```tcl
# ################################################################################
# SE 201B: NONLINEAR STRUCTURAL ANALYSIS
# NONLINEAR FIBER SECTION ANALYSIS
# ################################################################################

#Always start with
wipe; # Clear memory of all past model definitions
model BasicBuilder -ndm 2 -ndf 3; # Define the model builder, ndm=#dimension, ndf=#dofs

# -------------------------------------------------------------------------------
# DEFINE NODES
# -------------------------------------------------------------------------------
set nodeTag1 1;
set nodeTag2 2;

node $nodeTag1        0. 0.;
node $nodeTag2        0. 0.;

#puts $modelExportFileID "node $nodeTag1        0. 0.;"
#puts $modelExportFileID "node $nodeTag2        0. 0.;"

# -------------------------------------------------------------------------------
# DEFINE CONSTRAINTS
# -------------------------------------------------------------------------------
fix $nodeTag1         1 1 1; # Pin
fix $nodeTag2         0 1 0; # Roller

# -------------------------------------------------------------------------------
# DEFINE MATERIAL
# -------------------------------------------------------------------------------

# Define unconfined concrete material parameters
set fpc             [expr -32.5*$MPa]
set Ec              [expr 27000.0*$MPa]
set epsc0           [expr 2.0*$fpc/$Ec]
set ft              [expr 1.9*$MPa]
set lambda          0.25
set Ets             [expr 0.1*$Ec]
set fpcU            [expr 0.2*$fpc]
set epsU            -0.004

# Define confined concrete material parameters
set fpcc            [expr -47.9*$MPa]
set Ecc             [expr 27000.0*$MPa]
set epscc0          [expr 2.0*$fpcc/$Ecc]
set ftc             [expr 1.9*$MPa]
set lambdac         0.25
set Etsc            [expr 0.1*$Ecc]
set fpccU           [expr 0.85*$fpcc]
set epscU           -0.0276

# Define steel material parameters
set fy              [expr 455.0*$MPa]
set Es              [expr 215000.0*$MPa]
set b               0.01
set R0              20.0
set cR1             0.925
set cR2             0.15
set a1              0.0
set a2              1.0
set a3              0.0
set a4              1.0
set sigInit         0.0

set matTagConcCover 1
set matTagConcCore  2
set matTagSteel     3
set modelnum 1.0
```

```
70    # Unconfined concrete:
71    uniaxialMaterial Concrete02 $matTagConcCover  $fpc $epsc0 $fpcU $epsU $lambda $ft $Ets
72
73    # Confined concrete:
74    uniaxialMaterial Concrete02 $matTagConcCore   $fpcc $epscc0 $fpccU $epscU $lambdac $ftc
      $Etsc
75
76    # Reinforcing steel:
77    uniaxialMaterial Steel02    $matTagSteel      $fy $Es $b $R0 $cR1 $cR2 $a1 $a2 $a3 $a4
      $sigInit
78
79    #puts $modelExportFileID "uniaxialMaterial Concrete02 $matTagConcCore   $fpcc $epscc0
      $fpccU $epscU $lambdac $ftc $Etsc"
80    #puts $modelExportFileID "uniaxialMaterial Concrete02 $matTagConcCover  $fpc $epsc0
      $fpcU $epsU $lambda $ft $Ets"
81    #puts $modelExportFileID "uniaxialMaterial Steel02    $matTagSteel      $fy $Es $b $R0
      $cR1 $cR2 $a1 $a2 $a3 $a4 $sigInit"
82
83    # ----------------------------------------------------------------------------
84    # DEFINE SECTION
85    # ----------------------------------------------------------------------------
86    set colWidth     [expr 400.*$mm]
87    set colDepth     [expr 400.*$mm]
88    set colArea      [expr $colWidth * $colDepth]
89    set cover        [expr 40.*$mm]
90    set dB           [expr 20.*$mm]
91    set As           [expr 314.159*$mm2]
92    set y1           [expr $colDepth/2.0]
93    set z1           [expr $colWidth/2.0]
94    set totNumBars   8
95
96    set secTag 1
97    set fiberA 3
98    set fiberB 1
99    set fiberC 3
100
101   section Fiber $secTag -GJ $Ubig {
102       #
      ----------------------------------------------------------------------------
103       # Create rectangular patches
104       #
      ----------------------------------------------------------------------------
105       # Cover concrete
106       patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
          $cover] [expr $cover - $z1]
107       patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover] [expr
          $y1 - $cover] [expr $z1]
108       patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
          [expr $z1]
109       patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
          [expr $z1]
110       # Core concrete
111       patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1] [expr
          $y1 - $cover] [expr $z1 - $cover]
112       #
      ----------------------------------------------------------------------------
113       # Create straight layers
114       #
      ----------------------------------------------------------------------------
115       # Reinforcing steel
116       layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr $y1
          - $cover] [expr $cover - $z1]
117       layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
118       layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
          $cover - $y1] [expr $z1 - $cover]
119   }
120
121
122   #puts $modelExportFileID "section Fiber $secTag -GJ $Ubig {
```

```tcl
123     #
        ----------------------------------------------------------------------------
124     # Create rectangular patches
125     #
        ----------------------------------------------------------------------------
126     # Cover concrete
127     #patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
        $cover] [expr $cover - $z1]
128     #patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover]
        [expr $y1 - $cover] [expr $z1]
129     #patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
        [expr $z1]
130     #patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
        [expr $z1]
131     # Core concrete
132     #patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1] [expr
        $y1 - $cover] [expr $z1 - $cover]
133     #
        ----------------------------------------------------------------------------
134     # Create straight layers
135     #
        ----------------------------------------------------------------------------
136     # Reinforcing steel
137     #layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr
        $y1 - $cover] [expr $cover - $z1]
138     #layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
139     #layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
        $cover - $y1] [expr $z1 - $cover]
140 #}"
141
142 set secTag 2
143 set fiberA 8
144 set fiberB 2
145 set fiberC 8
146
147 section Fiber $secTag -GJ $Ubig {
148     #
        ----------------------------------------------------------------------------
149     # Create rectangular patches
150     #
        ----------------------------------------------------------------------------
151     # Cover concrete
152     patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
        $cover] [expr $cover - $z1]
153     patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover] [expr
        $y1 - $cover] [expr $z1]
154     patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
        [expr $z1]
155     patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
        [expr $z1]
156     # Core concrete
157     patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1] [expr
        $y1 - $cover] [expr $z1 - $cover]
158     #
        ----------------------------------------------------------------------------
159     # Create straight layers
160     #
        ----------------------------------------------------------------------------
161     # Reinforcing steel
162     layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr $y1
        - $cover] [expr $cover - $z1]
163     layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
164     layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
        $cover - $y1] [expr $z1 - $cover]
165 }
166
167
168 # puts $modelExportFileID "section Fiber $secTag -GJ $Ubig {
169     # #
```

```tcl
                 -------------------------------------------------------------------------
170    # # Create rectangular patches
171    # #
                 -------------------------------------------------------------------------
172    # # Cover concrete
173    # patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
       $cover] [expr $cover - $z1]
174    # patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover]
       [expr $y1 - $cover] [expr $z1]
175    # patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
       [expr $z1]
176    # patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
       [expr $z1]
177    # # Core concrete
178    # patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1]
       [expr $y1 - $cover] [expr $z1 - $cover]
179    # #
                 -------------------------------------------------------------------------
180    # # Create straight layers
181    # #
                 -------------------------------------------------------------------------
182    # # Reinforcing steel
183    # layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr
       $y1 - $cover] [expr $cover - $z1]
184    # layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
185    # layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
       $cover - $y1] [expr $z1 - $cover]
186  # }"
187
188  set secTag 3
189  set fiberA 20
190  set fiberB 5
191  set fiberC 20
192
193  section Fiber $secTag -GJ $Ubig {
194    #
                 -------------------------------------------------------------------------
195    # Create rectangular patches
196    #
                 -------------------------------------------------------------------------
197    # Cover concrete
198    patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
       $cover] [expr $cover - $z1]
199    patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover] [expr
       $y1 - $cover] [expr $z1]
200    patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
       [expr $z1]
201    patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
       [expr $z1]
202    # Core concrete
203    patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1] [expr
       $y1 - $cover] [expr $z1 - $cover]
204    #
                 -------------------------------------------------------------------------
205    # Create straight layers
206    #
                 -------------------------------------------------------------------------
207    # Reinforcing steel
208    layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr $y1
       - $cover] [expr $cover - $z1]
209    layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
210    layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
       $cover - $y1] [expr $z1 - $cover]
211  }
212
213
214  # puts $modelExportFileID "section Fiber $secTag -GJ $Ubig {
215    # #
                 -------------------------------------------------------------------------
```

```
216         # # Create rectangular patches
217         # #
            -------------------------------------------------------------------------
218         # # Cover concrete
219         # patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr -$z1] [expr $y1 -
            $cover] [expr $cover - $z1]
220         # patch rect $matTagConcCover $fiberA 1 [expr $cover - $y1] [expr $z1 - $cover]
            [expr $y1 - $cover] [expr $z1]
221         # patch rect $matTagConcCover $fiberB 1 [expr -$y1] [expr -$z1] [expr $cover - $y1]
            [expr $z1]
222         # patch rect $matTagConcCover $fiberB 1 [expr $y1 - $cover] [expr -$z1] [expr $y1]
            [expr $z1]
223         # # Core concrete
224         # patch rect $matTagConcCore $fiberC 1 [expr $cover - $y1] [expr $cover - $z1]
            [expr $y1 - $cover] [expr $z1 - $cover]
225         # #
            -------------------------------------------------------------------------
226         # # Create straight layers
227         # #
            -------------------------------------------------------------------------
228         # # Reinforcing steel
229         # layer straight $matTagSteel 3 $As [expr $y1 - $cover] [expr $z1 - $cover] [expr
            $y1 - $cover] [expr $cover - $z1]
230         # layer straight $matTagSteel 2 $As 0 [expr $cover - $z1] 0 [expr $z1 - $cover]
231         # layer straight $matTagSteel 3 $As [expr $cover - $y1] [expr $cover - $z1] [expr
            $cover - $y1] [expr $z1 - $cover]
232     # }"
233
234     # -----------------------------------------------------------------------
235     # DEFINE ELEMENT
236     # -----------------------------------------------------------------------
237     set eleTag 1
238     set secTag 3
239     element zeroLengthSection $eleTag $nodeTag1 $nodeTag2 $secTag -orient 1 0 0 0 1 0
240     # puts $modelExportFileID "element zeroLengthSection $eleTag $nodeTag1 $nodeTag2
        $secTag -orient 1 0 0 0 1 0"
241     # close $modelExportFileID
242
243     set controlNode $nodeTag2
```