SPREAD FOOTING DESIGN

Number of load cases = $n := 5$ $n1 := 0..n-1$ $As := 1$

Max soil pressure (ksf) = $qmax := 10$

Strength of materials (psi) = $fc := 3$ $fy := 60$

Max cover for bars on bottom of ftg = $cover := 3$

Bar ddiameter for Preliminary calculations (in) = $bd := 1.0$ $stirrupd := bd$ $dcolbar := bd$

Max column dimension (in) = $columnd := 36$

Bend radius (in) = $bendrad := 1$

Unit weight of concrete (kcf) = $\lambda c := 0.150$

Long. column dimension (ft) = $DL := 3$

Trans. column dimension (ft) = $DT := 3$

Is column round or square (1 for round 2 for square) $type := 2$

Applied loads (k*ft) =

SL := READPRN("sl_foot.prn") LD := READPRN("ld_foot.prn")

Service LD

$$SL = \begin{pmatrix} 983.5 & 1372 & 2505 \\ 1070 & 879.5 & 2928 \\ 925.9 & 538.6 & 1802 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

Load factor

$$LD = \begin{pmatrix} 1415 & 1165 & 3942 \\ 1300 & 932.7 & 3041 \\ 910.6 & 1579 & 537.9 \\ 1043 & 161.1 & 0 \\ 1300 & 1702 & 3331 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

$P2 := LD^{\langle 0 \rangle}$ $P := SL^{\langle 0 \rangle}$

$MT2 := LD^{\langle 1 \rangle}$ $MT := SL^{\langle 1 \rangle}$

$ML2 := LD^{\langle 2 \rangle}$ $ML := SL^{\langle 2 \rangle}$

PRELIMINARY CALCUALTIONS

Approximate footing dimensions

Length and width: T is along the CL. of bent. First estimate using the max applied "P" load and divide it by the max allowable bearing pressure, and take the square root of it and add one.

$$LTfirst := \mathrm{floor}\left(\sqrt{\frac{\max\left(LD^{\langle 0 \rangle}\right)}{qmax}}\right) + 1 \qquad LTfirst = 12$$

Footing Length and Width to Use

$L := 15.5$ ft

$T := 15.5$ ft

If the user dissagrees with the initial guess, the values may be changed here. Also shown on the next page are the required values to satisfy the SL stresses.

Depth: The minimum depth shall be the larger of the (development length + 2*bd*cover) and the minimum embedment length

Development length (in) = $develop := 38 \cdot \frac{bd}{\sqrt{fc}} + 2 \cdot bd + cover \qquad develop = 26.939$

Embedment (in) = $embed := \frac{columnd}{2} + \frac{stirrupd}{2} + 4 \cdot bendrad + dcolbar + 2 + 3 \qquad embed = 28.5$

Minimum Depth (ft) = $depthfirst := \max\left(\begin{pmatrix} develop \\ embed \end{pmatrix}\right) \cdot \frac{1}{12} \qquad depthfirst = 2.375$

Footing Depth to use (ft) = $D := 4.0$

If the user dissagrees with the initial guess, the values may be changed here.

Additional P load due to footing

$Pa(T, L) := L \cdot T \cdot D \cdot \lambda c \qquad Pa(T, L) = 144.15$

$fa := 1$

$Pa2 := L \cdot T \cdot D \cdot \lambda c \cdot 1.25 \qquad Pa2 = 180.188$

Constants

$T = 15.5$ ft $L = 15.5$ ft $D = 4$ ft

Footing Area (ft^2) = $A(T,L) := T \cdot L$ $A(T,L) = 240.25$

Inertia in the transverse direction (ft^4) = $IT(T,L) := \frac{T \cdot L^3}{12}$ $IT(T,L) = 4810.005$

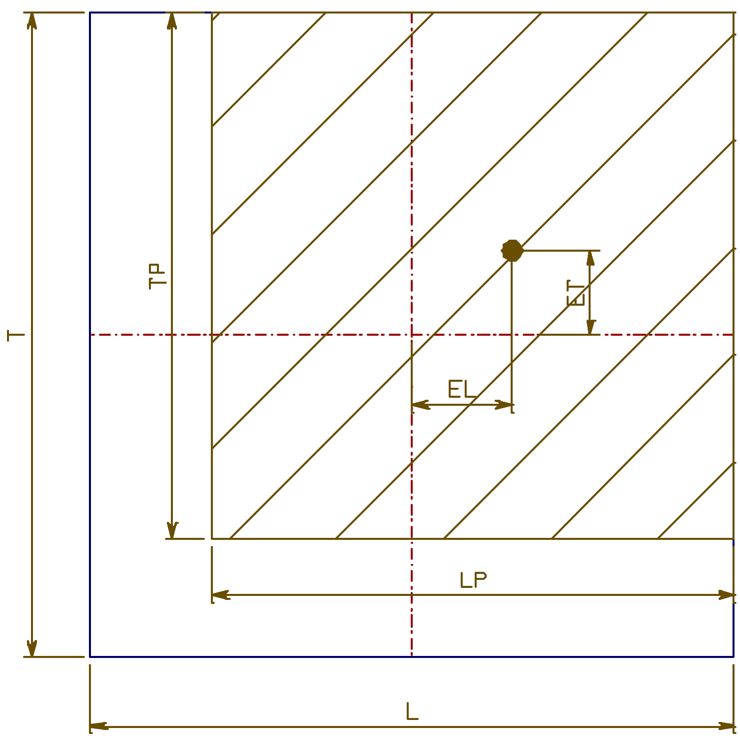
Distance from center to outer edge (ft) =
Transverse direction $CT(T) := \frac{T}{2}$ $CT(T) = 7.75$

Inertia in the longitudinal direction (ft^4) = $IL(T,L) := \frac{L \cdot T^3}{12}$ $IL(T,L) = 4810.005$

Distance form center to outer edge (ft) =
Longitudinal direction $CL(L) := \frac{L}{2}$ $CL(L) = 7.75$

Eccentricity about transvese axis (ft) = $et_{n1} := \frac{MT2_{n1}}{P2_{n1}}$

Eccentricity about the Longitudinal axis (ft) = $el_{n1} := \frac{ML2_{n1}}{P2_{n1}}$



$Tp_{n1} := T - et_{n1}$

$Lp_{n1} := L - el_{n1}$

$Ap_{n1} := Tp_{n1} \cdot Lp_{n1}$

$$Ap = \begin{pmatrix} 186.601 \\ 194.55 \\ 205.241 \\ 237.856 \\ 183.596 \end{pmatrix}$$

$T \cdot L = 240.25$

Soil Pressures based on the Soil Method

The soil method assumes that the bearing pressure on the soil is more or less evenly distributed over the affected area.

$$qs_{n1} := \frac{P2_{n1} + Pa2}{Ap_{n1}} \qquad qs = \begin{pmatrix} 8.549 \\ 7.608 \\ 5.315 \\ 5.143 \\ 8.062 \end{pmatrix}$$

Since most of our footings are on rock I shall use the presumptive method of 10.6.2.3.1. This allows for the use of a value of "q" and the Service Loads. The presumptive method is also allowed in 10.5.2.

Check Eccentricity

The eccentricity should be within 3/8 for service loads and 1/4 for factored loads of the corresponding footing dimension.

Transverse

$$T \cdot \frac{3}{8} = 5.813 \qquad et1_{n1} := \frac{MT_{n1}}{P_{n1}} \qquad et1 = \begin{pmatrix} 1.395 \\ 0.822 \\ 0.582 \\ 0 \\ 0 \end{pmatrix}$$

$$\left| \begin{array}{ll} \text{"OK"} & \text{if } et1_{n1} < T \cdot \frac{3}{8} \\ \text{"NG"} & \text{otherwise} \end{array} \right. = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

Longitudinal

$$L \cdot \frac{3}{8} = 5.813 \qquad el1_{n1} := \frac{ML_{n1}}{P_{n1}} \qquad el1 = \begin{pmatrix} 2.547 \\ 2.736 \\ 1.946 \\ 0 \\ 0 \end{pmatrix}$$

$$\left| \begin{array}{ll} \text{"OK"} & \text{if } el_{n1} < L \cdot \frac{3}{8} \\ \text{"NG"} & \text{otherwise} \end{array} \right. = \begin{pmatrix} \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \\ \text{"OK"} \end{pmatrix}$$

Corner stresses on the soil

If any stress is greater than the max, increast the L and/or T dimensions. If any stress is less than 0, see SMO 37.

Service Load stresses

$$\sigma max(T,L) := \frac{P + \frac{Pa(T,L)}{fa}}{A(T,L)} + \frac{ML \cdot CL(L)}{IL(T,L)} + \frac{MT \cdot CT(T)}{IT(T,L)}$$

$$\sigma min(T,L) := \frac{P + \frac{Pa(T,L)}{fa}}{A(T,L)} - \frac{ML \cdot CL(L)}{IL(T,L)} - \frac{MT \cdot CT(T)}{IT(T,L)}$$

$$\sigma nML(T,L) := \frac{P + \frac{Pa(T,L)}{fa}}{A(T,L)} - \frac{ML \cdot CL(L)}{IL(T,L)} + \frac{MT \cdot CT(T)}{IT(T,L)}$$

All values in k and ft

$$\sigma nMT(T,L) := \frac{P + \frac{Pa(T,L)}{fa}}{A(T,L)} + \frac{ML \cdot CL(L)}{IL(T,L)} - \frac{MT \cdot CT(T)}{IT(T,L)}$$

$$\sigma max(T,L) = \begin{pmatrix} 10.94 \\ 11.188 \\ 8.225 \\ 0.6 \\ 0.6 \\ 0.6 \\ 0.6 \end{pmatrix} \quad \sigma min(T,L) = \begin{pmatrix} -1.553 \\ -1.081 \\ 0.683 \\ 0.6 \\ 0.6 \\ 0.6 \\ 0.6 \end{pmatrix} \quad \sigma nML(T,L) = \begin{pmatrix} 2.868 \\ 1.753 \\ 2.418 \\ 0.6 \\ 0.6 \\ 0.6 \\ 0.6 \end{pmatrix} \quad \sigma nMT(T,L) = \begin{pmatrix} 6.519 \\ 8.354 \\ 6.49 \\ 0.6 \\ 0.6 \\ 0.6 \\ 0.6 \end{pmatrix}$$

REQUIRED VALUE OF L, AND T TO SATISFY CORNER STRESSES

$$root(max(\sigma max(T,L)) - qmax, T) = 16.617$$

$$root(max(\sigma max(T,L)) - qmax, L) = 18.16$$

$$\sigma max := \sigma max(T,L)$$

$$\sigma min := \sigma min(T,L)$$

$$\sigma nML := \sigma nML(T,L)$$

$$\sigma nMT := \sigma nMT(T,L)$$

LOAD FACTOR STRESSES

$$\sigma max2(T,L) := \frac{P2 + Pa(T,L)\cdot 1.3}{A(T,L)} + \frac{ML2\cdot CL(L)}{IL(T,L)} + \frac{MT2\cdot CT(T)}{IT(T,L)}$$

$$\sigma min2(T,L) := \frac{P2 + Pa(T,L)\cdot 1.3}{A(T,L)} - \frac{ML2\cdot CL(L)}{IL(T,L)} - \frac{MT2\cdot CT(T)}{IT(T,L)}$$

$$\sigma nML2(T,L) := \frac{P2 + Pa(T,L)\cdot 1.3}{A(T,L)} - \frac{ML2\cdot CL(L)}{IL(T,L)} + \frac{MT2\cdot CT(T)}{IT(T,L)}$$

$$\sigma nMT2(T,L) := \frac{P2 + Pa(T,L)\cdot 1.3}{A(T,L)} + \frac{ML2\cdot CL(L)}{IL(T,L)} - \frac{MT2\cdot CT(T)}{IT(T,L)}$$

$$\sigma max2(T,L) = \begin{pmatrix} 14.898 \\ 12.594 \\ 7.981 \\ 5.381 \\ 14.3 \\ 0.78 \\ 0.78 \end{pmatrix} \quad \sigma min2(T,L) = \begin{pmatrix} -1.559 \\ -0.211 \\ 1.159 \\ 4.862 \\ -1.918 \\ 0.78 \\ 0.78 \end{pmatrix} \quad \sigma nML2(T,L) = \begin{pmatrix} 2.195 \\ 2.794 \\ 6.248 \\ 5.381 \\ 3.566 \\ 0.78 \\ 0.78 \end{pmatrix} \quad \sigma nMT2(T,L) = \begin{pmatrix} 11.144 \\ 9.588 \\ 2.893 \\ 4.862 \\ 8.816 \\ 0.78 \\ 0.78 \end{pmatrix}$$

$\sigma max2 := \sigma max2(T,L)$

$\sigma min2 := \sigma min2(T,L)$

$\sigma nML2 := \sigma nML2(T,L)$

$\sigma nMT2 := \sigma nMT2(T,L)$

Steel Design Based on Bending Moment

For simplicity I will check all groups, Use Load Factor

Transverse Moment Reinforcing

MAX Stress at the edge of footing

$$\sigma TnML_{n1} := \frac{\sigma max2_{n1} + \sigma nML2_{n1}}{2} \qquad \sigma TnML = \begin{pmatrix} 8.547 \\ 7.694 \\ 7.114 \\ 5.381 \\ 8.933 \end{pmatrix}$$

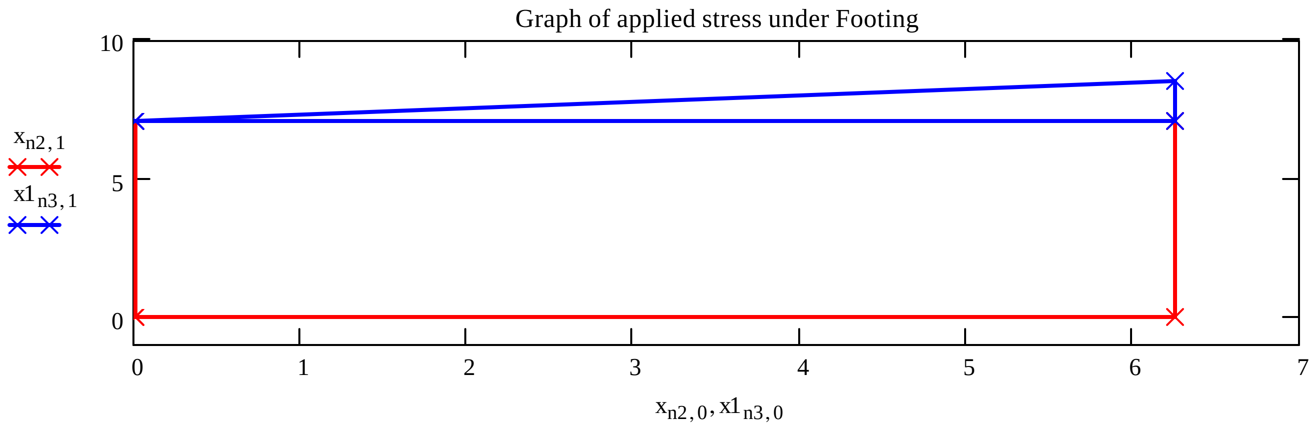
Neg ML

$$\sigma TnMT_{n1} := \frac{\sigma min2_{n1} + \sigma nMT2_{n1}}{2} \qquad \sigma TnMT = \begin{pmatrix} 4.793 \\ 4.688 \\ 2.026 \\ 4.862 \\ 3.449 \end{pmatrix}$$

Neg MT

$$\sigma edgeT_{n1} := \left(\sigma TnML_{n1} - \sigma TnMT_{n1}\right)\cdot\frac{T\cdot 0.5 + DT\cdot 0.5}{T} + \sigma TnMT_{n1} \qquad \sigma edgeT = \begin{pmatrix} 7.033 \\ 6.482 \\ 5.063 \\ 5.172 \\ 6.722 \end{pmatrix}$$

Width of loaded block (ft) = $width := T\cdot 0.5 - DT\cdot 0.5 \qquad width = 6.25$



Effective section depth

$d := D \cdot 12 - cover - 1.5 \cdot bd$ $\qquad d = 43.5$ in

Max Moment (k*ft) = $Mu_{n1} := L \cdot \left[\sigma edgeT_{n1} \cdot width \cdot \frac{width}{2} + 0.5 \cdot \left(\sigma TnML_{n1} - \sigma edgeT_{n1} \right) \cdot width \cdot width \cdot \frac{2}{3} \right]$ $\qquad Mu = \begin{pmatrix} 2434.646 \\ 2206.886 \\ 1946.715 \\ 1607.853 \\ 2481.258 \end{pmatrix}$

Required As (in^2) = $AsT := root\left[12 \cdot max(Mu) - 0.9 \cdot As \cdot fy \cdot \left(d - \frac{As \cdot fy}{1.7 \cdot L \cdot 12 \cdot fc} \right), As \right]$ $\qquad AsT = 12.918$

I shall multiply the requred steel by 4/3 to take care of any cracking requirements

$$AsfinalMT := AsT \cdot \frac{4}{3}$$

$$AsfinalMT = 17.224$$

BAR PATTERN REQUIRMENTS

$$n4 := 0, 1 .. 6$$

$$bars := \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad Asone := \begin{pmatrix} 0.31 \\ 0.44 \\ 0.60 \\ 0.79 \\ 1.0 \\ 1.27 \\ 1.56 \end{pmatrix} \quad nbars_{n4} := floor\left(\frac{AsfinalMT}{Asone_{n4}}\right) + 1 \qquad Sbars_{n4} := \frac{L \cdot 12 - 12}{nbars_{n4} - 1}$$

Bar pattern for size of bars, number of bars, and relative spacing.

$$bars = \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad nbars = \begin{pmatrix} 56 \\ 40 \\ 29 \\ 22 \\ 18 \\ 14 \\ 12 \end{pmatrix} \quad Sbars = \begin{pmatrix} 3.1636 \\ 4.4615 \\ 6.2143 \\ 8.2857 \\ 10.2353 \\ 13.3846 \\ 15.8182 \end{pmatrix}$$

Longitudinal Moment resistance

Stress at the edge of footing

$$\sigma LnMT_{n1} := \frac{\sigma max2_{n1} + \sigma nMT2_{n1}}{2}$$

$$\sigma LnMT = \begin{pmatrix} 13.021 \\ 11.091 \\ 5.437 \\ 5.121 \\ 11.558 \end{pmatrix}$$

Neg MT

$$\sigma LnML_{n1} := \frac{\sigma min2_{n1} + \sigma nML2_{n1}}{2}$$

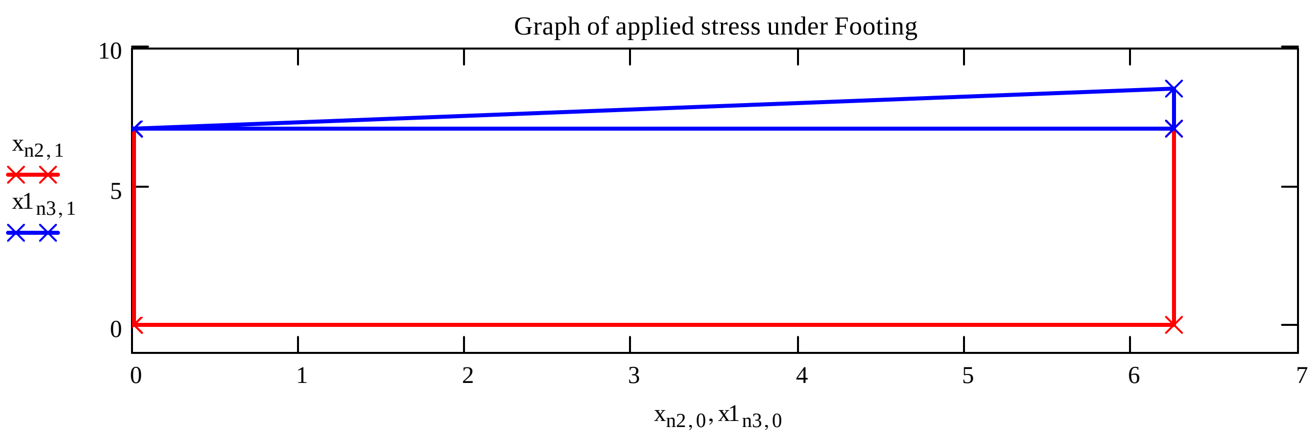
$$\sigma LnML = \begin{pmatrix} 0.318 \\ 1.291 \\ 3.704 \\ 5.121 \\ 0.824 \end{pmatrix}$$

Neg ML

$$\sigma edgeL_{n1} := \left(\sigma LnMT_{n1} - \sigma LnML_{n1}\right)\cdot\frac{L\cdot 0.5 + DL\cdot 0.5}{L} + \sigma LnML_{n1}$$

$$\sigma edgeL = \begin{pmatrix} 7.899 \\ 7.139 \\ 4.738 \\ 5.121 \\ 7.23 \end{pmatrix}$$

Width of Loaded block (ft) = $width := L\cdot 0.5 - DL\cdot 0.5$ $width = 6.25$



Max Moment

$$MuL_{n1} := L\cdot\left[\sigma edgeL_{n1}\cdot width\cdot\frac{width}{2} + 0.5\cdot\left(\sigma LnMT_{n1} - \sigma edgeL_{n1}\right)\cdot width\cdot width\cdot\frac{2}{3}\right]$$

$$MuL = \begin{pmatrix} 3425.066 \\ 2958.814 \\ 1575.405 \\ 1550.397 \\ 3062.243 \end{pmatrix}$$

$AsL := 0$

Required As

$$AsL := root\left[12\cdot max(MuL) - 0.9\cdot AsL\cdot fy\cdot\left(d - \frac{AsL\cdot fy}{1.7\cdot T\cdot 12\cdot fc}\right), AsL\right]$$

$AsL = 17.967$

Check required reinforcing ratio

$$AsfinalML := AsL\cdot\frac{4}{3} \qquad AsfinalML = 23.955$$

BAR PATTERN REQUIRMENTS

$$barsL := \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad AsoneL := \begin{pmatrix} 0.31 \\ 0.44 \\ 0.60 \\ 0.79 \\ 1.0 \\ 1.27 \\ 1.56 \end{pmatrix} \quad nbarsL_{n4} := floor\left(\frac{AsfinalML}{AsoneL_{n4}}\right) + 1 \quad SbarsL_{n4} := \frac{T\cdot 12 - 12}{nbarsL_{n4} - 1}$$

Bar pattern for size of bars, number of bars, and relative spacing.

$$barsL = \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad nbarsL = \begin{pmatrix} 78 \\ 55 \\ 40 \\ 31 \\ 24 \\ 19 \\ 16 \end{pmatrix} \quad SbarsL = \begin{pmatrix} 2.26 \\ 3.222 \\ 4.462 \\ 5.8 \\ 7.565 \\ 9.667 \\ 11.6 \end{pmatrix}$$

Shear Checks

LRFD 5.13.3.6; In determining the shear resistance of slabs and footings in the vicinity of concentrated loads or reaction forces, the more critical of the following conditions shall govern:

1. One was action, with a critical section extending in a plane across the entire width and located at a distance taken as specified in LRFD 5.8.3.2
2. Two-way action, with a critical section perpendicular to the plane of the slab and located so that its perimeter, bo, is a minimum but not closer than 0.5dv to the perimeter of the concentrated load or reaction area.

LRFD 5.8.3.2 Critical section

The location of the critical section for shear shall be taken as the larger of 0.5dv*cotθ or dv from the internal face of support. Since this is a non-prestressed section the value of dv will always govern, I shall therefore use dv from the face of support.

LRFD 5.13.3.6.2 One way action

For one-was action, the shear resistance of the footing or slab shall satisfy the requirements specified in article 5.8.3.

LRFD 5.8.3.3 Shear capacity for one way action

If Vn < Vc no stirrups are required.

$$Vc = 0.0316\beta \cdot \sqrt{fc} \cdot bv \cdot dv$$

LRFD 5.13.3.6.3 Two-Way Action

For two-way action for sections without transverse reinforcement, the nominal shear resistance, Vn i Kip, of the concrete shall be taken as:

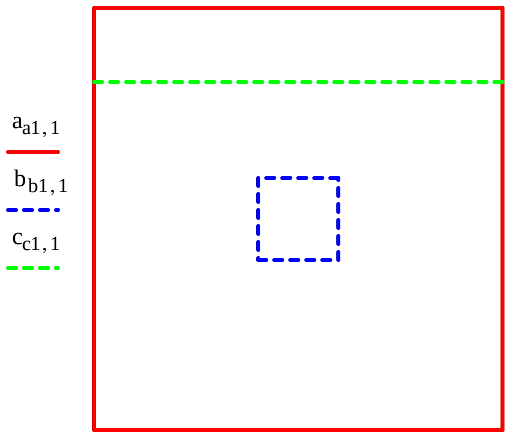
$$Vm = \left(0.063 + \frac{0.126}{\beta c}\right) \cdot \sqrt{fc} \cdot bo \cdot dv \le 0.126 \cdot \sqrt{fc} \cdot bo \cdot dv$$

βc = ratio of long side to short side of the rectangle through wiich the concentrated load or reaction force is transmitted.
bo = the perimeter of the critical section
dv = effective shear depth

One way shear in the Long. direction

Effective shear depth (in) = $dv := d - \frac{AsL \cdot fy}{1.7 \cdot fc \cdot L \cdot 12}$ $dv = 42.364$

Width of shear plane $LLW := \frac{T}{2} - \frac{DT}{2} - \frac{dv}{12}$ $LLW = 2.72$ ft



Applied shear Force (k) = $Vu_{n1} := \frac{|\sigma max2_{n1} + \sigma nML2_{n1}|}{2} \cdot L \cdot LLW$ $\max(Vu) = 376.588$

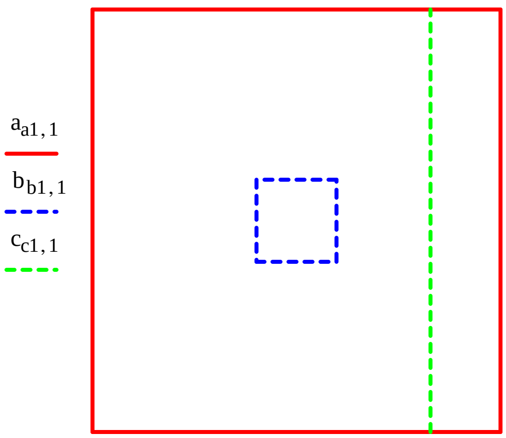
Allowable shear force (k) = $VcL := 0.0316 \cdot 2.0 \cdot \sqrt{fc} \cdot L \cdot 12 \cdot dv$ $VcL = 862.548$

| "OK" if max(Vu) < VcL = "OK"
| "NG" otherwise

One way shear in the Transverse direction

Effective shear depth (in) = $dv := d - \frac{AsT \cdot fy}{1.7 \cdot fc \cdot L \cdot 12}$ $dv = 42.683$

$TLW := \frac{L}{2} - \frac{DL}{2} - \frac{dv}{12}$ $TLW = 2.693$ ft



Applied shear force (k) = $VuT_{n1} := \frac{\sigma max2_{n1} + \sigma nMT2_{n1}}{2} \cdot T \cdot TLW$ $max(VuT) = 543.541$

Allowable shear force (k) = $VcT := 0.0316 \cdot 2.0 \cdot \sqrt{fc} \cdot T \cdot 12 \cdot dv$ $VcT = 869.05$

$$\begin{cases} \text{"OK"} & \text{if } max(VuT) < VcT \\ \text{"NG"} & \text{otherwise} \end{cases} = \text{"OK"}$$

Two way Shear at d/2

Perimeter of shear plane (in) =

$$bo := \begin{cases} \pi \cdot \left(DT \cdot 12 + 2 \cdot \frac{dv}{2}\right) & \text{if } type = 1 \\ 2 \cdot \left(DT \cdot 12 + 2 \cdot \frac{dv}{2}\right) + 2 \cdot \left(DL \cdot 12 + 2 \cdot \frac{dv}{2}\right) & \text{otherwise} \end{cases}$$

$bo = 314.732$

Average stress (psi) =

$$\sigma avg_{n1} := \frac{\sigma max2_{n1} + \sigma min2_{n1} + \sigma nMT2_{n1} + \sigma nML2_{n1}}{4} \qquad \max(\sigma avg) = 6.67$$

Loaded area (ft^2) =

$$LA := T \cdot L - \begin{cases} \pi \cdot \left(\frac{DT}{2} + \frac{0.5 \cdot d}{12}\right)^2 & \text{if } type = 1 \\ \left(DT + \frac{d}{12}\right) \cdot \left(DL + \frac{d}{12}\right) & \text{otherwise} \end{cases} \qquad LA = 196.359$$

Applied Shear Load (k) =

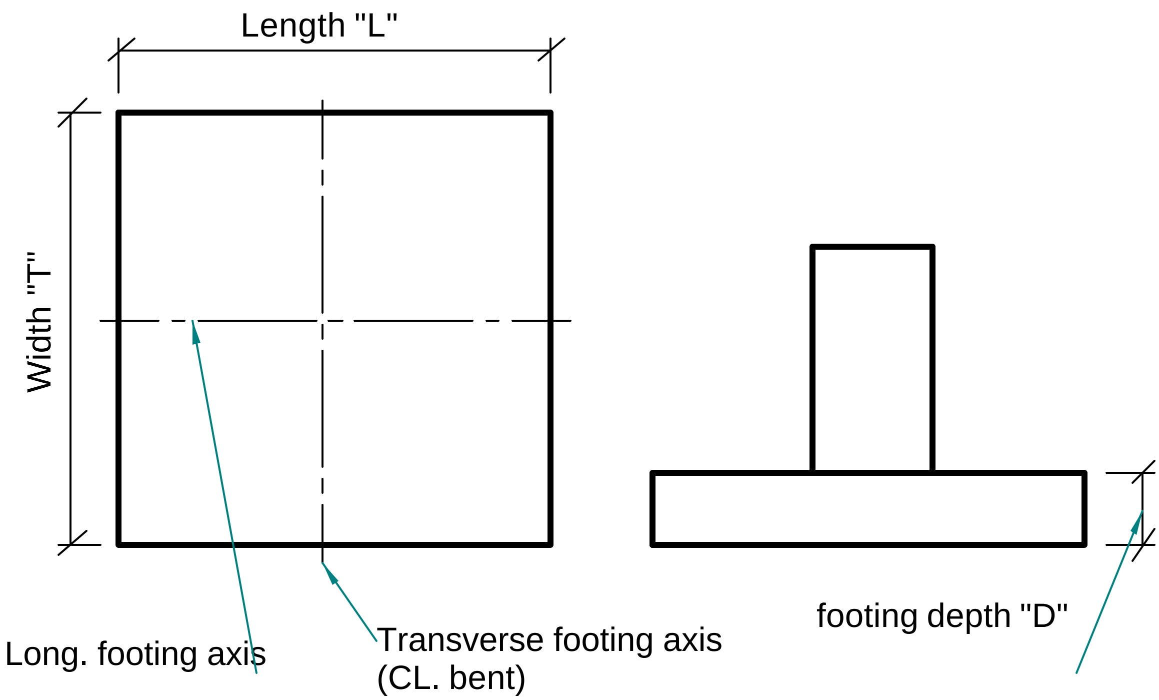
$$Vu_{n1} := \sigma avg_{n1} \cdot LA \qquad Vu = \begin{pmatrix} 1309.658 \\ 1215.667 \\ 897.405 \\ 1005.617 \\ 1215.667 \end{pmatrix} \qquad \max(Vu) = 1309.658$$

Allowable shear (k) =

$$Vc2 := \begin{vmatrix} \beta c \leftarrow \frac{\max\left(\begin{pmatrix} DL \\ DT \end{pmatrix}\right)}{\min\left(\begin{pmatrix} DL \\ DT \end{pmatrix}\right)} \\ j1 \leftarrow \left(0.063 + \frac{0.126}{\beta c}\right) \cdot \sqrt{fc} \cdot bo \cdot dv \\ j2 \leftarrow 0.126 \cdot \sqrt{fc} \cdot bo \cdot dv \\ \min\left(\begin{pmatrix} j1 \\ j2 \end{pmatrix}\right) \end{vmatrix} \qquad Vc2 = 2931.74$$

$$\begin{cases} \text{"OK"} & \text{if } \max(Vu) < Vc2 \\ \text{"NG"} & \text{otherwise} \end{cases} = \text{"OK"}$$

SUMMARY



$L = 15.5$

$T = 15.5$

$D = 4$

Required Reinforcing for theTransverse Moment

$$bars = \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad nbars = \begin{pmatrix} 56 \\ 40 \\ 29 \\ 22 \\ 18 \\ 14 \\ 12 \end{pmatrix} \quad Sbars = \begin{pmatrix} 3.164 \\ 4.462 \\ 6.214 \\ 8.286 \\ 10.235 \\ 13.385 \\ 15.818 \end{pmatrix}$$

Required Reinforcing for the Longitudinal Moment

$$barsL = \begin{pmatrix} 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \end{pmatrix} \quad nbarsL = \begin{pmatrix} 78 \\ 55 \\ 40 \\ 31 \\ 24 \\ 19 \\ 16 \end{pmatrix} \quad SbarsL = \begin{pmatrix} 2.26 \\ 3.222 \\ 4.462 \\ 5.8 \\ 7.565 \\ 9.667 \\ 11.6 \end{pmatrix}$$