JOHN S. HARTMAN
110
813
THS

THE DESIGN OF A STEEL TAINTOR GATE FOR MOORE'S PARK DAM LANSING, MICHIGAN

Thesis for the Degree of B. S.

JOHN S. HARTMAN

1929

THESIS

c.1

Davis
Tile Taintor gate

SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK

THE DESIGN OF A STEEL TAINTOR GATE FOR MOORE'S PARK DAM
LANSING, MICHIGAN

A Thesis Submitted to the Faculty of

Michigan State College

of

Agriculture and Applied Science

by

John S. Hartman

Candidate for the Degree of

Bachelor of Science

June 1929

THESIS
cop. 1

- MOORE'S PARK DAM -

Moore's Park Dam was constructed in 1906. Its purpose is to furnish water to the condensers of the steam power plant near by, however, some power is developed by the turbines and generators at the dam when water is abundant.

Below is a picture of the dam, showing the power plant, overflow dam with splash-boards, and the spillway proper. The steam power plant is at the right, but cannot be seen in the picture.

The picture below is a more distinct view of the spillway. The wooden Taintor gates can easily be distinguished. An "II beam can be seen on top of the axis of the gate to the left. The reinforcement was placed there after the gate had been installed, as it was necessary to keep that portion of the gate from failing.

96517

-REMARKS-

This thesis is a design of a steel Taintor gate to take the place of the wooden one now in use. The wooden gates have proven satisfactory except for their axis, which is of steel and is designed of insufficient strength.

In studying the subject of this thesis, one great fault that can be found with the present design of the dam is the fact that there is no means of keeping the ice melted away from the spillway gates. By experience, it has been found that although the gates are only open about once a year, this time always occurs in the spring while the ice is still solid. Before the gates can be raised it is necessary to cut the ice away from them, which often takes three or four days. This is both expensive and dangerous. It is not only expensive due to the amount of work required to remove the ice, but also due to the damage often done to the gates. The last time the ice was removed, one gate was so badly damaged that it had to be replaced. The danger factor due to the great length of time required to get the gates open is of no less importance. If the water should rise very rapidly in the spring before it was expected to, it might even become necessary to dynamite the gates in order to save the power plant. It is therefore essential that some means of keeping the ice melted away from the gates be installed, whether wooden or steel gates are used.

After a careful study of the situation it has been decided that of the three possible methods of heating Taintor gates, steam, electricity, and compressed air, the latter would be the most satisfactory. An air compressor could be installed in the power house and pipes laid to the spillway, the discharge pipe being laid slightly above the gates in the bottom of the river.

Although this steel Taintor gate is designed to be placed in the buttments as they are now, there are two suggestions which could be made if the buttments were to be designed new. (1) Embedded in the wall of the buttment for the belting of the gate to fit against is a wooden member. This piece is not satisfactory due to the fact that it is out of water part of the time causing it to rot. A good grade of concrete would be just as watertight and would be more lasting than this inlaid timber. (2) As the gate now stands, the wooden sill of the gate rests on the concrete base of the buttment, to form a watertight joint. If a steel gate is used, wood against steel gives the most satisfactory joint. In such a design a treated oak timber embedded in the concrete at the base of the gate, for the steel beam of the gate to rest upon, would prove satisfactory as this would be watertight and the timber, always being under water, would last a long time.

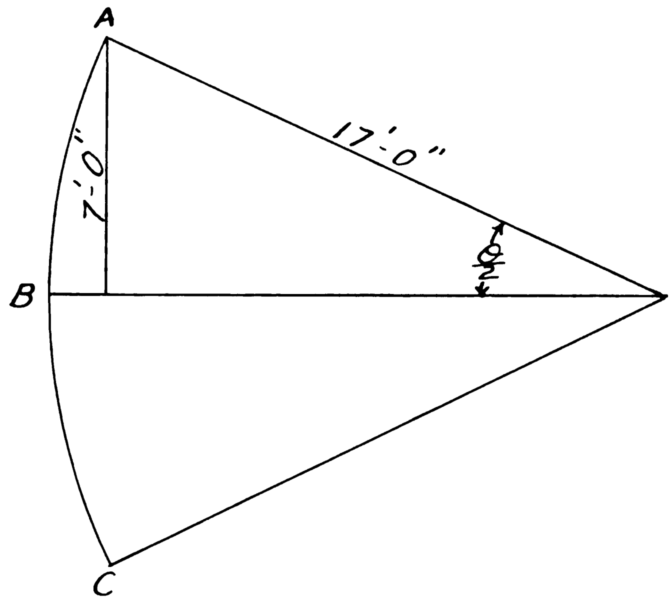
- PROCEDURE -

In undertaking this design the first step was to scale the dimentions of the spillway. A sketch of the piers as found is one of the blueprints. The taintor gate was designed to fit the piers as they are in this sketch. All dimentions would necessarily have to be checked before the actual building of the gate.

Welded joints were selected not because they are more satisfactory than riveted joints, but because of the desire of the author to become more familiar with them. In the investigation it has become appearant that until more is known about such welding, it would be advisable to continue with the old reliable method of riveted joints.

In this design the unit allowable stress for welded joints in tension and shear is used as 5,000 Lbs. per Sq. In. giving a factor of safty of six which is recommended by most authorities on structual welding.

COMPUTATIONS



$\text{Sin } \frac{0}{2} = \frac{7}{17} = .412$

$\frac{0}{2} = 24^{0} - 20'$

$0 = 48^{0} - 40'$

$\text{ABC} = \frac{48.67}{360} (2)\ 3.1416\ (17) = 14.45'$

Total pressure against gate:

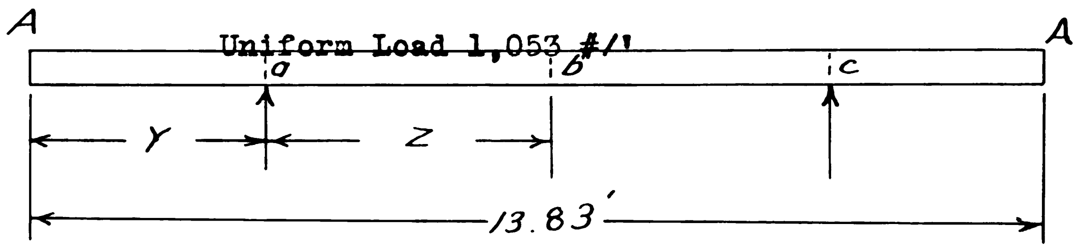
$14.45 \times 62.5 \times \frac{14}{2} = 6{,}320\#/'$ width of gate 6,320#/

Use six channels.

Uniform load on each channel:

$\frac{6{,}320}{6} = 1{,}053\#/'$ 1,053#/'

MEMBER A-A



$$M_a = M_b = 1,053 \times \frac{Y^2}{2} + 1,053 \times \frac{(6.915)^2}{2} - 1,053 \times 6.915\,(6.915 - Y) = 0$$

$$Y^2 + 13.83Y - 47.6 = 0$$

$$Y = -\frac{13.83 \pm \sqrt{(13.83)^2 + 4 \times 47.6}}{2} = -6.915 \pm \frac{\sqrt{191+191}}{2}$$

$$Y = -6.915 + 9.8 = 2.885'$$

$$M_a = \frac{1,053 \times (2.885)^2}{2} = 4,350\ \#'$$

$$M_b = \frac{1,053 \times (6.915)^2}{2} - 6.915 \times 1,053 \times 4.03 =$$

$$25,100 - 29,450 = 4,350\ \#'$$

$$Z = 6.915 - 2.885 = 4.03'$$

Z=4.03'

X=2.88'

$$4,350\ \#' = 52,200\ \#''$$

$$\frac{M}{S} = \frac{I}{C} = \frac{52,200}{16,000} = 3.27$$

Try a 5", 9 # channel

$$\frac{I}{C} = \frac{8.8}{2.5} = 3.52 \quad \text{(O.K.)}$$

5", 9 # channel

MEMBER B - B

Total pressure against gate = 6,320 #/' width.

6,320 x 6.915 = 43,700 # on half the gate.

Devide two ways the center beam taking half the load.

$\frac{43,700}{2}$ = 21,850 #, eccentric loading.

Try 6" x 6" x $\frac{5"}{8}$ angle

L = 16' = 192"

r = 1.17"

A = 7.11 sq. "

$\frac{L}{r} = \frac{192}{1.17} = 164$ (allowable stress = 4,800 #/sq. ")

$\frac{21,850}{7.11}$ = 3,080 #/sq." (compression for axial loading)

x = 1.73 - .625 = 1.105"

M = 1.105 x 21,850 = 24,100 #"

MC = IS

24,100 x 1.73 = 24.2 x S

S = 1,720 #/sq." (compression due to bending moment)

Total compressive stress = 1,720 + 3,080 = 4,800 #/sq."

Total allowable compressive stress = 4,800 #/sq."

6" x 6" x $\frac{5"}{8}$ Ang

O.K.

MEMBER C - C

Compression load = 1,053 x 6.915 = 7,500 #

Unsupported length not over 24"

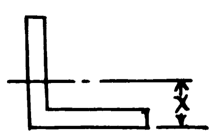
Assume a 3" x 3" x $\frac{3}{8}$" angle

A = 2.11 sq."

r = .58"

$\frac{L}{r} = \frac{24}{.58}$ = 41.4 #/sq." (allowable stress = 13,000 #/sq.")

$\frac{7,500}{2.11}$ = 3,550 #/sq." (compression for axial loading)



x = .89"

M = 7500 x .89 = 6,680 #"

M C = I S

6,680 x .89 = 1.8 x S

S = 3,300 #/sq." (compression due to bending moment)

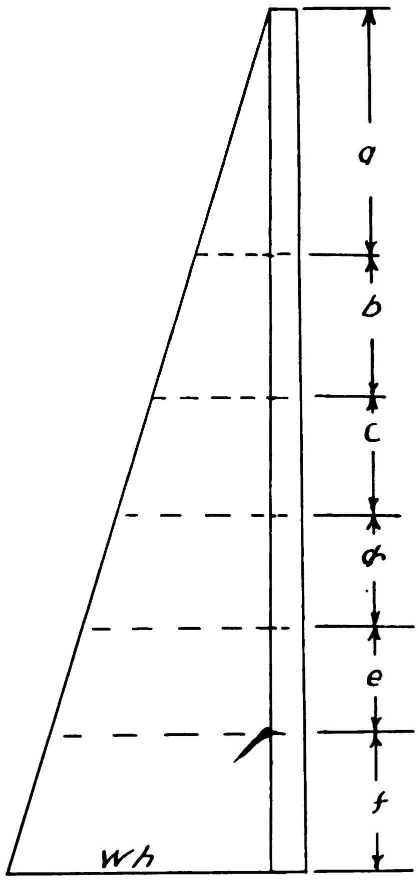
Total compressive stress =

3,550 + 3,300 = 6,850 #/sq."

Total allowable compressive stress = 13,000 #/sq."

3"x3"x3"
Angle O.K.

SPACING OF CHANNELS



Uniform load of 1,053 #/'

of each beam.

$$\frac{wh_1^2}{2} = 1{,}053$$

$$h_1^2 = \frac{1{,}053 \times 2 \times 2}{62.5} = 33.7$$

$a = h_1 = 5.81'$ a=5.81'

$$h_2^2 = \frac{1{,}053 \times 2 \times 2}{62.5} = 67.4$$

$h_2 = 8.22'$

$b = 8.22' - 5.81' = 2.41'$ b=2.41'

$$h_3^2 = \frac{1053 \times 2 \times 3}{62.5} = 101'$$

$h_3 = 10.07$

$c = 10.07 - 8.22 = 1.85'$ c=1.85'

$$h_4^2 = \frac{1053 \times 2 \times 4}{62.5} = 135'$$

$h_4 = 11.62'$

$d = 11.62' - 10.07' = 1.55'$ d=1.55'

$$h_5^2 = \frac{1{,}053 \times 2 \times 5}{62.5} = 168.4'$$

$h_5 = 13.00'$

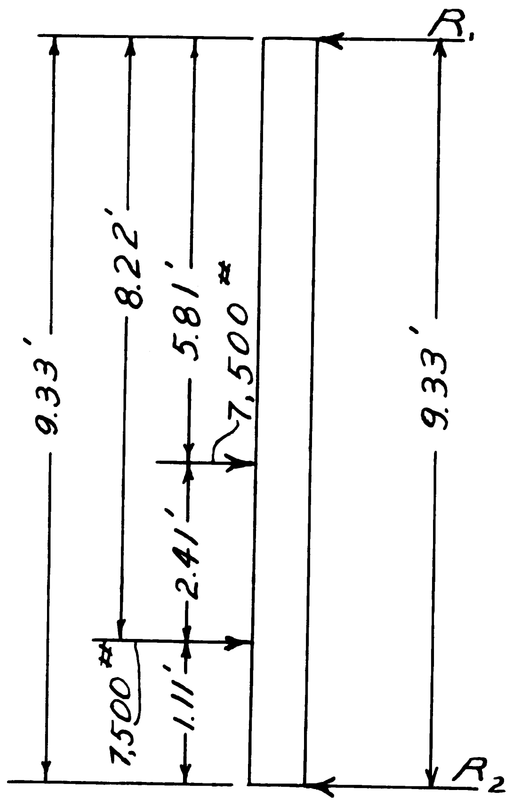
$e = 13.00 - 11.62 = 1.38'$ e=1.38'

$$h_6^2 = \frac{1{,}053 \times 2 \times 6}{62.5} = 202$$

$h_6 = 14.22'$

$f = 14.22 - 13.00 = 1.22'$ f=1.22'

MEMBER D * D



$$R_1 = \frac{3.52 \times 7{,}500 + 1.11 \times 7{,}500}{9.33}$$

$R_1 = 7{,}500 \; (.377 + .119)$

$R_1 = 3{,}720$ #

$M_a = 3{,}720 \times 5.81 \times 12 = 259{,}000$ #"

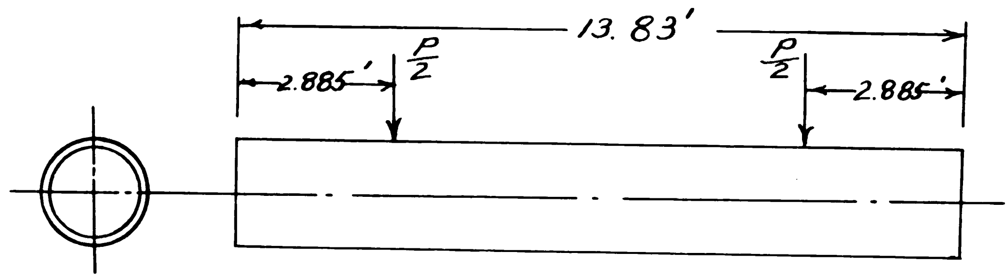
M C = I S

$$I = \frac{259{,}000 \times 5}{16{,}000} = 81 \text{ In.}^4$$

Use a 10", 25 # channel.

10", 25 #
channel

MEMBER - AXIS



$$\frac{P}{2} = \frac{wh^2}{2} \times \frac{13.83}{2} = \frac{62.5 \times (14)^2 \times 13.83}{4} = 42,400 \#$$

$M = 42,400 \times 2.885 \times 12 = 1,470,000$ #"

Try a 12" steel pipe 1" thick.

$$I = \frac{1}{4}(3.1416)(6^4 - 5^4) = .785\ (1296 - 625) = 525 \text{ In.}^4$$

$M\ C = I\ S$

$1,470,000 \times 6 = 525 \times S$

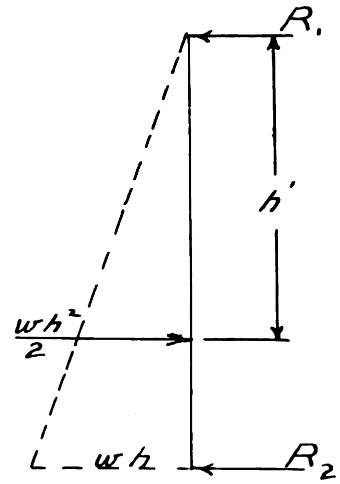
$S = 16,010$ #/sq."

(O.K.)

10" pipe

1" thick

MEMBER F - F



$$\frac{wh^2}{2} = \frac{62.5 \times (5.5)^2}{2} = 945 \#$$

$$R_1 = 315 \#$$

$$R_2 = 630 \#$$

$$\frac{wh_1^2}{2} = 315$$

$$h_1^2 = 10.08$$

$$h' = 3.18$$

$$M = 315 \times 3.18 \times 12 - 315 \times 1.06 \times 12 =$$

$$315 \times 12 \; (\; 3.18 - 1.06 \;) = 8{,}000 \; \#''$$

Moment taken up by the $\frac{3''}{8}$ plate:

$$M \, C = I \, S$$

$$M \times .1875 = \frac{12 \times (.375)^3 \times 16{,}000}{12}$$

$$M = \frac{.0527 \times 16{,}000}{.1875} = 4{,}500 \; \#''$$

8,000 - 4,500 = 3,500 #" to be taken up by angles per foot width of gate.

Try 3" x 3" x $\frac{1''}{4}$ angles

$$M \text{ (per angle)} = \frac{1.2 \times 16{,}000}{2.16} = 8{,}900 \; \#''$$

$\frac{8{,}900}{3{,}500} = 2.57$ (space angles 2.5' or less)

3"x3"x$\frac{1''}{4}$ angles spaced 2.5' or less

TIE ROD (axis to pier)

$\frac{P}{2} = 42{,}400$ #

Area $= \frac{42{,}000}{16{,}000} = 2.62$ sq."

$2.62 \times 1.5 = 3.94$ sq." (use)

2.25" rod = 3.976 sq."

use

$2\frac{1}{4}$" rd

WELDED CONNECTIONS

(all welds are $\frac{1}{4}$" bead)

(allowable strength of weld is 5,000 #/sq." which gives a factor of safty of six.)

Plate to Member E - E

At ends and in center 1" on each side of E - E.

Members A-A to C-C and C-C to D-D

Shearing load : 7,500 #

$\frac{7,500}{5,000}$ = 1.5 sq. In. weld

Members D-D to B-B

Shearing load: 21,850 #

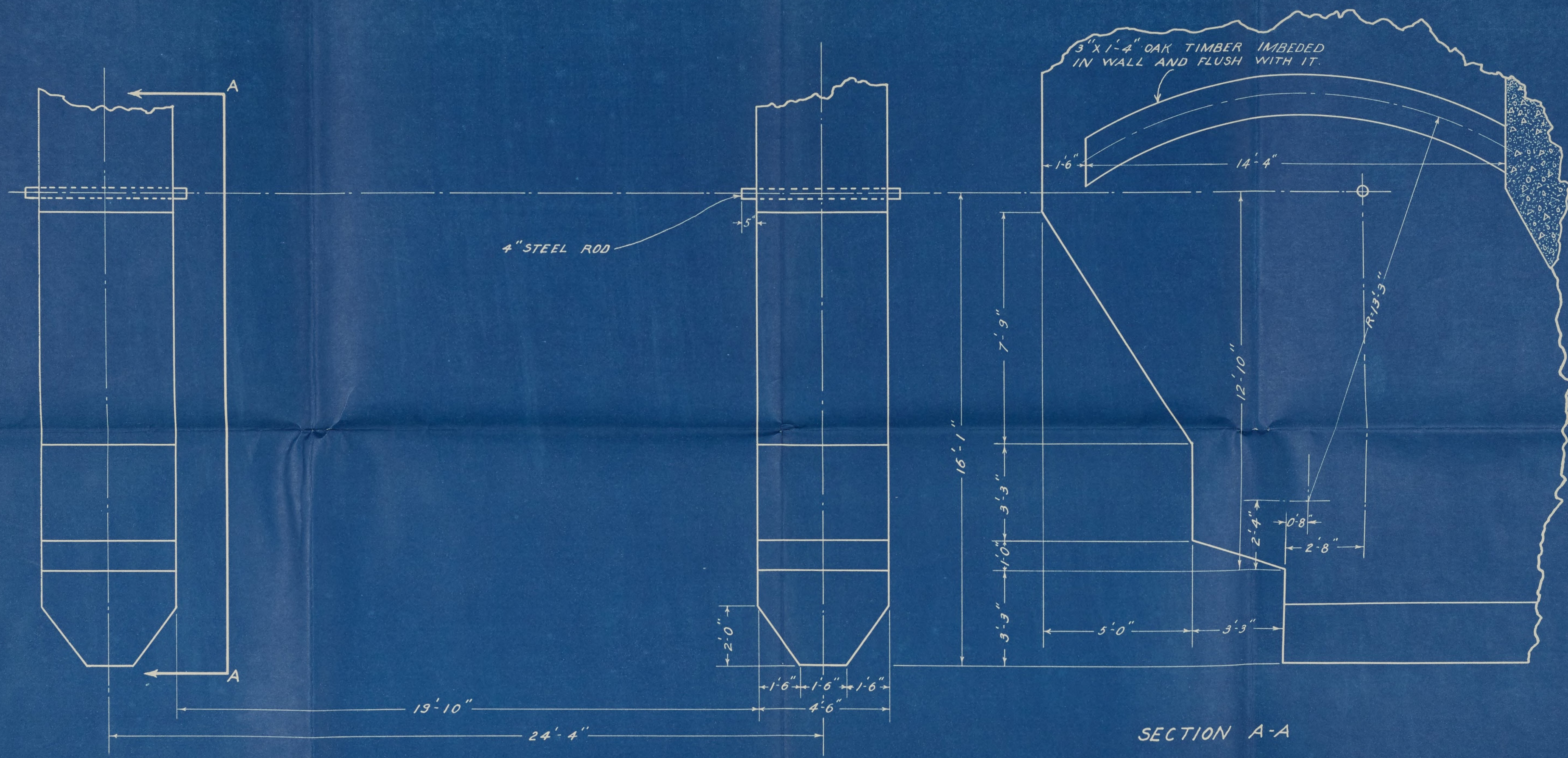
$\frac{21,850}{5,000}$ = 4.37 sq. in. weld.

[redacted]

[redacted]

Pocket has:
2 Blueprints

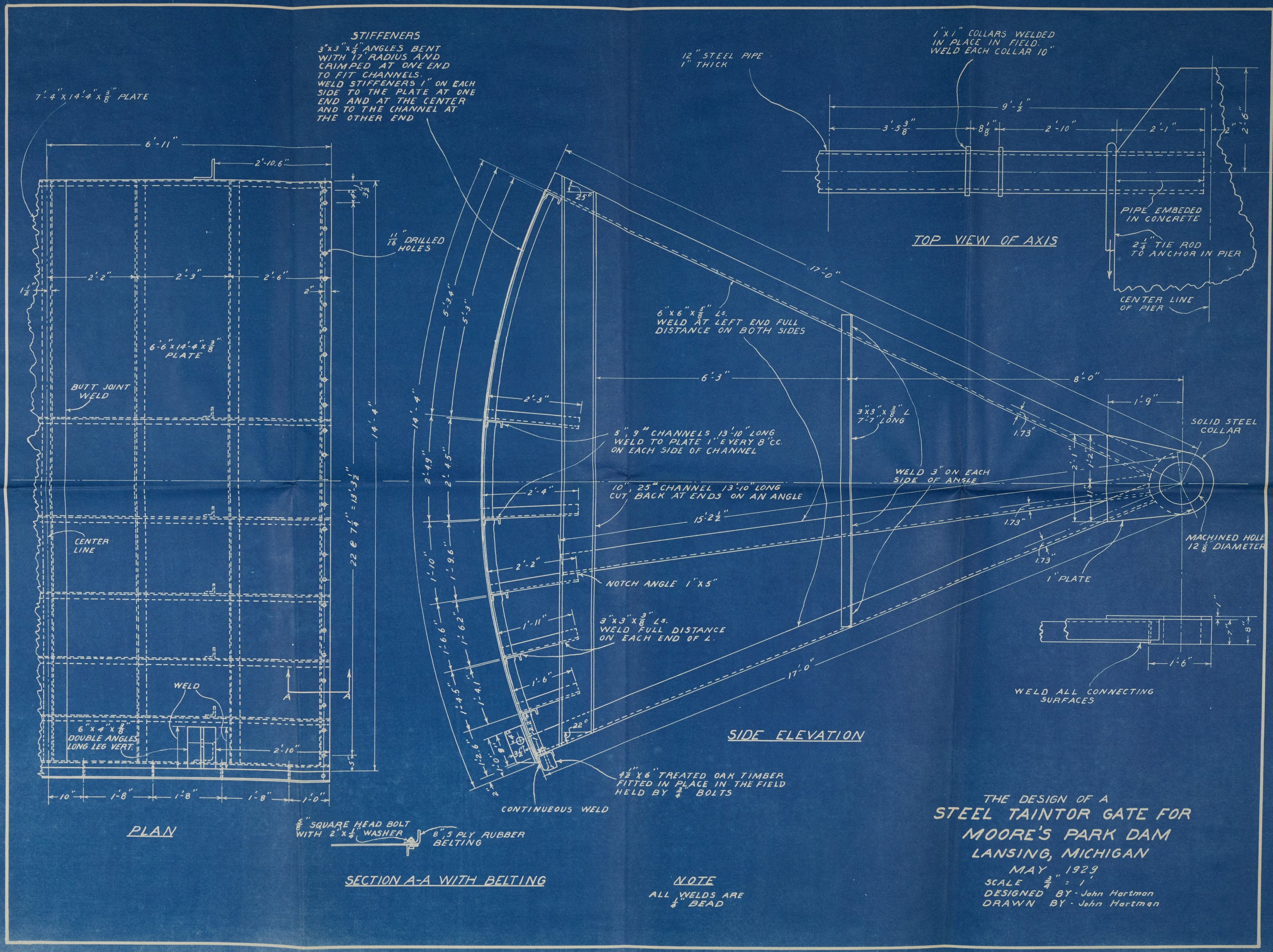
NOTE - THESE DIMENSIONS WERE ROUGHLY SCALED OFF IN THE FIELD.
CHECK ALL IMPORTANT DIMENSIONS BEFORE USING THIS DESIGN.



PLAN

SECTION A-A

SKETCH OF SPILLWAY PIERS AS IS
MOORE'S PARK DAM
LANSING, MICHIGAN
MAY, 1929
SCALE - $\frac{3}{8}$" = 1'-0"
SCALED BY - John Hartman
DRAWN BY - John Hartman


STIFFENERS
3"x3"x1/4" ANGLES BENT WITH 17' RADIUS AND CRIMPED AT ONE END TO FIT CHANNELS. WELD STIFFENERS 1" ON EACH SIDE TO THE PLATE AT ONE END AND AT THE CENTER AND TO THE CHANNEL AT THE OTHER END
7'-4"x14'-4"x3/8" PLATE
6'-11"
2'-10.6"
11/16" DRILLED HOLES
2'-2"
2'-3"
2'-6"
6'-6"x14'-4"x3/8" PLATE
BUTT JOINT WELD
CENTER LINE
22 @ 7 1/4" = 13'-3 1/2"
14'-4"
WELD
6"x4"x3/8" DOUBLE ANGLES LONG LEG VERT.
2'-10"
10"
1'-8"
1'-8"
1'-8"
1'-0"
PLAN
5/8" SQUARE HEAD BOLT WITH 2"x1/4" WASHER
8", 5 PLY RUBBER BELTING
SECTION A-A WITH BELTING
12" STEEL PIPE 1" THICK
1"x1" COLLARS WELDED IN PLACE IN FIELD. WELD EACH COLLAR 10"
9'-1/2"
3'-5 3/8"
8 1/8"
2'-10"
2'-1"
2'-6"
PIPE EMBEDED IN CONCRETE
2 1/4" TIE ROD TO ANCHOR IN PIER
TOP VIEW OF AXIS
CENTER LINE OF PIER
17'-0"
6"x6"x3/8" Ls. WELD AT LEFT END FULL DISTANCE ON BOTH SIDES
6'-3"
8'-0"
1'-9"
SOLID STEEL COLLAR
3"x3"x3/8" L 7'-7" LONG
5", 9# CHANNELS 13'-10" LONG WELD TO PLATE 1" EVERY 8" C.C. ON EACH SIDE OF CHANNEL
WELD 3" ON EACH SIDE OF ANGLE
10", 25# CHANNEL 13'-10" LONG CUT BACK AT ENDS ON AN ANGLE
15'-2 1/2"
MACHINED HOLE 12 1/8" DIAMETER
NOTCH ANGLE 1"x5"
1" PLATE
3"x3"x3/8" Ls. WELD FULL DISTANCE ON EACH END OF L.
17'-0"
WELD ALL CONNECTING SURFACES
1'-6"
SIDE ELEVATION
4 1/2"x6" TREATED OAK TIMBER FITTED IN PLACE IN THE FIELD HELD BY 3/4" BOLTS
CONTINUEOUS WELD
NOTE
ALL WELDS ARE 1/4" BEAD
THE DESIGN OF A
STEEL TAINTOR GATE FOR
MOORE'S PARK DAM
LANSING, MICHIGAN
MAY 1929
SCALE 3/4" = 1'
DESIGNED BY - John Hartman
DRAWN BY - John Hartman

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03084 9719