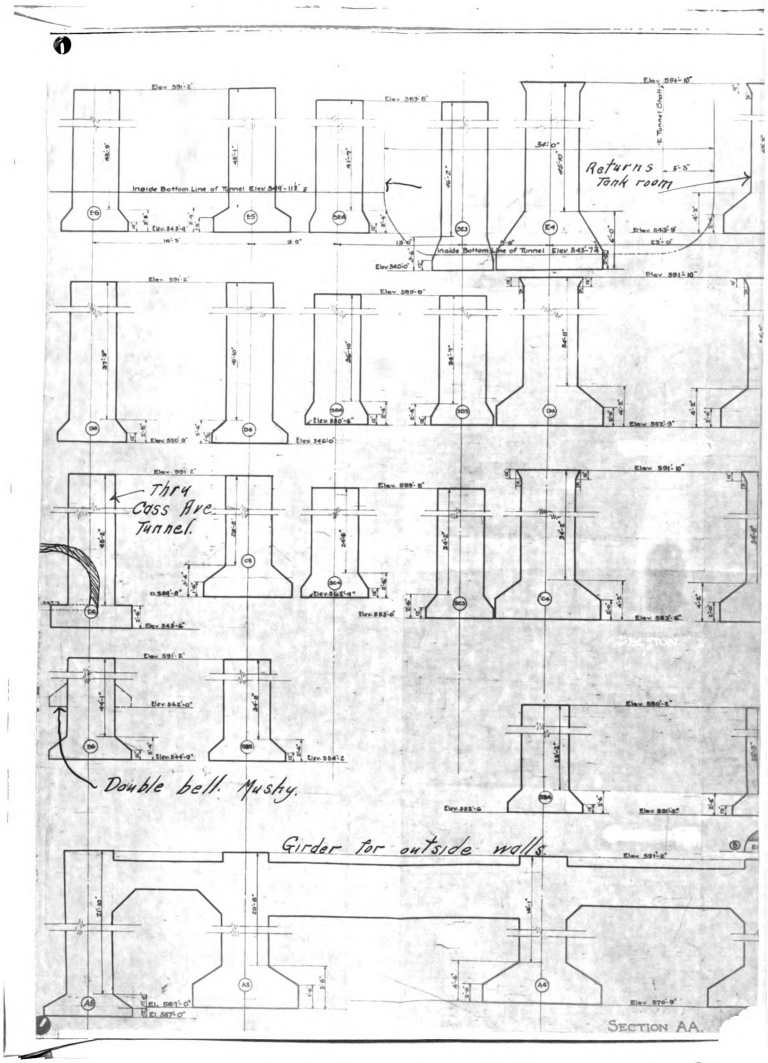
The larger drawings I have had photostated as they were very awkward to handle. I have noted the important items of interest on them with ink. The three smaller drawings are interesting sections showing the loading and the stepping up and down of the piers. A final section as the piers were constructed would appear very different. This because of the nature of the soil,we had in some cases,to go much deeper than planned.

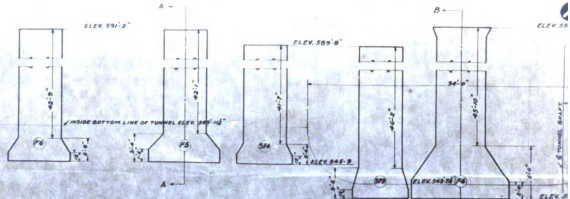
The bills of material need no special mention as I have noted items on them.

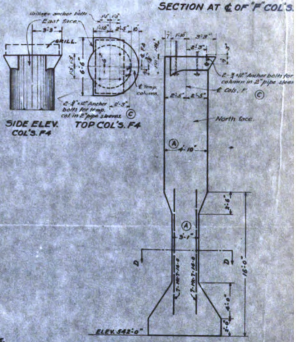


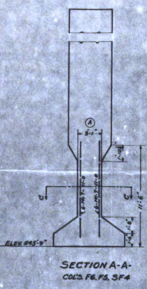
Original plan. 3'-0" square shafts.


FOOTING "C"
FOOTING "F2"
FOOTING "A"
FOOTING "A"
FOOTING "N"
8 vertical bars shown. 6 used
PROPERTY LINE
9'-0"
13'-0"
9'-0"
Square section on account of old test pier being located here.
FOOTING "C"
FOOTING "F2"
FOOTING "A"
FOOTING "A"
FOOTING "N"
For Details and Location of Tunnel see Drwg. #M-1365. C.T. 2080.
FOOTING "D"
FOOTING "F2"
FOOTING "B"
FOOTING "B"
FOOTING "N"
Cass Ave tunnel.
FOOTING "G2"
FOOTING "K2"
FOOTING "C"
FOOTING "C"
FOOTING "G2"
FOOTING "F1"
FOOTING "E"
FOOTING "K1"
FOOTING "L"
FOOTING "M"
Revised Plan
Round shafts.
16'-3"
31'-0"


Inside Bottom Line of Tunnel Elev 849'-11½"
Returns Tank room
Inside Bottom Line of Tunnel Elev 843-7½
Thru Coss Ave. Tunnel.
Double bell. Mushy.
Girder for outside walls
SECTION AA.





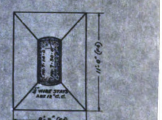


SECTION A-A-
COL'S. F6, F5, SF4

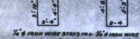
SECTION B-B-
COL'S. F3, F4

NOTE.
PIERS FOR "E" COL'S ARE NOTCHED SIMILAR TO PIERS FOR "F" COL'S. WITH SAME NUMBER.

SECTION C-C-



SECTION D-D-



3/4" ø FROM WIRE STAYS FIG. B-64 REQ'D. 3/4" ø FROM WIRE STAYS FIG. B-65 REQ'D.

TYPICAL SECTIONS SHOWING NOTCHING OF FOUNDATION PIERS FOR TUNNEL WALLS.

NOTE REVISIONS. RETURN TO OFFICE ALL PRINTS MADE PREVIOUS TO LAST REVISION

METHODS OF CONSTRUCTION

Original plans

Our first plans did not take into consideration the idea of not being able to get just what equipment we figured on. We first considered a platform over the entire foundation area upon which the tripods could be erected and on which we could install a railway system for industrial cars. With this method we would be able to work any hole without interfering with the balance of the work. The wagons would all load at one edge of the platform, empty wagons being used to keep the number of teams down. Concreting was to have been done with small machines that would handle easily on the platform. The one feature not solved to our satisfaction was that of handling concrete materials. This plan was finally abandoned as being too expensive.

We then considered a concrete tower and shutes, the dirt being scraped into a hopper in the alley in which case the teams could be loaded in the alley. We actually began construction on the tower but had to give the idea up as the equipment was needed for another job.

The piers being of different depths, some of which required such a short time to excavate, the spool idea for tripods was not considered. Past experience and distance from the river made us cautious about digging adjacent holes but we afterwards found this to be an unecessary precaution.

The excavating was to be done by hand, the dirt being hoisted to the surface by lines running over blocks on the tripods set up over the holes. Here a discussion on the handling of excavated material and method of hoisting developed. The mater was simply a question of individual lines to the tripod or spool drives for a row of tripods. The individual line proposition worked itself out. This will be mentioned elsewhere. The low platforms, you will notice, were used only on the outside row of holes. This convinced us that the scraper idea was out of the question and that high platforms on a modified scale would prove most efficient.

METHODS OF CONSTRUCTION

Reasons for methods adopted:---

The final plans adopted were, as we have since found, justifiable. They were the result of the following line of reasoning:---

Platform over the foundations, too expensive, investment in equipment too heavy.

Scraper plan, of handling dirt, impossible, as proven by the nature of the excavated material.

Spool drive with individual niggerhead for each tripod impractical, because of the short length of time required to complete some of the caissons, and the danger of digging adjacent holes so near to the river.
Concreting equipment determined by what we could and could not have.

After a thorough study of our methods adopted we feel that the work was carried on in the most economical and efficient manner possible with the equipment forced upon us. This equipment consisted of two small " ChicagoMixers" one large and one small electric hoist and one gasoline hoist The gasoline hoist was not of sufficient horse power , re - quiring too much coaxing, while the large hoist was too powerful, almost to the danger point. The most efficient of these figuring speed in hoisting and dependability, was the small electric hoist with a speed of one hundred to one hundred and twenty-five feet per minute.

Procedure -----

Permanent marks for center lines of all rows of caissons were establised with a transit, from these, as wanted,the centers of all holes could be determined. The center of the hole as thus determined, was marked by means of an inch iron pipe driven to a depth of two or three feet to insure permanency. Templets (see diagram 1) of the exact size of the hole were then placed over the pipe as a center and the hole marked out by the diggers, who used the templet with the pipe as a center, to a depth of three or four feet to assure an exact hole from the start.

When deep enough, a permanent set of lagging was placed inthe hole, allowing eight or ten inches of the lagging to extend above the surface of the surrounding ground to keep the surface water from running into the hole and to facilitate marking center lines etc.

Cross lines were establised on the top of this lagging and the exact center of the hole again determined.

METHODS OF CONSTRUCTION

Procedure -------

A movable rod, with a nail in the end to act as a hinge and allow swinging the rod on and off the hole (see diagram 2) was attached and the center of the shaft, when the rod was in position was determined by permanent marks on it. From this center and a plumb line, the circumference of the hole was marked off by the diggers who used short sticks as radii from the plumb line and scraped off the sides of the hole to the exact size before putting in sets of lagging.

Movable platforms with tripods, (see diagram 4) were so built that an extra dump wagon could be placed along side and loaded by dumping the dirt directly intothem as it was brought up from below, thus eliminating hand shoveling from the ground. One careful and efficient laborer was stationed on each platform to guide the bucket from the bottom of the hole, signal the engineer, unload the dirt from the bucket, and in general, tend to all the needs of the men below.
On this job,an average of seven holes were kept working and besides the men tending on the platform, a small gang were needed on the ground for miscellaneous work such as backing the empty wagons up to the hole etc. Contrivances were made on the top of the tripods so that tarpaulins could be thrown over them in case of rain which protected the tender and diggers so that the work could progress in spite of the weather.

The hoisting lines were run directly from the nigger-heads of the hoist engines and the dirt hauled to the surface by the engineer pulling from the nigger-head. In several cases the engineer handled five or six lines but three lines were handled with most efficiency.

The holes were dug to the exact diameter as wanted for the finished concrete and the lagging placed . When placed (see diagram 2), two iron half-bands of the diameter of the inside of the lagging were driven into place and bolted to-gether. Some nailing of the lagging to these bands was necessary but for the most part they fitted tightly enough to stay solidly in place.It is not advisable to use many nails as it makes the removal of the rings and the lagging,,when concreting, much more difficult. In some special cases it was found necessary to use short sections of lagging as the banks were too soft to permit digging to the usual depth and caving would have started.

METHODS OF CONSTRUCTION

Procedure -------

In case of quicksand, it was found necessary to pack the lagging from behind, as placed, with salt marsh hay to stop the flow of the quicksand and hold the lagging in place.

Arbitrary elevations should be established on the top set of lagging from the start so that the depth of the hole can be determined at any time.

Two kinds of platforms were used on this job. The first kind tried was a low platform where the dirt was thrown on the ground around the platform as it was brought to the surface where it was accumulated and later loaded into dump wagons by hand-shoveling from the ground. The second kind with the method already discussed, was found to be much more efficient and operated at a considerably lower cost in spite of the charges made for extra empty wagons etc for evident reasons.

Diagram No 1

Template

Exact circumference of shaft.

Hole to fit over center pipe.

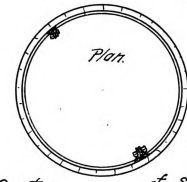


Diagram No 2

Rings and Logging.

Diagram No 3.

Hinge nail

Grade

Exact mark for plumb line.

Center line.

Beveled Logging

Section of Shaft.

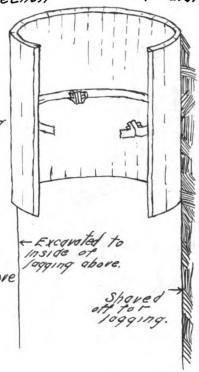
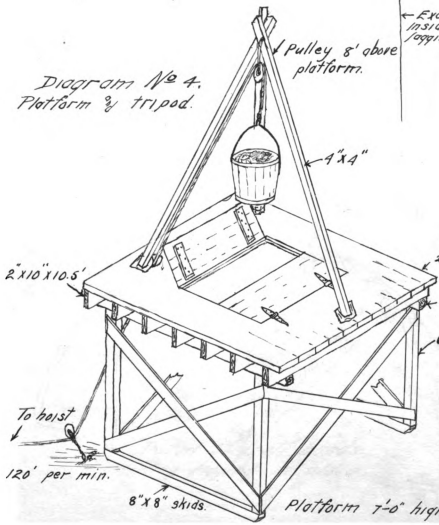


Diagram No 4.

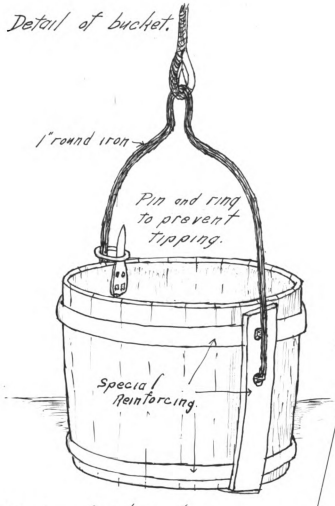
Platform 3/4 tripod.



Note:-

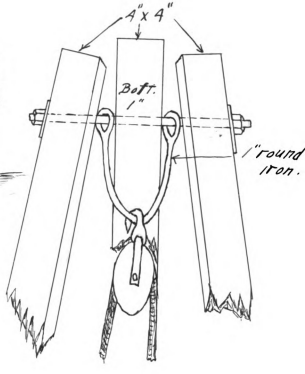
Side of platform along which wagon is being loaded should be boarded up to prevent dirt from falling back on men below.

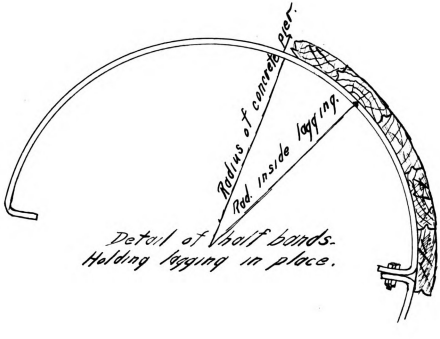
Detail of bucket.



Made of a barrel sawed thru the middle. Reinforced as shown. Diameter at top of bucket's 24".

Top of tripod. Showing method of attaching block.





Detail of half bands. Holding logging in place.

METHODS OF CONSTRUCTION.

Handling of Materials----- Excavated dirt--

So much has been said on this subject in the following pages,that here,I will mention only a few facts of interest.

When using the low platforms,the dirt had to be shoveled by hand into the wagons.It was very sticky and made the loading slow work,it also cost more than it ordinarily should. Clay forks are almost a necessity for this work.

While dumping the buckets from the high platforms,it was impossible to keep the dirt from spilling on the ground,and three men were busy most of the time loading this into the wagons.

The haul differed in length,one dump was very close by,a distance of three blocks and the other was about two miles away. The first was not managed well, teams were unable,at times,to make more than three trips in five hours. The second dump was more efficient but the distance too great,the dirt was dropped from the wagons, thru trap doors,directly onto a boat. The charges for dumping privileges were 55¢ and 90¢ respectively.

As a rule,the shafts passed thru a fill to a depth of five feet and then thru six to nine feet of yellow sand where they struck a layer of hardpan varying in thickness from two to five feet; the remainder of the shaft was dug thru blue clay of varying consistency but usually rather tough and plastic. Pockets of quicksand and water pockets were struck accasionally. The entire job was of normal character,for caissons of this type.

METHODS OF CONSTRUCTION

Handling of material ----- Lagging ----

Hemlock was used for lagging. The first order calling for material 2" X 6" tongued and groved cut to the radius of the piers 2' - 3". The length of the pieces being 14' - 0", we cut them up into 4' -8" pieces and this governed the depth of all excavation where the regular lagging was used. Special lengths were used for the first sections and in such places as needed extra attension.

When the diggers were ready to lag four or five pieces were sent down with the iron rings. These were set up and the rings placed, nails being driven in to support them. The balance of the lagging was then set up behind the ring, the last lengths requiring driving. Where the excavation was irregular, wedges were forced in between the ring and the lagging. It is not good policy to have too many nails as the lagging is more difficult to get out when the time comes to remove it.

When soft clay or sand with an abundance of water was encountered the lagging was driven down before the excavation was started. As the hole was carried down marsh hay was packed in behind the lagging, this kept the mush confined and provided backing for the rings to work or push against.

Only one ring was used, this being placed in the center of the 4'-8" lengths. We found this sufficient except where we used the extra long lengths at the top of the holes or where we ran into the soft mushy clay and sand. Never more than two rings were required in either case. In only one instance did we have any trouble with the buckets catching on the ring. This was on account of using a faulty bucket. No damage was done altho there was some excitement as two men were some 40' below at the time the accident occurred. Buckets were carefully inspected after that and kept in good repair.

Hemlock can be obtained with fewer knots and and everyone connected with the work seemed to feel that this was the best material. The idea of having the lagging tongued and groved is not a very good one nor is it necessary to have it cut to a radius. After using it once or twice and knocking the concrete off it the tongue, groove and radius features are entirely lost. Where we ran thru fill with water in it the idea proved its worth as the swelling of the lagging prevented the water from dripping into the hole.

METHODS OF CONSTRUCTION

Handling of material----- Lagging ----

The lumber was dressed on all sides but except for the one side which should be inside this was not necessary. The side next to the ring should be dressed as the rings frequently have to be driven and any unevenness adds to the labor required in setting rings or lagging.

Handling of material-----Sand -Gravel-Stone.

The bankrun gravel or more properly the lake gravel which we were able to obtain averaged 67% sand, this percentage passed a ¼" mesh. For this reason,we never ordered sand but depended upon the percentage of sand in the gravel to make the proper mixtures. Limestone,of a very poor quality,was used in the majority of the work. Gravel was used exclusively for the balance of the time.Reasons for this will be found in the following subject.

Trucks were used entirely for delivery,the space being too limited for handling wagons. Our ability to get quick delivery of materials,did away with any storage bins. Stock piles were built up during the day. When possible,the material was dumped somewhere near the mixers,thus saving a large amount of wheeling.

Methods of Construction-

Handling of material-----Reinforcing steel.

The question of reinforcing steel was not a hard one to solve as we are located in the same city as the plant which furnished all of our steel. Bills of material were written and at first forwarded to the Steel Co. This method proved unsatisfactory for the reason that they furnished the steel that they wanted to and it was many times not what we were in need of. We found the best plan was the have a representative call and give him a list of the sizes and the lengths that we wanted. These were delivered in a very short time and piled according to sizes and lengths. By following this plan we never had a large stock on hand and had that much more room something that we needed very badly.

Two men were chosen to handle all of this work, extra help being given them as they required it. They were responsible for the stock on hand and the placing of the steel.

All bottom rods were laid on two supporting rods set upon bricks to keep them the required distance up from the bottom of the footing. Soft iron wire was used for fatening the rods to-gether. We never experienced any trouble from displacement the concrete was dumped 55' in some instances down dnto them.

The vertical rods were driven into the concrete of footings after the bell of each pier had been poured and the concrete began to fill up the shaft of the pier. The rods being properly spaced with the tops held by nails driven into the lagging. Where the second and third sections of rods were put in the lap was made about two ft. and securely wired the top of the rod below.

Mention of concreting around the rods will be made under another subject on the concreting of piers.

CONSTRUCTION OF PIERS.

Concreting:---

As mentioned before,the concreting proposition was the outcome of the equipment that we were forced to use. The stock pile had to be located in one corner as it was the only space available,but instead of having a big mixer with one setup,we had to use the little "ChicageMixers". These had to be shifted with the work and it necessitated wheeling the sand etc. from the stock pile, sometimes across the lot a distance of 75 yards.

These small mixers proved to be more economical than we had expected. It generally required from one hour to one hour and a half to move and complete the setup of runways and platforms. One setting took care of as many as five piers at one or two different times. The platforms were large enough to allow for the piling of a large supply of cement on them,this did away with moving it back to the cement shed when any amount was left over. Aprotection of some sort had,of course,to be provided. Water was piped to different locations and a hose used between them and the mixers. Two men attended the mixer,one dumping and the other loading;the number of men wheeling differing,depending upon whether we had to wheel from the stock pile or from a position close by.

We found it was impossible to use stone in puoring the bells as it piled up and did not fill out to the cornersof the footings. We tried proportioning the stone and gravel but finally poured gravel exclusively,getting very good results. Frequent inspections were made to be sure the bells were filling up properly. The gravel also filled in around the steel more satisfactorily. As soon as the bell was full,we mixed the stone with the gravel and continued this proportion to the top of the pier. The excess water was taken care of by making the mixture more dry. We found that in placing the concrete that dumping it did no harm and the idea of using tremies was discarded. This dumping had a good ramming effect and when it was possible to obtain any large boulders,they were dropped in for the same reason.

As it was impossible to lag or shore the bells,we planned to have them excavated and concreted as soon after as possible; the bottom steel being placed but the vertical rods held until later. This was,invariably,late in the afternoon, and as soon as the bell was poured, the concreting was stopped until the next day. The first section of steel placed before leaving. Upon continuing the

CONSTRUCTION OF PIERS.

Concreting:---

concreting,the latent was never considered as too short a time elapsed between the time of stopping and starting again. As it was sometimes weeks before the anchor bolts were set, it was necessary to chip the latent off the top of the shaft before finishing the final concreting of the pier.

On Saturday march 17,1917,running both mixers, we were able to make the following record--

Total time		5 hrs. 55 min.
Batches		130
Average batch		2 min. 44 sec.
30.66 cu.yds.		computed quantity
6.35 cu.ft. avg. batch	checks	" "
11½ min.per yd.		
5.2 yds. per hour		

One mixer ran at the rate of one yard in 8 min. 53 sec. 6¾ yards per hour.

One mixer ran at the rate of one yard in 13 min. 28 sec. 4½ yards per hour.

Removal of lagging:---

The chutes used in concreting were covered on the end to prevent the concrete from splashing,too much, on the lagging. The platforms were moved from over the holes as soon as the excavation was completed and a small tripod was set up to attach the tackle to for lowering the men into the caisson,who removed the lagging and bands and placed the reinforcing steel.

Two men took care of the removal of lagging bands and setting of steel. As the concreting went on,these men with hip boots and rubber gloves,waited until the concrete had almost reached a ring and then went down to remove it and the lagging. After sending these up,the stay bars were sent down and placed. The concrete was very hard on the hands and these,if not protected,soon cracked and got very sore. Where the lagging had been driven on account of mush,the concrete was poured up to a point where the lagging was firmly held and then only the ring removed, the lagging being buried in the concrete.About 25% of the lagging was lost in this manner.There were several instances in which the rings and all had to be left in the concrete. The lagging was immediately washed and cleaned and piled away until wanted for use again.

CONSTRUCTION OF PIERS.

Inspection:---

Every hole was inspected before laying the steel in the bottom,measurements being checked up with the plumb. A box ,holding one cubic foot,was used to measure the proportions and each wheeler instructed as to the amount for his particular wheelbarrow. A sample was taken and allowed to set; these were tested later on however but the concreting was not held up. After dumping a few batches in the hole,an inspection was made to be sure the steel had not been disturbed and that the corners were filling up. Frequently a man had to be sent down to puddle and ram the mass. When concreting the shaft,this puddling was done by the man,who removed the lagging,walking around in the concrete.

Gravel,sand and stone was tested for voids by the water displacement method and all proportions made from this basis. The samples,after having time to set thoroughly,were broken and note made of the voids and the distribution of aggregates.

Special care was exercised with the piers that had the change of section providing for the tunnel. The steel was increased in these piers and it was awkward work to get it set for making connections to the steel where the pier changed from rectangular to cylindrical section. It is interesting to note here that whereever the piers were uncovered afterwards,we never found any steel exposed on the surface of the shafts.

During the excavating,frequent inspections were made with the sweeps and the plumb to be sure the holes were not running off center. As a rule the diggers were careful,the discrepency showed up very plainly when the lagging was placed. This can be clearly seen in two of the photos taken looking down into the caisson.

Proportions:---

The specifications called for 1-2½-5 mixture but the samples of this proportion proved too lean and a 1-2-4 mixture was used. The gravel tested 67% sand passing a ¼" mesh and because of this no sand was used; the proportion sand figured from the above basis proving satisfactory,the balance of the gravel counting in the stone proportion. Samples of this mixture gave excellent tests.

CONSTRUCTION OF PIERS.

Proportions:---

The mixture was figured from the following--

1-2-4 mixture

Cement	Sand	Stone
1.57%	.44 %	.88%
5.5 sks.	11.9 cu.ft.	23.8 cu.ft.

The above proportions being for one cubic yard.

Figuring a sack of cement at .9 cu.ft.

Sand	1.95 "	"
Stone	3.9 "	"

Inspection:---

Under this heading I neglected to mention the test borings that were made. When the elevation for the bottom of the bell was reached, test borings for twenty feet down were made and then if these proved satisfactory the bell excavation was begun. In one instance it was nesessary to go down twenty feet further.

INTERESTING ITEMS ON OPPOSITE PAGE.

View showing the low platforms,which were tried at first.

Big mixer which we were planning on using with a tower.

Stock pile--- lower center.

Absolutely impossible to use a scraper on the excavated material shown beside the platforms.


TORAGE & CARTAGE CO
F WAREHOUSE "C"
RIVERSIDE STORAGE CO.
RIVERSIDE STORAGE CO.
CONGRESS ST. PROGRESS - FOUNDATION CAISSONS FOR HEATING PLANT
M-5182 3-14-17

INTERESTING ITEMS ON OPPOSITE PAGE.

1--- High platforms -wagon in bwtween.

2---Close up view of plaŝform - lower right.

3--- Four wagons loading -one team on job.


DETROIT METALLIC BED CO.
RIVERSIDE STORAGE & CARTAGE
FIREPROOF WAREHOUSE
CONGRESS PROGRESS - FOUNDATION CAISSONS
M-5213 3-26-17

INTERESTING ITEMS ON OPPOSITE PAGE.

1--- Mud buckets-- left center.

2--- Concrete mixer-- center.

3--- Completed caissons-- left.

4--- Contrivances for holding tarpaulins on tripods.
Upper right--tarpaulin rigged up.

5--- Grillage for 5'-6" piers,behind template.
Upper right.


RIVERSIDE STORAGE CO.
CONGRESS ST. PROGRESS - FOUNDATION PROGRESS
M-5306 4-20-17

INTERESTING ITEMS ON OPPOSITE PAGE.

View taken thru the trap doors on the platform.

Notice the template for locating exact center of the caisson. Shown thrown out of the way.

INTERESTING ITEMS ON OPPOSITE PAGE.

View taken thru the trap door.

The irregularities and unevenness of the lagging.

Reinforcment 55'- 0" below surface, concrete dumped directly onto it without displacement.

Shute from mixer on right of caisson.

Wedges between rings and lagging.

CONGRESS ST. PROGRESS - INTERIOR OF CAISSONS FROM ABOVE

M-5281 4-20-17

INTERESTING ITEMS ON OPPOSITE PAGE.

This view was taken at the bottom of a shaft. It shows the squaring off for the footing from the round shaft.

Reinforcing bars used to measure with.

INTERESTING ITEMS ON OPPOSITE PAGE.

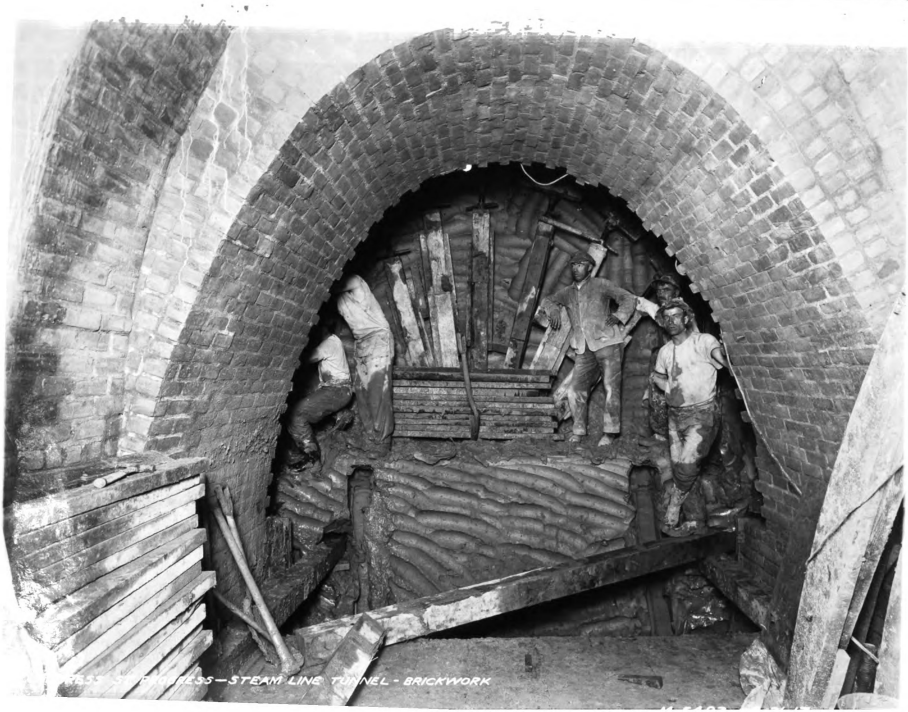
Tunnel which was driven thru between the "E" and "F" row of caissons. Photostat shows sections of these piers cut out to allow tunnel to pass between them.

Clay removed with knives, 5 men operating them.

Note jacks and bracing for supporting roof while excavating is going on.

Note the two creases in the clay where the shoring gave away nearly catching four men under it.

Brickwork of the tunnel passed within 13" of inside face of foundation pier.


STEAM LINE TUNNEL - BRICKWORK

COSTS.

Distribution of Charges:--

The distribution of charges was kept under the following headings---

Excavation
- Supervision
- Tending
  - Labor
- Lagging
  - Diggers
  - Laborers
- Hoisting
  - Engineer
  - Laborers
- Teaming
- Dumping privileges
- Extra wagons

Miscellaneous Labor
- Cutting of lagging,cleaning,handling etc.
- All work on platforms,tripods etc.
- Miscellaneous charges.

Material
- Lagging
- Miscellaneous excavation,operating etc.
- Platforms,tripods,tackle etc.

The above outline will be readily understood when reading over the following pages of costs on the different types.

Manner of Reporting---

The cost keeping clerk checked all of the work done and kept records of the ground thru which the holes were being driven,rate of progress and the number of men engaged on any enterprize. Separate costs were kept on each hole excavated. One large cost sheet was provided for each hole,the cost of work done under the items as noted above being kept in columns.

The cost engineer checked up four times a day and at the close of working hours took measurements. The labor time was checked with the total time for each man and distributed immediately,charges being made against the caisson on which the work was done.

COSTS.

Manner of Reporting:---

No charges were made for time worked less than one half hour. The amount of dirt excavated was recorded daily and this with the labor cost was plotted giving points on the cost curve for that particular caosson. Extensions were made daily, this enabled us to know the unit cost of operation as the work progressed. When a caisson was complete, the sheet for that job was totaled up and the curve plotted. The final cost and the total yardage was noted on the curve and the sheet then filed.

All miscellaneous charges were made under their proper headings and this totaled up, the unit charges were then added to the unit cost for excavation.

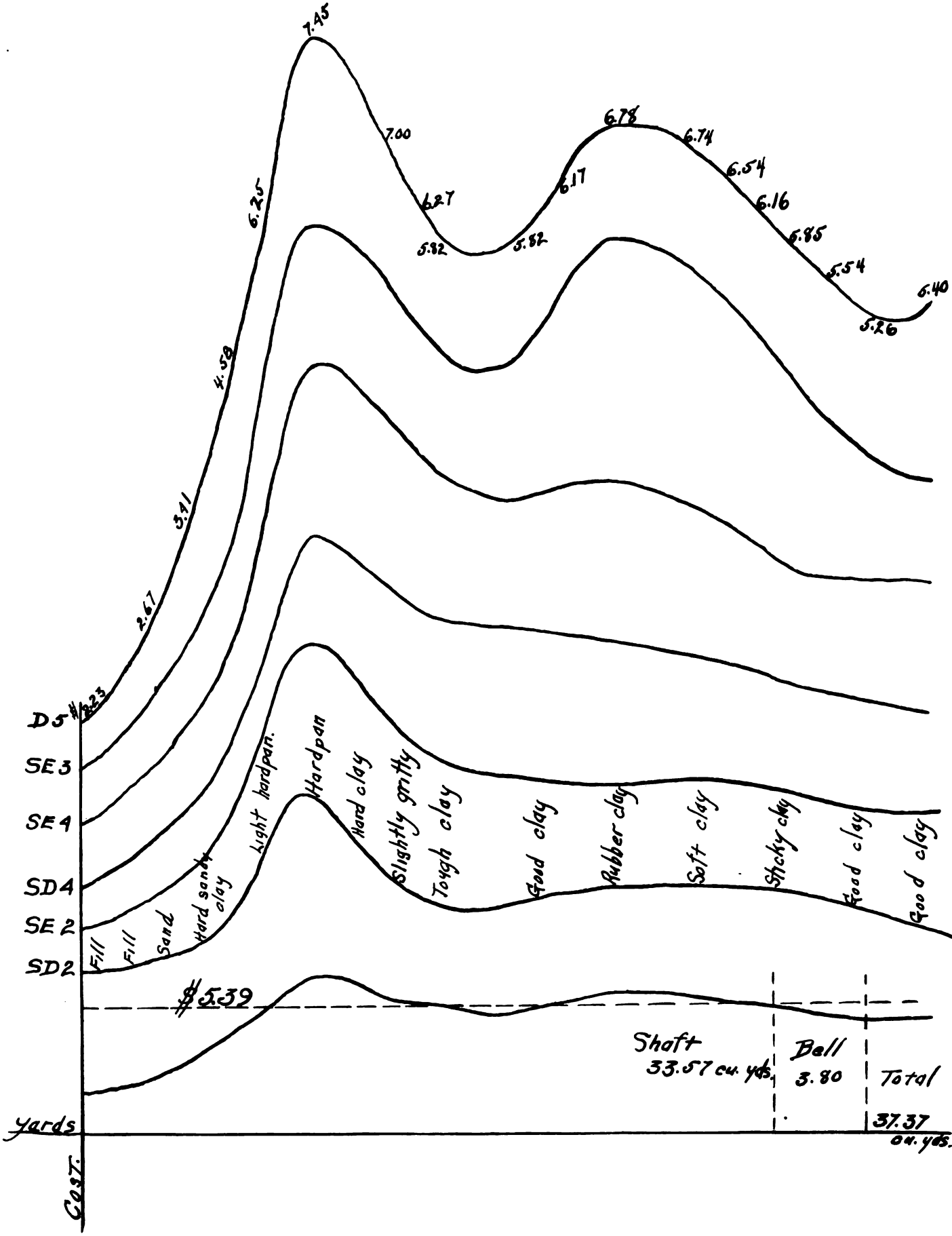
Records and Curves:---

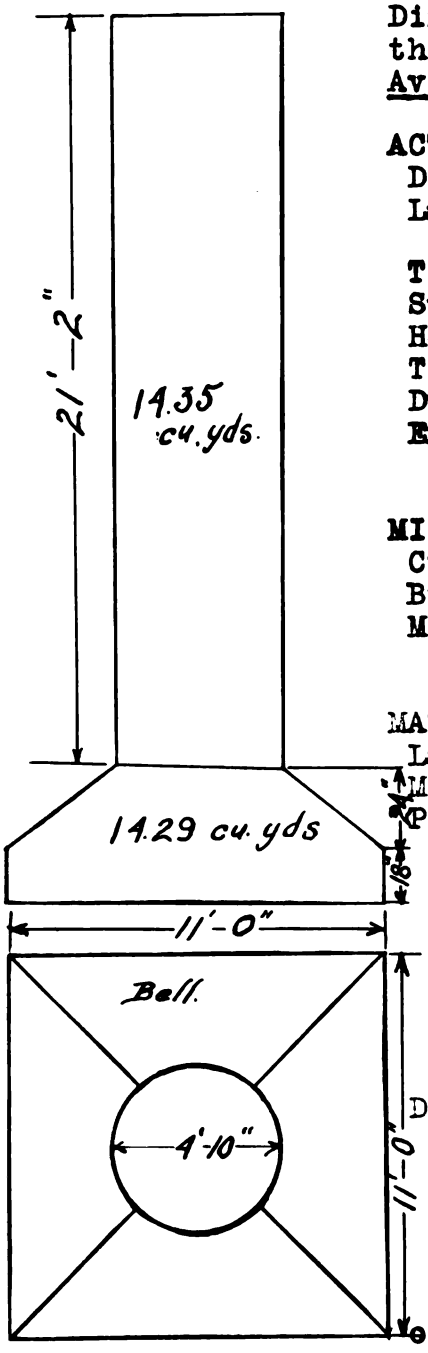
As the cost for caissons, which were similar, differed, and there were so many piers, it was decided to groupe these and get an average cost and curve for that particular type of caisson. Where extraordinary efforts were expended on account of irregularities encountered, the cost ran up. These cases were exceptional but nevertheless occurred; the charges being high and the curve abnormal. These are not in the seven types listed nor can they properly be figured in.

The classification into types is made according to the varying size of the holes in regard to: diameter of shafts, size of bell and depth of shaft: and is not made according to their location or the character of the soil passed thru etc. Types 1 and 11 are separated from the other five types because of the different methods of digging employed. There are no special-section types or types where special work was necessary other than that incidental to ordinary digging, included in any of these types.

TYPE	DIAM.	DEPTH	BELL CU.YDS.	TOTAL CU.YDS.	
1	4'-10"	21.1'	14.29	27.65	Low platforms.
11	"	21.6'	5.41	20.08	
111	5'- 6"	41.5'	13.16	49.68	High platforms.
1V	4'-10"	37.6'	3.95	29.48	
V	"	26.3'	10.88	28.72	
V1	"	25.2'	3.85	20.96	
V11	"	49.4'	3.80	37.37	

Developement of unit cost curve for caissons for TYPE V11
Unit cost per cu.yd. noted only on caisson D 5 .





Dirt delivered by use of low platforms thrown on ground, loaded by hand.
Average of four 4'-10" holes.

ACTUAL LABOR OPERATIONS		TOTAL	UNIT
Digging	117½ digger hrs.	$78.00	cu.yd.
Lagging	6½ " "		
"	3½ labor "	5.17	
Tending	99½ " "	35.22	
Supervision	6 foreman "	3.32	
Hoisting	27½ engineer "	12.32	
Teaming	@ 70¢ per "	14.47	
Dumping priveleges		10.04	
Extra wagons	$2.25 / day	3.05	
		161.60	5.850

MISCELL. LABOR #	
Cutting lagging and analogous work	.154
Building tripods, platforms. etc.	.320
Miscell. excavation charges	.287
	.761

MATERIAL #	
Lagging	.555
Miscell. excavation, operating	.035
Platforms, tripods, rope, tackle etc.	.274
	.864

Total cost per cu.yd.

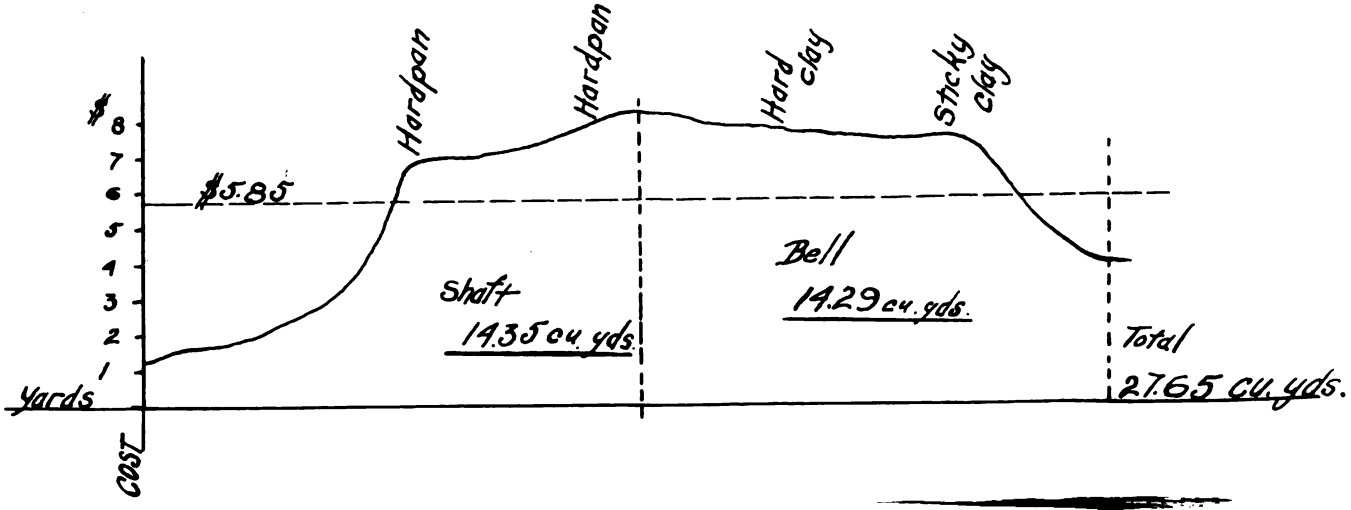
$ 7.47

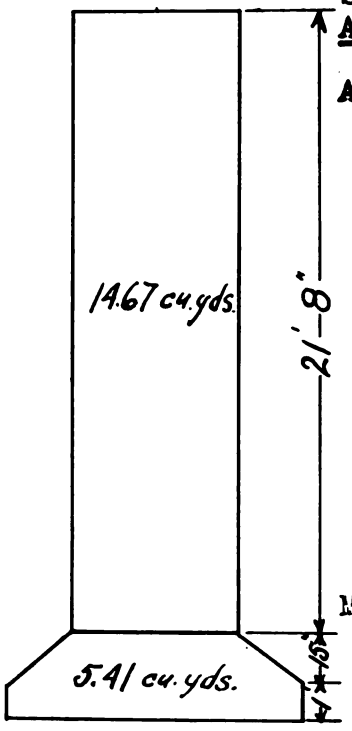
#See other sheets for details.

Diagram is for typical caisson of this class.

Yardage cost curve, showing increase or decrease in actual digging cost per cu.yd. excavated.

Yardage excavated is proportional to depth of shaft.

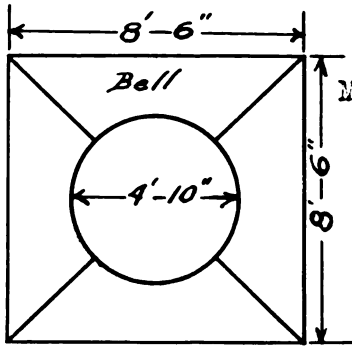




Same procedure as for Type I
Average of six 4'-10" holes.

ACTUAL LABOR OPERATIONS			TOTAL	UNIT cu.yd.
Digging	76½	digger hrs.		
"	9	labor "	$45.29	
Lagging	7½	digger "		
"	6	labor "	6.58	
Tending	70½	" "	24.43	
Supervis.	8	foreman "	4.37	
Hoisting	15½	engineer"		
"	3	labor "	8.57	
Teaming @ 70¢/hr.			10.17	
Dumping privileges			7.05	
Extra wagons			1.12	
			$107.57	5.361

MISCELL. LABOR#	
Lagging(cutting) and analogous work	.154
Building tripods,platforms etc.	.320
Miscell. excavation charges	.287
	.761

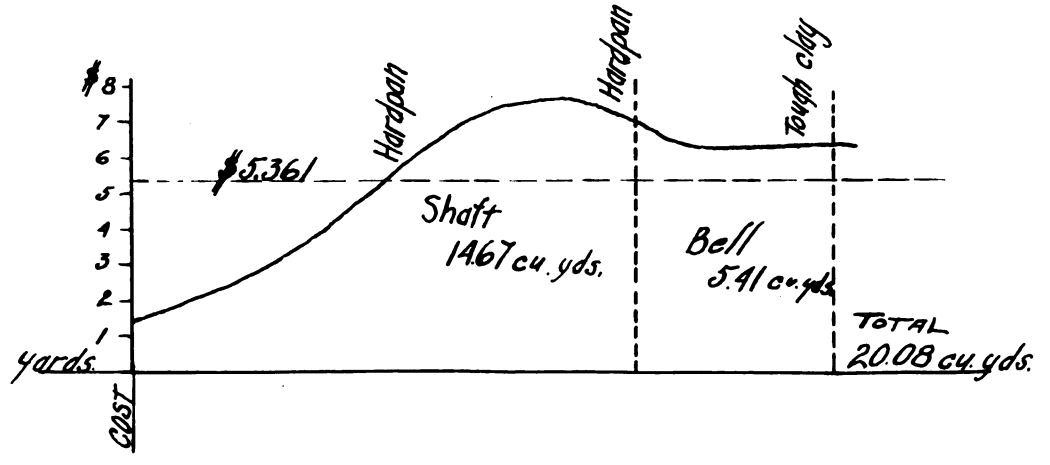


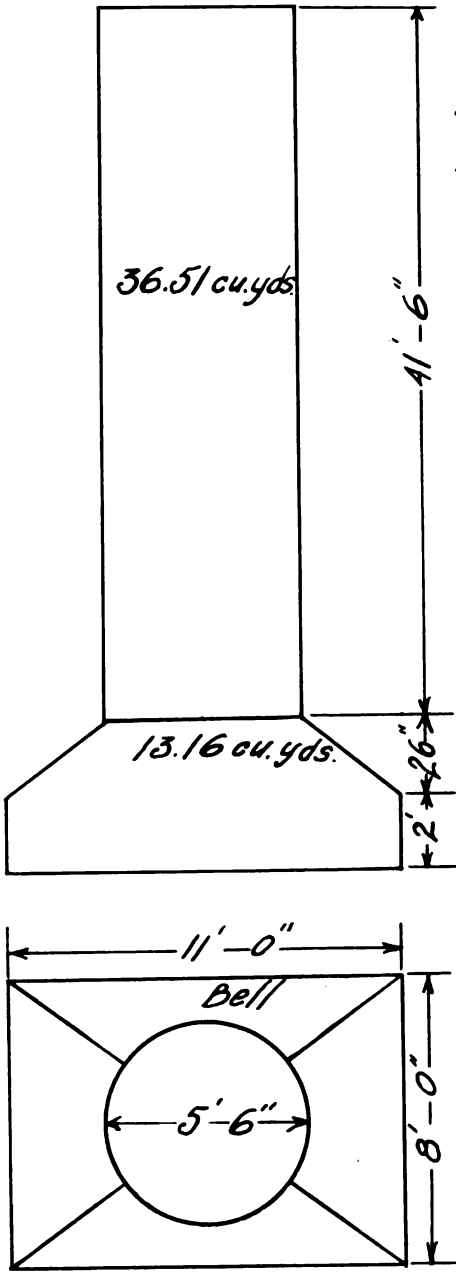
MATERIAL#	
Lagging	.555
Miscell. excavation,operating	.035
Platforms,tripods,tackle etc.	.274
	.864

TOTAL COST PER CU.YD. $6.986

#See other sheets for details.
Diagram of typical caisson of this class.

Yardage cost curve showing increase or decrease in actual digging cost per cu. yd. excavated.
Yardage excavated is proportional to the depth of shaft.





Dirt delivered from high platforms directly into wagons.
Hand-shoveling eliminated.
Average of six 5'- 6" holes.

ACTUAL LABOR OPERATIONS.

Digging	126½	digger hrs.	$76.99
Lagging	16	" "	
"	9	labor "	13.96
Tending	87	" "	30.66
Supervis.	7	foreman "	4.41
Hoisting	40	engineer "	20.26
Teaming	@ 70¢ per	"	32.86
Dumping privileges			23.31
Extra wagons @ $2.25 per day			13.36
			$215.72

UNIT CU.YD. $4.340

MISCELL.LABOR#

Cutting lagging,etc	.154
Building tripods,platforms	.320
Miscell. excavation charges	.287
	.761

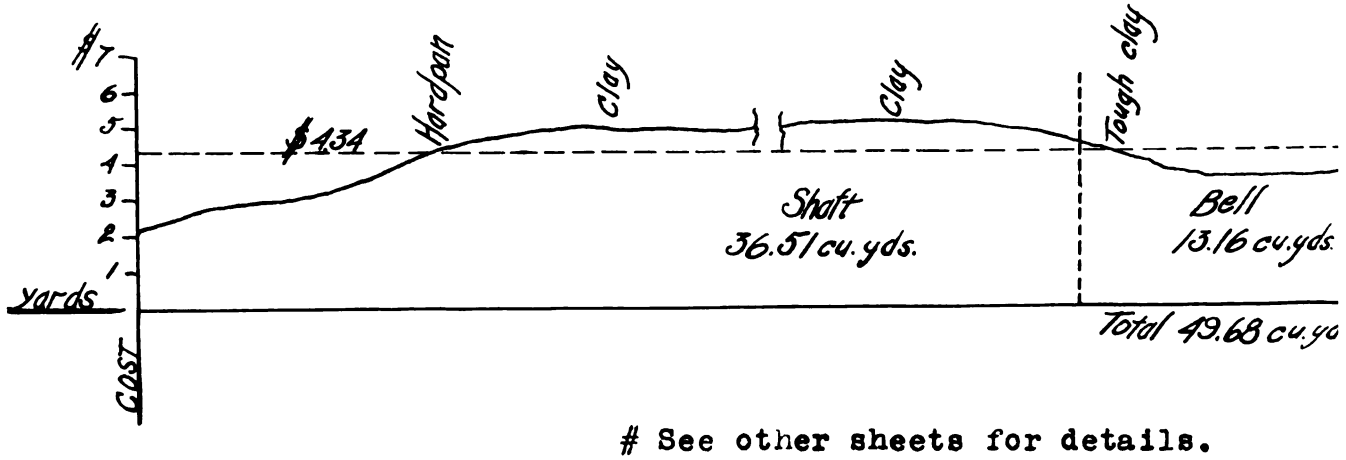
MATERIAL#

Lagging	.555
Miscell.excavation,operating	.035
Platforms,tripods,tackle.	.274
	.864

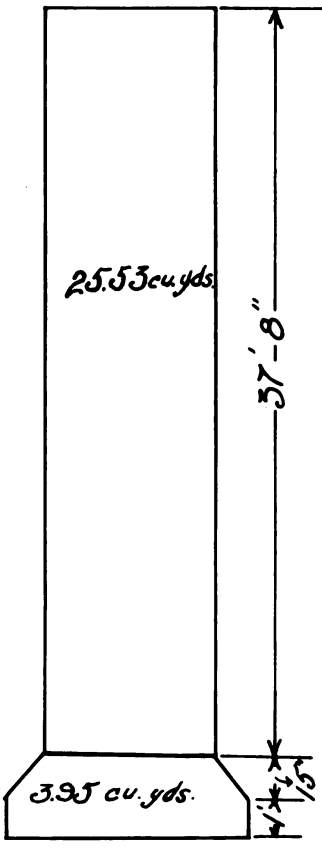
TOTAL UNIT COST PER CU.YD. $5.965

Diagram is typical of this class.

Yardage cost curve showing increase or decrease in actual digging cost per cu.yd. excavated.
Yardage is proportional to depth of shaft.



See other sheets for details.

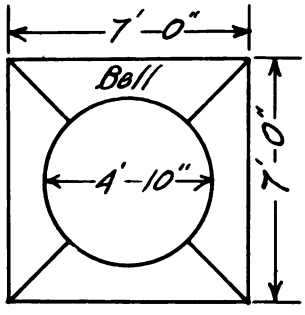


PROCEDURE SAME AS TYPE III.
High platforms.
Average of seven 4'- 10" holes.

ACTUAL LABOR OPERATIONS.

Digging	93½	hrs. diggers	$56.69
Lagging	16½	digger hrs.	
"	9	labor "	13.09
Tending	70½	" "	24.79
Supervis.	6½	foreman "	3.76
Hoisting	24	engineer "	
"	2	labor "	11.72
Teaming @ 70¢ per hr.			20.27
Dumping privileges			15.53
Extra wagons @ $2.25 per day			8.81
			$154.82

UNIT COST PER CU.YD. $5.23



MISCELL. LABOR#

Cutting lagging and analogous etc	.154
Building tripods, platforms etc.	.320
Miscell. excavation charges	.287
	.761

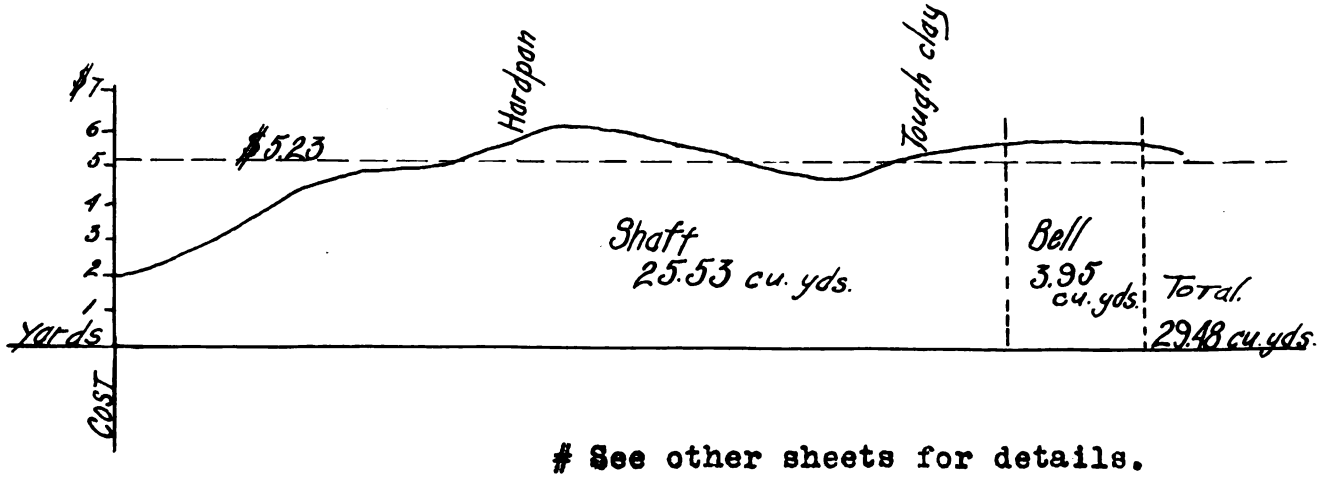
MATERIALS#

Lagging	.555
Miscell. excavation, operating	.035
Platforms, tripods, tackle etc.	.274
	.864

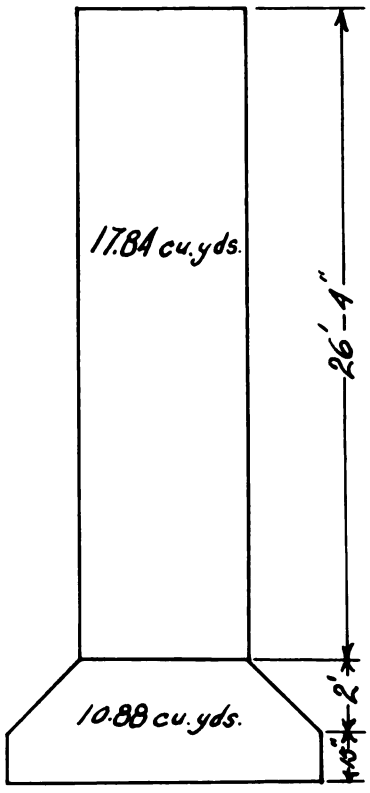
TOTAL UNIT COST PER CU.YD. $6.855

Diagram is of typical caisson of this class.

Yardage cost curve showing increase or decrease in actual digging cost per cu.yd. excavated.
Yardage excavated is proportional to the depth of shaft.



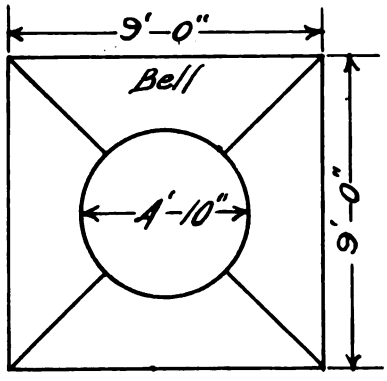
See other sheets for details.



Dirt loaded from high platforms.
Dumped directly into wagons.
Average of four 4'- 10" holes.

ACTUAL LABOR OPERATIONS.		TOTAL.
Digging	79 digger hrs	$
"	3 labor "	48.69
Lagging	11 digger "	
"	7 labor "	9.42
Tending	57 " "	20.23
Supervis,	5 foreman "	2.81
Hoisting	20 engineer"	
"	2 labor "	11.09
Teaming @ 70¢ per hour.		17.89
Dumping privileges		12.55
Extra wagons @ $2.25 per day		10.17
		$132.86

UNIT COST PER CU.YD. $4.64



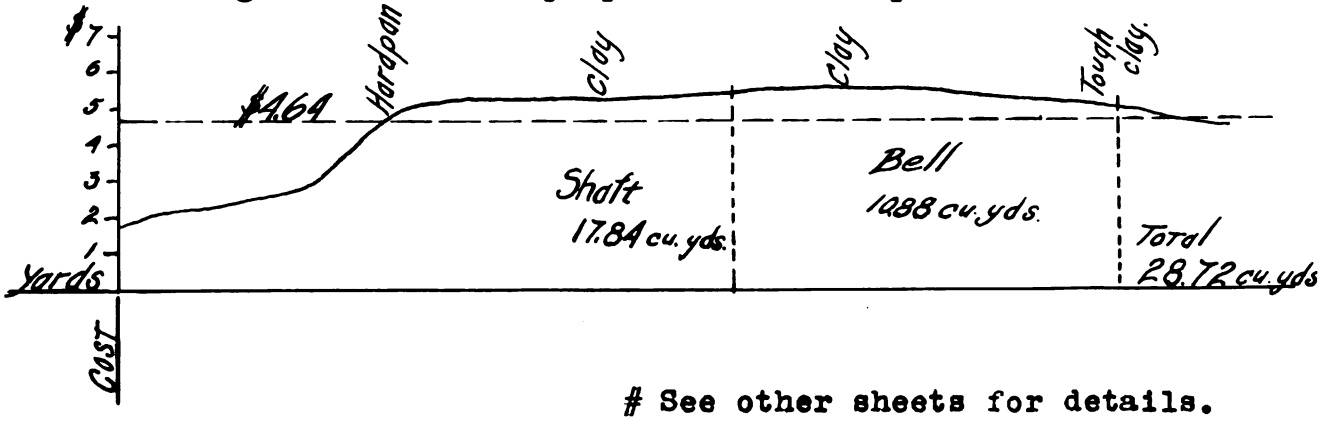
MISCELL. LABOR#	
Cutting lagging etc.	.154
Building tripods,platforms	.320
Miscell excavation charges	.287
	.761

MATERIALS#	
Lagging	.555
Miscell. excavation operating	035
Platforms,tripods,tackle etc.	.274
	.864

TOTAL UNIT COST PER CU.YD. $6.265

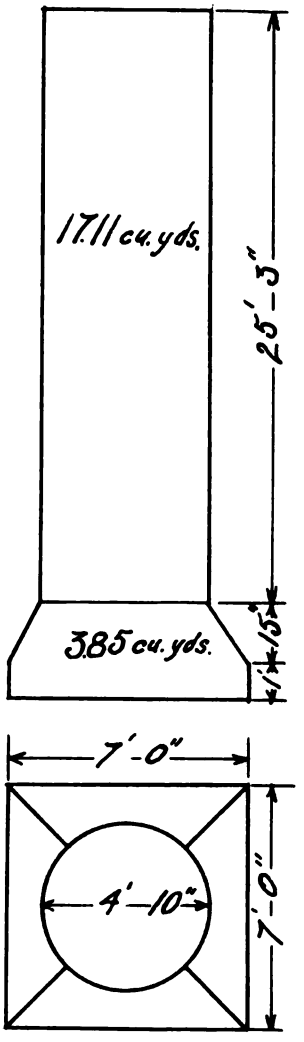
Diagram is of typical caisson of this class.

Yardage cost curve showing increase or decrease in actual digging cost per cu.yd. excavated.
Yardage excavated is proportional to depth of shaft.



See other sheets for details.

Dirt loaded from high platforms.
Dumped directly into wagons.
Average of four 4'- 10" holes.



ACTUAL LABOR OPERATIONS.			TOTAL.
Digging	76 digger	hrs.	$45.59
Lagging	13 "	"	
"	7½ labor	"	10.35
Tending	54 "	"	19.24
Supervis.	5½ foreman	"	2.70
Hoisting	19½ engineer	"	
"	1½ labor	"	9.81
Teaming @ 70¢ per hour			14.31
Dumping privileges			10.49
Extra wagons @ $2.25 per day			6.60
			$109.11

UNIT COST PER CU. YD. $5.670

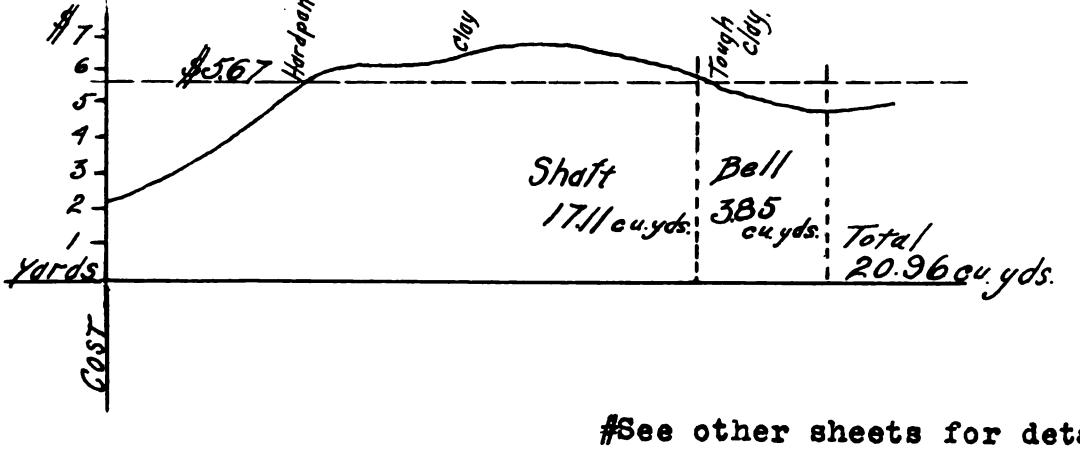
MISCELL. LABOR#	
Cutting lagging and etc.	.154
Building tripods, platforms etc.	.320
Miscell. excavation charges	.287
	.761

MATERIAL#	
Lagging	.555
Miscell. excavation, operating	.035
Platforms, tripods, tackle etc.	.274
	.864

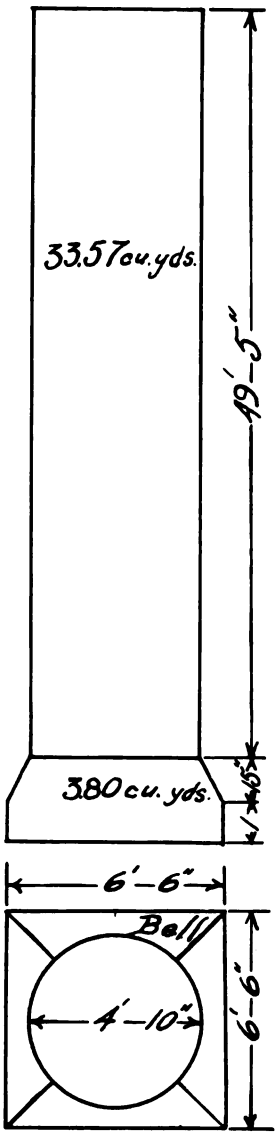
TOTAL UNIT COST PER CU.YD. $7.295

Diagram is of typical caisson of this class.

Yardage cost curve showing increase or decrease in actual digging cost per cu.yd. excavated.
Yardage excavated is proportional to depth of shaft.



#See other sheets for details.



Dirt loaded from high platforms.
Dumped directly into wagons.
Average of six 4'-10" holes.

ACTUAL LABOR OPERATIONS.			TOTAL
Digging	119	digger hrs.	$71.40
Lagging	21½	" "	
"	10	labor "	17.36
Tending	92	" "	32.28
Supervis.	7½	foreman "	4.24
Hoisting	32	engineer "	
"	4	labor "	17.77
Teaming @ 70¢ per hour			26.54
Dumping privileges			19.24
Extra wagons @ $2.25 per day			12.48
			$201.47

UNIT COST PER CU.YD. $5.39

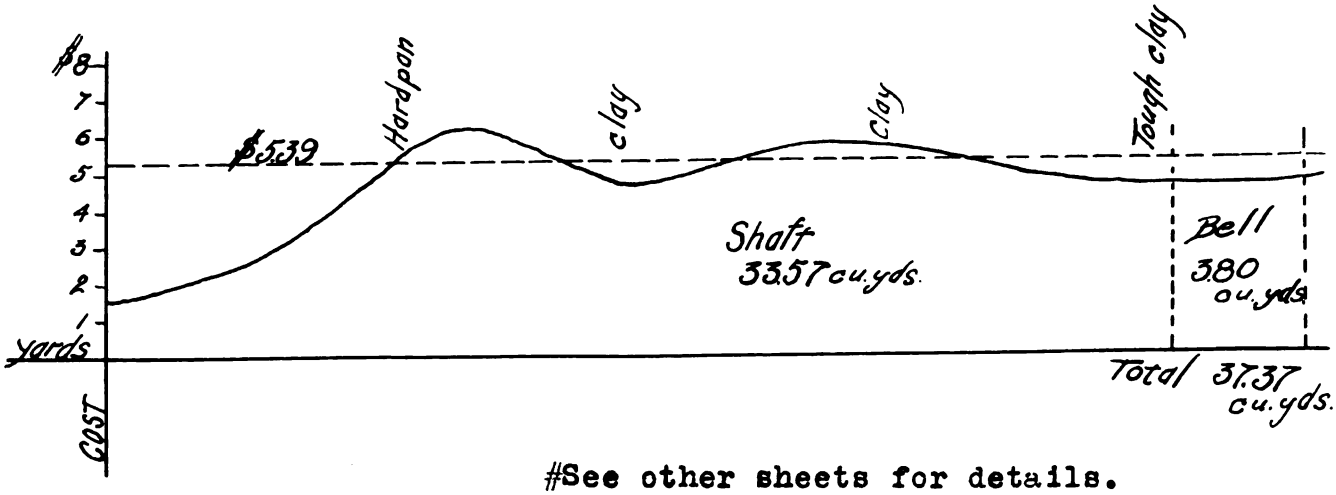
MISCELLANEOUS LABOR#	
Cutting lagging etc.	.154
Building tripods, platforms etc.	.320
Miscell. excavation, operating	.287
	.761

MATERIAL#	
Lagging	.555
Miscell. excavation operating	.035
Platforms, tripods, tackle etc.	.274
	.864

TOTAL COST PER CU.YD. $7.015

Diagram is of typical caisson of this class.

Yardage cost curve showing the increase or decrease in actual digging cost per cu. yd. excavated.
Yardage excavated is proportional to the depth of shaft.



#See other sheets for details.

COST OF TRIPODS,PLATFORMS ETC.

LABOR#				TOTAL	UNIT
Supervision	80 hrs.	@	.56	$44.80	cu.yd.
Carpenter	720 "	@	.50	360.00	
Laborers	140 "	@	.35	49.00	
Engineer	55 "	@	.50	27.50	
				$481.30	.320

MATERIAL#		
Lumber 5.2M rough @ $20	$104.14	
Miscellaneous hardware	21.43	
Rope,cable etc 2000'	250.00	
Blocks and accessories	60.00	
	$435.57	.274

#Labor distributed over 1500 cu.yds.
#Material distributed over 1650 cu.yds.

NOTES:-

The contractor furnished three hoists,the hoisting buckets,a small percentage of the operating materials and accessories. The material charges covers the lumber necessary for approximately twenty platforms etc.

The tripods and the platforms for Types I and II were located directly over the shafts but were only about two feet above the ground. The dirt was dumped on the ground,as brought to the surface,and,as accumulated,was loaded into wagons by hand-shoveling.

The tripods and platforms for the other types were located directly over the shafts and were about six or seven feet above the ground and movable.
They were so built that an extra empty dump wagon could be placed along side and filled by dumping the dirt,as it was hauled to the surface,directly into the standing wagon. An extra charge of $2.25 per day,was made for each of the five wagons used,but the labor eliminated by this method greatly offset this cost.
Seven of these movable platforms were found sufficient for approximately forty holes,as only three hoists were used. An average of seven holes were kept working and the hoisting lines run from nigger heads on the engine, allowing two or three lines to each hoist and engineer.

COST OF LAGGING.

LABOR#			TOTAL	UNIT
Supervision	55hrs.	@ .56	$30.80	cu.yds.
Carpenter	336 "	@ .50	168.00	
Labor	51 "	@ .35	17.85	
Truck	14 "	@ 1.00	14.00	
			$230.65	.154

MATERIAL#

Lumber 26.5 M 2" x 6" x 14'-0"	@ $32	$847.81	
Miscellaneous hardware		15.30	
Operating ,hay ,wedges etc.		12.82	
Alterations to extra bands		38.50	
		$914.43	.555

#Labor distributed over 1500 cu.yds.

#Material distributed over 1650 cu.yds.

NOTES:-

The lumber used was beveled to allow for the curvature of the shaft. It was delivered in 14 feet lengths and wascut to the needed length on the job. 90% of the lagging was cut into 4'-8" lengths(each 14' length cut to three pieces) and the remainder cut into desired lengths. In concreting,it was necessary that some of the lagging be left to prevent the banks from caving,but the greater part removed and used again.

The labor unit for removing the bands and the lagging during concreting was,in this case $0.232 per cu.yd.

The bands or rings used to hold the lagging were furnished by the contractor,a few had to be altered on account of the change in size of a few of the caissons. Approximately 350 of these bands wereused on the job and some were lost in the concreting.
The truck time charged to this item is due, mostly,to the transporting of these bands.
The miscellaneous hardware charged is for belts,nuts and similar equipment.

MISCELLANEOUS EXCAVATION CHARGES.

LABOR#				TOTAL	UNIT
Supervision	95	hrs. @	.56	$53.20	CU.YD.
Carpenter	145	" @	.50	72.50	
Laborer	595	" @	.35	208.25	
Engineer	50	" @	.50	25.00	
Truck	50	" @	1.50	75.00	
				$433.95	.289

MATERIAL#

Operating(gasoline,oils,batteries etc.)

$52.20 .035

Labor and material both distributed over 1500 cu.yds.

NOTES:-

These miscellaneous charges are charges which could not be charged directly to either actual labor of digging or to building platforms and tripods.
They include the erection and setting up of hoist engines making alterations and repairs to the equipment,messenger service after oils and material,"safety first" precautions etc., and all other miscellaneous work including truck time for the hauling of materials.
Also includes miscellaneous supervision for the laying of the work as well as the labor foreman's time.
Allowance has been made for the cleaning up of the job when completed.

None of the charges made in this study of the costs include the office organization,or of the material or of tool-room or general up-keep costs.
Most of the tools and the miscellaneous equipment used were furnished by the contractor and are not included in these reports. Contractor's percentages on labor and materials are not included.

As this work was done by a company,which generates electric current, there are no charges for the power used by the electric hoists included in these miscellaneous expenditures.

CONCRETING CAISSONS, 1325 cu.yds. at this report.

MATERIAL			ITEM	TOTAL	UNIT
Cement	1730 bbls	@ $1.90	$3287.00		
Stone	985.8 T	@ 2.00	1971.60		
Gravel	566 cu.yds.	@ 3.25	1839.50		
Sharp sand	231 " "	@ 2.75	635.25	$7733.35	$5.842
Operating	280 gals. gas.		56.00		
"	6.0 M lumber		120.00		
"	miscellaneous		6.00	182.00	.137
"					

LABOR	HOURS.				
Pouring	134 super.	@ .56	$ 75.04		
"	2668 labor	@ .35	960.48		
"	86 engin.	@ .52	44.72	1080.24	.817
Move mixer etc.	35½ super.	@ .56	19.88		
" " "	375 labor	@ .40	150.00	169.88	.128
Miscell.	26½ super	@ .56	14.84		
"	super. expense		14.25		
"	290½ labor	@ .36	104.40		
"	51½ engr	@ .52	26.78		
"	105 truck	@1.32	138.60	298.87	.226

TOTAL COST $9464.34

UNIT COST PER CU.YD. $7.150

NOTE:-
This includes only actual labor time and does not include time of the tool-room clerk or office organization. Includes charges for transportation and setting up of the mixers and equipment. Most of the truck time charged is for the hauling of cement.
Two small "Chicago" mixers were used.

REINFORCING STEEL 51,150# at this report.

LABOR			
Placing	84 super.hrs.	@ .60	$ 50.40
"	508½ labor "	@ .45	228.82
Miscell.	58 " "	@ .45	26.10

TOTAL COST $305.32

UNIT COST PER POUND $0.00597

PRICES OF THE PRINCIPAL MATERIALS USED. SPRING OF 1917.

Lumber for lagging (special design)		$32.00/M
Miscell.rough lumber(mostly 2nd-hand)		20.00/M
Other miscell. lumber(average price)		32.00/M
Heavy strap hinges(6"for platform doors)		2.00/doz.
Hartz blocks 10"		2.25 ea.
Thimbles 1½"		.06 "
Marsh hay (extraordinary lagging)		.80/100#
Manilla rope 1 1/8"		.32/#
Manilla rope 5/8"		.25/#
Gasoline		.20/gal.
Motor oil		.40/ "
Batteries		.35 ea.
Spark plugs		.75 "
Nails	$3.60 &	4.00/kg
Wedges(wood)		.03 ea.

LABOR RATES DURING EXCAVATION SPRING OF 1917.

Foreman	$ .55 - .60 per hr.
Diggers	.60 " "
Carpenters	.45 - .55 " "
Laborers	.35 - .37½ " "
Engineers	.45 - .52½ " "
Team and driver	.70 " "
Extra wagons	2.25 per day.
Dumping privileges (two dumps)	.55 - .90 per load.

NOTE:-

Labor scarce and times good,contractor working on a percentage basis.

GENERAL ITEM REINFORCING STEEL for SUB- GENERAL DRAWING NO. 6 C 17 -3-4-5

DETAILED SUBJECT STRUCTURE WORK ORDER 187085 FHM JOB 13

PLANT CONGRESS STREET HEATING PLANT DATE WANTED IN FIELD

THIS SHEET COVERS MATERIAL FOR Reinforcing Bars for Foundation Complete.
(GIVE NUMBER OF UNITS OR COMPLETE DESCRIPTION)

This Bill of Material supersedes B.M. 2254 Sheet #2. ← N.B.

No. OFF	ITEMS	KIND OF MATERIAL	PATTERN NO. OR DETAIL NO.	DETAIL DRAWING NO.	REMARKS
4	1" Gabriel Ovoid Bars 32' - 0" long	MEDIUM STEEL	8 -32 - 0 *		

* Mark means 8/8 or 1" rod 32'-0" long.

All bars to be wired in bundles and tagged with our detail number.

All bars shall be in accordance with the "Current Standard Specifications for Billet Steel" Reinforcing Bars as adopted by the American Society for Testing Materials. ← N.B.

MAR 8 - 1917 C.H.D

WRITTEN BY H.C.M. K DATE Feb. 20, '17. APPROVED BY [signature] DATE 3-6-17

CHECKED BY W.R.L. J.R.F. DATE 3-6-17 DATE PRINTED MAR 7 1917

GENERAL ITEM REINFORCING STEEL FOR SUBSTRUCTURE — GENERAL DRAWING NO.

DETAILED SUBJECT — WORK ORDER — JOB

PLANT CONGRESS STREET HEATING PLANT — DATE WANTED IN FIELD

THIS SHEET COVERS MATERIAL FOR Reinforcing Bars for Foundations Complete.
(GIVE NUMBER OF UNITS OR COMPLETE DESCRIPTION)

Wire Stays for Concrete Piers.

Item No.	No. Required	ITEMS	KIND OF MATERIAL	PATTERN NO. OR DETAIL NO.	DETAIL DRAWING NO.	REMARKS
1.	950	1/4" Center Line Wire Stays 11' - 8" long	Iron Wire	"A"	3 C 17-2	
2.	240	1/4" Center Line Wire Stays 19' - 0" long	"	"B"	"	
3.	50	1/4" Center Line Wire Stays 12' - 4" long	"	"C"	"	
4.	50	1/4" Center Line Wire Stays 14' - 0" long	"	"D"	"	

All wire stays to be wired in bundles and tagged with our detail number.

To be taken care of by C. H. Dickinson then the A.A.A. to Feb. 6/17

Void. Sheet #8 supersedes Sheet #5

Shows method of record when bills are revised. Detail letters "A" etc are for bent rods.

H.C.M. 2/20/17

W.R.L. APR 3 1917 C.H.D.

WRITTEN BY H.C.M. DATE Feb. 2, '17 APPROVED BY [illegible] DATE 2-4-17

CHECKED BY J.R.J. DATE 2-3-17 DATE PRINTED MAR 7 1917

GTCB-4

GENERAL ITEM REINFORCING STEEL for SUB- GENERAL DRAWING NO. 6 0 17 -3-4-5

DETAILED SUBJECT STRUCTURE WORK ORDER 187055 FHM JOB 13

PLANT CONGRESS STREET HEATING PLANT DATE WANTED IN FIELD

THIS SHEET COVERS MATERIAL FOR Reinforcing Bars for Foundations Complete.
(GIVE NUMBER OF UNITS OR COMPLETE DESCRIPTION)

Wire Stays for Concrete Piers. This Sheet Supersedes B.M.2254 Sheet 5.

Item No.	No. Required	ITEMS	KIND OF MATERIAL	PATTERN NO. OR DETAIL NO.	DETAIL DRAWING NO.	REMARKS
1.	950	1/4" Diameter Wire Stays 15' - 3" long	IRON WIRE	"A"	3017-2	
2.	225	1/4" Diameter Wire Stays 16' - 9" long	IRON WIRE	"B"	3017-2	
		All wire stays to be wired in bundles and tagged with our Detail Number.				

No special features.
Not as complete as it should be.

WRITTEN BY J.R.J. K DATE Feb. 20, '17. APPROVED BY [illegible] DATE 3-6-17

CHECKED BY C.M.C DATE 3-7-17 DATE PRINTED MAR 7 1917

C.J.M.R.

TITLE Reinforcing Steel

GENERAL DRAWING NO. 6C17-9

WORK ORDER 187D55 JOB 13

PLANT Congress St. Heating Plant

DATE WANTED IN FIELD

THIS SHEET COVERS MATERIAL FOR Pipe Gallery Floor (3 sheets - sheet #1)
(GIVE NUMBER OF UNITS OR COMPLETE DESCRIPTION)

- Gabriel Bars -

Item No.	No. Required	ITEMS	KIND OF MATERIAL	PATTERN NO. OR DETAIL NO.	DETAIL DRAWING NO.	REMARKS
1	6	MK 3-2-0				
2	450	MK 3-2-6 (25 to a bundle)				This is the bill written in the field office.
3	367	MK 3-2-6 (21 to a bundle)				
4	253	MK 3-2-6 (23 to a bundle)				
5	224	MK 3-2-6 (14 to a bundle)				
6	86	MK 3-2-6				
7	4	MK 3-2-9				
8	207	MK 3-3-0 (23 to a bundle)				
9	50	MK 3-3-0				
10	16	MK 4-4-0				

WRITTEN BY H.J.Q. DATE 5/24/17 APPROVED BY DATE C.R. BROOKS

CHECKED BY DATE