# Isolated Footing Design(ACI 318-11)



| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 124 | 1 | 1.300m | 1.300m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 124 | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 125 | 2 | 1.480m | 1.480m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 125 | #16 @ 44 cm c/c | #16 @ 44 cm c/c | #16 @ 44 cm c/c | #16 @ 44 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 126 | 3 | 1.730m | 1.730m | 0.340m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 126 | #12 @ 14 cm c/c | #16 @ 31 cm c/c | #12 @ 17 cm c/c | #12 @ 17 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 127 | 4 | 1.540m | 1.540m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 127 | #16 @ 34 cm c/c | #20 @ 45 cm c/c | #12 @ 20 cm c/c | #12 @ 20 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 128 | 5 | 1.550m | 1.550m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 128 | #16 @ 35 cm c/c | #12 @ 20 cm c/c | #12 @ 20 cm c/c | #12 @ 20 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 129 | 6 | 1.740m | 1.740m | 0.340m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 129 | #12 @ 14 cm c/c | #20 @ 45 cm c/c | #12 @ 18 cm c/c | #12 @ 18 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 130 | 7 | 1.720m | 1.720m | 0.340m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 130 | #20 @ 45 cm c/c | #16 @ 31 cm c/c | #12 @ 17 cm c/c | #12 @ 17 cm c/c | N/A | N/A |

| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 131 | 8 | 1.490m | 1.490m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 131 | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | N/A | N/A |

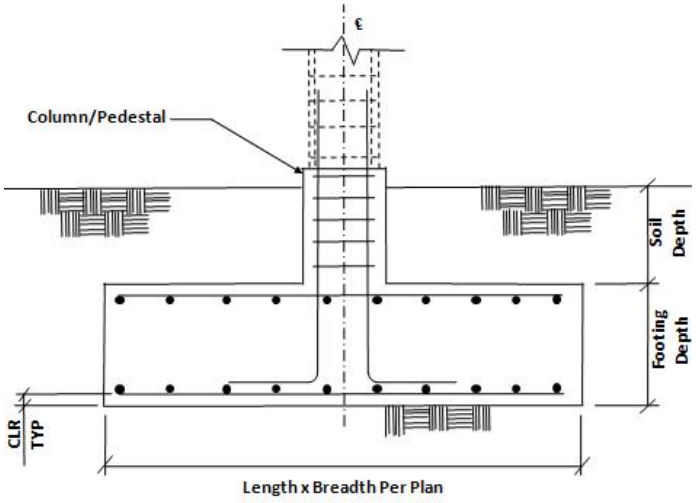
| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 132 | 9 | 1.320m | 1.320m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 132 | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | #12 @ 19 cm c/c | N/A | N/A |

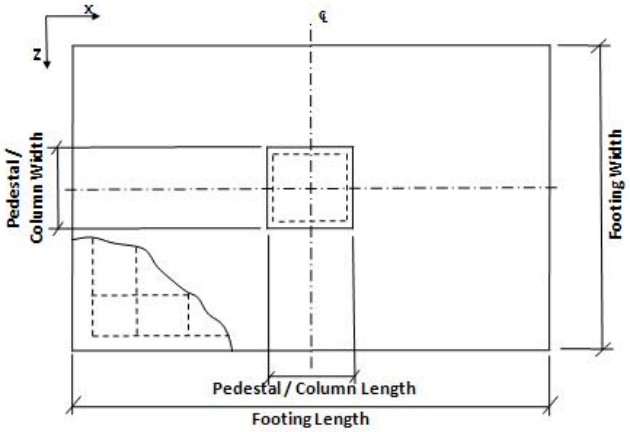
| Footing No. | Group ID | Foundation Geometry | | |
|---|---|---|---|---|
| - | - | Length | Width | Thickness |
| 133 | 10 | 1.480m | 1.480m | 0.300m |

| Footing No. | Footing Reinforcement | | | | Pedestal Reinforcement | |
|---|---|---|---|---|---|---|
| - | Bottom Reinforcement($M_z$) | Bottom Reinforcement($M_x$) | Top Reinforcement($M_z$) | Top Reinforcement($M_x$) | Main Steel | Trans Steel |
| 133 | #12 @ 19 cm c/c | #16 @ 44 cm c/c | #16 @ 44 cm c/c | #16 @ 44 cm c/c | N/A | N/A |

## Isolated Footing 124




ELEVATION




PLAN

## Input Values

### Footing Geomtery

| | |
|---|---|
| Design Type : | Calculate Dimension |
| Footing Thickness (Ft) : | 300.000mm |
| Footing Length - X (Fl) : | 1000.000mm |
| Footing Width - Z (Fw) : | 1000.000mm |
| Eccentricity along X (Oxd) : | 0.000mm |
| Eccentricity along Z (Ozd) : | 0.000mm |

### Column Dimensions

| | |
|---|---|
| Column Shape : | Rectangular |
| Column Length - X ($D_{col}$) : | 0.350m |
| Column Width - Z ($B_{col}$) : | 0.350m |

### 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 Parameters

### Concrete and Rebar Properties

| | |
|---|---|
| Unit Weight of Concrete : | 24.000kN/m3 |
| Strength of Concrete : | 21.000N/mm2 |
| Yield Strength of Steel : | 420.000N/mm2 |
| Minimum Bar Size : | #12 |
| Maximum Bar Size : | #20 |
| Pedestal Minimum Bar Size : | 8 |
| Pedestal Maximum Bar Size : | 9 |
| Minimum Bar Spacing : | 50.000mm |
| Maximum Bar Spacing : | 450.000mm |
| Pedestal Clear Cover (P, CL) : | 75.000mm |
| Footing Clear Cover (F, CL) : | 75.000mm |

### Soil Properties

| | |
|---|---|
| Soil Type : | Drained |
| Unit Weight : | 19.000kN/m3 |
| Soil Bearing Capacity : | 281.200kN/m2 |
| Soil Bearing Capacity Type: | Gross Bearing Capacity |
| Soil Surcharge : | 0.000kN/m2 |
| Depth of Soil above Footing : | 2.000m |
| Cohesion : | 0.000kN/m2 |

### Sliding and Overturning

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

---

## Design Calculations

### Footing Size

| | |
|---|---|
| Initial Length ($L_o$) = | 1.000m |
| Initial Width ($W_o$) = | 1.000m |

| Load Combination/ s- Service Stress Level | | | | |
|---|---|---|---|---|
| Load | | Load | Soil | Self |

| Combination Number | Load Combination Title | Combination Factor | Bearing Factor | Weight Factor |
|---|---|---|---|---|
| 22 | CM + CV | 1.00 | 1.00 | 1.00 |
| 23 | CM + 0,75 CV + 0.75 (0.7)(SX + 0,3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 24 | CM + 0,75 CV - 0.75 (0.7)(SX - 0,3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 25 | CM + 0,75 CV + 0.75 (0.7)(SX - 0,3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 26 | CM + 0,75 CV - 0.75 (0.7)(SX + 0,3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 27 | CM + 0,75 CV + 0.75 (0.7)(0,3 SX + SZ)/R | 1.00 | 1.00 | 1.00 |
| 28 | CM + 0,75 CV - 0.75 (0.7)(0.3 SX - SZ)/R | 1.00 | 1.00 | 1.00 |
| 29 | CM + 0,75 CV + 0.75 (0.7)(0.3 SX - SZ)/R | 1.00 | 1.00 | 1.00 |
| 30 | CM + 0,75 CV - 0.75 (0.7)(0.3 SX + SZ)/R | 1.00 | 1.00 | 1.00 |
| 31 | 0.6 CM + 0.700 ( SX + 0.3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 32 | 0.6 CM - 0.700 ( SX - 0.3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 33 | 0.6 CM + 0.700 ( SX - 0.3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 34 | 0.6 CM - 0.700 ( SX + 0.3 SZ)/R | 1.00 | 1.00 | 1.00 |
| 35 | 0.6 CM + 0.700 ( 0.3 SX + SZ)/R | 1.00 | 1.00 | 1.00 |
| 36 | 0.6 CM - 0.700 ( 0.3 SX - SZ)/R | 1.00 | 1.00 | 1.00 |
| 37 | 0.6 CM - 0.700 ( 0.3 SX + SZ)/R | 1.00 | 1.00 | 1.00 |
| 38 | 0.6 CM + 0.700 ( 0.3 SX - SZ)/R | 1.00 | 1.00 | 1.00 |

| Load Combination Number | Load Combination Title | Load Combination Factor | Soil Bearing Factor | Self Weight Factor |
|---|---|---|---|---|
| 5 | 1.2 CM + 1.600 CV | 1.00 | 1.00 | 1.00 |
| 6 | 1.2 CM + CV + (SX/R + 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 7 | 1.2 CM + CV - (SX/R - 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 8 | 1.2 CM + CV + (SX/R - 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 9 | 1.2 CM + CV - (SX/R + 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 10 | 1.2 CM + CV + (0.3 SX/R + SZ/R) | 1.00 | 1.00 | 1.00 |
| 11 | 1.2 CM + CV - (0.3 SX/R - SZ/R) | 1.00 | 1.00 | 1.00 |
| 12 | 1.2 CM + CV + (0.3 SX/R - SZ/R) | 1.00 | 1.00 | 1.00 |
| 13 | 1.2 CM + CV - (0.3 SX/R + SZ/R) | 1.00 | 1.00 | 1.00 |
| 14 | 0.9 CM + (SX/R + 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 15 | 0.9 CM - (SX/R - 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 16 | 0.9 CM + (SX/R - 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 17 | 0.9 CM - (SX/R + 0,30 SZ/R) | 1.00 | 1.00 | 1.00 |
| 18 | 0.9 CM + (0.3 SX/R + SZ/R) | 1.00 | 1.00 | 1.00 |
| 19 | 0.9 CM - (0.3 SX/R - SZ/R) | 1.00 | 1.00 | 1.00 |
| 20 | 0.9 CM + (0.3 SX/R - SZ/R) | 1.00 | 1.00 | 1.00 |
| 21 | 0.9 CM - (0.3 SX/R + SZ/R) | 1.00 | 1.00 | 1.00 |

| Applied Loads - Service Stress Level | | | | | |
|---|---|---|---|---|---|
| LC | Axial (kN) | Shear X (kN) | Shear Z (kN) | Moment X (kNm) | Moment Z (kNm) |
| 22 | 192.570 | -6.063 | -7.422 | -2.129 | 4.042 |
| 23 | 170.351 | 5.167 | -3.063 | 5.429 | -15.446 |
| 24 | 198.499 | -16.908 | -5.609 | 1.008 | 22.613 |
| 25 | 179.875 | 4.532 | -9.559 | -5.811 | -14.426 |
| 26 | 208.022 | -17.542 | -12.105 | -10.232 | 23.633 |
| 27 | 171.776 | -1.985 | 1.784 | 13.810 | -3.050 |
| 28 | 177.623 | -8.460 | 2.813 | 15.587 | 8.134 |
| 29 | 200.751 | -3.916 | -17.981 | -20.389 | 0.053 |
| 30 | 209.231 | -10.566 | -18.748 | -21.721 | 11.519 |
| 31 | 82.466 | 11.127 | 1.132 | 8.417 | -23.375 |
| 32 | 119.816 | -18.164 | -2.246 | 2.551 | 27.127 |

| | | | | | |
|---|---|---|---|---|---|
| 33 | 95.029 | 10.290 | -7.437 | -6.410 | -22.029 |
| 34 | 132.379 | -19.001 | -10.815 | -12.277 | 28.473 |
| 35 | 80.858 | 1.847 | 9.970 | 23.701 | -7.260 |
| 36 | 92.045 | -6.926 | 8.958 | 21.944 | 7.866 |
| 37 | 133.987 | -9.721 | -19.653 | -27.560 | 12.358 |
| 38 | 122.800 | -0.947 | -18.641 | -25.803 | -2.768 |

| Applied Loads - Strength Level | | | | | |
|---|---|---|---|---|---|
| LC | Axial (kN) | Shear X (kN) | Shear Z (kN) | Moment X (kNm) | Moment Z (kNm) |
| 5 | 236.497 | -7.077 | -8.647 | -2.121 | 4.768 |
| 6 | 192.657 | 14.168 | -0.470 | 12.064 | -32.182 |
| 7 | 246.065 | -27.717 | -5.301 | 3.675 | 40.033 |
| 8 | 210.690 | 12.966 | -12.771 | -9.221 | -30.250 |
| 9 | 264.098 | -28.919 | -17.602 | -17.609 | 41.965 |
| 10 | 190.360 | 0.919 | 12.146 | 33.883 | -9.177 |
| 11 | 206.419 | -11.675 | 10.693 | 31.361 | 12.536 |
| 12 | 250.336 | -3.077 | -28.765 | -36.906 | -2.753 |
| 13 | 266.395 | -15.671 | -30.218 | -39.428 | 18.960 |
| 14 | 125.413 | 15.638 | 1.304 | 11.942 | -33.250 |
| 15 | 178.821 | -26.247 | -3.527 | 3.553 | 38.965 |
| 16 | 143.446 | 14.437 | -10.997 | -9.343 | -31.318 |
| 17 | 196.855 | -27.448 | -15.828 | -17.731 | 40.897 |
| 18 | 123.116 | 2.390 | 13.920 | 33.761 | -10.245 |
| 19 | 139.175 | -10.204 | 12.467 | 31.239 | 11.468 |
| 20 | 183.092 | -1.606 | -26.992 | -37.028 | -3.821 |
| 21 | 199.151 | -14.200 | -28.444 | -39.550 | 17.892 |

Reduction of force due to buoyancy = 0.000kN

Effect due to adhesion = 0.000kN

Area from initial length and width, $A_o = L_o \times W_o$ = 1.000$m^2$

Min. area required from bearing pressure, $A_{min} = P / q_{max}$ = 0.870$m^2$

**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 ($L_2$) = 1.300 m Governing Load Case : # 26

Width ($W_2$) = 1.300 m Governing Load Case : # 26

Depth ($D_2$) = 0.300 m Governing Load Case : # 13

Depth is governed by Ultimate Load Case

(Service check is performed with footing thickness requirements from concrete check)

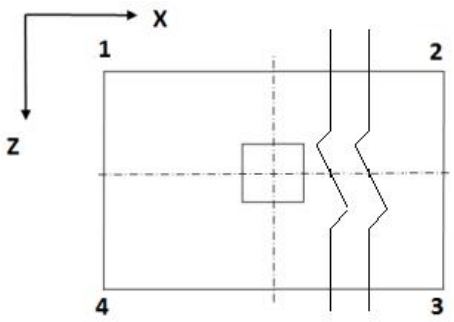
Area ($A_2$) = 1.690 $m^2$

Final Soil Height = 1.700 m

Footing Self Weight = 12.168 kN

Soil Weight On Top Of Footing = 50.628 kN

## Pressures at Four Corners




| Load Case | Pressure at corner 1 ($q_1$) (kN/ m2) | Pressure at corner 2 ($q_2$) (kN/ m2) | Pressure at corner 3 ($q_3$) (kN/ m2) | Pressure at corner 4 ($q_4$) (kN/ m2) | Area of footing in uplift ($A_u$) ($m^2$) |
|---|---|---|---|---|---|
| 26 | **277.0238** | 119.1927 | 43.4713 | 201.3024 | 0.000 |
| 29 | 229.7125 | **223.0075** | 82.1776 | 88.8826 | 0.000 |
| 23 | 79.2212 | 172.0553 | **196.6929** | 103.8588 | 0.000 |
| 24 | 232.0638 | 80.8436 | 77.1612 | **228.3815** | 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

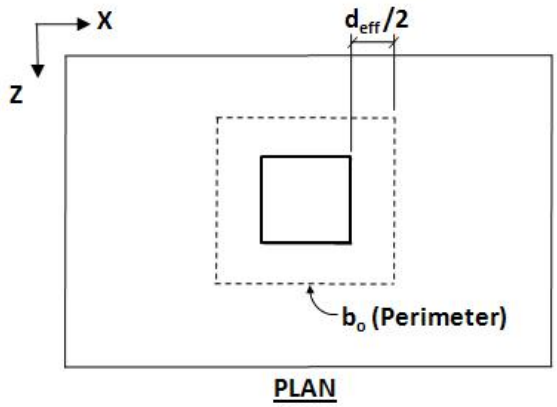
| Load Case | Pressure at corner 1 ($q_1$) (kN/ m2) | Pressure at corner 2 ($q_2$) (kN/ m2) | Pressure at corner 3 ($q_3$) (kN/ m2) | Pressure at corner 4 ($q_4$) (kN/ m2) |
|---|---|---|---|---|
| 26 | **277.0238** | 119.1927 | 43.4713 | 201.3024 |
| 29 | 229.7125 | **223.0075** | 82.1776 | 88.8826 |
| 23 | 79.2212 | 172.0553 | **196.6929** | 103.8588 |
| 24 | 232.0638 | 80.8436 | 77.1612 | **228.3815** |

## Compression Development Length Check

Development length skipped as column reinforcement is not specified in input (Column Dimnesion Task Pane)

## Shear Calculation

## Punching Shear Check




PLAN

| | | |
|---|---|---|
| Total Footing Depth, D = | 0.300m | |
| Calculated Effective Depth, $d_{eff}$ = | D - $C_{cover}$ - 0.5 * $d_b$ = | 0.219m |
| For rectangular column, $\beta_c$ = | $B_{col}$ / $D_{col}$ = | 1.000 |

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

Punching Shear Force, Vu = 266.126kN, Load Case # 13

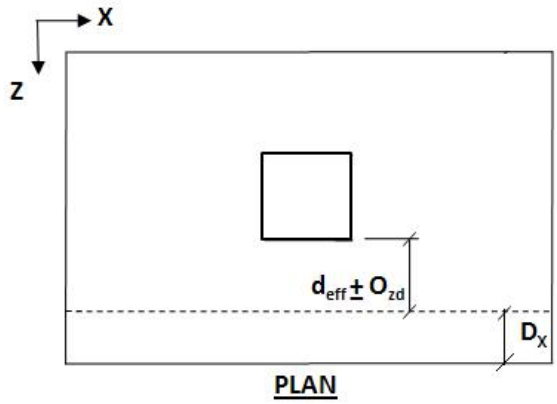
| | | |
|---|---|---|
| From ACI Cl.11.11.2, $b_o$ for column= | $2 \times (B_{col} + D_{col} + 2 \times d_{eff})$ = | 2.276m |
| Equation 11-31, $V_{c1}$ = | $\left(2 + \frac{4}{\beta_c}\right) \times b_o \times d_{eff} \times \sqrt{1000 \times F_c'}$ = | 1137.986kN |
| Equation 11-32, $V_{c2}$ = | $\left(2 + 40 \times \frac{d_{eff}}{b_o}\right) \times b_o \times d_{eff} \times \sqrt{1000 \times F_c'}$ = | 1109.320kN |
| Equation 11-33, $V_{c3}$ = | $4 \times b_o \times d_{eff} \times \sqrt{1000 \times F_c'}$ = | 758.657kN |
| Punching shear strength, $V_c$ = | 0.75 X minimum of ($V_{c1}$, $V_{c2}$, $V_{c3}$) = | 568.993kN |

0.75 X $V_c$ > $V_u$ hence, OK

## One-Way Shear Check

### Along X Direction

### (Shear Plane Parallel to Global X Axis)




PLAN

| | | |
|---|---|---|
| From ACI Cl.11.2.1.1, $V_c$ = | $2 \times L \times d_{eff} \times \sqrt{1000 \times F_c'}$ = | 216.664kN |

Distance along X to design for shear, $D_x$ = $0.5 \times (W - D_{col}) - d_{eff} + O_{zd}$ = 0.256m

Check that 0.75 X $V_c$ > $V_{ux}$ where $V_{ux}$ 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 X axis.

From above calculations, 0.75 X $V_c$ = 162.498 kN

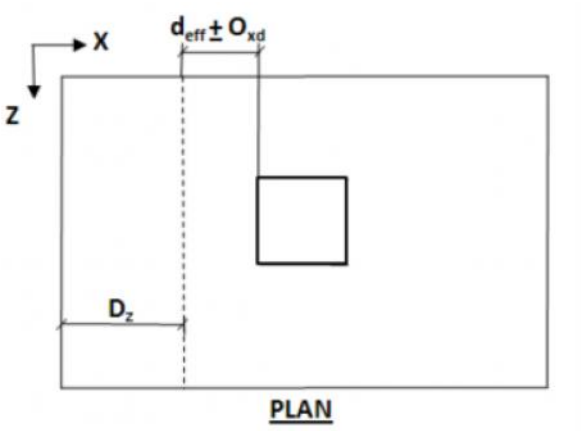
Critical load case for $V_{ux}$ is # 13 $V_{ux} = V_{ux}|_{x=D_x}$ = 100.221 kN

0.75 X $V_c$ > $V_{ux}$ hence, OK

## One-Way Shear Check

### Along Z Direction

### (Shear Plane Parallel to Global Z Axis)




From ACI Cl.11.2.1.1, $V_c$ =

$2 \times W \times d_{eff} \times \sqrt{1000 \times F_c'}$ = 216.664 kN

Distance along X to design for shear, $D_z$ = $0.5 \times (L - B_{col}) - d_{eff} + O_{xd}$ = 0.256 m

Check that **0.75 X $V_c$ > $V_{uz}$** 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.

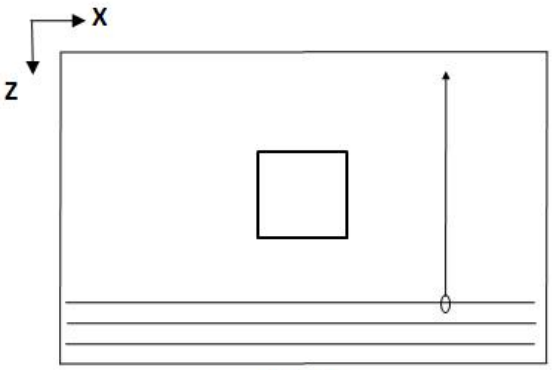
From above calculations, 0.75 X $V_c$ = 162.498 kN

Critical load case for $V_{uz}$ is # 9 $V_{uz} = V_{uz}|_{z=D_z}$ = 101.336 kN

0.75 X $V_c$ > $V_{uz}$ hence, OK

## Design for Flexure about Z Axis

### (For Reinforcement Parallel to X Axis)




PLAN

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

Bars parallel to X Direction are placed at bottom

| | | | |
|---|---|---|---|
| Effective Depth $d_{eff}$= | | 0.219 | m |
| Factor $\beta_1$ from ACI Cl.10.2.7.3 = | | 0.850 | |
| From ACI Cl. 10.3.2, $\rho_{bal}$ = | $0.85 \times \beta_1 \times F_c' \times \frac{87}{[f_y \times (87 + F_y)]}$ = | 0.02125 | |
| From ACI Cl. 10.3.3, $\rho_{max}$ = | $0.75 \times \rho_{bal}$ = | 0.01594 | |
| From ACI Cl. 7.12.2, $\rho_{min}$ = | | 0.00180 | |
| From Ref. 1, Eq. 3.8.4a, constant m = | $\frac{F_y}{(0.85 \times F_c')}$ = | 23.529 | |

**Calculate reinforcement ratio ρ for critical load case**

| | | | |
|---|---|---|---|
| Design for flexure about Z axis is performed at the face of the column at a distance, $D_x$ = | $0.5 \times L - 0.5 \times D_{col} + O_{xd}$ = | 0.475 | m |
| Ultimate moment, | $M_u\big\vert_{z=D_z}$ = | 43.705 | kNm |
| Nominal moment capacity, $M_n$ = | $\frac{M_u}{\Phi}$ = | 48.561 | kNm |
| (Based on effective depth) Required ρ = | $\frac{1}{m} \times \left[1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{eff}^2)}}\right]$ = | 0.00190 | |
| (Based on gross depth) ρ x $d_{eff}$ / Depth = | | 0.00138 | |
| Since | $\rho \leq \rho_{min}$ | $\rho_{min}$ Governs | |
| Area of Steel Required, $A_s$ = | $\rho \times W \times d_{eff}$ = | 702.002 | mm2 |

Selected bar Size = #12

Minimum spacing allowed ($S_{min}$) = = 5.000cm

Selected spacing (S) = 18.967cm

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

The reinforcement is accepted.

According to ACI 318 Clause No- 10.6.4

Max spacing for Cracking Consideration = 18.777cm

Warning:Calculated spacing is more than maximum spacing cosidering cracking condition. Modify spacing manually if cracking consideration is necessary.

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

| **# 12 @ 18.500cm o.c.** |
|---|

| | | | |
|---|---|---|---|
| Required development length for bars = | $\frac{0.87 \times d_b \times f_y}{4 \times \beta \times \sqrt{f_c}}$ = | =0.305 | m |
| Available development length for bars, $D_L$ = | $0.5 \times (L - D_{col}) \cdot - C_{cover}$ = | 0.400 | m |
| Try bar size # 12 | Area of one bar = | 113.097 | mm2 |
| Number of bars required, $N_{bar}$ = | $\frac{A_s}{A_{bar}}$ = | 7 | |

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

| | | | |
|---|---|---|---|
| Total reinforcement area, $A_{s\_total}$ = | $N_{bar}$ X (Area of one bar) = | 791.676 | mm2 |
| $d_{eff}$ = | D - $C_{cover}$ - 0.5 X (dia. of one bar) = | 0.219 | m |
| Reinforcement ratio, $\rho$ = | $\frac{A_{s\_total}}{(d_{eff} \times W)}$ = | 0.00278 | |

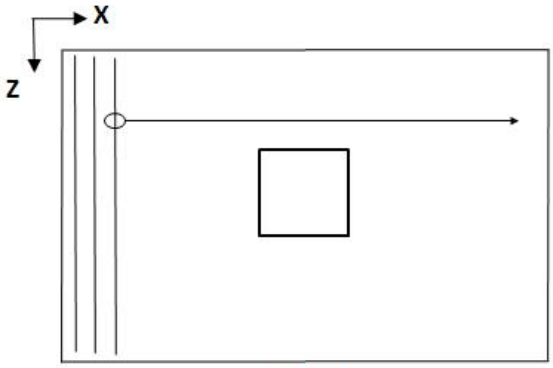
From ACI Cl.7.6.1, minimum req'd clear distance between bars

$C_d$ = max (Diameter of one bar, 1.0" (25.4mm), Min. User Spacing) = 5.000cm

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

Design for Flexure about X axis

(For Reinforcement Parallel to Z Axis)




PLAN

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 # 13

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

Bars parallel to X Direction are placed at bottom

| | | | |
|---|---|---|---|
| Effective Depth $d_{eff}$= | | 0.207 | m |
| Factor $\beta_1$ from ACI Cl.10.2.7.3 = | | 0.850 | |
| From ACI Cl. 10.3.2, $\rho_{bal}$ = | $0.85 \times \beta_1 \times F_c' \times \frac{87}{[f_y \times (87 + F_y)]}$ = | 0.02125 | |
| From ACI Cl. 10.3.3, $\rho_{max}$ = | $0.75 \times \rho_{bal}$ = | 0.01594 | |
| From ACI Cl.7.12.2, $\rho_{min}$ = | | 0.00180 | |
| From Ref. 1, Eq. 3.8.4a, constant m = | $\frac{F_y}{(0.85 \times F_c')}$ = | 23.529 | |

**Calculate reinforcement ratio ρ for critical load case**

| | | | |
|---|---|---|---|
| Design for flexure about X axis is performed at the face of the column at a distance, $D_z$ = | $0.5 \times L + 0.5 \times B_{col} + O_{zd}$ = | 0.475 | m |
| Ultimate moment, | $M_u\|_{x=D_x}$ = | 43.254 | kNm |
| Nominal moment capacity, $M_n$ = | $\frac{M_u}{\Phi}$ = | 48.060 | kNm |
| (Based on effective depth) Required ρ = | $\frac{1}{m} \times \left[1 - \sqrt{1 - 2 \times m \times \frac{M_n}{(F_y \times W \times d_{eff}^2)}}\right]$ = | 0.00211 | |
| (Based on gross depth) ρ x $d_{eff}$ / Depth = | | 0.00145 | |
| Since | $\rho \leq \rho_{min}$ | $\rho_{min}$ Governs | |
| Area of Steel Required, $A_s$ = | $\rho \times W \times d_{eff}$ = | 702.002 | mm2 |

Selected Bar Size = #12

Minimum spacing allowed ($S_{min}$) = 5.000cm

Selected spacing (S) = 18.967cm

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

The reinforcement is accepted.

According to ACI 318 Clause No- 10.6.4

Max spacing for Cracking Consideration = 18.777cm

Warning:Calculated spacing is more than maximum spacing cosidering cracking condition. Modify spacing manually if cracking consideration is necessary.

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

| **#12 @18.500cm o.c.** |
|---|

Required development length for bars = 0.305 m

$$\frac{0.87 \times d_b \times f_y}{4 \times \beta \times \sqrt{f_c}} =$$

Available development length for bars, $D_L$ = $0.5 \times (L - D_{col}) \cdot - C_{cover}$ = 0.400 m

Try bar size # 12 Area of one bar = 113.097 mm2

Number of bars required, $N_{bar}$ = $\frac{A_s}{A_{bar}}$ = 7

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

Total reinforcement area, $A_{s\_total}$ = $N_{bar}$ X (Area of one bar) = 791.676 mm2

$d_{eff}$ = D - $C_{cover}$ - 1.5 X (dia. of one bar) = 0.207 m

Reinforcement ratio, $\rho$ = $\frac{A_{s\_total}}{(d_{eff} \times W)}$ = 0.00294

From ACI Cl.7.6.1, minimum req'd clear distance between bars

$C_d$ = max (Diameter of one bar, 1.0" (25.4mm), Min. User Spacing) = 5.000cm

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

## Isolated Footing 125