# CAP DESIGN

## CAP DESIGN

Code: AASHTO STANDARD (17th Edition 2002) - Ultimate Strength Design

Units: US

Pier View: Upstation.

## DESIGN PARAMETERS

f'c = 3500.0 psi

| | |
|---|---|
| Fy flex = 60000.0 psi | Fy shear = 60000.0 psi |
| phi flex = 0.90 | phi shear = 0.85 |
| Ec = 3586.6 ksi | Es = 29000.0 ksi |

crack control factor z = 170.00 kips / in

Concrete Type : Normal Weight.

Design of cap at face of column.

## CAP GEOMETRY

Variable Cap : Length(X) = 35.25 ft Depth(Z) = 72.00 in

## Cap Section Properties

| Sec. | Area ft ^2 | Ixx in ^4 | Izz in ^4 |
|---|---|---|---|
| 1 | 24.00 | 1492992.00 | 663552.00 |
| 2 | 60.00 | 3732480.00 | 10368000.00 |
| 3 | 60.00 | 3732480.00 | 10368000.00 |
| 4 | 24.00 | 1492992.00 | 663552.00 |

## MAIN REINFORCEMENT

| | Bar size | Quantity | Bar dist. in | As total in^2 | From ft | To ft | Hook |
|---|---|---|---|---|---|---|---|
| TOP | | | | | | | |
| | # 11 | 17 | 3.33 | 26.520 | 0.00 | 35.25 | Both |
| | # 11 | 17 | 7.00 | 26.520 | 0.00 | 35.25 | Both |
| BOTTOM | | | | | | | |
| | # 6 | 4 | 3.33 | 1.760 | 0.00 | 18.11 | Left |
| | # 6 | 4 | 3.33 | 1.760 | 12.83 | 26.92 | None |
| | # 6 | 4 | 3.33 | 1.760 | 21.64 | 35.25 | Right |

## STIRRUPS

| From ft | To ft | Stirrup Size | n legs | Spacing in | Aprv/s in^2 / ft |
|---|---|---|---|---|---|

| From ft | To ft | Stirrup Size | n legs | Spacing in | Aprv/s in^2 / ft |
|---|---|---|---|---|---|
| 0.00 | 10.62 | # 5 | 4 | 18.00 | 9.92 |
| 10.62 | 16.63 | # 5 | 4 | 6.00 | 29.76 |
| 16.63 | 24.63 | # 5 | 4 | 24.00 | 7.44 |
| 24.63 | 35.25 | # 5 | 4 | 18.00 | 9.92 |

Clear Cover on Sides = 2.00 in

## FLEXURE DESIGN

### Span 1: From 0.00 ft To 12.62 ft

| Loc ft | AbsLoc ft | H in | Mmax Mmin kips-ft | pMn kips-ft | Comb | Asb-req in^2 | Asb-prv in^2 | Asb-eff in^2 | Ast-req in^2 | Ast-prv in^2 | Ast-eff in^2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.6 | 3.6 | 80 | 0.0 | 768.5 | 0 | 0.00 | 1.76 | 1.76 | 0.00 | 53.04 | 53.04 |
| | | | -76.5 | -16192.4 | 696 | 0.00 | 1.76 | 1.76 | 0.30 | 53.04 | 53.04 |

### Span 2: From 12.62 ft To 35.25 ft

| Loc ft | AbsLoc ft | H in | Mmax Mmin kips-ft | pMn kips-ft | Comb | Asb-req in^2 | Asb-prv in^2 | Asb-eff in^2 | Ast-req in^2 | Ast-prv in^2 | Ast-eff in^2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.5 | 17.1 | 120 | 0.0 | 1665.8 | 0 | 0.00 | 3.52 | 2.92 | 0.00 | 53.04 | 53.04 |
| | | | -14729.0 | -25784.4 | 683 | 0.00 | 3.52 | 3.13 | 29.57 | 53.04 | 53.04 |
| 5.0 | 17.6 | 120 | 0.0 | 1368.1 | 0 | 0.00 | 3.52 | 2.32 | 0.00 | 53.04 | 53.04 |
| | | | -13740.2 | -25752.1 | 683 | 0.00 | 3.52 | 2.43 | 27.51 | 53.04 | 53.04 |
| 12.0 | 24.6 | 91 | 0.0 | 1516.5 | 0 | 0.00 | 3.52 | 3.52 | 0.00 | 53.04 | 53.04 |
| | | | -4475.0 | -18981.9 | 683 | 0.00 | 3.52 | 3.52 | 15.73 | 53.04 | 53.04 |
| 19.0 | 31.6 | 63 | 0.0 | 631.9 | 0 | 0.00 | 1.76 | 1.76 | 0.00 | 53.04 | 53.04 |
| | | | -71.2 | -12075.2 | 691 | 0.00 | 1.76 | 1.76 | 0.37 | 53.04 | 53.04 |

## SHEAR AND TORSION DESIGN

### Span 1: From 0.00 ft To 12.62 ft

| Loc ft | AbsLoc ft | Pos | Vu kips | Comb | Tu kips-ft | Comb | phi*Vc kips | T-lim kips-ft | Avs/s in^2/ft | 2Ats/s in^2/ft | Av/s in^2/ft | Aprv/s in^2/ft | Alt in^2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3.62 | 3.62 | L | 22.6 | 671 | 0.0 | 0 | 542.5 | 458.0 | 0.00 | 0.00 | 0.00 | 9.92 | 0.00 |
| | | R | 611.4 | 682 | 59.9 | 1132 | 542.5 | 458.0 | 0.72 | 0.00 | 0.72 | 9.92 | 0.00 |

**Span 2: From 12.62 ft To 35.25 ft**

| Loc ft | AbsLoc ft | Pos | Vu kips | Comb | Tu kips-ft | Comb | phi*Vc kips | T-lim kips-ft | Avs/s in^2/ft | 2Ats/s in^2/ft | Av/s in^2/ft | Aprv/s in^2/ft | Alt in^2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.50 | 17.12 | R | 1980.4 | 688 | 357.2 | 1138 | 831.6 | 814.6 | 2.35 | 0.00 | 2.35 | 7.44 | 0.00 |
| 5.00 | 17.63 | L | 1974.6 | 688 | 357.2 | 1138 | 831.6 | 814.6 | 2.34 | 0.00 | 2.34 | 7.44 | 0.00 |
| | | R | 1360.6 | 688 | 123.3 | 1138 | 831.6 | 814.6 | 1.08 | 0.00 | 1.08 | 7.44 | 0.00 |
| 12.00 | 24.62 | L | 1288.5 | 688 | 123.3 | 1138 | 624.6 | 555.5 | 1.81 | 0.00 | 1.81 | 7.44 | 0.00 |
| | | R | 660.5 | 688 | 59.9 | 1138 | 624.6 | 555.5 | 0.72 | 0.00 | 0.72 | 7.44 | 0.00 |
| 19.00 | 31.62 | L | 607.9 | 688 | 59.9 | 1138 | 417.6 | 318.0 | 0.78 | 0.00 | 0.78 | 9.92 | 0.00 |
| | | R | 19.6 | 671 | 0.0 | 0 | 417.6 | 318.0 | 0.00 | 0.00 | 0.00 | 9.92 | 0.00 |

**Shear and Torsion Design : Notes**

- Pos is the design position. L suggests the calculation is done at immediate left of "Loc" and R suggests at immediate right of it.
- T-lim is the limiting value of torsion for the concrete section. If actual torsion is higher than this value, torsional steel has to be provided.
- Avs/s is the required area of steel per unit length for shear force.
- 2Ats/s is the required area of steel per unit length for two legs of torsional reinforcement.
- Av/s is the total required area of steel per unit length due to shear plus torsion.
- Aprvs/s is the total provided area of steel per unit length due to shear (stirrups).
- Alt is the total longitudinal steel required due to torsion in addition to the REQUIRED flexural steel.

## CRACKING/FATIGUE CHECK

**Span 1: From 0.00 ft To 12.62 ft**

| Loc ft | AbsLoc ft | H in | Cracking fs-t fs-b ksi | Cracking ratio fs-t ratio fs-b | Cracking Comb | Fatigue fs-t fs-b ksi | Fatigue ratio fs-t ratio fs-b |
|---|---|---|---|---|---|---|---|
| 3.62 | 3.6 | 80.1 | 0.2 | 0.01 | 26 | 0.0 | 0.00 |
| | | | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

**Span 2: From 12.62 ft To 35.25 ft**

| Loc ft | AbsLoc ft | H in | Cracking fs-t fs-b ksi | Cracking ratio fs-t ratio fs-b | Cracking Comb | Fatigue fs-t fs-b ksi | Fatigue ratio fs-t ratio fs-b |
|---|---|---|---|---|---|---|---|
| 4.50 | 17.1 | 120.0 | 23.7 | 0.66 | 13 | 4.1 | 0.22 |
| | | | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| 5.00 | 17.6 | 120.0 | 22.1 | 0.61 | 13 | 3.8 | 0.20 |
| | | | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

| Loc ft | AbsLoc ft | H in | Cracking fs-t fs-b ksi | Cracking ratio fs-t ratio fs-b | Cracking Comb | Fatigue fs-t fs-b ksi | Fatigue ratio fs-t ratio fs-b |
|---|---|---|---|---|---|---|---|
| 12.00 | 24.6 | 91.4 | 9.7 | 0.27 | 13 | 1.6 | 0.07 |
| | | | 0.0 | 0.00 | 0 | 0.0 | 0.00 |
| 19.00 | 31.6 | 62.8 | 0.2 | 0.01 | 21 | 0.0 | 0.00 |
| | | | 0.0 | 0.00 | 0 | 0.0 | 0.00 |

* Cracking / fatigue checking failed.

# Column Design

## COLUMN DESIGN - Column: 1

Code: AASHTO STANDARD (17th Edition 2002) - Factored Load Design

Units: US

Pier View: Upstation.

Design/Analysis Method: Moment Magnification - Unbraced Column.

## Column Type: Rectangular 108.00 x 72.00 in

## Column Section Properties

| Sec. | Area ft^2 | Ixx in^4 | Izz in^4 |
|---|---|---|---|
| 1 | 54.00 | 3359232.00 | 7558272.00 |

## DESIGN PARAMETERS

| | |
|---|---|
| f'c = 3500.0 psi | fy = 60000.0 psi |
| phi flex = 0.90 | phi axial = 0.70 |
| Ec = 3586.6 ksi | Es = 29000 ksi |

Concrete Type : Normal Weight.

## Reinforcement

Rebar Pattern: Rectangular

Rebar Orientation: Face Parallel

## Reinforcement Schedule

| Layer | Dir | Size | No. bars | Bar Dist. in |
|---|---|---|---|---|
| 1 | X | 11 | 25 | 3.20 |
| 1 | Z | 11 | 16 | 3.20 |

## Reinforcement summary

Main bars summary:

| | |
|---|---|
| | 78 # 11 bars |
| Total number of bars in the column: 78 | |
| Ties size: # 3 | |

## Moment Magnification calculation - Mx (global)

| Loc ft | Comb | K | Cm | Beta | Delta B | Delta S | pPc kips |
|---|---|---|---|---|---|---|---|
| 50.00 | 25C | 3.4219 | 1.0000 | 0.7649 | ---- | 3.2110 | 4856.03 |
| 98.00 | 25C | 3.4219 | 1.0000 | 0.7311 | ---- | 2.4407 | 4951.07 |

## Moment Magnification calculation - Mz (global)

| Loc ft | Comb | K | Cm | Beta | Delta B | Delta S | pPc kips |
|---|---|---|---|---|---|---|---|
| 50.00 | 25C | 3.4219 | 1.0000 | 0.5460 | ---- | 1.3662 | 12473.70 |
| 98.00 | 25C | 3.4219 | 1.0000 | 0.5460 | ---- | 1.3060 | 12473.70 |

## Design values used after Moment Magnification ( e-min effect included ).

| Loc ft | Comb | Fx kips | Fy kips | Fz kips | Mx kips-ft | My kips-ft | Mz kips-ft |
|---|---|---|---|---|---|---|---|
| 50.00 | 25C | -0.0 | 3343.7 | 0.0 | -2469.4 | -0.0 | 25995.9 |
| 98.00 | 25C | -0.0 | 2922.5 | 0.0 | 1640.6 | -0.0 | -24849.5 |

## COLUMN DESIGN

| Bot/Top Elev. ft | Comb | Pu kips | Mux kips-ft | Muz kips-ft | pMn kips-ft | Incl deg | pPn/Pu | pMn/Mu |
|---|---|---|---|---|---|---|---|---|
| 50.00 | 25C | 3343.7 | 2469.4 | 25995.9 | 27372.1 | 84.57 | 1.00 | 1.04822 |
| 98.00 | 25C | 2922.5 | 1640.6 | 24849.5 | 26820.4 | 86.22 | 1.00 | 1.07697 |

## COLUMN DESIGN

| Bot/Top Elev. ft | Comb | As_min in^2 | As_max in^2 | As_req in^2 |
|---|---|---|---|---|
| 50.00 | 25C | 77.76 | 622.08 | 121.68 |
| 98.00 | 25C | 77.76 | 622.08 | 121.68 |

## K values for all columns used in unbraced moment magnification

| Column | Kx | Kz |
|---|---|---|
| 1 | 3.42 | 3.42 |

## Column Design : Notes

Min reinforcement = 1.0000 % of Ag = 77.76 in^2.

For layer 1, direction X: Minimum bar distance is: 1.41 in. Effective bar distance is: 2.82 in.

For layer 1, direction Z: Minimum bar distance is: 1.41 in. Effective bar distance is: 2.96 in.

---- Values do not exist at that location as computation is done at the top and bottom of clear length of column.

# ISOLATED FOOTING DESIGN

## ISOLATED FOOTING DESIGN

Code: AASHTO STANDARD (17th Edition 2002) - Ultimate Strength Design
Units: US
Pier View: Upstation.

## GEOMETRY

Name : FTG08
Shape : Rectangular, Type : Spread
Bf(X) = 24.00 ft, Hf(Z) = 24.00 ft, Thickness(Y) = 66.00 in
Ag = 576.00 ft^2, Ix = 27648.00 ft^4, Iz = 27648.00 ft^4
Footing eccentric: Start at X = -9.00 ft from centerline of column.
Footing eccentric: Start at Z = -12.00 ft from centerline of column.
Columns located on the footing:
Column No. 1 at x = 0.00 ft, Rectangular 108.00 in x 72.00 in
Surcharge = 0.30 ksf

## DESIGN PARAMETERS

| | |
|---|---|
| f'c = 3500.00 psi | fy = 60000.00 psi |
| phi flex = 0.90 | phi shear = 0.85 |
| Ec = 3586.6 ksi | Es = 29000.0 ksi |
| Crack control factor z = 130.00 kips/in | |
| Concrete Type : Normal Weight. | |

## Max Soil Pressures, Service (Without the reduction of overstress allowance)

| Corner | X ft | Z ft | comb | Ovs | P kips | Mxx kft | Mzz kft | Soil press. ksf |
|---|---|---|---|---|---|---|---|---|
| 1 | 15.00 | -12.00 | 448 | 1.400 | -2198.67 | -3786.38 | -12334.55 | 9.08 |
| | | | 253 | 1.400 | -1967.47 | 3670.93 | -4384.90 | 2.29 |
| 2 | -9.00 | -12.00 | 266 | 1.400 | -2066.17 | -2556.63 | -3565.06 | 6.96 |
| | | | 251 | 1.400 | -1868.77 | 2556.48 | -12416.71 | 0.30 |
| 3 | -9.00 | 12.00 | 261 | 1.400 | -2066.17 | 2556.47 | -3565.06 | 6.96 |
| | | | 256 | 1.400 | -1868.77 | -2556.62 | -12416.71 | 0.30 |
| 4 | 15.00 | 12.00 | 583 | 1.400 | -2198.67 | 3042.32 | -12432.21 | 8.80 |
| | | | 266 | 1.400 | -2066.17 | -2556.63 | -3565.06 | 2.46 |

## Max Soil Pressures, Factored

| Corner | X ft | Z ft | comb | Ovs | P kips | Mxx kft | Mzz kft | Soil press. ksf |
|---|---|---|---|---|---|---|---|---|
| 1 | 15.000 | -12.000 | 1118 | --- | -2748.34 | -4732.98 | -15418.19 | 11.35 |
| | | | 923 | --- | -2459.34 | 4588.66 | -5481.12 | 2.86 |
| 2 | -9.000 | -12.000 | 936 | --- | -2582.71 | -3195.78 | -4456.33 | 8.71 |

| Corner | X ft | Z ft | comb | Ovs | P kips | Mxx kft | Mzz kft | Soil press. ksf |
|---|---|---|---|---|---|---|---|---|
| | | | 921 | --- | -2335.96 | 3195.60 | -15520.89 | 0.38 |
| 3 | -9.000 | 12.000 | 931 | --- | -2582.71 | 3195.59 | -4456.33 | 8.71 |
| | | | 926 | --- | -2335.96 | -3195.77 | -15520.89 | 0.38 |
| 4 | 15.000 | 12.000 | 1253 | --- | -2748.34 | 3802.89 | -15540.26 | 10.99 |
| | | | 936 | --- | -2582.71 | -3195.78 | -4456.33 | 3.07 |

## Max Soil Pressures, Service (After the reduction of overstress allowance)

| Corner | X ft | Z ft | comb | Ovs | P kips | Mxx kft | Mzz kft | Soil press. ksf |
|---|---|---|---|---|---|---|---|---|
| 1 | 15.00 | -12.00 | 8 | 1.000 | -2198.67 | -52.08 | -10532.14 | 6.67 |
| | | | 253 | 1.400 | -1967.47 | 3670.93 | -4384.90 | 1.63 |
| 2 | -9.00 | -12.00 | 266 | 1.400 | -2066.17 | -2556.63 | -3565.06 | 4.97 |
| | | | 251 | 1.400 | -1868.77 | 2556.48 | -12416.71 | 0.22 |
| 3 | -9.00 | 12.00 | 261 | 1.400 | -2066.17 | 2556.47 | -3565.06 | 4.97 |
| | | | 256 | 1.400 | -1868.77 | -2556.62 | -12416.71 | 0.22 |
| 4 | 15.00 | 12.00 | 3 | 1.000 | -2198.67 | 51.92 | -10532.14 | 6.67 |
| | | | 266 | 1.400 | -2066.17 | -2556.63 | -3565.06 | 1.76 |

## Footing Design : Notes

Only max. positive pressure is considered for design.

## Max. Soil Pressure Used in Design: (without selfweight and surcharge)

| | |
|---|---|
| Factored soil pressure | 9.94 ksf |
| Service soil pressure | 8.27 ksf |
| Fatigue soil pressure | 1.23 ksf |

## Reinforcement Schedule

| Dir | Quantity | Size | Bar dist. in | As total in^2 | Spacing in | Hook |
|---|---|---|---|---|---|---|
| X | 48 | # 11 | 3.63 | 74.88 | 5.97 | None |
| Z | 48 | # 11 | 5.14 | 74.88 | 5.97 | None |

## Flexure

| Dir ft | Loc | d in | Mmax kft | Comb | Asb_req in^2 | Asb_prv in^2 | Asb_eff in^2 | Ast_req in^2 | Ast_prv in^2 | Ast_eff in^2 |
|---|---|---|---|---|---|---|---|---|---|---|
| X | -4.50 | 62.37 | 2415.2 | 1118 | 11.52 | 74.88 | 63.89 | 0.00 | 0.00 | 0.00 |
| X | 4.50 | 62.37 | 13149.3 | 1118 | 53.16 | 74.88 | 74.88 | 0.00 | 0.00 | 0.00 |

| Dir ft | Loc | d in | Mmax kft | Comb | Asb_req in^2 | Asb_prv in^2 | Asb_eff in^2 | Ast_req in^2 | Ast_prv in^2 | Ast_eff in^2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Z | -3.00 | 60.86 | 9660.7 | 1118 | 48.25 | 74.88 | 74.88 | 0.00 | 0.00 | 0.00 |
| Z | 3.00 | 60.86 | 9660.7 | 1118 | 48.25 | 74.88 | 74.88 | 0.00 | 0.00 | 0.00 |

## Cracking/Fatigue

| Dir | Loc ft | d in | Cracking Mmax kft | Cracking Comb | Cracking fs ksi | Cracking ratio fs | Fatigue Mmax kft | Fatigue Comb | Fatigue fs ksi | Fatigue ratio fs |
|---|---|---|---|---|---|---|---|---|---|---|
| X | -4.50 | 62.37 | 2010.3 | 448 | 6.52 | 0.22 | 297.9 | 8 | 0.97 | 0.04 |
| X | 4.50 | 62.37 | 10944.7 | 448 | 30.44 | 1.04 * | 1621.9 | 8 | 4.51 | 0.24 |
| Z | -3.00 | 60.86 | 8041.0 | 448 | 22.93 | 0.78 | 1191.6 | 8 | 3.40 | 0.17 |
| Z | 3.00 | 60.86 | 8041.0 | 448 | 22.93 | 0.78 | 1191.6 | 8 | 3.40 | 0.17 |

## Cracking/Fatigue Note

* Cracking / fatigue ratio exceeds allowable.

## One Way Shear

| Col | Dir | Dist ft | Comb | d in | Vu kips | phi*Vc kips |
|---|---|---|---|---|---|---|
| 1 | X | -9.70 | Outside of Footing | --- | --- | --- |
| | X | 9.70 | 1118 | 62.37 | 1264.9 | 1806.4 |
| | Z | -8.07 | 1118 | 60.86 | 937.0 | 1763.0 |
| | Z | 8.07 | 1118 | 60.86 | 937.0 | 1763.0 |

## Two Way Shear

| # | Bo ft | Ao ft^2 | Comb | Avg. d in | Vu kips | phi*Vc kips |
|---|---|---|---|---|---|---|
| Columns | | | | | | |
| 1 | 50.54 | 157.38 | 1118 | 61.61 | 4160.6 | 7516.3 |

## Two Way Shear Note

TWO WAY SHEAR IN FOOTING IS NOT DESIGNED AND STIRRUPS ARE NOT CONSIDERED.