PDHonline Course S235 (1 PDH)

Pole Foundation Design with Spreadsheet

Instructor: John W. Andrew, PE

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone & Fax: 703-988-0088
www.PDHonline.org
www.PDHcenter.com

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INTRODUCTION

Poles foundations are commonly used for sign, flagpole and light pole foundations and pole framed buildings. A design criteria for pole foundations is indicated in Section 1804 and Paragraph 1805.7 of the 2006 International Building Code. This criteria applies to vertical poles considered columns embedded in either earth or in concrete footings in the earth and used to resist lateral loads. The backfill in the annular space around a column that is not embedded in a concrete footing shall be clean sand thoroughly compacted by tamping in layers not exceeding 8 inches in depth.

ALLOWABLE FOUNDATION AND LATERAL BEARING PRESSURES

The allowable lateral pressures for various classes of soil are indicated in Table 1804.2. The values for lateral bearing pressure are permitted to be increased by the tabular value for each additional foot of depth to a maximum of 15 times the tabular value. Poles for uses such as signs or flagpoles and poles used to support buildings that are not adversely affected by a 1/2-inch motion at the ground surface due to short-term loads are permitted to be designed using lateral bearing values equal to two times the tabular values.

MINIMUM EMBEDMENT DEPTH CALCULATIONS

Where no constraint is provided at the ground surface, such as rigid floor or rigid ground surface pavement, and where no lateral constraint is provided above the ground surface, such as a structural diaphragm, the following equation is used to determine the required minimum embedment depth.

$$d = 0.5\, A \{1 + [1 + (4.36\, h\, /\, A)]^{1/2}\}$$

where:

$A = 2.34\, P\, /\, S_1\, b$

b = diameter of round post or footing or diagonal dimension of square post or footing in feet

d = depth of embedment in earth in feet, but not over 12 feet for the purpose of computing lateral pressure

h = distance in feet from ground surface to point of application of "P"

P = applied lateral force in pounds

S_1 = allowable soil-bearing pressure as set forth in Section 1804.3 based on a depth of one-third the depth of embedment in pounds per square foot

Where constraint is provided at the ground surface, the following equation is used to determine the required embedment depth.

$$d^2 = 4.25 (P\,h\,/\,S_3\,b)$$

where:

b = diameter of round post or footing or diagonal dimension of square post or footing in feet

d = depth of embedment in earth in feet, but not over 12 feet for the purpose of computing lateral pressure

h = distance in feet from ground surface to point of application of "P"

P = applied lateral load in pounds

S_3 = allowable soil-bearing pressure as set forth in Section 1804.3 based on a depth equal to the depth of embedment in pound per square foot

Since the solution of these equations to determine the required embedment depth requires an estimated depth to determine a calculated depth for comparison with the estimated depth, a trial and error approach is necessary. Additional trial depths must be used until the trial depth and calculated depth converge.

VERTICAL LOADS

The foundation pressure resulting from the applied vertical load may not exceed the allowable foundation pressure indicated in Table 1804.2 for the class of soil. The Code does not require a combined lateral and vertical load to be considered.

EXAMPLE PROBLEM

A sign is to be constructed at a site with sandy clay soil. The column for the sign will be a steel tube encased in a circular concrete footing with a diameter of 32 inches. There will be no lateral support at the ground surface and the assembly will not be adversely affected by a 1/2-inch motion at the ground surface. The design lateral force is 1,200 pounds and the height to the load is 16'-0" above the ground surface. The vertical load is 775 pounds. What is the depth of embedment required?

From Table 1804.2, for sandy clay soil, the allowable foundation pressure is indicated to be 1,500 pounds per square foot and the allowable lateral bearing pressure is indicated to be

100 pounds per square foot per foot below natural grade. Since the assembly will not be adversely affected by a 1/2-inch motion at the ground surface, Paragraph 1804.3.1 permits the allowable lateral bearing to be two times the tabular value, or 200 pounds per square

foot per foot below natural grade. Per Section 1804.3.1, the allowable lateral bearing may not exceed 15 times the tabular value, or 1,500 pounds per square foot.

Using a trial depth of 8.00 feet,

S_1 = (200) (8.00) / 3

S_1 = 533 psf

A = (2.34) (1,200) / (533) (2.67)

A = 1.97

d = (0.5) (1.97) $\{1 + [1 + (4.36) (16.00) / 1.97]^{1/2}\}$

d = 6.93 ft

Since 6.93 feet is less than the trial depth of 8.00 feet, the new trial depth should be between 6.93 feet and 8.00 feet.

Using a trial depth of 7.50 feet,

S_1 = (200) (7.50) / 3

S_1 = 500 psf

A = (2.34) (1,200) / (500) (2.67)

A = 2.10

d = (0.5) (2.10) $\{1 + [1+ (4.36) (16.00) / 2.10]^{1/2}\}$

d = 7.19 ft

Since 7.19 feet is less than the trial depth of 7.50 feet, the new trial depth should be between 7.19 feet and 7.50 feet.

Using a trial depth of 7.31 feet,

S_1 = (200) (7.31) / 3

S_1 = 487 psf

A = (2.34) (1,200) / (487) (2.67)

A = 2.16

$d = (0.5) (2.16) \{1 + [1 + (4.36) (16.00) / 2.16]^{1/2}\}$

d = 7.31 ft

The calculated depth equals the trial depth. Therefore the depth of embedment required is 7.31 feet.

The foundation pressure resulting from the vertical load,

$P_f = 775 / (3.14) (1.333)^2$

$P_f = 139$ psf

The example problem above is entered in the spreadsheet. The Excel© spreadsheet has the appropriate formulas embedded. The formulas and calculated results are in protected cells so that they may not be inadvertently changed. Information provided by the user is entered into yellow unprotected cells. Calculation results are provided in blue colored cells. With the data entered in the appropriate cells, the spreadsheet will calculate the required embedment depth and the foundation pressure resulting from the vertical load. For the cases where the embedment depth required or the lateral bearing stress exceed the limitations required by the Code, the user will be alerted with a warning statement.

REFERENCES

1. 2006 International Building Code, International Code Council, Inc. 500 New Jersey Ave., NW, Washington, DC 20001.

2. 2006 IBC Handbook Structural Provisions, International Code Council, 4051 Flossmoor Rd., Country Club Hills, IL 60478.