Print Calculation Sheet

## COMBINED FOUNDATION DESIGN (ACI 318-11) - Metric

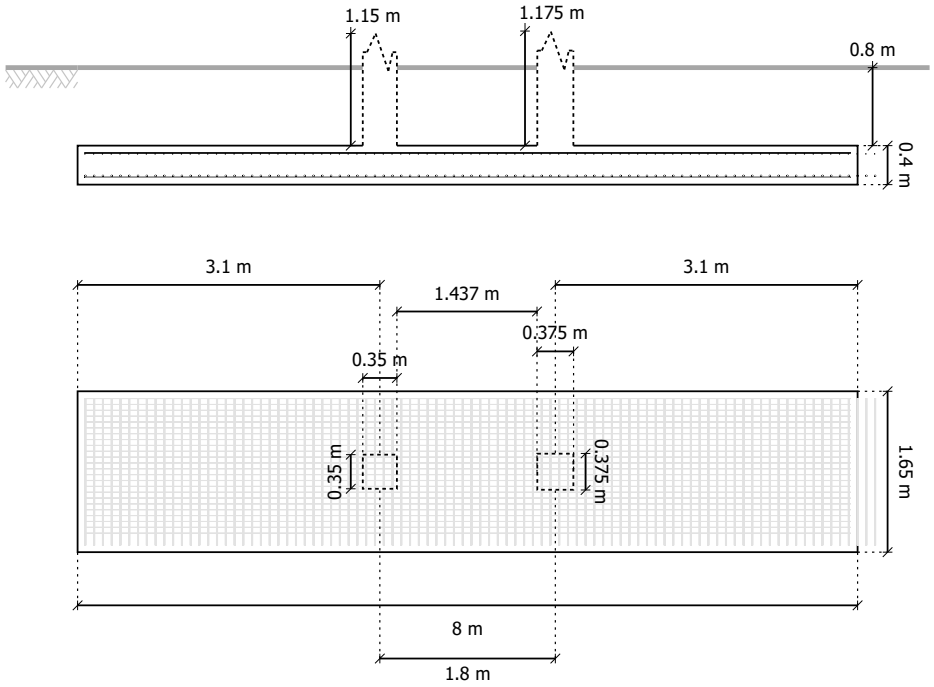
# Result Summary

| Footing No. | Left Overhang (m) | Right Overhang (m) | Length (m) | Width (m) | Thickness (m) |
|---|---|---|---|---|---|
| 1 | 3.10 | 3.10 | 8.00 | 1.65 | 0.40 |

| Footing No. | Footing Reinforcement | | | |
|---|---|---|---|---|
| - | Main Steel Top | Main Steel Bottom | Secondary Steel Top | Secondary Steel Bottom |
| 1 | 19 - ϕ10 | 24 - ϕ19 | 91 - ϕ10 | 91 - ϕ10 |

# Combined Footing 1

Input Data




Geometry of Footing

**For Column 1004**

Column Dimensions

Column Shape : Rectangular

Column Length - X ($D_{col}$) : 0.35 m

Column Width - Z ($B_{col}$) : 0.35 m

Pedestal

Include Pedestal : No

Pedestal Shape : N/A

## Eccentricity

Column Offset in Transverse Direction : 0.00 m

**For Column 1005**

## Column Dimensions

Column Shape : Rectangular

Column Length - X ($D_{col}$) : 0.37 m

Column Width - Z ($B_{col}$) : 0.37 m

## Pedestal

Include Pedestal : No

Pedestal Shape : N/A

## Eccentricity

Column Offset in Transverse Direction : 0.00 m

Length of left overhang : 3000.00 mm

Length of right overhang : 3000.00 mm

Is the length of left overhang fixed : No

Is the length of right overhang fixed : No

Minimum width of footing (Wo) : 1000.00 mm

Minimum Thickness of footing (Do) : 350.00 mm

Maximum Width of Footing (Wo) : 8000.00 mm

Maximum Thickness of Footing (Do) : 1000.00 mm

Maximum Length of Footing (Lo) : 8000.00 mm

Length Increment : 50.00 mm

Depth Increment : 50.00 mm

## Cover and Soil Properties

Pedestal Clear Cover : 75.00 mm

Footing Clear Cover : 75.00 mm

Unit Weight of soil : 22.00 kN/m3

Base Value of Soil Bearing Capacity : 100.00 kN/m2

Soil Bearing Capacity Type : Gross Bearing Capacity

Soil Surcharge : 0.00 kN/m2

Depth of Soil above Footing : 1.20 m

Type of Depth : Fixed Bottom

Depth of Water Table : 10.00 m

## Concrete and Rebar Properties

Unit Weight of Concrete : 24.00 kN/m3

Compressive Strength of Concrete : 20.68 N/mm2

| | | | |
|---|---|---|---|
| Yield Strength of Steel | : | 225.00 | N/mm2 |
| Minimum Bar Size | : | #10 | |
| Maximum Bar Size | : | #57 | |
| Minimum Pedestal Bar Size | : | #16 | |
| Maximum Pedestal Bar Size | : | #22 | |
| Minimum Bar Spacing | : | 50.00 | mm |
| Maximum Bar Spacing | : | 250.00 | mm |

---

## Design Calculations

### Footing Size Calculations

Reduction of force due to buoyancy = 0.000 kN

Buoyancy force reported above is unfactored.

Whether it would affect bearing pressure or not depends upon Global Setting

Area from initial length and width, $A_o = L_o \times W_o$ = 12.80 m^2

Min. area required from bearing pressure, $A_{min} = \frac{P}{q_{max}}$ = 7.90 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 dimensions are:**

| | | |
|---|---|---|
| Length of footing, L : | 8.00 | m |
| Width of footing, W : | 1.65 | m |
| Depth of footing, Do : | 0.40 | m |
| Area, A : | 13.20 | m^2 |
| Length of left overhang, $L_{left\_overhang}$ : | 3.10 | m |
| Length of right overhang, $L_{right\_overhang}$ : | 3.10 | m |
| Footing self weight(including pedestal weight): | 126.72 | kN |
| Soil weight on top of footing : | 227.68 | kN |

---

## Load Combinations

| Load Combination Number | Load Combination Title | Load Case Multiplier | Soil Bearing Factor | Self Weight Factor | Co |
|---|---|---|---|---|---|
| 129 | GENERATED NSCP 2015 BASIC USD COMBO 21 | 1.00 | 1.00 | 1.00 | - |
| 130 | GENERATED NSCP 2015 SERVICE COMBO 1 | 1.00 | 1.00 | 1.00 | - |
| 131 | GENERATED NSCP 2015 SERVICE COMBO 2 | 1.00 | 1.00 | 1.00 | - |
| 132 | GENERATED NSCP 2015 SERVICE COMBO 3 | 1.00 | 1.33 | 1.00 | - |
| 133 | GENERATED NSCP 2015 SERVICE COMBO 4 | 1.00 | 1.33 | 1.00 | - |
| 134 | GENERATED NSCP 2015 SERVICE COMBO 5 | 1.00 | 1.33 | 1.00 | - |
| 135 | GENERATED NSCP 2015 SERVICE COMBO 6 | 1.00 | 1.33 | 1.00 | - |
| 136 | GENERATED NSCP 2015 SERVICE COMBO 7 | 1.00 | 1.33 | 1.00 | - |
| 137 | GENERATED NSCP 2015 SERVICE COMBO 8 | 1.00 | 1.33 | 1.00 | - |
| 138 | GENERATED NSCP 2015 SERVICE COMBO 9 | 1.00 | 1.33 | 1.00 | - |
| 139 | GENERATED NSCP 2015 SERVICE COMBO 10 | 1.00 | 1.33 | 1.00 | - |
| 140 | GENERATED NSCP 2015 SERVICE COMBO 11 | 1.00 | 1.33 | 1.00 | - |
| 141 | GENERATED NSCP 2015 SERVICE COMBO 12 | 1.00 | 1.33 | 1.00 | - |
| 142 | GENERATED NSCP 2015 SERVICE COMBO 13 | 1.00 | 1.33 | 1.00 | - |

| Load Combination Number | Load Combination Title | Load Case Multiplier | Soil Bearing Factor | Self Weight Factor | Co |
|---|---|---|---|---|---|
| 143 | GENERATED NSCP 2015 SERVICE COMBO 14 | 1.00 | 1.33 | 1.00 | - |
| 144 | GENERATED NSCP 2015 SERVICE COMBO 15 | 1.00 | 1.33 | 1.00 | - |
| 145 | GENERATED NSCP 2015 SERVICE COMBO 16 | 1.00 | 1.33 | 1.00 | - |
| 146 | GENERATED NSCP 2015 SERVICE COMBO 17 | 1.00 | 1.33 | 1.00 | - |
| 147 | GENERATED NSCP 2015 SERVICE COMBO 18 | 1.00 | 1.33 | 1.00 | - |
| 148 | GENERATED NSCP 2015 SERVICE COMBO 19 | 1.00 | 1.33 | 1.00 | - |
| 149 | GENERATED NSCP 2015 SERVICE COMBO 20 | 1.00 | 1.33 | 1.00 | - |
| 150 | GENERATED NSCP 2015 SERVICE COMBO 21 | 1.00 | 1.33 | 1.00 | - |
| 151 | GENERATED NSCP 2015 SERVICE COMBO 22 | 1.00 | 1.33 | 1.00 | - |
| 152 | GENERATED NSCP 2015 SERVICE COMBO 23 | 1.00 | 1.33 | 1.00 | - |
| 153 | GENERATED NSCP 2015 SERVICE COMBO 24 | 1.00 | 1.33 | 1.00 | - |
| 154 | GENERATED NSCP 2015 SERVICE COMBO 25 | 1.00 | 1.33 | 1.00 | - |
| 155 | GENERATED NSCP 2015 SERVICE COMBO 26 | 1.00 | 1.33 | 1.00 | - |
| 156 | GENERATED NSCP 2015 SERVICE COMBO 27 | 1.00 | 1.33 | 1.00 | - |
| **Load Combination Number** | **Load Combination Title** | **Load Case Multiplier** | **Soil Bearing Factor** | **Self Weight Factor** | **Co** |
| 109 | GENERATED NSCP 2015 BASIC USD COMBO 1 | 1.00 | 1.00 | 1.00 | - |
| 110 | GENERATED NSCP 2015 BASIC USD COMBO 2 | 1.00 | 1.00 | 1.00 | - |
| 111 | GENERATED NSCP 2015 BASIC USD COMBO 3 | 1.00 | 1.00 | 1.00 | - |
| 112 | GENERATED NSCP 2015 BASIC USD COMBO 4 | 1.00 | 1.00 | 1.00 | - |
| 113 | GENERATED NSCP 2015 BASIC USD COMBO 5 | 1.00 | 1.00 | 1.00 | - |
| 114 | GENERATED NSCP 2015 BASIC USD COMBO 6 | 1.00 | 1.00 | 1.00 | - |
| 115 | GENERATED NSCP 2015 BASIC USD COMBO 7 | 1.00 | 1.00 | 1.00 | - |
| 116 | GENERATED NSCP 2015 BASIC USD COMBO 8 | 1.00 | 1.00 | 1.00 | - |
| 117 | GENERATED NSCP 2015 BASIC USD COMBO 9 | 1.00 | 1.00 | 1.00 | - |
| 118 | GENERATED NSCP 2015 BASIC USD COMBO 10 | 1.00 | 1.00 | 1.00 | - |
| 119 | GENERATED NSCP 2015 BASIC USD COMBO 11 | 1.00 | 1.00 | 1.00 | - |
| 120 | GENERATED NSCP 2015 BASIC USD COMBO 12 | 1.00 | 1.00 | 1.00 | - |
| 121 | GENERATED NSCP 2015 BASIC USD COMBO 13 | 1.00 | 1.00 | 1.00 | - |
| 122 | GENERATED NSCP 2015 BASIC USD COMBO 14 | 1.00 | 1.00 | 1.00 | - |
| 123 | GENERATED NSCP 2015 BASIC USD COMBO 15 | 1.00 | 1.00 | 1.00 | - |
| 124 | GENERATED NSCP 2015 BASIC USD COMBO 16 | 1.00 | 1.00 | 1.00 | - |
| 125 | GENERATED NSCP 2015 BASIC USD COMBO 17 | 1.00 | 1.00 | 1.00 | - |
| 126 | GENERATED NSCP 2015 BASIC USD COMBO 18 | 1.00 | 1.00 | 1.00 | - |
| 127 | GENERATED NSCP 2015 BASIC USD COMBO 19 | 1.00 | 1.00 | 1.00 | - |
| 128 | GENERATED NSCP 2015 BASIC USD COMBO 20 | 1.00 | 1.00 | 1.00 | - |

## Applied Loads on Top of Pedestal

Before consideration of self weight and load multiplier table
For the loads shown in this table, the sign convention is the same as that for JOINT LOADS in STAAD.Pro when global Y is the vertical axis

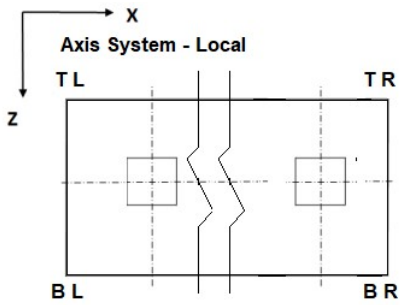
| Applied Loads - Service Stress Level | | | | | |
|---|---|---|---|---|---|
| **Load Case** | **$F_x$** (kN) | **$F_y$** (kN) **Downwards is negative Upwards is positive** | **$F_z$** (kN) | **$M_x$** (kNm) | **$M_z$** (kNm) |
| - | | | | | |
| **Column Number : 1004** | | | | | |
| 129 | -2.19 | -237.10 | -22.98 | -40.95 | 3.19 |
| 130 | 0.09 | -281.24 | -8.36 | -5.43 | 0.06 |
| 131 | 0.06 | -270.28 | -7.95 | -5.15 | 0.08 |
| 132 | 18.19 | -264.61 | -8.17 | -5.53 | -26.91 |
| 133 | 20.76 | -262.77 | -8.04 | -5.32 | -30.72 |
| 134 | -20.65 | -277.79 | -7.85 | -4.97 | 30.88 |
| 135 | -18.07 | -275.94 | -7.72 | -4.77 | 27.08 |
| 136 | -0.62 | -259.02 | 1.04 | 14.58 | 1.14 |
| 137 | 1.21 | -257.70 | 1.14 | 14.73 | -1.56 |
| 138 | -1.10 | -282.85 | -17.03 | -25.02 | 1.73 |
| 139 | -1.10 | -282.85 | -17.03 | -25.02 | 1.73 |
| 140 | -0.02 | -142.43 | -4.02 | -2.58 | 0.08 |
| 141 | 24.13 | -134.88 | -4.33 | -3.09 | -35.88 |
| 142 | 27.56 | -132.42 | -4.15 | -2.82 | -40.95 |
| 143 | -27.61 | -152.43 | -3.90 | -2.34 | 41.11 |
| 144 | -24.17 | -149.97 | -3.72 | -2.07 | 36.04 |

| Applied Loads - Service Stress Level | | | | | |
|---|---|---|---|---|---|
| Load Case | $F_x$ (kN) | $F_y$ (kN) Downwards is negative Upwards is positive | $F_z$ (kN) | $M_x$ (kNm) | $M_z$ (kNm) |
| 145 | -0.92 | -127.43 | 7.95 | 23.70 | 1.49 |
| 146 | 1.51 | -125.68 | 8.07 | 23.89 | -2.11 |
| 147 | -1.56 | -159.18 | -16.12 | -29.05 | 2.27 |
| 148 | -1.56 | -159.18 | -16.12 | -29.05 | 2.27 |
| 149 | 24.24 | -273.70 | -8.66 | -5.93 | -35.89 |
| 150 | 27.67 | -271.24 | -8.49 | -5.66 | -40.97 |
| 151 | -27.49 | -291.25 | -8.23 | -5.19 | 41.10 |
| 152 | -24.06 | -288.79 | -8.05 | -4.92 | 36.02 |
| 153 | -0.81 | -266.24 | 3.61 | 20.86 | 1.47 |
| 154 | 1.62 | -264.49 | 3.74 | 21.05 | -2.13 |
| 155 | -1.45 | -297.99 | -20.46 | -31.90 | 2.25 |
| 156 | -1.45 | -297.99 | -20.46 | -31.90 | 2.25 |
| - | | | | | |
| Column Number : 1005 | | | | | |
| 129 | -1.11 | -164.26 | -39.88 | -63.34 | 2.70 |
| 130 | 1.93 | -154.48 | -2.29 | 0.28 | -1.45 |
| 131 | 1.85 | -150.45 | -2.24 | 0.23 | -1.40 |
| 132 | 21.74 | -220.76 | -6.88 | -7.37 | -33.52 |
| 133 | 24.76 | -226.27 | -4.40 | -3.42 | -38.21 |
| 134 | -21.07 | -74.63 | -0.08 | 3.88 | 35.42 |
| 135 | -18.05 | -80.13 | 2.40 | 7.83 | 30.72 |
| 136 | 1.07 | -125.21 | 16.38 | 31.41 | -0.11 |
| 137 | 3.22 | -129.14 | 18.13 | 34.22 | -3.43 |
| 138 | 0.48 | -171.75 | -22.61 | -33.75 | 0.64 |
| 139 | 0.48 | -171.75 | -22.61 | -33.75 | 0.64 |
| 140 | 0.96 | -83.00 | -1.25 | 0.05 | -0.73 |
| 141 | 27.46 | -176.67 | -7.43 | -10.08 | -43.52 |
| 142 | 31.49 | -184.00 | -4.13 | -4.81 | -49.78 |
| 143 | -29.56 | 17.99 | 1.63 | 4.91 | 48.31 |
| 144 | -25.54 | 10.66 | 4.93 | 10.17 | 42.05 |
| 145 | -0.07 | -49.39 | 23.55 | 41.58 | 0.99 |
| 146 | 2.79 | -54.62 | 25.89 | 45.32 | -3.45 |
| 147 | -0.86 | -111.39 | -28.39 | -45.22 | 1.98 |
| 148 | -0.86 | -111.39 | -28.39 | -45.22 | 1.98 |
| 149 | 28.42 | -248.14 | -8.48 | -9.84 | -44.24 |
| 150 | 32.45 | -255.48 | -5.18 | -4.58 | -50.50 |
| 151 | -28.60 | -53.48 | 0.59 | 5.14 | 47.59 |
| 152 | -24.57 | -60.82 | 3.89 | 10.41 | 41.33 |
| 153 | 0.90 | -120.87 | 22.51 | 41.82 | 0.27 |
| 154 | 3.75 | -126.10 | 24.84 | 45.55 | -4.17 |
| 155 | 0.10 | -182.87 | -29.43 | -44.99 | 1.26 |
| 156 | 0.10 | -182.87 | -29.43 | -44.99 | 1.26 |

| Applied Loads - Strength Level | | | | | |
|---|---|---|---|---|---|
| Load Case | $F_x$ (kN) | $F_y$ (kN) Downwards is negative Upwards is positive | $F_z$ (kN) | $M_x$ (kNm) | $M_z$ (kNm) |
| - | | | | | |
| Column Number : 1004 | | | | | |
| 109 | -0.05 | -332.33 | -9.39 | -6.02 | 0.19 |
| 110 | 0.16 | -355.04 | -10.69 | -6.96 | 0.05 |
| 111 | 0.02 | -306.79 | -8.87 | -5.72 | 0.13 |
| 112 | -0.05 | -284.85 | -8.05 | -5.16 | 0.16 |
| 113 | 33.84 | -296.22 | -9.30 | -6.43 | -50.23 |
| 114 | 38.65 | -292.78 | -9.05 | -6.06 | -57.34 |
| 115 | -38.61 | -320.79 | -8.69 | -5.39 | 57.60 |
| 116 | -33.81 | -317.36 | -8.45 | -5.02 | 50.49 |
| 117 | -1.24 | -285.78 | 7.89 | 31.08 | 2.10 |
| 118 | 2.17 | -283.33 | 8.07 | 31.35 | -2.94 |
| 119 | -2.13 | -330.25 | -25.82 | -42.80 | 3.20 |

| Applied Loads - Strength Level | | | | | |
|---|---|---|---|---|---|
| Load Case | $F_x$ (kN) | $F_y$ (kN) Downwards is negative Upwards is positive | $F_z$ (kN) | $M_x$ (kNm) | $M_z$ (kNm) |
| 120 | -2.13 | -330.25 | -25.82 | -42.80 | 3.20 |
| 121 | -0.03 | -213.64 | -6.04 | -3.87 | 0.12 |
| 122 | 33.79 | -203.07 | -6.46 | -4.58 | -50.24 |
| 123 | 38.60 | -199.63 | -6.21 | -4.21 | -57.34 |
| 124 | -38.67 | -227.65 | -5.86 | -3.54 | 57.59 |
| 125 | -33.86 | -224.21 | -5.61 | -3.16 | 50.48 |
| 126 | -1.29 | -192.63 | 10.73 | 32.94 | 2.09 |
| 127 | 2.12 | -190.18 | 10.91 | 33.20 | -2.94 |
| 128 | -2.19 | -237.10 | -22.98 | -40.95 | 3.19 |
| - | | | | | |
| Column Number : 1005 | | | | | |
| 109 | 2.24 | -193.68 | -2.91 | 0.11 | -1.71 |
| 110 | 2.44 | -191.83 | -2.84 | 0.42 | -1.84 |
| 111 | 2.09 | -174.08 | -2.60 | 0.19 | -1.58 |
| 112 | 1.92 | -166.01 | -2.50 | 0.09 | -1.47 |
| 113 | 39.20 | -305.26 | -11.26 | -13.99 | -61.51 |
| 114 | 44.84 | -315.54 | -6.64 | -6.61 | -70.27 |
| 115 | -40.67 | -32.62 | 1.43 | 7.00 | 67.11 |
| 116 | -35.03 | -42.90 | 6.05 | 14.38 | 58.34 |
| 117 | 0.65 | -127.00 | 32.13 | 58.37 | 0.83 |
| 118 | 4.64 | -134.32 | 35.41 | 63.60 | -5.38 |
| 119 | -0.47 | -213.83 | -40.61 | -63.21 | 2.21 |
| 120 | -0.47 | -213.83 | -40.61 | -63.21 | 2.21 |
| 121 | 1.44 | -124.51 | -1.87 | 0.07 | -1.10 |
| 122 | 38.55 | -255.69 | -10.53 | -14.11 | -61.03 |
| 123 | 44.19 | -265.96 | -5.91 | -6.74 | -69.79 |
| 124 | -41.31 | 16.95 | 2.16 | 6.88 | 67.59 |
| 125 | -35.67 | 6.67 | 6.78 | 14.25 | 58.83 |
| 126 | 0.00 | -77.43 | 32.87 | 58.25 | 1.31 |
| 127 | 4.00 | -84.75 | 36.14 | 63.47 | -4.90 |
| 128 | -1.11 | -164.26 | -39.88 | -63.34 | 2.70 |

## Gross Pressures at 4 Corners




| Load Case | Pressure at top left corner (kN/m^2) | Pressure at top right corner (kN/m^2) | Pressure at bottom right corner (kN/m^2) | Pressure at bottom left corner (kN/m^2) | Area of footing in uplift ($A_u$) (sq. m) | Gross Bearing Capacity (kN/m^2) |
|---|---|---|---|---|---|---|
| 129 | **97.0604** | 88.7595 | 17.4483 | 25.7492 | 0.00 | 100.0000 |
| 129 | 97.0604 | **88.7595** | 17.4483 | 25.7492 | 0.00 | 100.0000 |
| 154 | 41.5555 | 28.3279 | **71.3213** | 84.5489 | 0.00 | 133.0000 |
| 130 | 68.8227 | 56.0752 | 50.8926 | **63.6401** | 0.00 | 100.0000 |

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 Gross Pressures at Four Corners

| Load Case | Pressure at top left corner (kN/m^2) | Pressure at top right corner (kN/m^2) | Pressure at bottom right corner (kN/m^2) | Pressure at bottom left corner (kN/m^2) | Gross Bearing Capacity (kN/m^2) |
|---|---|---|---|---|---|
| 129 | **97.0604** | 88.7595 | 17.4483 | 25.7492 | 100.0000 |
| 129 | 97.0604 | **88.7595** | 17.4483 | 25.7492 | 100.0000 |
| 154 | 41.5555 | 28.3279 | **71.3213** | 84.5489 | 133.0000 |
| 130 | 68.8227 | 56.0752 | 50.8926 | **63.6401** | 100.0000 |

---

## Stability Check

| Load Case | Shear X (kN) | Shear Z (kN) | Resultant Shear (kN) | Resisting Sliding Force (kN) | Ratio X | Ratio Z | Resultant Ratio | Required FOS |
|---|---|---|---|---|---|---|---|---|
| **129** | -3.299 | -62.862 | 62.948 | 226.727 | 68.716 | **3.607** | 3.602 | 1.500 |
| 130 | 2.015 | -10.653 | 10.842 | 237.036 | 117.653 | 22.251 | 21.864 | 1.500 |
| 131 | 1.902 | -10.186 | 10.362 | 232.536 | 122.260 | 22.828 | 22.440 | 1.500 |
| 132 | 39.923 | -15.054 | 42.667 | 251.930 | 6.310 | 16.735 | 5.905 | 1.500 |
| 133 | 45.523 | -12.445 | 47.194 | 253.030 | 5.558 | 20.332 | 5.361 | 1.500 |
| 134 | -41.719 | -7.927 | 42.466 | 212.042 | 5.083 | 26.748 | 4.993 | 1.500 |
| 135 | -36.119 | -5.319 | 36.508 | 213.141 | 5.901 | 40.075 | 5.838 | 1.500 |
| 136 | 0.459 | 17.420 | 17.426 | 221.587 | 482.399 | 12.720 | 12.716 | 1.500 |
| 137 | 4.425 | 19.269 | 19.770 | 222.371 | 50.255 | 11.541 | 11.248 | 1.500 |
| 138 | -0.621 | -39.641 | 39.646 | 242.701 | 390.882 | 6.122 | 6.122 | 1.500 |
| 139 | -0.621 | -39.641 | 39.646 | 242.701 | 390.882 | 6.122 | 6.122 | 1.500 |
| 140 | 0.938 | -5.272 | 5.355 | 173.948 | 185.394 | 32.994 | 32.483 | 1.500 |
| 141 | 51.585 | -11.756 | 52.908 | 199.784 | 3.873 | 16.994 | 3.776 | 1.500 |
| 142 | 59.046 | -8.281 | 59.624 | 201.248 | 3.408 | 24.302 | 3.375 | 1.500 |
| **143** | -57.169 | -2.263 | 57.214 | 146.649 | **2.565** | 64.798 | 2.563 | 1.500 |
| 144 | -49.709 | 1.212 | 49.724 | 148.113 | 2.980 | 122.198 | 2.979 | 1.500 |
| 145 | -0.983 | 31.502 | 31.518 | 159.364 | 162.045 | 5.059 | 5.056 | 1.500 |
| 146 | 4.299 | 33.964 | 34.235 | 160.408 | 37.313 | 4.723 | 4.685 | 1.500 |
| 147 | -2.422 | -44.509 | 44.575 | 187.489 | 77.397 | 4.212 | 4.206 | 1.500 |
| 148 | -2.422 | -44.509 | 44.575 | 187.489 | 77.397 | 4.212 | 4.206 | 1.500 |
| 149 | 52.662 | -17.137 | 55.380 | 262.871 | 4.992 | 15.339 | 4.747 | 1.500 |
| 150 | 60.122 | -13.662 | 61.655 | 264.336 | 4.397 | 19.349 | 4.287 | 1.500 |
| 151 | -56.093 | -7.644 | 56.611 | 209.737 | 3.739 | 27.439 | 3.705 | 1.500 |
| 152 | -48.632 | -4.169 | 48.811 | 211.201 | 4.343 | 50.665 | 4.327 | 1.500 |
| 153 | 0.093 | 26.122 | 26.122 | 222.452 | 2392.083 | 8.516 | 8.516 | 1.500 |
| 154 | 5.375 | 28.584 | 29.085 | 223.496 | 41.577 | 7.819 | 7.684 | 1.500 |
| 155 | -1.346 | -49.889 | 49.908 | 250.577 | 186.165 | 5.023 | 5.021 | 1.500 |
| 156 | -1.346 | -49.889 | 49.908 | 250.577 | 186.165 | 5.023 | 5.021 | 1.500 |

### Check for stability against overturning (Moments printed against Local axis)

| Load Case | Moment X (kNm) | Moment Z (kNm) | Resisting Moment X (kNm) | Resisting Moment Z (kNm) | Ratio X | Ratio Z | Required FOS |
|---|---|---|---|---|---|---|---|
| **129** | -129.430 | 73.047 | 623.489 | 3022.973 | **4.817** | 41.384 | 1.500 |
| 130 | -9.406 | 112.176 | 651.838 | 3160.425 | 69.299 | 28.174 | 1.500 |
| 131 | -8.990 | 106.058 | 639.462 | 3100.421 | 71.134 | 29.233 | 1.500 |
| 132 | -18.918 | -36.643 | 692.796 | 3359.009 | 36.622 | 91.668 | 1.500 |
| 133 | -13.720 | -54.005 | 695.818 | 3373.664 | 50.715 | 62.469 | 1.500 |
| 134 | -4.259 | 266.122 | 583.106 | 2827.177 | 136.909 | 10.624 | 1.500 |
| 135 | 0.939 | 248.760 | 586.128 | 2841.832 | 624.503 | 11.424 | 1.500 |

| Load Case | Moment X (kNm) | Moment Z (kNm) | Resisting Moment X (kNm) | Resisting Moment Z (kNm) | Ratio X | Ratio Z | Required FOS |
|---|---|---|---|---|---|---|---|
| 136 | 52.967 | 121.556 | 609.354 | 2954.442 | 11.505 | 24.305 | 1.500 |
| 137 | 56.651 | 109.230 | 611.510 | 2964.893 | 10.795 | 27.144 | 1.500 |
| 138 | -74.630 | 102.886 | 667.415 | 3235.948 | 8.943 | 31.452 | 1.500 |
| 139 | -74.630 | 102.886 | 667.415 | 3235.948 | 8.943 | 31.452 | 1.500 |
| 140 | -4.644 | 52.739 | 478.349 | 2319.269 | 103.008 | 43.977 | 1.500 |
| 141 | -17.869 | -137.353 | 549.395 | 2663.731 | 30.746 | 19.393 | 1.500 |
| 142 | -10.945 | -160.480 | 553.421 | 2683.253 | 50.563 | 16.720 | 1.500 |
| **143** | 1.658 | 265.958 | 403.278 | 1955.284 | 243.278 | **7.352** | 1.500 |
| 144 | 8.582 | 242.830 | 407.304 | 1974.806 | 47.464 | 8.132 | 1.500 |
| 145 | 77.888 | 73.383 | 438.243 | 2124.812 | 5.627 | 28.955 | 1.500 |
| 146 | 82.795 | 56.964 | 441.114 | 2138.734 | 5.328 | 37.545 | 1.500 |
| 147 | -92.083 | 48.513 | 515.585 | 2499.803 | 5.599 | 51.528 | 1.500 |
| 148 | -92.083 | 48.513 | 515.585 | 2499.803 | 5.599 | 51.528 | 1.500 |
| 149 | -22.632 | -77.916 | 722.883 | 3504.887 | 31.942 | 44.983 | 1.500 |
| 150 | -15.708 | -101.043 | 726.910 | 3524.409 | 46.277 | 34.880 | 1.500 |
| 151 | -3.105 | 325.395 | 576.766 | 2796.440 | 185.769 | 8.594 | 1.500 |
| 152 | 3.819 | 302.267 | 580.792 | 2815.962 | 152.082 | 9.316 | 1.500 |
| 153 | 73.125 | 132.820 | 611.731 | 2965.968 | 8.366 | 22.331 | 1.500 |
| 154 | 78.033 | 116.401 | 614.603 | 2979.890 | 7.876 | 25.600 | 1.500 |
| 155 | -96.846 | 107.950 | 689.073 | 3340.959 | 7.115 | 30.949 | 1.500 |
| 156 | -96.846 | 107.950 | 689.073 | 3340.959 | 7.115 | 30.949 | 1.500 |

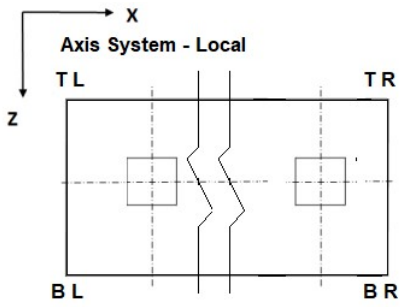
---

## Calculations of Footing Thickness

**Footing thickness is calculated based on the ultimate load cases**

## Ultimate Gross Pressures

The base pressures reported in this table include the effect of buoyancy (if any).




| Load Case / Load Combination ID | Pressure at top left corner (kN/m^2) | Pressure at top right corner (kN/m^2) | Pressure at bottom right corner (kN/m^2) | Pressure at bottom left corner (kN/m^2) | Factored Gross Bearing capacity for Ultimate Load Cases (kN/m^2) |
|---|---|---|---|---|---|
| 109 | 76.6526 | 62.7121 | 56.7420 | 70.6825 | 170.0000 |
| 110 | 79.7725 | 63.3697 | 56.7833 | 73.1861 | 170.0000 |
| 111 | 72.7376 | 59.3937 | 53.8173 | 67.1613 | 170.0000 |
| 112 | 69.5400 | 57.5863 | 52.4691 | 64.4228 | 170.0000 |
| 113 | 71.8505 | 88.7610 | 72.9791 | 56.0686 | 170.0000 |
| 114 | 67.8564 | 88.4479 | 78.0088 | 57.4174 | 170.0000 |
| 115 | 77.6189 | 30.3395 | 29.6258 | 76.9052 | 170.0000 |
| 116 | 73.6248 | 30.0264 | 34.6555 | 78.2540 | 170.0000 |

| | | | | | |
|---|---|---|---|---|---|
| 117 | 37.3792 | 20.7495 | 78.8593 | 95.4890 | 170.0000 |
| 118 | 34.5483 | 20.5319 | **82.4288** | **96.4453** | 170.0000 |
| 119 | **110.9270** | **98.2555** | 25.2058 | 37.8773 | 170.0000 |
| 120 | **110.9270** | **98.2555** | 25.2058 | 37.8773 | 170.0000 |
| 121 | 58.8711 | 49.8977 | 46.0598 | 55.0332 | 170.0000 |
| 122 | 57.9839 | 79.2650 | 65.2216 | 43.9405 | 170.0000 |
| 123 | 53.9899 | 78.9519 | 70.2513 | 45.2893 | 170.0000 |
| 124 | 63.7524 | 20.8435 | 21.8683 | 64.7771 | 170.0000 |
| 125 | 59.7583 | 20.5304 | 26.8980 | 66.1259 | 170.0000 |
| 126 | 23.5127 | 11.2536 | 71.1018 | 83.3610 | 170.0000 |
| 127 | 20.6818 | 11.0359 | 74.6713 | 84.3172 | 170.0000 |
| 128 | 97.0604 | 88.7595 | 17.4483 | 25.7492 | 170.0000 |

## Punching Shear Check

### For Column 1004

Critical Load case for Punching Shear Check : 115

Total Footing Depth, $D_o$ = 0.40 m

Calculated Effective Depth,d = 0.31 m

For rectangular column, $\beta$ = $\frac{B_{col}}{D_{col}}$ : 1.00

Considering the particular column as interior column, Slab Edge Factor $\alpha_s$ : 40.0

Effective depth, d, increased until 0.75*$V_c \geq$ Punching Shear Force

Punching Shear Force, Vu = 430.90kN

From ACI Cl.11.11.2, $b_o$ for column = 2.64 m

Equation 11-31, $V_{c1}$ = $0.17 \times \lambda \times \left(1 + \frac{2}{\beta}\right) \times b_0 \times d \times \sqrt{f_c'}$ = 1889.97 kN

Equation 11-32, $V_{c2}$ = $0.083 \times \lambda \times \left(\frac{a_s d}{b_o} + 2\right) \times b_0 \times d \times \sqrt{f_c'}$ = 2057.65 kN

Equation 11-33, $V_{c3}$ = $0.33 \times \lambda \times b_0 \times d \times \sqrt{f_c'}$ = 1222.92 kN

Punching shear strength,$V_c$= 0.75 x minimum of ($V_{c1}$,$V_{c2}$,$V_{c3}$) = 917.19 kN

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

### For Column 1005

Critical Load case for Punching Shear Check : 114

Total Footing Depth, $D_o$ = 0.40 m

Calculated Effective Depth,d = 0.31 m

For rectangular column, $\beta$ = $\frac{B_{col}}{D_{col}}$ : 1.00

Considering the particular column as interior column, Slab Edge Factor $\alpha_s$ : 40.0

Effective depth, d, increased until 0.75*$V_c \geq$ Punching Shear Force

Punching Shear Force, Vu = 437.79kN

From ACI Cl.11.11.2, $b_o$ for column = 2.74 m

Equation 11-31, $V_{c1}$ = $0.17 \times \lambda \times \left(1 + \frac{2}{\beta}\right) \times b_0 \times d \times \sqrt{f_c'}$ = 1961.66 kN

Equation 11-32, $V_{c2}$ = $0.083 \times \lambda \times \left(\frac{a_s d}{b_o} + 2\right) \times b_0 \times d \times \sqrt{f_c'}$ = 2080.99 kN

Equation 11-33, $V_{c3}$ = $0.33 \times \lambda \times b_0 \times d \times \sqrt{f_c'}$ = 1269.31 kN

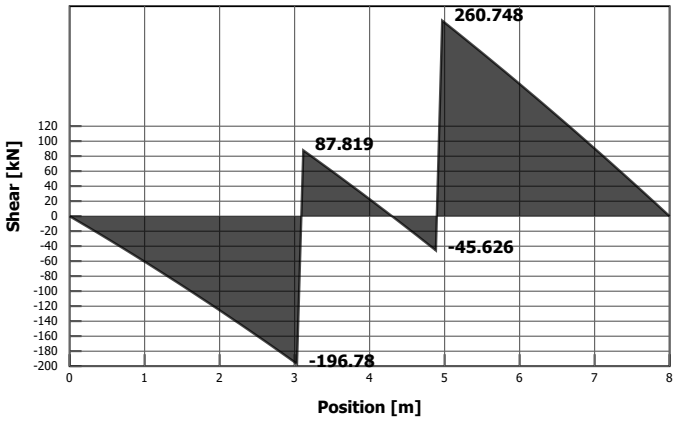
Punching shear strength,$V_c$= 0.75 x minimum of ($V_{c1}$,$V_{c2}$,$V_{c3}$) = 951.98 kN

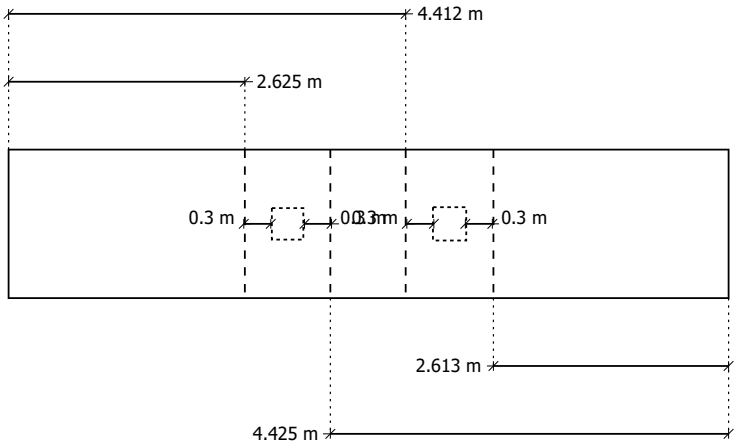
0.75 * $V_c$ > $V_u$ hence, OK

---

## One-Way Shear

### Shear Diagram



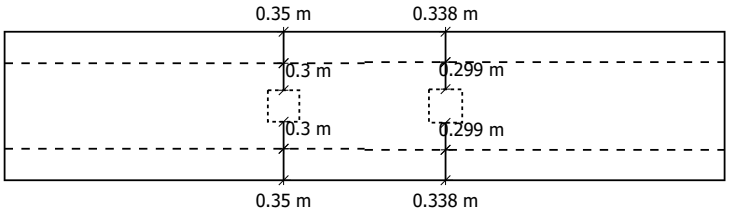




**Shear Plane Parallel to Foundation Width**

Critical load case for maximum shear force along the length of footing : 114

| | | | |
|---|---|---|---|
| Critical Shear force,$V_u$: | | = | 229.09 kN |
| Point of occurance of $V_u$: | | = | 5.39 m |
| From ACI Cl.11.2.1.1, $V_c$ : | $0.17 \times \lambda \times b_w \times d \times \sqrt{f_c'}$ | = | 384.14 kN |
| | | 0.75 x $V_c$ = | 288.11 kN |

Since 0.75 * $V_c$ > $V_u$ hence, OK




**Shear Plane Parallel to Foundation Length**

Critical load case for maximum shear force along the width of footing : 119

Critical Shear force,$V_u$: = 194.43 kN

Point of occurance of $V_u$: = 0.34 m

From ACI Cl.11.2.1.1, $V_c$ : $0.17 \times \lambda \times b_w \times d \times \sqrt{f_c'}$ = 1862.50 kN

0.75 x $V_c$ = 1396.88 kN

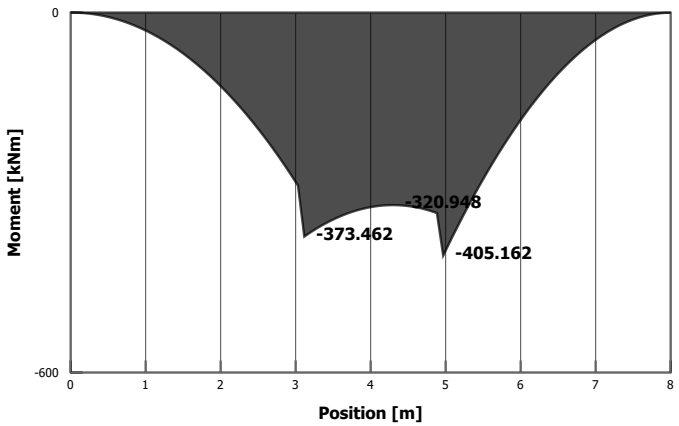
Since 0.75 * $V_c$ > $V_u$ hence, OK

---

## Design for Flexure

### Design of flexure

### Moment Diagram




### Bottom Reinforcement

Critical load case : 114

Required Effective Depth : 0.30 m

$\beta_1$ , from ACI Cl.10.2.7.3 = $\begin{cases} 0.85, & f_c' \le 28\ Mpa \\ \max\left[0.65, 0.85 - \frac{0.05}{7}(f_c' - 28\ Mpa)\right], & f_c' > 28\ Mpa \end{cases}$ = 0.8500

From Appendix B 8.4.2, $\rho_{bal}$ = $\frac{0.85 \times \beta_1 \times f_c'}{f_y} \times \left(\frac{600}{600 + f_y}\right)$ = 0.04829

From Appendix B 10.3.3, $\rho_{max}$ = $0.75 \times \rho_{bal}$ = 0.03622

From ACI Cl. 7.12.2, $\rho_{min}$ = $\begin{cases} 0.0020, & \text{Grade 280, 350 deformed bars} \\ 0.0018, & \text{Grade 420, welded wire reinforcement} \\ \dfrac{0.0018 \times 420\ Mpa}{f_y}, & \text{yield stress exceeds 420 } Mpa \text{ @ yield strain 0.35\%} \end{cases}$ = 0.00200

Modular Ratio,m = $\frac{f_y}{0.85 \times f_c'}$ = 12.8001

| | | |
|---|---|---|
| Ultimate Moment (Mz) : | 374.68 | kNm |
| Point of occurrence of the ultimate moment along the length of footing : | 5.09 | m |
| Nominal Moment Capacity : | 416.32 | kNm |
| Required $\rho$ (based on effective depth) : | 0.0135 | |
| $\rho$ x d / Depth (based on gross depth) : | 0.0102 | |
| Area of main steel required, $A_s = \rho \times W \times d$ : | 6727.06 | mm2 |

Note - "Area of Steel required" reported here is the larger value between the calculated area of steel and minimum steel required as per code stipulations

## Top Reinforcement

| | |
|---|---|
| Critical load case : | 124 |
| Required Effective Depth : | 0.31 m |

$\beta_1$ , from ACI Cl.10.2.7.3 = $\begin{cases} 0.85, & f_c' \le 28\ Mpa \\ \max\left[0.65, 0.85 - \dfrac{0.05}{7}(f_c' - 28\ Mpa)\right], & f_c' > 28\ Mpa \end{cases}$ = 0.8500

From Appendix B 8.4.2, $\rho_{bal}$ = $\frac{0.85 \times \beta_1 \times f_c'}{f_y} \times \left(\frac{600}{600 + f_y}\right)$ = 0.04829

From Appendix B 10.3.3, $\rho_{max}$ = $0.75 \times \rho_{bal}$ = 0.03622

From ACI Cl. 7.12.2, $\rho_{min}$ = $\begin{cases} 0.0020, & \text{Grade 280, 350 deformed bars} \\ 0.0018, & \text{Grade 420, welded wire reinforcement} \\ \dfrac{0.0018 \times 420\ Mpa}{f_y}, & \text{yield stress exceeds 420 } Mpa \text{ @ yield strain 0.35\%} \end{cases}$ = 0.00200

Modular Ratio,m $\frac{f_y}{0.85 \times f_c'}$ = = 12.8001

| | | |
|---|---|---|
| Ultimate Moment (Mz) : | 7.86 | kNm |
| Point of occurrence of the ultimate moment along the length of footing : | 5.81 | m |
| Nominal Moment Capacity : | 8.73 | kNm |
| Required $\rho$ (based on effective depth): | 0.0026 | |
| $\rho$ x d / Depth (based on gross depth) : | 0.0020 | |
| Area of main steel required, $A_s = \rho \times W \times d$ : | 1320.00 | mm2 |

Note - "Area of Steel required" reported here is the larger value between the calculated area of steel and minimum steel required as per code stipulation.

## Distribution Reinforcement

| | | |
|---|---|---|
| Critical load case : | 119 | |
| Critical Moment for distribution steel (Mx) : | 114.5666 | kNm |
| Nominal moment Capacity : | 127.2963 | kNm |
| Point of occurance of the critical moment along length: | 1.0125 | m |
| Required $\rho$ (based on effective depth): | 0.0027 | |

| | |
|---|---|
| $\rho$ x d / Depth (based on gross depth) : | 0.0102 |
| Area of distribution steel required, $A_s = \rho \times W \times d$ : | 6400.00 mm2 |
| Note - "Area of Steel required" reported here is the larger value between the calculated area of steel and minimum steel required as per code stipulations | |

Top surface disribution reinforcement

| | |
|---|---|
| Moment at column face : | 45.3727 kNm |
| Provided Area for distribution steel along Z(Top reinforcement): | 6400.00 mm2 |

Provided Reinforcement

Main bar no. for top Reinforcement: #10

Spacing of top reinforcement bar : 83.33 mm

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

**#10 @ 80mm o.c.**

Main bar no. for bottom Reinforcement: #19

Spacing of bottom reinforcement bar : 65.22 mm

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

**#19 @ 65mm o.c.**

Distribution bar no. (Bottom): #10

Spacing of distribution bars (Bottom): 87.22 mm

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

**#10 @ 85mm o.c.**

Distribution bar no.(Top): #10

Spacing of distribution bars(Top) : 87.12 mm

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

**#10 @ 85mm o.c.**

## Material Take Off

### Footing Reinforcement

| Direction | Size | Number | Total Length (m) | Weight (kg) |
|---|---|---|---|---|
| Along X on Bottom | 10 mm | 24 | 188.40 | 421.12 |
| Along Z on Bottom | 19 mm | 91 | 136.50 | 76.38 |
| Along X on Top | 10 mm | 19 | 149.15 | 83.46 |
| Along Z on Top | 10 mm | 91 | 136.50 | 76.38 |

Total Reinforcement Weight : 657.33 kg

### Concrete

| - | Length (m) | Width (m) | Thickness (m) | Volume ($m^3$) |
|---|---|---|---|---|
| Footing | 8.00 | 1.65 | 0.40 | 5.28 |

Total Concrete Volume : 5.28 $m^3$

### Formwork

Footing : 7.72 $m^2$

Total : 7.72 $m^2$

### Soil Excavation

| | | | |
|---|---|---|---|
| Pit Depth | : | 1.25 | m |
| Pit Slope (a : b) | : | 1 : 1 | (Assumed) |
| Side Distance, s | : | 0 | (Assumed) |
| Excavation Volume | : | 33.65 | $m^3$ |
| Backfill Volume | : | 28.37 | $m^3$ |

---