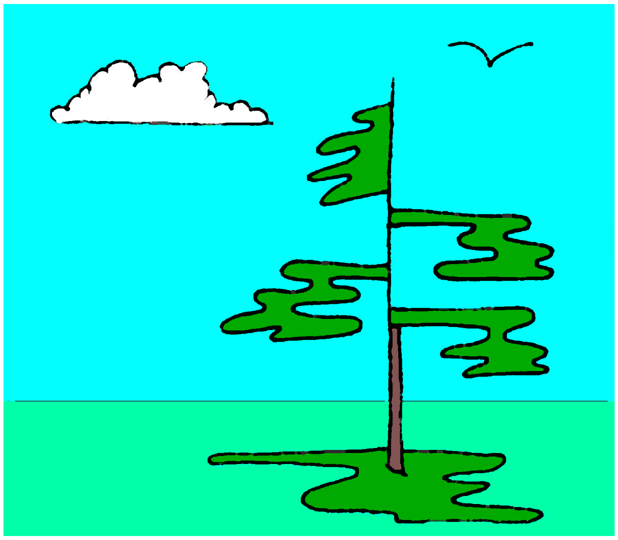
NorthWood Software



Program Name: Embedded Post

Project Name: Name

Project Number: Number

Project Description: Describe

Project Designer: Dik

Last Revised (yy-mm-dd): 18-08-06

Reference: Reference?

Created using SMath Studio, a MathCAD workalike from https://en.smath.info/view/SMathStudio
The User is responsible to verify data using an alternative method

Menu:

.... Enter Data Space .... Important Output .... Logical Constructs Blue Text: Units

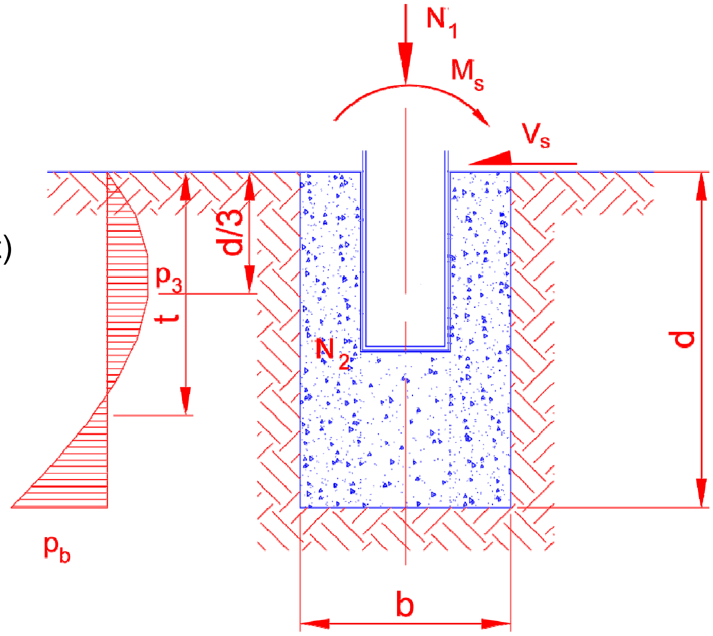
.... Summation

Defined Units:

$K := kip$ kilopounds (force)

$ft\_K := ft\ kip$ foot-kips (Moment)

$kN\_m := kN\ m$ kiloNewton-Metres (Moment)



User Defined Functions

```
Check(arg) := if arg = 1
                  Check := "OK"
              else
                  Check := "NG"
```

$Check(2 = 3) = \text{"NG"}$

$Check(2 \le 3) = \text{"OK"}$

$Check(3 \ge 2) = \text{"OK"}$

Input Data:

Materials

$\gamma_{soil} := 16.5 \frac{kN}{m^3}$ | $\gamma_{soil} = 105 \frac{lbf}{ft^3}$ | Unit Weight of Soi

$\gamma_c := 23.5 \frac{kN}{m^3}$ | $\gamma_c = 149.6 \frac{lbf}{ft^3}$ | Unit Weight Concrete

Pier Properties

$b := 400\ mm$ | $b = 15.75\ in$ | Pier Diameter

$d := 1800\ mm$ | $d = 70.87\ in$ | Pier Embedded Depth

$\alpha := 0.01\ rad$ | Angular Rotation of Pier

Loads

$N_{s1} := 2.6\ kN$ | $N_{s1} = 0.58\ K$ | Applied Vertical Load

$M_s := 5.00\ kN\_m$ | $M_s = 3.69\ ft\_K$ | Applied Moment

$V_s := 2.75\ kN$ | $V_s = 0.62\ K$ | Applied Shear at Ground Line

Embedded Object

$bb := 2\ in$ | Maximum Dimension

Data from a Project Geotechnical Report

$q_{P\_sls} := 60\ kPa$ | $q_{P\_sls} = 1253\ psf$

$q_{p\_uls} := q_{P\_sls} \cdot 2$ | $q_{p\_uls} = 2506\ psf$

$q_{b\_sls} := 120\ kPa$ | $q_{b\_sls} = 2506\ psf$

$q_{b\_uls} := q_{b\_sls} \cdot 2$ | $q_{b\_uls} = 5013\ psf$

Bearing Restraint (Compare with Data Above)

Transverse Bearing (Coulomb Passive Earth Pressure)

$\varphi := 30\ °$ | Angle of Friction

$c := 0\ kPa$ | Cohesion

$$P_{a3} := \gamma_{soil} \cdot \frac{d}{3} \cdot \frac{(1 + \sin(\varphi))}{(1 - \sin(\varphi))} + 2 \cdot c \cdot \frac{(\cos(\varphi))}{(1 + \sin(\varphi))}$$

$P_{a3} = 30\ kPa$ | $P_{a3} = 620\ psf$

$$P_{ab} := \gamma_{soil} \cdot d \cdot \frac{(1 + \sin(\varphi))}{(1 - \sin(\varphi))} + 2 \cdot c \cdot \frac{(\cos(\varphi))}{(1 + \sin(\varphi))}$$

$P_{ab} = 89\ kPa$ | $P_{ab} = 1861\ psf$

Vertical Bearing

$\sigma_{SLS} := 75\ kPa$ | $\sigma_{SLS} = 75\ kPa$ | $\sigma_{SLS} = 1566\ psf$ | SLS Bearing

$\sigma_{ULS} := \sigma_{SLS} \cdot 2$ | $\sigma_{ULS} = 150\ kPa$ | $\sigma_{ULS} = 3133\ psf$ | ULS Bearing

Calculations:

$$Res1 := \begin{bmatrix} 1 & \text{"Pier is Restrained at Grade"} \\ 2 & \text{"Pier is not Restrained at Grade"} \end{bmatrix}$$

$$NDX_{res1} := 2$$

$$Restraint := Res1_{NDX_{res1}\ 2}$$

$$Restraint = \text{"Pier is not Restrained at Grade"}$$

if $NDX_{res1} = 1$ — Pier is Restrained at Grade

$$\sigma_p := \frac{3 \cdot M_s}{b \cdot d^2}$$

$$\sigma_s := \frac{\sigma_p}{3}$$

$$F := V_s + 0.5 \cdot \sigma_p \cdot b \cdot d$$

else — Pier is not Restrained at Grade

$$\sigma_p := \left(M_s + V_s \cdot \frac{d}{3}\right) \cdot \frac{54}{5 \cdot b \cdot d^2}$$

$$\sigma_s := \left(M_s + 8 \cdot V_s \cdot \frac{d}{9}\right) \cdot \frac{81}{20 \cdot b \cdot d^2}$$

$$F := 0.0$$

$\sigma_s = 29.4\ \text{kPa}$	$\sigma_s = 613.5\ \text{psf}$	Stress @ h/3
$\sigma_p = 55.4\ \text{kPa}$	$\sigma_p = 1157.4\ \text{psf}$	Base Stress
$F = 0.0\ \text{kN}$	$F = 0\ \text{K}$	Restraint Force at Grade

$$Check\left(\sigma_p \le P_{ab}\right) = \text{"OK"}$$

$$Check\left(\sigma_s \le P_{a3}\right) = \text{"OK"}$$

Weight of Soil Displaced by Concrete

$$N_{s2} := \frac{\pi \cdot b^2}{4} \cdot d \cdot \left(\gamma_c - \gamma_{soil}\right)$$

$N_{s2} = 1.6\ \text{kN}$ $\quad N_{s2} = 0.4\ \text{K}$ $\quad$ Included Concrete

Bearing Stress

$$\sigma_b := \frac{\left(N_{s1}\right)}{\frac{\pi \cdot b^2}{4}}$$

$\sigma_b = 20.7\ \text{kPa}$ $\quad \sigma_b = 432.1\ \text{psf}$ $\quad$ Bearing Stress

$$\sigma_b := \frac{\left(N_{s1} + N_{s2}\right)}{\frac{\pi \cdot b^2}{4}}$$

$\sigma_b = 33.3\ \text{kPa}$ $\quad \sigma_b = 695.3\ \text{psf}$ $\quad$ Bearing Stress

$$Check\left(\sigma_b \le \sigma_{SLS}\right) = \text{"OK"}$$

IBC 1806 Method

Non-Constrained (Eq 18-1)

$$A := \frac{2.34 \cdot V_s}{P_{a3} \cdot b} \qquad A = 0.5417\ \mathrm{m} \qquad A = 1.78\ \mathrm{ft}$$

$$d_1 := 0.5 \cdot A \cdot \left(1 + \left(1 + \frac{4.36 \cdot \frac{M_s}{V_s}}{A}\right)^{.5}\right)$$

$$d_1 = 1.342\ \mathrm{m} \qquad d_1 = 4.40\ \mathrm{ft}$$

Constrained (Eq 18-2)

$$d_{1c} := \left(\frac{4.25 \cdot \frac{M_s}{\mathrm{ft\_K}}}{\frac{d}{3\ \mathrm{ft}} \cdot \frac{b}{\mathrm{ft}}}\right)^{\frac{1}{3}} \mathrm{ft} \qquad d_{1c} = 0.556\ \mathrm{m} \qquad d_{1c} = 1.82\ \mathrm{ft}$$

ASTM F567

$Check\left(b \ge 4 \cdot bb\right) = \text{"OK"}$ Check Diameter

$$d_2 := 24\ \mathrm{in} + \left(3\ \mathrm{in} \cdot \left(\frac{\frac{M_s}{V_s}}{\mathrm{ft}} - 4\right)\right) \qquad d_2 = 0.759\ \mathrm{m} \qquad d_2 = 2.49\ \mathrm{ft}$$

Min Footing Depth

Davisson (1960s)

Non-Constrained

$$d_3 := 0.54 \cdot A \cdot \left(1 + \left(1 + \frac{4.36 \cdot \frac{M_s}{V_s}}{A}\right)^{.5}\right)$$

$$d_3 = 1.45\ \mathrm{m} \qquad d_3 = 4.75\ \mathrm{ft}$$

Constrained

$$d_{3c} := \left(\frac{4.25 \cdot M_s\ \mathrm{m}}{P_{ab} \cdot b}\right)^{\frac{1}{3}} \qquad d_{3c} = 0.842\ \mathrm{m} \qquad d_{3c} = 2.76\ \mathrm{ft}$$

Pole Building Design (1969)

Non-Constrained

$$d_4 := 0.50 \cdot A \cdot \left(1 + \left(1 + \frac{4.36 \cdot \frac{M_s}{V_s}}{A} \right)^{.5} \right)$$

$d_4 = 1.342\ \mathrm{m}$ $\qquad$ $d_4 = 4.40\ \mathrm{ft}$

Constrained

$$d_{4c} := \left(\frac{4.25 \cdot M_s\ \mathrm{m}}{P_{ab} \cdot b} \right)^{\frac{1}{3}}$$

$d_{4c} = 0.842\ \mathrm{m}$ $\qquad$ $d_{4c} = 2.76\ \mathrm{ft}$

Summary:

Modified Bowling

Diameter of Pier	$b = 400$ mm	$b = 15.748$ in

$Restraint$ = "Pier is not Restrained at Grade"

Depth of Pier	$d = 70.8661$ in	$d = 1.800$ m
Stress @ h/3	$\sigma_s = 29.4$ kPa	$\sigma_s = 613.5$ psf
Base Stress	$\sigma_p = 55.4$ kPa	$\sigma_p = 1157.4$ psf
Restraint Force at Grade	$F = 0$ kN	$F = 0$ K

IBC 1806 Method

Non-Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_1 = 1.342$ m	$d_1 = 4.40$ ft

Constrained

Diameter of Pier	$b = 0.4$ m	$b = 15.75$ in
Depth of Pier	$d_{1c} = 0.556$ m	$d_{1c} = 1.82$ ft

ASTM F567

Non-Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_2 = 0.759$ m	$d_2 = 2.49$ ft

Davisson (1960s)

Non-Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_3 = 1.449$ m	$d_3 = 4.75$ ft

Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_{3c} = 0.842$ m	$d_{3c} = 2.76$ ft

Pole Building Design (1969)

Non-Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_4 = 1.342$ m	$d_4 = 4.4$ ft

Constrained

Diameter of Pier	$b = 400$ mm	$b = 15.75$ in
Depth of Pier	$d_{4c} = 0.842$ m	$d_{4c} = 2.76$ ft