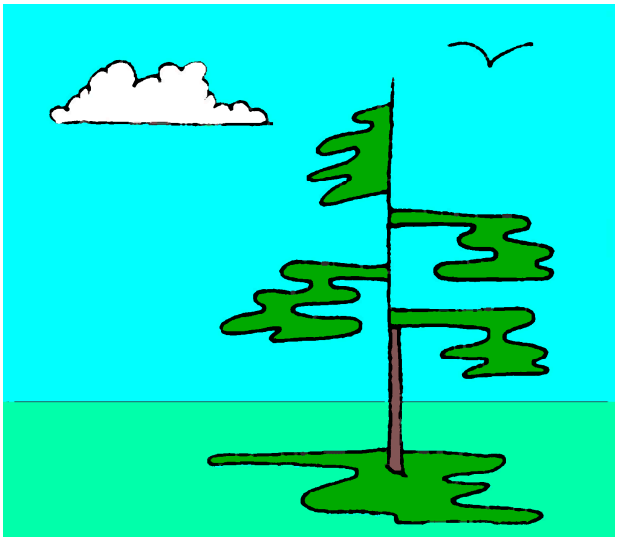
NorthWoods Software



Program Name: Conc-Creep

Project Name: -

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 21-05-06

Reference: Eurocode, AS 3600:2018

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:

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..... Sum / For	Red **Important Note**	Gray Temporary Variables	

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

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

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

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

$ispf := \frac{in^2}{ft}$ $mmspm := \frac{mm^2}{m}$ — Area per Unit Length

User Defined Functions:

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

c

$Check(2 = 3) = "...NG"$

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

b

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

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

a

Input Data:

Concrete Strength: $rc_{NDX} := 3$

28 Day Concrete Strength:

NDX	f'c	ccb
1	20 MPa	5.20
2	25 MPa	4.20
3	30 MPa	3.63
4	32 MPa	3.40
5	35 MPa	3.18
6	40 MPa	2.80
7	45 MPa	2.60
8	50 MPa	2.40
9	65 MPa	2.00
10	80 MPa	1.70
11	100 MPa	1.50

$rc :=$

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

$\varphi_{ccb} := rc_{rc_{NDX},3}$

Table 3.1.8.2 (Modified)

$f'_c = 4.35\ Ksi$ $\quad f'_c = 30.00\ MPa$ Concrete Strength

$\varphi_{ccb} = 3.63$ Basic Creep Coefficient

Concrete Modulus of Elasticity:

$\gamma_c := 2300\ kgpcm$ $\quad \gamma_c = 143.58\ pcf$ $\quad \gamma_c = 2300\ kgpcm$

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

$E_c = 3622\ ksi$ $\quad E_c = 24975\ MPa$

Sustained Stress:

$ss := 40\ \%$ $\quad ss = 40.00\ \%$ Sustained Stress Relative to f'c

$f_{cmi} := ss \cdot f'_c$ $\quad f_{cmi} = 1.74\ Ksi$ $\quad f_{cmi} = 12.00\ MPa$ Sustained Concrete Stress

$f_{cm} := 15\ MPa$ Mean Concrete Stress

$f_{cmo} := 10\ MPa$ $\quad f_{cmo} = 1.45\ Ksi$ $\quad f_{cmo} = 10.00\ MPa$???

Concrete Class: $cc_{NDX} := 3$

NDX	Class	α	αds1	αds2
1	"Class S"	−1.0	3	0.13
2	"Class N"	0	4	0.12
3	"Class R"	1.0	6	0.11

$cc :=$

$des_{cc} := cc_{cc_{NDX},2}$ $\quad \alpha := cc_{cc_{NDX},3}$

$\alpha_{ds1} := cc_{cc_{NDX},4}$ $\quad \alpha_{ds2} := cc_{cc_{NDX},5}$

Concrete Section:

$A_c := 400\ in^2$ $\quad A_c = 400.00\ in^2$ $\quad A_c = 2.58 \cdot 10^5\ mm^2$ Conc Area for Consideration

$u := 50\ in$ $\quad u = 50.00\ in$ $\quad u = 1270.00\ mm$ Exp Perimeter of Conc Area

Notational Member Size:

$h_0 := \frac{A_c}{u}$ $\quad h_0 = 8.00\ in$ $\quad h_0 = 203.2\ mm$ **Equation B.6**

Time Constraints:

$t_i := 365\ day$ Concrete Age for Consideration

$t_0 := 7\ day$ Concrete Age at Initial Load

$Check\left(\left(t_i \geq t_0\right) \wedge \left(t_0 \geq 1\ day\right)\right) = "...OK"$ to > 1 day

$t := t_i - t_0$ $\quad t = 358\ day$ Ellapsed Time

Time-Temperature Constraints:

NDX day temp (C)

$$tt := \begin{bmatrix} 1 & 150\ \text{day} & 25 \\ 2 & 150\ \text{day} & 30 \\ 3 & 65\ \text{day} & 28 \end{bmatrix}$$

Enter time-temperature data starting with the initial data in Row 1. The first column is the episode number, the second number is the duration of the episode, and the third number is the temperature experienced in that episode. Increase the number of episodes by dragging downward on the 'grip' created when the array has focus.

$sum_{ET} := 0\ \text{day}$

$t_T := 0$

Initialise Variables

$$\text{for } i \in [1..\text{rows}(tt)]$$
$$tt_{i,4} := tt_{i,2} \cdot tt_{i,3}$$
$$sum_{ET} := sum_{ET} + tt_{i,2}$$
$$t_T := t_T + \mathbf{e}^{-\left(\frac{4000}{(273 + tt_{i,3})} - 13.65\right) \cdot \frac{tt_{i,2}}{\text{day}}}$$

Equation B.10

$sum_{ET} = 365.00\ \text{day}$

$t_T = 516.45$

$Check\left(sum_{ET} \le t_i\right) = \text{"...OK"}$

$t_{0T} := t_T$

$$t'_0 := \max\left(\left[t_{0T} \cdot \left(\frac{9}{2 + t_{0T}^{1.2}} + 1\right)^{\alpha}\ 0.5\right]\right)$$

Equation B.9

$t'_0 = 519.03$

Humidity:

$RH := 40\ \%$

$RH_0 := 100\ \%$

Relative Humidity

Environment: $en_{NDX} := 3$

NDX environment k4

$$en := \begin{bmatrix} 1 & \text{"Arid"} & 0.70 \\ 2 & \text{"Interior"} & 0.65 \\ 3 & \text{"Temporate"} & 0.60 \\ 4 & \text{"Tropical"} & 0.50 \\ 5 & \text{"Coastal"} & 0.50 \end{bmatrix}$$

$des_E := en_{en_{NDX},2}$

$k_4 := en_{en_{NDX},3}$

$$\alpha_1 := \left(\frac{35}{\frac{f'_c}{\text{MPa}}}\right)^{0.7}$$

$\alpha_1 = 1.11$

Equation B.8C

$$\alpha_2 := \left(\frac{35}{\frac{f'_c}{\text{MPa}}}\right)^{0.2}$$

$\alpha_2 = 1.0313$

Equation B.8C

$$\alpha_3 := \left(\frac{35}{\frac{f'_c}{\text{MPa}}}\right)^{0.5}$$

$\alpha_3 = 1.0801$

Equation B.8C

$\alpha'_2 := 1.0 + 1.12 \cdot \mathbf{e}^{-0.008 \cdot \frac{h_0}{mm}}$ $\alpha'_2 = 1.22$???

$k_2 := \frac{\alpha'_2 \cdot \left(\frac{t}{day}\right)^{0.8}}{\left(\frac{t}{day}\right)^{0.8} + 0.15 \cdot \frac{h_0}{mm}}$ $k_2 = 0.96$???

$k_3 := \frac{2.7}{1 + \log10\left(\frac{t_0}{day}\right)}$ $k_3 = 1.46$???

$des_E = "Temporate"$ $k_4 = 0.60$???

$\alpha'_3 := \frac{0.7}{k_4 \cdot \alpha'_2}$ $\alpha'_3 = 0.96$???

$\beta_{RH} := 1.55 \cdot \left(1 - \left(\frac{RH}{RH_0}\right)^3\right)$ $\beta_{RH} = 1.45$

$\varepsilon_{CD0} := 0.85 \cdot \left(220 + 110 \cdot \alpha_{ds1}\right) \cdot \mathbf{e}^{\left(-\alpha_{ds2} \cdot \frac{f_{cm}}{f_{cmo}}\right)} \cdot 10^{-6} \cdot \beta_{RH}$ Basic Drying Shrinkage Strain

$\varepsilon_{CD0} = 0.000920$

if $f'_c \le 50\ MPa$

$k_5 := 1$

else

$k_5 := \left(2 - \alpha_3\right) - 0.02 \cdot \left(1 - \alpha'_3\right) \cdot \frac{f'_c}{MPa}$

$k_5 = 1.00$???

$\beta_{t0} := \frac{1}{\left(.1 + \left(\frac{t_0}{day}\right)^{0.2}\right)}$ $\beta_{t0} = 0.63$ **Equation B.5**

if $f'_c \le 35\ MPa$

$\varphi_{RH} := 1 + \frac{\left(1 - RH\right)}{0.1 \cdot \left(\frac{h_0}{mm}\right)^{.3333}}$ **Equation B.3a**

else

$\varphi_{RH} := \left(1 + \frac{\left(1 - RH\right)}{0.1 \cdot \left(\frac{h_0}{mm}\right)^{.3333}} \cdot \alpha_1\right) \cdot \alpha_1$ **Equation B.3b**

$\varphi_{RH} = 2.02$

$\beta_{fcm} := \frac{16.8}{\left(\frac{f_{cm}}{MPa}\right)^{.5}}$ $\beta_{fcm} = 4.34$ **Equation B.4**

$\varphi_0 := \varphi_{RH} \cdot \beta_{fcm} \cdot \beta_{t0}$ $\varphi_0 = 5.56$ **Equation B.2**

if $f'_c \leq 35\ \text{MPa}$

$\beta_H := \max\left(\left[1.5 \cdot \left(1 + (0.012 \cdot RH)^{18}\right) \cdot \frac{h_0}{\text{mm}} + 250 \quad 1500\right]\right)$ **Equation B.8a**

else

$\beta_H := \max\left(\left[1.5 \cdot \left(1 + (0.012 \cdot RH)^{18}\right) \cdot \frac{h_0}{\text{mm}} + 250 \cdot \alpha_3 \quad 1500 \cdot \alpha_3\right]\right)$ **Equation B.8b**

$\beta_H = 1500.00$

$\beta_{ctt0} := \left(\frac{\frac{t - t_0}{\text{day}}}{\beta_H + \frac{t}{\text{day}} - \frac{t_0}{\text{day}}}\right)^{0.3}$ **Equation B.7**

Equation B.1

$\varphi_{tt0} := \varphi_0 \cdot \beta_{ctt0}$ $\varphi_{tt0} = 3.38$

$f_{cmi} = 1.74\ \text{Ksi}$

$\sigma_0 := 0.6 \cdot f_{cmi}$

if $\sigma_0 \leq 0.45 \cdot f_{cmi}$

$k_6 := 1$

else

$k_6 := \mathbf{e}^{1.5 \cdot \left(\frac{\sigma_0}{f_{cmi}} - 0.45\right)}$

$k_6 = 1.25$

$\varphi_{cc} := k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_6 \cdot \varphi_{ccb}$ $\varphi_{cc} = 3.82$

Summary: