Detailed Member Calculations

Units: N & mm

Regulation: ASCE 41-17

Calculation No. 1

column C1, Floor 1

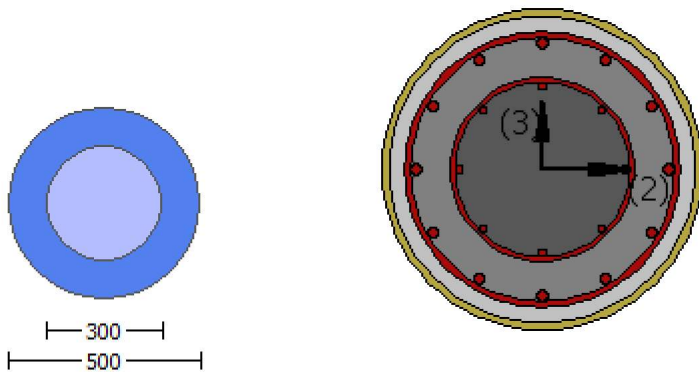Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00

Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4081E+007
Shear Force, Va = -4692.378
EDGE -B-
Bending Moment, Mb = 0.06280399
Shear Force, Vb = 4692.378
BOTH EDGES
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 409200.703
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 481412.592
   VCol = 481412.592
   knl = 1.00

displacement_ductility_demand = 0.01726922

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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 4.00
    Mu = 1.4081E+007
    Vu = 4692.378
  d = 0.8*D = 400.00
  Nu = 7387.337
  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 = 400.00
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 389409.072
    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   = 0.00016098
  y = (My*Ls/3)/EIeff = 0.00932169 ((4.29),Biskinis Phd))
  My = 2.2494E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3000.756
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7387.337
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+013

Calculation of Yielding Moment My

Calculation of y and My according to (7) - (8) in Biskinis and Fardis

----

$My = Min(My\_ten, My\_com) = 2.2494E+008$

$y = 6.4601594E-006$

My_ten (8c) $= 2.2494E+008$

$\_ten$ (7c) $= 62.07297$

error of function (7c) $= 0.00023516$

My_com (8d) $= 8.0674E+008$

$\_com$ (7d) $= 63.84406$

error of function (7d) $= -0.00846593$

  with ((10.1), ASCE 41-17) $ey = Min(ey, 1.25*ey*(lb/ld)^{2/3}) = 0.00277778$

    $eco = 0.002$

    $apl = 0.45$ ((9c) in Biskinis and Fardis for FRP Wrap)

    $d1 = 44.00$

    $R = 250.00$

    $v = 0.00103635$

    $N = 7387.337$

    $Ac = 196349.541$

    ((10.1), ASCE 41-17) $= Min(, 1.25* *(lb/ld)^{2/3}) = 0.23799161$

  with $fc*$ ((12.3), ACI 440) $= 36.3038$

    $fc = 33.00$

    $fl = 1.05384$

    $k = 1$

      Effective FRP thickness, $tf = NL*t*Cos(b1) = 1.016$

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

    $fu = 0.01$

    $Ef = 64828.00$

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

At local axis: 2

Integration Section: (a)

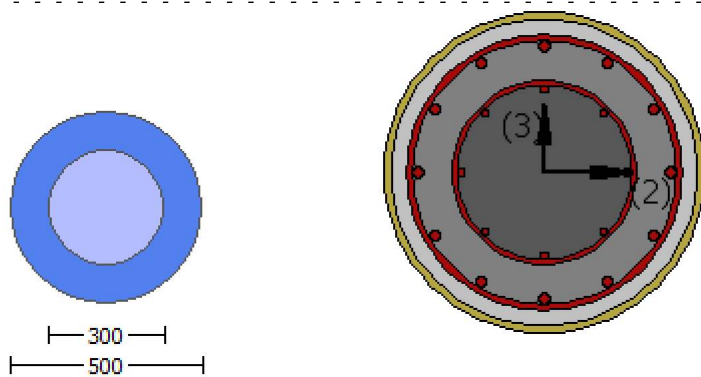

Calculation No. 2

column C1, Floor 1

Limit State: Immediate Occupancy (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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

```

Stepwise Properties
-------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008
-------------------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor  c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-------------------------------------------------------------
Calculation of ratio lb/ld
-------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Mu1-
-------------------------------------------------------------------------

```
----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------
    = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------


----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------
    = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu2-
------------------------------------------------------------------


----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------
    = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
```

conf. factor   c = 1.46748
fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        = *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
      Mu = 9.5189389E-012
      Vu = 2.8066262E-032
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
      Ef = 64828.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712

```
     bw*d =   *d*d/4 = 125663.706
----------------------------------------------------------------

--------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.5189389E-012
      Vu = 2.8066262E-032
    d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.5556
      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 = 444.4444
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
       f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
      Ef = 64828.00
       fe = 0.004, from (11.6a), ACI 440
        with   fu = 0.01
   From (11-11), ACI 440: Vs + Vf <= 444245.712
      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,   = 0.85
Mean strength values are used for both shear and moment calculations.
```

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
         N = 7389.214
         Ac = 196349.541
         =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525

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).

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.5525950E-011
Vu = 2.0052783E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.5556
s = 100.00
Vs1 is multiplied by Col1 = 1.00
s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
Av = π/2*A_stirrup = 78956.835
fy = 444.4444
s = 250.00
Vs2 is multiplied by Col2 = 0.00
s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
⍺f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinβ + cosβ is replaced with (cotθ+cotα)sinα which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1: α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
Ef = 64828.00
εfe = 0.004, from (11.6a), ACI 440
with εfu = 0.01
From (11-11), ACI 440: Vs + Vf <= 444245.712
bw*d = π*d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
VCol0 = 653958.525
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).

λ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
Mu = 1.5525950E-011
Vu = 2.0052783E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
Av = π/2*A_stirrup = 123370.055
fy = 555.5556

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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin   + cos   is replaced with (cot + cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   = 45° and   = -45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with   fu = 0.01
  From (11-11), ACI 440: Vs + Vf < = 444245.712
    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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 7.4950559E-011
Shear Force, V2 = -4692.378
Shear Force, V3 = -3.4868473E-014
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R = * u = 0.00396072
 u = y + p = 0.00465967

 - Calculation of y -
----
 y = (My*Ls/3)/Eleff = 0.00465967 ((4.29),Biskinis Phd))
 My = 2.2494E+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 = 2.4137E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
        N = 7387.337
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
  y = 6.4601594E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07297
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
 error of function (7d) = -0.00846593
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.00277778
       eco = 0.002
       apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
       d1 = 44.00
       R = 250.00
       v = 0.00103635
       N = 7387.337
       Ac = 196349.541

((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
  with fc* ((12.3), ACI 440) = 36.3038
      fc = 33.00
      fl = 1.05384
      k   = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.01
      Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - 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 = 0.2531139
   d = d_external = 0.00
   s = s_external = 0.00
    t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00702812
   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 = 7387.337
    Ag = 196349.541
    f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32
    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 =
539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
    f'cE = 28.32

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: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Shear capacity VRd

Edge: Start

Local Axis: (3)


```
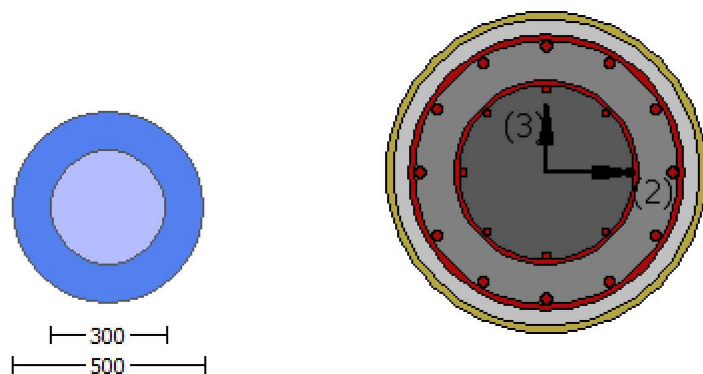300
500
```

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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 7.4950559E-011
Shear Force, Va = -3.4868473E-014
EDGE -B-
Bending Moment, Mb = 2.9619897E-011
Shear Force, Vb = 3.4868473E-014
BOTH EDGES
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.694
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 573416.111
  VCol = 573416.111
  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 = 21.76, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 7.4950559E-011
    Vu = 3.4868473E-014
  d = 0.8*D = 400.00
  Nu = 7387.337
  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 = 400.00
    s = 250.00

Vs2 is multiplied by   Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
  ψf = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where   is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
orientation 1:   1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
  Ef = 64828.00
   fe = 0.004, from (11.6a), ACI 440
     with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 389409.072
  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   = 1.5704874E-021
 y = (My*Ls/3)/EIeff = 0.00465967 ((4.29),Biskinis Phd))
 My = 2.2494E+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 = 2.4137E+013
    factor = 0.30
       Ag = 196349.541
       Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
       N = 7387.337
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 y = 6.4601594E-006
 My_ten (8c) = 2.2494E+008
  _ten (7c) = 62.07297
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
  _com (7d) = 63.84406
 error of function (7d) = -0.00846593
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.00277778
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00103635
      N = 7387.337
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^ 2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
    fc = 33.00
    fl = 1.05384
    k = 1
       Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
    efe ((12.5) and (12.7)) = 0.004

fu = 0.01
        Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: Start

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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008

Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

  = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

  = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
$\quad$ Mu = 9.5189389E-012
$\quad$ Vu = 2.8066262E-032
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
$\quad$ Av = /2*A_stirrup = 123370.055
$\quad$ fy = 555.5556
$\quad$ s = 100.00
Vs1 is multiplied by Col1 = 1.00
$\quad$ s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
$\quad$ Av = /2*A_stirrup = 78956.835
$\quad$ fy = 444.4444
$\quad$ s = 250.00
Vs2 is multiplied by Col2 = 0.00
$\quad$ s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
$\quad$ f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
$\quad$ Ef = 64828.00
$\quad$ fe = 0.004, from (11.6a), ACI 440
$\quad$ with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 444245.712
$\quad$ bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
$\quad$ VCol0 = 653958.525
$\quad$ 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).

$\quad$ = 1 (normal-weight concrete)
Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

M/Vd = 2.00
$\quad$ Mu = 9.5189389E-012
$\quad$ Vu = 2.8066262E-032
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
$\quad$ Av = /2*A_stirrup = 123370.055
$\quad$ fy = 555.5556
$\quad$ s = 100.00
Vs1 is multiplied by Col1 = 1.00
$\quad$ s/d = 0.25
Vs2 = 0.00 is calculated for core, with:
$\quad$ Av = /2*A_stirrup = 78956.835
$\quad$ fy = 444.4444

s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
    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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167

```
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
--------------------------------------------------------------


Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------
------------------------------------------------------------------
------------------------------------------------------------------
Calculation of Mu1-
------------------------------------------------------------------


------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
--------------------------------------------------------------


Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------
------------------------------------------------------------------
------------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------------


------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
--------------------------------------------------------------


Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------------
```

```
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------------

----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------------
```

     = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

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

Calculation of ratio lb/ld

```
------------------------------------------------------------
```
Inadequate Lap Length with lb/ld = 0.30

```
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
```
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

```
----------------------------------------------------------------------
```
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 1.5525950E-011
     Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
    bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
    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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.4081E+007
Shear Force, V2 = -4692.378
Shear Force, V3 = -3.4868473E-014
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
       -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
       -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R =   * u = 0.00792343

$\theta u = \theta y + \theta p = 0.00932169$

- Calculation of θy -

$\theta y = (My*Ls/3)/Eleff = 0.00932169 ((4.29),Biskinis Phd))$
$My = 2.2494E+008$
$Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.756$
From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4137E+013
    factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
        N = 7387.337
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+013

Calculation of Yielding Moment My

Calculation of θy and My according to (7) - (8) in Biskinis and Fardis
----
$My = Min(My\_ten,My\_com) = 2.2494E+008$
$\theta y = 6.4601594E-006$
$My\_ten (8c) = 2.2494E+008$
$\xi\_ten (7c) = 62.07297$
error of function (7c) = 0.00023516
$My\_com (8d) = 8.0674E+008$
$\xi\_com (7d) = 63.84406$
error of function (7d) = -0.00846593
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
        eco = 0.002
        apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
        d1 = 44.00
        R = 250.00
        v = 0.00103635
        N = 7387.337
        Ac = 196349.541
        ((10.1), ASCE 41-17) ϵ = Min(ϵ, 1.25*ϵ*(lb/ld)^2/3) = 0.23799161
    with fc* ((12.3), ACI 440) = 36.3038
        fc = 33.00
        fl = 1.05384
        k = 1
            Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
        efe ((12.5) and (12.7)) = 0.004
        ϵfu = 0.01
        Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of θp -

From table 10-9: $\theta p = 0.00$
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.2531139
  d = d_external = 0.00
  s = s_external = 0.00
    $\rho t = \rho s1 + \rho s2 + 2*tf/bw*(ffe/fs) = 0.00702812$
  jacket: $\rho s1 = Av1*(\pi*Dc1/2)/(s1*Ag) = 0.0027646$
        Av1 = 78.53982, is the area of stirrup
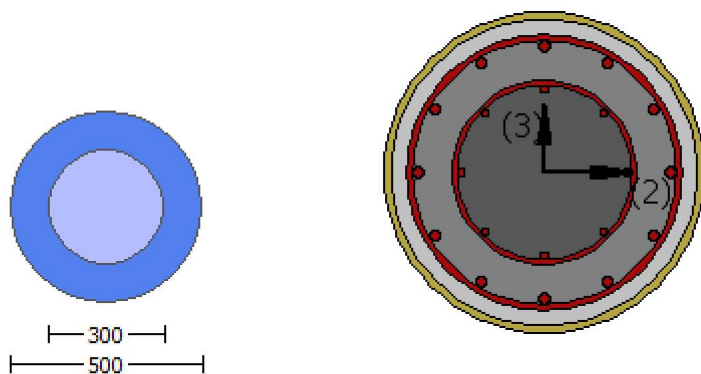   Dc1 = Dext - 2*cover - External Hoop Diameter = 440.00, is the total Length of all stirrups parallel to loading
(shear) direction

```
        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 = 7387.337
     Ag = 196349.541
     f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32
     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 =
539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
     f'cE = 28.32
-------------------------------------------------------------
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: Immediate Occupancy (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.4081E+007
Shear Force, Va = -4692.378
EDGE -B-
Bending Moment, Mb = 0.06280399
Shear Force, Vb = 4692.378
BOTH EDGES
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
   -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876

```
        -Compression: Asl,com = 1017.876
           -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00
-------------------------------------------------------------
-------------------------------------------------------------


Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.694
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 573416.111
   VCol = 573416.111
   knl = 1.00
       displacement_ductility_demand = 0.09388782
-------------------------------------------------------------
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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
       Mu = 0.06280399
       Vu = 4692.378
   d = 0.8*D = 400.00
   Nu = 7387.337
   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 = 400.00
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
       Ef = 64828.00
        fe = 0.004, from (11.6a), ACI 440
          with  fu = 0.01
    From (11-11), ACI 440: Vs + Vf <= 389409.072
      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    = 8.7497238E-005
  y = (My*Ls/3)/Eleff = 0.00093193 ((4.29),Biskinis Phd))
   My = 2.2494E+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 = 2.4137E+013
   factor = 0.30
     Ag = 196349.541
     Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
     N = 7387.337
   Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 y = 6.4601594E-006
 My_ten (8c) = 2.2494E+008
  _ten (7c) = 62.07297
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
  _com (7d) = 63.84406
 error of function (7d) = -0.00846593
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
    eco = 0.002
    apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
    d1 = 44.00
    R = 250.00
    v = 0.00103635
    N = 7387.337
    Ac = 196349.541
   ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
   fc = 33.00
   fl = 1.05384
   k   = 1
    Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
   efe ((12.5) and (12.7)) = 0.004
    fu = 0.01
   Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

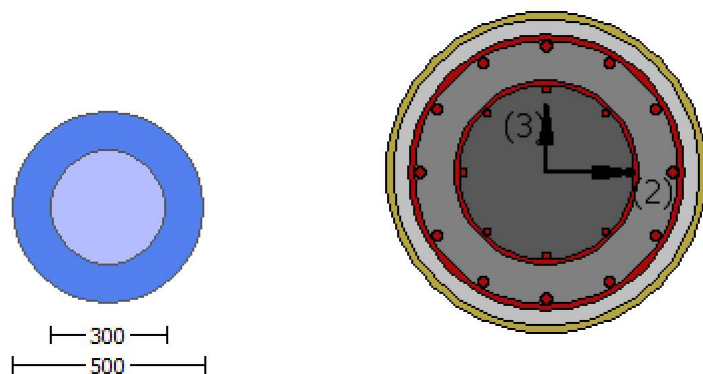End Of Calculation of Shear Capacity for element: column JCC1 of floor 1
At local axis: 2
Integration Section: (b)

Calculation No. 6

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

     = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167

```
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------

--------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
--------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor  c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------
--------------------------------------------------------------
--------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------

--------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
--------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor  c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------
```


Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

     = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
    conf. factor   c = 1.46748
    fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.5189389E-012
      Vu = 2.8066262E-032
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.5556
      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 = 444.4444
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
     bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.5189389E-012
     Vu = 2.8066262E-032
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av = /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
       fe = 0.004, from (11.6a), ACI 440
         with fu = 0.01
    From (11-11), ACI 440: Vs + Vf <= 444245.712
       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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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  =  0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008
---------------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------------
---------------------------------------------------------------------------
---------------------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------------------


---------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
---------------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
```

From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

  = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

  = 0.82030475
 ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   =45° and   =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
    bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)
M/Vd = 2.00
   Mu = 1.5525950E-011
   Vu = 2.0052783E-030
d = 0.8*D = 400.00
Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
   Av =   /2*A_stirrup = 123370.055
   fy = 555.5556
   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 = 444.4444
   s = 250.00
Vs2 is multiplied by   Col2 = 0.00
   s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
   f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where   is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1:   1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 444245.712
   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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039

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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 2.9619897E-011
Shear Force, V2 = 4692.378
Shear Force, V3 = 3.4868473E-014
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta u,R = \ast \theta u = 0.00396072$
 $\theta u = \theta y + \theta p = 0.00465967$

 - Calculation of θy -

 $\theta y = (My\ast Ls/3)/Eleff = 0.00465967$ ((4.29),Biskinis Phd))
  $My = 2.2494E+008$
  $Ls = M/V$ (with Ls >0.1*L and Ls < 2*L) = 1500.00
  From table 10.5, ASCE 41_17: Eleff = factor*Ec*Ig = 2.4137E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
        N = 7387.337
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 $\theta y = 6.4601594E-006$
 My_ten (8c) = 2.2494E+008

_ten (7c) = 62.07297
error of function (7c) = 0.00023516
My_com (8d) = 8.0674E+008
_com (7d) = 63.84406
error of function (7d) = -0.00846593
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
    eco = 0.002
    apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
    d1 = 44.00
    R = 250.00
    v = 0.00103635
    N = 7387.337
    Ac = 196349.541
    ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
    fc = 33.00
    fl = 1.05384
    k   = 1
       Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.01
    Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - 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 = 0.2531139
  d = d_external = 0.00
  s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00702812
  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 = 7387.337
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32
   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 = 539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
   f'cE = 28.32

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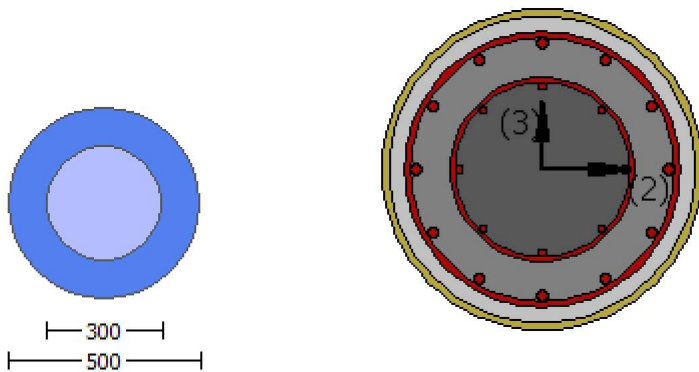Integration Section: (b)

Calculation No. 7

column C1, Floor 1

Limit State: Immediate Occupancy (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 7.4950559E-011
Shear Force, Va = -3.4868473E-014
EDGE -B-
Bending Moment, Mb = 2.9619897E-011
Shear Force, Vb = 3.4868473E-014
BOTH EDGES
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
      -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.694
Vn ((10.3), ASCE 41-17) = knl*VColO = 573416.111
   VCol = 573416.111
   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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 2.9619897E-011
     Vu = 3.4868473E-014
   d = 0.8*D = 400.00
   Nu = 7387.337

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 = 400.00
  s = 250.00
Vs2 is multiplied by Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
  f = 0.95, for fully-wrapped sections
 wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where   is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
orientation 1:   1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
 From (11-11), ACI 440: Vs + Vf <= 389409.072
   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   = 7.2269272E-023
 y = (My*Ls/3)/EIeff = 0.00465967 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7387.337
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 y = 6.4601594E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07297
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
 error of function (7d) = -0.00846593
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^ 2/3) = 0.00277778
     eco = 0.002
     apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)

```
    d1 = 44.00
    R = 250.00
    v = 0.00103635
    N = 7387.337
    Ac = 196349.541
    ((10.1), ASCE 41-17)    = Min( , 1.25* *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
    fc = 33.00
    fl = 1.05384
    k  = 1
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.01
    Ef = 64828.00
```


Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

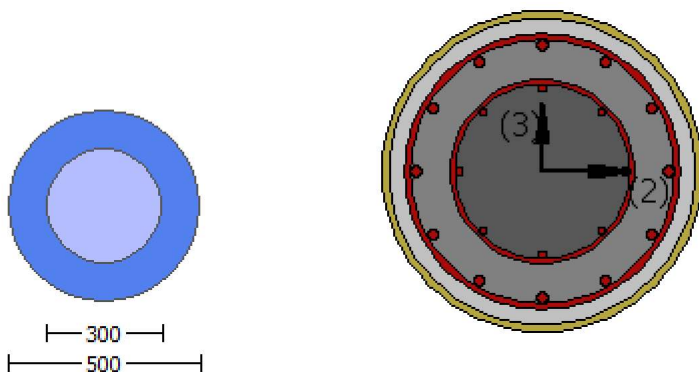# Calculation No. 8

column C1, Floor 1

Limit State: Immediate Occupancy (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
   conf. factor c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541

```
    =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu2+
--------------------------------------------------------------------

--------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
--------------------------------------------------------------------------
    = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Mu2-
--------------------------------------------------------------------

--------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
--------------------------------------------------------------------------
    = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------
--------------------------------------------------------------------
--------------------------------------------------------------------
```

```
-----------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
-----------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.5189389E-012
     Vu = 2.8066262E-032
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.5556
     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 = 444.4444
     s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin   + cos   is replaced with (cot  +cota)sina which is more a generalised expression,
  where    is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf( ,  ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
       with   fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
     bw*d =   *d*d/4 = 125663.706
  ------------------------------------------------------------
  ------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 9.5189389E-012
     Vu = 2.8066262E-032
  d = 0.8*D = 400.00
```

Nu = 7389.214
Ag = 196349.541
From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
Vs1 = 274155.678 is calculated for jacket, with:
  Av =   /2*A_stirrup = 123370.055
  fy = 555.5556
  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 = 444.4444
  s = 250.00
Vs2 is multiplied by   Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
  f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where   is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
orientation 1:   1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
  Ef = 64828.00
   fe = 0.004, from (11.6a), ACI 440
    with fu = 0.01
From (11-11), ACI 440: Vs + Vf < = 444245.712
  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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556

```
##########################################################
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00
-------------------------------------------------------------

Stepwise Properties
-------------------------------------------------------------
At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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  =  0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 =  Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008
```

```
-------------------------------------------------------------------
    = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor  c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------
---------------------------------------------------------------------
---------------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------------

---------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
---------------------------------------------------------------------
    = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor  c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------------
---------------------------------------------------------------------
---------------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------------

---------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
---------------------------------------------------------------------
    = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor  c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
```

```
      d1 = 44.00
      R = 250.00
      v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Mu2-
-------------------------------------------------------------------------

-------------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-------------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
----------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
--------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
```

```
     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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
        with  fu = 0.01
   From (11-11), ACI 440: Vs + Vf < = 444245.712
     bw*d =   *d*d/4 = 125663.706
--------------------------------------------------------------
--------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 < = 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 1.5525950E-011
     Vu = 2.0052783E-030
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.5556
     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 = 444.4444
     s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
```

total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
 From (11-11), ACI 440: Vs + Vf < = 444245.712
  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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 0.06280399
Shear Force, V2 = 4692.378
Shear Force, V3 = 3.4868473E-014
Axial Force, F = -7387.337
Longitudinal Reinforcement Area Distribution (in 2 divisions)

```
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00
------------------------------------------------------------
------------------------------------------------------------


Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity  u,R =  * u = 0.00079214
  u =  y +  p = 0.00093193


------------------------------------------------------------
 - Calculation of  y -
------------------------------------------------------------
 y = (My*Ls/3)/EIeff = 0.00093193 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
        N = 7387.337
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
  y = 6.4601594E-006
  My_ten (8c) = 2.2494E+008
    _ten (7c) = 62.07297
  error of function (7c) = 0.00023516
  My_com (8d) = 8.0674E+008
    _com (7d) = 63.84406
  error of function (7d) = -0.00846593
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00103635
      N = 7387.337
      Ac = 196349.541
      ((10.1), ASCE 41-17)    = Min(  , 1.25*   *(lb/ld)^2/3) = 0.23799161
  with fc* ((12.3), ACI 440) = 36.3038
      fc = 33.00
      fl = 1.05384
      k  = 1
         Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
      efe ((12.5) and (12.7)) = 0.004
       fu = 0.01
      Ef = 64828.00
------------------------------------------------------------
------------------------------------------------------------


Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30


------------------------------------------------------------
 - 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/VCol0E = 0.2531139

  d = d_external = 0.00

  s = s_external = 0.00

   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00702812

  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 = 7387.337

  Ag = 196349.541

  f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32

  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 = 539.4201

pl = Area_Tot_Long_Rein/(Ag) = 0.015552

  f'cE = 28.32

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: Collapse Prevention (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1

Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.7582E+007
Shear Force, Va = -5859.331
EDGE -B-
Bending Moment, Mb = 0.0784228
Shear Force, Vb = 5859.331
BOTH EDGES
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR = *Vn = 409200.663
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 481412.545
   VCol = 481412.545
   knl = 1.00
      displacement_ductility_demand = 0.02156393

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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 4.00
      Mu = 1.7582E+007
      Vu = 5859.331
   d = 0.8*D = 400.00
   Nu = 7386.87
   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 = 400.00
      s = 250.00
   Vs2 is multiplied by Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
   orientation 1: 1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00

ffe ((11-5), ACI 440) = 259.312
  Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
      with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 389409.072
    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   = 0.00020101
 y = (My*Ls/3)/EIeff = 0.00932168 ((4.29),Biskinis Phd))
  My = 2.2494E+008
  Ls = M/V (with Ls > 0.1*L and Ls < 2*L) = 3000.756
  From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7386.87
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
  y = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07296
  error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
  error of function (7d) = -0.00846594
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
     eco = 0.002
     apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00103628
     N = 7386.87
     Ac = 196349.541
     ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
  with fc* ((12.3), ACI 440) = 36.3038
     fc = 33.00
     fl = 1.05384
     k = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.01
     Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

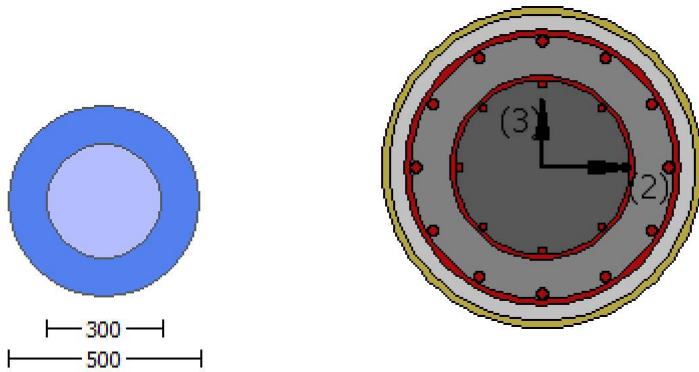
Calculation No. 10

column C1, Floor 1

Limit State: Collapse Prevention (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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##

External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

```
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c =  48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu1-
----------------------------------------------------------------


----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c =  48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu2+
----------------------------------------------------------------


----------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c =  48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
```

```
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------------

----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
----------------------------------------------------------------------
   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor  c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
----------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
----------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 9.5189389E-012
     Vu = 2.8066262E-032
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.5556
     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 = 444.4444
  s = 250.00
Vs2 is multiplied by Col2 = 0.00
  s/d = 1.04167
Vf ((11-3)-(11.4), ACI 440) = 247653.332
  f = 0.95, for fully-wrapped sections
wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
orientation 1: 1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
  Ef = 64828.00
   fe = 0.004, from (11.6a), ACI 440
    with fu = 0.01
From (11-11), ACI 440: Vs + Vf <= 444245.712
  bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
   Mu = 9.5189389E-012
   Vu = 2.8066262E-032
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
   Av = /2*A_stirrup = 123370.055
   fy = 555.5556
   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 = 444.4444
   s = 250.00
  Vs2 is multiplied by Col2 = 0.00
   s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
   f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1: 1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016

dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.01
 From (11-11), ACI 440: Vs + Vf <= 444245.712
  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, = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
  Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
  Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

  = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      = *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

```
-------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu2+
----------------------------------------------------------------

-------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
----------------------------------------------------------------
----------------------------------------------------------------
----------------------------------------------------------------
Calculation of Mu2-
----------------------------------------------------------------

-------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
```

conf. factor   c = 1.46748
 fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 1.5525950E-011
     Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712

```
       bw*d =    *d*d/4 = 125663.706
-------------------------------------------------------------

-------------------------------------------------------------------
Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 1.5525950E-011
      Vu = 2.0052783E-030
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
      Av =   /2*A_stirrup = 123370.055
      fy = 555.5556
      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 = 444.4444
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin   + cos   is replaced with (cot  +cota)sina which is more a generalised expression,
   where    is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( ,  ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and   =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
      Ef = 64828.00
       fe = 0.004, from (11.6a), ACI 440
        with   fu = 0.01
   From (11-11), ACI 440: Vs + Vf <= 444245.712
      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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 9.1222828E-011
Shear Force, V2 = -5859.331
Shear Force, V3 = -4.3539955E-014
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity u,R =   * u = 0.03966072
 u = y + p = 0.04665967

 - Calculation of y -
----
 y = (My*Ls/3)/Eleff = 0.00465967 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
     factor = 0.30
        Ag = 196349.541
        Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
        N = 7386.87

Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
  y = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07296
  error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
  error of function (7d) = -0.00846594
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00103628
      N = 7386.87
      Ac = 196349.541
      ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
     fc = 33.00
     fl = 1.05384
     k = 1
       Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.01
     Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of p -

From table 10-9: p = 0.042
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.2531139
  d = d_external = 0.00
  s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00702812
  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 = 7386.87
   Ag = 196349.541
   f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32

fyIE = (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 = 539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
f'cE = 28.32

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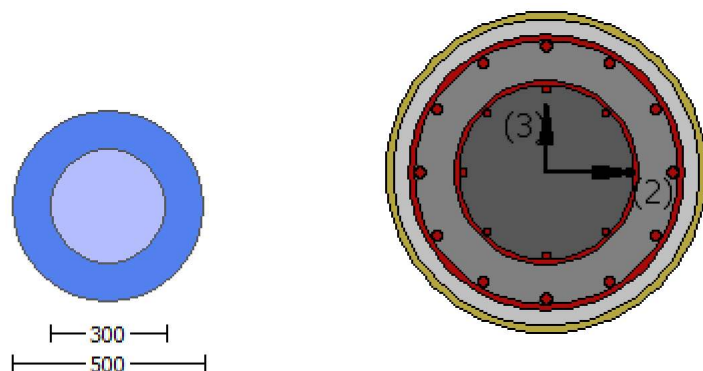At local axis: 2
Integration Section: (a)

Calculation No. 11

column C1, Floor 1

Limit State: Collapse Prevention (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
###
Note: Especially for the calculation of y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
###
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.1222828E-011
Shear Force, Va = -4.3539955E-014
EDGE -B-
Bending Moment, Mb = 3.9353382E-011
Shear Force, Vb = 4.3539955E-014
BOTH EDGES
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 1272.345
     -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
     -Compression: Asl,com = 1017.876
        -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.616
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 573416.018
   VCol = 573416.018
   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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 9.1222828E-011
     Vu = 4.3539955E-014
   d = 0.8*D = 400.00
   Nu = 7386.87
   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 = 400.00
     s = 250.00
   Vs2 is multiplied by Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where   is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.01
   From (11-11), ACI 440: Vs + Vf <= 389409.072
     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 = 1.9610538E-021
 y = (My*Ls/3)/EIeff = 0.00465967 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
     factor = 0.30
       Ag = 196349.541
       Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
       N = 7386.87
     Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 y = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07296
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
 error of function (7d) = -0.00846594
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
     eco = 0.002
     apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00103628
     N = 7386.87
     Ac = 196349.541
     ((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
     fc = 33.00
     fl = 1.05384
     k   = 1
       Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.01
     Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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

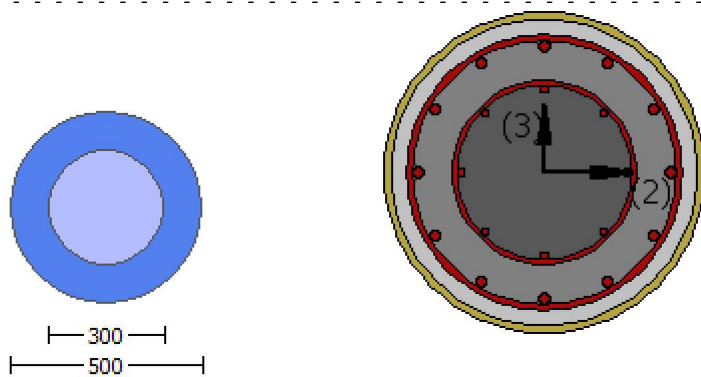
Calculation No. 12

column C1, Floor 1

Limit State: Collapse Prevention (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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

```

Stepwise Properties
--------------------------------------------------------------
At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
   Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008
--------------------------------------------------------------------------
  = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor  c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =  *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
--------------------------------------------------------------

Calculation of ratio lb/ld
--------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
--------------------------------------------------------------------------
--------------------------------------------------------------------------
--------------------------------------------------------------------------
Calculation of Mu1-
--------------------------------------------------------------------------

```
------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
Calculation of Mu2+
------------------------------------------------------------

------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
------------------------------------------------------------
------------------------------------------------------------
------------------------------------------------------------
Calculation of Mu2-
------------------------------------------------------------

------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
```

```
     conf. factor   c = 1.46748
     fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
      lb/ld = 0.30
      d1 = 44.00
      R = 250.00
      v = 0.00103167
         N = 7389.214
         Ac = 196349.541
         =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
---------------------------------------------------------------

Calculation of ratio lb/ld
---------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
-------------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
-------------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 9.5189389E-012
      Vu = 2.8066262E-032
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
      Av =    /2*A_stirrup = 123370.055
      fy = 555.5556
      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 = 444.4444
      s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
      s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
      f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
   where    is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions,  =45° and  =-45° to take into consideration the cyclic seismic loading.
   orientation 1:   1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
      Ef = 64828.00
       fe = 0.004, from (11.6a), ACI 440
        with  fu = 0.01
   From (11-11), ACI 440: Vs + Vf <= 444245.712
```

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

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
     Mu = 9.5189389E-012
     Vu = 2.8066262E-032
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
     Av = /2*A_stirrup = 123370.055
     fy = 555.5556
     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 = 444.4444
     s = 250.00
   Vs2 is multiplied by Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
   In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
   where is the angle of the crack direction (see KANEPE).
   This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
   as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
   orientation 1: 1 = b1 + 90° = 90.00
   Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
   total thickness per orientation, tf1 = NL*t/NoDir = 1.016
   dfv = d (figure 11.2, ACI 440) = 470.00
   ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
   From (11-11), ACI 440: Vs + Vf <= 444245.712
     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, = 0.85
Mean strength values are used for both shear and moment calculations.

Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with

Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
  Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
  Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

```
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Mu2+
-----------------------------------------------------------------------

-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-----------------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Mu2-
-----------------------------------------------------------------------

-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-----------------------------------------------------------------------
   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
  conf. factor   c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
-----------------------------------------------------------

Calculation of ratio lb/ld
-----------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
-----------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
```

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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556
    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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos   is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   =45° and   =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 444245.712
    bw*d =   *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
    Av =   /2*A_stirrup = 123370.055
    fy = 555.5556

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 = 444.4444
    s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin   + cos   is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   = 45° and   =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
     fe = 0.004, from (11.6a), ACI 440
       with   fu = 0.01
  From (11-11), ACI 440: Vs + Vf < = 444245.712
    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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon

Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = -1.7582E+007
Shear Force, V2 = -5859.331
Shear Force, V3 = -4.3539955E-014
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 1272.345
    -Compression: Aslc = 1781.283
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
       -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity $\theta_{u,R}$ = * θ_u = 0.04362343
 θ_u = θ_y + θ_p = 0.05132168

 - Calculation of θ_y -

 θ_y = (My*Ls/3)/EIeff = 0.00932168 ((4.29),Biskinis Phd))
 My = 2.2494E+008
 Ls = M/V (with Ls >0.1*L and Ls < 2*L) = 3000.756
 From table 10.5, ASCE 41_17: EIeff = factor*Ec*Ig = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7386.87
   Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+013

Calculation of Yielding Moment My

Calculation of ϕ_y and My according to (7) - (8) in Biskinis and Fardis
----
My = Min(My_ten,My_com) = 2.2494E+008
 ϕ_y = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
  ξ_ten (7c) = 62.07296
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
  ξ_com (7d) = 63.84406
 error of function (7d) = -0.00846594
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00103628
      N = 7386.87
      Ac = 196349.541

((10.1), ASCE 41-17)   = Min(, 1.25*   *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
     fc = 33.00
     fl = 1.05384
     k   = 1
        Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.01
     Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

 - Calculation of   p -

From table 10-9:   p = 0.042
with:
 - Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
   shear control ratio VyE/VColOE = 0.2531139
  d = d_external = 0.00
  s = s_external = 0.00
   t =   s1 +   s2 + 2*tf/bw*(ffe/fs) = 0.00702812
  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 = 7386.87
    Ag = 196349.541
    f'cE = (fc_jacket*Area_jacket+fc_core*Area_core)/section_area = 28.32
    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 =
539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
    f'cE = 28.32

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: Collapse Prevention (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = -1.7582E+007
Shear Force, Va = -5859.331
EDGE -B-
Bending Moment, Mb = 0.0784228
Shear Force, Vb = 5859.331
BOTH EDGES
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876
      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00

Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.616
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 573416.018
   VCol = 573416.018
   knl = 1.00
      displacement_ductility_demand = 0.11723693

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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 0.0784228
      Vu = 5859.331
   d = 0.8*D = 400.00
   Nu = 7386.87
   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 = 400.00
     s = 250.00

Vs2 is multiplied by   Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
    φf = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
In (11.3) sinβ + cosβ is replaced with (cotθ +cotα)sinα which is more a generalised expression,
where θ is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(θ,α), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, θ=45° and θ=-45° to take into consideration the cyclic seismic loading.
orientation 1:   α1 = b1 + 90° = 90.00
Vf = Min(|Vf(45,α1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
    Ef = 64828.00
    εfe = 0.004, from (11.6a), ACI 440
        with εfu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 389409.072
    bw*d = π*d*d/4 = 125663.706

----
displacement_ductility_demand is calculated as θ/θy

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

From analysis, chord rotation θ = 0.00010926
 θy = (My*Ls/3)/EIeff = 0.00093193 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7386.87
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 φy = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
   ξ_ten (7c) = 62.07296
  error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   ξ_com (7d) = 63.84406
  error of function (7d) = -0.00846594
    with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
      eco = 0.002
      apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
      d1 = 44.00
      R = 250.00
      v = 0.00103628
      N = 7386.87
      Ac = 196349.541
      ((10.1), ASCE 41-17) α = Min(α, 1.25*α*(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
    fc = 33.00
    fl = 1.05384
    k = 1
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
    efe ((12.5) and (12.7)) = 0.004

```
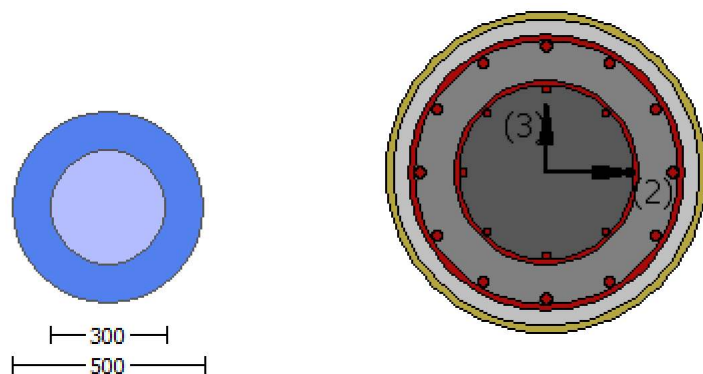    fu = 0.01
    Ef = 64828.00
```


Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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: Collapse Prevention (data interpolation between analysis steps 1 and 2)

Analysis: Uniform +X

Check: Chord rotation capacity (u)

Edge: End

Local Axis: (2)


```
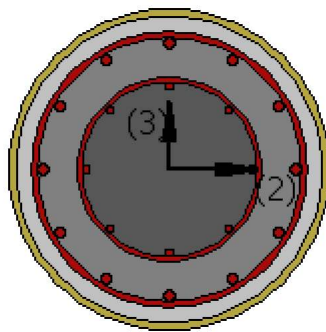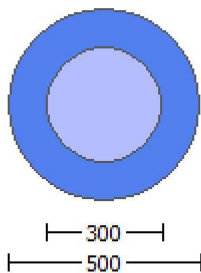├─ 300 ─┤
├──── 500 ────┤
```

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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00

Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 3
EDGE -A-
Shear Force, Va = -2.8066262E-032
EDGE -B-
Shear Force, Vb = 2.8066262E-032
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
   Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008

Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

  = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu1-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

  = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167
      N = 7389.214
      Ac = 196349.541
      =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2+

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Mu2-

Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008

   = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525

Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

  M/Vd = 2.00

    Mu = 9.5189389E-012

    Vu = 2.8066262E-032

  d = 0.8*D = 400.00

  Nu = 7389.214

  Ag = 196349.541

  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678

  Vs1 = 274155.678 is calculated for jacket, with:

    Av = /2*A_stirrup = 123370.055

    fy = 555.5556

    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 = 444.4444

    s = 250.00

  Vs2 is multiplied by Col2 = 0.00

    s/d = 1.04167

  Vf ((11-3)-(11.4), ACI 440) = 247653.332

    f = 0.95, for fully-wrapped sections

  wf/sf = 1 (FRP strips adjacent to one another).

In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,

where is the angle of the crack direction (see KANEPE).

This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,

as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.

orientation 1: 1 = b1 + 90° = 90.00

Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:

total thickness per orientation, tf1 = NL*t/NoDir = 1.016

dfv = d (figure 11.2, ACI 440) = 470.00

ffe ((11-5), ACI 440) = 259.312

    Ef = 64828.00

     fe = 0.004, from (11.6a), ACI 440

      with fu = 0.01

  From (11-11), ACI 440: Vs + Vf <= 444245.712

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

Calculation of Shear Strength at edge 2, Vr2 = 653958.525

Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0

  VCol0 = 653958.525

  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 = 28.32, but fc^0.5 <= 8.3 MPa (22.5.3.1, ACI 318-14)

  M/Vd = 2.00

    Mu = 9.5189389E-012

    Vu = 2.8066262E-032

  d = 0.8*D = 400.00

  Nu = 7389.214

  Ag = 196349.541

  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678

  Vs1 = 274155.678 is calculated for jacket, with:

    Av = /2*A_stirrup = 123370.055

    fy = 555.5556

    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 = 444.4444

s = 250.00
  Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
     f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, =45° and =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
        with fu = 0.01
   From (11-11), ACI 440: Vs + Vf < = 444245.712
     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,   = 0.85
Mean strength values are used for both shear and moment calculations.
Consequently:
Jacket
New material of Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of moment strengths,
the above steel re-bar strengths are multiplied by 1.25 according to R18.6.5, ACI 318-14
Jacket
New material: Steel Strength, fs = 1.25*fsm = 694.4444
Existing Column
Existing material: Steel Strength, fs = 1.25*fsm = 555.5556
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Mean Confinement Factor overall section = 1.46748
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min = 0.30

FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

At local axis: 2
EDGE -A-
Shear Force, Va = -2.0052783E-030
EDGE -B-
Shear Force, Vb = 2.0052783E-030
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 = 0.2531139
Member Controlled by Flexure (Ve/Vr < 1)
Calculation of Shear Demand from fig. R18.6.5, ACI 318-14 Ve = (Mpr1 + Mpr2)/ln = 165525.992
with
Mpr1 = Max(Mu1+ , Mu1-) = 2.4829E+008
  Mu1+ = 2.4829E+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- = 2.4829E+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-) = 2.4829E+008
  Mu2+ = 2.4829E+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- = 2.4829E+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 = 2.4829E+008

    = 0.82030475
  ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc* c = 48.42699
  conf. factor c = 1.46748
  fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
    lb/ld = 0.30
    d1 = 44.00
    R = 250.00
    v = 0.00103167

```
    N = 7389.214
    Ac = 196349.541
    =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
Calculation of Mu1-
---------------------------------------------------------------

---------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
---------------------------------------------------------------
    = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------
---------------------------------------------------------------
---------------------------------------------------------------
Calculation of Mu2+
---------------------------------------------------------------

---------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
---------------------------------------------------------------
    = 0.82030475
    ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor   c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
        N = 7389.214
        Ac = 196349.541
        =    *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
------------------------------------------------------------

Calculation of ratio lb/ld
------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
---------------------------------------------------------------
```

```
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Mu2-
-----------------------------------------------------------------------

-----------------------------------------------------------------------
Calculation of ultimate Moment Strength ((3.67), Biskinis Phd), Mu
Mu = 2.4829E+008
-----------------------------------------------------------------------

   = 0.82030475
   ' = 0.72936354
error of function (3.68), Biskinis Phd = 58395.855
From 5A.2, TBDY: fcc = fc*  c = 48.42699
   conf. factor  c = 1.46748
   fc = 33.00
From 10.3.5, ASCE 41-17, Final value of fy: fy*Min(1,1.25*(lb/ld)^2/3) = 389.0108
     lb/ld = 0.30
     d1 = 44.00
     R = 250.00
     v = 0.00103167
       N = 7389.214
       Ac = 196349.541
       =   *Min(1,1.25*(lb/ld)^2/3) = 0.16585198
----------------------------------------------------------------

Calculation of ratio lb/ld
----------------------------------------------------------------
Inadequate Lap Length with lb/ld = 0.30
-------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
-----------------------------------------------------------------------
Calculation of Shear Strength Vr = Min(Vr1,Vr2) = 653958.525
-----------------------------------------------------------------------
Calculation of Shear Strength at edge 1, Vr1 = 653958.525
Vr1 = VCol ((10.3), ASCE 41-17) = knl*VCol0
   VCol0 = 653958.525
   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 = 28.32, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
   M/Vd = 2.00
      Mu = 1.5525950E-011
      Vu = 2.0052783E-030
   d = 0.8*D = 400.00
   Nu = 7389.214
   Ag = 196349.541
   From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
   Vs1 = 274155.678 is calculated for jacket, with:
     Av =   /2*A_stirrup = 123370.055
     fy = 555.5556
     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 = 444.4444
     s = 250.00
   Vs2 is multiplied by   Col2 = 0.00
     s/d = 1.04167
   Vf ((11-3)-(11.4), ACI 440) = 247653.332
     f = 0.95, for fully-wrapped sections
   wf/sf = 1 (FRP strips adjacent to one another).
```

In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
where   is the angle of the crack direction (see KANEPE).
This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
orientation 1:   1 = b1 + 90° = 90.00
Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
total thickness per orientation, tf1 = NL*t/NoDir = 1.016
dfv = d (figure 11.2, ACI 440) = 470.00
ffe ((11-5), ACI 440) = 259.312
   Ef = 64828.00
    fe = 0.004, from (11.6a), ACI 440
     with fu = 0.01
  From (11-11), ACI 440: Vs + Vf < = 444245.712
    bw*d = *d*d/4 = 125663.706

Calculation of Shear Strength at edge 2, Vr2 = 653958.525
Vr2 = VCol ((10.3), ASCE 41-17) = knl*VCol0
  VCol0 = 653958.525
  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 = 28.32, but fc^0.5 < = 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
    Mu = 1.5525950E-011
    Vu = 2.0052783E-030
  d = 0.8*D = 400.00
  Nu = 7389.214
  Ag = 196349.541
  From (11.5.4.8), ACI 318-14: Vs = Vs1 + Vs2 = 274155.678
  Vs1 = 274155.678 is calculated for jacket, with:
   Av = /2*A_stirrup = 123370.055
   fy = 555.5556
   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 = 444.4444
   s = 250.00
  Vs2 is multiplied by Col2 = 0.00
    s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
   f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin + cos is replaced with (cot +cota)sina which is more a generalised expression,
  where   is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf(,), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions, = 45° and = -45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45, 1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
       with fu = 0.01
   From (11-11), ACI 440: Vs + Vf < = 444245.712
     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,   = 0.85
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 Primary Member: Concrete Strength, fc = fcm = 33.00
New material of Primary Member: Steel Strength, fs = fsm = 555.5556
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fcm = 20.00
Existing material of Primary Member: Steel Strength, fs = fsm = 444.4444
Concrete Elasticity, Ec = 21019.039
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
Primary 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
Inadequate Lap Length with lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

Bending Moment, M = 3.9353382E-011
Shear Force, V2 = 5859.331
Shear Force, V3 = 4.3539955E-014
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
      -Tension: Aslt = 0.00
    -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
      -Tension: Asl,ten = 1017.876
    -Compression: Asl,com = 1017.876
      -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL = 18.00

Existing component: From table 7-7, ASCE 41_17: Final chord rotation Capacity   u,R =   * u = 0.03966072

u = y + p = 0.04665967

- Calculation of y -
----
y = (My*Ls/3)/EIeff = 0.00465967 ((4.29),Biskinis Phd))
 My = 2.2494E+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 = 2.4137E+013
   factor = 0.30
     Ag = 196349.541
     Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
     N = 7386.87
   Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 y = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
   _ten (7c) = 62.07296
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
   _com (7d) = 63.84406
 error of function (7d) = -0.00846594
   with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
     eco = 0.002
     apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
     d1 = 44.00
     R = 250.00
     v = 0.00103628
     N = 7386.87
     Ac = 196349.541
     ((10.1), ASCE 41-17)   = Min(, 1.25* *(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
     fc = 33.00
     fl = 1.05384
     k = 1
       Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
     efe ((12.5) and (12.7)) = 0.004
      fu = 0.01
     Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

- Calculation of p -

From table 10-9: p = 0.042
with:
- Columns controlled by inadequate development or splicing along the clear height because lb/ld < 1
  shear control ratio VyE/VColOE = 0.2531139
 d = d_external = 0.00
 s = s_external = 0.00
   t = s1 + s2 + 2*tf/bw*(ffe/fs) = 0.00702812
 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 = 7386.87
     Ag = 196349.541
     f'cE = (fc_jacket*Area_jacket+ fc_core*Area_core)/section_area = 28.32
     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 = 539.4201
pl = Area_Tot_Long_Rein/(Ag) = 0.015552
     f'cE = 28.32

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: Collapse Prevention (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,   = 0.85
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 Primary Member: Concrete Strength, fc = fc_lower_bound = 25.00
New material of Primary Member: Steel Strength, fs = fs_lower_bound = 500.00
Concrete Elasticity, Ec = 26999.444
Steel Elasticity, Es = 200000.00
Existing Column
Existing material of Primary Member: Concrete Strength, fc = fc_lower_bound = 16.00
Existing material of Primary Member: Steel Strength, fs = fs_lower_bound = 400.00
Concrete Elasticity, Ec = 21019.039
Steel Elasticity, Es = 200000.00
##
Note: Especially for the calculation of   y for displacement ductility demand,
the expected (mean value) strengths are used (7.5.1.3, 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 = 555.5556
Existing Column
Existing material: Concrete Strength, fc = fcm = 20.00
Existing material: Steel Strength, fs = fsm = 444.4444
##
External Diameter, D = 500.00
Internal Diameter, D = 300.00
Cover Thickness, c = 25.00
Element Length, L = 3000.00
Primary 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
Inadequate Lap Length with lo/lou,min =lb/ld = 0.30
FRP Wrapping Data
Type: Carbon
Cured laminate properties (design values)
Thickness, t = 1.016
Tensile Strength, ffu = 1055.00
Tensile Modulus, Ef = 64828.00
Elongation, efu = 0.01
Number of directions, NoDir = 1
Fiber orientations, bi: 0.00°
Number of layers, NL = 1
Radius of rounding corners, R = 40.00

Stepwise Properties

EDGE -A-
Bending Moment, Ma = 9.1222828E-011
Shear Force, Va = -4.3539955E-014
EDGE -B-
Bending Moment, Mb = 3.9353382E-011
Shear Force, Vb = 4.3539955E-014
BOTH EDGES
Axial Force, F = -7386.87
Longitudinal Reinforcement Area Distribution (in 2 divisions)
        -Tension: Aslt = 0.00
     -Compression: Aslc = 3053.628
Longitudinal Reinforcement Area Distribution (in 3 divisions)
        -Tension: Asl,ten = 1017.876

```
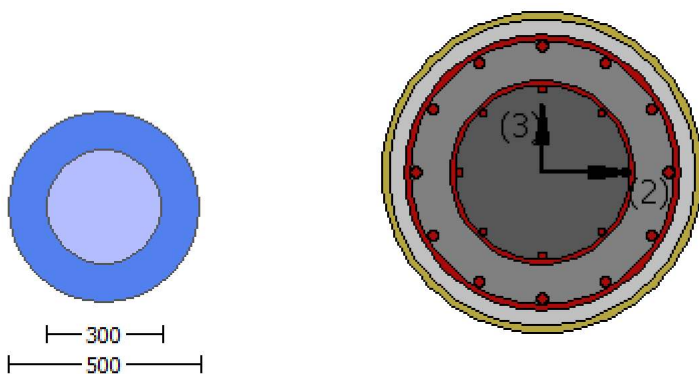      -Compression: Asl,com = 1017.876
         -Middle: Asl,mid = 1017.876
Mean Diameter of Tension Reinforcement, DbL,ten = 18.00
-------------------------------------------------------------
-------------------------------------------------------------


Existing component: From table 7-7, ASCE 41_17: Final Shear Capacity VR =   *Vn = 487403.616
Vn ((10.3), ASCE 41-17) = knl*VCol0 = 573416.018
  VCol = 573416.018
  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 = 21.76, but fc^0.5 <= 8.3
MPa (22.5.3.1, ACI 318-14)
  M/Vd = 2.00
     Mu = 3.9353382E-011
     Vu = 4.3539955E-014
  d = 0.8*D = 400.00
  Nu = 7386.87
  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 = 400.00
     s = 250.00
  Vs2 is multiplied by  Col2 = 0.00
     s/d = 1.04167
  Vf ((11-3)-(11.4), ACI 440) = 247653.332
     f = 0.95, for fully-wrapped sections
  wf/sf = 1 (FRP strips adjacent to one another).
  In (11.3) sin  + cos  is replaced with (cot +cota)sina which is more a generalised expression,
  where    is the angle of the crack direction (see KANEPE).
  This later relation, considered as a function Vf( , ), is implemented for every different fiber orientation ai,
  as well as for 2 crack directions,   =45° and   =-45° to take into consideration the cyclic seismic loading.
  orientation 1:   1 = b1 + 90° = 90.00
  Vf = Min(|Vf(45,  1)|,|Vf(-45,a1)|), with:
  total thickness per orientation, tf1 = NL*t/NoDir = 1.016
  dfv = d (figure 11.2, ACI 440) = 470.00
  ffe ((11-5), ACI 440) = 259.312
     Ef = 64828.00
      fe = 0.004, from (11.6a), ACI 440
       with  fu = 0.01
  From (11-11), ACI 440: Vs + Vf <= 389409.072
     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    = 9.0242004E-023
  y = (My*Ls/3)/Eleff = 0.00465967 ((4.29),Biskinis Phd))
  My = 2.2494E+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 = 2.4137E+013
    factor = 0.30
      Ag = 196349.541
      Mean concrete strength: fc' = (fc'_jacket*Area_jacket + fc'_core*Area_core)/Area_section = 28.32
      N = 7386.87
    Ec*Ig = Ec_jacket*Ig_jacket + Ec_core*Ig_core = 8.0455E+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) = 2.2494E+008
 φy = 6.4601586E-006
 My_ten (8c) = 2.2494E+008
  ξ_ten (7c) = 62.07296
 error of function (7c) = 0.00023516
 My_com (8d) = 8.0674E+008
  ξ_com (7d) = 63.84406
 error of function (7d) = -0.00846594
  with ((10.1), ASCE 41-17) ey = Min(ey, 1.25*ey*(lb/ld)^2/3) = 0.00277778
    eco = 0.002
    apl = 0.45 ((9c) in Biskinis and Fardis for FRP Wrap)
    d1 = 44.00
    R = 250.00
    v = 0.00103628
    N = 7386.87
    Ac = 196349.541
    ((10.1), ASCE 41-17) ε = Min(ε, 1.25*ε*(lb/ld)^2/3) = 0.23799161
 with fc* ((12.3), ACI 440) = 36.3038
    fc = 33.00
    fl = 1.05384
    ka = 1
      Effective FRP thickness, tf = NL*t*Cos(b1) = 1.016
    efe ((12.5) and (12.7)) = 0.004
     fu = 0.01
    Ef = 64828.00

Calculation of ratio lb/ld

Inadequate Lap Length with lb/ld = 0.30

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