# A DESIGN OF A PRIMARY TANK AND AN AERATION TANK FOR A SEWAGE TREATMENT PLANT

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

E. Ribeiro I.

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This is to certify that the

thesis entitled

A Design of a Primary Tank and an Aeration
Tank for a Sewage Treatment Plant

presented by

Efrain Ribeiro-Ibanez

has been accepted towards fulfilment
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Chester L. Allen
Major professor

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# A Design of a Primary Tank and an Aeration Tank for a Sewage Treatment Plant.

A Thesis Submitted to

the Faculty of

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of

AGRICULTURE AND APPLIED SCIENCE

by

E. [illegible] I.

Candidate for the Degree

of

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THESIS

## DESIGN OF THE PRIMARY TANK.

The primary tank must have the following dimensions:

Length: 60 ft.

Height: 9 ft., 6 in.

Level of sewage: 8 ft., 3 in.

Width: 14 ft.

The tank must be designed of reinforced concrete and constructed according to the prescriptions and regulations of the American Concrete Institute.

We tried to design this tank according to a new method prepared by the Structural Bureau of the Portland Cement Association and presented in the No. 8 of the publication in *Modern Developments in Reinforced Concrete*. However, the [illegible] in that publication are only for a ratio of [illegible] to 3 between length and width, and, in our case, we have a ratio of 60 over 14, with the resulting ratio 4.28. Thus, this new method would be impracticable for our tank.

Then we decided to design the tank by considering the walls as cantilever walls which would support an interior pressure of the sewage and an exterior pressure of the earth and ground water. We therefore accept in our design the density of the sewage approximately the same as that of water, or 62.4 lbs. per cubic foot. For the short walls we are going to suppose these are continuous walls and a base slab like one supported on four sides.

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1. Design of the long walls.

We are going to design these walls like cantilever walls which will support the pressure of the water. Then we have:

If the pressure of the water is w, the total pressure P is:

$$P = \frac{w \times h^2}{2}$$

With: w = 62.4 lbs. per cubic foot, and h = [illegible] ft., then:

$$P = \frac{62.4 \times [illegible]^2}{2}$$

P = 177[illegible].7 lbs.

We know the resultant is applied at the lower third of the height of the wall, and then the maximum moment produced at the bottom of the wall is:

$$M = P \times \frac{h}{3}$$

$$M = 177[illegible].7 \times \frac{[illegible]}{3}$$

M = [illegible] lbs. in.

The minimum thickness of the wall is:

$$d = \frac{M}{R \times b}$$

where: M--maximum moment

R--[illegible], (from the Reinforced Concrete Handbook)

b--width of the wall, 1 ft.

Then we have:

$$d = \frac{[illegible]}{[illegible]}$$

$$d = [illegible] \text{ in.}$$

The prescription for tanks gives a minimum thickness of 12 in., so, in our case, we adopt a minimum thickness of 12 in. If we consider a recovery for the steel of 1.5 in. at each side, our net thickness is then 12 - 2 x 1.5 = 9 in. We must check this value for the shear, and have:

$$v = \frac{V}{b \times j \times d}$$

Replacing the values, we have:

$$v = \frac{1760}{12 \times .875 \times 9}$$

$$v = 18.6 \text{ lbs. p.s.i.}$$

The allowable shear is:

$$v = 0.12 \times 2,000$$

$$v = 240 \text{ lbs. p.s.i}$$

and therefore is safe for the shear.

<u>Quantity of steel.</u>

To obtain the quantity of steel necessary, we apply the formula:

$$A_s = \frac{M}{f_s \times j \times d}$$

in which:

$M$ = maximum moment

$f_s$ = 20,000 p.s.i.

$j$ = 0.875

$d$ = thickness: 9 in.

Then we have:

$$A_s = \frac{[illegible]6,850}{20,000 \times .875 \times 9}$$

$$A_s = 0.62 \text{ sq. in.}$$

Given an area of .62 sq. in. and a total perimeter of 3.9 in, we choose round steel 5/8 in. with 6 in. of separation between centers. We must check this steel for bond, and have:

$$u = \frac{V}{\Sigma_o \times j \times d}$$

in which:

$u$ = unit bond

$\Sigma_o$ = total perimeter of bars

$j$ = 0.875

$d$ = 9 in.

Then we have:

$$u = \frac{1,760}{3.9 \times 0.875 \times 9}$$

$$u = 58 \text{ lbs. p.s.i.}$$

The allowable bond is:

$$0.05 \times 2,000 = 100 \text{ lbs. p.s.i.}$$

Thus our case is safe.

<u>Anchorage</u>

The bars are going to continue into the base and bend down into the toe of the base slab a distance of 40 diameters of the bars giving a distance of 25 in.

<u>Temperature steel.</u>

We must put temperature steel in both sides for prevention of changes of temperature. This steel is going to be perpendicular to the principal reinforcement and the minimum prescribed is 0.125% of the section of the wall.

$$A_s = 0.00125 \times b \times d$$

$$A_s = 0.00125 \times 12 \times 9$$

$$A_s = 0.13 \text{ sq. in.}$$

Thus we select for the temperature steel round steel 3/8 in. with 10 in. spaces between centers.

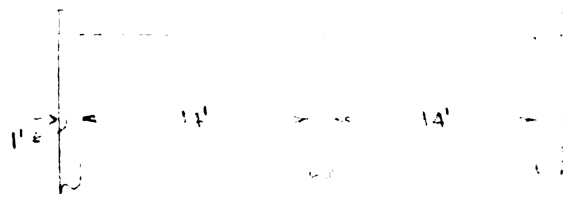
Another consideration.

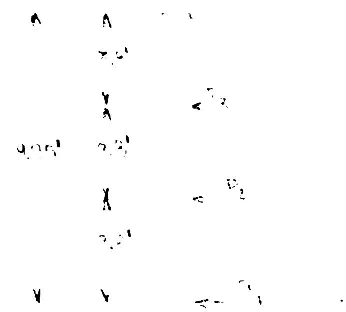
We can cut off some of the bars of the principal re-inforcement because the pressure of the water is less in the high part of the wall. For that reason, the moment is going to vary from its maximum value to zero at the superior level of the sewage, and less steel can be used in those parts. However, in our case, we are not going to do this because the height of our wall is small and we can continue all of the bars to the top.

Also, for the anterior calculus of the long walls, we have made the assumption that the tank was completely filled with the sewage, and now we must consider the problem of an empty tank. In such a case, we are not going to have any interior pressure but we must consider the exterior pressure of the soil and ground water. For our tank, we shall assume that this exterior pressure is equal to our interior pressure (much less possible), and, with that assumption, we shall put the same re-inforcement in both sides of the tank.

## 2. Design of the short walls.

Since these walls have short lengths, we cannot design them like cantilever walls. Therefore we shall consider them as continuous walls. Thus the principal reinforcement is horizontal, and for the calculus we shall divide the height of the wall into three parts since the pressure of the [illegible] is going to vary from a maximum value at the bottom to zero at the top.




### Lowest third.

The length of the continuous wall is:

$$14 + (1.5 \; [illegible]) \times 0.5 = 1[illegible] \text{ feet}$$

We are going to design for the moment $0.1\, w\, l^2$, because we consider the wall as partly fixed in both extremes.

Then we are going to have:

$$M = \frac{w\, l^2}{10}$$

The pressure w in this third is then:

$$W = [illegible].4 \times 9.[illegible]$$

$$w = [illegible] \text{ lbs. per sq. ft.}$$

Then we have:

$$M = \frac{[illegible] \times 1[illegible]^2}{10} \times 12$$

and:

$$M = 1[illegible],[illegible]0 \text{ lbs.}$$

The minimum thickness is:

$$d = \sqrt{\frac{M}{K \times b}}$$

$$d = \text{[illegible]}$$

$$d = \text{[illegible] in.}$$

If [illegible], [illegible] both sides, the total thickness [illegible] in. but [illegible] in. [illegible] of steel [illegible] then:

$$A_s = \frac{M}{f_s \times j \times d}$$

$$A_s = \frac{15[illegible],[illegible]}{[illegible],[illegible] \times .[illegible] \times [illegible]}$$

$$A_s = \text{[illegible] sq. in.}$$

We select for [illegible] of the [illegible] round steel at 3/4 in., spaced [illegible] in. between centers [illegible] giving an area of 1.31 sq. in. and a total perimeter of [illegible] in.

We must now check for the shear for the section we have determined.

$$v = \frac{V}{b \times j \times d}$$

$$v = \frac{[illegible] \times [illegible]}{1[illegible] \times .[illegible] \times [illegible]}$$

$$v = \text{[illegible] lbs. p.s.i.}$$

The allowable shear is [illegible] lbs. p.s.i., so our [illegible] is safe.

Then we check the bond for the steel

$$u = \frac{V}{\Sigma o \times j \times d}$$

Replacing the values in the formula we get:

$$U = \frac{576x7.5}{5.4x0.875x9}$$

$$u = 100 \text{ lbs p.s.i}$$

the allowable bond is 100 lbs, so is safe.

Middle third.

For the middle third we have:

$$w = 62.4 \times 6.25$$

$$w = 390 \text{ lbs per sq. ft.}$$

Then the maximun moment for this section is:

$$M = \frac{w \times l^2}{10}$$

$$M = \frac{390 \times \overline{15}^2}{10} \times 12$$

$$M = 105,400 \text{ in lbs.}$$

Then the quantity of steel for this section is:

$$A_s = \frac{M}{f_s \times j \times d}$$

$$A_s = \frac{105,400}{20,000x.875x9}$$

$$A_s = 0.745 \text{ sq. in.}$$

We select for this section of the wall: round steel $\frac{3}{4}$ in spaced 8 in between centers.

Upper third.

For the upper third we have:

$$w = 62.4 \times 2$$

$$w = 124.8 \text{ lbs.}$$

Then the maximum moment is :

$$M = \frac{w \times l^2}{12}$$

$$M = \frac{[illegible] \times [illegible]^2}{12}$$

$$M = [illegible] \text{ in. lb.}$$

The quantity of steel for this section is:

$$A_s = \frac{[illegible]}{[illegible] \times .[illegible] \times [illegible]}$$

$$A_s = [illegible] \text{ sq. in.}$$

We use round steel [illegible] in., spaced [illegible] in. between centers.

Temperature steel

We must now consider the steel we must put in this wall for the temperature. As in the long walls, we are going to use 0.2[illegible] of the section of the wall:

$$A_s = 0.[illegible] \times b \times d$$

$$A_s = 0.[illegible] \times [illegible] \times [illegible]$$

$$A_s = 0.[illegible] \text{ sq. in.}$$

We select round steel 3/[illegible] in. and with 1[illegible] in. spaces between centers, for both sides of the wall.

As in the long walls, [illegible] reinforce-ment in [illegible] wall, for protection [illegible] the tank [illegible] round steel.

## 3. Design of the base slab.

We are going to design the base of the tank like an slab suppor-ted in two sides and the principal reinforcement is going to be in the short direction.

Then the dimensions of the base slab is 60 x 14 fts. and is going to support a pressure of the sewage at a heigth of 8.75 ft, then we have for the unitary pression in the base:

$$w = 62.5 \times 8.75$$

$$w = 546 \text{ lbs per sq. ft.}$$

For the moment we are going to use 1/12 because we considered the slab like fixed in both extremes, then:

$$M = 1/12 \times w \times l^2$$

Then we have:

$$M = 1/12 \times 546 \times \overline{14}^2 \times 12$$

$$M \cong 107{,}000 \text{ in. lbs.}$$

To get the minimun thickness of the slab we know:

$$M = k \times b \times d^2$$

or

$$b \times d^2 = \frac{M}{k}$$

from table NO 6 from the book " Design of Concrete Structure" of O'Rourke we get for $f_s = 20{,}000$ and $f_c = 900$ a value for $k = 157$,

So we obtain:

$$bd^2 = \frac{107{,}000}{157}$$

$$bd^2 = 680 \text{ in}^3$$

if we take a value for b of 12 in we have:

$$d^2 = \frac{680}{12} = 56.5 \text{ sq. in.}$$

$$d = 7.5 \text{ in.}$$

Then the minimun thickness for the slab is 7.5 in, if we put 1.5 in. to each side for covering the steel we get 10.5 in. of thickness, but we are going to use 12 in. for the total thickness of the base, so considering the 15 in at each side we have 12 - 3 equal to 9 in. for the net thickness.

The steel required for the base slab is then:

$$A_s = \frac{M}{f_s \times j \times d}$$

$$A_s = \frac{107,000}{20,000 \times .875 \times 9}$$

$$A_s = 0.67 \text{ sq in.}$$

We select for the reinforcement in the base slab, round steel of 5/8 in of diameter and spaced 5.5 in between centers. This steel is in the short direction and the temperature steel is going to be in the other direction.

We check now the shear for our section :

$$v = \frac{V}{b \times j \times d}$$

$$v = \frac{546 \times 7}{12 \times .875 \times 9}$$

$$v = 61 \text{ lbs p.s.i.}$$

if the allowable shear is 240 lbs p.s.i. we are safe.

Now we check the bond for the steel:

$$u = \frac{546 \times 7}{4.3 \times .875 \times 9}$$

$$u = 113 \text{ lbs. psi.}$$

## DESIGN OF THE AERATION TANK

**Dimensions and prescriptions.**

This tank is going to be designed for the next dimensions:

Interior length: 83 ft

Interior width: 28 ft ( two divisions)

Total heigth: 14.5 ft

Sewage level: 13 ft

Maximun thickness of walls: 16 in.

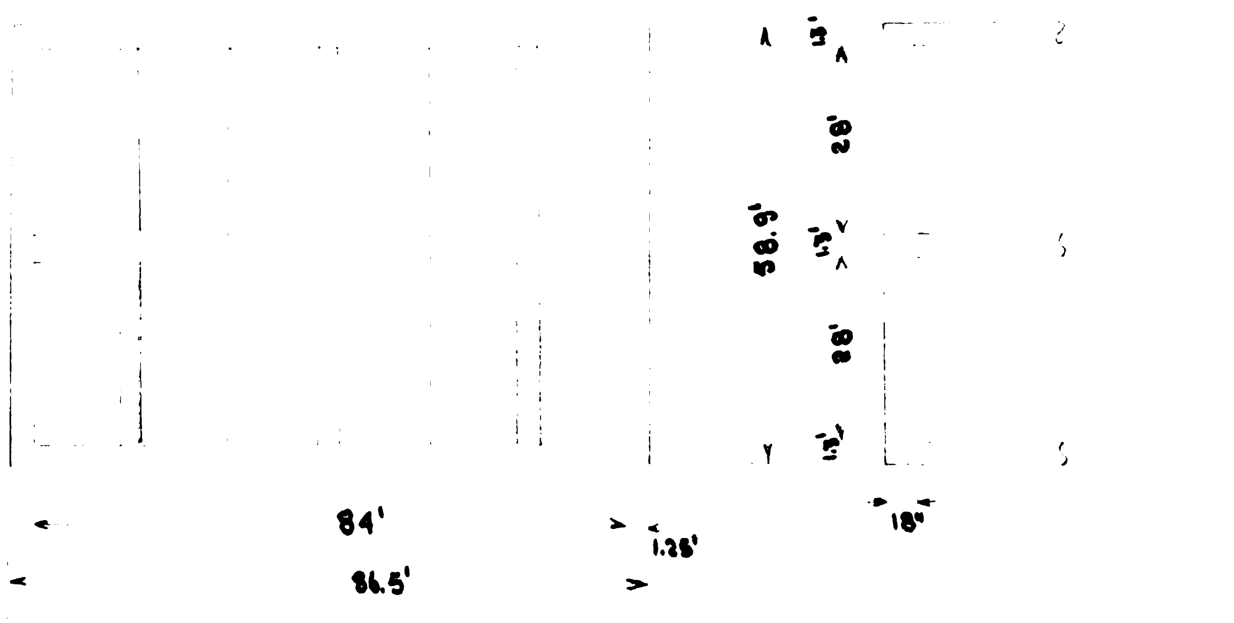
Three beams which are going to support each one a motor of 1200 lbs. plus 500 lbs, and a load of 100 lbs per linear foot for the people which is going to walk by the beams.

Allowable stress of concrete: 900 lbs psi.

Allowable stress of the steel: 20,000 lbs psi.

Value of "n" : 15

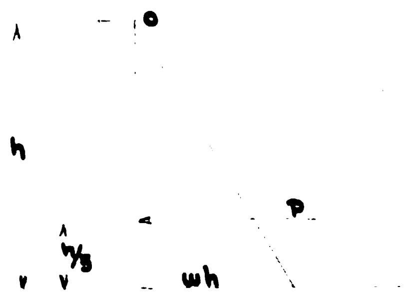
Then an sketch of the tank whit it dimensions and the tentative thickness of the walls and beams is the following:



<u>1. Design of the walls.</u>

In this case all the walls of the aeration tank are of long spans and must be desingned then like a cantilevers walls, for this reason we are going to consider the four walls of our tank like a cantilevers and design it in that way.

If we assume athickness of 1 ft 3 in for the walls, we have:




The maximun pressure of the water is in the bottom of the wall and is equal then to:

$$p = w \times h$$

$$p = 62.4 \times 13$$

$$p = 811.2 \text{ lbs}$$

Now we know the resultant of the pressure of the water is going to be applied at the 1/3 of the wall, and its value is then:

$$P = \tfrac{1}{2} \times w \times h^2$$

$$P = \tfrac{1}{2} \times 811.2 \times 13$$

$$P = 5{,}272.8 \text{ lbs.}$$

The maximun moment of this force is at the bottom of the wall and is equal to:

$$M = P \times h/3 \times 12$$

$$M = 5272.8 \times 13/3 \times 12$$

$$M = 274{,}185 \text{ in lbs}$$

The minimun thickness for the wall is then:

$$d = \frac{M}{k \times b}$$

we have:

M = 274,185 in lbs.

b = 12 in

k = 157 ( From O'Rourke )

Then we have:

$$d = \frac{274,185}{157x12}$$

$$d = 12.06 \text{ in}$$

Practically we can considered 12 in for the minimun thickness, and if we assume 1.5 in for covering at each side we have a net thicness of 12 plus 2 x 1.5 equal to 15 in. for the thickness.

Now we must check this value for the shear:

$$V = 5,272 \text{ lbs}$$

then:

$$v = \frac{V}{b x \; j x \; d}$$

$$v = \frac{5272}{12x7/8x12}$$

$$v = 42.5 \text{ lbs psi.}$$

The allowable shear is:

$$v = 0.12 \times f_c'$$

$$v = 0.12 \times 900$$

$$v = 240 \text{ lbs psi.}$$

Then our section is safe.

This shear is in the bottom of the wall but all the other sections are also safe because the value of "d" varies with the value of "h"

and in this way the value for the shear is each time smallest when the value for "d" is smallest.

Quantity of steel.

For the steel we have:

$$A_s = \frac{M}{f_s \times j \times d}$$

in which:

M: 274,185 in lbs.

$f_s$: 20,000 lbs psi.

j : 7/8

d : 12 in.

then:

$$A_s = \frac{274,185}{20,000 x .875 x 12} \times 12$$

$$A_s = \sim 1.14 \text{ sq in.}$$

We select round steel of 7/8 in and 6 in of space between centers with a total area of 1.20 sq in and a perimeter of 5.5 in.

We have to check the bond for this steel:

$$u = \frac{V}{E_o \times j \times d}$$

$$u = \frac{5,273}{5.5 x .875 x 12}$$

$$u = 91.5 \text{ lbs psi.}$$

The allowable bond is:

$$u = 0.05 f'_c$$

$$u = 0.05 \times 2,000 = 100 \text{ lbs psi.}$$

then in our case is safe.

Cut-Off Bars.

We are going to have at the middle of the wall a moment which is going to be half of the maximun moment at the bottom, so the steel required in that section is only the half of the steel used in the lower third of the wall, for this reason at a heigth of ½ of 13 or 6.5 ft. we cut every other bar.

Anchorage.

The steel wil be bent down in the toe of the footing at a distance beyond the top of the footing or base slab suficient to dvelop their strength in bond or:

$$\text{distance} = \frac{20{,}000}{6 \times 100} \times 7/8$$

$$\text{distance} = 30 \text{ in.}$$

Temperature Steel.

The outside of the wall is exposed to the full temperature variation while the inside somewhat insulated, but we are going to place the same quantity of steel in both sides, so we have:

$$A_s = p \times b \times d$$

$$A_s = 0.00125 \times 12. \times 12$$

$$A_s = 0.18 \text{ sq in.}$$

We place round steel of ½ in, and spaced 12 in between centers given a total area of 0.20 sq in.

Considerations.

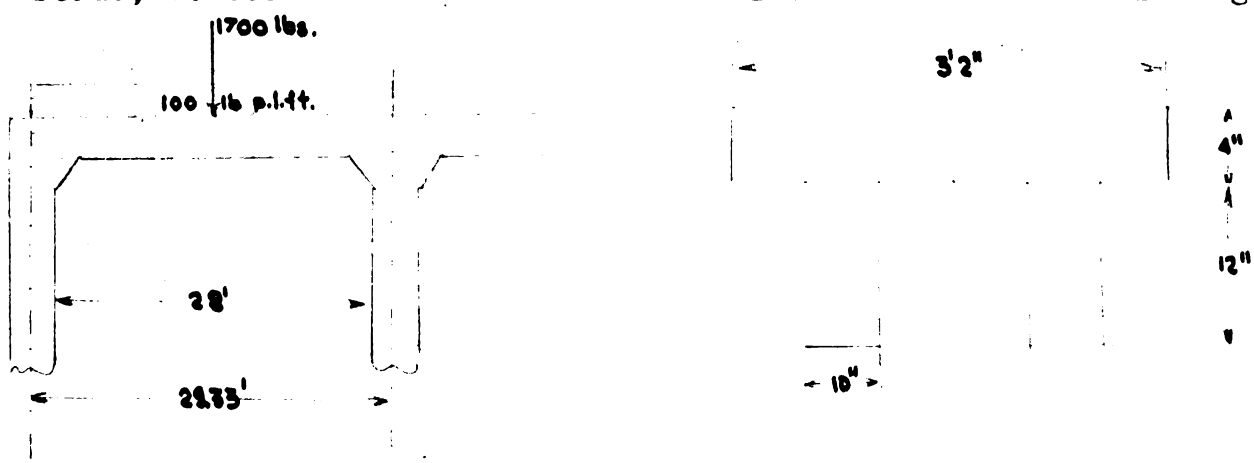
We had designed the walls considering only the interior side of it supporting the pressure of the sewage, but also the exterior side is going to support the pressure of the soil and for the ground water, so providing we are going to have the tank sometimes empty, and in that case we are going to have areversal of efforts with the exterior side supporting all the pressure, so we are going to put the same reinforcement in both sides of the wall.

Also the length of our four walls is very close, so we adopt the same dimensions and reinforcements for all of them are going the same providong the efforts which are going to support are very close and is unnecesary to repeat the same calculus.

## 2. Design of the Beams.

These beams are going to support the motors employed in the aeration of the sewage, this motors has a weigth of 1,200 lbs each one, also the beams are going to be used to walk so we are ging to assume 100 lbs per linear foot for the weigth of the people, the weight in the center of the beam is 1,200 lbs plus 500 more conssidering accesories and impact of the motor. Then for our design we have a uniform load of 100 lbs per linear foot, and a concentrated load of 1,700 lbs at the center of the beam.

We adopt for a preliminary calculus the following dimensions, for our design we are going to consider each beam composed by two Tee beams, so our tentative section and dimensions is the following:




Then the weigth of each Tee beam is:

$$w = \frac{18 \times 4 + 10 \times 12}{144} \times 150$$

$$w = 199.50 \text{ lbs per linear foott}$$

this is considering each linear foot of the beam, and 150 lbs per each cubic foot of reinforced concrete.

We have a uniform load of 100 lbs per linear foot, so the total uniform load is :

$$W = 200 + 100$$

$$W = 300 \text{ lbs p.l.f.}$$

The shear caused by this uniform load is then:

$$V = 300 \times \tfrac{1}{2} \times 29.33$$

$$V = 4,400 \text{ lbs.}$$

For the moment cause by this uniform load we are going to consider the beams like partially continuos beams and for this reason we assume a moment of 1/10 $wl^2$, so we have:

$$M = 1/10 \times w \times l^2$$

$$M = 1/10 \times 300 \times \overline{29.33}^2$$

$$M = 309,600 \text{ in. lbs.}$$

Concentrated load.

We know the concentrated load is:

$$P = 1200 + 500$$

$$P = 1700 \text{ lbs.}$$

of this concentrated load, half of this is for each of the tee beams so the concentrated load is:

$$P = \tfrac{1}{2} \times 1700 = 850 \text{ lbs.}$$

The shear due to the concentrated load is:

$$V = \tfrac{1}{2} \times 850$$

$$V = 425 \text{ lbs}$$

For the maximun moment due to the concentrated load, if we con sidered the beam like a partially continuos, we have to make a reduction in the moment which is $\tfrac{1}{4}$ Pl, and this reduction mus be in the same proportion like the uniform load, so our moment is going to be:

$$M = 8/10 \times \tfrac{1}{4} \times P \times l$$

$$M = 8/10 \times \tfrac{1}{4} \times 850 \times 29.33 \times 12$$

$$M = 59{,}832 \text{ in-lbs.}$$

Total moment and total shear.

Making the sume of the values we got before we have:

Total shear: $V = 4{,}400 + 425 = 4825$ lbs

Total moment: $M = 309{,}600 + 59{,}832 = 369{,}432$ in-lbs.

With this total moment we can check our first tentative section. Assuming that web reinforcement is to be provided, the allowable unit shearing stress is :

$$v = 0.06 \times f'_c$$

$$v = 0.006 \times 2{,}500 = 120 \text{ lbs p.s.i.}$$

So we have:

$$b'd = \frac{V}{j \times 120}$$

$$b'd = \frac{4{,}824}{0.875 \times 120}$$

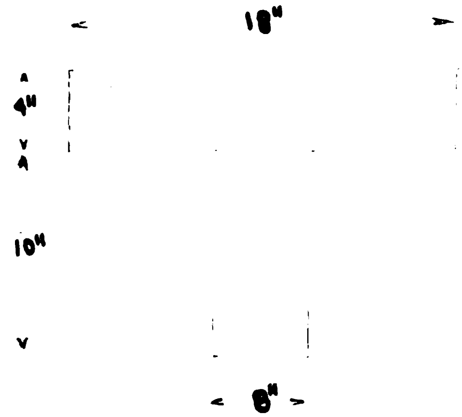
$$b'd = 46 \text{ sq in.}$$

But we have a tentative section of 16 x 10 or 160 sq in, this section is to big for the value we obtained before, so we must reduce our section and check again.

For this purposse we are going to adopt another dimensions and proceed to the calculus.

## New Section For The Tee Beams.-

We adopt the following dimensions for our new tentative section for the tee beams:




Then the weigth of the beam is in this case:

$$w = \frac{18x4 + 8x10}{144} x 150$$

$$w = 158 \text{ lbs per linear ft.}$$

then the total uniform load is:

$$W = 158 + 100 = 258 \text{ lbs p.l.ft.}$$

The shear for this load is then:

$$V = 258 x \tfrac{1}{2} x 29.33$$

$$V = 3{,}780 \text{ lbs.}$$

The maximun moment for the uniform load is considering like before the beams partially continuos:

$$M = 1/10 x W x l^2$$

$$M = 0.1 x 258 x \overline{29.33}^2 x 12$$

$$M = 266{,}000 \text{ in-lbs}$$

Concentrated Load.

The concentrated load is the same like in the other case or:

$$P = 850 \text{ lbs}$$

Then the shear for the concentrated load is:

$$V = \tfrac{1}{2} \times 850 = 425 \text{ lbs}$$

The maximun moment for the concentrated load is then:

$$M = 8/10 \times \tfrac{1}{4} \times P \times l$$

$$M = 8/10 \times 1/4 \times 850 \times 29.33 \times 12$$

$$M = 59{,}772 \text{ in-lbs}$$

Then the total moment and the total shear are:

Total Shear: $V = 3780 + 425$

$V = 4{,}205$ lbs

Total moment: $M = 266{,}000 + 59{,}772$

$M = 325{,}772$ in-lbs.

So we can check our new section with the values we got, assuming like in our first section that web reinforcement is to be provided the allowable unit shearing stress is 120 lbs p.s.i., and the minimun section is then:

$$b'd = \frac{V}{j \times 120}$$

$$b'd = \frac{4{,}205}{0.875 \times 120}$$

$$b'd = 40 \text{ sq in.}$$

Our new tentative section is 8 x 14 in. or 112 sq. in, and like in the first case we have a biggest section than that required, but we are going to adopt this second section for our definite section , because is impossible to reduce more our section.

Steel for the Tee Beam.

To get the steel for the beams we must compute first in which portion of the beam is the neutral axis.

First we must get the value of "k", we know:

$$k = \frac{n}{n + \frac{f_s}{f_c}}$$

in which:

$n = 15$

$f_s = 20{,}000$ lbs psi.

$f_c = 900$ lbs psi.

so we have:

$$k = \frac{15}{15 + \frac{20{,}000}{900}}$$

$$k = 0.55$$

The value of "kd" isthen:

$$kd = 0.55(14 - 1.5)$$

$$kd = 6.875 \text{ in.}$$

We put 14 - 1.5 for the value of "d" considering 1.5 in for covering the steel, and also we are considering one row of bars.

The value obtained for "kd" of 6.875 in indicates that the neutral axis is on the stem of the beam and then the Tee-beams formulas can be apply to obtain the steel necesary for our case.

To obtain the quantity of steel required we must get first the values of "z" and "j" :

The value of "z" is :

$$z = \frac{3kd - 2t}{2kd - t} \times \frac{t}{3}$$

$$z = \frac{(\ 3x6.875 - 2x4\ ) x\ 4}{(\ 2x6.875 - 1x4\ ) x\ 3}$$

$$z = 1.72$$

To obtain the value of "j" we know:

$$jd = d - z$$

then:

$$j \times 12.5 = 12.50 - 1.72$$

$$j = \frac{10.78}{12.50}$$

$$j = 0.862$$

Then with this value for "j" and the maximun moment we got before, we can get the value of the quantity of steel required:

$$A_s = \frac{M}{f_s x\ j x\ d}$$

And replacing with the values we have:

$$A_s = \frac{352,772}{20,000 x .862 x 12.5}$$

$$A_s = 1.63 \text{ sq in.}$$

We select round steel , 4 bars, of $\frac{3}{4}$ in of diameter given a total area of 1.76 sq in. and a perimeter of 9.424 in.

Now we must check if all this steel can be put in one row like we assume before, if the separation of the bars between centers is 2.5 times the diameter of the bars , and if we considered for tthe exterior covering of the steel 1 in at each side we have:

$$3 \times \frac{3}{4} \times 2.5 + 2x1 = 7.6 \text{ in}$$

Then we obtain a value of 7.7 in, and we have a width of 8 in son in this case is right and we can put all of our bars in only one row.

We check for the bond:

$$u = \frac{V}{E_o \times j \times d}$$

$$u = \frac{4,205}{9.424 \times .862 \times 12.5}$$

$$u = 43 \text{ lbs p.s.i.}$$

The allowable bond is:

$$u = 0.05 \times 2,000 = 100 \text{ lbs psi.}$$

then we are safe.

Width of flange of the tee beam.

To check the width of flange of the beam we use the nexte formula:

$$M_c = f_c \times \left( \frac{1 - \frac{t}{d}}{2k} \right) \times \frac{t}{d} \times b \times j \times d^2$$

in which:

$M_c$ : 352,772 in-lbs

$f_c$ : 900 lbs psi.

$t$ : 4 in

$d$ : 12.5 in

$j$ : 8.62

$b$ : width of flange.

Then replacing this values in the formula we obtain:

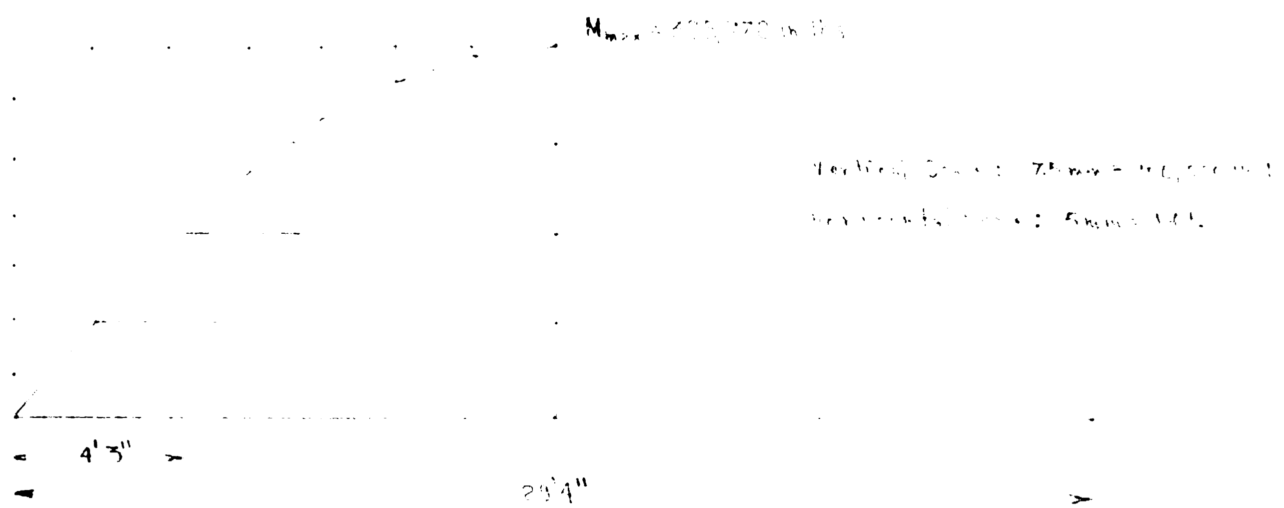
$$b = \frac{352,772}{23,895}$$

$$b = 10.5 \text{ in.}$$

So the munimun width of flange we can use is 10.5 in but we have assumed a value of 18 in, son our case is safe.

## Bent of bars.

The number of the bars in the beams is four, and we can bent two of them. To know the distance at which we must do it, we drew the parabola of moments of the beam, and then divided the vertical maximun distance( corresponding to the maximun moment), in four parts and we assume each of this parts are absorbed for each of the bars. In this way we know we can bent two of the bars at 4.25 ft of the extreme, the others two bars are prolongued until the end of the beams.




## Stirrups.

Making the investigacion for stirrups we noticed that the shear is very small for the section of the beams and so theoretically we do no need to put stirrups. But considering we need some support for the horizontal bars and for prevention of any extra stress we are going to place vertical stirrups of ½ in and spaced one ft. all along the beams.

Anchorage and extensions of bars.

For end anchorage we are going to use a hook in the end of the bars , then the bars are bent in a full semicircle with a radius of four diameters, then $4 \times \frac{3}{4} = 3$ in, and a free end of eight diameters or $8 \times \frac{3}{4} = 6$ in.

The extension of the bars in the beams in the middle support is prescribed by a minimun of 12 diameters or $12 \times \frac{3}{4} = 9$ in, but we are going to give an extension of 18 in.

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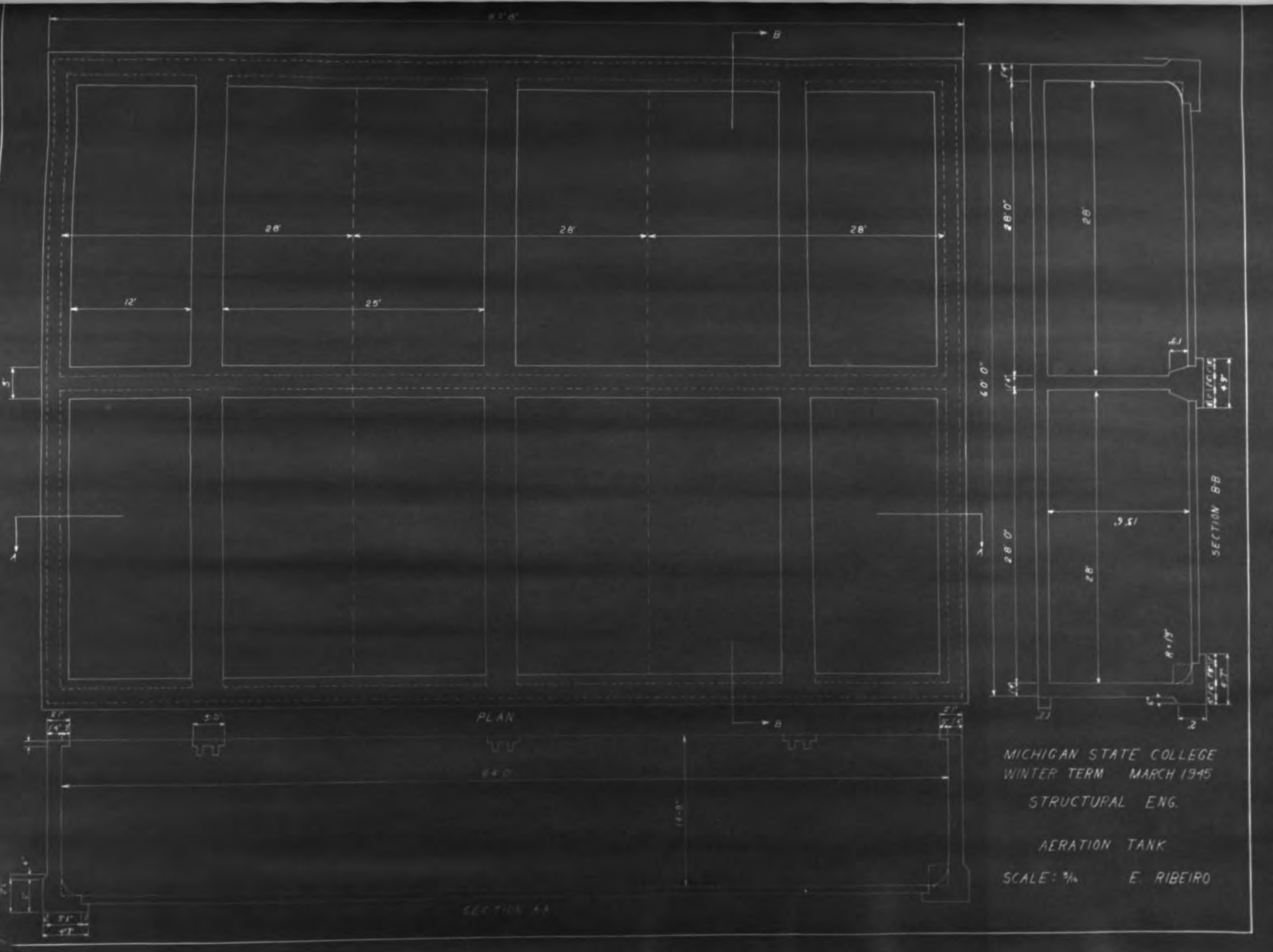
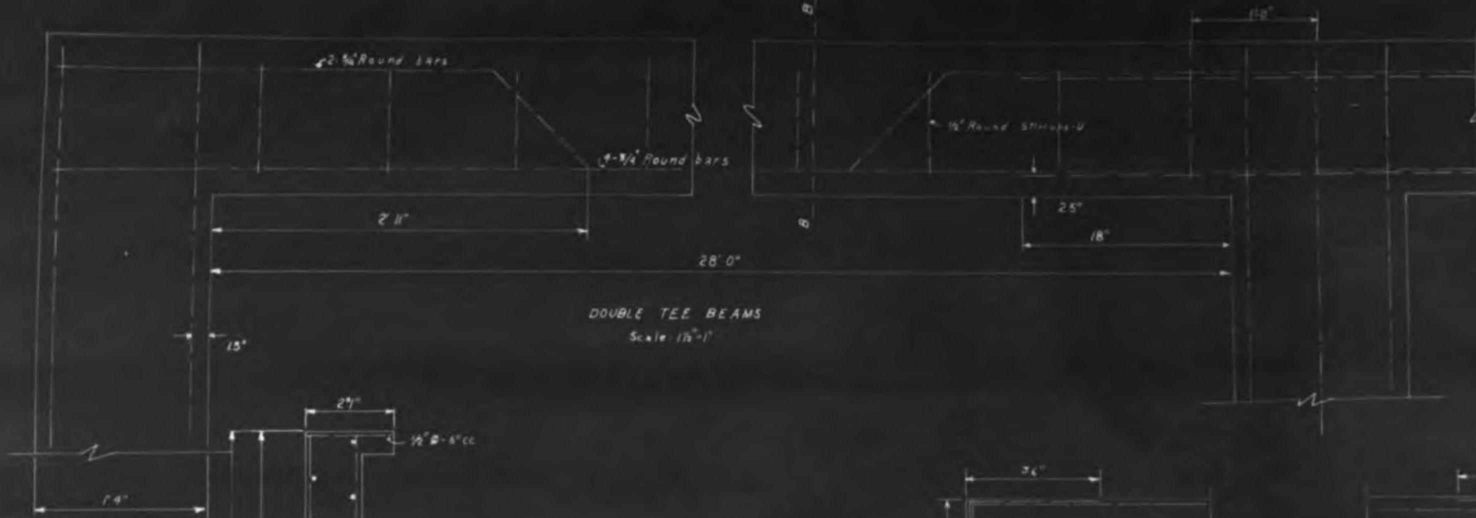
PLAN
SECTION D-D
WALL A
WALL B
WALL C
SLOPE
62' 0"
31' 0"
FINISH FLOOR
MICHIGAN STATE COLLEGE
EAST LANSING FALL 1944
PRIMARI SETLING TANK
SCALE 1"=4'
E. RIBEIRO

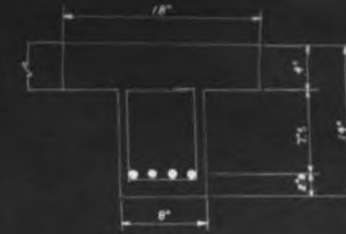


PLAN
SECTION B-B
SECTION A-A
28'
25'
12'
28' 0"
60' 0"
64' 0"
5' 0"
MICHIGAN STATE COLLEGE
WINTER TERM MARCH 1945
STRUCTURAL ENG.
AERATION TANK
SCALE: 3/16
E. RIBEIRO

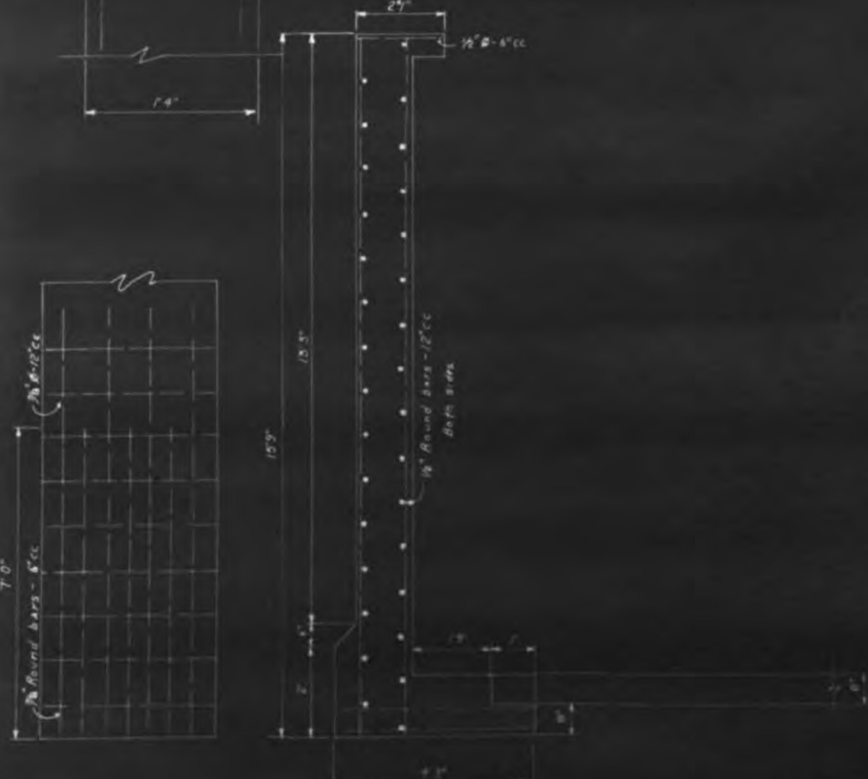



DOUBLE TEE BEAMS

Scale 1½"-1'




SECTION B-B




DETAILS OF WALLS

Same reinforcement for all walls

Scale ½"=1'


INTERSECTIONS OF WALLS

Scale ½"=1'

MICHIGAN STATE COLLEGE

WINTER TERM MARCH 1945

STRUCTURAL ENG

DETAILS OF WALLS AND BEAMS

AERATION TANK

E. Ribeiro