engineer's notebook

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Soil Pressure under Footings (Part 2)

The June 2004 discussion on soil pressure under spread footings dealt with square or rectangular footings subject to both axial load and overturning moment. Part 2 of this topic deals with circular footings.

The general procedure for using the curves is the same. The eccentricity "e" of the resultant vertical force "P" is found from the applied loads and moments, and the value for e/d is established. The value for "C" can then be readily determined. An iterative process can be used to optimize the footing diameter (d), while maintaining a comfortable percentage of the footing still in bearing with the soil or "k" as indicated on the graph. As discussed in the June 2004 article, a minimum "k" value of 0.85 is recommended for permanent loads. The derivation of Case 1 for a circular footing is provided. However, the Case 2 derivation is lengthy and is therefore not shown in this article. It can be found in some textbooks.

The kern distance for a circular footing of diameter (d) is approached more rapidly than that of a square footing of the same length (d) distance. Therefore, a square footing might be a better choice for applications where the direction of applied loads and moments is predictable. For structures such as towers, where the applied loads and moments may come from any direction, circular footings are more efficient.

Many contractors would probably agree that constructing formwork for a square footing is easier than forming a circular footing. Many would probably opt to balance ease of construction with material efficiency by forming an octagonal footing. Soil pressure curves can be derived for octagonal shapes, though they are not provided in this article. For cases where an octagon is preferred, the curves for a circular footing can be used. The required footing diameter obtained from the circular footing curve should be used as the inner radius of the octagon, and not the outer radius.▪

Bearing pressure determination for circular footings.

Limitations:

1. Forces and moments must occur at center of footing in each direction.
2. Lateral load and applied moment are in one direction only.

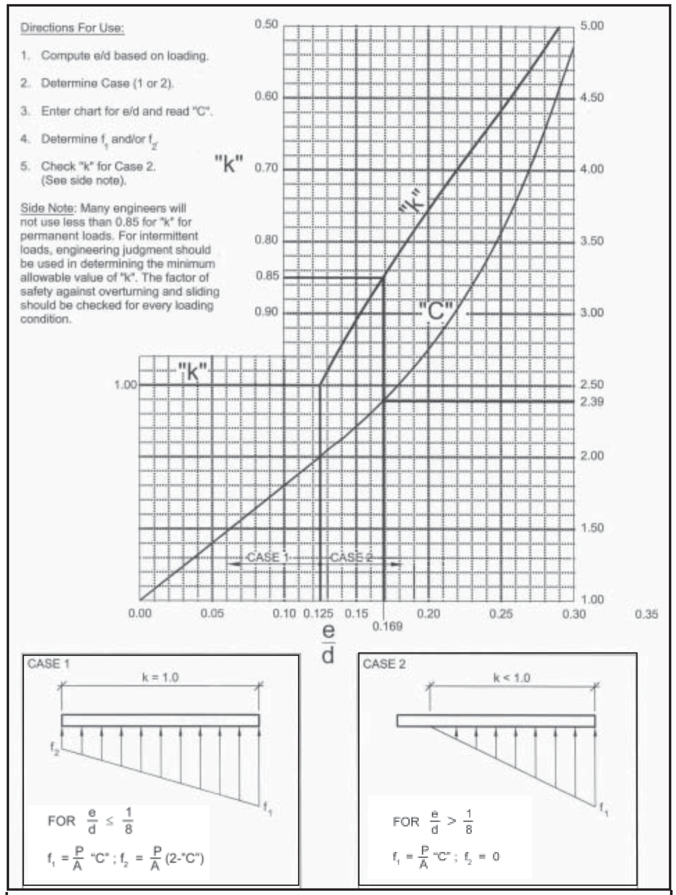
Notation:

- P_a = Applied vertical load [column load]
- M_a = Applied moment at top of pier
- V_a = Applied shear at top of pier
- P = Total vertical reaction to soil
- M = Total overturning moment at base of footing
- A = Area of footing
- S = Section modulus of footing about axis of bending
- d = Diameter of footing
- e = Eccentricity of vertical reaction P
- f_1 = Maximum soil pressure
- f_2 = Minimum soil pressure
- h = Vertical distance from top of pier to bottom of footing

This shorthand method is a variation that is given in various textbooks.

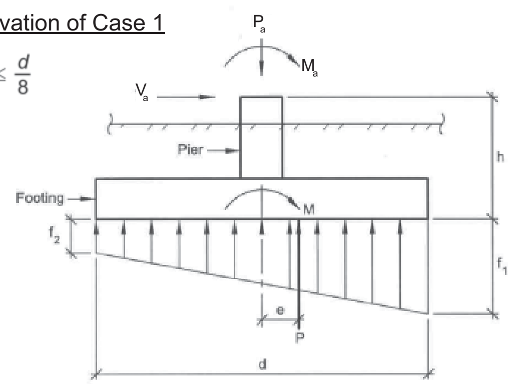
This footing solution is provided by Allen H. Seckinger, P.E., Tampa, Florida. Thanks to Christopher N. Latreille of Ryan-Biggs Associates for assisting the author with the development and review of this article.

Circular Footings



Derivation of Case 1

$e \leq \frac{d}{8}$



Governing Equations for Soil Pressure Distribution (Case 1)

$$f_1 = \frac{P}{A} + \frac{M}{S} \; ; \; f_2 = \frac{P}{A} - \frac{M}{S} \quad \text{where } A = \frac{\pi d^2}{4} \text{ and } S = \frac{\pi d^3}{32} = \frac{Ad}{8}$$

$P = P_a$ + [weight of soil, footing, and pier]

$$M = M_a + V_a h = Pe$$

$$f_1 = \frac{4P}{\pi d^2} + \frac{Pe32}{\pi d^3} = \frac{4P}{\pi d^2}\left(1 + \frac{8e}{d}\right) = \frac{P}{A}\left(1 + \frac{8e}{d}\right) = \frac{P}{A}\text{“C”}$$

$$f_2 = \frac{P}{A}\left(1 - \frac{8e}{d}\right) = \frac{P}{A} = (2\text{-“C”})$$

$$\text{“C” [CASE 1]} = \left(1 + \frac{8e}{d}\right)$$