Appendix H: Equilibrium Program for Pre-bent Struts with Filler

Mathematica Code

Input and initial guesses for moment and shear force:

(* Equilibrium, clamped buckled strut with initial curvature defined by the equation theta(s)=ao*sin2pi(s),y1=x,y2=y,y3=theta,y4=moment,y21= shear force q and yo is the initial prebent deflection of the strut which varies along the length, m in leftBC is moment at s=0, p=po (larger than 39.48 = 4*pi^2) Also includes a filler material with stiffness k, which varies with the value of yo along the length. Equilibrium program analyzes one strut and they are assumed to be symmetric.*)

```
Clear[pi,gm,gq,m,q,po,ao]
pi = N[π];
po =40.0;
ao=0.2;
gm =6.010127367;
gq =0.20775;
k=0.1;
(*yo[t]==(ao/2*pi)/(1-Cos[2*pi*t]),*)
```

Equilibrium equations and boundary conditions for s=0:

```
endpt[m_?NumberQ, q_?NumberQ] :=
  First[NDSolve[{y1′[t] == Cos[y3[t]], y2′[t] == Sin[y3[t]], y3′[t] == y4[t] + 2 * pi * ao * Cos[2 * pi * t],
    y4′[t] == y21[t] * Cos[y3[t]] - po * Sin[y3[t]], y21'[t] == -k * (y2[t] - yo[t]) / (yo[t] + 0.0000001), yo'[t] == Sin[ao * Sin[2 * pi * t]],
    y1[0] == 0, y2[0] == 0, y3[0] == 0, y4[0] == m, y21[0] == q, yo[0] == 0}, {y1, y2, y3, y4, y21, yo}, {t, 0, 1}, MaxSteps → 2000]];
```

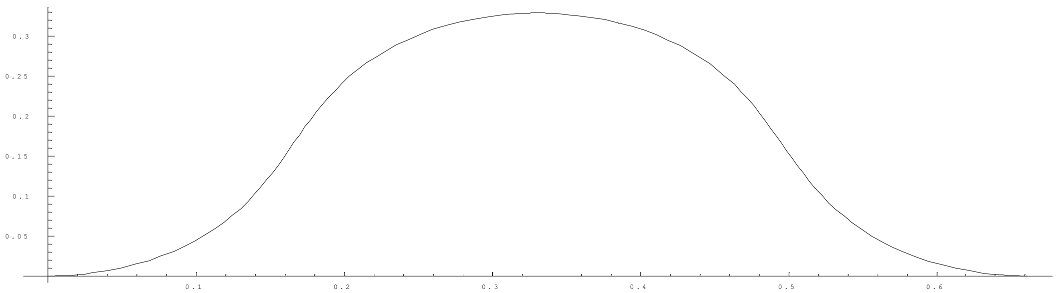
Solution:

```
soln := NDSolve[{y1′[t] == Cos[y3[t]], y2′[t] == Sin[y3[t]], y3′[t] == y4[t] + 2 * pi * ao * Cos[2 * pi * t],
   y4′[t] == y21[t] * Cos[y3[t]] - po * Sin[y3[t]], y21'[t] == -k * (y2[t] - yo[t]) / (yo[t] + 0.0000001), yo'[t] == Sin[ao * Sin[2 * pi * t]],
   y1[0] == 0, y2[0] == 0, y3[0] == 0, y4[0] == m, y21[0] == q, yo[0] == 0}, {y1, y2, y3, y4, y21, yo}, {t, 0, 1}, MaxSteps → 2000];
(*soln*)
endpt[gm, gq]

f2[m_?NumberQ, q_?NumberQ] := y2[1] /. endpt[m, q];
f3[m_?NumberQ, q_?NumberQ] := y3[1] /. endpt[m, q];
(*fo[m_?NumberQ,q_?NumberQ]:=yo[1]/.endpt[m,q];*)
f2[gm, gq]
Clear[m, q]
rts = FindRoot[{f2[m, q] == 0, f3[m, q] == 0}, {m, gm}, {q, gq}, AccuracyGoal → 5, MaxIterations → 2000]
(*fo[m,q]==0,*)

endpt[m /. rts, q /. rts];
m = m /. rts
q = q /. rts
```

{m→6.54711,q→0.221487}

Create plot of struts in deformed state:

```
{yy1[t_],yy2[t_],yy3[t_],yy4[t_],yy21[t_],yyo[t_]}={y1[t],y2[t],y3[t],y4[t],y21[t],yo[t]}/.First[soln];

ParametricPlot[Evaluate[{yy1[t],yy2[t]}/.soln/.rts],{t,0,1},PlotRange→All,AspectRatio→Automatic,PlotPoints→100]
```



Create table of x and y values of struts:

numbers=TableForm[Table[Evaluate[{yy1[t]/.soln/.rts,yy2[t]/.soln/.rts}],{t,0,1,0.05}],TableHeadings→{None,{"x","y"}}]

x	y
-5.30223×10^{-22}	1.20159×10^{-26}
0.0487681	0.00954697
0.0909644	0.0359151
0.123361	0.0738077
0.146904	0.117853
0.165402	0.164297
0.183893	0.210745
0.207413	0.254802
0.239782	0.292719
0.281959	0.319118
0.330722	0.328682
0.379486	0.319118
0.421663	0.292719
0.454032	0.254802
0.477552	0.210745
0.496042	0.164297
0.514541	0.117853
0.538083	0.0738076
0.57048	0.0359151
0.612677	0.00954697
0.661445	4.51596×10^{-12}