Engineering Notes

WELLS & SCALETTY LLC

Simplified Design of Square Footings

Issue No. 2 December 2003

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Some engineering tasks are straight-forward enough that any architect should be able to perform them. Lightly-loaded square footings are a prime example. Most one and two story structures bear on shallow footings. These pads are placed on the in-situ, undisturbed soils or on engineered fill.

The procedure outlined below explains the steps necessary to properly design and detail these footings.

Assumptions and Restrictions

The method is based on the following assumptions:

- 12" thick footings.
- 3000 psi concrete and Grade 60 reinforcement.
- Column or pedestal has a minimum bearing area on the footing of 6"x6".
- There is no shear or bending moment at the base of the column, i.e. axial loads only.
- Allowable soil bearing pressure is between 2000 and 4000 psf.
- Applied load is less than or equal to 50 kips (50,000 lbs.).

Design Steps

1. Verify the axial load is less than or equal to 50 kips (50,000 lbs.)

2. Find the required footing area by dividing the load by the allowable soil bearing pressure.

3. Find the length of the footing sides by taking the square root of the area and rounding up to the nearest 6" increment.

4. Find the required amount of reinforcing steel by multiplying 0.0033 by the length of one side (in inches) times 8.25".

5. Translate this steel area into the required quantity of #4 bars by dividing it by 0.20 square inches. Round this value up to the nearest whole number.

Detailing

OSHA requires four anchor bolts on steel columns for erection stability. The minimum steel base plate size for this method is approximately 9" square (see ACI 318 15.4.2(c)).

If the footing supports a concrete pedestal, the development length of the bars in the footing should be checked. It may be necessary to increase the footing thickness. The minimum practical size of a concrete pedestal is 12" square. I like to enclose steel anchor bolts with at least (3) #3 ties spaced 2" on center.

Bars shall have 3" of clear cover to the soil-concrete interface. Reinforcement needs to be evenly distributed across the width of the footing.

Supplemental

Most geotechnical engineers recommend that pad footings be 2'-0" square minimum. This limit should be observed with this design method otherwise the reinforcement may not have enough development length.

Any project of significant size should have a geotechnical investigation. This report will give the allowable bearing capacity of the soil

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and any other important considerations.

This simplified method is based on a 1.7 load factor. That is equivalent to 100% live load and is conservative. The upper limit of 50 kips is based on the punching shear, beam shear, and bending capacity of the footing. Loads under 50 kips will be satisfactorily carried by 12” thick footings containing the minimum code-specified reinforcement. Calculations justifying this statement can be found on our website at www.wsengineer.com.

For loads exceeding 50 kips, and for allowable bearing capacities in excess of 4000 psf, specific calculations will be required. Thicker footings and a higher steel reinforcement ratio may be needed.

It may be economical to substitute fewer #5 or #6 bars instead of the #4’s listed in the Design Steps. The derivation is based on #4’s, but the substitution will cause no significant loss of accuracy. I like to use #4’s for small footings because they can be cut in the field.

Example

An interior column of a single-story building supports a tributary area of 500 square feet. Loads are 20 psf DL and 30 psf LL. The allowable soil bearing capacity is 2500 psf.

$$P=\left(500\text{ ft}^2\right)\left(20\text{ psf}+30\text{ psf}\right)=25{,}000\text{ lbs.}$$
$$=25\text{ kips}$$

25 kips is less than 50 kips; therefore, method is valid

$$\text{Footing Area} = \frac{25{,}000\text{ lbs.}}{2500\ \frac{\text{lbs.}}{\text{ft}^2}}=10\text{ ft}^2$$

$$L=\sqrt{10\text{ ft}^2}=3.16', \text{ say } 3'\text{-}6''\text{ square}$$

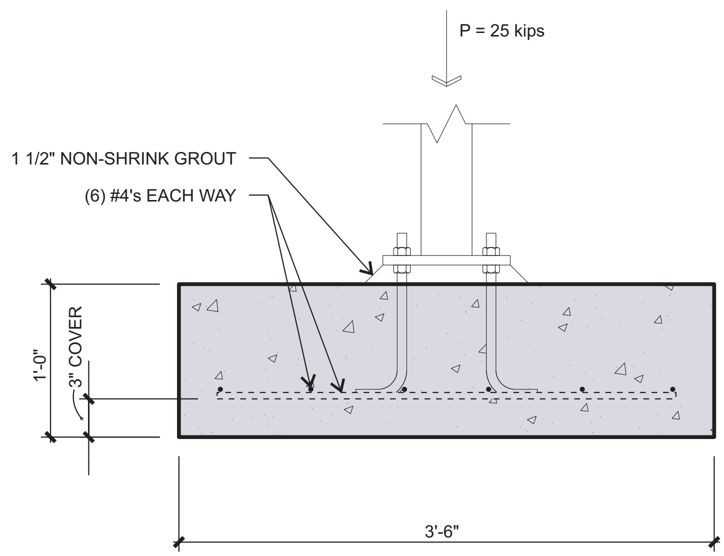
$$\text{Area of Steel, } A_s=(0.0033)(8.25'')(42'')=1.14\text{ in}^2$$

$$\frac{1.14\text{ in}^2}{0.20\ \text{in}^2/\text{bar}}=5.7, \text{ say 6 bars}$$

Use 3'-6"x3'-6"x12" thick footing reinforced with (6) #4's each way

Cross-sectional Area of Rebar

#4	*0.20 in^2*
#5	*0.31 in^2*
#6	*0.44 in^2*



EXAMPLE

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