Steelwork design 28

NOTE
Concrete roof substituted for timber roof on 13 March 1956

For calculations on this see fig. 32 of text

Date: 13/3/56
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Ceiling Beams  
Vault  
Columns  
Ceiling Beams (Continued)  
Girder Foundation  

1st. 2nd New Calculation

\[
\begin{align*}
\text{Start} N. E. & = 13 + 12 \\
\text{N. W.} & = 23 + 12 \\
\text{S. W.} & = 23 \times 3 \\
\text{S. E.} & = 23 \times 3 \\
\sum Z & = 58.7 + 2.3 = 58.9 \text{ with units} \\
\text{Equil_valence} & = \frac{25}{44.80} \\
\end{align*}
\]
Re-calculate using a 6 in. W.C. joist if his design allowed. See NEW Braining

Side Beams for ceiling
Beams A.A. type. effective span = 14'

\[ w = 9 \times 88 \times 64 \times 2240 \]

\[ = 612 \text{ lb. per ft. run.} \]

\[ Z' = \frac{wL^2}{64} = \frac{612 \times 14^2 \times 12}{64 \times 2240} \]

\[ = 10.04 \text{ cu. ft. units} \]

\[ \text{Select No. 53B-7} \]

\[ \frac{8 \times 4}{18} = [Z = 15.9] \]

\[ 20.53 \text{ cu. ft. units} \]

\[ \sum Z = 10.04 + 0.30 = 10.34 \text{ cu. ft. units} \]

Equal resistance = \[ \frac{12}{4480} \times 612 = \frac{14 \times 630}{4480} \]

\[ = 1.97 \text{ tons} \]

with total load = \( L = 3.94 \text{ tons} \)
Elastic Bending Type 13 B.

Effective span = 21.5'

\[ w = 68 \times 14 \]

= 952 lbs. per ft. per in.

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= 952 lbs. per ft. per in.

\[ Z = \frac{wL^2}{6t} = \frac{952 \times 21.5^2 \times 12}{64} \]

= 36.83 inch^3 units.

Select NBSR 11

\[ 13' \times 5'' \times 3.5'' \]

\[ Z = 43.6 \]

\[ Z'' = \frac{wL^2}{6t} = \frac{36 \times 21.5^2 \times 12}{64} \]

= 1.36 inch^3 units.

and \[ Z = 36.83 + 1.36 = 38.19 \text{ inch}^3 \text{ units} \]

Equal reaction = \[ \frac{21.5}{414.80} \]

= 0.0515 inch

\[ Z = 92.8 \text{ ft. } \]

\[ R = 4.74 \text{ tons} \]

and total load = \[ L = 9.48 \text{ tons} \]

Equal reaction = \[ \frac{6.12}{6.81} \]

= 0.896 inch

\[ X = 57 + 2.615 \times 6.77 \]

= 2.63 ft.

\[ = 2.37 \times 4.37 \]

= 10.5 ft.

\[ = 10.5 \]
Effective span = 26.5′

Central load \[ W = 4.74 \text{ tons} \]

Distributed load \[ w = 68 \times 9 = 612 \text{ lb. per ft.} \]

\[ M = \frac{Wd}{4} + \frac{wd^2}{8} \quad \text{moment on } x \text{-axis} \]

\[ Z' = \frac{Wd}{3.2} + \frac{wd^2}{6.44} \]

\[ = \frac{4.74 \times 28.5 \times 12}{3.2} + \frac{612 \times 28.5^2 \times 12}{64} \times 2240 \]

\[ = 50,66 + 41,61 \]

\[ = 92,27 \text{ with } 3 \text{-in. } \]

Order \( NB553 - 16 \)

Equal Reactions: \[ 2.37 + \frac{28.5}{2240} \]

Load on foundation \[ = 2.37 + 4.31 = 6.68 \text{ tons} \]
Columns Type D

Height = 26'

Load on top = 13.36 + 44.74

= 58.10 tons.

Load cannot be eccentric on \( X \)-axis.
Allow for 1" eccentricity on \( Y \)-axis.

Required minimum \( X = \frac{26 \times 12}{100} = 2.23' \)

Try Bend 4:10

8\(^{\circ}\) 6\(^{\circ}\) P.S.I.

Eccentricity on \( X \)-axis.

\[
\frac{e}{R} = \frac{26 \times 12}{2.25} = 138.7 \text{ Safe Allow.} = 2 \text{ tons/min.}
\]

1" eccentricity coefficient = 0.99
Equivalent load on column = 0.99 \times 2.23 = 3.52 tons.

Weight of column = \( \frac{26 \times 7.15}{2240} = 0.83' \)

and Safe load = 2 \times 20.3 = 40.6 tons. Safe.

Load on foundation = 18.1 + 0.83

= 18.93 tons.
Beams Type DD

Effective Span = 20'

Contract Load = W = 15,360 lb.

W = 14 x 238

= 3332 lb. per foot run.

\[ Z' = \frac{W^2}{64} = \frac{3332 \times 20^2}{21.8^2 \times 12} = \frac{114.05 + 23.72}{21.82 \times 12} \]

\[ Z' = 128.9 \text{ cu. in.} \]

Select NBS 17

\[ Z'' = \frac{W^2}{64} = \frac{3332 \times 20^2}{21.8^2 \times 12} = \frac{64 \times 2240}{21.82 \times 12} \]

= 2.90 cu. in. units

\[ \Sigma Z = 128.9 + 2.90 = 131.8 \text{ cu. in. units} \]

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\[ \Sigma Z = \frac{21.5 \times 3407}{15480} = 3332 \text{ cu. in.} \]

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and Total Load = L = 32.70 ton.
Beam 4" x 6.6" - Type EE

Effective Span = 28 ft

Central Load = \( W = 16,350 \) Tons

Distributed Load = \( w = 9 \times 238 \) lb/ft

\[ M = \frac{Wl}{4} + \frac{Wl^2}{2} = 16,350 \times 28 + 2,412 \times 2 = 114,450 + 93,744 \]

\[ Z = \frac{Wl}{3} + \frac{Wl^2}{6} = 16,350 \times 28 \times 12 + 2,412 \times 28 \times 12 \]

\[ = 6,408 \times 12 + 109,248 \]

\[ Z = 43,612 \text{ in}^3 \]

The lightest beam to carry this is 2-20, 2-1/2 in.

\[ Z = 35,140 \times 12 = 357,708 \]

\[ Z = 250 \times 12 \times 14 \frac{3}{8} \]

\[ Z = 340.8 \text{ in}^3 \]

\[ \Sigma Z = 312.3 + 9.6 = 321.8 \text{ in}^3 \]

Equal Reactions

\[ R = R = \frac{2,442}{14.3} = 170 \]

\[ V = 8,18 + \frac{2,442}{14.3} = 22,48 \]

Total Load = 22,48 tons
There cannot be any eccentricity in the Y-axis.

To find the eccentricity on the X-axis:

\[
(6.8 + 18.93 + 16.35 + 22.5)(\rho + \bar{e}) = 6.8 \rho + (18.93 + 16.35)(\rho + \bar{e}) + 22.5(\rho + d)
\]
\[
64.58 \rho + 64.58 \bar{e} = 6.8 \rho + 35.28 \rho + 35.28 \bar{e} + 22.5 \rho + 22.5 \bar{e}
\]
\[
64.58 \bar{e} = (17.64 + 22.5) \bar{e}
\]
\[
\bar{e} = \frac{40.14}{64.58} \bar{d} = 0.6215 \bar{d}
\]

and eccentricity = (0.6215 - 5) \bar{d}.

\bar{e} = 0.1215 \bar{d} \text{ in cm}.
Try section X, 10 as before.

The eccentricity = \(1.215 \times 9 = 10.935\) in. (including 0.35 in.)

Eccentricity on X-axis:

\[
\frac{e}{l} = \frac{8 \times 12}{3.81} = 25.2
\]

Safe Stress = 4.85 tons per sq in.

1.1 eccentricity coefficient = 1 + \(13 \times 1.1 = 14.34\) = 1.34

Equivalent per cent for load = 54.23 \(\times 1.34\) = 71.91

Eccentricity on X-axis:

\[
2 = 2.25 = 25.2 \times \frac{l}{e} \quad \text{Safe Stress} = 4.85 \text{ tons}
\]

Equiv of load = 71.91 \(\times 2.25\) = 161.5

Safe stress = 4.85 tons

Load on foundation = 64.5 tons

\[
71.91 = 97.97 = 98 \text{ tons}
\]

and Safe stress = 4.85 tons

Foot or foundation = 64.5 tons

71.91 = 97.97 = 98 tons
Grillage foundation.

There are 48 tons in ground. 

Steel needed per ft. 

Steel in grillage beams: 

Case 1: 

Load w = 6.5 tons. 

Area foundations = 0.35 = 2.17 ft. 

Area = 8.68 in. 

Steel: N = 3.815 

Note: All steel 

It has a minimum cover of 6 in. 

Horizontal section of form. 

Concrete throughout 

depth.
See R.B. p. 430 for formulae.

Load per beam = \( \frac{65}{3} \) = 21.7 tons.

- \( L = 4.5' \)
- \( P = 1.6' \)
- \( f = 12 \text{ ft/min} \)
- \( L = 3 \frac{Pw}{4} = 1.6 \times 21.7 \)

- \( = 8.68 \text{ inch}^3 \text{ units} \)

\( \text{Select } N 38.8 - 6 \)

\( 7' \times 3 \frac{1}{2}'' \times 15'' \)

\( = 0.9 \)

\( 8'' \times 8'' \times 18'' \)

\( = 13.9 \)

\( \text{Select } N 38.8 - 7 \)

\( \text{This beam is safe for } \)

\( \text{Load.} \)

\( \text{N.O.T. Safe.} \)
Bottom trim.

Load per beam = \( \frac{6.5}{4} = 1.6 \text{ tons} \)

\( L = 4.5' \)
\( P = 1.6' \)
\( f = 12 \text{ fps} \text{ per min} \)

\[
I = \frac{3 \times P \times W}{12} = \frac{3 \times 1.6 \times 1.6}{12} = 0.44 \text{ in}^3 \text{ units.}
\]

Mean = \( \frac{1.6 \times 1.6}{4.5} = 0.7 \text{ tons} \)

Select: W. B. S. B. = 5

6" x 3" x 12" \( \sqrt{2} = 6.97 \text{ in.} \)

Mean = 5.7 \text{ tons}

Rev. 2/76
R. B.
Top Truss is 24 ft long and has beams = \( \frac{3}{8} \times 3 \times 12 \) in.

21' 6"

6" x 3' x 12"

1' 2" x 4' beam

11' 8" x 2' 8" x 9"

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Case II. 

Load = 242 tons.

Area formula = \( \frac{42}{3} = 14 \) ft²

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5' 6" x 2' 8" x 9"