Continuous Beam Design for Gravity and Lateral Loads

The partial plan of a typical floor in a cast-in-place reinforced concrete building is shown in Figure 1. The floor framing consists of standard one-way joist – 66" module (pan). Design the continuous beam along grid C for the combined effects of gravity (dead + live) and lateral (wind) loads according to ACI 318-11.

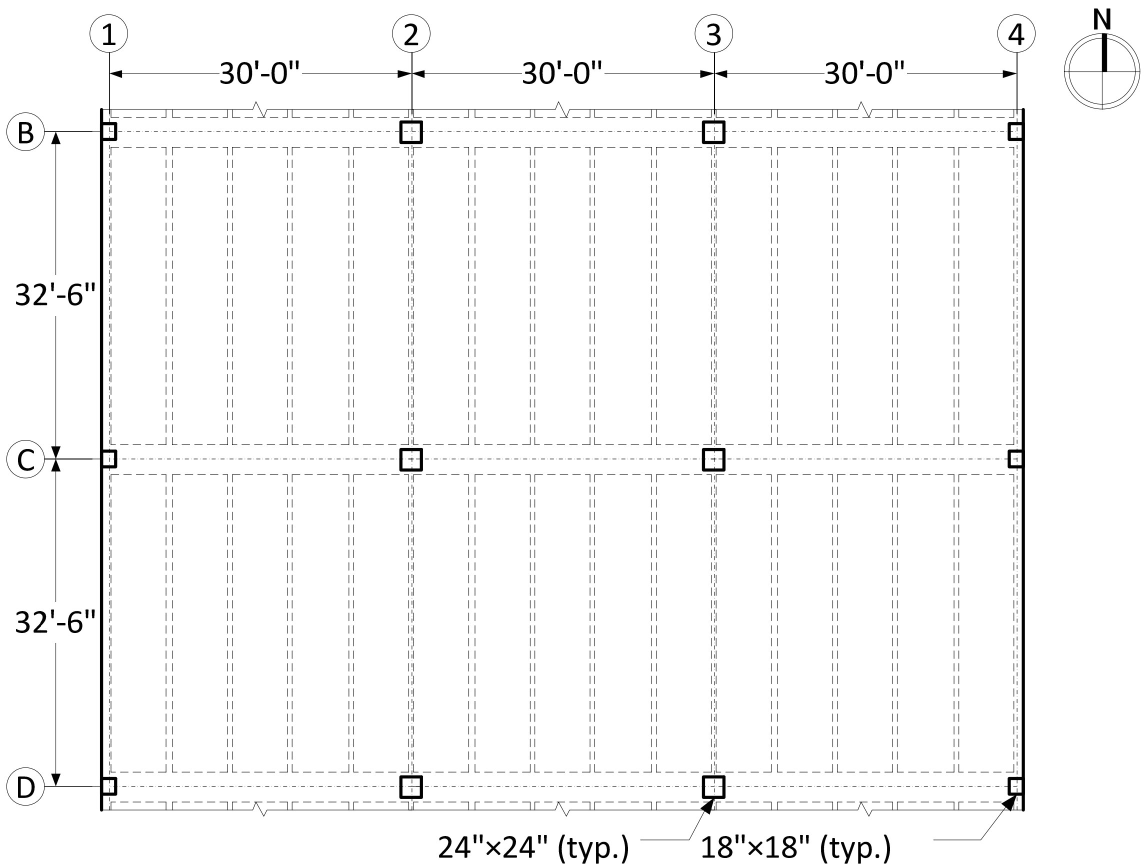


Figure 1 – One-way Joist Concrete Floor Framing System (Partial Plan)

Code

Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary (ACI 318R-11)

Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7-10)

Design Data

Concrete: Normal weight (150 pcf)

$f'_c = 4{,}000\text{ psi}$

$f_y = 60{,}000\text{ psi}$

Superimposed Dead Loads $= 30$ psf
Live Load, LL $= 100$ psf

Solution

1. **Load Calculations**

   The approximate coefficients per ACI 318-11, Section 8.3 will be utilized to compute the bending moments and shear forces along the length of the beam.

   From "Concrete Floor Systems – Guide to Estimating and Economizing" book of PCA, select the following:

   Pan Depth = 16 in.; Rib Width = 6"

   Slab h = $4^{1/2"}$; Beam width = 36"

   The preliminary beam size is therefore, 36×20.5 in.

   Live load reduction is taken per ASCE 7-10.

   a. Determine self-weight of the joist

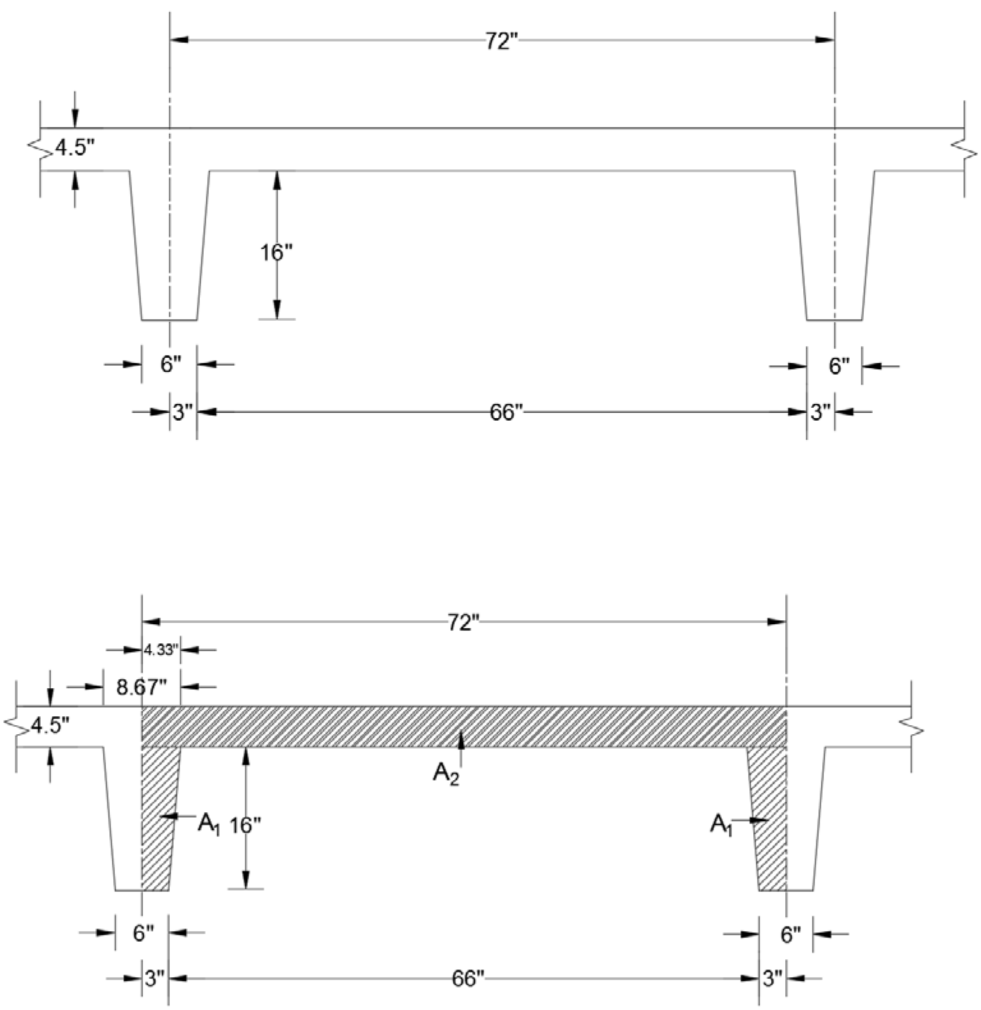


Figure 2 – One-way Joist Concrete Floor Framing System (Elevation)

$$\text{Joist Average Thickness} = \frac{2\times A_1 + A_2}{\text{Total Width}}$$

$$\text{Joist Average Thickness} = \frac{2\times\frac{3+4.33}{2}\times 16 + 4.5\times 72}{72} = 6.1289 \text{ in}$$

Joist Average Thickness = 0.5107 ft

Weight of the Joist = 0.5107 x 150 pcf = 76.6 psf

b. Determine self-weight of the beam

$$\text{Beam Weight} = \frac{\frac{36\times 20.5}{144}\times 150}{32.5} = 23.7 \text{ psf}$$

c. Determine live loads

Live load reduction per ASCE 7-10 Sect. 4.7:

$$L = L_o(0.25 + \frac{15}{\sqrt{K_{LL}A_T}})$$

From Table 4-2 of ASCE 7-10 K_{LL} = live load element factor $= 2$ for interior beams

$$A_T = \text{Tributary area} = 32.5\times 30 = 975 \text{ ft}^2$$

$$K_{LL}A_T = 2\times 975 = 1{,}950 \text{ ft2} > 400 \text{ ft}^2$$

$$L = L_o(0.25 + \frac{15}{\sqrt{1{,}950}}) = 0.59L_o$$

Since beams support only one floor, L shall not be less than $0.50L_o$.

Therefore, $L = 0.59\times 100 = 59 \text{ psf}$

In summary:

Total unfactored dead load, $w_d = (76.6 + 23.7 + 30)\times\frac{32.5}{1000} = 4.23 \text{ klf}$

Total unfactored live load, $w_l = 59\times\frac{32.5}{1000} = 1.92 \text{ klf}$

For gravity load combination (No.1)

Total factored load, $w_u = 1.2\times w_d + 1.6\times w_l = 1.2\times 4.23 + 1.6\times 1.92 = 8.15 \text{ klf}$

d. Determine wind loads

Wind forces are computed per ASCE 7-10. Calculations yield the following forces

$M_w = 144.5$ ft-kips

$V_w = 6.0$ kips

Table 1 below tabulates the design moments for load combinations 2, and 3 (gravity + wind load combinations). The calculation utilizes the same approximate moment coefficients shown above.

2. Flexure Design

a. Determine the design moments

The approximate moments and shears for load combination no. 1 are calculated below per ACI 318-11, Sect. 8.3 and listed in Table 1.

Negative M_u at exterior support $= \dfrac{w_u \ell_n^2}{16}$

where, ℓ_n = average of the adjacent clear spans (for negative moment)

Negative M_u at exterior support $= \dfrac{8.15 \times 28.25^2}{16} = 406.5$ ft-kips

Positive M_u at end span $= \dfrac{w_u \ell_n^2}{14} = \dfrac{8.15 \times 28.25^2}{14} = 464.6$ ft-kips

Negative M_u at first interior support $= \dfrac{w_u \ell_n^2}{10} = \dfrac{8.15 \times 28.125^2}{10} = 644.7$ ft-kips

Positive M_u at interior span $= \dfrac{w_u \ell_n^2}{16} = \dfrac{8.15 \times 28^2}{16} = 399.4$ ft-kips

V_u at the face of exterior support $= \dfrac{w_u \ell_n}{2} = \dfrac{8.15 \times 28.25}{2} = 115.1$ ft

V_u at the face of first interior support. $= 1.15(\dfrac{w_u \ell_n}{2}) = 1.15 \times 115.1 = 132.4$ kips

Beam moments along the span are summarized in tables 1 and 2 below.

Table 1 – Beam Moments Summary – Interior Span – Load Combinations					
Load Combination	**Total Load (kips)**	**Exterior Span**	**Moment Coefficient**	**Clear Span, ln (ft)**	**Moment**
1.2D+1.6L (9-2)	8.15	Exterior Negative	$\frac{w_u \ell_n^2}{16}$	28.25	406.5
		Positive	$\frac{w_u \ell_n^2}{14}$	28.25	464.6
		Interior Negative	$\frac{w_u \ell_n^2}{10}$	28.125	644.7
1.2D+.05L+1.0W (9-4)	6.04	Exterior Negative	$\frac{w_u \ell_n^2}{16}$	28.25	445.8
		Positive	$\frac{w_u \ell_n^2}{14}$	28.25	344.3
		Interior Negative	$\frac{w_u \ell_n^2}{10}$	28.125	622.3
0.9D+1.0W (9-6)	3.81	Exterior Negative	$\frac{w_u \ell_n^2}{16}$	28.25	33.5
		Positive	$\frac{w_u \ell_n^2}{14}$	28.25	217.2
		Interior Negative	$\frac{w_u \ell_n^2}{10}$	28.125	445.9
1.2D+.05L−1.0W (9-4)	6.04	Exterior Negative	$\frac{w_u \ell_n^2}{16}$	28.25	156.8
		Positive	$\frac{w_u \ell_n^2}{14}$	28.25	344.3
		Interior Negative	$\frac{w_u \ell_n^2}{10}$	28.125	333.3
0.9D−1.0W (9-6)	3.81	Exterior Negative	$\frac{w_u \ell_n^2}{16}$	28.25	45.5
		Positive	$\frac{w_u \ell_n^2}{14}$	28.25	217.2
		Interior Negative	$\frac{w_u \ell_n^2}{10}$	28.125	156.9

Table 2 – Beam Moments Summary – Exterior Span - Load Combinations					
Load Combination	**Total Load (kips)**	**Interior Span**	**Moment Coefficient**	**Clear Span, ln (ft)**	**Moment**
$1.2D+1.6L$ (9-2)	8.15	Exterior Negative	N/A	N/A	N/A
		Positive	$\frac{w_u \ell_n^2}{16}$	28.25	399.4
		Interior Negative	$\frac{w_u \ell_n^2}{11}$	28.125	586.1
$1.2D+0.5L+1.0W$ (9-4)	6.04	Exterior Negative	N/A	N/A	N/A
		Positive	$\frac{w_u \ell_n^2}{16}$	28.25	296
		Interior Negative	$\frac{w_u \ell_n^2}{11}$	28.125	578.8
$0.9D+1.0W$ (9-6)	3.81	Exterior Negative	N/A	N/A	N/A
		Positive	$\frac{w_u \ell_n^2}{16}$	28.25	186.7
		Interior Negative	$\frac{w_u \ell_n^2}{11}$	28.125	418.5
$1.2D+0.5L-1.0W$ (9-4)	6.04	Exterior Negative	N/A	N/A	N/A
		Positive	$\frac{w_u \ell_n^2}{16}$	28.25	296
		Interior Negative	$\frac{w_u \ell_n^2}{11}$	28.125	289.8
$0.9D-1.0W$ (9-6)	3.81	Exterior Negative	N/A	N/A	N/A
		Positive	$\frac{w_u \ell_n^2}{16}$	28.25	186.7
		Interior Negative	$\frac{w_u \ell_n^2}{11}$	28.125	129.5

b. Determine the flexural reinforcement

The flexural reinforcement calculation for the end span – exterior negative location is provided below.

$M_u = -445.8$ ft-kips

Assume tension-controlled section. This assumption will be checked later.

Effective depth, d = depth of the beam – cover – dia of the stirrup – dia of the bar /2

Note: The top and bottom cover in spBeam is the clear cover to the longitudinal bars but not to the stirrups. Clear cover in spBeam is entered as 1.5 in.

Use #4 stirrups and #8 flexural reinforcement.

(This bar size can be specified by the user in spBeam or spBeam can choose automatically if allowed by the user. For this example purpose, #8 bar has been used)

Therefore, effective depth, $d = 20.5 - 1.5 - 1.0/2 = 18.5$ in.

$$A_s = \frac{0.85 f'_c b}{f_y}\left(d - \sqrt{d^2 - \frac{2M_u}{\phi\, 0.85 f'_c b}}\right)$$

$$A_s = \frac{0.85 \times 4 \times 36}{60} \times \left[18.5 - \sqrt{18.5^2 - \frac{2 \times 445.8 \times 12}{0.9 \times 0.85 \times 4 \times 36}}\right]$$

A_s required = 5.8 in^2

A_s provided = 6.32 in^2 (8 #8)

$$a = \frac{A_s f_y}{0.85 f'_c b} = \frac{6.32 \times 60000}{0.85 \times 4000 \times 36} = 3.098 \text{ in}$$

$$c = \frac{a}{\beta_1} = \frac{3.098}{0.85} = 3.645 \text{ in}$$

$$\varepsilon_y = \frac{f_y}{E_s} = \frac{60}{29000} = 0.00207$$

$$\varepsilon_t = \left(\frac{0.003}{c}\right)d_t - 0.003 = \left(\frac{0.003}{3.645}\right) \times 18.5 - 0.003 = 0.01522 > 0.005$$

Therefore, section is tension-controlled as assumed earlier and

$$\varepsilon_t = 0.01522 > \varepsilon_y = 0.00207$$

Hence, the tension reinforcement has yielded.

All the values on Table 3 are calculated based on the procedure outlined above.

Table 3 – Reinforcing Design Summary					
Location		M_u **(ft-kips)**	A_s Required **(in.^{2})***	A_s Provided **(in.^{2})***	Reinforcement
End Span	Exterior Negative	-445.8	5.8	6.32	8-No. 8
	Positive	464.6	6.07	6.32	8-No. 8
	Interior Negative	-644.7	8.76	9.48	12-No. 8
Interior Span	Positive	399.4	5.15	5.53	7-No. 8

c. Determine the minimum area of reinforcement

Per ACI 318-11, Sect. 10.5.1, A_{smin} should be

$$A_{s,min} = 3\frac{\sqrt{f'_c}}{f_y}b_w d = 3\times\frac{\sqrt{4000}}{60000}\times 36\times 18.5 = 2.11\text{ in.}^2$$

, and not less than $\dfrac{200b_w d}{f_y} = \dfrac{200\times 36\times 18.5}{60000} = 2.22\text{ in}^2$ (Governs)

d. Determine the maximum area of reinforcement

$$\rho_{max} = \frac{0.003}{0.003+0.005}\times\frac{0.85\,\beta_1\,f_c'}{f_y}$$

$$\rho_{max} = \frac{0.003}{0.003+0.005}\times\frac{0.85 \text{ x } 0.85 \text{ x } 4}{60}$$

$\rho_{max} = 0.01806$

$A_{smax} = \rho_{max}\,bd = 0.01806 \text{ x } 36 \text{ x } 18.5$

$A_{smax} = 12.03\text{ in}^2$

e. Determine the reinforcement spacing provided

Span 2:

Stirrup size: #4

Longitudinal bar size: #8

Inside radius, $r = 2 \text{ x } d_s = 2 \text{ x } \dfrac{4}{8} = 1\text{ in}$

$$W_{bend} = \left(1-\frac{\sqrt{2}}{2}\right)\left(r-\frac{d_b}{2}\right)$$

$$W_{bend} = \left(1 - \frac{\sqrt{2}}{2}\right)\left(1 - \frac{1}{2}\right)$$

W_{bend} = 0.1464 in

Distance from the edge to the center of the corner bar = (clear cover + dia of stirrup + W_{bend} + #8 dia /2)

Distance from the edge to the center of the corner bar = (1.5 + 0.5 + 0.1464 + 1/2) = 2.6464 in

For both sides = 2 x 2.6464 = 5.293 in

Distance between the centers of the corner bars = 36 – 5.293 = 30.707 in

Spacing provided = 30.707 / spaces between the bars = 30.707 / 7

Spacing provided = 4.39 in

Note: If the same number of bars are provided as spBeam for each segmentation of the span, the spacing provided will match with spBeam. For example, for span 2, left segment, 7#8 bars are provided. Therefore, Spacing provided = 30.707/6 = 5.118 in.

f. Determine the maximum spacing of flexural reinforcement

According to ACI 318-11, 10.6.4, maximum spacing allowed should be;

$$s = 15\left(\frac{40000}{f_s}\right) - 2.5c_c \le 12\left(\frac{40000}{f_s}\right)$$

But not greater than, $s = 12\left(\frac{40{,}000}{f_s}\right)$

$$c_c = 1.5 + 0.5 = 2.0 \text{ in.}$$

Use $f_s = \frac{2}{3} f_y = 40 \text{ ksi}$

$$s = 15 \times \left(\frac{40000}{40000}\right) - 2.5 \times 2.0 = 10 \text{ in. (governs)}$$

$$s = 12 \times \left(\frac{40000}{40000}\right) = 12 \text{ in.}$$

Spacing provided for 8 #8 bars = 4.39 in. < 10 in. O.K.

g. Determine the minimum width of the section
Check whether the width of the section is sufficient for 6-#9 bars. This criteria is automatically considered during the reinforcement selection process by spBeam.

Minimum width of the beam = n D +(n-1) s+ 2 x dia of stuirrups+2 x concrete cover + 2 x W_{bend}

n = number of bars

D = diameter of the bar

s= spacing between bars (equal to 1 in or D, whichever is greater)

Minimum width of the beam = 8 x 1 + 7 x 1+ 2 x 0.5 + 2 x 1.5 + 2 x 0.1464

Minimum width of the beam = 19.3 in > 36 in (Width provided) (O.K.)

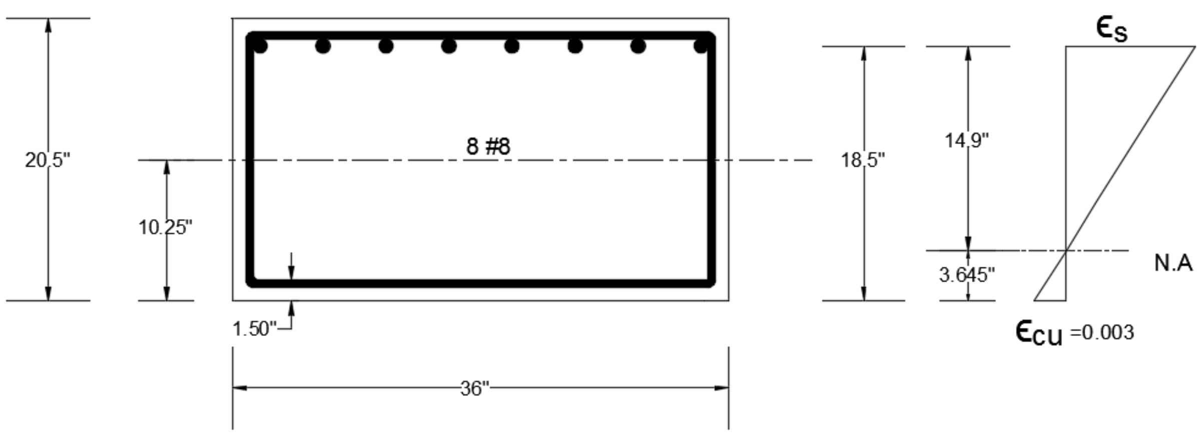
h. Determine the design capacity for the exterior span
For Exterior support, A_s = 6.32 in^2

$$M_n = A_s f_y \left[d - \frac{a}{2} \right]$$

$$\phi M_n = 0.9 \text{ x } 6.32 \text{ x } 60 \left[18.5 - \frac{3.098}{2} \right]$$

$$\varphi M_n = 5785 \text{ k} - \text{in} = 482.1 \text{ k-ft}$$

Note: If the As value is used same as provided by spBeam (i.e. A_s = 5.53 in^2 for 7 #8), the value of depth of compressive black, "a", will become 2.711 inches which will lead to Moment Capacity, ϕM_n = 426.64 k-ft.



3. Shear Design

Shear design is performed for the exterior face of the interior column (governs).

$V_u = 132.4$ kips (at the face of the support)

At d distance from the face of support, $V_u = 132.4 - 8.15(\frac{18.5}{12}) = 119.84$ kips

Shear strength provided by concrete

$$V_c = 2\sqrt{f'_c}b_w d \quad (11\text{-}3)$$

$\phi = 0.75$

$$\phi V_c = \phi 2\sqrt{f'_c}b_w d = 0.75 \times 2 \times \sqrt{4000} \times 36 \times 18.5 = 63.18$$

$V_u = 119.84\text{kips} > \phi V_c == 63.18$ kips

Therefore, stirrups are required.

$\phi V_c = 63.18$ kips

$$\frac{\phi V_c}{2} = \frac{63.18}{2} = 31.59 \text{ kips}$$

Since $V_u = 119.84\text{kips} > \frac{\phi V_c}{2} = 31.59$ kips, Stirrups are required.

Distance x_1 from support beyond which minimum reinforcement is required $(V_u = \phi V_c)$:

$$x_1 = \frac{V_u@support - \phi V_c}{w_u} = \left(\frac{132.4 - 63.18}{8.15}\right) = \approx 8.5 \text{ ft} = 102 \text{ in}$$

Distance x, at which no shear reinforcement is required (At $V_u = \frac{\phi V_c}{2}$);

$$x = \left(\frac{V_u@support - \frac{\phi V_c}{2}}{w_u}\right)$$

$$x = \left(\frac{132.4 - 31.59}{8.15}\right) = 12.37 \text{ ft} = 148.44 \text{ in}$$

$$V_s = \frac{V_u - \phi V_c}{\phi} = \frac{119.84 - 63.18}{0.75} = 75.55 \text{ kips}$$

V_s should not be greater than $\phi 8\sqrt{f'_c}b_w d$ (11.4.7.9)

$V_s = 0.75 \times 8\sqrt{4000} \times 36 \times 18.5 = 252.73 \text{ kip } > 75.55 \text{ kips}$ (O.K.)

$\phi 4\sqrt{f'_c} b_w d = 0.75 \times 4 \times \sqrt{4000} \times 36 \times 18.5 = 126.36 \text{ kips}$

$V_s = 75.55 \text{ kips} < \phi 4\sqrt{f'_c} b_w d = 126.36 \text{ kips}$ (O.K.) (11.4.5.3)

Therefore, maximum permissible spacing of stirrups per ACI 318-11, 11.4.5.1 must be considered.

$S_1 = s(max) \leq d/2 = 18.5/2 = 9.25$ in, Say 9 in (Governs)

Spacing, S_2

$$V_s = \frac{A_v f_{yt} d}{S_2}$$ (Section 11.4.7.2, Eq 11-15)

$$S_2 = \frac{A_v f_{yt} d}{V_s} = \frac{0.62 \times 60 \times 18.5}{75.55}$$

$S_2 = 9.11$ in, Say 9 in

Maximum stirrup spacing based on minimum shear reinforcement based on ACI 318, 11.4.6.3

$$A_{v,min} = 0.75\sqrt{f'_c} \frac{b_w s}{f_{yt}}$$ (11-13)

But not less than $A_{v,min} = \dfrac{50 b_w s}{f_{yt}}$

$$s(max) \leq \frac{A_v f_{yt}}{0.75\sqrt{f'_c} b_w} = \frac{0.62 \times 60000}{0.75 \times \sqrt{4000} \times 36} = 21.8 \text{ in, Say } 22 \text{ in}$$

$$s(max) \leq \frac{A_v f_{yt}}{50 b_w} = \frac{0.62 \times 60000}{50 \times 36} = 20.7 \text{ in, Say } 21 \text{ in}$$ (Governs)

$S_3 = 21$ in

$S_4 = s(max) \leq 24$ in.

$S_{max} = 9$ in (Governs)

$V_s = 76.55$ kips (Calculated previously)

$\phi V_s = 57.38$ kips

$\phi V_s + \phi V_c = 57.38 + 63.18 = 120.56$ kips

$S_{max} = 9 \text{ in} = S_1 = 9$ in, provide #5 stirrups at 9 in

Required spacing:

$$\frac{A_v}{s} = \frac{V_u - \phi V_c}{\phi f_{yt} d} \qquad \text{(R.11.4.7)}$$

$$s(req'd) = \frac{\phi A_v f_{yt} d}{V_u - \phi V_c}$$

Assuming #5 U-stirrups ($A_v = 0.62\ in^2$) with two legs.

$$s(req'd) = \frac{0.75 \times 0.62 \times 60 \times 18.5}{119.84 - 63.18} = 9.11 \text{ in} \approx 9 \text{ in} = S_{max}$$

Location where stirrups are not required = 148.44 in (from face of the support)

First stirrup location = 2 in from face of the support

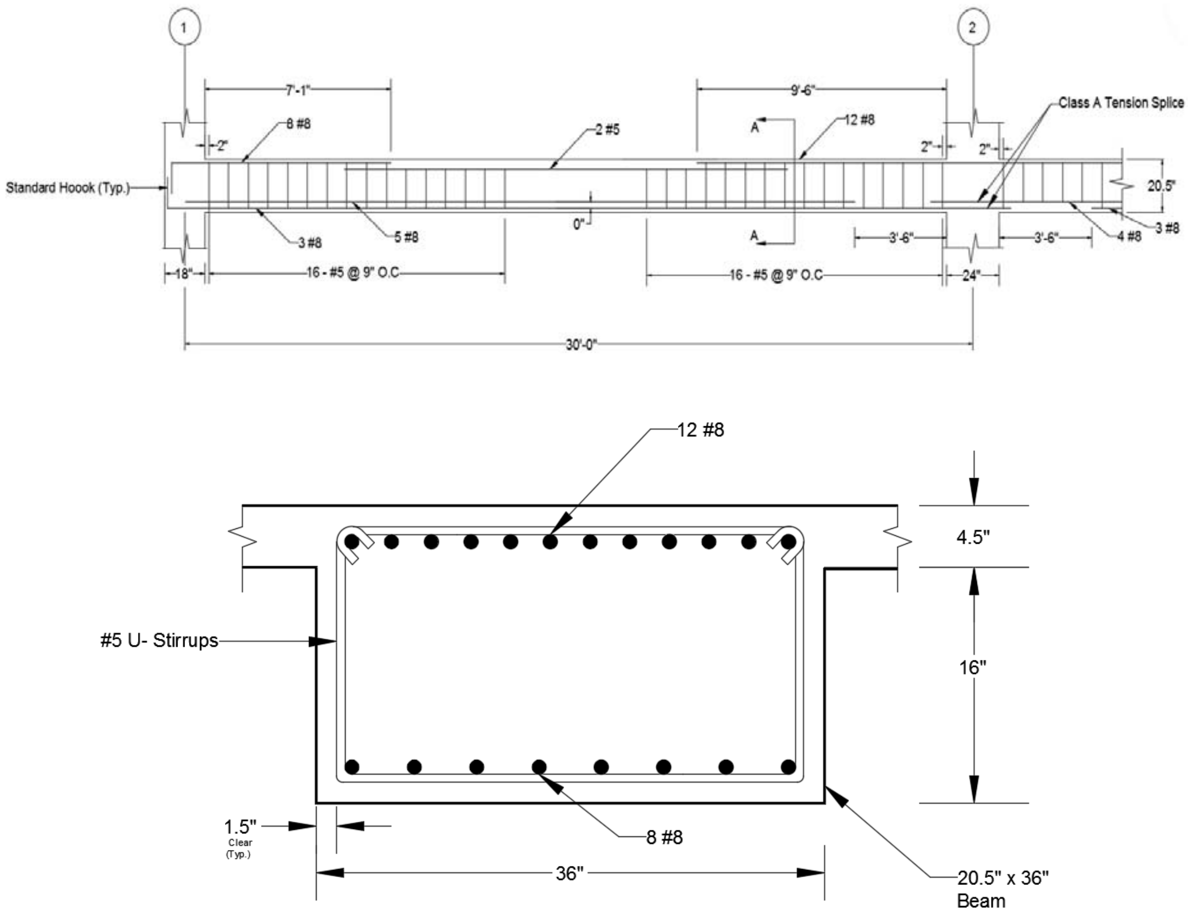
Provide 16 #5 @ 9 in = 153 in

Note: Flexural Design has been done using #4 stirrups. The calculations for flexural can be repeated using #5 stirrups.

4. Reinforcement Details

Figure 3 below shows the reinforcement details for the beam. In lieu of computing the bar lengths in accordance with ACI 318-11, 12.10 through 12.12, 2-No. 5 bars are provided within the center portion of the span to account for any variations in required bar lengths due to wind effect. For overall economy, it may be worthwhile to forego the No. 5 bars and determine the actual bar lengths per the above ACI sections.

Since the beams are part of the primary lateral-load-resisting system, ACI 318-11, 12.11.2 requires that at least one-fourth of the positive moment reinforcement extend into the support and be anchored to develop f_y in tension at the face of the support.



Section A-A

Figure 3 – Beam Elevation and Cross-Section

The graphical and text results are provided below for both the input and output of the spBeam model.

5. Conclusions & Observations

In order to complete the design of the one-way joist system, a typical joist in the transverse direction is required to be modeled. Also the interior, edge, and corner columns are required to be designed. spBeam and spColumn Software Programs can be utilized to complete these designs respectively.

The graphical and text results are provided below for both the input and output of the spBeam model.

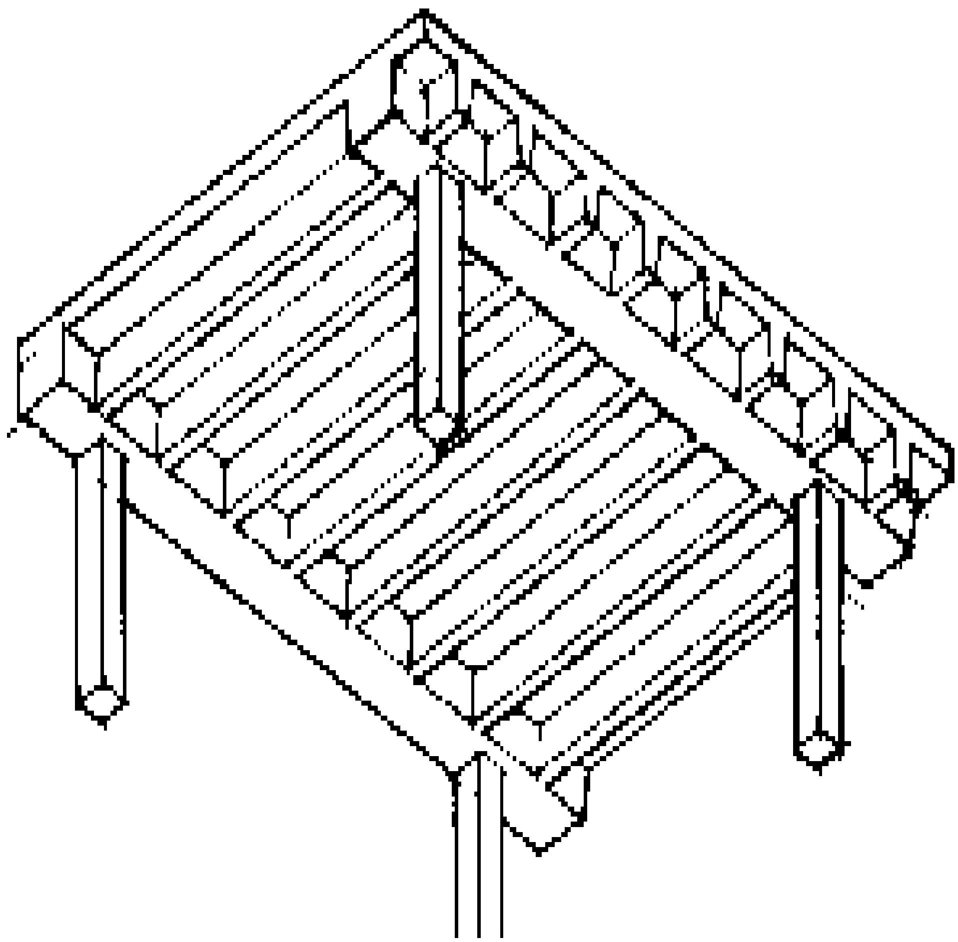
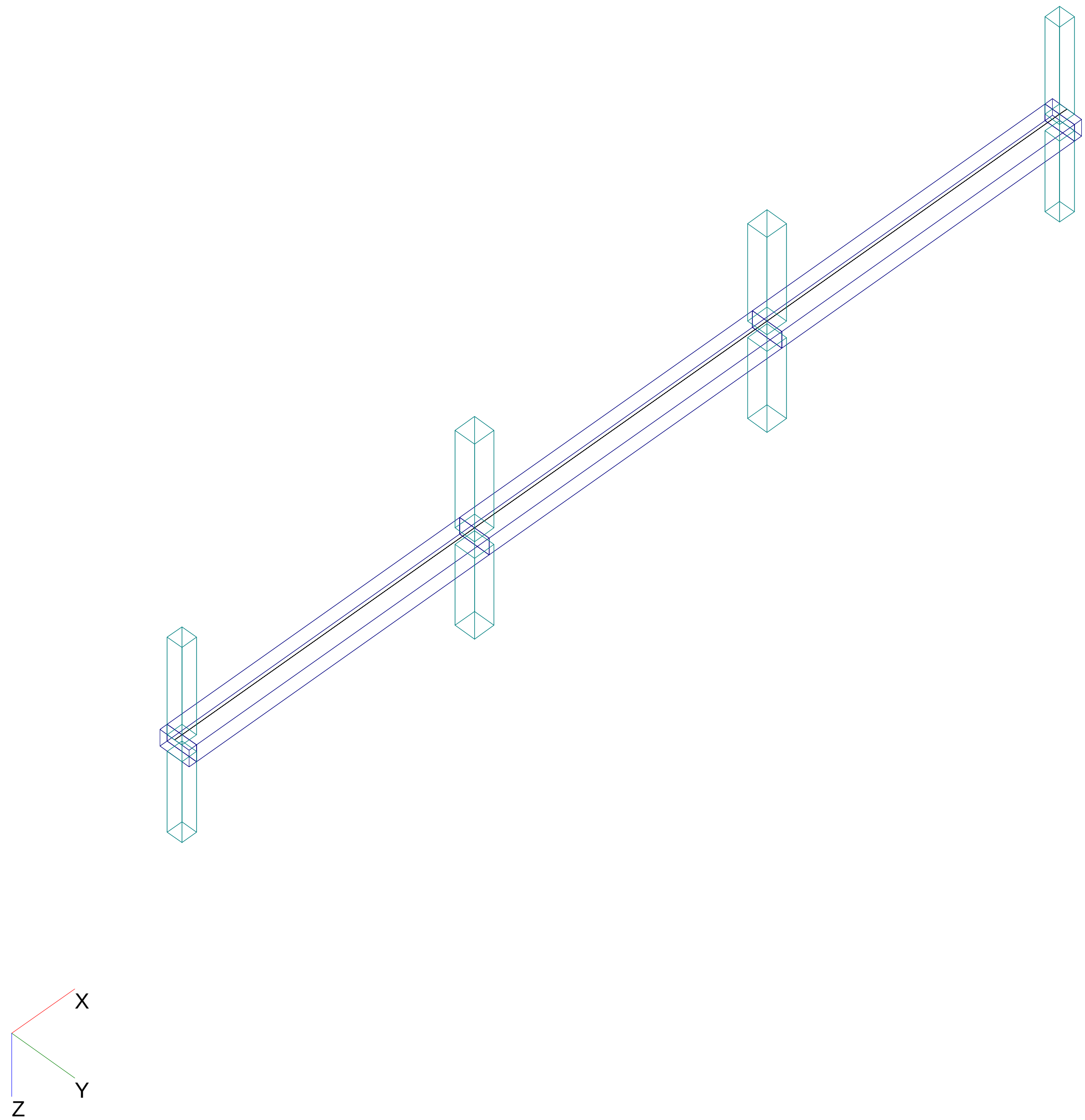


Figure 4 – Isometric View of Typical One-Way Joist Floor System



spBeam v5.00. Licensed to: StructurePoint. License ID: 00000-0000000-4-2A05D-2471B

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

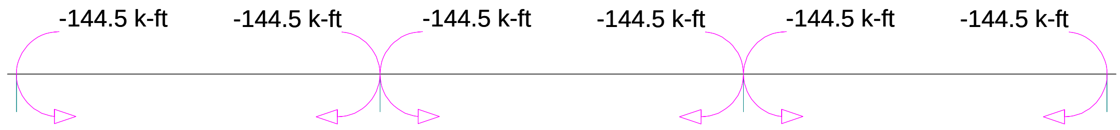
Frame: Continuous Beam

Engineer: SP

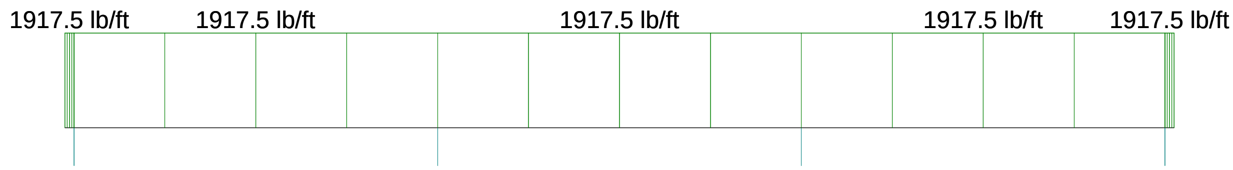
Code: ACI 318-11

Date: 07/22/16

Time: 10:20:38

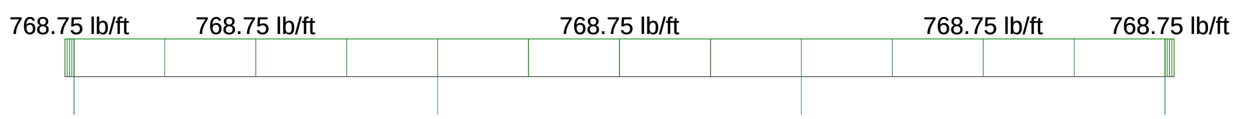


CASE: Wind



CASE/PATTERN: Live/All

CASE: Dead



CASE: SELF

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

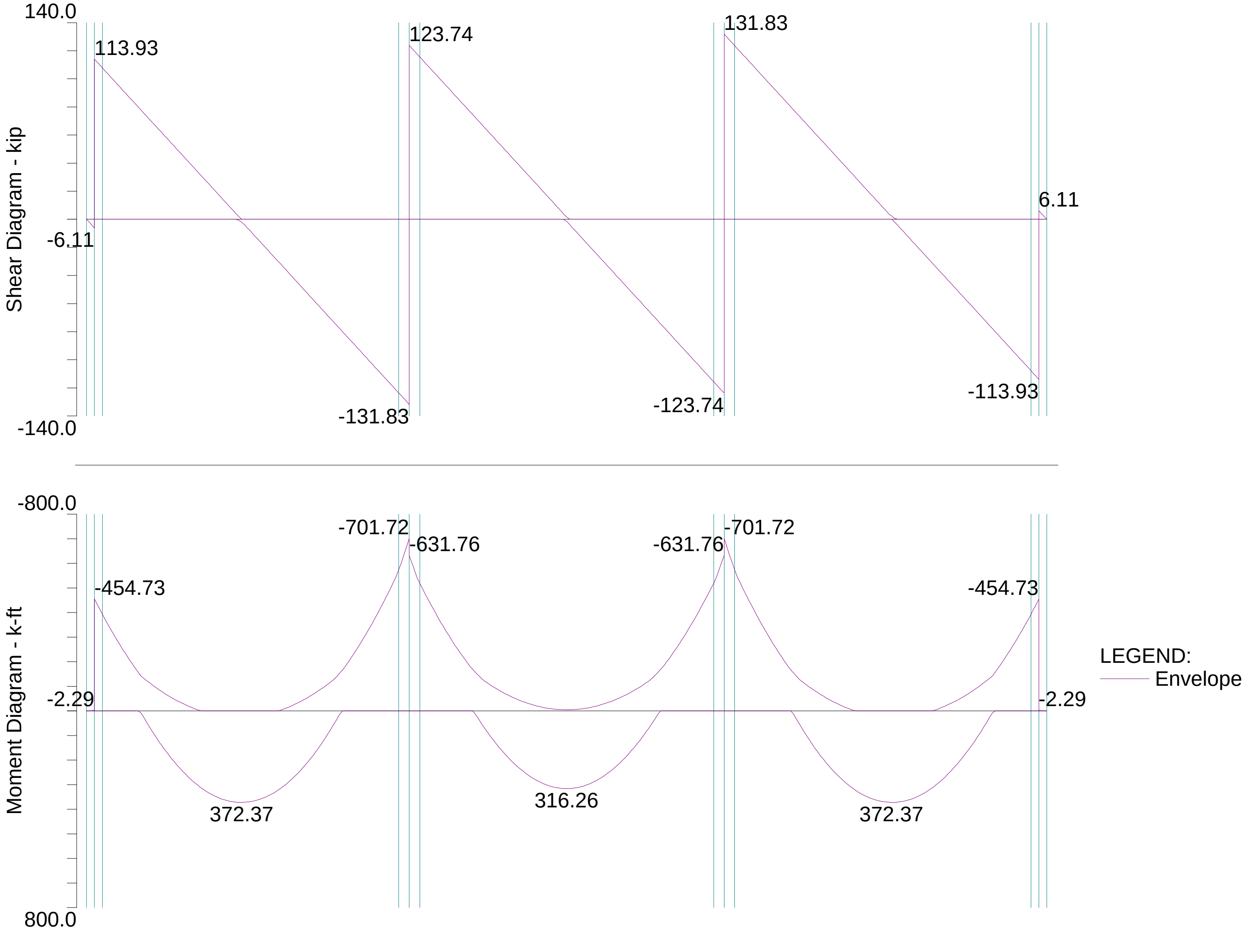
Frame: Continuous Beam

Engineer: SP

Code: ACI 318-11

Date: 07/22/16

Time: 10:52:20



spBeam v5.00. Licensed to: StructurePoint. License ID: 00000-0000000-4-2A05D-2471B

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

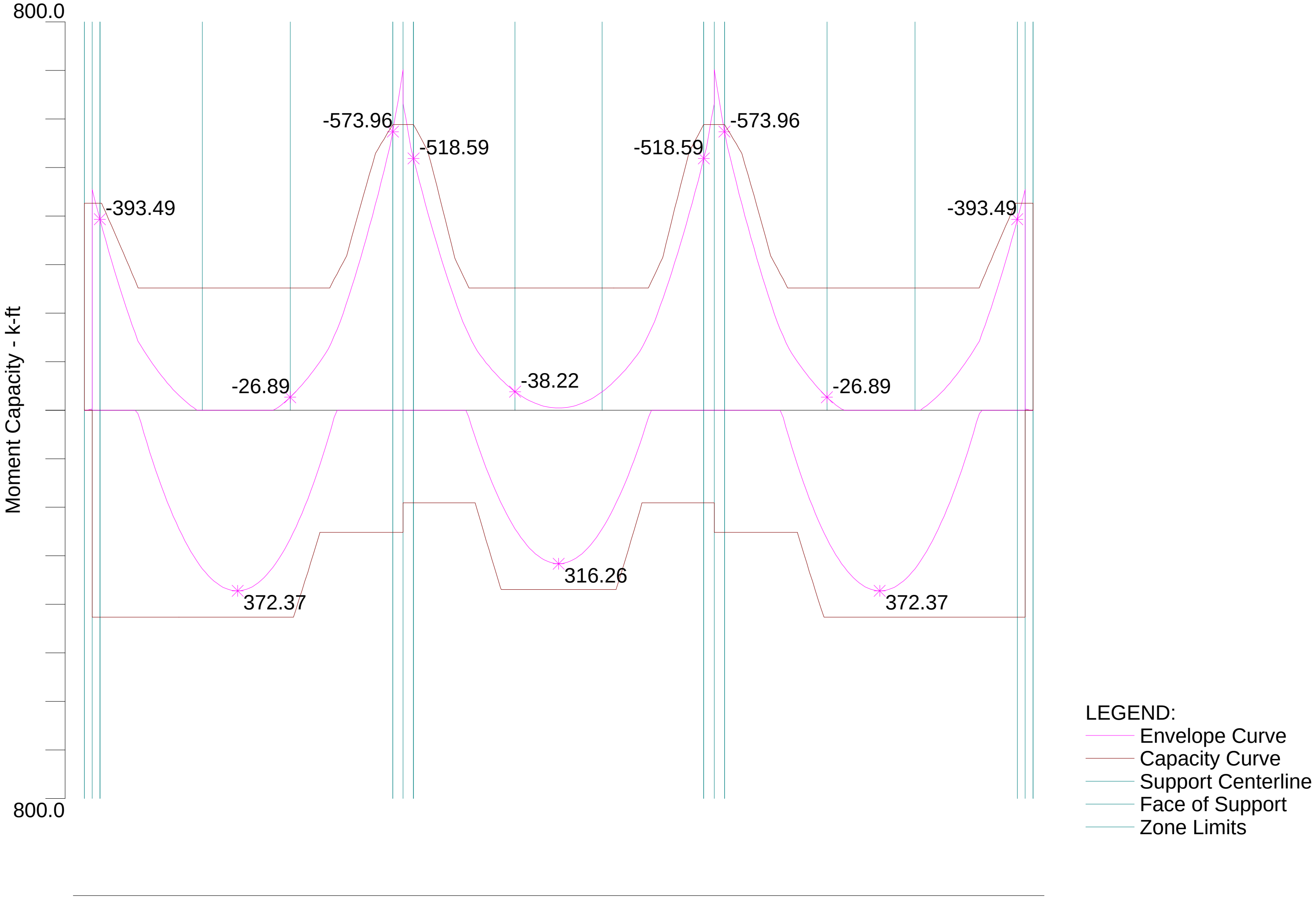
Frame: Continuous Beam

Engineer: SP

Code: ACI 318-11

Date: 07/22/16

Time: 10:51:36



spBeam v5.00. Licensed to: StructurePoint. License ID: 00000-0000000-4-2A05D-2471B

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

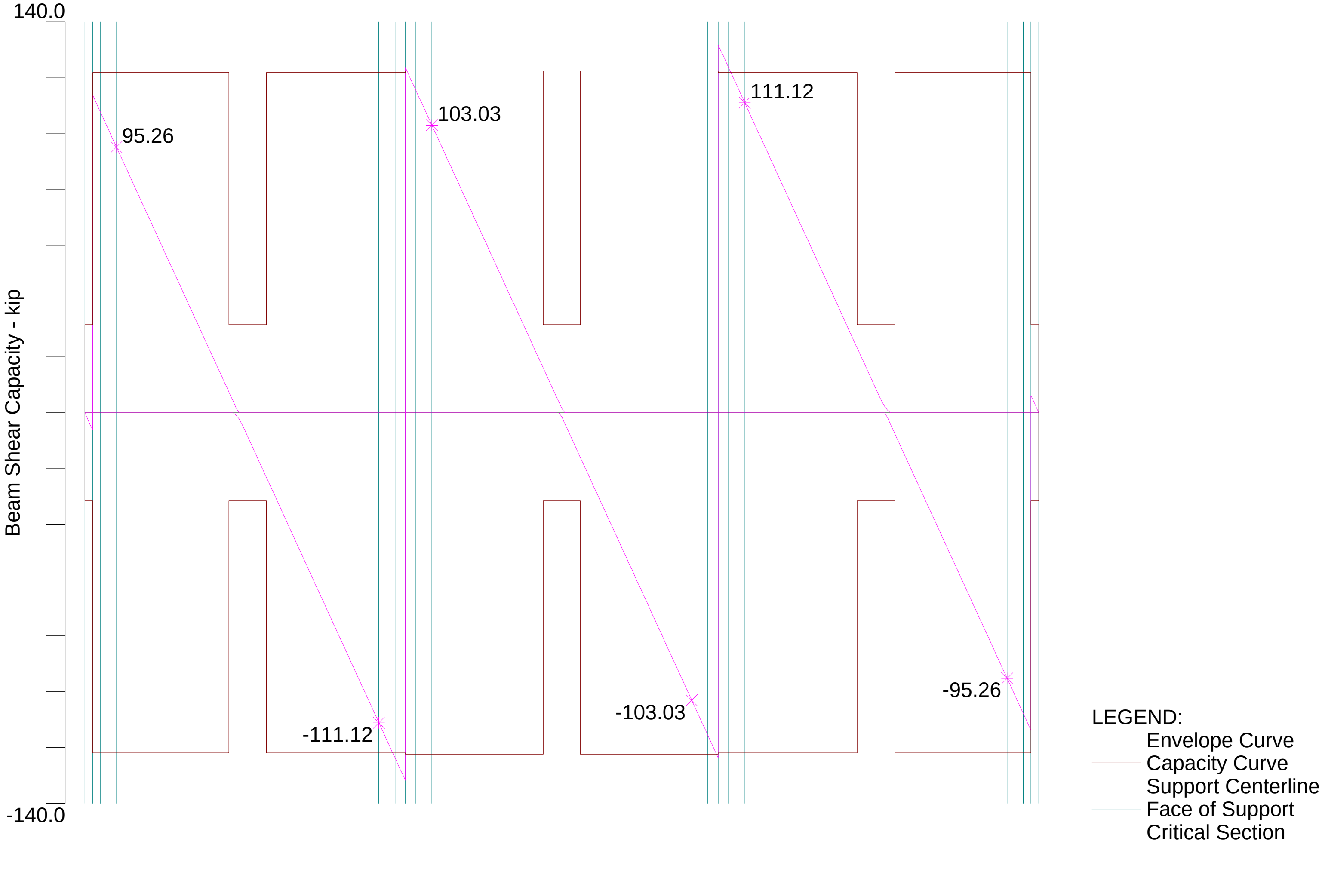
Frame: Continuous Beam

Engineer: SP

Code: ACI 318-11

Date: 07/22/16

Time: 10:54:22



spBeam v5.00. Licensed to: StructurePoint. License ID: 00000-0000000-4-2A05D-2471B

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

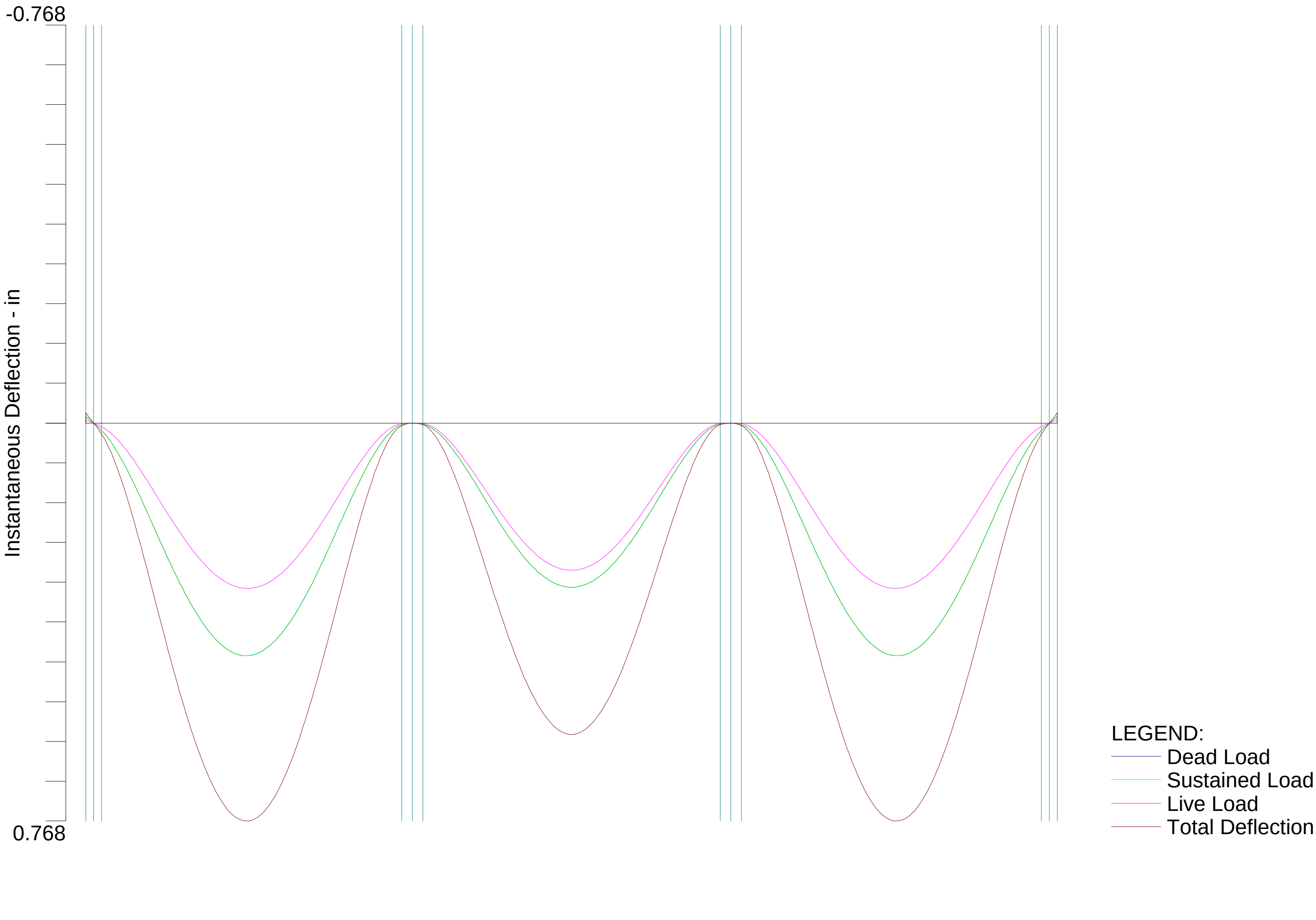
Frame: Continuous Beam

Engineer: SP

Code: ACI 318-11

Date: 07/22/16

Time: 10:55:22



spBeam v5.00. Licensed to: StructurePoint. License ID: 00000-0000000-4-2A05D-2471B

File: C:\TSDA-spBeam-Beams and One-way Slabs.slb

Project: TSDA-Beams and One-way Slabs

Frame: Continuous Beam

Engineer: SP

Code: ACI 318-11

Date: 07/22/16

Time: 10:50:24

```
                                 oooooo
                                 oo   oo
   ooooo    oooooo   oo   oo     ooooo     ooooo    o oooooooooo
  oo    o   oo   oo  oo   oo    oo   oo   o    oo    oo   oo   oo
  oo        oo   oo  ooooooo    oo   oo    oooooo    oo   oo   oo
   ooooo    oo   oo  oo     oo  oo   oo   oo   oo    oo   oo   oo
       oo   oooooo   oo     oo  ooooo     oo   oo    oo   oo   oo
  o    oo   oo       oo     oo  oo     o  oo   oo    oo   oo   oo
   ooooo    oo       ooooooo     ooooo     ooooo o   oo   oo   oo  (TM)
```

===

spBeam v5.00 (TM)

A Computer Program for Analysis, Design, and Investigation of
Reinforced Concrete Beams and One-way Slab Systems

===

===

[1] INPUT ECHO

===

General Information

File name: C:\TSDA-spBeam-Beams and One-way Slabs.slb
Project: TSDA-Beams and One-way Slabs
Frame: Continuous Beam
Engineer: SP
Code: ACI 318-11
Reinforcement Database: ASTM A615
Mode: Design
Number of supports = 4 + Left cantilever + Right cantilever
Floor System: One-Way/Beam

Live load pattern ratio = 100%
Deflections are based on cracked section properties.
In negative moment regions, Ig and Mcr DO NOT include flange/slab contribution (if available)
Long-term deflections are calculated for load duration of 60 months.
0% of live load is sustained.
Compression reinforcement calculations NOT selected.
Default incremental rebar design selected.
Moment redistribution NOT selected.
Effective flange width calculations selected.
Rigid beam-column joint NOT selected.
Torsion analysis and design NOT selected.

Material Properties

		Slabs|Beams	Columns	
wc	=	150	150	lb/ft3
f'c	=	4	4	ksi
Ec	=	3834.3	3834.3	ksi
fr	=	0.47434	0.47434	ksi

fy = 60 ksi, Bars are not epoxy-coated
fyt = 60 ksi
Es = 29000 ksi

Reinforcement Database

Units: Db (in), Ab (in^2), Wb (lb/ft)

Size	Db	Ab	Wb	Size	Db	Ab	Wb
#3	0.38	0.11	0.38	#4	0.50	0.20	0.67
#5	0.63	0.31	1.04	#6	0.75	0.44	1.50
#7	0.88	0.60	2.04	#8	1.00	0.79	2.67
#9	1.13	1.00	3.40	#10	1.27	1.27	4.30
#11	1.41	1.56	5.31	#14	1.69	2.25	7.65
#18	2.26	4.00	13.60				

Span Data

Slabs

Units: L1, wL, wR (ft); t, bEff, Hmin (in)

Span	Loc	L1	t	wL	wR	bEff	Hmin	
1	Int	0.750	0.00	1.500	1.500	36.00	0.00	LC
2	Int	30.000	0.00	1.500	1.500	36.00	0.00	
3	Int	30.000	0.00	1.500	1.500	36.00	0.00	
4	Int	30.000	0.00	1.500	1.500	36.00	0.00	
5	Int	0.750	0.00	1.500	1.500	36.00	0.00	RC

Ribs and Longitudinal Beams

Units: b, h, Sp (in)

	Ribs			Beams		Span
Span	b	h	Sp	b	h	Hmin
1	0.00	0.00	0.00	36.00	20.50	1.13
2	0.00	0.00	0.00	36.00	20.50	19.46
3	0.00	0.00	0.00	36.00	20.50	17.14
4	0.00	0.00	0.00	36.00	20.50	19.46
5	0.00	0.00	0.00	36.00	20.50	1.13

Support Data

Columns

Units: c1a, c2a, c1b, c2b (in); Ha, Hb (ft)

Supp	c1a	c2a	Ha	c1b	c2b	Hb	Red%
1	18.00	18.00	10.000	18.00	18.00	10.000	100
2	24.00	24.00	10.000	24.00	24.00	10.000	100
3	24.00	24.00	10.000	24.00	24.00	10.000	100
4	18.00	18.00	10.000	18.00	18.00	10.000	100

Boundary Conditions

Units: Kz (kip/in); Kry (kip-in/rad)

Supp	Spring Kz	Spring Kry	Far End A	Far End B
1	0	0	Fixed	Fixed
2	0	0	Fixed	Fixed
3	0	0	Fixed	Fixed
4	0	0	Fixed	Fixed

Load Data

Load Cases and Combinations

Case	SELF	Dead	Live	Wind
Type	DEAD	DEAD	LIVE	LATERAL
U1	1.400	1.400	0.000	0.000
U2	1.200	1.200	1.600	0.000
U3	1.200	1.200	0.500	1.000
U4	0.900	0.900	0.000	1.000

Line Loads

Units: Wa, Wb (lb/ft), La, Lb (ft)

Case/Patt	Span	Wa	La	Wb	Lb
SELF	1	768.75	0.000	768.75	0.750
	2	768.75	0.000	768.75	30.000
	3	768.75	0.000	768.75	30.000
	4	768.75	0.000	768.75	30.000
	5	768.75	0.000	768.75	0.750
Dead	1	3465.00	0.000	3465.00	0.750
	2	3465.00	0.000	3465.00	30.000
	3	3465.00	0.000	3465.00	30.000
	4	3465.00	0.000	3465.00	30.000
	5	3465.00	0.000	3465.00	0.750
Live	1	1917.50	0.000	1917.50	0.750
	2	1917.50	0.000	1917.50	30.000
	3	1917.50	0.000	1917.50	30.000
	4	1917.50	0.000	1917.50	30.000
	5	1917.50	0.000	1917.50	0.750
Live/Odd	1	1917.50	0.000	1917.50	0.750
	3	1917.50	0.000	1917.50	30.000
	5	1917.50	0.000	1917.50	0.750
Live/Even	2	1917.50	0.000	1917.50	30.000
	4	1917.50	0.000	1917.50	30.000
Live/S1	1	1917.50	0.000	1917.50	0.750
	2	1917.50	0.000	1917.50	30.000
Live/S2	2	1917.50	0.000	1917.50	30.000
	3	1917.50	0.000	1917.50	30.000
Live/S3	3	1917.50	0.000	1917.50	30.000

	4	1917.50	0.000	1917.50	30.000
Live/S4	4	1917.50	0.000	1917.50	30.000
	5	1917.50	0.000	1917.50	0.750

Lateral Load Effects

Units: M (k-ft)

Case	Span	Mleft	Mright
Wind	2	-144.50	-144.50
	3	-144.50	-144.50
	4	-144.50	-144.50

Reinforcement Criteria

Slabs and Ribs

	Top bars		Bottom bars		
	Min	Max	Min	Max	
Bar Size	#8	#8	#8	#8	
Bar spacing	1.00	18.00	1.00	18.00	in
Reinf ratio	0.14	5.00	0.14	5.00	%
Cover	1.50		1.50		in

There is more than 12 in of concrete below top bars.

Beams

	Top bars		Bottom bars			Stirrups		
	Min	Max	Min	Max		Min	Max	
Bar Size	#8	#8	#8	#8		#5	#5	
Bar spacing	1.00	18.00	1.00	18.00		6.00	18.00	in
Reinf ratio	0.14	5.00	0.14	5.00	%			
Cover	1.50		1.50		in			
Layer dist.	1.00		1.00		in			
No. of legs						2	6	
Side cover						1.50		in
1st Stirrup						3.00		in

There is more than 12 in of concrete below top bars.

```
                                oooooo
                                oo   oo
 ooooo    oooooo    oo   oo     ooooo     ooooo    o oooooooooo
oo    o   oo   oo   oo   oo   oo   oo   o    oo    oo   oo   oo
oo        oo   oo   ooooooo   oo   oo    oooooo    oo   oo   oo
 ooooo    oo   oo   oo    oo  oo   oo   oo   oo    oo   oo   oo
     oo   oooooo    oo    oo  ooooo     oo   oo    oo   oo   oo
o    oo   oo        oo    oo  oo    o   oo   oo    oo   oo   oo
 ooooo    oo        ooooooo     ooooo     ooooo o  oo   oo   oo  (TM)
```

==

spBeam v5.00 (TM)
A Computer Program for Analysis, Design, and Investigation of
Reinforced Concrete Beams and One-way Slab Systems

==

==

[2] DESIGN RESULTS

==

Top Reinforcement

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Zone	Width	Mmax	Xmax	AsMin	AsMax	AsReq	SpProv	Bars
1	Left	3.00	0.00	0.000	0.932	12.030	0.000	10.104	4-#8 *3 *5
	Midspan	3.00	0.00	0.000	0.932	12.030	0.000	10.104	4-#8 *3 *5
	Right	3.00	0.00	0.000	0.932	12.030	0.000	5.052	7-#8 *3 *5
2	Left	3.00	393.49	0.750	2.220	12.030	5.067	5.052	7-#8
	Midspan	3.00	26.89	19.113	0.932	12.030	0.324	10.104	4-#8 *3 *5
	Right	3.00	573.96	29.000	2.220	12.030	7.675	3.368	10-#8
3	Left	3.00	518.59	1.000	2.220	12.030	6.851	3.368	10-#8
	Midspan	3.00	38.22	10.800	0.932	12.030	0.462	10.104	4-#8 *3 *5
	Right	3.00	518.59	29.000	2.220	12.030	6.851	3.368	10-#8
4	Left	3.00	573.96	1.000	2.220	12.030	7.675	3.368	10-#8
	Midspan	3.00	26.89	10.887	0.932	12.030	0.324	10.104	4-#8 *3 *5
	Right	3.00	393.49	29.250	2.220	12.030	5.067	5.052	7-#8
5	Left	3.00	0.00	0.750	0.932	12.030	0.000	5.052	7-#8 *3 *5
	Midspan	3.00	0.00	0.750	0.932	12.030	0.000	10.104	4-#8 *3 *5
	Right	3.00	0.00	0.750	0.932	12.030	0.000	10.104	4-#8 *3 *5

NOTES:
*3 - Design governed by minimum reinforcement.
*5 - Number of bars governed by maximum allowable spacing.

Top Bar Details

Units: Length (ft)

	Left				Continuous		Right			
Span	Bars	Length	Bars	Length	Bars	Length	Bars	Length	Bars	Length
1	---		---		4-#8	0.75	3-#8	0.75	---	
2	3-#8	4.44	---		4-#8	30.00	3-#8	7.09	3-#8*	5.45
3	3-#8*	6.34	3-#8*	4.97	4-#8	30.00	3-#8*	6.34	3-#8*	4.97
4	3-#8	7.09	3-#8*	5.45	4-#8	30.00	3-#8	4.44	---	
5	3-#8	0.75	---		4-#8	0.75	---		---	

NOTES:
* - Bar cut-off location does not meet ACI 318, 12.10.5.1. Revise location,
unless the requirements of either 12.10.5.2 or 12.10.5.3 are manually checked and satisfied.

Top Bar Development Lengths

Units: Length (in)

Left　　Continuous　　Right

Span	Bars	Length	Bars	DevLen	Bars	DevLen	Bars	DevLen	Bars	DevLen
1	---		---		4-#8	12.00	3-#8	12.00	---	
2	3-#8	42.37	---		4-#8	12.00	3-#8	53.36	3-#8	53.36
3	3-#8	47.64	3-#8	47.64	4-#8	12.00	3-#8	47.64	3-#8	47.64
4	3-#8	53.36	3-#8	53.36	4-#8	12.00	3-#8	42.37	---	
5	3-#8	12.00	---		4-#8	12.00	---		---	

Bottom Reinforcement

Units: Width (ft), Mmax (k-ft), Xmax (ft), As (in^2), Sp (in)

Span	Width	Mmax	Xmax	AsMin	AsMax	AsReq	SpProv	Bars
1	3.00	0.00	0.000	0.000	12.030	0.000	0.000	---
2	3.00	372.37	14.028	2.220	12.030	4.775	5.052	7-#8
3	3.00	316.26	15.000	2.220	12.030	4.012	6.062	6-#8
4	3.00	372.37	15.973	2.220	12.030	4.775	5.052	7-#8
5	3.00	0.00	0.750	0.000	12.030	0.000	0.000	---

Bottom Bar Details

Units: Start (ft), Length (ft)

	Long Bars			Short Bars		
Span	Bars	Start	Length	Bars	Start	Length
1	---			---		
2	4-#8	0.00	30.00	3-#8*	0.00	21.98
3	3-#8	0.00	30.00	3-#8	6.95	16.10
4	4-#8	0.00	30.00	3-#8	8.02	21.98
5	---			---		

NOTES:
* - Bar cut-off location does not meet ACI 318, 12.10.5.1. Revise location,
unless the requirements of either 12.10.5.2 or 12.10.5.3 are manually checked and satisfied.

Bottom Bar Development Lengths

Units: DevLen (in)

	Long Bars		Short Bars	
Span	Bars	DevLen	Bars	DevLen
1	---		---	
2	4-#8	30.72	3-#8	30.72
3	3-#8	30.11	3-#8	30.11
4	4-#8	30.72	3-#8	30.72
5	---		---	

Flexural Capacity

Units: x (ft), As (in^2), PhiMn, Mu (k-ft)

		Top						Bottom					
Span	x	AsTop	PhiMn-	Mu-	Comb	Pat	Status	AsBot	PhiMn+	Mu+	Comb	Pat	Status
1	0.000	5.53	-426.64	0.00	U1	All	OK	0.00	0.00	0.00	U1	All	OK
	0.375	5.53	-426.64	-0.64	U2	Odd	---	0.00	0.00	0.00	U1	All	---
	0.750	5.53	-426.64	-2.29	U2	Odd	---	0.00	0.00	0.00	U1	All	---
2	0.000	5.53	-426.64	-454.73	U3	Even	---	5.53	426.64	0.00	U1	All	---
	0.250	5.53	-426.64	-433.94	U3	Even	---	5.53	426.64	0.00	U1	All	---
	0.750	5.53	-426.64	-393.49	U3	Even	OK	5.53	426.64	0.00	U1	All	OK
	0.907	5.53	-426.64	-381.16	U3	Even	OK	5.53	426.64	0.00	U1	All	OK
	4.438	3.16	-252.06	-141.95	U4	All	OK	5.53	426.64	7.57	U2	Odd	OK
	10.637	3.16	-252.06	0.00	U1	All	OK	5.53	426.64	326.81	U2	Even	OK
	14.028	3.16	-252.06	0.00	U1	All	OK	5.53	426.64	372.37	U2	Even	OK
	15.000	3.16	-252.06	0.00	U1	All	OK	5.53	426.64	368.07	U2	Even	OK
	19.113	3.16	-252.06	-26.89	U4	All	OK	5.53	426.64	265.13	U2	Even	OK
	19.416	3.16	-252.06	-33.17	U4	All	OK	5.53	426.64	252.06	U2	Even	OK
	21.975	3.16	-252.06	-100.12	U4	All	OK	3.16	252.06	112.00	U2	Even	OK
	22.909	3.16	-252.06	-131.85	U3	Odd	OK	3.16	252.06	47.63	U2	Even	OK
	24.553	4.04	-318.06	-221.42	U3	S2	OK	3.16	252.06	0.00	U1	All	OK
	27.356	7.02	-530.31	-426.64	U3	S2	OK	3.16	252.06	0.00	U1	All	OK
	29.000	7.90	-588.84	-573.96	U2	S2	OK	3.16	252.06	0.00	U1	All	OK

	29.250	7.90	-588.84	-605.14	U2 S2	---	3.16	252.06	0.00	U1 All	---
	30.000	7.90	-588.84	-701.72	U2 S2	---	3.16	252.06	0.00	U1 All	---
3	0.000	7.90	-588.84	-631.76	U2 S2	---	2.37	191.11	0.00	U1 All	---
	0.250	7.90	-588.84	-601.07	U2 S2	---	2.37	191.11	0.00	U1 All	---
	1.000	7.90	-588.84	-518.59	U3 S2	OK	2.37	191.11	0.00	U1 All	OK
	2.374	7.08	-534.09	-407.47	U3 S2	OK	2.37	191.11	0.00	U1 All	OK
	4.970	3.98	-313.90	-228.69	U3 S2	OK	2.37	191.11	0.00	U1 All	OK
	6.344	3.16	-252.06	-155.10	U3 S1	OK	2.37	191.11	15.54	U2 S3	OK
	6.949	3.16	-252.06	-129.15	U3 S1	OK	2.37	191.11	55.78	U2 S3	OK
	9.459	3.16	-252.06	-63.13	U4 All	OK	4.74	369.82	191.11	U2 Odd	OK
	10.800	3.16	-252.06	-38.22	U4 All	OK	4.74	369.82	244.39	U2 Odd	OK
	15.000	3.16	-252.06	-4.61	U4 All	OK	4.74	369.82	316.26	U2 Odd	OK
	19.200	3.16	-252.06	-38.22	U4 All	OK	4.74	369.82	244.39	U2 Odd	OK
	20.541	3.16	-252.06	-63.13	U4 All	OK	4.74	369.82	191.11	U2 Odd	OK
	23.051	3.16	-252.06	-129.15	U3 S4	OK	2.37	191.11	55.78	U2 S2	OK
	23.656	3.16	-252.06	-155.10	U3 S4	OK	2.37	191.11	15.54	U2 S2	OK
	25.030	3.98	-313.90	-228.69	U3 S3	OK	2.37	191.11	0.00	U1 All	OK
	27.626	7.08	-534.09	-407.47	U3 S3	OK	2.37	191.11	0.00	U1 All	OK
	29.000	7.90	-588.84	-518.59	U3 S3	OK	2.37	191.11	0.00	U1 All	OK
	29.750	7.90	-588.84	-601.07	U2 S3	---	2.37	191.11	0.00	U1 All	---
	30.000	7.90	-588.84	-631.76	U2 S3	---	2.37	191.11	0.00	U1 All	---
4	0.000	7.90	-588.84	-701.72	U2 S3	---	3.16	252.06	0.00	U1 All	---
	0.750	7.90	-588.84	-605.14	U2 S3	---	3.16	252.06	0.00	U1 All	---
	1.000	7.90	-588.84	-573.96	U2 S3	OK	3.16	252.06	0.00	U1 All	OK
	2.644	7.02	-530.31	-426.64	U3 S3	OK	3.16	252.06	0.00	U1 All	OK
	5.447	4.04	-318.06	-221.42	U3 S3	OK	3.16	252.06	0.00	U1 All	OK
	7.091	3.16	-252.06	-131.85	U3 Odd	OK	3.16	252.06	47.63	U2 Even	OK
	8.025	3.16	-252.06	-100.12	U4 All	OK	3.16	252.06	112.00	U2 Even	OK
	10.584	3.16	-252.06	-33.17	U4 All	OK	5.53	426.64	252.06	U2 Even	OK
	10.887	3.16	-252.06	-26.89	U4 All	OK	5.53	426.64	265.13	U2 Even	OK
	15.000	3.16	-252.06	0.00	U1 All	OK	5.53	426.64	368.07	U2 Even	OK
	15.973	3.16	-252.06	0.00	U1 All	OK	5.53	426.64	372.37	U2 Even	OK
	19.363	3.16	-252.06	0.00	U1 All	OK	5.53	426.64	326.81	U2 Even	OK
	25.562	3.16	-252.06	-141.95	U4 All	OK	5.53	426.64	7.57	U2 Odd	OK
	29.093	5.53	-426.64	-381.16	U3 Even	OK	5.53	426.64	0.00	U1 All	OK
	29.250	5.53	-426.64	-393.49	U3 Even	OK	5.53	426.64	0.00	U1 All	OK
	29.750	5.53	-426.64	-433.94	U3 Even	---	5.53	426.64	0.00	U1 All	---
	30.000	5.53	-426.64	-454.73	U3 Even	---	5.53	426.64	0.00	U1 All	---
5	0.000	5.53	-426.64	-2.29	U2 S4	---	0.00	0.00	0.00	U1 All	---
	0.375	5.53	-426.64	-0.64	U2 S4	---	0.00	0.00	0.00	U1 All	---
	0.750	5.53	-426.64	0.00	U1 All	OK	0.00	0.00	0.00	U1 All	OK

Longitudinal Beam Transverse Reinforcement Demand and Capacity

Section Properties

Units: d (in), Av/s (in^2/in), PhiVc (kip)

Span	d	(Av/s)min	PhiVc
1	18.50	0.0300	63.18
2	18.50	0.0300	63.18
3	18.50	0.0300	63.18
4	18.50	0.0300	63.18
5	18.50	0.0300	63.18

Beam Transverse Reinforcement Demand

Units: Start, End, Xu (in), Vu (ft), Av/s (kip/in^2)

			Required				Demand	
Span	Start	End	Xu	Vu	Comb/Patt	Av/s	Av/s	
1	0.000	0.000	0.000	0.00	U1/All	0.0000	0.0000	
2	1.000	5.887	2.292	95.26	U2/Even	0.0385	0.0385	
	5.887	9.482	5.887	65.96	U2/Even	0.0033	0.0300	*8
	9.482	13.077	9.482	36.67	U2/Even	0.0000	0.0300	*8
	13.077	16.673	16.673	23.23	U2/S2	0.0000	0.0000	
	16.673	20.268	20.268	52.53	U2/S2	0.0000	0.0300	*8
	20.268	23.863	23.863	81.82	U2/S2	0.0224	0.0300	*8
	23.863	28.750	27.458	111.12	U2/S2	0.0576	0.0576	
3	1.250	6.101	2.542	103.03	U2/S2	0.0479	0.0479	
	6.101	9.661	6.101	74.03	U2/S2	0.0130	0.0300	*8
	9.661	13.220	9.661	45.02	U2/S2	0.0000	0.0300	*8
	13.220	16.780	13.220	16.02	U2/S2	0.0000	0.0000	
	16.780	20.339	20.339	45.02	U2/S3	0.0000	0.0300	*8
	20.339	23.899	23.899	74.03	U2/S3	0.0130	0.0300	*8
	23.899	28.750	27.458	103.03	U2/S3	0.0479	0.0479	
4	1.250	6.137	2.542	111.12	U2/S3	0.0576	0.0576	
	6.137	9.732	6.137	81.82	U2/S3	0.0224	0.0300	*8
	9.732	13.327	9.732	52.53	U2/S3	0.0000	0.0300	*8
	13.327	16.923	13.327	23.23	U2/S3	0.0000	0.0000	
	16.923	20.518	20.518	36.67	U2/Even	0.0000	0.0300	*8

	20.518	24.113	24.113	65.96	U2/Even	0.0033	0.0300	*8
	24.113	29.000	27.708	95.26	U2/Even	0.0385	0.0385	
5	0.750	0.750	0.750	0.00	U1/All	0.0000	0.0000	

NOTES:
*8 - Minimum transverse (stirrup) reinforcement governs.

Beam Transverse Reinforcement Details

Units: spacing & distance (in).

Span	Size	Stirrups (2 legs each unless otherwise noted)
1	#5	--- None ---
2	#5	17 @ 8.8 + <-- 43.1 --> + 17 @ 8.8
3	#5	17 @ 8.7 + <-- 42.7 --> + 17 @ 8.7
4	#5	17 @ 8.8 + <-- 43.1 --> + 17 @ 8.8
5	#5	--- None ---

Beam Transverse Reinforcement Capacity

Units: Start, End, Xu (ft), Vu, PhiVn (kip), Av/s (in^2/in), Av (in^2), Sp (in)

			Required				Provided			
Span	Start	End	Xu	Vu	Comb/Patt	Av/s	Av	Sp	Av/s	PhiVn
1	0.000	0.750	0.000	0.00	U1/All	-----	-----	-----	-----	-----
2	0.000	1.000	2.292	95.26	U2/Even	-----	-----	-----	-----	-----
	1.000	13.077	2.292	95.26	U2/Even	0.0385	0.62	8.8	0.0706	121.95
	13.077	16.673	16.673	23.23	U2/S2	0.0000	-----	-----	-----	31.59
	16.673	28.750	27.458	111.12	U2/S2	0.0576	0.62	8.8	0.0706	121.95
	28.750	30.000	27.458	111.12	U2/S2	-----	-----	-----	-----	-----
3	0.000	1.250	2.542	103.03	U2/S2	-----	-----	-----	-----	-----
	1.250	13.220	2.542	103.03	U2/S2	0.0479	0.62	8.7	0.0712	122.47
	13.220	16.780	13.220	16.02	U2/S2	0.0000	-----	-----	-----	31.59
	16.780	28.750	27.458	103.03	U2/S3	0.0479	0.62	8.7	0.0712	122.47
	28.750	30.000	27.458	103.03	U2/S3	-----	-----	-----	-----	-----
4	0.000	1.250	2.542	111.12	U2/S3	-----	-----	-----	-----	-----
	1.250	13.327	2.542	111.12	U2/S3	0.0576	0.62	8.8	0.0706	121.95
	13.327	16.923	13.327	23.23	U2/S3	0.0000	-----	-----	-----	31.59
	16.923	29.000	27.708	95.26	U2/Even	0.0385	0.62	8.8	0.0706	121.95
	29.000	30.000	27.708	95.26	U2/Even	-----	-----	-----	-----	-----
5	0.000	0.750	0.750	0.00	U1/All	-----	-----	-----	-----	-----

Slab Shear Capacity

Units: b, d (in), Xu (ft), PhiVc, Vu(kip)

Span	b	d	Vratio	PhiVc	Vu	Xu
1	--- Not checked ---					
2	--- Not checked ---					
3	--- Not checked ---					
4	--- Not checked ---					
5	--- Not checked ---					

Material Takeoff

Reinforcement in the Direction of Analysis

Top Bars:	1442.4 lb	<=>	15.76 lb/ft	<=>	5.255 lb/ft^2
Bottom Bars:	1362.1 lb	<=>	14.89 lb/ft	<=>	4.962 lb/ft^2
Stirrups:	895.4 lb	<=>	9.79 lb/ft	<=>	3.262 lb/ft^2
Total Steel:	3700.0 lb	<=>	40.44 lb/ft	<=>	13.479 lb/ft^2
Concrete:	468.9 ft^3	<=>	5.13 ft^3/ft	<=>	1.708 ft^3/ft^2

```
                    oooooo
                    oo   oo
 ooooo   oooooo     oo   oo    ooooo    ooooo    o ooooooooo
oo   o   oo   oo    oo   oo   oo   oo  o    oo    oo   oo   oo
oo       oo   oo    ooooooo   oo   oo   oooooo    oo   oo   oo
 ooooo   oo   oo    oo    oo  oo   oo  oo   oo    oo   oo   oo
     oo  oooooo     oo    oo  ooooo    oo   oo    oo   oo   oo
o    oo  oo         oo    oo  oo    o  oo   oo    oo   oo   oo
 ooooo   oo         ooooooo    ooooo    ooooo o   oo   oo   oo  (TM)
```

spBeam v5.00 (TM)
A Computer Program for Analysis, Design, and Investigation of
Reinforced Concrete Beams and One-way Slab Systems

[3] DEFLECTION RESULTS

Section Properties

Frame Section Properties

Units: Ig, Icr (in^4), Mcr (k-ft)

		M+ve			M-ve		
Span	Zone	Ig	Icr	Mcr	Ig	Icr	Mcr
1	Left	25845	0	99.67	25845	5773	-99.67
	Midspan	25845	0	99.67	25845	9065	-99.67
	Right	25845	0	99.67	25845	9065	-99.67
2	Left	25845	5773	99.67	25845	9065	-99.67
	Midspan	25845	5773	99.67	25845	5773	-99.67
	Right	25845	5773	99.67	25845	11893	-99.67
3	Left	25845	4532	99.67	25845	11893	-99.67
	Midspan	25845	4532	99.67	25845	5773	-99.67
	Right	25845	4532	99.67	25845	11893	-99.67
4	Left	25845	5773	99.67	25845	11893	-99.67
	Midspan	25845	5773	99.67	25845	5773	-99.67
	Right	25845	5773	99.67	25845	9065	-99.67
5	Left	25845	0	99.67	25845	9065	-99.67
	Midspan	25845	0	99.67	25845	9065	-99.67
	Right	25845	0	99.67	25845	5773	-99.67

NOTES: M+ve values are for positive moments (tension at bottom face).
M-ve values are for negative moments (tension at top face).

Frame Effective Section Properties

Units: Ie, Ie,avg (in^4), Mmax (k-ft)

			Load Level					
			Dead		Sustained		Dead+Live	
Span	Zone	Weight	Mmax	Ie	Mmax	Ie	Mmax	Ie
1	Right	1.000	-1.19	25845	-1.19	25845	-1.73	25845
	Span Avg	----	----	25845	----	25845	----	25845
2	Middle	0.850	189.66	8686	189.66	8686	275.57	6723
	Right	0.150	-363.61	12180	-363.61	12180	-528.29	11987
	Span Avg	----	----	9210	----	9210	----	7512
3	Left	0.150	-320.86	12311	-320.86	12311	-466.18	12029
	Middle	0.700	155.44	10151	155.44	10151	225.83	6364
	Right	0.150	-320.86	12311	-320.86	12311	-466.18	12029
	Span Avg	----	----	10799	----	10799	----	8064
4	Left	0.150	-363.61	12180	-363.61	12180	-528.29	11987
	Middle	0.850	189.66	8686	189.66	8686	275.57	6723
	Span Avg	----	----	9210	----	9210	----	7512
5	Left	1.000	-1.19	25845	-1.19	25845	-1.73	25845
	Span Avg	----	----	25845	----	25845	----	25845

Instantaneous Deflections

Extreme Instantaneous Frame Deflections and Corresponding Locations

Units: Def (in), Loc (ft)

				Live			Total	
Span	Direction	Value	Dead	Sustained	Unsustained	Total	Sustained	Dead+Live
1	Down	Def	---	---	---	---	---	---
		Loc	---	---	---	---	---	---
	Up	Def	-0.013	---	-0.007	-0.007	-0.013	-0.020
		Loc	0.000	---	0.000	0.000	0.000	0.000
2	Down	Def	0.449	---	0.319	0.319	0.449	0.768
		Loc	14.310	---	14.592	14.592	14.310	14.310
	Up	Def	---	---	---	---	---	---
		Loc	---	---	---	---	---	---
3	Down	Def	0.317	---	0.284	0.284	0.317	0.601
		Loc	15.000	---	15.000	15.000	15.000	15.000
	Up	Def	---	---	---	---	---	---
		Loc	---	---	---	---	---	---
4	Down	Def	0.449	---	0.319	0.319	0.449	0.768
		Loc	15.690	---	15.408	15.408	15.690	15.690
	Up	Def	---	---	---	---	---	---
		Loc	---	---	---	---	---	---
5	Down	Def	---	---	---	---	---	---
		Loc	---	---	---	---	---	---
	Up	Def	-0.013	---	-0.007	-0.007	-0.013	-0.020
		Loc	0.750	---	0.750	0.750	0.750	0.750

Long-term Deflections

Long-term Deflection Factors

Time dependant factor for sustained loads = 2.000
Units: Astop, Asbot (in^2), b, d (in), Rho' (%), Lambda (-)

		M+ve					M-ve				
Span	Zone	Astop	b	d	Rho'	Lambda	Asbot	b	d	Rho'	Lambda
1	Right	----	----	----	0.000	2.000	----	----	----	0.000	2.000
2	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
3	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
4	Midspan	----	----	----	0.000	2.000	----	----	----	0.000	2.000
5	Left	----	----	----	0.000	2.000	----	----	----	0.000	2.000

NOTES: Deflection multiplier, Lambda, depends on moment sign at sustained load level and Rho' in given zone.
Rho' is assumed zero because Compression Reinforcement option is NOT selected in Solve Options.

Extreme Long-term Frame Deflections and Corresponding Locations

Units: Def (in), Loc (ft)

Span	Direction	Value	cs	cs+lu	cs+l	Total
1	Down	Def	---	---	---	---
		Loc	---	---	---	---
	Up	Def	-0.026	-0.033	-0.033	-0.046
		Loc	0.000	0.000	0.000	0.000
2	Down	Def	0.898	1.217	1.217	1.666
		Loc	14.310	14.310	14.310	14.310
	Up	Def	---	---	---	---
		Loc	---	---	---	---
3	Down	Def	0.634	0.918	0.918	1.235
		Loc	15.000	15.000	15.000	15.000
	Up	Def	---	---	---	---
		Loc	---	---	---	---
4	Down	Def	0.898	1.217	1.217	1.666
		Loc	15.690	15.690	15.690	15.690
	Up	Def	---	---	---	---
		Loc	---	---	---	---
5	Down	Def	---	---	---	---
		Loc	---	---	---	---
	Up	Def	-0.026	-0.033	-0.033	-0.046
		Loc	0.750	0.750	0.750	0.750

NOTES: Incremental deflections due to creep and shrinkage (cs) based on sustained load level values.
Incremental deflections after partitions are installed can be estimated by deflections due to:
- creep and shrinkage plus unsustained live load (cs+lu), if live load applied before partitions,
- creep and shrinkage plus live load (cs+l), if live load applied after partitions.
Total deflections consist of dead, live, and creep and shrinkage deflections.