Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17
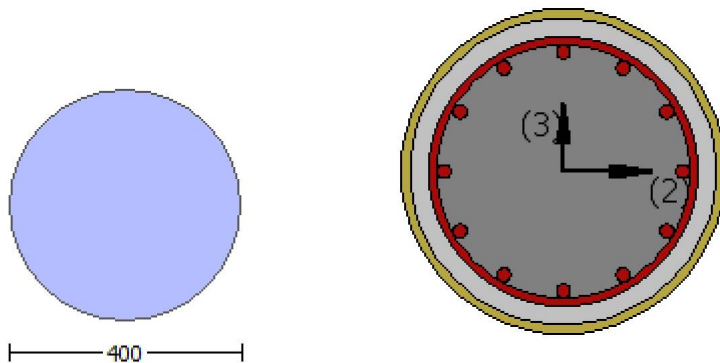
Calculation No. 1

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039

Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3466E+007
Shear Force, Va = -4485.237
EDGE -B-
Bending Moment, Mb = 2677.261
Shear Force, Vb = 4485.237
BOTH EDGES
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 1272.345
    -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
      -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = *Vn = 211415.457
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 264269.321
   VCol = 264269.321
   knl = 1.00
      displacement_ductility_demand = 0.02700807

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
  fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 4.00
     Mu = 1.3466E+007
     Vu = 4485.237
   d = 0.8*D = 320.00

```
   Nu = 4783.19
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 157913.67
     Av =   /2*A_stirrup = 123370.055
     fy = 400.00
     s = 100.00
   Vs is multiplied by   Col = 0.00
     s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin   + cos   is replaced with (cot +cota)sina which is more a generalised expression,
   where    is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( ,  ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with  fu = 0.009
   From (11-11), ACI 440: Vs + Vf < = 213705.936
     bw*d =   *d*d/4 = 80424.772
----------------------------------------------------------

----------------------------------------------------------
displacement_ductility_demand is calculated as   /  y

 - Calculation of   /  y for END A -
 for rotation axis 3 and integ. section (a)
----------------------------------------------------------
From analysis, chord rotation    = 0.00054058
  y = (My*Ls/3)/EIeff = 0.02001558 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.332
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
     Ec*Ig = 2.6413E+013
----------------------------------------------------------
----------------------------------------------------------

Calculation of Yielding Moment My
----------------------------------------------------------
Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
    _ten (7c) = 72.04135
 error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
    _com (7d) = 69.66663
 error of function (7d) = 0.01095904
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.00151397
      N = 4783.19
      Ac = 125663.706
      ((10.1), ASCE 41-17)    = Min( , 1.25*  *(lb/ld)^ 2/3) = 0.42956605
```

with fc* ((12.3), ACI 440) = 25.1414
    fc = 20.00
    fl = 1.64
    k = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.009
     Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

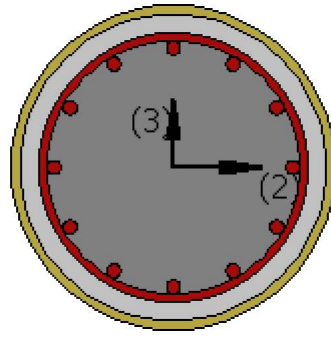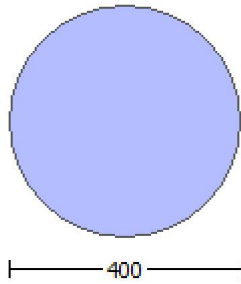
Calculation No. 2

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

```
        -Tension: Aslt = 0.00
      -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876
------------------------------------------------------------
------------------------------------------------------------


Calculation of Shear Capacity ratio , Ve/Vr  =  0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 =  Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 =  Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination


-----------------------------------------------------------------------
Calculation of Mu1+
-----------------------------------------------------------------------


-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-----------------------------------------------------------------------
    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =    *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
-----------------------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00
```

```
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------

------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =    /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------

------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
```

```
    =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
---------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-------------------------------------------------------------------
-------------------------------------------------------------------
-------------------------------------------------------------------
Calculation of Mu2-
-------------------------------------------------------------------

-------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-------------------------------------------------------------------
    = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
---------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-------------------------------------------------------------------
-------------------------------------------------------------------
```


Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
      with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf < = 238930.50
     bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

= 0.90757121
' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
conf. factor c = 1.9158
fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
lb/ld = 0.29836497
d1 = 44.00
R = 200.00
v = 0.00149411
N = 4771.233
Ac = 125663.706
= *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
= 1
db = 18.00
Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
t = 1.00
s = 0.80
e = 1.00
cb = 25.00
Ktr = 4.11234
Atr = /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

= 0.90757121
' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3})$ = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *$Min(1,1.25*(lb/ld)^{2/3})$ = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but $fc^{0.5}$ <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
  Atr = /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3})$ = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *$Min(1,1.25*(lb/ld)^{2/3})$ = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but $fc^{0.5}$ <= 8.3 MPa (22.5.3.1, ACI 318-14)

```
        t = 1.00
        s = 0.80
        e = 1.00
      cb = 25.00
      Ktr = 4.11234
      Atr =   /2 * Area of stirrup = 123.3701
        s = 100.00
        n = 12.00
```


Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.7935525E-012
     Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
     Av =   /2*A_stirrup = 123370.055
     fy = 444.44
      s = 100.00
   Vs is multiplied by   Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, = 45° and   =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
     bw*d =   *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.7935525E-012

Vu = 9.3792788E-032
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175457.879
Av = /2*A_stirrup = 123370.055
fy = 444.44
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 242720.00
f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 1.0702967E-010
Shear Force, V2 = -4485.237
Shear Force, V3 = -5.5836813E-014
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = * θu = 0.00800001
 θu = θy + θp = 0.01000002

 - Calculation of θy -

 θy = (My*Ls/3)/EIeff = 0.01000002 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of θy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  ϕy = 8.7295799E-006
  My_ten (8c) = 1.5848E+008
   ξ_ten (7c) = 72.04135
  error of function (7c) = 0.00084362
  My_com (8d) = 3.8197E+008
   ξ_com (7d) = 69.66663
  error of function (7d) = 0.01095904
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
       eco = 0.002
       apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
       d1 = 44.00
       R = 200.00
       v = 0.00151397
       N = 4783.19
       Ac = 125663.706
       ((10.1), ASCE 41-17) δ = Min(δ, 1.25* δ*(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
     fc = 20.00
     fl = 1.64
     k = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00

efe ((12.5) and (12.7)) = 0.004
 fu = 0.009
 Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
 db = 18.00
 Mean strength value of all re-bars: fy = 444.44
 fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
 cb = 25.00
 Ktr = 4.11234
  Atr =   /2 * Area of stirrup = 123.3701
  s = 100.00
  n = 12.00

 - Calculation of   p -

From table 10-9:   p = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.27120072
  d = 0.00
  s = 0.00
   t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  Av = 78.53982, is the area of the circular stirrup
  dc = D - 2*cover - Hoop Diameter = 340.00
  The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
  where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises   f to steel strength
  All these variables have already been given in Shear control ratio calculation.
   NUD = 4783.19
   Ag = 125663.706
   f'cE = 20.00
   fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
   f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.0702967E-010
Shear Force, Va = -5.5836813E-014
EDGE -B-
Bending Moment, Mb = 6.0269141E-011
Shear Force, Vb = 5.5836813E-014
BOTH EDGES
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 251866.165
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314832.706
   VCol = 314832.706
   knl = 1.00
      displacement_ductility_demand = 0.00

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 1.0702967E-010
     Vu = 5.5836813E-014
  d = 0.8*D = 320.00
  Nu = 4783.19
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 157913.67
     Av =   /2*A_stirrup = 123370.055
     fy = 400.00
     s = 100.00
  Vs is multiplied by   Col = 0.00
     s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,   =45° and   =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 213705.936
     bw*d =   *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as   / y

 - Calculation of   / y for END A -
 for rotation axis 2 and integ. section (a)

From analysis, chord rotation   = 1.4714309E-020
 y = (My*Ls/3)/EIeff = 0.01000002 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04135
  error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66663
  error of function (7d) = 0.01095904
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
       eco = 0.002
       apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
       d1 = 44.00
       R = 200.00
       v = 0.00151397
       N = 4783.19
       Ac = 125663.706
       ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.42956605
  with fc* ((12.3), ACI 440) = 25.1414
     fc = 20.00
     fl = 1.64
     k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.009
     Ef = 82000.00

Calculation of ratio lb/ld
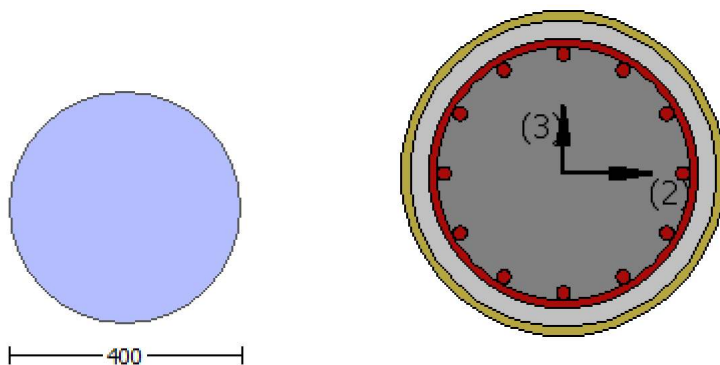---
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00

Ktr = 4.11234
Atr =   /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform + X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
   -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121

```
 ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
     Atr =    /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------------

----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
----------------------------------------------------------------------
   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
```

Mean strength value of all re-bars: fy = 555.55
    fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
    cb = 25.00
    Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

     = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
          =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
    cb = 25.00
    Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

     = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc*ψc = 38.31603
  conf. factor ψc = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by λCol = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    ψf = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sinβ + cosβ is replaced with (cotθ+cotα)sinα which is more a generalised expression,
  where θ is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(α,θ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, θ =45° and θ =-45° to take into consideration the cyclic seismic loading.
  orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
   -Compression: Asl,com = 1017.876
      -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

```
-----------------------------------------------------------------------
Calculation of Mu1+
-----------------------------------------------------------------------


-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-----------------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
  Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Mu1-
-----------------------------------------------------------------------


-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-----------------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
      Vu = 9.3792788E-032
    d = 0.8*D = 320.00
    Nu = 4771.233
    Ag = 125663.706
    From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00

Vs is multiplied by Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
    wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
      Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av = /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
    wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.3466E+007
Shear Force, V2 = -4485.237
Shear Force, V3 = -5.5836813E-014
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R = * u = 0.01601247
 u = y + p = 0.02001558

 - Calculation of y -
----
 y = (My*Ls/3)/Eleff = 0.02001558 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3002.332
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30

```
        Ag = 125663.706
        fc' = 20.00
         N = 4783.19
     Ec*Ig = 2.6413E+013
---------------------------------------------------------
---------------------------------------------------------

Calculation of Yielding Moment My
---------------------------------------------------------
Calculation of  y and My according to (7) - (8) in Biskinis and Fardis
---------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04135
 error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66663
 error of function (7d) = 0.01095904
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
        eco = 0.002
        apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
        d1 = 44.00
        R = 200.00
        v = 0.00151397
        N = 4783.19
        Ac = 125663.706
        ((10.1), ASCE 41-17)    = Min(  , 1.25*   *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00
---------------------------------------------------------
---------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 444.44
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
   cb = 25.00
   Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00


---------------------------------------------------------
 - Calculation of  p -
---------------------------------------------------------
From table 10-9:  p = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VColOE = 0.27120072
   d = 0.00
   s = 0.00
```

t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4783.19
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

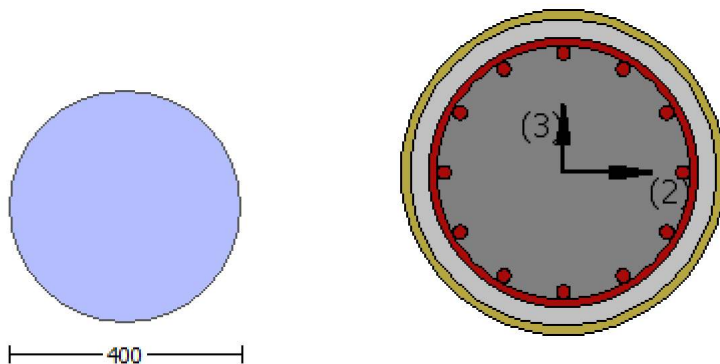
Calculation No. 5

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.3466E+007
Shear Force, Va = -4485.237
EDGE -B-
Bending Moment, Mb = 2677.261
Shear Force, Vb = 4485.237
BOTH EDGES
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 251866.165
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314832.706
   VCol = 314832.706
   knl = 1.00
       displacement_ductility_demand = 0.12748842

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
      Mu = 2677.261
      Vu = 4485.237
    d = 0.8*D = 320.00
    Nu = 4783.19
    Ag = 125663.706
    From (11.5.4.8), ACI 318-14: Vs = 157913.67
      Av =   /2*A_stirrup = 123370.055
      fy = 400.00
      s = 100.00
    Vs is multiplied by   Col = 0.00
      s/d = 0.3125
    Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
    wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.009
    From (11-11), ACI 440: Vs + Vf < = 213705.936
      bw*d =   *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as   / y

 - Calculation of / y for END B -
 for rotation axis 3 and integ. section (b)

From analysis, chord rotation   = 0.00025498
  y = (My*Ls/3)/Eleff = 0.002 ((4.29),Biskinis Phd))
   My = 1.5848E+008
   Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
   From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
      factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
      Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
  My_ten (8c) = 1.5848E+008
    _ten (7c) = 72.04135
  error of function (7c) = 0.00084362
  My_com (8d) = 3.8197E+008
    _com (7d) = 69.66663
  error of function (7d) = 0.01095904
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00

```
     v = 0.00151397
     N = 4783.19
     Ac = 125663.706
     ((10.1), ASCE 41-17)    = Min( , 1.25*  *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
    fc = 20.00
    fl = 1.64
    k  = 1
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.009
    Ef = 82000.00
```


Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
```
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 444.44
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
    Atr =  /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00
```

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

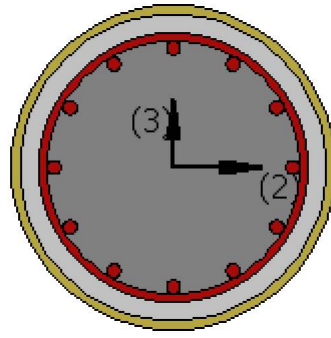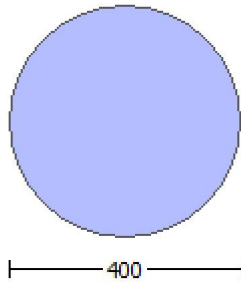
Calculation No. 6

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

```
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876
------------------------------------------------------------
------------------------------------------------------------


Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination


--------------------------------------------------------------------------
Calculation of Mu1+
--------------------------------------------------------------------------


--------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
--------------------------------------------------------------------------
    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor  c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
         N = 4771.233
         Ac = 125663.706
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
   cb = 25.00
   Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00
```

```
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------

---------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
---------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
---------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------

---------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
---------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
```

```
  =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
----------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------

--------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
--------------------------------------------------------------
   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
  conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
----------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00
--------------------------------------------------------------
--------------------------------------------------------------
```

```
-------------------------------------------------------------------
-------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387
-------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
   -----------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
   -----------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 6.5550131E-012
      Vu = 3.0148615E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by  Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where  is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  = 45° and  = -45° to take into consideration the cyclic seismic loading.
   orientation 1:  1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with  fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772
   -----------------------------------------------------------
   -----------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
   -----------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
   -----------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 6.5550131E-012
      Vu = 3.0148615E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by  Col = 0.00
      s/d = 0.3125
```

Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
 where   is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
 as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
 orientation 1:   1 = b1 + 90° = 90.00
 Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
 total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf < = 238930.50
    bw*d =   *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
     -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
     -Tension: Asl,ten = 1017.876
   -Compression: Asl,com = 1017.876
      -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  t = 1.00
  s = 0.80
  e = 1.00
cb = 25.00
Ktr = 4.11234
  Atr = /2 * Area of stirrup = 123.3701
  s = 100.00
  n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

```
         t = 1.00
         s = 0.80
         e = 1.00
       cb = 25.00
      Ktr = 4.11234
       Atr =   /2 * Area of stirrup = 123.3701
         s = 100.00
         n = 12.00
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387
--------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)
------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
     = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.7935525E-012
     Vu = 9.3792788E-032
   d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av =   /2*A_stirrup = 123370.055
    fy = 444.44
     s = 100.00
  Vs is multiplied by   Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,  = 45° and  = -45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with   fu = 0.009
  From (11-11), ACI 440: Vs + Vf < = 238930.50
    bw*d =   *d*d/4 = 80424.772
------------------------------------------------------------
------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)
------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
     = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.7935525E-012
```

Vu = 9.3792788E-032
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175457.879
Av = /2*A_stirrup = 123370.055
fy = 444.44
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 242720.00
f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 6.0269141E-011
Shear Force, V2 = 4485.237
Shear Force, V3 = 5.5836813E-014
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity   u,R =   * u = 0.00800001
  u =   y +   p = 0.01000002

 - Calculation of   y -
----
 y = (My*Ls/3)/EIeff = 0.01000002 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
    Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04135
 error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66663
 error of function (7d) = 0.01095904
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.00151397
      N = 4783.19
      Ac = 125663.706
      ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
     fc = 20.00
     fl = 1.64
     k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00

efe ((12.5) and (12.7)) = 0.004
  fu = 0.009
  Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

 - Calculation of   p -

From table 10-9:   p = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VCol0E = 0.27120072
  d = 0.00
  s = 0.00
   t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  Av = 78.53982, is the area of the circular stirrup
  dc = D - 2*cover - Hoop Diameter = 340.00
  The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
  where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises   f to steel strength
  All these variables have already been given in Shear control ratio calculation.
   NUD = 4783.19
   Ag = 125663.706
   f'cE = 20.00
   fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
   f'cE = 20.00
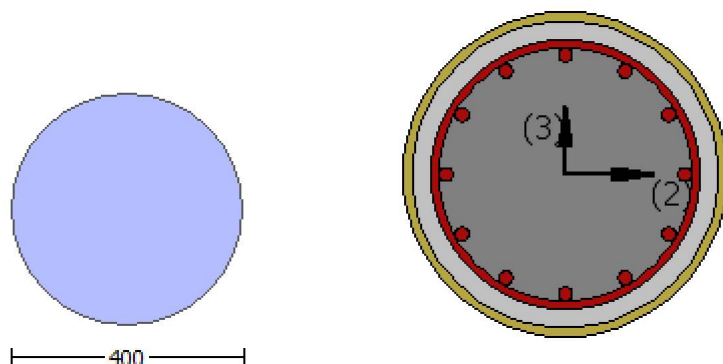---
End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.0702967E-010
Shear Force, Va = -5.5836813E-014
EDGE -B-
Bending Moment, Mb = 6.0269141E-011
Shear Force, Vb = 5.5836813E-014
BOTH EDGES
Axial Force, F = -4783.19
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = *Vn = 251866.165
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314832.706
  VCol = 314832.706
  knl = 1.00
     displacement_ductility_demand = 0.00

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
 fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
    Mu = 6.0269141E-011
    Vu = 5.5836813E-014
 d = 0.8*D = 320.00
 Nu = 4783.19
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 157913.67
    Av =   /2*A_stirrup = 123370.055
    fy = 400.00
    s = 100.00
 Vs is multiplied by   Col = 0.00
    s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
 where   is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
 as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
 orientation 1: 1 = b1 + 90° = 90.00
 Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
 total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 213705.936
    bw*d =   *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as   / y

 - Calculation of   / y for END B -
 for rotation axis 2 and integ. section (b)

From analysis, chord rotation   = 3.7985701E-022
 y = (My*Ls/3)/Eleff = 0.01000002 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04135
 error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66663
 error of function (7d) = 0.01095904
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.00151397
      N = 4783.19
      Ac = 125663.706
      ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k   = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00

Calculation of ratio lb/ld
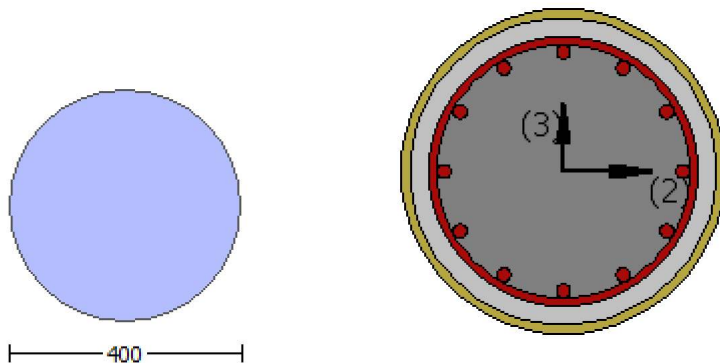---
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
  cb = 25.00

Ktr = 4.11234
Atr = /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 8

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (3)

─── 400 ───

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121

' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00

Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc*ʎc = 38.31603
  conf. factor ʎc = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    ψt = 1.00
    ψs = 0.80
    ψe = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = ʎ/2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   ʎ = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = ʎ/2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by λCol = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
   ψf = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sinβ + cosβ is replaced with (cotθ+cotα)sinα which is more a generalised expression,
  where θ is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(α,θ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
  orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

```
-------------------------------------------------------------------------
Calculation of Mu1+
-------------------------------------------------------------------------


-------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-------------------------------------------------------------------------
   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Mu1-
-------------------------------------------------------------------------


-------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-------------------------------------------------------------------------
   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
      Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
     Av =   /2*A_stirrup = 123370.055
     fy = 444.44
     s = 100.00

Vs is multiplied by Col = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
 where   is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
 as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
 orientation 1:   1 = b1 + 90° = 90.00
 Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
 total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.009
 From (11-11), ACI 440: Vs + Vf < = 238930.50
   bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
 VCol0 = 351879.387
 knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
 fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
   Mu = 9.7935525E-012
   Vu = 9.3792788E-032
 d = 0.8*D = 320.00
 Nu = 4771.233
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 175457.879
   Av = /2*A_stirrup = 123370.055
   fy = 444.44
   s = 100.00
 Vs is multiplied by Col = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
 where   is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
 as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
 orientation 1:   1 = b1 + 90° = 90.00
 Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
 total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.009
 From (11-11), ACI 440: Vs + Vf < = 238930.50
   bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, $fc = fcm = 20.00$
Existing material of Secondary Member: Steel Strength, $fs = fsm = 444.44$
Concrete Elasticity, $Ec = 21019.039$
Steel Elasticity, $Es = 200000.00$
Diameter, $D = 400.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length $lb = 300.00$
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, $t = 1.00$
Tensile Strength, $ffu = 840.00$
Tensile Modulus, $Ef = 82000.00$
Elongation, $efu = 0.009$
Number of directions, $NoDir = 1$
Fiber orientations, bi: 0.00°
Number of layers, $NL = 1$
Radius of rounding corners, $R = 40.00$

Stepwise Properties

Bending Moment, $M = 2677.261$
Shear Force, $V2 = 4485.237$
Shear Force, $V3 = 5.5836813E-014$
Axial Force, $F = -4783.19$
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: $Aslt = 0.00$
    -Compression: $Aslc = 3053.628$
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: $Asl,ten = 1017.876$
    -Compression: $Asl,com = 1017.876$
       -Middle: $Asl,mid = 1017.876$
Mean Diameter of Tension Reinforcement, $DbL = 18.00$

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity   u,R =   * u = 0.0016
  u =   y +   p = 0.002

 - Calculation of y -
----
 y = (My*Ls/3)/EIeff = 0.002 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30

```
        Ag = 125663.706
        fc' = 20.00
        N = 4783.19
     Ec*Ig = 2.6413E+013
-----------------------------------------------------------
-----------------------------------------------------------

Calculation of Yielding Moment My
-----------------------------------------------------------
Calculation of  y and My according to (7) - (8) in Biskinis and Fardis
-----------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295799E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04135
 error of function (7c) = 0.00084362
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66663
 error of function (7d) = 0.01095904
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.00151397
      N = 4783.19
      Ac = 125663.706
      ((10.1), ASCE 41-17)   = Min( , 1.25* *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k  = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00
-----------------------------------------------------------
-----------------------------------------------------------


Calculation of ratio lb/ld
-----------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 444.44
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
    cb = 25.00
   Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00


-----------------------------------------------------------
 - Calculation of   p -
-----------------------------------------------------------
From table 10-9:   p = 0.00
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VColOE = 0.27120072
   d = 0.00
   s = 0.00
```

t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  Av = 78.53982, is the area of the circular stirrup
  dc = D - 2*cover - Hoop Diameter = 340.00
  The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
  where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
  All these variables have already been given in Shear control ratio calculation.
    NUD = 4783.19
    Ag = 125663.706
    f'cE = 20.00
    fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
    f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

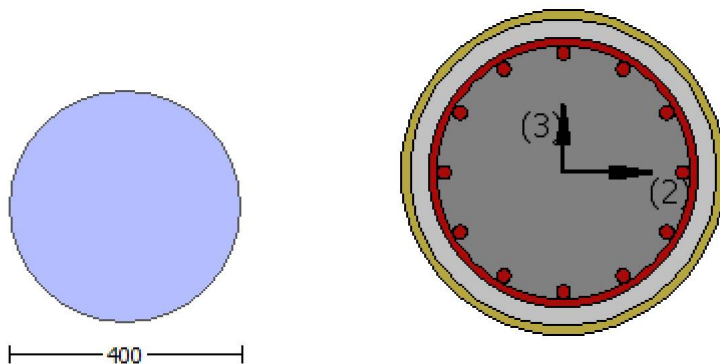
Calculation No. 9

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.2368E+007
Shear Force, Va = -4120.316
EDGE -B-
Bending Moment, Mb = 881.7217
Shear Force, Vb = 4120.316
BOTH EDGES
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 211414.738
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 264268.422
   VCol = 264268.422
   knl = 1.00
      displacement_ductility_demand = 0.02230181

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 4.00
   Mu = 1.2368E+007
   Vu = 4120.316
  d = 0.8*D = 320.00
  Nu = 4774.113
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 157913.67
   Av = /2*A_stirrup = 123370.055
   fy = 400.00
   s = 100.00
  Vs is multiplied by Col = 0.00
   s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
     with fu = 0.009
  From (11-11), ACI 440: Vs + Vf < = 213705.936
   bw*d = *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as / y

 - Calculation of / y for END A -
 for rotation axis 3 and integ. section (a)

From analysis, chord rotation   = 0.0004463
 y = (My*Ls/3)/EIeff = 0.02001164 ((4.29),Biskinis Phd))
 My = 1.5848E+008
 Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.765
 From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
  factor = 0.30
   Ag = 125663.706
   fc' = 20.00
   N = 4774.113
  Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
 y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
  _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
  _com (7d) = 69.66654
 error of function (7d) = 0.01096192
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0022222
   eco = 0.002
   apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
   d1 = 44.00
   R = 200.00

$v = 0.0015111$

$N = 4774.113$

$Ac = 125663.706$

((10.1), ASCE 41-17) = Min(, 1.25* *(lb/ld)^2/3) = 0.42956605

with fc* ((12.3), ACI 440) = 25.1414

fc = 20.00

fl = 1.64

k = 1

Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00

efe ((12.5) and (12.7)) = 0.004

fu = 0.009

Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621

lb = 300.00

ld = 804.384

Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

= 1

db = 18.00

Mean strength value of all re-bars: fy = 444.44

fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

t = 1.00

s = 0.80

e = 1.00

cb = 25.00

Ktr = 4.11234

Atr = /2 * Area of stirrup = 123.3701

s = 100.00

n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1

At local axis: 2

Integration Section: (a)

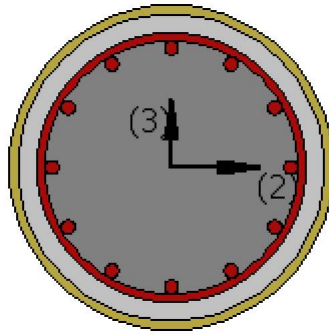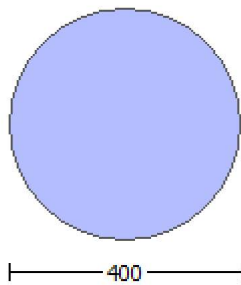
Calculation No. 10

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
      -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
         -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
         N = 4771.233
         Ac = 125663.706
         = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
   cb = 25.00
   Ktr = 4.11234
      Atr = /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706

```
 =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------

----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
----------------------------------------------------------------
   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00
----------------------------------------------------------------
----------------------------------------------------------------
```


Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
    wf/sf = 1 (FRP strips adjacent to one another).
    In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
    where is the angle of the crack direction (see KANEPE).
    This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
    as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
    orientation 1: 1 = b1 + 90° = 90.00
    Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
    total thickness per orientation, tf1 = NL*t/NoDir = 1.00
    dfv = d (figure 11.2, ACI 440) = 370.00
    ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
        with fu = 0.009
   From (11-11), ACI 440: Vs + Vf < = 238930.50
      bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00

Mean strength value of all re-bars: fy = 555.55
    fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
        t = 1.00
        s = 0.80
        e = 1.00
      cb = 25.00
      Ktr = 4.11234
        Atr =   /2 * Area of stirrup = 123.3701
        s = 100.00
        n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
    conf. factor c = 1.9158
    fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
        lb/ld = 0.29836497
        d1 = 44.00
        R = 200.00
        v = 0.00149411
          N = 4771.233
          Ac = 125663.706
          =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
        = 1
      db = 18.00
      Mean strength value of all re-bars: fy = 555.55
      fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
        t = 1.00
        s = 0.80
        e = 1.00
      cb = 25.00
      Ktr = 4.11234
        Atr =   /2 * Area of stirrup = 123.3701
        s = 100.00
        n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
     =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
 ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
     =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

```
        t = 1.00
        s = 0.80
        e = 1.00
       cb = 25.00
      Ktr = 4.11234
      Atr =   /2 * Area of stirrup = 123.3701
        s = 100.00
        n = 12.00
-----------------------------------------------------------------
-----------------------------------------------------------------
-----------------------------------------------------------------
-----------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387
-----------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
      Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by   Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with  fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772
------------------------------------------------------------
------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
------------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
```

Vu = 9.3792788E-032
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175457.879
Av = /2*A_stirrup = 123370.055
fy = 444.44
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 242720.00
f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 8.2089604E-011
Shear Force, V2 = -4120.316
Shear Force, V3 = -4.3946636E-014
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta_{u,R}$ =   * θ_u = 0.04159995
 θ_u = θ_y + θ_p = 0.05199994

 - Calculation of θ_y -

 θ_y = (My*Ls/3)/Eleff = 0.00999994 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4774.113
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of ϕ_y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  ϕ_y = 8.7295410E-006
  My_ten (8c) = 1.5848E+008
    ξ_ten (7c) = 72.04104
  error of function (7c) = 0.00084335
  My_com (8d) = 3.8197E+008
    ξ_com (7d) = 69.66654
  error of function (7d) = 0.01096192
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
       eco = 0.002
       apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
       d1 = 44.00
       R = 200.00
       v = 0.0015111
       N = 4774.113
       Ac = 125663.706
       ((10.1), ASCE 41-17) ε = Min(ε, 1.25* ε*(lb/ld)^2/3) = 0.42956605
  with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00

efe ((12.5) and (12.7)) = 0.004
fu = 0.009
Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

 - Calculation of θp -

From table 10-9: θp = 0.042
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VColOE = 0.27120072
  λd = 0.00
  λs = 0.00
  ρt = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  Av = 78.53982, is the area of the circular stirrup
  dc = D - 2*cover - Hoop Diameter = 340.00
  The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
  where ρf = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises ρf to steel strength
  All these variables have already been given in Shear control ratio calculation.
  NUD = 4774.113
  Ag = 125663.706
  f'cE = 20.00
  fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
  f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11
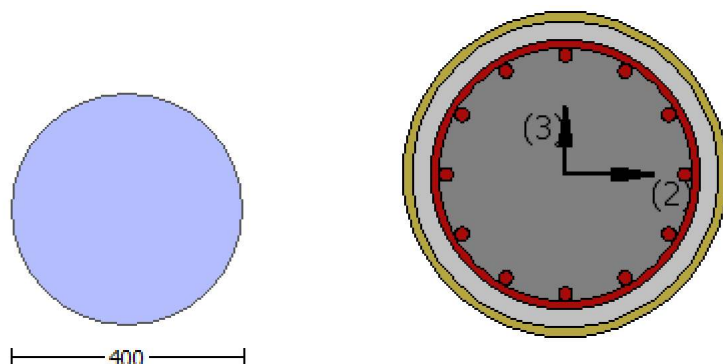
column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 8.2089604E-011
Shear Force, Va = -4.3946636E-014
EDGE -B-
Bending Moment, Mb = 4.9623746E-011
Shear Force, Vb = 4.3946636E-014
BOTH EDGES
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 251864.727
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.908
   VCol = 314830.908
   knl = 1.00
      displacement_ductility_demand = 0.00

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
 fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
     Mu = 8.2089604E-011
     Vu = 4.3946636E-014
  d = 0.8*D = 320.00
  Nu = 4774.113
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 157913.67
     Av =   /2*A_stirrup = 123370.055
     fy = 400.00
     s = 100.00
  Vs is multiplied by   Col = 0.00
     s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 213705.936
     bw*d =   *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as   / y

 - Calculation of   / y for END A -
 for rotation axis 2 and integ. section (a)

From analysis, chord rotation   = 8.8095796E-021
 y = (My*Ls/3)/EIeff = 0.00999994 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
        Ag = 125663.706
        fc' = 20.00
        N = 4774.113
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.0015111
      N = 4774.113
      Ac = 125663.706
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00

Calculation of ratio lb/ld

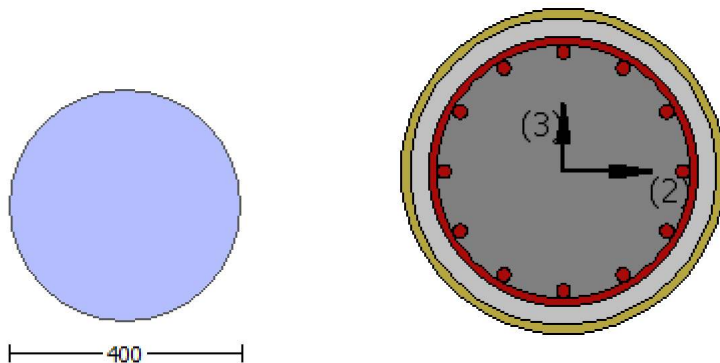Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00

Ktr = 4.11234
Atr = /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 12

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121

' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00

Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
     cb = 25.00
     Ktr = 4.11234
      Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

     = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
     cb = 25.00
     Ktr = 4.11234
      Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

     = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc*Ω c = 38.31603
  conf. factor Ω c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = ε*Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   ψ = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   ψt = 1.00
   ψs = 0.80
   ψe = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = π/2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   λ = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = π/2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by λCol = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
   ψf = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sinβ + cosβ is replaced with (cotθ +cotα)sinα which is more a generalised expression,
  where θ is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(α,θ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, θ =45° and θ =-45° to take into consideration the cyclic seismic loading.
  orientation 1: α1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 6.5550131E-012
      Vu = 3.0148615E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by   Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
     -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
     -Tension: Asl,ten = 1017.876
   -Compression: Asl,com = 1017.876
     -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
  Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
  Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
  Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
  Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
   cb = 25.00
   Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
     s = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

     = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 9.7935525E-012
     Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
     Av =   /2*A_stirrup = 123370.055
     fy = 444.44
     s = 100.00

Vs is multiplied by ΦCol = 0.00
   s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 242720.00
   Ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinβ + cosβ is replaced with (cotθ +cotα)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ, α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
    εfe = 0.004, from (11.6a), ACI 440
     with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
   bw*d = π*d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+Ψf*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

  λ = 1 (normal-weight concrete)
 fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
   Mu = 9.7935525E-012
   Vu = 9.3792788E-032
 d = 0.8*D = 320.00
 Nu = 4771.233
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 175457.879
   Av = π/2*A_stirrup = 123370.055
   fy = 444.44
   s = 100.00
 Vs is multiplied by ΦCol = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   Ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinβ + cosβ is replaced with (cotθ +cotα)sina which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ, α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
    εfe = 0.004, from (11.6a), ACI 440
     with εfu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
   bw*d = π*d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.2368E+007
Shear Force, V2 = -4120.316
Shear Force, V3 = -4.3946636E-014
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 1272.345
    -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R = * u = 0.04960931
  u = y + p = 0.06201164

 - Calculation of y -
----
 y = (My*Ls/3)/Eleff = 0.02001164 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3001.765
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
    factor = 0.30

```
        Ag = 125663.706
        fc' = 20.00
        N = 4774.113
     Ec*Ig = 2.6413E+013
------------------------------------------------------------
------------------------------------------------------------

Calculation of Yielding Moment My
------------------------------------------------------------
Calculation of  y and My according to (7) - (8) in Biskinis and Fardis
------------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.0015111
      N = 4774.113
      Ac = 125663.706
      ((10.1), ASCE 41-17)    = Min(  , 1.25*  *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00
------------------------------------------------------------
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00


------------------------------------------------------------
 - Calculation of  p -
------------------------------------------------------------
From table 10-9:  p = 0.042
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VColOE = 0.27120072
   d = 0.00
   s = 0.00
```

t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4774.113
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (a)

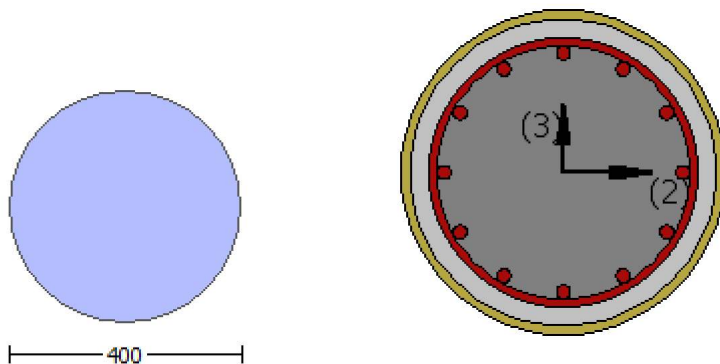
Calculation No. 13

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.2368E+007
Shear Force, Va = -4120.316
EDGE -B-
Bending Moment, Mb = 881.7217
Shear Force, Vb = 4120.316
BOTH EDGES
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
       -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
       -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 251864.727
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.908
   VCol = 314830.908
   knl = 1.00
      displacement_ductility_demand = 0.11706805

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
  fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
   Mu = 881.7217
   Vu = 4120.316
 d = 0.8*D = 320.00
 Nu = 4774.113
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 157913.67
   Av =   /2*A_stirrup = 123370.055
   fy = 400.00
   s = 100.00
 Vs is multiplied by   Col = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
 where   is the angle of the crack direction (see KANEPE).
 This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
 as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
 orientation 1:   1 = b1 + 90° = 90.00
 Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
 total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
   Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.009
 From (11-11), ACI 440: Vs + Vf < = 213705.936
   bw*d =   *d*d/4 = 80424.772

----
displacement_ductility_demand is calculated as   / y

 - Calculation of   / y for END B -
 for rotation axis 3 and integ. section (b)

From analysis, chord rotation   = 0.00023413
  y = (My*Ls/3)/EIeff = 0.00199999 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
    factor = 0.30
       Ag = 125663.706
       fc' = 20.00
       N = 4774.113
    Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0022222
     eco = 0.002
     apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
     d1 = 44.00
     R = 200.00

```
    v = 0.0015111
    N = 4774.113
    Ac = 125663.706
    ((10.1), ASCE 41-17)    = Min( , 1.25* *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
    fc = 20.00
    fl = 1.64
    k  = 1
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.009
    Ef = 82000.00
--------------------------------------------------------------
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =  /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
--------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)


--------------------------------------------------------------
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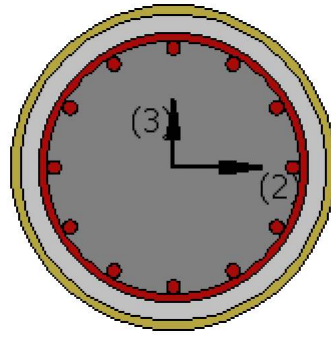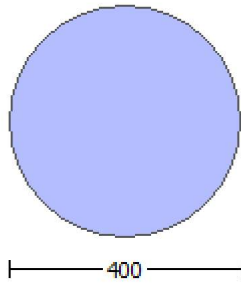
Calculation No. 14

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)

-Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706

```
=    *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
    bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by Col = 0.00
    s/d = 0.3125

Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   = 45° and   = -45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
  From (11-11), ACI 440: Vs + Vf < = 238930.50
    bw*d =   *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

    = 0.90757121
    ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
     lb/ld = 0.29836497
     d1 = 44.00
     R = 200.00
     v = 0.00149411
       N = 4771.233
       Ac = 125663.706
       = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
   db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  t = 1.00
  s = 0.80
  e = 1.00
cb = 25.00
Ktr = 4.11234
  Atr = /2 * Area of stirrup = 123.3701
  s = 100.00
  n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
 ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr = /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

  = 0.90757121
 ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

```
      t = 1.00
      s = 0.80
      e = 1.00
    cb = 25.00
   Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00
-----------------------------------------------------------------
-----------------------------------------------------------------
-----------------------------------------------------------------
-----------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387
-----------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
-------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
      Vu = 9.3792788E-032
   d = 0.8*D = 320.00
   Nu = 4771.233
   Ag = 125663.706
   From (11.5.4.8), ACI 318-14: Vs = 175457.879
      Av =   /2*A_stirrup = 123370.055
      fy = 444.44
      s = 100.00
   Vs is multiplied by   Col = 0.00
      s/d = 0.3125
   Vf ((11-3)-(11.4), ACI 440) = 242720.00
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where    is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
   dfv = d (figure 11.2, ACI 440) = 370.00
   ffe ((11-5), ACI 440) = 328.00
      Ef = 82000.00
       fe = 0.004, from (11.6a), ACI 440
         with   fu = 0.009
   From (11-11), ACI 440: Vs + Vf <= 238930.50
      bw*d =   *d*d/4 = 80424.772
-----------------------------------------------------------
-----------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 351879.387
   knl = 1 (zero step-static loading)
-------------------------------------------------------------
NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+  f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).
-------------------------------------------------------------
      = 1 (normal-weight concrete)
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.7935525E-012
```

Vu = 9.3792788E-032
d = 0.8*D = 320.00
Nu = 4771.233
Ag = 125663.706
From (11.5.4.8), ACI 318-14: Vs = 175457.879
Av = /2*A_stirrup = 123370.055
fy = 444.44
s = 100.00
Vs is multiplied by Col = 0.00
s/d = 0.3125
Vf ((11-3)-(11.4), ACI 440) = 242720.00
f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
Ef = 82000.00
fe = 0.004, from (11.6a), ACI 440
with fu = 0.009
From (11-11), ACI 440: Vs + Vf <= 238930.50
bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 4.9623746E-011
Shear Force, V2 = 4120.316
Shear Force, V3 = 4.3946636E-014
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
          -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = * θu = 0.04159995
 θu = θy + θp = 0.05199994

 - Calculation of θy -

 θy = (My*Ls/3)/Eleff = 0.00999994 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30
         Ag = 125663.706
         fc' = 20.00
         N = 4774.113
     Ec*Ig = 2.6413E+013

Calculation of Yielding Moment My

Calculation of ϕy and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5848E+008
 ϕy = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   ξ_ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   ξ_com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.0015111
      N = 4774.113
      Ac = 125663.706
      ((10.1), ASCE 41-17) ε = Min(ε, 1.25* ε*(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00

efe ((12.5) and (12.7)) = 0.004
  fu = 0.009
  Ef = 82000.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
  Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

 - Calculation of   p -

From table 10-9:   p = 0.042
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
  shear control ratio VyE/VColOE = 0.27120072
  d = 0.00
  s = 0.00
    t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
  Av = 78.53982, is the area of the circular stirrup
  dc = D - 2*cover - Hoop Diameter = 340.00
  The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
  where   f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises   f to steel strength
  All these variables have already been given in Shear control ratio calculation.
    NUD = 4774.113
    Ag = 125663.706
    f'cE = 20.00
    fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
    f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15
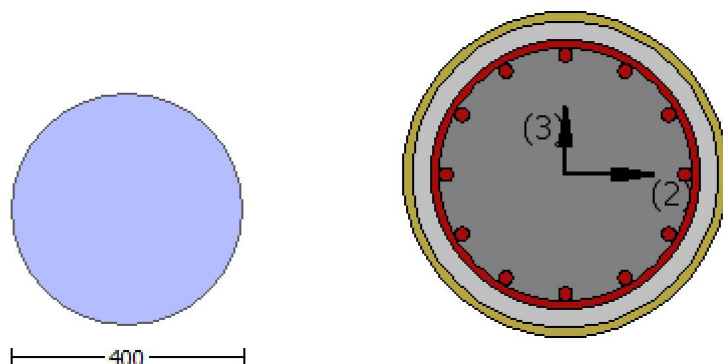
column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor,   = 0.80
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Secondary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, ASCE41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE41-17).
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.44
##
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1

Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 8.2089604E-011
Shear Force, Va = -4.3946636E-014
EDGE -B-
Bending Moment, Mb = 4.9623746E-011
Shear Force, Vb = 4.3946636E-014
BOTH EDGES
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 251864.727
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 314830.908
   VCol = 314830.908
   knl = 1.00
       displacement_ductility_demand = 0.00

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
 fc' = 16.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
    Mu = 4.9623746E-011
    Vu = 4.3946636E-014
 d = 0.8*D = 320.00
 Nu = 4774.113
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 157913.67
    Av =   /2*A_stirrup = 123370.055
    fy = 400.00
    s = 100.00
 Vs is multiplied by   Col = 0.00
    s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
 In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,   =45° and   =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.00
 dfv = d (figure 11.2, ACI 440) = 370.00
 ffe ((11-5), ACI 440) = 328.00
    Ef = 82000.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.009
 From (11-11), ACI 440: Vs + Vf <= 213705.936
    bw*d =   *d*d/4 = 80424.772

```
--------------------------------------------------------------

--------------------------------------------------------------
displacement_ductility_demand is calculated as   / y

 - Calculation of   /  y for END B -
 for rotation axis 2 and integ. section (b)
--------------------------------------------------------------
From analysis, chord rotation    = 4.6075130E-022
  y = (My*Ls/3)/EIeff = 0.00999994 ((4.29),Biskinis Phd))
   My = 1.5848E+008
   Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 1500.00
   From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 7.9240E+012
      factor = 0.30
         Ag = 125663.706
         fc' = 20.00
         N = 4774.113
      Ec*Ig = 2.6413E+013
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of Yielding Moment My
-------------------------------------------------------------
Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
-------------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0022222
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 200.00
      v = 0.0015111
      N = 4774.113
      Ac = 125663.706
      ((10.1), ASCE 41-17)   = Min(  , 1.25*  *(lb/ld)^ 2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
      fc = 20.00
      fl = 1.64
      k   = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.009
      Ef = 82000.00
-------------------------------------------------------------
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^ 0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
     t = 1.00
     s = 0.80
     e = 1.00
  cb = 25.00
```
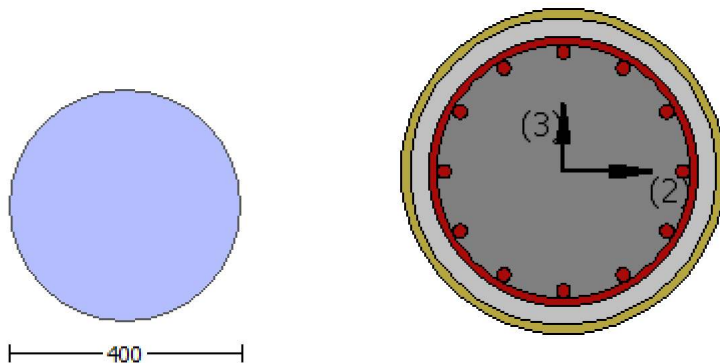
Ktr = 4.11234
Atr = /2 * Area of stirrup = 123.3701
s = 100.00
n = 12.00

End Of Calculation of Shear Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

Limit State: Collapse Prevention (data interpolation between analysis steps 2 and 3)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
##

Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 3.0148615E-032
EDGE -B-
Shear Force, Vb = -3.0148615E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
     -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
     -Tension: Asl,ten = 1017.876
   -Compression: Asl,com = 1017.876
     -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
   Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction which is defined for the static loading combination
   Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
   Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction which is defined for the the static loading combination
   Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment direction which is defined for the the static loading combination

----
Calculation of Mu1+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121

' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.55
   fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
      t = 1.00
      s = 0.80
      e = 1.00
   cb = 25.00
   Ktr = 4.11234
     Atr =   /2 * Area of stirrup = 123.3701
      s = 100.00
      n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
   conf. factor   c = 1.9158
   fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
      lb/ld = 0.29836497
      d1 = 44.00
      R = 200.00
      v = 0.00149411
        N = 4771.233
        Ac = 125663.706
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
      = 1
   db = 18.00

Mean strength value of all re-bars: fy = 555.55
fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   t = 1.00
   s = 0.80
   e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519

From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 6.5550131E-012
    Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av =   /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00
  Vs is multiplied by   Col = 0.00
    s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
     bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

    = 1 (normal-weight concrete)
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 6.5550131E-012
     Vu = 3.0148615E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
     Av = /2*A_stirrup = 123370.055
     fy = 444.44
     s = 100.00
  Vs is multiplied by Col = 0.00
     s/d = 0.3125
  Vf ((11-3)-(11.4), ACI 440) = 242720.00
     f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.00
  dfv = d (figure 11.2, ACI 440) = 370.00
  ffe ((11-5), ACI 440) = 328.00
     Ef = 82000.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.009
  From (11-11), ACI 440: Vs + Vf <= 238930.50
     bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Mean strength values are used for both shear and moment calculations.

Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Existing material: Steel Strength, fs = 1.25*fsm = 555.55
###
Diameter, D = 400.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.9158
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = 9.3792788E-032
EDGE -B-
Shear Force, Vb = -9.3792788E-032
BOTH EDGES
Axial Force, F = -4771.233
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876

Calculation of Shear Capacity ratio , Ve/Vr = 0.27120072
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 95429.943
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.4314E+008
  Mu1+ = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the actual moment direction
which is defined for the static loading combination
  Mu1- = 1.4314E+008, is the ultimate moment strength at the edge 1 of the member in the opposite moment
direction which is defined for the static loading combination
Mpr2 = Max(Mu2+ , Mu2-) = 1.4314E+008
  Mu2+ = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the actual moment direction
which is defined for the the static loading combination
  Mu2- = 1.4314E+008, is the ultimate moment strength at the edge 2 of the member in the opposite moment
direction which is defined for the the static loading combination

```
-------------------------------------------------------------------------
Calculation of Mu1+
-------------------------------------------------------------------------


-------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-------------------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Mu1-
-------------------------------------------------------------------------


-------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-------------------------------------------------------------------------
    = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
  conf. factor  c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
```

```
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Mu2+
-----------------------------------------------------------------------


-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008
-----------------------------------------------------------------------
    = 0.90757121
   ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc*  c = 38.31603
  conf. factor   c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.29650531
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
    Atr =   /2 * Area of stirrup = 123.3701
    s = 100.00
    n = 12.00
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
```

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.4314E+008

   = 0.90757121
  ' = 0.80580716
error of function (3.68), Biskinis Phd = 17845.519
From 5A.2, TBDY: fcc = fc* c = 38.31603
  conf. factor c = 1.9158
  fc = 20.00
From 10.3.5, ASCE41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3})$ = 310.0738
    lb/ld = 0.29836497
    d1 = 44.00
    R = 200.00
    v = 0.00149411
      N = 4771.233
      Ac = 125663.706
      = $*Min(1,1.25*(lb/ld)^{2/3})$ = 0.29650531

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.29836497
lb = 300.00
ld = 1005.48
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
   = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.55
  fc' = 20.00, but $fc^{0.5}$ <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
   Atr = /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 351879.387

Calculation of Shear Strength at edge 1, Vr1 = 351879.387
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 351879.387
  knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

   = 1 (normal-weight concrete)
  fc' = 20.00, but $fc^{0.5}$ <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 9.7935525E-012
    Vu = 9.3792788E-032
  d = 0.8*D = 320.00
  Nu = 4771.233
  Ag = 125663.706
  From (11.5.4.8), ACI 318-14: Vs = 175457.879
    Av = /2*A_stirrup = 123370.055
    fy = 444.44
    s = 100.00

Vs is multiplied by Col = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
  Ef = 82000.00
   fe = 0.004, from (11.6a), ACI 440
    with fu = 0.009
 From (11-11), ACI 440: Vs + Vf < = 238930.50
  bw*d = *d*d/4 = 80424.772

Calculation of Shear Strength at edge 2, Vr2 = 351879.387
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
 VCol0 = 351879.387
 knl = 1 (zero step-static loading)

NOTE: In expression (10-3) 'Vs = Av*fy*d/s' is replaced by 'Vs+ f*Vf'
where Vf is the contribution of FRPs (11.3), ACI 440).

  = 1 (normal-weight concrete)
 fc' = 20.00, but fc^0.5 < = 8.3 MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
  Mu = 9.7935525E-012
  Vu = 9.3792788E-032
 d = 0.8*D = 320.00
 Nu = 4771.233
 Ag = 125663.706
 From (11.5.4.8), ACI 318-14: Vs = 175457.879
  Av = /2*A_stirrup = 123370.055
  fy = 444.44
  s = 100.00
 Vs is multiplied by Col = 0.00
   s/d = 0.3125
 Vf ((11-3)-(11.4), ACI 440) = 242720.00
   f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.00
dfv = d (figure 11.2, ACI 440) = 370.00
ffe ((11-5), ACI 440) = 328.00
  Ef = 82000.00
   fe = 0.004, from (11.6a), ACI 440
    with fu = 0.009
 From (11-11), ACI 440: Vs + Vf < = 238930.50
  bw*d = *d*d/4 = 80424.772

End Of Calculation of Shear Capacity ratio for element: column CC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rccs

Constant Properties

Knowledge Factor, = 0.80
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Existing material of Secondary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Secondary Member: Steel Strength, fs = fsm = 444.44
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
Diameter, D = 400.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Ribbed Bars
Ductile Steel
Without Detailing for Earthquake Resistance (including stirrups not closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
FRP Wrapping Data
Type: Carbon
Dry properties (design values)
Thickness, t = 1.00
Tensile Strength, ffu = 840.00
Tensile Modulus, Ef = 82000.00
Elongation, efu = 0.009
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 881.7217
Shear Force, V2 = 4120.316
Shear Force, V3 = 4.3946636E-014
Axial Force, F = -4774.113
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R = * u = 0.03519999
 u = y + p = 0.04399999

 - Calculation of y -
----
 y = (My*Ls/3)/Eleff = 0.00199999 ((4.29),Biskinis Phd))
  My = 1.5848E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 300.00
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 7.9240E+012
     factor = 0.30

```
        Ag = 125663.706
        fc' = 20.00
         N = 4774.113
     Ec*Ig = 2.6413E+013
-----------------------------------------------------------
-----------------------------------------------------------

Calculation of Yielding Moment My
-----------------------------------------------------------
Calculation of   y and My according to (7) - (8) in Biskinis and Fardis
-----------------------------------------------------------
My = Min(My_ten,My_com) = 1.5848E+008
  y = 8.7295410E-006
 My_ten (8c) = 1.5848E+008
   _ten (7c) = 72.04104
 error of function (7c) = 0.00084335
 My_com (8d) = 3.8197E+008
   _com (7d) = 69.66654
 error of function (7d) = 0.01096192
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0022222
       eco = 0.002
       apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
       d1 = 44.00
       R = 200.00
       v = 0.0015111
       N = 4774.113
       Ac = 125663.706
       ((10.1), ASCE 41-17)    = Min(  , 1.25*  *(lb/ld)^2/3) = 0.42956605
 with fc* ((12.3), ACI 440) = 25.1414
     fc = 20.00
     fl = 1.64
     k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.00
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.009
     Ef = 82000.00
-----------------------------------------------------------
-----------------------------------------------------------


Calculation of ratio lb/ld
-----------------------------------------------------------
Lap Length: ld/ld,min = 0.37295621
lb = 300.00
ld = 804.384
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 444.44
  fc' = 20.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
    t = 1.00
    s = 0.80
    e = 1.00
  cb = 25.00
  Ktr = 4.11234
  Atr =   /2 * Area of stirrup = 123.3701
   s = 100.00
   n = 12.00


-----------------------------------------------------------
 - Calculation of   p -
-----------------------------------------------------------
From table 10-9:   p = 0.042
with:
 - Columns not controlled by inadequate development or splicing along the clear height because lb/ld >= 1
   shear control ratio VyE/VColOE = 0.27120072
   d = 0.00
   s = 0.00
```

t = 2*Av/(dc*s) + 4*tf/D*(ffe/fs) = 0.00
Av = 78.53982, is the area of the circular stirrup
dc = D - 2*cover - Hoop Diameter = 340.00
The term 2*tf/bw*(ffe/fs) is implemented to account for FRP contribution
where f = 2*tf/bw is FRP ratio (EC8 - 3, A.4.4.3(6)) and ffe/fs normalises f to steel strength
All these variables have already been given in Shear control ratio calculation.
NUD = 4774.113
Ag = 125663.706
f'cE = 20.00
fytE = fylE = 444.44
pl = Area_Tot_Long_Rein/(Ag) = 0.0243
f'cE = 20.00

End Of Calculation of Chord Rotation Capacity for element: column CC1 of floor 1
At local axis: 3
Integration Section: (b)