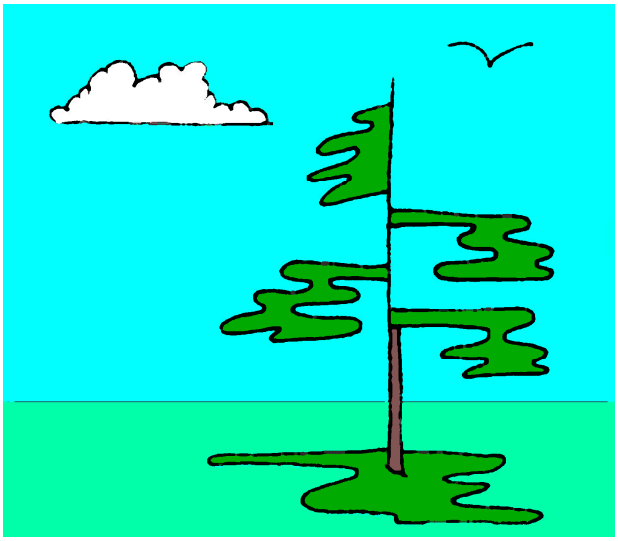
NorthWoods Software



Program Name: Bolt-Circle

Project Number: -

Project Description: -

Project Designer: Dik

Last Revised (yy-mm-dd): 23.01.02

Reference: NBCC, CSA S16

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

Menu:

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

Input Data:

Material Property Factors:

$\varphi_s := 0.90$ Rolled Sections

$\varphi_w := 0.67$ Weld

$\varphi_b := 0.80$ Bolt

$\varphi_{br} := 0.80$ Bolt Bearing

$\varphi_u := 0.75$ Block Shear

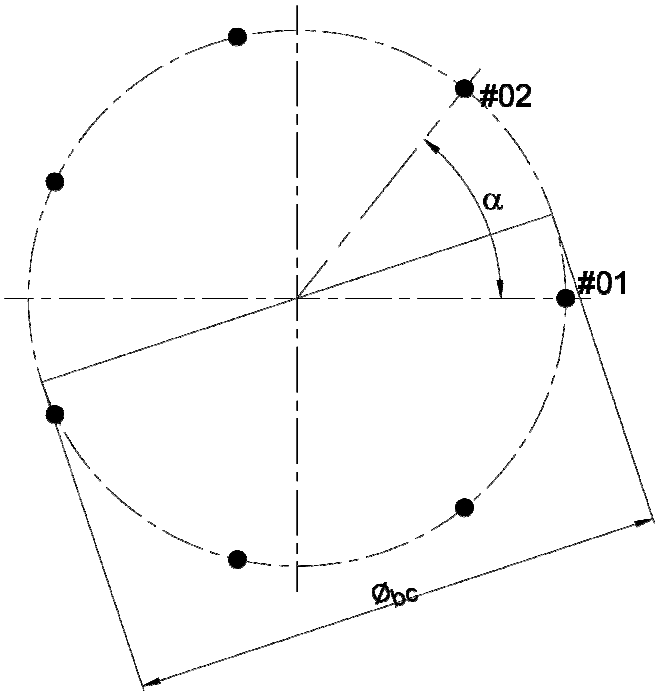
Load Factors:

$\alpha_D := 1.25$

$\alpha_L := 1.5$

$Check\left(\alpha_D \geq 1.25\right) = "...OK"$

$Check\left(\alpha_L \geq 1.5\right) = "...OK"$



Steel Properties:

Structure: $st_{NDX} := 1$

$st :=$

NDX	des	fy	Fu
1	"G40.21-350W"	50 Ksi	65 Ksi
2	"G40.21-300W"	44 Ksi	65 Ksi
3	"A36"	36 Ksi	58 Ksi

$desM_1 := st_{st_{NDX},2}$ $f_{y1} := st_{st_{NDX},3}$ $F_{u1} := st_{st_{NDX},4}$

$\nu := 0.3$ $E_s := 29000\ Ksi$ $\gamma_s := 489\ pcf$

$G_s := \frac{E_s}{2 \cdot (1 + \nu)}$

Base Plate: $st_{NDX} := 2$ $desM_2 := st_{st_{NDX},2}$ $f_{y2} := st_{st_{NDX},3}$ $F_{u2} := st_{st_{NDX},4}$

Anchor:

CSA O86 references SAE J429. Fy from Portland Bolt states fy = 36Ksi, and CSA O86 lists this at 44Ksi.

Grade: $bg_{NDX} := 1$

NDX	des	fy	Fu
1	"F1554 Gr 55S1"	55 Ksi	65 Ksi
2	"G40.21-300W"	44 Ksi	65 Ksi
3	"A36"	36 Ksi	58 Ksi
4	"ASTM A307"	45 Ksi	60 Ksi
5	"SAE J429 Gr 1"	44 Ksi	60 Ksi
6	"Other"	45 Ksi	45 Ksi

$bg :=$

$desM_b := bg_{bg_{NDX},2}$ $f_{yb} := bg_{bg_{NDX},3}$ $F_{ub} := bg_{bg_{NDX},4}$

Diameter:

$bd_{NDX} := 6$

NDX	Dia
1	0.5 in
2	0.625 in
3	0.75 in
4	0.875 in
5	1.00 in
6	1.125 in
7	1.25 in
8	1.375 in

$bd :=$

$\phi_b := bd_{bd_{NDX},2}$ $\phi_h := bd_{bd_{NDX},2} + o$ $A_b := \frac{\pi \cdot \phi_b^2}{4}$

$o := \frac{1}{16}$ in $o = 0.06$ in $o = 1.59$ mm Bolt Hole Oversize

Threads: $th_{NDX} := 1$

NDX	des
1	"Included"
2	"Excluded"

$th :=$ $des_{th} := th_{th_{NDX},2}$

Connection Type: $cn_{NDX} := 1$

NDX	des
1	"Snug Tight"

$cn :=$ $des_{cn} := cn_{cn_{NDX},2}$

Base Plate Dimensions:

$\phi_{bc} := 469.68$ in	$\phi_{bc} = 469.68$ in	$\phi_{bc} = 11929.87$ mm	Bolt Circle Diameter
$\phi_p := 472.68$ in	$\phi_p = 472.68$ in	$\phi_p = 12006.07$ mm	Base Plate Diameter
$t_p := 1$ in	$t_p = 1.00$ in	$t_p = 25.40$ mm	Base Plate Thickness
$e_1 := 1.5$ in	$e_1 = 1.50$ in	$e_1 = 38.10$ mm	Bolt Edge Distance
$N_b := 7$	$N_b = 7$		Number of Fasteners
$\alpha_i := 0°$	$\alpha_i = 0.00°$	$\alpha_i = 0.00$ rad	First Fastener Angle Offset
$\alpha := \frac{360°}{N_b}$	$\alpha = 51.43°$	$\alpha = 0.90$ rad	Angle Between Fasteners

Factored Design Loads:

$M_{fx} := 1607.249$ K_ft	$M_{fx} = 1607.25$ K_ft	$M_{fx} = 2179.14$ kN_m	Factored Moment (X-Axis)
$V_{fy} := 100$ K	$V_{fy} = 100.00$ K	$V_{fy} = 444.82$ kN	Factored Shear (Y-Axis)
$P_{fz} := 40$ K	$P_{fz} = 40.00$ K	$P_{fz} = 177.93$ kN	Factored Axial Load (Z-Axis)

Anchor Geometry:

$jc := \text{matrix}(N_b, 1)$ Initialise Matrix

```
for c1 ∈ [1..Nb]
    jc[c1,1] := c1                                  jc(i, 1) Count
    jc[c1,2] := (c1 − 1)·α + αi                     jc(i,2)  Angle
    jc[c1,3] := (φbc/2)·cos(jc[c1,2])               jc(i,3)  X-coordinates
    jc[c1,4] := (φbc/2)·sin(jc[c1,2])               jc(i, 4) Y-coordinates
    jc[c1,5] := (jc[c1,4])^2                        jc(i, 5) (Y-coord)^2
```

$x := \text{submatrix}(jc, 1, \text{rows}(jc), 3, 3)$

$y := \text{submatrix}(jc, 1, \text{rows}(jc), 4, 4)$

$y2 := \text{submatrix}(jc, 1, \text{rows}(jc), 5, 5)$

$S_{y2} := \sum \text{submatrix}(jc, 1, \text{rows}(jc), 5, 5)$

$S_{y2} = 1340.45\ \text{ft}^2$ $S_{y2} = 1340.45\ \text{ft}^2$ Sum y^2

```
for c1 ∈ [1..Nb]
    jc[c1,6] := (Mfx·jc[c1,4]) / Sy2                jc(i,6)  Force
    jc[c1,7] := jc[c1,4]·jc[c1,6]                   jc(i, 7) Moment
```

c b a

$F := \text{submatrix}(jc, 1, \text{rows}(jc), 6, 6)$ Force in Anchor

$F_{max} := \max(\text{submatrix}(jc, 1, \text{rows}(jc), 6, 6))$

$F_{max} = 22.88\ \text{K}$ $F_{max} = 101.76\ \text{kN}$ Maximum Force in Anchor

$M := \text{submatrix}(jc, 1, \text{rows}(jc), 7, 7)$ Moment Effect of Force

$S_M := \sum \text{submatrix}(jc, 1, \text{rows}(jc), 7, 7)$

$S_M = 1607.25\ \text{K\_ft}$ $S_M = 2179.14\ \text{kN\_m}$ Summation of Moment Effect should equal Applied Moment

Anchor Strength:

Shear Strength:

```
if thNDX = 1
    vrb := 0.70·0.6·φb·Ab·Fub
else
    vrb := 0.6·φb·Ab·Fub
```

$v_{rb} = 21.7\ \text{K}$ $v_{rb} = 96.6\ \text{kN}$ Shear Strength per Anchor

Tensile Strength:

$t_{rb} := 0.75 \cdot \varphi_b \cdot A_b \cdot F_{ub}$ $t_{rb} = 38.77\ \text{K}$ $t_{rb} = 172.44\ \text{kN}$ Tensile Strength per Anchor

Bearing Strength:

$b_{rb} := 3 \cdot \varphi_{br} \cdot F_{u2} \cdot \phi_b \cdot t_p$	$b_{rb} = 175.5$ K	$b_{rb} = 780.7$ kN	Bearing Strength per Anchor

Anchor Combined Stresses:

$T_f := F_{max}$	$T_f = 22.88$ K	$T_f = 101.76$ kN	Max Tension Force per Anchor
$V_f := \frac{V_{fy}}{N_b}$	$V_f = 14.29$ K	$V_f = 63.55$ kN	Max Shear Force per Anchor
$cs := \left(\frac{T_f}{t_{rb}}\right)^2 + \left(\frac{V_f}{v_{rb}}\right)^2$	$cs = 0.78$		Combined Stresses

Summary:

Material Property Factors:

$\varphi_s := 0.90$ Rolled Sections

$\varphi_w := 0.67$ Weld

$\varphi_b := 0.80$ Bolt

$\varphi_{br} := 0.80$ Bolt Bearing

$\varphi_u := 0.75$ Block Shear

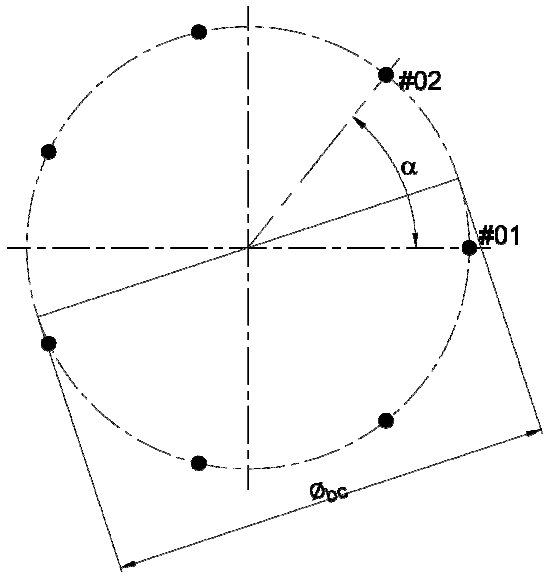
Load Factors:

$\alpha_D := 1.25$

$\alpha_L := 1.5$

$Check\left(\alpha_D \geq 1.25\right) = "...OK"$

$Check\left(\alpha_L \geq 1.5\right) = "...OK"$



Steel Properties: c b a

Structure:

Designation	$desM_1 = "G40.21\text{-}350W"$	
Yield Strength	$f_{y1} = 50\ Ksi$	$f_{y1} = 345\ MPa$
Ultimate Strength	$F_{u1} = 65\ Ksi$	$F_{u1} = 448\ MPa$

Base Plate:

Designation	$desM_2 = "G40.21\text{-}300W"$	
Yield Strength	$f_{y2} = 44\ Ksi$	$f_{y2} = 303\ MPa$
Ultimate Strength	$F_{u2} = 65\ Ksi$	$F_{u2} = 448\ MPa$
Young's Modulus	$E_s = 29000\ Ksi$	$E_s = 2.00 \cdot 10^5\ MPa$
Shear Modulus	$G_s = 11154\ Ksi$	$G_s = 76903\ MPa$
Poisson's Ratio	$\nu = 0.3$	
Density	$\gamma_s = 489\ pcf$	$\gamma_s = 76.8158\ kNpcm$

Anchor:

Designation	$desM_b = "F1554\ Gr\ 55S1"$	
Yield Strength	$f_{yb} = 55\ Ksi$	$f_{yb} = 379\ MPa$
Ultimate Strength	$F_{ub} = 65\ Ksi$	$F_{ub} = 448\ MPa$
Diameter of Bolt	$\phi_b = 1.125\ in$	$\phi_b = 28.6\ mm$
Area of Bolt	$A_b = 0.99\ in^2$	$A_b = 641.3\ mm^2$
Diameter of Hole	$\phi_h = 1.188\ in$	$\phi_h = 30.2\ mm$
Threads Included or Excluded	$des_{th} = "Included"$	
Connection Type	$des_{cn} = "Snug\ Tight"$	

Base Plate Dimensions:

Bolt Circle Diameter	$\phi_{bc} = 469.68\ in$	$\phi_{bc} = 11929.87\ mm$
Base Plate Diameter	$\phi_p = 472.68\ in$	$\phi_p = 12006.07\ mm$
Base Plate Thickness	$t_p = 1.00\ in$	$t_p = 25.40\ mm$
Bolt Edge Distance	$e_1 = 1.50\ in$	$e_1 = 38.10\ mm$

Number of Fasteners	$N_b = 7$	
First Fastener Angle Offset	$\alpha_i = 0.00\ °$	$\alpha_i = 0.00\ rad$
Angle Between Fasteners	$\alpha = 51.43\ °$	$\alpha = 0.90\ rad$

Factored Design Loads:

Factored Moment (X-Axis)	$M_{fx} = 1607.25\ K\_ft$	$M_{fx} = 2179.14\ kN\_m$
Factored Shear (Y-Axis)	$V_{fy} = 100.00\ K$	$V_{fy} = 444.82\ kN$
Factored Axial Load (Z-Axis)	$P_{fz} = 40.00\ K$	$P_{fz} = 177.93\ kN$

Anchor Strength:

Shear Strength per Anchor	$v_{rb} = 21.7\ K$	$v_{rb} = 96.6\ kN$
Tensile Strength per Anchor	$t_{rb} = 38.77\ K$	$t_{rb} = 172.44\ kN$
Bearing Strength per Anchor	$b_{rb} = 175.5\ K$	$b_{rb} = 780.7\ kN$

Anchor Combined Stresses:

Max Tension Force per Anchor	$T_f = 22.88\ K$	$T_f = 101.76\ kN$
Max Shear Force per Anchor	$V_f = 14.29\ K$	$V_f = 63.55\ kN$
Combined Stresses	$cs = 0.78$	

$Check\ (cs \le 1) = "...OK"$