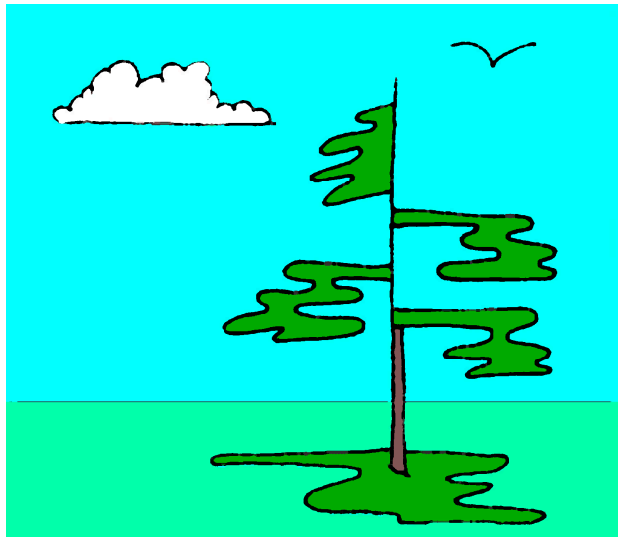
NorthWoods Software



Program Name: Conc-Punching_Shear_Circular

Project Name: -

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 21-04-09

Reference: NBCC, CSA A23.3

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:

.....	Input Data	.....	Important Output	.....	Logical Constructs	Blue	**Units**
.....	Sum / For	Red	**Important Note**				

Defined Units:

$K := kip$ — Force

$K\_ft := K\ ft$ $kN\_m := kN\ m$ $K\_in := K\ in$ $kN\_mm := kN\ mm$ $lb\_in := lbf\ in$ — Moment

$pcf := \frac{lbm}{ft^3}$ $kNpcm := \frac{kN}{m^3}$ $kgpcm := \frac{kg}{m^3}$ — Density

$Klf := \frac{K}{ft}$ $plf := \frac{lbf}{ft}$ $kNpm := \frac{kN}{m}$ $Kpi := \frac{K}{in}$ $kNpmm := \frac{kN}{mm}$ — Force/Unit Length

$psf := \frac{lbf}{ft^2}$ $Ksf := \frac{K}{ft^2}$ $Ksi := \frac{K}{in^2}$ $kNpsm := \frac{kN}{m^2}$ $psi := \frac{lbf}{in^2}$ — Pressure

$pci := \frac{lbf}{in^3}$ — Subgrade Modulus

$psfpf := \frac{psf}{ft}$ $kPapm := \frac{kPa}{m}$ — Pressure per Depth

$pmcf := \frac{lb}{ft^3}$ $lb := lbf$ — Force

$mph := \frac{mi}{hr}$ $kph := \frac{km}{hr}$ — Velocity

User Defined Functions:

c

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

b

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

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

a

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

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

Data Input

Material Property Factors:

$\varphi_r := 0.85$ Reinforcing Steel

$\varphi_c := 0.65$ Concrete

$\varphi_v := 0.75$ Shear

Load Factors:

$\alpha_D := 1.25$

$\alpha_L := 1.50$

Concrete Strength: $rc_{NDX} := 1$ **[8.6.1.1]**

$$rc := \begin{array}{c} \begin{array}{cc} \text{NDX} & \text{f'c} \end{array} \\ \begin{bmatrix} 1 & 20\ \text{MPa} \\ 2 & 25\ \text{MPa} \\ 3 & 30\ \text{MPa} \\ 4 & 35\ \text{MPa} \\ 5 & 40\ \text{MPa} \end{bmatrix} \end{array}$$

$f'_c := rc_{rc_{NDX},2}$

Concrete Density Factor (Lambda) $base_{NDX} := 1$

$$base := \begin{array}{c} \begin{array}{cccc} \text{NDX} & \text{des} & \text{gamma} & \text{lambda} \end{array} \\ \begin{bmatrix} 1 & \text{"Regular Weight Concrete"} & 2240\ \text{kgpcm} & 1.00 \\ 2 & \text{"Semi-Low Density Concrete"} & 1840\ \text{kgpcm} & 0.85 \\ 3 & \text{"Low Density Concrete"} & 1440\ \text{kgpcm} & 0.75 \end{bmatrix} \end{array}$$

$des_c := base_{base_{NDX},2}$

$\gamma_c := base_{base_{NDX},3}$

$\lambda := base_{base_{NDX},4}$

Slab Properties:

$t := 6\ \text{in}$	$t = 6.00\ \text{in}$	$t = 152.4\ \text{mm}$	Slab Thickness
$Check(t \geq 200\ \text{mm}) = \text{"...NG"}$			
$\phi_c := 24\ \text{in}$	$\phi_c = 24.00\ \text{in}$	$\phi_c = 609.6\ \text{mm}$	Load Diameter
$l_s := 8\ \text{ft}$	$l_s = 8\ \text{ft}$	$l_s = 2.438\ \text{m}$	Slab Length
$w_s := 4\ \text{ft}$	$w_s = 4\ \text{ft}$	$w_s = 1.219\ \text{m}$	Slab Width
$t' := t - 50\ \text{mm}$	$t' = 4.0315\ \text{in}$	$t' = 102.4\ \text{mm}$	Effective Slab Thickness
$\beta_c := 1$	$\beta_c = 1.00$		**for Circular Column**
$b_o := \pi \cdot (\phi_c + t')$	$b_o = 88.06\ \text{in}$	$b_o = 2236.8\ \text{mm}$	Punching Shear Perimeter
$A_c := b_o \cdot (t')$	$A_c = 355\ \text{in}^2$	$A_c = 2.29 \cdot 10^5\ \text{mm}^2$	Area of Concrete

Service Loads:

$P_s := 1.25\ K$	$P_s = 1.25\ K$	$P_s = 5.56\ kN$	Service Axial Load
$M_s := 8.75\ K\_ft$	$M_s = 8.75\ K\_ft$	$M_s = 11.86\ kN\_m$	Service Moment

Factored Loads:

$P_f := P_s \cdot \alpha_L$	$P_f = 1.88\ K$	$P_f = 8.34\ kN$	Factored Axial Load
$M_f := M_s \cdot \alpha_L$	$M_f = 13.13\ K\_ft$	$M_f = 17.80\ kN\_m$	Factored Moment

Override Factored Loads:

$P_o := 0\ K$	$P_o = 0.00\ K$	$P_o = 0.00\ kN$	
$M_o := 0\ K\_ft$	$M_o = 0.00\ K\_ft$	$M_o = 0.00\ kN\_m$	

```
if P_o ≠ 0 K = 8340.42 N
  P'_f := P_o
else
  P'_f := P_f
```

```
if M_o ≠ 0 K_ft
  M'_f := M_o
else
  M'_f := M_f
```

	$P'_f = 1.88\ K$	$P'_f = 8.34\ kN$	Override Factored Axial Load
	$M'_f = 13.13\ K\_ft$	$M'_f = 17.80\ kN\_m$	Override Factored Moment

$c := \frac{(\phi_c + t')}{2}$	$c = 14.02\ in$	$c = 356.0\ mm$	Distance to Outer Fibre
$J := \left(\left(\pi \cdot (t') \cdot \left(\frac{(\phi_c + t')}{2}\right)^2 + \left(\frac{t'}{3}\right)^3\right) \cdot c\right)$	$J = 34905\ in^4$	$J = 1.45 \cdot 10^{10}\ mm^4$	Polar Moment of Inertia
$\beta := 0.21$			11.3.6.2
$v_{r1} := \frac{2}{3} \cdot \left(1 + \frac{2}{\beta_c}\right) \cdot 0.18 \cdot \lambda \cdot \varphi_c \cdot \sqrt{\frac{f'_c}{MPa}}\ MPa$	$v_{r1} = 151.8\ psi$	$v_{r1} = 1.05\ MPa$	Equation 22.3
$v_{r2} := \frac{2}{3} \cdot \left(0.37 \cdot \lambda \cdot \varphi_c \cdot \sqrt{\frac{f'_c}{MPa}}\right) MPa$	$v_{r2} = 104.0\ psi$	$v_{r2} = 0.72\ MPa$	Equation 22.4
$v_r := \min([v_{r1}\ \ v_{r2}])$	$v_r = 104.0\ psi$	$v_r = 0.72\ MPa$	Resisting Shear Stress

Flexural and Shear Distribution:

$\gamma_f := \frac{1}{\left(1 + \frac{2}{3} \cdot \left(\sqrt{\frac{l_s}{w_s}}\right)\right)}$	$\gamma_f = 0.51$		Flexural Distribution Factor

$\gamma_v := 1 - \gamma_f$ $\quad \gamma_v = 0.49$ Shear Distribution Factor

Override Shear Distribution Factor:

Value to Approximate Moment Transfer. 1.0 for Full Moment Transfer by Shear. 0.40 Usual Value

$\boxed{\gamma_o := 1.0}$

if $\gamma_o \neq 0$
  $\gamma'_v := \gamma_o$
else
  $\gamma'_v := \gamma_v$ $\quad \gamma'_v = 1.00$

Combined Stresses

$v_c := \frac{P_f}{A_c}$ $\quad v_c = 5.3\ \text{psi}$ $\quad v_c = 0.036\ \text{MPa}$ Axial Shear Stress

$v_f := \frac{\gamma'_v \cdot M_f \cdot c}{J}$ $\quad v_f = 63.2\ \text{psi}$ $\quad v_f = 0.436\ \text{MPa}$ Flexural Shear Stress

$v'_f := v_c + v_f$ $\quad \boxed{v'_f = 68.5\ \text{psi}}$ $\quad \boxed{v'_f = 0.472\ \text{MPa}}$ Combined Shear Stress

Summary:

Material Property Factors

Reinforcing Steel	$\varphi_r = 0.85$	
Concrete	$\varphi_c = 0.65$	
Shear	$\varphi_v = 0.75$	

Load Factors

Dead Load Factor	$\alpha_D = 1.25$	
Live Load Factor	$\alpha_L = 1.50$	

Concrete

28 day Concrete Strength	$f'_c = 2.90\ \text{Ksi}$	$f'_c = 20\ \text{MPa}$
Designation	$des_c = \text{"Regular Weight Concrete"}$	
Density	$\gamma_c = 139.8\ \text{pcf}$	$\gamma_c = 2240\ \text{kgpcm}$
λ Factor	$\lambda = 1$	

Slab Properties

Slab Thickness	$t = 6\ \text{in}$	$t = 152.4\ \text{mm}$
Effective Slab Thickness	$t' = 4.03\ \text{in}$	$t' = 102.4\ \text{mm}$
Load Diameter	$\phi_c = 24\ \text{in}$	$\phi_c = 609.6\ \text{mm}$
Slab Length	$l_s = 8\ \text{ft}$	$l_s = 2.438\ \text{m}$
Slab Width	$w_s = 4\ \text{ft}$	$w_s = 1.219\ \text{m}$
β Factor (for Shear)	$\beta_c = 1$	
Punching Shear Perimeter	$b_o = 88.0635\ \text{in}$	$b_o = 2236.8\ \text{mm}$
Area of Concrete	$A_c = 355\ \text{in}^2$	$A_c = 2.29 \cdot 10^5\ \text{mm}^2$

Loading

Service Axial Load	$P_s = 1.25\ \text{K}$	$P_s = 5.56\ \text{kN}$
Service Moment	$M_s = 8.75\ \text{K\_ft}$	$M_s = 11.86\ \text{kN\_m}$
Factored Axial Load	$P_f = 1.88\ \text{K}$	$P_f = 8.34\ \text{kN}$
Factored Moment	$M_f = 13.13\ \text{K\_ft}$	$M_f = 17.80\ \text{kN\_m}$
Design Factored Axial Load (with Override)	$P'_f = 1.88\ \text{K}$	$P'_f = 8.34\ \text{kN}$
Design Factored Moment (With Override)	$M'_f = 13.13\ \text{K\_ft}$	$M'_f = 17.80\ \text{kN\_m}$

Combined Stresses

Resisting Shear Stress	$v_r = 104.0\ \text{psi}$	$v_r = 0.72\ \text{MPa}$
Axial Load Shear Stress	$v_c = 5.3\ \text{psi}$	$v_c = 0.04\ \text{MPa}$
Flexural Shear Stress	$v_f = 63.2\ \text{psi}$	$v_f = 0.44\ \text{MPa}$
Combined Shear Stress	$v'_f = 68.5\ \text{psi}$	$v'_f = 0.47\ \text{MPa}$

$Check\left(v_r \geq v_f\right) = \text{"...OK"}$