

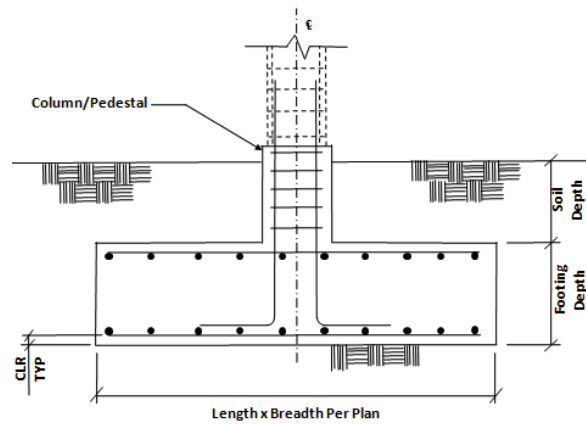
## Isolated Footing Design(ACI 318-05)

### Design For Isolated Footing 54

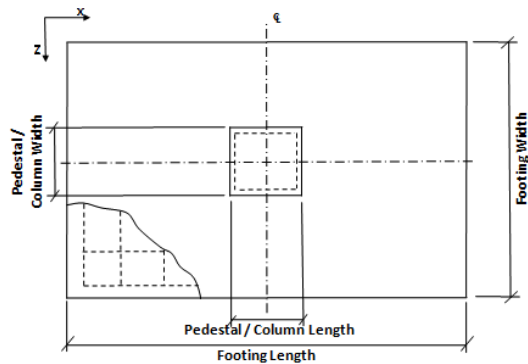
Footing No.	Group ID	Foundation Geometry		
-	-	Length	Width	Thickness
54	1	12.333 ft	12.333 ft	1.000 ft

Footing No.	Footing Reinforcement				Pedestal Reinforcement	
-	Bottom Reinforcement( $M_y$ )	Bottom Reinforcement( $M_x$ )	Top Reinforcement( $M_y$ )	Top Reinforcement( $M_x$ )	Main Steel	Trans Steel
54	#9 @ 18 in c/c	#7 @ 18 in c/c	#6 @ 18 in c/c	#8 @ 18 in c/c	N/A	N/A

### Isolated Footing 54



**ELEVATION**



**PLAN**

### Input Values

#### Footing Geometry

Design Type : Calculate Dimension

Footing Thickness (Ft) : 12.000 in

Footing Length - X (Fl) : 40.000 in

Footing Width - Z (Fw) : 40.000 in

Eccentricity along X (Oxd) : 0.000 in

Eccentricity along Z (Ozd) : 0.000 in

#### Column Dimensions

Column Shape : Rectangular

Column Length - X (Pl) : 1.167 ft

Column Width - Z (Pw) : 1.000 ft

Pedestal

Include Pedestal? No  
 Pedestal Shape : N/A  
 Pedestal Height (Ph) : N/A  
 Pedestal Length - X (Pl) : N/A  
 Pedestal Width - Z (Pw) : N/A

Design ParametersConcrete and Rebar Properties

Unit Weight of Concrete : 150.000 lb/ft<sup>3</sup>  
 Strength of Concrete : 4.000 ksi  
 Yield Strength of Steel : 60.000 ksi  
 Minimum Bar Size : #6  
 Maximum Bar Size : #10  
 Minimum Bar Spacing : 2.000 in  
 Maximum Bar Spacing : 18.000 in  
 Pedestal Clear Cover (P, CL) : 3.000 in  
 Footing Clear Cover (F, CL) : 3.000 in

Soil Properties

Soil Type : UnDrained  
 Unit Weight : 112.000 lb/ft<sup>3</sup>  
 Soil Bearing Capacity : 4.000 kip/ft<sup>2</sup>  
 Soil Surcharge : 0.000 ksi  
 Depth of Soil above Footing : 24.000 in  
 Undrained Shear Strength : 0.000 kip/in<sup>2</sup>

Sliding and Overturning

Coefficient of Friction : 0.500  
 Factor of Safety Against Sliding : 1.500  
 Factor of Safety Against Overturning : 1.500

-----

Design CalculationsFooting Size

Initial Length ( $L_o$ ) = 3.333 ft

Initial Width ( $W_o$ ) = 3.333 ft

Load Combination/s- Service Stress Level	
Load Combination Number	Load Combination Title
5	1.5(DL+LL)
6	1.2(DL+LL+ELX)
7	1.2(DL+LL+ELY)
8	1.2(DL+LL-ELX)
9	1.2(DL+LL-ELY)
10	1.5(DL+ELX)
11	1.5(DL+ELY)
12	1.5(DL-ELX)

13	1.5(DL-ELY)
14	.9DL+1.5ELX
15	.9DL+1.5ELY
16	.9DL-1.5ELX
17	.9DL-1.5ELY
<b>Load Combination/s- Strength Level</b>	
<b>Load Combination Number</b>	<b>Load Combination Title</b>
5	1.5(DL+LL)
6	1.2(DL+LL+ELX)
7	1.2(DL+LL+ELY)
8	1.2(DL+LL-ELX)
9	1.2(DL+LL-ELY)
10	1.5(DL+ELX)
11	1.5(DL+ELY)
12	1.5(DL-ELX)
13	1.5(DL-ELY)
14	.9DL+1.5ELX
15	.9DL+1.5ELY
16	.9DL-1.5ELX

<b>Applied Loads - Service Stress Level</b>					
<b>LC</b>	<b>Axial (kip)</b>	<b>Shear X (kip)</b>	<b>Shear Z (kip)</b>	<b>Moment X (kip-ft)</b>	<b>Moment Z (kip-ft)</b>
5	58.739	1.616	-20.732	-116.125	-13.529
6	26.707	9.809	-16.276	-91.662	-62.566
7	17.204	2.817	-7.651	-40.109	-19.487
8	67.275	-7.223	-16.895	-94.138	40.920
9	76.778	-0.231	-25.519	-145.691	-2.160
10	0.718	9.697	-0.829	-2.403	-61.677
11	-11.161	0.957	9.951	62.038	-7.827
12	51.427	-11.593	-1.603	-5.499	67.680
13	63.306	-2.853	-12.384	-69.940	13.831
14	-9.711	10.076	-0.343	-0.823	-62.878
15	-21.590	1.336	10.438	63.618	-9.028
16	40.998	-11.214	-1.116	-3.919	66.480
17	52.877	-2.474	-11.897	-68.360	12.630

<b>Applied Loads - Strength Level</b>					
<b>LC</b>	<b>Axial (kip)</b>	<b>Shear X (kip)</b>	<b>Shear Z (kip)</b>	<b>Moment X (kip-ft)</b>	<b>Moment Z (kip-ft)</b>
5	58.739	1.616	-20.732	-116.125	-13.529
6	26.707	9.809	-16.276	-91.662	-62.566
7	17.204	2.817	-7.651	-40.109	-19.487
8	67.275	-7.223	-16.895	-94.138	40.920
9	76.778	-0.231	-25.519	-145.691	-2.160
10	0.718	9.697	-0.829	-2.403	-61.677
11	-11.161	0.957	9.951	62.038	-7.827
12	51.427	-11.593	-1.603	-5.499	67.680
13	63.306	-2.853	-12.384	-69.940	13.831
14	-9.711	10.076	-0.343	-0.823	-62.878
15	-21.590	1.336	10.438	63.618	-9.028
16	40.998	-11.214	-1.116	-3.919	66.480

Reduction of force due to buoyancy = 0.000 kip

Effect due to adhesion = 0.000 kip

Area from initial length and width,  $A_o = L_o \times W_o = 11.111 \text{ ft}^2$

Min. area required from bearing pressure,  $A_{min} = P / q_{max} = 20.169 \text{ ft}^2$

**Note:**  $A_{min}$  is an initial estimation.

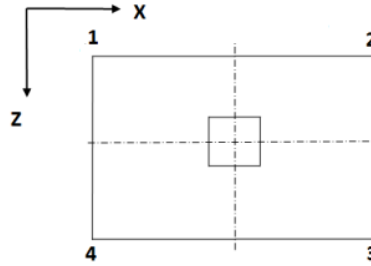
$P$  = Critical Factored Axial Load(without self weight/buoyancy/soil).

$q_{max}$  = Respective Factored Bearing Capacity.

### Final Footing Size

Length ( $L_2$ ) =	12.333 ft	Governing Load Case :	# 15
Width ( $W_2$ ) =	12.333 ft	Governing Load Case :	# 15
Depth ( $D_2$ ) =	1.000 ft	Governing Load Case :	# 15
Area ( $A_2$ ) =	152.111 ft <sup>2</sup>		

### Pressures at Four Corners



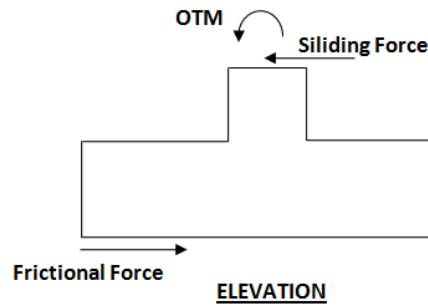
Load Case	Pressure at corner 1 ( $q_1$ ) (kip/ft <sup>2</sup> )	Pressure at corner 2 ( $q_2$ ) (kip/ft <sup>2</sup> )	Pressure at corner 3 ( $q_3$ ) (kip/ft <sup>2</sup> )	Pressure at corner 4 ( $q_4$ ) (kip/ft <sup>2</sup> )	Area of footing in uplift ( $A_u$ ) (ft <sup>2</sup> )
9	<b>1.4184</b>	1.4308	0.3356	0.3233	0.000
9	1.4184	<b>1.4308</b>	0.3356	0.3233	0.000
10	0.1591	0.6156	<b>0.5949</b>	0.1384	0.000
12	0.9866	0.4795	0.4341	<b>0.9412</b>	0.000

If  $A_u$  is zero, there is no uplift and no pressure adjustment is necessary. Otherwise, to account for uplift, areas of negative pressure will be set to zero and the pressure will be redistributed to remaining corners.

### Summary of Adjusted Pressures at 4 corners Four Corners

Load Case	Pressure at corner 1 ( $q_1$ ) (kip/ft <sup>2</sup> )	Pressure at corner 2 ( $q_2$ ) (kip/ft <sup>2</sup> )	Pressure at corner 3 ( $q_3$ ) (kip/ft <sup>2</sup> )	Pressure at corner 4 ( $q_4$ ) (kip/ft <sup>2</sup> )
9	<b>1.4184</b>	1.4308	0.3356	0.3233
9	1.4184	<b>1.4308</b>	0.3356	0.3233
10	0.1591	0.6156	<b>0.5949</b>	0.1384
12	0.9866	0.4795	0.4341	<b>0.9412</b>

### Check for stability against overturning and sliding



Load Case No.	Factor of safety against sliding		Factor of safety against overturning	
	Along X-Direction	Along Z-Direction	About X-Direction	About Z-Direction
5	35.685	2.782	5.198	46.973
6	4.248	2.560	4.761	7.101
7	13.103	4.825	9.533	20.413
8	8.577	3.667	6.881	15.871
9	288.707	2.614	4.805	426.467
10	2.957	34.570	109.395	4.955
11	23.749	2.284	3.895	31.917
12	4.660	33.708	93.826	8.406
13	21.017	4.842	8.984	44.330
14	2.328	68.398	248.184	3.966
15	13.109	1.678	2.918	20.847
16	4.353	43.724	119.570	7.749
17	22.131	4.602	8.414	44.709

#### Critical Load Case And The Governing Factor Of Safety For Overturning And Sliding - X Direction

Critical Load Case for Sliding along X-Direction : 14

Governing Disturbing Force : 10.076 kip

Governing Restoring Force : 23.459 kip

Minimum Sliding Ratio for the Critical Load Case : 2.328

Critical Load Case for Overturning about X-Direction : 15

Governing Overturning Moment : 74.056 kip-ft

Governing Resisting Moment : 216.068 kip-ft

Minimum Overturning Ratio for the Critical Load Case : 2.918

#### Critical Load Case And The Governing Factor Of Safety For Overturning And Sliding - Z Direction

Critical Load Case for Sliding along Z-Direction : 15

Governing Disturbing Force : 10.438 kip

Governing Restoring Force : 17.519 kip

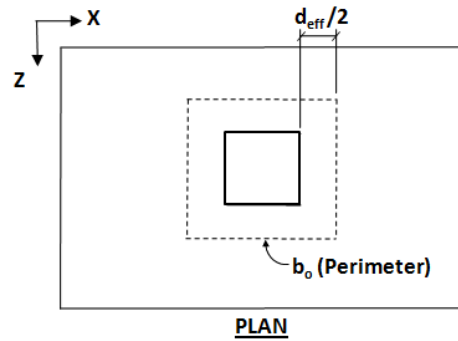
Minimum Sliding Ratio for the Critical Load Case : 1.678

Critical Load Case for Overturning about Z-Direction : 14

Governing Overturning Moment : -72.954 kip-ft

Governing Resisting Moment : 289.323 kip-ft

Minimum Overturning Ratio for the Critical Load Case : 3.966

Shear CalculationPunching Shear Check

Total Footing Depth,  $D = 1.000\text{ft}$

Calculated Effective Depth,  $d_{\text{eff}} = D - C_{\text{cover}} - 1.0 = 0.667\text{ ft}$  **1 inch is deducted from total depth to cater bar dia(US Convention).**

For rectangular column,  $\beta_c = B_{\text{col}} / D_{\text{col}} = 1.167$

Effective depth,  $d_{\text{eff}}$ , increased until  $0.75XV_c \geq \text{Punching Shear Force}$

Punching Shear Force,  $V_u = 75.236\text{ kip}$ , Load Case # 9

From ACI Cl.11.12.2.1,  $b_o$  for column =  $2 \times (B_{\text{col}} + D_{\text{col}} + 2 \times d_{\text{eff}}) = 7.000\text{ ft}$

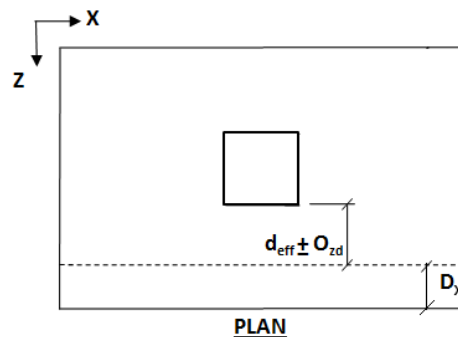
Equation 11-33,  $V_{c1} = \left(1 + \frac{4}{\beta_c}\right) \times b_o \times d_{\text{eff}} \times \sqrt{1000 \times F_c'} = 230.720\text{ kip}$

Equation 11-34,  $V_{c2} = \left(2 + 40 \times \frac{d_{\text{eff}}}{b_o}\right) \times b_o \times d_{\text{eff}} \times \sqrt{1000 \times F_c'} = 246.911\text{ kip}$

Equation 11-35,  $V_{c3} = 4 \times b_o \times d_{\text{eff}} \times \sqrt{1000 \times F_c'} = 170.004\text{ kip}$

Punching shear strength,  $V_c = 0.75 \times \text{minimum of } (V_{c1}, V_{c2}, V_{c3}) = 127.503\text{ kip}$

$0.75 \times V_c > V_u$  hence, OK

Along X Direction(Shear Plane Parallel to Global X Axis)

From ACI Cl.11.3.1.1,  $V_c = 2 \times L \times d_{\text{eff}} \times \sqrt{1000 \times F_c'} = 149.765\text{ kip}$

Distance along X to design for shear,  $D_x = 0.5 \times (L + B_{\text{col}}) + d_{\text{eff}} + O_{zd} = 4.917\text{ ft}$

Check that  $0.75 \times V_c > V_{ux}$  where  $V_{ux}$  is the shear force for the critical load cases at a distance  $d_{\text{eff}}$  from the face of the column caused by bending about the X axis.

From above calculations,  $0.75 \times V_c = 112.324\text{ kip}$

Critical load case for  $V_{ux}$  is # 9

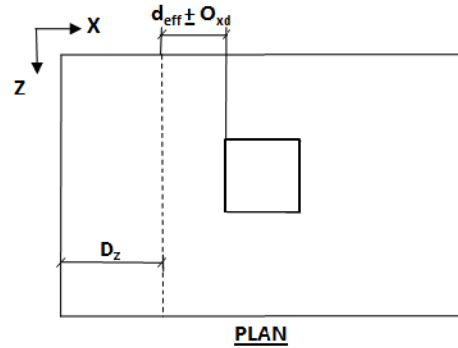
$$V_{ux} = V_{ux}|_{x=D_x} = 51.081 \text{ kip}$$

 $0.75 \times V_c > V_{ux}$  hence, OK

### One-Way Shear Check

#### Along Z Direction

(Shear Plane Parallel to Global Z Axis)



$$\text{From ACI Cl.11.3.1.1, } V_c = 2 \times W \times d_{eff} \times \sqrt{1000 \times F_c'} = 149.765 \text{ kip}$$

$$\text{Distance along X to design for shear, } D_z = 0.5 \times (L - D_{col}) - d_{eff} + O_{xd} = 7.333 \text{ ft}$$

Check that  $0.75 \times V_c > V_{uz}$  where  $V_{uz}$  is the shear force for the critical load cases at a distance  $d_{eff}$  from the face of the column caused by bending about the Z axis.

$$\text{From above calculations, } 0.75 \times V_c = 112.324 \text{ kip}$$

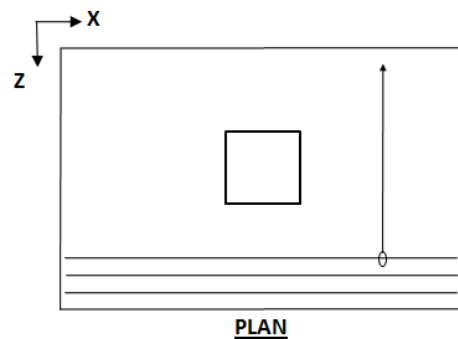
Critical load case for  $V_{uz}$  is # 8

$$V_{uz} = V_{uz}|_{z=D_z} = 32.433 \text{ kip}$$

 $0.75 \times V_c > V_{uz}$  hence, OK

### Design for Flexure about Z Axis

(For Reinforcement Parallel to X Axis)



Calculate the flexural reinforcement along the X direction of the footing. Find the area of steel required, A, as per Section 3.8 of Reinforced Concrete Design (5th ed.) by Salmon and Wang (Ref. 1)

Critical Load Case # 9

The strength values of steel and concrete used in the formulae are in ksi

$$\text{Factor } \beta_1 \text{ from ACI Cl.10.2.7.3} = 0.850$$

$$\text{From ACI Cl. 10.3.2, } \rho_{bal} = \frac{0.85 \times \beta_1 \times F_c'}{F_y \times (87 + F_y)} = 0.02851$$

$$\begin{aligned}
 \text{From ACI Cl. 10.3.3, } \rho_{\max} &= 0.75 \times \rho_{\text{bal}} = 0.02138 \\
 \text{From ACI Cl. 7.12.2, } \rho_{\min} &= 0.00180 \\
 \text{From Ref. 1, Eq. 3.8.4a, constant } m &= \frac{F_y}{(0.85 \times F_c')} = 17.647
 \end{aligned}$$

### Calculate reinforcement ratio $\rho$ for critical load case

$$\begin{aligned}
 \text{Design for flexure about Z axis is performed at the face of the column at a distance, } D_x &= 0.5 \times L - 0.5 \times D_{\text{col}} + O_{\text{xd}} = 5.583 \text{ ft} \\
 \text{Ultimate moment, } M_u|_{z=D_x} &= 143.110 \text{ kip-ft} \\
 \text{Nominal moment capacity, } M_n &= \frac{M_u}{\phi} = 159.011 \text{ kip-ft} \\
 \text{Required } \rho &= \frac{1}{m} \times \left[ 1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{\text{eff}}^2)}} \right] = 0.00346 \\
 \text{Since } \rho_{\min} \leq \rho \leq \rho_{\max} & \quad \text{OK} \\
 \text{Area of Steel Required, } A_s &= \rho \times W \times d_{\text{eff}} = 4.101 \text{ in}^2
 \end{aligned}$$

Selected bar Size = #7

Minimum spacing allowed ( $S_{\min}$ ) = 2.000 in

Selected spacing (S) = 18.000 in

$S_{\min} \leq S \leq S_{\max}$  and selected bar size < selected maximum bar size...

The reinforcement is accepted.

According to ACI 318-05 Clause No- 10.6.4

Max spacing for Cracking Consideration = 7.500 in

Unsafe for Cracking Aspect.

**Based on spacing reinforcement increment; provided reinforcement is**

**#7 @ 18.000 in o.c.**

$$\begin{aligned}
 \text{Required development length for bars} &= \frac{0.87 \times d_b \times F_y}{4 \times \text{beta} \times \sqrt{f_{cu}}} = 1.000 \text{ ft} \\
 \text{Available development length for bars, } D_L &= 0.5 \times (L - D_{\text{col}}) - C_{\text{cover}} = 5.333 \text{ ft} \\
 \text{Try bar size } \# 7 & \quad \text{Area of one bar} = 0.600 \text{ in}^2 \\
 \text{Number of bars required, } N_{\text{bar}} &= \frac{A_s}{A_{\text{bar}}} = 7
 \end{aligned}$$

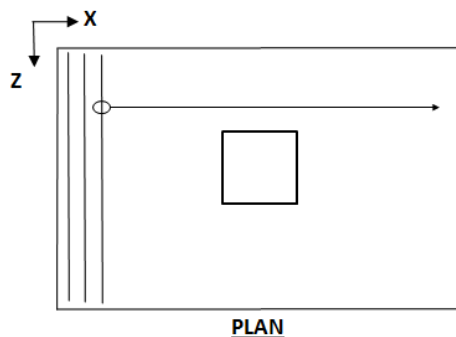
**Because the number of bars is rounded up, make sure new reinforcement ratio <  $\rho_{\max}$**

$$\begin{aligned}
 \text{Total reinforcement area, } A_{s_{\text{total}}} &= N_{\text{bar}} \times (\text{Area of one bar}) = 4.200 \text{ in}^2 \\
 d_{\text{eff}} &= D - C_{\text{cover}} - 0.5 \times (\text{dia. of one bar}) = 0.714 \text{ ft} \\
 \text{Reinforcement ratio, } \rho &= \frac{A_{s_{\text{total}}}}{(d_{\text{eff}} \times W)} = 0.00331 \\
 \text{From ACI Cl.7.6.1, minimum req'd clear distance between bars, } C_d &= \max(\text{Diameter of one bar, 1.0, Min. User Spacing}) = 18.000 \text{ in}
 \end{aligned}$$

**Check to see if width is sufficient to accomodate bars**

[Design for Flexure about X axis](#)

(For Reinforcement Parallel to Z Axis)



Calculate the flexural reinforcement along the Z direction of the footing. Find the area of steel required, A, as per Section 3.8 of Reinforced Concrete Design (5th ed.) by Salmon and Wang (Ref. 1)

Critical Load Case # 9

The strength values of steel and concrete used in the formulae are in ksi

Factor $\beta_1$ from ACI Cl.10.2.7.3 =		0.850
From ACI Cl. 10.3.2, $\rho_{bal}$ =	$0.85 \times \beta_1 \times F_c' \times \frac{87}{[f_y \times (87 + F_y)]}$	0.02851
From ACI Cl. 10.3.3, $\rho_{max}$ =	$0.75 \times \rho_{bal}$	0.02138
From ACI Cl.7.12.2, $\rho_{min}$ =		0.00180
From Ref. 1, Eq. 3.8.4a, constant m =	$\frac{F_y}{(0.85 \times F_c')}$	17.647

#### Calculate reinforcement ratio $\rho$ for critical load case

Design for flexure about X axis is performed at the face of the column at a distance, $D_z$ =	$0.5 \times L + 0.5 \times B_{col} + O_{zd}$	5.667	ft
Ultimate moment,	$M_u _{x=D_x}$	176.026	kip-ft
Nominal moment capacity, $M_n$ =	$\frac{M_u}{\phi}$	195.584	kip-ft
Required $\rho$ =	$\frac{1}{m} \times \left[ 1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{eff}^2)}} \right]$	0.00547	
Since	$\rho_{min} \leq \rho \leq \rho_{max}$	OK	
Area of Steel Required, $A_s$ =	$\rho \times W \times d_{eff}$	5.769	in <sup>2</sup>

Selected Bar Size = #9

Minimum spacing allowed ( $S_{min}$ ) = 2.000 in

Selected spacing (S) = 18.000 in

$S_{min} \leq S \leq S_{max}$  and selected bar size < selected maximum bar size...

The reinforcement is accepted.

According to ACI 318-05 Clause No- 10.6.4

Max spacing for Cracking Consideration = 7.500 in

Unsafe for Cracking Aspect.

**Based on spacing reinforcement increment; provided reinforcement is**

**#9 @ 18.000 in o.c.**

$$\begin{aligned} \text{Required development length for bars} &= \frac{0.87 \times d_b \times f_y}{4 \times \text{beta} \times \sqrt{f_{cu}}} = 1.000 \text{ ft} \\ \text{Available development length for bars, } D_L &= 0.5 \times (L - D_{col}) - C_{cover} = 5.417 \text{ ft} \\ \text{Try bar size} & \# 9 \quad \text{Area of one bar} = 1.000 \text{ in}^2 \\ \text{Number of bars required, } N_{bar} &= \frac{A_s}{A_{bar}} = 6 \end{aligned}$$

**Because the number of bars is rounded up, make sure new reinforcement ratio  $< \rho_{max}$**

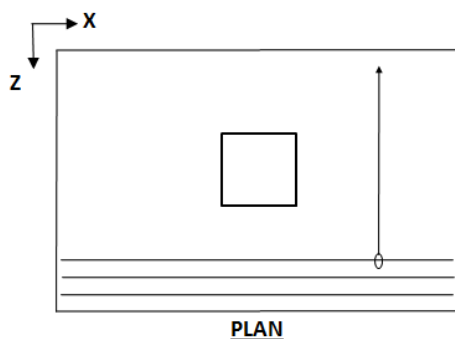
$$\begin{aligned} \text{Total reinforcement area, } A_{s\_total} &= N_{bar} \times (\text{Area of one bar}) = 6.000 \text{ in}^2 \\ d_{eff} &= D - C_{cover} - 0.5 \times (\text{dia. of one bar}) = 0.624 \text{ ft} \\ \text{Reinforcement ratio, } \rho &= \frac{A_{s\_total}}{(d_{eff} \times W)} = 0.00541 \\ \text{From ACI Cl.7.6.1, minimum req'd clear distance between bars, } C_d &= \max(\text{Diameter of one bar, 1.0, Min. 18.000 in, User Spacing}) = \end{aligned}$$

**Check to see if width is sufficient to accomodate bars**

Bending moment for uplift cases will be calculated based solely on selfweight, soil depth and surcharge loading.

As the footing size has already been determined based on all serviceability load cases, and design moment calculation is based on selfweight, soil depth and surcharge only, top reinforcement value for all pure uplift load cases will be the same.

#### Design For Top Reinforcement Parallel to Z Axis



**Calculate the flexural reinforcement for  $M_x$ . Find the area of steel required**

The strength values of steel and concrete used in the formulae are in ksi

$$\begin{aligned} \text{Factor } \beta_1 \text{ from ACI Cl.10.2.7.3} &= 0.850 \\ \text{From ACI Cl. 10.3.2, } \rho_{bal} &= \frac{0.85 \times \beta_1 \times F_c' \times \frac{87}{[F_y \times (87 + F_y)]}} = 0.02851 \\ \text{From ACI Cl. 10.3.3, } \rho_{max} &= 0.75 \times \rho_{bal} = 0.02138 \\ \text{From ACI Cl. 7.12.2, } \rho_{min} &= 0.00180 \\ \text{From Ref. 1, Eq. 3.8.4a, constant } m &= \frac{F_y}{(0.85 \times F_c')} = 17.647 \end{aligned}$$

**Calculate reinforcement ratio  $\rho$  for critical load case**

$$\begin{aligned} \text{Design for flexure about A axis is performed at the face of the column} \quad 0.5 \times L - 0.5 \times D_{col} + O_{xd} &= 5.667 \text{ ft} \end{aligned}$$

at a distance,  $D_x =$

Ultimate moment,  $M_u|_{z=D_z} = 74.059 \text{ kip-ft}$

Nominal moment capacity,  $M_n = \frac{M_u}{\phi} = 82.288 \text{ kip-ft}$

$$\text{Required } \rho = \frac{1}{m} \times \left[ 1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{eff}^2)}} \right] = 0.00216$$

Since  $\rho_{min} \leq \rho \leq \rho_{max}$  OK

Area of Steel Required,  $A_s = \rho \times W \times d_{eff} = 2.314 \text{ in}^2$

Selected bar Size = #8

Minimum spacing allowed ( $S_{min}$ ) = 2.000 in

Selected spacing ( $S$ ) = 18.000 in

$S_{min} \leq S \leq S_{max}$  and selected bar size < selected maximum bar size...

The reinforcement is accepted.

According to ACI 318-05 Clause No- 10.6.4

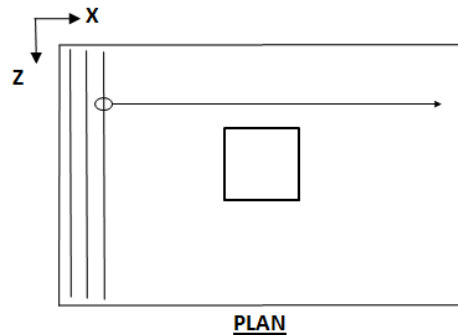
Max spacing for Cracking Consideration = 7.500 in

Unsafe for Cracking Aspect.

**Based on spacing reinforcement increment; provided reinforcement is**

**#8 @ 18.000 in o.c.**

#### Design For Top Reinforcement Parallel to X Axis



First load case to be in pure uplift # 0

**Calculate the flexural reinforcement for  $M_z$ . Find the area of steel required**

The strength values of steel and concrete used in the formulae are in ksi

Factor  $\beta_1$  from ACI Cl.10.2.7.3 = 0.850

From ACI Cl. 10.3.2,  $\rho_{bal} = \frac{0.85 \times \beta_1 \times F_c^1 \times \frac{87}{[F_y \times (87 + F_y)]}} = 0.02851$

From ACI Cl. 10.3.3,  $\rho_{max} = 0.75 \times \rho_{bal} = 0.02138$

From ACI Cl.7.12.2,  $\rho_{min} = 0.00180$

From Ref. 1, Eq. 3.8.4a, constant  $m = \frac{F_y}{(0.85 \times F_c^1)} = 17.647$

Calculate reinforcement ratio  $\rho$  for critical load case

Design for flexure about A axis is

performed at the face of the column  
at a distance,  $D_x =$   $0.5 \times L - 0.5 \times D_{col} + O_{xd} =$  5.583 ft

Ultimate moment,  $M_u|_{x=D_x} =$  71.897 kip-ft

Nominal moment capacity,  $M_n =$   $\frac{M_u}{\phi} =$  79.885 kip-ft

$$\text{Required } \rho = \frac{1}{m} \times \left[ 1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{eff}^2)}} \right] = 0.00171$$

Since  $\rho_{min} \leq \rho \leq \rho_{max}$  OK

Area of Steel Required,  $A_s =$   $\rho \times W \times d_{eff} =$  2.131 in<sup>2</sup>

Selected bar Size = #6

Minimum spacing allowed ( $S_{min}$ ) = 2.000 in

Selected spacing (S) = 18.000 in

$S_{min} \leq S \leq S_{max}$  and selected bar size < selected maximum bar size...

The reinforcement is accepted.

According to ACI 318-05 Clause No- 10.6.4

Max spacing for Cracking Consideration = 7.500 in

UnSafe for Cracking Aspect.

**Based on spacing reinforcement increment; provided reinforcement is**

**#6 @ 18.000 in o.c.**

Print Calculation Sheet