

APPENDIX A: Sample ABAQUS Program

```
*heading
flat length-to-width ratio is 2:1
distributed spring stiffness,  $K_d$ , is  $4.20 \times 10^6$  N/m3
*preprint,echo=yes,history=no,model=no
*node
1,1.42925,0.0,.042926
15,1.42925,0.679968,.042926
436,0.0,0.0,.042926
450,0.0,.679968,.042926
451,1.42925,0.0,0.0
465,1.42925,.679968,0.0
886,0.0,0.0,0.0
900,0.0,.679968,0.0
*ngen,nset=top1
1,15
*ngen,nset=top2
436,450
*ngen,nset=bot1
451,465
*ngen,nset=bot2
886,900
*nfill,nset=top12
top1,top2,29,15
*nfill,nset=bot12
bot1,bot2,29,15
**
*node
2001,1.478537,0.0,.042926
2097,1.5,0.0,.021463
```

2193,1.478537,0.0,0.0
9997,1.478537,0.0,.021463
2016,1.478537,.728537,.042926
2017,1.478537,.728537,.042926
2112,1.5,.728537,.021463
2208,1.478537,.728537,0.0
2209,1.478537,.728537,0.0
9999,1.478537,.728537,.021463
2018,1.478537,.728537,.042926
2114,1.478537,.75,.021463
2210,1.478537,.728537,0.0
2048,0.0,.728537,.042926
2144,0.0,.75,.021463
2240,0.0,.728537,0.0
9998,0.0,.728537,.021463
*ngen,nset=curve1,line=c
2001,2097,48,9997
2097,2193,48,9997
*ngen,nset=curve2,line=c
2016,2112,48,9999
2112,2208,48,9999
*ngen,nset=curve3,line=c
2018,2114,48,9999
2114,2210,48,9999
*ngen,nset=curve4,line=c
2048,2144,48,9998
2144,2240,48,9998
*ngen,line=c
2112,2114,1,9999
*nfill,nset=curve
curve1,curve2,15,1

curve3,curve4,30,1
*ngen,line=c,nset=ncorn
2017,2113,48,9999
2113,2209,48,9999
*nset,nset=center
436,886
*ngen,nset=bcxa
1,436,15
451,886,15
*nset,nset=bcx
bcxa,curve1
*ngen,nset=bcya
436,450
886,900
*nset,nset=bcy
bcya,curve4
*nset,nset=nall
top12,bot12,curve,ncorn
*element,type=s4r
1,1,2,17,16
451,451,452,467,466
2001,2001,2002,2,1
4193,2193,2194,452,451
*elgen,elset=etop1a
1,1,,14,1,1,29,15,15
*elgen,elset=ebot1a
451,1,,14,1,1,29,15,15
*elgen,elset=erow1t
2001,1,,14,1,1
*element,type=s4r,elset=erow2t
2015,2015,2016,2019,15

15,15,2019,2020,30
30,30,2020,2021,45
45,45,2021,2022,60
60,60,2022,2023,75
75,75,2023,2024,90
90,90,2024,2025,105
105,105,2025,2026,120
120,120,2026,2027,135
135,135,2027,2028,150
150,150,2028,2029,165
165,165,2029,2030,180
180,180,2030,2031,195
195,195,2031,2032,210
210,210,2032,2033,225
225,225,2033,2034,240
240,240,2034,2035,255
255,255,2035,2036,270
270,270,2036,2037,285
285,285,2037,2038,300
300,300,2038,2039,315
315,315,2039,2040,330
330,330,2040,2041,345
345,345,2041,2042,360
360,360,2042,2043,375
375,375,2043,2044,390
390,390,2044,2045,405
405,405,2045,2046,420
420,420,2046,2047,435
435,435,2047,2048,450
*elset,elset=erowt
erow1t,erow2t

```
*elset,elset=etop1
etop1a,erowt
*elgen,elset=erow1b
4193,1,,,14,1,1
*element,type=s4r,elset=erow2b
4207,2207,2208,2211,465
465,465,2211,2212,480
480,480,2212,2213,495
495,495,2213,2214,510
510,510,2214,2215,525
525,525,2215,2216,540
540,540,2216,2217,555
555,555,2217,2218,570
570,570,2218,2219,585
585,585,2219,2220,600
600,600,2220,2221,615
615,615,2221,2222,630
630,630,2222,2223,645
645,645,2223,2224,660
660,660,2224,2225,675
675,675,2225,2226,690
690,690,2226,2227,705
705,705,2227,2228,720
720,720,2228,2229,735
735,735,2229,2230,750
750,750,2230,2231,765
765,765,2231,2232,780
780,780,2232,2233,795
795,795,2233,2234,810
810,810,2234,2235,825
825,825,2235,2236,840
```

840,840,2236,2237,855
855,855,2237,2238,870
870,870,2238,2239,885
885,885,2239,2240,900
*elset,elset=erowb
erow1b,erow2b
*elset,elset=ebot1
ebot1a,erowb
*element,type=s4r
2049,2049,2050,2002,2001
2097,2097,2098,2050,2049
2193,2193,2194,2146,2145
2067,2067,2068,2020,2019
2211,2211,2212,2164,2163
*elgen,elset=edgea
2049,1,,15,1,1
2097,1,,47,1,1,2,48,48
2193,1,,15,1,1
2067,1,,1,,29,1,1
2211,1,,1,,29,1,1
*element,type=s4r,elset=edgeb
2066,2066,2067,2019,2016
2208,2208,2211,2163,2162
*element,type=s3r,elset=edgec
2064,2064,2065,2016
2065,2065,2066,2016
4160,2160,2208,2161
4161,2161,2208,2162
*elset,elset=edge
edgea,edgeb,edgec
*elset,elset=estress2

```
2001,2049,2097,2145,2193,4193
435,2095,2143,2191,2239,885
*elgen,elset=estress1
1,1,,1,,29,15,15
451,1,,1,,29,15,15
422,1,,13,1,1
872,1,,13,1,1
*elset,elset=estress
estress1,estress2
*elset,elset=etop
edge,etop1
*elset,elset=ebot
ebot1
*elset,elset=eall
etop,ebot
*shell section,elset=eall,material=m1
.003
*material,name=m1
*elastic
7.0346e9,0.45
*density
75.0
*element,type=spring1
12193,2193
12194,2194
12211,2211
10451,451
10452,452
10886,886
10887,887
12240,2240
```

```
*elgen,elset=spr1
12194,1,,15,1,1
12211,1,,1,,29,1,1
10452,1,,14,1,1,29,15,15
*elgen,elset=spr2a
10451,1,,1,,29,15,15
10887,1,,14,1,1
*elset,elset=spr2
spr2a,12193,12240
*elset,elset=spr3
10886
*spring,elset=spr1,nonlinear
3
-10000,-1.0
0.0,0.0
0.0,1.0
*spring,elset=spr2,nonlinear
3
-5000,-1.0
0.0,0.0
0.0,1.0
*spring,elset=spr3,nonlinear
3
-2500,-1.0
0.0,0.0
0.0,1.0
*boundary
center,1,2
center,4,6
bcx,2
bcx,4
```



```

bcx,6
bcy,1
bcy,5
bcy,6
*restart,write,frequency=1
*step,nlgeom,inc=1000
*static
.01,1.0,1e-7
*dload
eall,GRAV,9.81,0.0,0.0,-1.0
*el print,frequency=0
*node print,frequency=100,summary=no,nset=center
u
*end step
**
*step,nlgeom,inc=1000,unsymm=yes
*static
.001,1.0,1e-7
*dload
etop,HP,11620.9,.79,0
ebot,HP,-11620.9,.79,0
*el print,frequency=100,position=averaged at nodes,elset=estress
3
s
*node print,frequency=100,nset=bcx,summary=no
u
*node print,frequency=100,nset=bcy,summary=no
u
*end step

```