1895

# A complete design of a 210 foot R.R. bridge

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# Thesis
For the Degree
of
B. Sc. in C. E.

# A Complete Design of A 210 foot R.R. Bridge

By

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1895

# Preface.

I have divided the subject into two divisions, viz. Part I and Part II.

Part I treats of the maximum stresses and the methods employed in finding them.

Part II treats of the design of the members to resist the stress.

# Part I.

## Stresses

### Dead Load

Use the formula

$w = 5l + 350.$

weight of floor = 400# per foot

$P = 5l + 750$

$P = 1800$

weight on one truss $= \frac{1800}{2} = 9000$ per ft

The Dead Load diagram in Plate I shows the dead load stresses

### Live Load

I used the concentrated wheel loads as shown in Plate I.

The stress in the upper chords was formed by taking moments at the lower joints and dividing by the ⊥ distance to the inclined chords.

The stresses in the lower chords was foundt by taking moments at the upper chord joint and dividing by the ⊥ distance

The stresses in the web members ~~was~~ were found by taking the max shear in the panels.

To illustrate this take the panel AHDB Plate I

lay of ab (Fig 1) = shear in the pannel draw ac ∥ to AB and cb ∥ to AD

Let T = stress in AD

then we get.

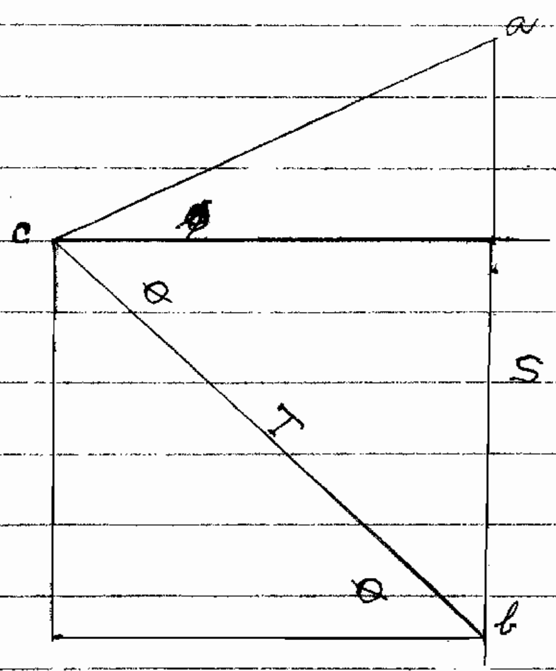



Fig 1

$T \sin\theta + T \cos\theta \tan\phi = S =$ Shear

From this we find T, which is shorter than the methods commonly used.

The stress in BD = the shear

## Wind Stress

Is shown in Plate I by the diagrams

# Part Second

Plate 1

## Design of Upper Chord

### C D

Stress = + 364600#

$L$ = 30'

Used formula

$$P = 8400 - 84\frac{L}{d}$$

$$P = 8400 - 84 \times \frac{360}{18}$$

$P = 6720$ = wrought iron.

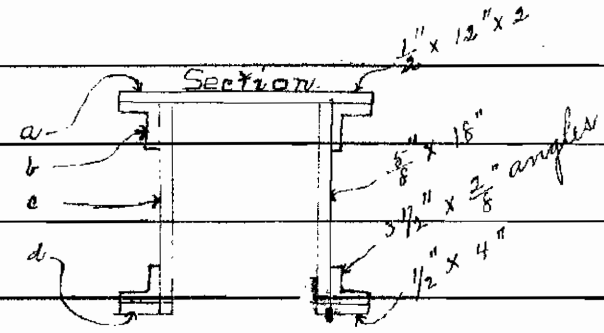
$P = 6720 + 20\%$ = steel.

$P = 8000$ (about)

Area required

$$A = \frac{S}{P} = \frac{364600}{8000} = 45.5 = 46 \text{ sq in.}$$

Section




$a = \frac{1}{2}$" x 24 = 12 sq in.

4b = $\frac{3}{8} \times 3\frac{1}{2}$ = 9 sq in = 9 9

2c = = 22 22

2d = = 4

47 sq in.

## B C

Stress = + 365000#

$L$ = 30' (about)

$P = 8400 - 84 \times \frac{360}{18}$

$P = 8000$

Area required

$A = \frac{S}{P} = \frac{365000}{8000} = 46$ sq in.

Section

Same as in C D.

## B A

Stress = + 327000#

$L$ = 31' (about)

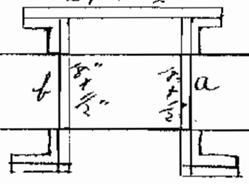
$P = 8400 - 84 \times \frac{372}{18}$

$P = 8000$

Area required

$A = \frac{S}{P} = \frac{327000}{8000} = 40$ sq in.

Section




Same as C D and B C except a and b

## A D.

Stress = + 301000#

$L$ = 42' {about}

$P = 8700 - 84 \times \frac{504}{18}$

$P = 7250$

Area required.

$A = \frac{S}{P} = 41$ sq in. (about)

Section

Same as C D. and B C.

N B

We use this excess area to resist the wind pressure transmitted to the portal

2°

Design of Posts.

## C F

Stress = + 50000#

$L$ = 40'

$P = 52500 - 220 \frac{l}{R}$

Take channel no 337. R = 4.49

$P = 52500 - 220 \times \frac{480}{4.5}$

$P = 5800$ {Safety factor 5}

Area required

$$A = \frac{S}{P} = \frac{50000}{5800} = 8.7 = 9$$

∴ channel no 357 is Ok as two of these have an area of 11.8 sq in.

B C

Stress $= + 90000^{\#}$

$L = 37.5'$

$$P = 52500 - 220\frac{L}{R}$$

Used channel 357, $30\frac{1}{4}^{\#}$ per ft.

$$P = 52500 - 220 \times \frac{480}{4}$$

$P = 5572 = 5600$ {Safety factor 5}

Areal required

$$A = \frac{S}{P} = \frac{90000}{5600} = 16 \text{ sq in.}$$

∴ channel 357 is Ok as two of these have an area of 17.5 sq in.

There are eight posts in the Bridge 4 as the first design and 4 as the second design.

5°

## Design of Tension Members
{15000# per sq in. allowed}

### F E.

Stress = + 365000.

Area required

$A = \frac{S}{P} = \frac{365000}{15000} = 36.5$ sq in.

Use 4 eye bars 9" x 1 1/8" = 40 sq ins.

### C E.

Stress = 65000

Area required

$A = \frac{S}{P} = \frac{65000}{10000} = 6$ sq in.

Use 2 eye bars 4" x 3/4 = 3 sq in = 6.

### B F

Stress = 14000#

Area Required

$A = \frac{S}{P} = \frac{14000}{1000} = 14.$ sq.in.

Use 4 eye bars 5" x 3/4"

<u>O F.</u>

Stress = 325 000#

Area required

$A = \frac{325\,000}{1\,000} = 32.5$

Use [illegible] eye bars [illegible]" x 1 1/2"

<u>A O</u>

Stress = 11 500#

Area required

$A = \frac{11\,500}{1\,100} = 19$ sq. in.

Use 4 eye bars 5 x 1 = 20 sq. in.

<u>I 26 and 26 O</u>

Stress = 250 000

Area required

$A = \frac{25\,000}{10\,000} = 25$ sq. in.

Use 2 eye bars 9" x 1 1/2 = 27 sq. in.

<u>H A</u>

Stress = S = 9 000

Area Required

$$A = \frac{135000}{15000} = 9 \text{ sq. in}$$

Use 2 eye bars 5"x 1" = 10 sq. in.

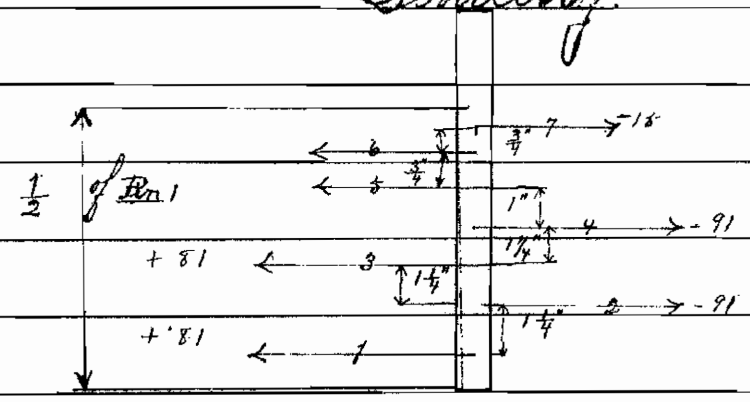
4°

## Design of Pin at F.

I will analyze this pin as a beam

1° for Bending.
2° for Crushing.
3° for Shear.

### Bending.




| Members | Shear | Moments. |
|---|---|---|
| 1 | +81 | 0 |
| 2 | -10 | +101 |
| 3 | +71 | + 88.5 |
| 4 | -20 | + 177.5 |
| 5 | 0 | + 157.5 |
| 6 | 0 | + 152.5 |
| 7 | + 5 | + 152.5 |

This analysis comes from this, that the bending moment at any point in a beam {considering the pin as a beam} is equal to the bending moment at any other section + the shear at that section into its arm about the centre of gravity of the section in question + the intervening loads into their respective arms about the C.G. of the section in question.

From this we see that 180 {177.5} is the greatest bending moment on half of the pin and as the members are symmetrical the other half will have the same bending moment.

By Carnegie's table we see that a 5" Pin will stand 184000

So 5" does for Bending.

## Crushing

The greatest stress on any member is 91000 and its bearing areas is = 5 x 1⅛ = 5⅝ or a 5" pin.

Allowing 15000# per sq. in.

15000# x 5⅝ = 84...

So as 5" is too small it takes a 5 3/8".

## Shear.

Greatest shear = 81000
allowing 10000# per sq. in.

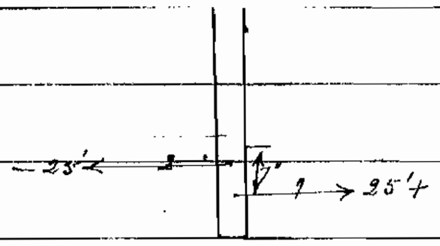
It requires 8.1 sq. ins

Area of $5\frac{3}{8}$" pin = 22.69 sq. in.
so it is ok for shear.

So I will use a $5\frac{3}{8}$" steel pin at F and also at O. H. J.

## Pin at C

Here there are no Horizon. components that effects the pin.
So I took the vertical components
∴ the condition is as shown




## Bending.

| Members | Shear | Moments. |
|---|---|---|
| 1 | + 25 | 0 |
| 2 | 0 | 2500. |
| | | |

So $1\frac{1}{4}$" would do for bending.

## Shear

Shear = 25000

Area = $\frac{25000}{10000}$ = 2.5 sq. in.

So a 2" would do.

## Crushing.

Bearing area = $\frac{25000}{15000}$ = $1\frac{2}{3}$ sq. in.

Bearing is here on a 2" pin is 2" x $\frac{3}{4}$" = $1\frac{1}{2}$. So a 2" is too small. I used a 3" Pin.

The pins of A and B was analyzed the same way by taking the Vertical Components.

5°



# Floor Stringers

[illegible] = wt of iron

= 325

wt of truck ties etc = 450

total D.L. per foot = 775

Bending Moment for dead load.

$$M = \frac{775 \times (30)^2}{2 \times 8} = 43600 \text{ ft. lbs}$$

Inch pounds = 43600 × 12 = 523200

Bending moments for live load

M = [illegible]000 ft. lbs

Inch pounds = 3,852,000

Econ Height = $1.41\sqrt{\frac{m}{ft}}$

$$\begin{array}{r} 523200 \\ m = \underline{3852000} \\ 4375200 \end{array}$$

$$h = 1.41\sqrt{\frac{4375200}{8000 \times \frac{3}{8}}}$$

where f = 8000

t = $\frac{3}{8}$

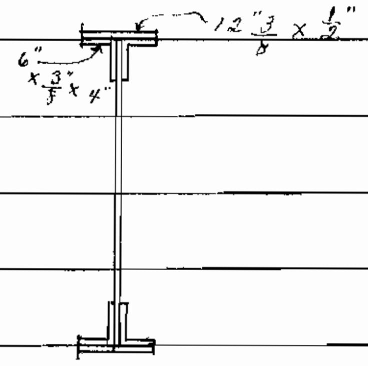
Take h = 48".

Assume that distance between the center of gravity of flanges is 45"

Total bending moment in inch lbs =
4375200

Then Area of flanges = $\frac{4375200}{45 \times 8000}$ = 12 sq in.

Allow 8000 lbs. per sq in.




Area of flange made up of

2 – 6" x 4" x $\frac{3}{8}$" angles
1 – $\frac{1}{2}$" x 12 $\frac{3}{8}$" Plate.

Shear

Live load shear is a max at the end with wheel 1 on the end and is

$= \frac{1460.1 - 34.8 \times 8 + 78 \times 3.3}{30} = 48000$

R from dead load = 5820

Total Shear = 48000
$$\frac{\begin{array}{r}48000\\5820\end{array}}{53820}$$

Allow 5000# per sq. in.

Area of web = $\frac{53820}{5000}$

But the web must not be less than $\frac{3}{8}$" therefore the web has an excess

$48" \times \frac{3}{8}" = 18$ sq in

An excess of 6 sq. in.

Rivets required in flanges

End Shear = 53820

Spacing $\frac{7}{8}$" in the ends = $P = \frac{rh}{S}$

P = pitch of rivets r = resistance of rivets
h = center to center of rivets in flanges
S = Shear

$\phi = \frac{4500 \times 45}{53800} = \frac{202500}{53800} = 3".8"$

Space them 3" out to 4 feet, then 4" for 4 feet, then 6" apart in the center.

Shear in the center = 12700#

Shear at quarter point = 30700#

# Floor Beams

Max. Moment is gotten by wheel 4

$$M_{max} = \frac{3349.3 + 113 \times 1}{2} - 608.6 = 1122.5$$

Mul. by the factor $\frac{2}{d}$ here $= \frac{2}{30}$.

$$1122.5 \times \frac{2}{30} = 74.8 = L.L.$$

Hence two such loads applied at the centre of stringers gives Max stress.

The depth $48'' + 4'' \times 2 + \frac{1}{2} \times 2 = 57''$

Assume D.W. of beam = 2500
the width of bridge = 16' to center to center of truss and the stringers are 7' apart.

Taking moments about the center.

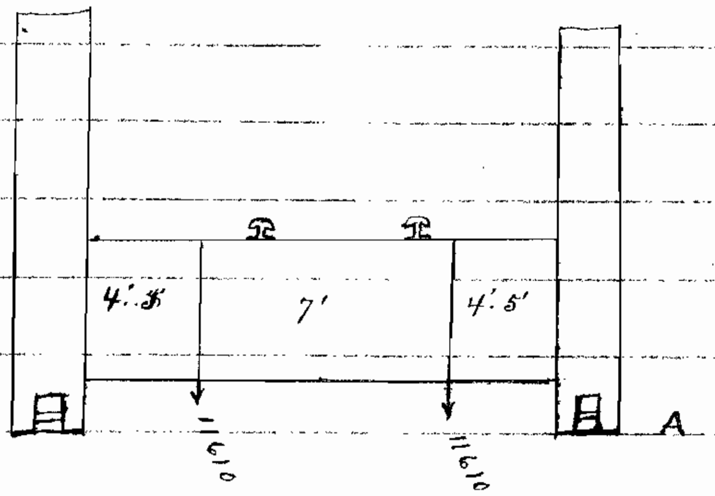
$$M = \frac{Pl^2}{8} = \frac{\frac{2500}{16}}{8} \times (16)^2 = \frac{2500 \times 16}{8} = 5000$$

The next thing to take into account is the dead load of stringers and track system.

Let this = 775 lbs. per foot as we found in the design of the stringer

$30 \times \frac{775}{2} = 11610$ lbs

Take moments about a




$11610 \times 4'.5' + 11610 \times 11'.5' = Rl = R16$

Moments at centre for stringer dead load

$M = R8' = 52245 = 11610 \times 4.5$

Moments L.L

$M = 74800 \times 4\frac{1}{2} = 336600$

Total moments

336600 L.L.
5000 D.L. Beam
52245
393845

Shear =

1200 = weight of $\frac{1}{2}$ beams.
11600 = " " Stringers.
74000 = Live Load
86800 = Total Shear

# Area of Flanges

$$\frac{393845}{4.5} = 87521$$

4.5' = distance from c.g of flange

$$\frac{87521}{8000} = 11 \text{ sq in (about)}$$

Web = $\frac{3}{8}$" x 57"

## Section