Detailed Member Calculations

Units: N&mm

Regulation: ASCE 41-17
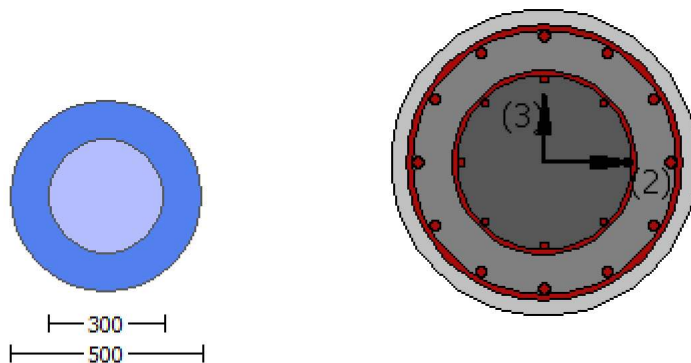
Calculation No. 1

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2535E+007
Shear Force, Va = -7509.70
EDGE -B-
Bending Moment, Mb = 0.03802603
Shear Force, Vb = 7509.70
BOTH EDGES
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 345302.777
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 345302.777
   VCol = 345302.777
   knl = 1.00
      displacement_ductility_demand = 0.04079522

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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 4.00
      Mu = 2.2535E+007

```
        Vu = 7509.70
      d = 0.8*D = 400.00
     Nu = 7386.21
     Ag = 196349.541
     From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
     Vs1 = 246740.11 is calculated for jacket, with:
       Av =   /2*A_stirrup = 123370.055
       fy = 500.00
       s = 100.00
     Vs1 is multiplied by  Col1 = 1.00
       s/d = 0.25
     Vs2 = 0.00 is calculated for core, with:
       Av =   /2*A_stirrup = 78956.835
       fy = 500.00
       s = 250.00
     Vs2 is multiplied by  Col2 = 0.00
       s/d = 1.04167
     Vf ((11-3)-(11.4), ACI 440) = 0.00
     From (11-11), ACI 440: Vs + Vf <= 417394.406
       bw*d =   *d*d/4 = 125663.706
-----------------------------------------------------------

-----------------------------------------------------------
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    = 0.00025064
  y = (My*Ls/3)/EIeff = 0.00614383 ((4.29),Biskinis Phd))
  My = 1.5264E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7386.21
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235118E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69826
 error of function (7c) = 9.5168516E-005
 My_com (8d) = 7.5621E+008
   _com (7d) = 64.56803
 error of function (7d) = -0.00721907
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113993
      N = 7386.21
      Ac = 196349.541
      ((10.1), ASCE 41-17)    = Min(  , 1.25*   *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00
-----------------------------------------------------------
-----------------------------------------------------------

Calculation of ratio lb/ld
```

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

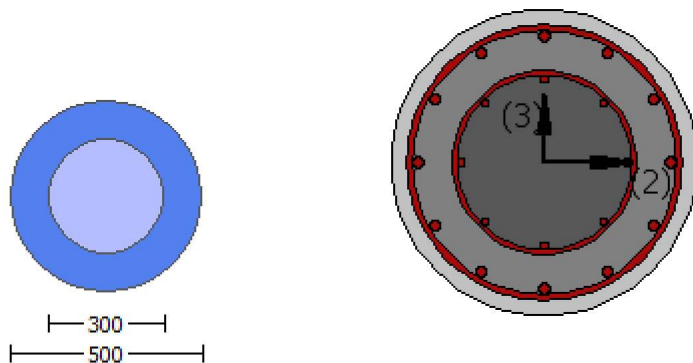

Calculation No. 2

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)

├─ 300 ─┤
├── 500 ──┤

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446

```
        lb/ld = 0.15329994
        d1 = 44.00
        R = 250.00
        v = 0.00113983
          N = 7389.214
          Ac = 196349.541
          =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
         s = s_external = 100.00
         n = 12.00
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------------

----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
----------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
----------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.5382294E-011
    Vu = 4.4860917E-031
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av = /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.5382294E-011
    Vu = 4.4860917E-031
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av = /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d = *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226

with

Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008

  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008

  Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      = *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6374E+008

   = 0.75049158

' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3}) = 248.6446$
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      = $*Min(1,1.25*(lb/ld)^{2/3}) = 0.09374352$

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

  = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3}) = 248.6446$
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      = $*Min(1,1.25*(lb/ld)^{2/3}) = 0.09374352$

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

    = 0.75049158
    ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      = *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.1979728E-011
      Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av = /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av = /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.1979728E-011
      Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av = /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av = /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d = *d*d/4 = 125663.706

```
------------------------------------------------------------
------------------------------------------------------------
End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2


------------------------------------------------------------


Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties
------------------------------------------------------------
```

Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, $fc = fcm = 33.00$
New material of Secondary Member: Steel Strength, $fs = fsm = 555.56$
Concrete Elasticity, $Ec = 26999.444$
Steel Elasticity, $Es = 200000.00$
Existing Column
New material of Secondary Member: Concrete Strength, $fc = fcm = 33.00$
New material of Secondary Member: Steel Strength, $fs = fsm = 555.56$
Concrete Elasticity, $Ec = 26999.444$
Steel Elasticity, $Es = 200000.00$
External Diameter, $D = 500.00$
Internal Diameter, $D = 300.00$
Cover Thickness, $c = 25.00$
Element Length, $L = 3000.00$
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

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


Stepwise Properties
------------------------------------------------------------
```

Bending Moment, $M = 1.5387606E\text{-}009$
Shear Force, $V2 = -7509.70$
Shear Force, $V3 = -5.3669914E\text{-}013$
Axial Force, $F = -7386.21$
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, $DbL = 18.00$

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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $u,R = 1.0* u = 0.00307116$
  $u = y + p = 0.00307116$

```
------------------------------------------------------------
 - Calculation of  y -
------------------------------------------------------------
```
  $y = (My*Ls/3)/Eleff = 0.00307116$ ((4.29),Biskinis Phd))

My = 1.5264E+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 = 2.4850E+013
    factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7386.21
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 φy = 4.3235118E-006
 My_ten (8c) = 1.5264E+008
   ξ_ten (7c) = 63.69826
 error of function (7c) = 9.5168516E-005
 My_com (8d) = 7.5621E+008
   ξ_com (7d) = 64.56803
 error of function (7d) = -0.00721907
    with ((10.1), ASCE 41-17) εy = Min(εy, 1.25*εy*(lb/ld)^2/3) = 0.0027778
        eco = 0.002
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 44.00
        R = 250.00
        v = 0.00113993
        N = 7386.21
        Ac = 196349.541
        ((10.1), ASCE 41-17) δ = Min(δ, 1.25*δ*(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    Ψ = 1
 db = 18.00
 Mean strength value of all re-bars: fy = 555.56
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

 - Calculation of φp -
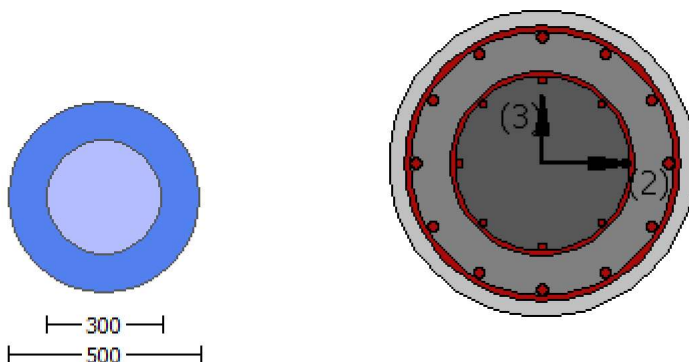--
From table 10-9: φp = 0.00
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
   shear control ratio VyE/VColOE = 0.21813131
 d = d_external = 0.00
 s = s_external = 0.00
    ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428

jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
        Av1 = 78.53982, is the area of stirrup
        Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
        s1 = 100.00
   core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
        Av2 = 50.26548, is the area of stirrup
        Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
        s2 = 250.00
   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.
   For the normalisation fs of jacket is used.
   NUD = 7386.21
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 3

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.5387606E-009
Shear Force, Va = -5.3669914E-013
EDGE -B-
Bending Moment, Mb = 7.1693020E-011
Shear Force, Vb = 5.3669914E-013
BOTH EDGES
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.445
Vn ((10.3), ASCE 41-17) = knl*VColO = 443865.445
  VCol = 443865.445
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5387606E-009
    Vu = 5.3669914E-013
  d = 0.8*D = 400.00
  Nu = 7386.21
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
  Vs1 = 246740.11 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 500.00
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 500.00
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 417394.406
    bw*d =   *d*d/4 = 125663.706

----
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   = 1.6170996E-020
 y = (My*Ls/3)/Eleff = 0.00307116 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
      N = 7386.21
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 y = 4.3235118E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69826
  error of function (7c) = 9.5168516E-005
 My_com (8d) = 7.5621E+008

_com (7d) = 64.56803
  error of function (7d) = -0.00721907
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113993
      N = 7386.21
      Ac = 196349.541
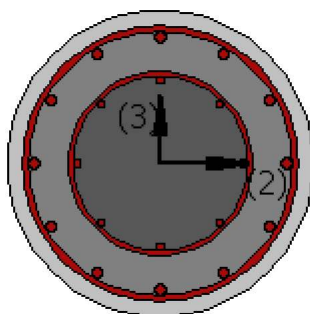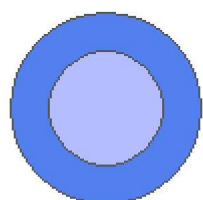   ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 4

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (3)

```
├── 300 ──┤
├──── 500 ────┤
```

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
    Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
    Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008
```
------------------------------------------------------------------------
```
    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       = *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
```
------------------------------------------------------------------------
```

Calculation of ratio lb/ld
```
------------------------------------------------------------------------
```
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701

```
    s = s_external = 100.00
    n = 12.00
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------


--------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
--------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
         N = 7389.214
         Ac = 196349.541
         =    *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------------


--------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
--------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
```

```
        R = 250.00
        v = 0.00113983
           N = 7389.214
           Ac = 196349.541
           =    *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-----------------------------------------------------------
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
    d = 0.8*D = 400.00
    Nu = 7389.214
    Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
    d = 0.8*D = 400.00
    Nu = 7389.214
    Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
```

fy = 555.56
         s = 100.00
     Vs1 is multiplied by   Col1 = 1.00
         s/d = 0.25
     Vs2 = 0.00 is calculated for core, with:
       Av =   /2*A_stirrup = 78956.835
       fy = 555.56
       s = 250.00
     Vs2 is multiplied by   Col2 = 0.00
         s/d = 1.04167
     Vf ((11-3)-(11.4), ACI 440) = 0.00
     From (11-11), ACI 440: Vs + Vf <= 479549.663
       bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-

Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
  Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
```


Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

```
   = 0.75049158
  ' = 0.66796627
```
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: $fcc = fc* c = 43.01531$
```
  conf. factor  c = 1.30349
   fc = 33.00
```
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3}) = 248.6446$
```
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
```
    = 1
  db = 18.00
```
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
```


Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

```
   = 0.75049158
  ' = 0.66796627
```
error of function (3.68), Biskinis Phd = 35731.202

From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
      s = s_external = 100.00
      n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1

db = 18.00
    Mean strength value of all re-bars: fy = 694.45
    Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.1979728E-011
     Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.56
     s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
     s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
     Av =   /2*A_stirrup = 78956.835
     fy = 555.56
     s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
     bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.1979728E-011
     Vu = 2.7468482E-047

d = 0.8*D = 400.00
    Nu = 7389.214
    Ag = 196349.541
    From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
    Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
    Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
    Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
    Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
    Vf ((11-3)-(11.4), ACI 440) = 0.00
    From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.2535E+007
Shear Force, V2 = -7509.70
Shear Force, V3 = -5.3669914E-013
Axial Force, F = -7386.21

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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta_{u,R}$ = 1.0* θ_u = 0.00614383
 θ_u = θ_y + θ_p = 0.00614383

 - Calculation of θ_y -

 θ_y = (My*Ls/3)/EIeff = 0.00614383 ((4.29),Biskinis Phd))
  My = 1.5264E+008
  Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.736
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
     factor = 0.30
       Ag = 196349.541
       Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
       N = 7386.21
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+013

Calculation of Yielding Moment My

Calculation of θ_y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 1.5264E+008
  ϕ_y = 4.3235118E-006
 My_ten (8c) = 1.5264E+008
   ξ_ten (7c) = 63.69826
 error of function (7c) = 9.5168516E-005
 My_com (8d) = 7.5621E+008
   ξ_com (7d) = 64.56803
 error of function (7d) = -0.00721907
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
     eco = 0.002
     apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00113993
     N = 7386.21
     Ac = 196349.541
     ((10.1), ASCE 41-17) ϵ = Min(ϵ, 1.25* ϵ*(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    ψ = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
 s = s_external = 100.00
 n = 12.00

 - Calculation of p -

From table 10-9: p = 0.00
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.21813131
 d = d_external = 0.00
 s = s_external = 0.00
  t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00323428
 jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
      Av1 = 78.53982, is the area of stirrup
      Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
      s1 = 100.00
  core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
      Av2 = 50.26548, is the area of stirrup
      Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
      s2 = 250.00
  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.
  For the normalisation fs of jacket is used.
   NUD = 7386.21
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 5
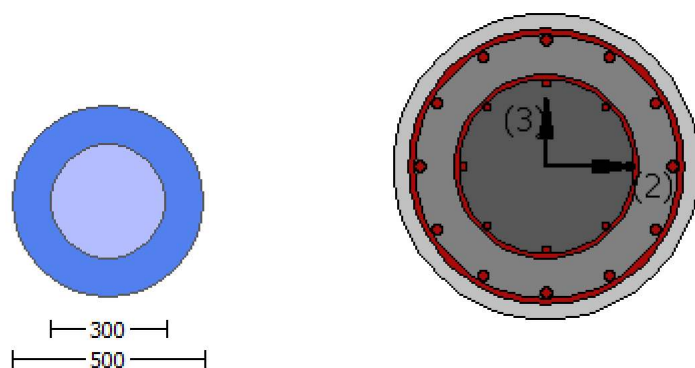
column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel

With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.2535E+007
Shear Force, Va = -7509.70
EDGE -B-
Bending Moment, Mb = 0.03802603
Shear Force, Vb = 7509.70
BOTH EDGES
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.445
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 443865.445
  VCol = 443865.445
  knl = 1.00
     displacement_ductility_demand = 0.22143137

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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 0.03802603
     Vu = 7509.70
  d = 0.8*D = 400.00
  Nu = 7386.21
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
  Vs1 = 246740.11 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 500.00
    s = 100.00
  Vs1 is multiplied by Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 500.00
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 417394.406
    bw*d =   *d*d/4 = 125663.706

----
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   = 0.00013601
 y = (My*Ls/3)/EIeff = 0.00061423 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
    factor = 0.30
       Ag = 196349.541
       Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
       N = 7386.21
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235118E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69826
 error of function (7c) = 9.5168516E-005
 My_com (8d) = 7.5621E+008
   _com (7d) = 64.56803
 error of function (7d) = -0.00721907
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
     eco = 0.002
     apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00113993
     N = 7386.21
     Ac = 196349.541
     ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

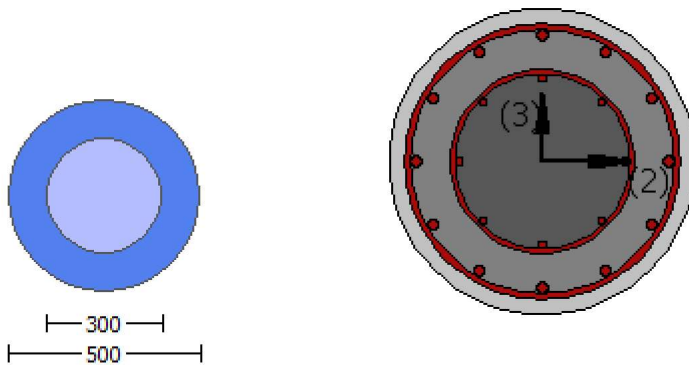
Calculation No. 6

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00

Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
  Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983

N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

     = 0.75049158
    ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3})$ = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       = $*Min(1,1.25*(lb/ld)^{2/3})$ = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3})$ = 248.6446

```
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------
```

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
    d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663

bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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

Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349

fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45

Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
$Mu = 1.6374E+008$

    = 0.75049158
    ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor   c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: $fy*Min(1,1.25*(lb/ld)^{2/3}) = 248.6446$
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
        =   *$Min(1,1.25*(lb/ld)^{2/3}) = 0.09374352$

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
$Mu = 1.6374E+008$

    = 0.75049158

' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.1979728E-011
      Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835

```
        fy = 555.56
        s = 250.00
     Vs2 is multiplied by   Col2 = 0.00
        s/d = 1.04167
     Vf ((11-3)-(11.4), ACI 440) = 0.00
     From (11-11), ACI 440: Vs + Vf <= 479549.663
        bw*d =   *d*d/4 = 125663.706
--------------------------------------------------------------
---------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
    VCol0 = 500419.792
    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)
    Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
    M/Vd = 2.00
       Mu = 2.1979728E-011
       Vu = 2.7468482E-047
    d = 0.8*D = 400.00
    Nu = 7389.214
    Ag = 196349.541
    From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
    Vs1 = 274157.871 is calculated for jacket, with:
       Av =   /2*A_stirrup = 123370.055
       fy = 555.56
       s = 100.00
     Vs1 is multiplied by   Col1 = 1.00
        s/d = 0.25
     Vs2 = 0.00 is calculated for core, with:
       Av =   /2*A_stirrup = 78956.835
       fy = 555.56
       s = 250.00
     Vs2 is multiplied by   Col2 = 0.00
        s/d = 1.04167
     Vf ((11-3)-(11.4), ACI 440) = 0.00
     From (11-11), ACI 440: Vs + Vf <= 479549.663
        bw*d =   *d*d/4 = 125663.706
--------------------------------------------------------------
--------------------------------------------------------------
End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2


--------------------------------------------------------------


Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties
--------------------------------------------------------------
Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
```

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 7.1693020E-011
Shear Force, V2 = 7509.70
Shear Force, V3 = 5.3669914E-013
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0* θu = 0.00307116
 θu = θy + θp = 0.00307116

 - Calculation of θy -

 θy = (My*Ls/3)/EIeff = 0.00307116 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7386.21
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  ϕy = 4.3235118E-006
  My_ten (8c) = 1.5264E+008
    ξ_ten (7c) = 63.69826
  error of function (7c) = 9.5168516E-005
  My_com (8d) = 7.5621E+008
    ξ_com (7d) = 64.56803
  error of function (7d) = -0.00721907
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
       eco = 0.002

```
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 44.00
        R = 250.00
        v = 0.00113993
        N = 7386.21
        Ac = 196349.541
        ((10.1), ASCE 41-17)    = Min(  , 1.25*  *(lb/ld)^2/3) = 0.26182028
 with fc =  33.00
-----------------------------------------------------------
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00


-----------------------------------------------------------
 - Calculation of   p -
-----------------------------------------------------------
From table 10-9:   p = 0.00
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.21813131
  d = d_external = 0.00
  s = s_external = 0.00
   t =    s1 +    s2 + 2*tf/bw*(ffe/fs) = 0.00323428
  jacket:   s1 = Av1*(  *Dc1/2)/(s1*Ag) = 0.0027646
       Av1 = 78.53982, is the area of stirrup
       Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading
(shear) direction
       s1 = 100.00
   core:    s2 = Av2*(  *Dc2/2)/(s2*Ag) = 0.00046968
       Av2 = 50.26548, is the area of stirrup
       Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear)
direction
       s2 = 250.00
  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.
  For the normalisation fs of jacket is used.
   NUD = 7386.21
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =
2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein =
555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00
-----------------------------------------------------------
End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
```
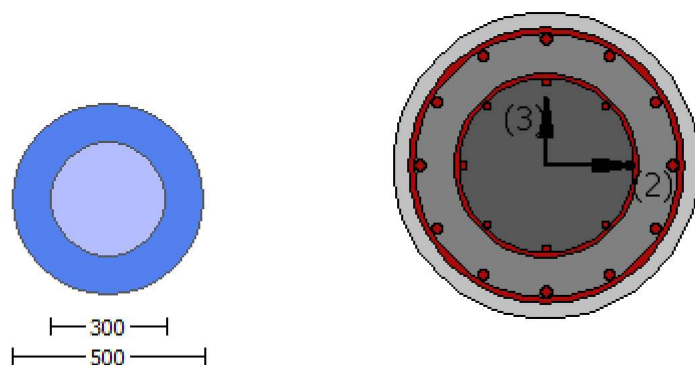
At local axis: 2
Integration Section: (b)

Calculation No. 7

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as

Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.5387606E-009
Shear Force, Va = -5.3669914E-013
EDGE -B-
Bending Moment, Mb = 7.1693020E-011
Shear Force, Vb = 5.3669914E-013
BOTH EDGES
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.445
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 443865.445
   VCol = 443865.445
   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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 7.1693020E-011
     Vu = 5.3669914E-013
  d = 0.8*D = 400.00
  Nu = 7386.21
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
  Vs1 = 246740.11 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 500.00
     s = 100.00
  Vs1 is multiplied by   Col1 = 1.00

```
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =    /2*A_stirrup = 78956.835
      fy = 500.00
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 417394.406
      bw*d =    *d*d/4 = 125663.706
------------------------------------------------------------
```

----
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   = 8.1228335E-021
  y = (My*Ls/3)/EIeff = 0.00307116 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7386.21
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
   y = 4.3235118E-006
  My_ten (8c) = 1.5264E+008
    _ten (7c) = 63.69826
  error of function (7c) = 9.5168516E-005
  My_com (8d) = 7.5621E+008
    _com (7d) = 64.56803
  error of function (7d) = -0.00721907
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.0027778
        eco = 0.002
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 44.00
        R = 250.00
        v = 0.00113993
        N = 7386.21
        Ac = 196349.541
        ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^ 2/3) = 0.26182028
  with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^ 0.5 <= 8.3

MPa (22.5.3.1, ACI 318-14)

    λ_t = 1.00

    ψ_s = 0.80

    ψ_e = 1.00

  cb = 25.00

  Ktr = 4.11234

  Atr = π/2 * Area of external stirrup = 123.3701

  s = s_external = 100.00

  n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

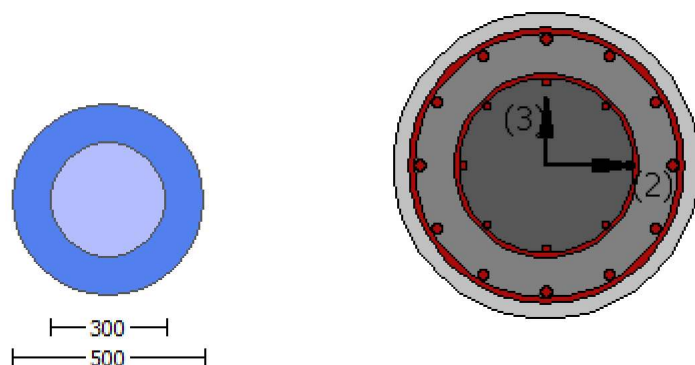

Calculation No. 8

column C1, Floor 1

Limit State: Operational Level (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (θu)

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 3

(Bending local axis: 2)

Section Type: rcjcs

Constant Properties

Knowledge Factor, γ = 1.00

Mean strength values are used for both shear and moment calculations.

Consequently:

Jacket

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00

New material of Secondary Member: Steel Strength, fs = fsm = 555.56

Concrete Elasticity, Ec = 26999.444

Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
  Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008
----------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------------

----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
----------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------

Calculation of ratio lb/ld
```

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

    = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.5382294E-011
     Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541

From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 is calculated for jacket, with:
  Av = /2*A_stirrup = 123370.055
  fy = 555.56
  s = 100.00
Vs1 is multiplied by Col1 = 1.00
  s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
  Av = /2*A_stirrup = 78956.835
  fy = 555.56
  s = 250.00
Vs2 is multiplied by Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 479549.663
  bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
  Mu = 2.5382294E-011
  Vu = 4.4860917E-031
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
Vs1 = 274157.871 is calculated for jacket, with:
  Av = /2*A_stirrup = 123370.055
  fy = 555.56
  s = 100.00
Vs1 is multiplied by Col1 = 1.00
  s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
  Av = /2*A_stirrup = 78956.835
  fy = 555.56
  s = 250.00
Vs2 is multiplied by Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 0.00
From (11-11), ACI 440: Vs + Vf <= 479549.663
  bw*d = *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00

Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983

```
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00
-------------------------------------------------------------
-------------------------------------------------------------
-------------------------------------------------------------
Calculation of Mu2+
-------------------------------------------------------------

-------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
-------------------------------------------------------------
   = 0.75049158
 ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

    = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
   Mu = 2.1979728E-011
   Vu = 2.7468482E-047
 d = 0.8*D = 400.00
 Nu = 7389.214
 Ag = 196349.541
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
 Vs1 = 274157.871 is calculated for jacket, with:
   Av =   /2*A_stirrup = 123370.055
   fy = 555.56
   s = 100.00
 Vs1 is multiplied by   Col1 = 1.00
   s/d = 0.25
 Vs2 = 0.00 is calculated for core, with:
   Av =   /2*A_stirrup = 78956.835
   fy = 555.56
   s = 250.00
 Vs2 is multiplied by   Col2 = 0.00
   s/d = 1.04167
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 479549.663
   bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
 M/Vd = 2.00
   Mu = 2.1979728E-011
   Vu = 2.7468482E-047
 d = 0.8*D = 400.00
 Nu = 7389.214
 Ag = 196349.541
 From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
 Vs1 = 274157.871 is calculated for jacket, with:
   Av =   /2*A_stirrup = 123370.055
   fy = 555.56
   s = 100.00
 Vs1 is multiplied by   Col1 = 1.00
   s/d = 0.25
 Vs2 = 0.00 is calculated for core, with:
   Av =   /2*A_stirrup = 78956.835
   fy = 555.56
   s = 250.00
 Vs2 is multiplied by   Col2 = 0.00
   s/d = 1.04167
 Vf ((11-3)-(11.4), ACI 440) = 0.00
 From (11-11), ACI 440: Vs + Vf <= 479549.663
   bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3

Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.03802603
Shear Force, V2 = 7509.70
Shear Force, V3 = 5.36699144E-013
Axial Force, F = -7386.21
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity   u,R = 1.0* u = 0.00061423
  u =   y +   p = 0.00061423

 - Calculation of y -
----
 y = (My*Ls/3)/EIeff = 0.00061423 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7386.21
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235118E-006
  My_ten (8c) = 1.5264E+008
    _ten (7c) = 63.69826
  error of function (7c) = 9.5168516E-005
  My_com (8d) = 7.5621E+008
    _com (7d) = 64.56803
  error of function (7d) = -0.00721907
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113993
      N = 7386.21
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

 - Calculation of p -

From table 10-9: p = 0.00
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
   shear control ratio VyE/VColOE = 0.21813131
  d = d_external = 0.00
  s = s_external = 0.00
    t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00323428
  jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
       Av1 = 78.53982, is the area of stirrup
       Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading
(shear) direction
       s1 = 100.00
   core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
       Av2 = 50.26548, is the area of stirrup
       Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear)
direction
       s2 = 250.00

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.

For the normalisation fs of jacket is used.

NUD = 7386.21

Ag = 196349.541

f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00

fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314

fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56

pl = Area_Tot_Long_Rein/(Ag) = 0.015552

f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1

At local axis: 3

Integration Section: (b)

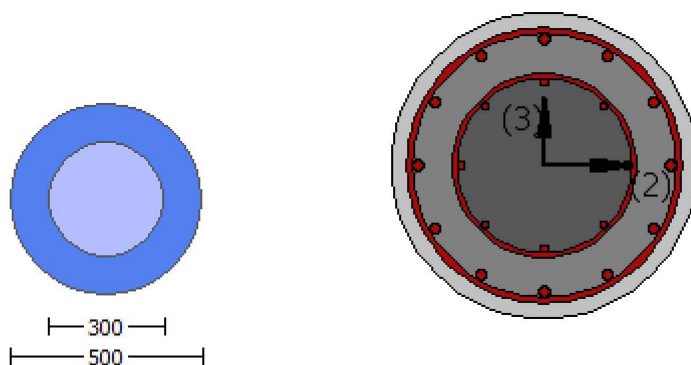
Calculation No. 9

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1

At local axis: 2

Integration Section: (a)

Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00

Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.

Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.7242E+007
Shear Force, Va = -9078.589
EDGE -B-
Bending Moment, Mb = 0.04597024
Shear Force, Vb = 9078.589
BOTH EDGES
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 345302.715
Vn ((10.3), ASCE 41-17) = knl*VColO = 345302.715
   VCol = 345302.715
   knl = 1.00
      displacement_ductility_demand = 0.04931799

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)
    Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
    M/Vd = 4.00
        Mu = 2.7242E+007
        Vu = 9078.589
    d = 0.8*D = 400.00
    Nu = 7385.582
    Ag = 196349.541
    From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
    Vs1 = 246740.11 is calculated for jacket, with:
        Av =   /2*A_stirrup = 123370.055
        fy = 500.00
        s = 100.00
    Vs1 is multiplied by   Col1 = 1.00
        s/d = 0.25
    Vs2 = 0.00 is calculated for core, with:
        Av =   /2*A_stirrup = 78956.835
        fy = 500.00
        s = 250.00
    Vs2 is multiplied by   Col2 = 0.00
        s/d = 1.04167
    Vf ((11-3)-(11.4), ACI 440) = 0.00
    From (11-11), ACI 440: Vs + Vf <= 417394.406
        bw*d =   *d*d/4 = 125663.706

----
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   = 0.000303
  y = (My*Ls/3)/EIeff = 0.00614382 ((4.29),Biskinis Phd))
  My = 1.5264E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3000.736
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
      factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7385.582
      Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
   _com (7d) = 64.56803
 error of function (7d) = -0.00721908
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
        eco = 0.002
        apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
        d1 = 44.00
        R = 250.00
        v = 0.00113983
        N = 7385.582
        Ac = 196349.541
        ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028

with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

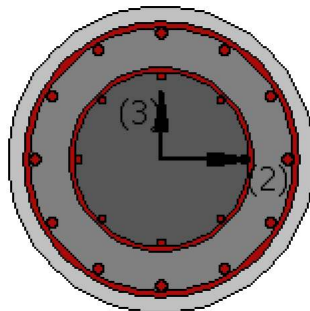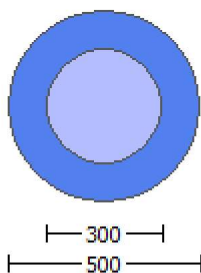# Calculation No. 10

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.48609117E-031
EDGE -B-
Shear Force, Vb = -4.48609117E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226

with

Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008

   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008

   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

    = 0.75049158

   ' = 0.66796627

error of function (3.68), Biskinis Phd = 35731.202

From 5A.2, TBDY: fcc = fc* c = 43.01531

  conf. factor c = 1.30349

  fc = 33.00

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446

    lb/ld = 0.15329994

    d1 = 44.00

    R = 250.00

    v = 0.00113983

      N = 7389.214

      Ac = 196349.541

      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994

lb = 300.00

ld = 1956.948

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

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)

    = 1

  db = 18.00

  Mean strength value of all re-bars: fy = 694.45

  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701

   s = s_external = 100.00

   n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu

Mu = 1.6374E+008

    = 0.75049158

' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.

ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
   lb/ld = 0.15329994
   d1 = 44.00
   R = 250.00
   v = 0.00113983
    N = 7389.214
    Ac = 196349.541
    =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792

Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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

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Calculation of Shear Capacity ratio , Ve/Vr = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

     = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

```
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.1979728E-011
     Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.56
     s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
     s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
     Av =   /2*A_stirrup = 78956.835
     fy = 555.56
     s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
     bw*d =   *d*d/4 = 125663.706
-----------------------------------------------------------
-----------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.1979728E-011
     Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.56
     s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
     s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
     Av =   /2*A_stirrup = 78956.835
     fy = 555.56
```

```
     s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
     bw*d =   *d*d/4 = 125663.706
---------------------------------------------------------------
---------------------------------------------------------------
End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2


---------------------------------------------------------------


Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)
Section Type: rcjcs

Constant Properties
---------------------------------------------------------------
Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping
---------------------------------------------------------------

Stepwise Properties
---------------------------------------------------------------
Bending Moment, M = 1.8549280E-009
Shear Force, V2 = -9078.589
Shear Force, V3 = -6.4882365E-013
Axial Force, F = -7385.582
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
---------------------------------------------------------------
---------------------------------------------------------------


New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity   u,R = 1.0*  u = 0.02422685
```

u = y + p = 0.02422685

- Calculation of y -
----
y = (My*Ls/3)/EIeff = 0.00307116 ((4.29),Biskinis Phd))
 My = 1.5264E+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 = 2.4850E+013
    factor = 0.30
       Ag = 196349.541
       Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
       N = 7385.582
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 y = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
   _com (7d) = 64.56803
 error of function (7d) = -0.00721908
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113983
      N = 7385.582
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

- Calculation of p -

From table 10-9: p = 0.02115569

with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VCol0E = 0.21813131
  d = d_external = 0.00
  s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00323428
 jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
      Av1 = 78.53982, is the area of stirrup
      Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
      s1 = 100.00
  core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
      Av2 = 50.26548, is the area of stirrup
      Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
      s2 = 250.00
  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.
  For the normalisation fs of jacket is used.
   NUD = 7385.582
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1
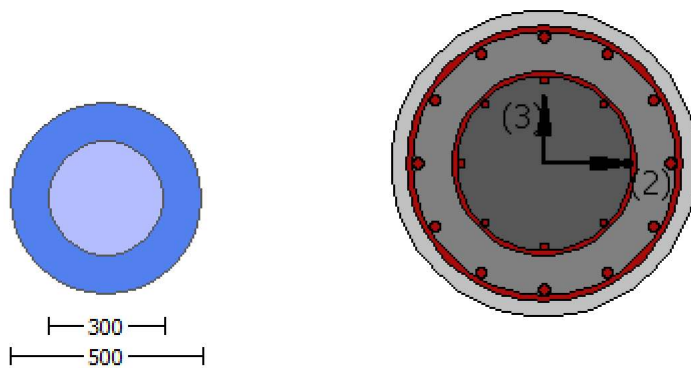
Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)

```
|— 300 —|
|——— 500 ———|
```

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.8549280E-009
Shear Force, Va = -6.4882365E-013
EDGE -B-
Bending Moment, Mb = 9.1973511E-011
```

Shear Force, Vb = 6.4882365E-013
BOTH EDGES
Axial Force, F = -7385.582
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
------------------------------------------------------------
------------------------------------------------------------


New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.32
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 443865.32
   VCol = 443865.32
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 1.8549280E-009
      Vu = 6.4882365E-013
   d = 0.8*D = 400.00
   Nu = 7385.582
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
   Vs1 = 246740.11 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 500.00
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 500.00
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 417394.406
      bw*d =   *d*d/4 = 125663.706
------------------------------------------------------------


------------------------------------------------------------
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    = 1.9549360E-020
  y = (My*Ls/3)/EIeff = 0.00307116 ((4.29),Biskinis Phd))
   My = 1.5264E+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 = 2.4850E+013
      factor = 0.30
         Ag = 196349.541
         Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
         N = 7385.582
      Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 φy = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
   ξ_ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
   ξ_com (7d) = 64.56803
 error of function (7d) = -0.00721908
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
     eco = 0.002
     apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00113983
     N = 7385.582
     Ac = 196349.541
     ((10.1), ASCE 41-17) ξ = Min(ξ, 1.25*ξ*(lb/ld)^2/3) = 0.26182028
 with fc = 33.00
------------------------------------------------------------
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
   ψ = 1
 db = 18.00
 Mean strength value of all re-bars: fy = 555.56
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 = π/2 * Area of external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00
------------------------------------------------------------
End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

------------------------------------------------------------

## Calculation No. 12

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity ( u)

Edge: Start

Local Axis: (3)



300
500

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties
-------------------------------------------------------------
Knowledge Factor,    = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
############################################################
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00

No FRP Wrapping
-------------------------------------------------------------

Stepwise Properties
-------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
    Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
    Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008
-----------------------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948

Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------------

------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
------------------------------------------------------------------------
   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
     N = 7389.214
     Ac = 196349.541
     = *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------------

---------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
---------------------------------------------------------------------
    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor  c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
---------------------------------------------------------------------
---------------------------------------------------------------------
---------------------------------------------------------------------
Calculation of Mu2-
---------------------------------------------------------------------

---------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
---------------------------------------------------------------------
    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor  c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
------------------------------------------------------------

Calculation of ratio lb/ld

----------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.5382294E-011
     Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.56
     s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
     s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
     Av =   /2*A_stirrup = 78956.835
     fy = 555.56
     s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
     bw*d =   *d*d/4 = 125663.706
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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).

```
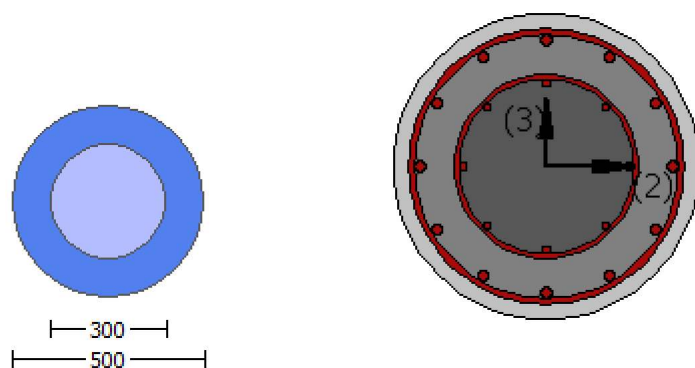-------------------------------------------------------------
     = 1 (normal-weight concrete)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706
-------------------------------------------------------------
-------------------------------------------------------------
End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3


-------------------------------------------------------------


Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties
-------------------------------------------------------------
Knowledge Factor,    = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
############################################################
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
```

Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
 ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
 ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983

```
    N = 7389.214
    Ac = 196349.541
    =    *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
-------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.1979728E-011
    Vu = 2.7468482E-047
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d =   *d*d/4 = 125663.706

-------------------------------------------------------------
-------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 500419.792
```

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.1979728E-011
      Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av = /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av = /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d = *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars

Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = -2.7242E+007
Shear Force, V2 = -9078.589
Shear Force, V3 = -6.4882365E-013
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity θu,R = 1.0* θu = 0.02729951
 θu = θy + θp = 0.02729951

 - Calculation of θy -

 θy = (My*Ls/3)/EIeff = 0.00614382 ((4.29),Biskinis Phd))
  My = 1.5264E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3000.736
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7385.582
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 ϕy = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
   ξ_ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
   ξ_com (7d) = 64.56803
 error of function (7d) = -0.00721908
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
       eco = 0.002
       apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
       d1 = 44.00
       R = 250.00
       v = 0.00113983
       N = 7385.582
       Ac = 196349.541
       ((10.1), ASCE 41-17) δ = Min(δ, 1.25*δ*(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

 - Calculation of   p -

From table 10-9:   p = 0.02115569
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.21813131
  d = d_external = 0.00
  s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00323428
  jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
     Av1 = 78.53982, is the area of stirrup
     Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
     s1 = 100.00
  core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
     Av2 = 50.26548, is the area of stirrup
     Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
     s2 = 250.00
  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.
  For the normalisation fs of jacket is used.
   NUD = 7385.582
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
   fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (a)

Calculation No. 13

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
###

External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -2.7242E+007
Shear Force, Va = -9078.589
EDGE -B-
Bending Moment, Mb = 0.04597024
Shear Force, Vb = 9078.589
BOTH EDGES
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.32
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 443865.32
  VCol = 443865.32
  knl = 1.00
     displacement_ductility_demand = 0.26769191

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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 0.04597024
     Vu = 9078.589
  d = 0.8*D = 400.00
  Nu = 7385.582
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
  Vs1 = 246740.11 is calculated for jacket, with:
     Av = /2*A_stirrup = 123370.055
     fy = 500.00
     s = 100.00
  Vs1 is multiplied by Col1 = 1.00
     s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
     Av = /2*A_stirrup = 78956.835
     fy = 500.00
     s = 250.00
  Vs2 is multiplied by Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00

From (11-11), ACI 440: Vs + Vf <= 417394.406
   bw*d =   *d*d/4 = 125663.706

----
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   = 0.00016442
  y = (My*Ls/3)/EIeff = 0.00061423 ((4.29),Biskinis Phd))
   My = 1.5264E+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 = 2.4850E+013
      factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7385.582
      Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235107E-006
  My_ten (8c) = 1.5264E+008
    _ten (7c) = 63.69823
  error of function (7c) = 9.5169719E-005
  My_com (8d) = 7.5621E+008
    _com (7d) = 64.56803
  error of function (7d) = -0.00721908
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113983
      N = 7385.582
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 555.56
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00

n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 14

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531

conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00

Mean strength value of all re-bars: fy = 694.45
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

```
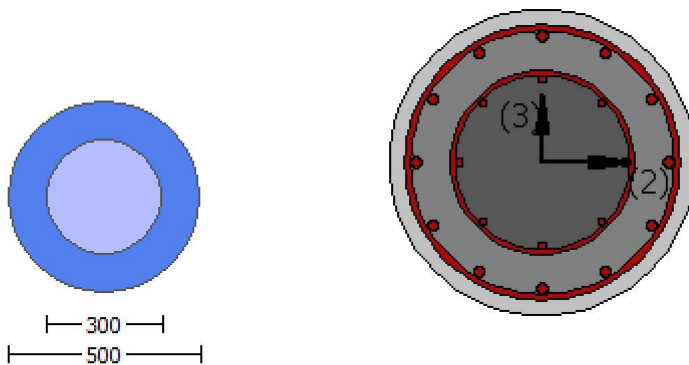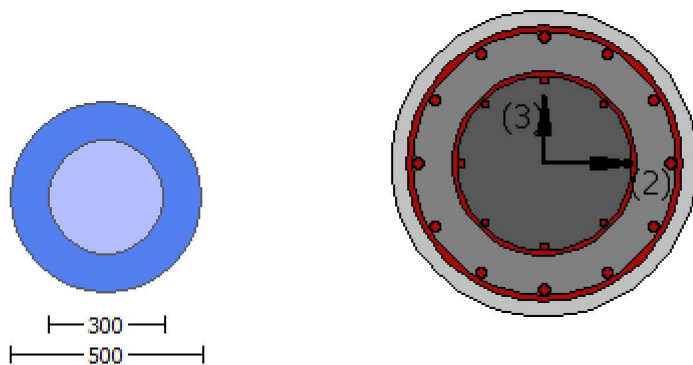    = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor  c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =    *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
----------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
----------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.56
     s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
     s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
```

Av =   /2*A_stirrup = 78956.835
        fy = 555.56
        s = 250.00
     Vs2 is multiplied by   Col2 = 0.00
        s/d = 1.04167
     Vf ((11-3)-(11.4), ACI 440) = 0.00
     From (11-11), ACI 440: Vs + Vf <= 479549.663
        bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.5382294E-011
      Vu = 4.4860917E-031
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994

lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
 ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
     N = 7389.214
     Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.1979728E-011
    Vu = 2.7468482E-047
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:

```
      Av =    /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =    /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =    *d*d/4 = 125663.706
-------------------------------------------------------------
--------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 2.1979728E-011
      Vu = 2.7468482E-047
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
   Vs1 = 274157.871 is calculated for jacket, with:
      Av =    /2*A_stirrup = 123370.055
      fy = 555.56
      s = 100.00
   Vs1 is multiplied by   Col1 = 1.00
      s/d = 0.25
   Vs2 = 0.00 is calculated for core, with:
      Av =    /2*A_stirrup = 78956.835
      fy = 555.56
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 0.00
   From (11-11), ACI 440: Vs + Vf <= 479549.663
      bw*d =    *d*d/4 = 125663.706
-------------------------------------------------------------
-------------------------------------------------------------
End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 2


-------------------------------------------------------------


Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)
Section Type: rcjcs

Constant Properties
-------------------------------------------------------------
Knowledge Factor,    = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
```

Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 9.1973511E-011
Shear Force, V2 = 9078.589
Shear Force, V3 = 6.4882365E-013
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R = 1.0* u = 0.02422685
  u =   y +   p = 0.02422685

 - Calculation of   y -
----
  y = (My*Ls/3)/Eleff = 0.00307116 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7385.582
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235107E-006
  My_ten (8c) = 1.5264E+008

_ten (7c) = 63.69823
error of function (7c) = 9.5169719E-005
My_com (8d) = 7.5621E+008
_com (7d) = 64.56803
error of function (7d) = -0.00721908
with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
eco = 0.002
apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
d1 = 44.00
R = 250.00
v = 0.00113983
N = 7385.582
Ac = 196349.541
((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.26182028
with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
   = 1
db = 18.00
Mean strength value of all re-bars: fy = 555.56
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
s = s_external = 100.00
n = 12.00

 - Calculation of p -

From table 10-9: p = 0.02115569
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
shear control ratio VyE/VColOE = 0.21813131
d = d_external = 0.00
s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00323428
jacket: s1 = Av1*(*Dc1/2)/(s1*Ag) = 0.0027646
      Av1 = 78.53982, is the area of stirrup
      Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading (shear) direction
      s1 = 100.00
core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
      Av2 = 50.26548, is the area of stirrup
      Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
      s2 = 250.00
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.
For the normalisation fs of jacket is used.
NUD = 7385.582
Ag = 196349.541
f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein =

2.1219958E-314
   fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein =
555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 15

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Member Shear Force is generally considered as Force-Controlled Action according to Table C7-1, ASCE 41-17.
Lower-bound strengths are used for Force-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column

New material of Secondary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Secondary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
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, ASCE 41-17) because bending is considered as
Deformation-Controlled Action (Table C7-1, ASCE 41-17).
Jacket
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
Existing Column
New material: Concrete Strength, fc = fcm = 33.00
New material: Steel Strength, fs = fsm = 555.56
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = lb = 300.00
No FRP Wrapping

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 1.8549280E-009
Shear Force, Va = -6.4882365E-013
EDGE -B-
Bending Moment, Mb = 9.1973511E-011
Shear Force, Vb = 6.4882365E-013
BOTH EDGES
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = 1.0*Vn = 443865.32
Vn ((10.3), ASCE 41-17) = knl*VColO = 443865.32
   VCol = 443865.32
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 25.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.1973511E-011
      Vu = 6.4882365E-013
   d = 0.8*D = 400.00
   Nu = 7385.582

Ag = 196349.541
    From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 246740.11
    Vs1 = 246740.11 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 500.00
      s = 100.00
    Vs1 is multiplied by   Col1 = 1.00
       s/d = 0.25
    Vs2 = 0.00 is calculated for core, with:
      Av =   /2*A_stirrup = 78956.835
      fy = 500.00
      s = 250.00
    Vs2 is multiplied by   Col2 = 0.00
       s/d = 1.04167
    Vf ((11-3)-(11.4), ACI 440) = 0.00
    From (11-11), ACI 440: Vs + Vf <= 417394.406
       bw*d =   *d*d/4 = 125663.706

----
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   = 9.8198153E-021
  y = (My*Ls/3)/EIeff = 0.00307116 ((4.29),Biskinis Phd))
   My = 1.5264E+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 = 2.4850E+013
      factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
        N = 7385.582
      Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
  y = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
   _ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
   _com (7d) = 64.56803
 error of function (7d) = -0.00721908
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
      eco = 0.002
      apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00113983
      N = 7385.582
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00

ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
   = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 555.56
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)

Calculation No. 16

column C1, Floor 1

Limit State: Life Safety (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (3)

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At Shear local axis: 3
(Bending local axis: 2)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = 4.4860917E-031
EDGE -B-
Shear Force, Vb = -4.4860917E-031
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
  Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
  Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00
      v = 0.00113983
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
      s = s_external = 100.00
      n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
   ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
      lb/ld = 0.15329994
      d1 = 44.00
      R = 250.00

```
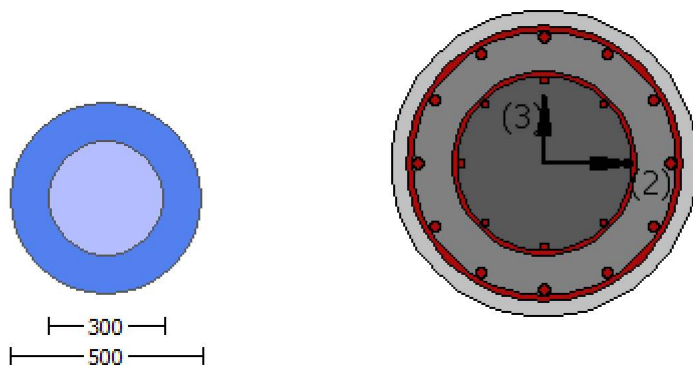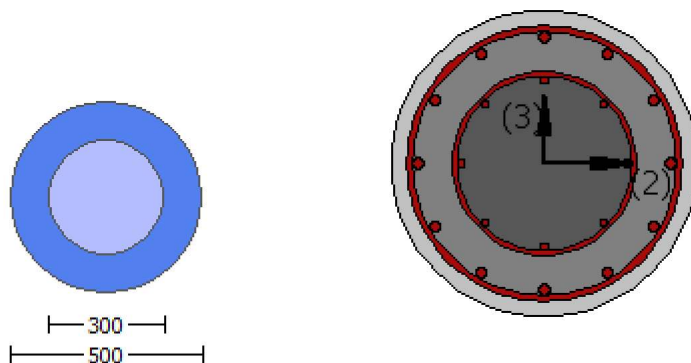    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00
-------------------------------------------------------------------
-------------------------------------------------------------------
-------------------------------------------------------------------
Calculation of Mu2+
-------------------------------------------------------------------


-------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
-------------------------------------------------------------------
    = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
  conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
-------------------------------------------------------------

Calculation of ratio lb/ld
-------------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
      = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------

----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008
----------------------------------------------------------------
   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc*  c = 43.01531
   conf. factor   c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352
----------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792
----------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 500419.792
   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)
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
```

MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.5382294E-011
    Vu = 4.4860917E-031
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.5382294E-011
    Vu = 4.4860917E-031
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by   Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av =   /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d =   *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1
At local axis: 3

Start Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At Shear local axis: 2
(Bending local axis: 3)
Section Type: rcjcs

Constant Properties

Knowledge Factor, = 1.00
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
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
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.45
Existing Column
New material: Steel Strength, fs = 1.25*fsm = 694.45
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.30349
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lo = 300.00
No FRP Wrapping

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.7468482E-047
EDGE -B-
Shear Force, Vb = 2.7468482E-047
BOTH EDGES
Axial Force, F = -7389.214
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 = 0.21813131
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 109157.226
with
Mpr1 = Max(Mu1+ , Mu1-) = 1.6374E+008
   Mu1+ = 1.6374E+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- = 1.6374E+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-) = 1.6374E+008
   Mu2+ = 1.6374E+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- = 1.6374E+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 = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
   conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
     lb/ld = 0.15329994
     d1 = 44.00
     R = 250.00
     v = 0.00113983
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
     = 1
   db = 18.00
   Mean strength value of all re-bars: fy = 694.45
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
     s = s_external = 100.00
     n = 12.00

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531

conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
   s = s_external = 100.00
   n = 12.00

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

  = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00

Mean strength value of all re-bars: fy = 694.45
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 1.6374E+008

   = 0.75049158
  ' = 0.66796627
error of function (3.68), Biskinis Phd = 35731.202
From 5A.2, TBDY: fcc = fc* c = 43.01531
  conf. factor c = 1.30349
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 248.6446
    lb/ld = 0.15329994
    d1 = 44.00
    R = 250.00
    v = 0.00113983
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.09374352

Calculation of ratio lb/ld

Lap Length: lb/ld = 0.15329994
lb = 300.00
ld = 1956.948
Calculation of lb,min according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (9.1.2, TS500 - No provision in ACI 318)
    = 1
  db = 18.00
  Mean strength value of all re-bars: fy = 694.45
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 external stirrup = 123.3701
    s = s_external = 100.00
    n = 12.00

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 500419.792

Calculation of Shear Strength at edge 1, Vr1 = 500419.792
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.1979728E-011
    Vu = 2.7468482E-047
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av = /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 500419.792
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 500419.792
  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)
  Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 2.1979728E-011
    Vu = 2.7468482E-047
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274157.871
  Vs1 = 274157.871 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.56
    s = 100.00
  Vs1 is multiplied by Col1 = 1.00
    s/d = 0.25
  Vs2 = 0.00 is calculated for core, with:
    Av = /2*A_stirrup = 78956.835
    fy = 555.56
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 0.00
  From (11-11), ACI 440: Vs + Vf <= 479549.663
    bw*d = *d*d/4 = 125663.706

End Of Calculation of Shear Capacity ratio for element: column JCC1 of floor 1

At local axis: 2

Start Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)
Section Type: rcjcs

Constant Properties

Knowledge Factor,   = 1.00
Chord Rotation is generally considered as Deformation-Controlled Action according to Table C7-1, ASCE 41-17.
Mean strengths are used for Deformation-Controlled Actions according to 7.5.1.3, ASCE 41-17
Consequently:
Jacket
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
New material of Secondary Member: Concrete Strength, fc = fcm = 33.00
New material of Secondary Member: Steel Strength, fs = fsm = 555.56
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Secondary Member
Smooth Bars
Ductile Steel
With Detailing for Earthquake Resistance (including stirrups closed at 135°)
Longitudinal Bars With Ends Lapped Starting at the End Sections
Lap Length lb = 300.00
No FRP Wrapping

Stepwise Properties

Bending Moment, M = 0.04597024
Shear Force, V2 = 9078.589
Shear Force, V3 = 6.4882365E-013
Axial Force, F = -7385.582
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

New component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta_{u,R}$ = 1.0* θ_u = 0.02176992
 θ_u = θ_y + θ_p = 0.02176992

 - Calculation of θ_y -

 θ_y = (My*Ls/3)/Eleff = 0.00061423 ((4.29),Biskinis Phd))
  My = 1.5264E+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 = 2.4850E+013

factor = 0.30
   Ag = 196349.541
   Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00
   N = 7385.582
  Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.2833E+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) = 1.5264E+008
 φy = 4.3235107E-006
 My_ten (8c) = 1.5264E+008
  ξ_ten (7c) = 63.69823
 error of function (7c) = 9.5169719E-005
 My_com (8d) = 7.5621E+008
  ξ_com (7d) = 64.56803
 error of function (7d) = -0.00721908
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.0027778
   eco = 0.002
   apl = 0.35 ((9a) in Biskinis and Fardis for no FRP Wrap)
   d1 = 44.00
   R = 250.00
   v = 0.00113983
   N = 7385.582
   Ac = 196349.541
   ((10.1), ASCE 41-17) δ = Min(δ, 1.25*δ*(lb/ld)^2/3) = 0.26182028
 with fc = 33.00

Calculation of ratio lb/ld

Lap Length: ld/ld,min = 0.19162492
lb = 300.00
ld = 1565.558
Calculation of l according to (25.4.3.2), ACI 318-14, using mean values for all the section re-bars.
ld,min from (25.4.3.2) is multiplied 2 times to account for smooth re-bars (10.3.5, ASCE 41-17)
  ψ = 1
 db = 18.00
 Mean strength value of all re-bars: fy = 555.56
 Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 33.00, 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 = ψ/2 * Area of external stirrup = 123.3701
  s = s_external = 100.00
  n = 12.00

 - Calculation of ρp -

From table 10-9: ρp = 0.02115569
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
 shear control ratio VyE/VCol0E = 0.21813131
 d = d_external = 0.00
 s = s_external = 0.00
  ρt = ρs1 + ρs2 + 2*tf/bw*(ffe/fs) = 0.00323428
 jacket: ρs1 = Av1*(π*Dc1/2)/(s1*Ag) = 0.0027646
   Av1 = 78.53982, is the area of stirrup
   Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading

(shear) direction
       s1 = 100.00
  core: s2 = Av2*(*Dc2/2)/(s2*Ag) = 0.00046968
       Av2 = 50.26548, is the area of stirrup
       Dc2 = Dint - Internal Hoop Diameter = 292.00, is the total Length of all stirrups parallel to loading (shear) direction
       s2 = 250.00
  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.
  For the normalisation fs of jacket is used.
  NUD = 7385.582
  Ag = 196349.541
  f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 33.00
  fylE = (fy_ext_Long_Reinf*Area_ext_Long_Reinf+fy_int_Long_Reinf*Area_int_Long_Reinf)/Area_Tot_Long_Rein = 2.1219958E-314
  fytE = (fy_ext_Trans_Reinf*Area_ext_Trans_Reinf+fy_int_Trans_Reinf*Area_int_Trans_Reinf)/Area_Tot_Trans_Rein = 555.56
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
    f'cE = 33.00

End Of Calculation of Chord Rotation Capacity for element: column JCC1 of floor 1
At local axis: 3
Integration Section: (b)