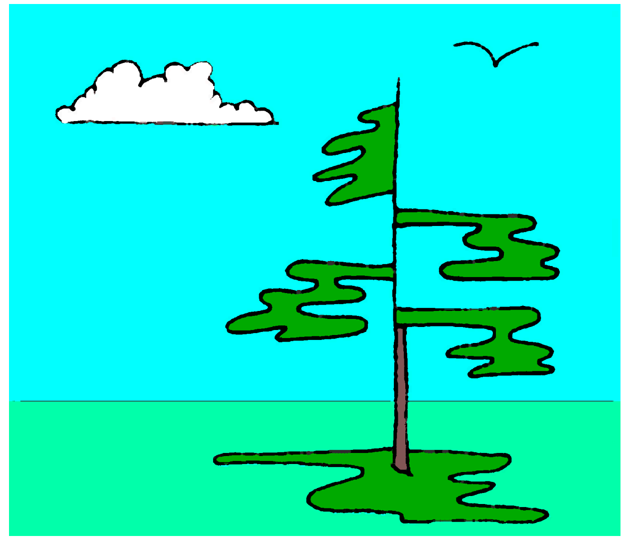
NorthWoods Software



Program Name: Conc-Column

Project Name: -

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 21-02-27

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

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

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

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

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

User Defined Functions:

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

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

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

Input Data

Material Property Factors:

$\varphi_c := 0.65$ Concrete

$\varphi_s := 0.85$ Reinforcing Steel

$\varphi_a := 0.90$ Composite Section Steel

$\varphi_{cpc} := 0.70$ Precast Concrete

$\varphi_p := 0.90$ Prestressed Steel

$\varphi_m := 0.75$

Load Factors:

$\alpha_L := 1.50$

$\alpha_D := 1.25$

Concrete Strength: $\boxed{rc_{NDX} := 13}$ [8.6.1.1]

NDX f'c

$$rc := \begin{bmatrix} 1 & 20\ \text{MPa} \\ 2 & 25\ \text{MPa} \\ 3 & 30\ \text{MPa} \\ 4 & 35\ \text{MPa} \\ 5 & 40\ \text{MPa} \\ 6 & 45\ \text{MPa} \\ 7 & 50\ \text{MPa} \\ 8 & 55\ \text{MPa} \\ 9 & 60\ \text{MPa} \\ 10 & 65\ \text{MPa} \\ 11 & 70\ \text{MPa} \\ 12 & 75\ \text{MPa} \\ 13 & 80\ \text{MPa} \end{bmatrix} \qquad f'_c := rc_{rc_{NDX}\ 2}$$

Material Properties

$\boxed{\gamma_c := 2300\ \text{kgpcm}}$ $\qquad \gamma_c = 143.6\ \text{pcf} \qquad \gamma_c = 2300.0\ \text{kgpcm}$

Young's Modulus for Concrete:

$$E_c := \left(3300 \cdot \sqrt{\frac{f'_c}{\text{MPa}}} + 6900 \cdot \left(\frac{\gamma_c}{2300\ \text{kgpcm}} \right)^{1.5} \right) \text{MPa}$$

$$E_c = 5282\ \text{Ksi} \qquad E_c = 36416\ \text{MPa}$$

Reinforcing Steel Data: $rs_{NDX} := 3$

$$rs := \begin{array}{cccccc} \text{NDX} & \text{bar} & \text{dia} & \text{As} & \text{Ps} & \text{Mass} \\ \end{array}$$

$$rs := \begin{bmatrix} 1 & \text{"10M"} & 11.3\ mm & 100\ mm^2 & 35.5\ mm & 0.785\ \frac{kg}{m} \\ 2 & \text{"15M"} & 16.0\ mm & 200\ mm^2 & 50.1\ mm & 1.570\ \frac{kg}{m} \\ 3 & \text{"20M"} & 19.5\ mm & 300\ mm^2 & 61.3\ mm & 2.355\ \frac{kg}{m} \\ 4 & \text{"25M"} & 25.2\ mm & 500\ mm^2 & 79.2\ mm & 3.925\ \frac{kg}{m} \\ 5 & \text{"30M"} & 29.9\ mm & 700\ mm^2 & 93.9\ mm & 5.495\ \frac{kg}{m} \\ 6 & \text{"35M"} & 35.7\ mm & 1000\ mm^2 & 112.2\ mm & 7.850\ \frac{kg}{m} \\ 7 & \text{"45M"} & 43.7\ mm & 1500\ mm^2 & 137.3\ mm & 11.775\ \frac{kg}{m} \\ 8 & \text{"55M"} & 56.4\ mm & 2500\ mm^2 & 177.2\ mm & 19.625\ \frac{kg}{m} \end{bmatrix}$$

$des_r := rs_{rs_{NDX}\ 2}$

$\phi_r := rs_{rs_{NDX}\ 3}$

$A_r := rs_{rs_{NDX}\ 4}$

$P_r := rs_{rs_{NDX}\ 5}$

$mass_r := rs_{rs_{NDX}\ 3}$

Reinforcing Steel Strength: $fy_{NDX} := 5$ **[8.5.1]**

$$fy := \begin{array}{ccc} \text{NDX} & \text{des} & \text{fy} \end{array}$$

$$fy := \begin{bmatrix} 1 & \text{"300 MPa"} & 300\ MPa \\ 2 & \text{"350 MPa"} & 350\ MPa \\ 3 & \text{"400 MPa"} & 400\ MPa \\ 4 & \text{"450 MPa"} & 450\ MPa \\ 5 & \text{"500 MPa"} & 500\ MPa \end{bmatrix}$$

$des_r := fy_{fy_{NDX}\ 2}$ $f_{yr} := fy_{fy_{NDX}\ 3}$ $E_s := 200000\ MPa$

Composite Steel Properties: $fy_{NDX} := 2$

$des_c := fy_{fy_{NDX}\ 2}$ $F_y := fy_{fy_{NDX}\ 3}$

$A_t := 0\ in^2$ Area of Comp Steel

Prestressing Steel Properties:

$f_{pr} := 0\ Ksi$ Stress in PS Tendons

$A_p := 0\ in^2$ Area of PS Tendons

Concrete Column Properties:

$d := 78.74\ in$ $d = 2000.0\ mm$ Depth of Column

$b := 78.74\ in$ $b = 2000.0\ mm$ Width of Column

$k := 1$ Effective Length Factor

$l_u := 65.65\ ft$ $l_u = 20.010\ m$ Unsupported Length

$I_g := \frac{b \cdot d^3}{12}$ $I_g = 3.20 \cdot 10^6\ in^4$ $I_g = 1.33 \cdot 10^{12}\ mm^4$

Concrete Column Reinforcing Properties:

$A_{st} := 220\ in^2$ $\quad A_{st} = 1 \cdot 10^5\ mm^2$ Area of Long Rebar

$A_g := b \cdot d$ $\quad A_g = 6199.99\ in^2$ $\quad A_g = 4.00 \cdot 10^6\ mm^2$ Gross Area of Section

$\rho_t := \dfrac{A_{st}}{A_g}$ $\quad \rho_t = 0.04$ Long Rfg Ratio

$\Sigma P_c := 1$ Sum of all Sway Resist Cols

Factored Loads

$P_f := 35971\ K$ $\quad P_f = 1.60 \cdot 10^5\ kN$ Factored Axial Load

$M_{ft} := 11801\ K\_ft$ $\quad M_{ft} = 16000\ kN\_m$ Factored Moment at Top

$M_{fb} := (-11801)\ K\_ft$ $\quad M_{fb} = -16000\ kN\_m$ Factored Moment at Bot

$Check\left(M_{fb} \neq 0\ K\_ft\right) = \text{"...OK"}$ **Mfb Cannot be Equal to 0. Enter +/- 1 Using the Same Sign as the Opposite Moment**

$\beta_d := 0.5$ **Ratio of Sustained Load to Factored Load** **[Def]**

$\Sigma P_f := P_f$ Sum of all Vert Loads

$M_{sgn} := \text{sign}\left(\dfrac{M_{ft}}{M_{fb}}\right)$ $\quad M_{sgn} = -1$

$M_{f1} := \min\left(\left[\left|M_{ft}\right|\ \left|M_{fb}\right|\right]\right)$ $\quad M_{f1} = 11801\ K\_ft$ $\quad M_{f1} = 16000\ kN\_m$

$M_{f2} := \max\left(\left[\left|M_{ft}\right|\ \left|M_{fb}\right|\right]\right)$ $\quad M_{f2} = 11801\ K\_ft$ $\quad M_{f2} = 16000\ kN\_m$

$h := \min\left(\left[b\ \ d\right]\right)$ $\quad h = 2000.00\ mm$ Min Dimension of Col

$r := 0.3 \cdot h$ $\quad r = 23.62\ in$ $\quad r = 600.00\ mm$ Radius of Gyration

[10.1]

$$\alpha_1 := \max\left(\left[0.85 - 0.0015 \cdot \frac{f'_c}{MPa}\ \ 0.67\right]\right)$$

$$\alpha_1 = 0.73$$

[10.10.5]

$$\alpha_t := 0.5 \cdot \left(1 + \frac{\rho_t}{0.01}\right) \qquad \alpha_t = 2.27$$

[10.11]

$$P_{ro} := \alpha_1 \cdot \varphi_c \cdot f'_c \cdot \left(A_g - A_{st} - A_t - A_p\right) + \varphi_s \cdot f_{yr} \cdot A_{st} + \varphi_a \cdot F_y \cdot A_t - f_{pr} \cdot A_p$$

$$P_{ro} = 46485\ K \qquad P_{ro} = 2.07 \cdot 10^5\ kN$$

[10.10.4 b)]

$$P_{rmax} := \max\left(\left[\left(0.2 + 0.002 \cdot \frac{h}{in}\right) \cdot P_{ro}\ \ 0.8 \cdot P_{ro}\right]\right)$$

$$P_{rmax} = 37188\ K \qquad P_{rmax} = 1.65 \cdot 10^5\ kN$$

[10.13.2]

$Q := 0.1$ **Non Sway**

$C_m := \max\left(\left[0.6 + 0.4 \cdot M_{sgn} \cdot \frac{M_{f1}}{M_{f2}} \;\; 0.4\right]\right)$ $C_m = 0.40$ **[10.14.1.2]**

$M' := \max\left(\left[\left|\frac{M_{f1}}{M_{f2}}\right| \;\; 0.5\right]\right)$ $M' = 1.00$ **[10.21]**

$M_v := M' \cdot M_{sgn}$ $M_v = -1.00$

$Check\left(\frac{k \cdot l_u}{r} \le \frac{25 - 10 \cdot M_v}{\sqrt{\frac{P_f}{f'_c \cdot A_g}}}\right) = \text{"...OK"}$

If OK, then Slenderness does not need to be considered

$EI := \frac{0.4 \cdot E_c \cdot I_g}{\left(1 + \beta_d\right)}$ $EI = 4.51 \cdot 10^{12}$ lb_inin **[10.20]**

$P_c := \frac{\pi^2 \cdot EI}{\left(k \cdot l_u\right)^2}$ $P_c = 71748.25$ K **[10.18]**

$M_2 := P_f \cdot (.05 \cdot h)$ $M_2 = 11801.49$ K_ft **5% Eccentricity**

$M'_c := \frac{C_m \cdot M_{f2}}{1 - \frac{P_f}{\varphi_m \cdot P_c}}$ $M'_c = 14238.10$ K_ft **[10.17]**

$P_f = 35971.00$ K

c b a

Summary: