```mathematica
$Assumptions = {L > 0};

dofExpand[nodeIds_, n_] := Flatten[Transpose[Table[n nodeIds - (n - i), {i, 1, n}]]]
transformation[dir_] := Module[{y = {0, 1, 0}, γ},

  γ = FullSimplify[If[Abs[dir[[2]]] > 0.99,

      (        0         Sign[dir[[2]]]  0 )
      ( -Sign[dir[[2]]]        0         0 ),
      (        0               0         1 )

      {dir, Cross[Normalize[Cross[dir, y]], dir], Normalize[Cross[dir, y]]}]

  ];

            ( γ  0  0  0 )
            ( 0  γ  0  0 )
  ArrayFlatten[( 0  0  γ  0 )]
            ( 0  0  0  γ )

]
```

```mathematica
beamStiffness[E_, ν_, A_, Iy_, Iz_, L_] := Module[{G = E/(1 + 2 ν), J = Iy + Iz},
```

$$\frac{E}{L} \begin{pmatrix}
A & 0 & 0 & 0 & 0 & 0 & -A & 0 & 0 & 0 & 0 & 0 \\
0 & 12\frac{Iz}{L^2} & 0 & 0 & 0 & 6\frac{Iz}{L} & 0 & -12\frac{Iz}{L^2} & 0 & 0 & 0 & 6\frac{Iz}{L} \\
0 & 0 & 12\frac{Iy}{L^2} & 0 & -6\frac{Iy}{L} & 0 & 0 & 0 & -12\frac{Iy}{L^2} & 0 & -6\frac{Iy}{L} & 0 \\
0 & 0 & 0 & \frac{G\,J}{E} & 0 & 0 & 0 & 0 & 0 & -\frac{G\,J}{E} & 0 & 0 \\
0 & 0 & -6\frac{Iy}{L} & 0 & 4\,Iy & 0 & 0 & 0 & 6\frac{Iy}{L} & 0 & 2\,Iy & 0 \\
0 & 6\frac{Iz}{L} & 0 & 0 & 0 & 4\,Iz & 0 & -6\frac{Iz}{L} & 0 & 0 & 0 & 2\,Iz \\
-A & 0 & 0 & 0 & 0 & 0 & A & 0 & 0 & 0 & 0 & 0 \\
0 & -12\frac{Iz}{L^2} & 0 & 0 & 0 & -6\frac{Iz}{L} & 0 & 12\frac{Iz}{L^2} & 0 & 0 & 0 & -6\frac{Iz}{L} \\
0 & 0 & -12\frac{Iy}{L^2} & 0 & 6\frac{Iy}{L} & 0 & 0 & 0 & 12\frac{Iy}{L^2} & 0 & 6\frac{Iy}{L} & 0 \\
0 & 0 & 0 & -\frac{G\,J}{E} & 0 & 0 & 0 & 0 & 0 & \frac{G\,J}{E} & 0 & 0 \\
0 & 0 & -6\frac{Iy}{L} & 0 & 2\,Iy & 0 & 0 & 0 & 6\frac{Iy}{L} & 0 & 4\,Iy & 0 \\
0 & 6\frac{Iz}{L} & 0 & 0 & 0 & 2\,Iz & 0 & -6\frac{Iz}{L} & 0 & 0 & 0 & 4\,Iz
\end{pmatrix}$$

```mathematica
]

beamMass[ρ_, A_, J_, L_] :=
```

$$\frac{\rho \, A \, L}{420} \begin{pmatrix} 140 & 0 & 0 & 0 & 0 & 0 & 70 & 0 & 0 & 0 & 0 & 0 \\ 0 & 156 & 0 & 0 & 0 & 22\,L & 0 & 54 & 0 & 0 & 0 & -13\,L \\ 0 & 0 & 156 & 0 & -22\,L & 0 & 0 & 0 & 54 & 0 & 13\,L & 0 \\ 0 & 0 & 0 & 140\,\frac{J}{A} & 0 & 0 & 0 & 0 & 0 & 70\,\frac{J}{A} & 0 & 0 \\ 0 & 0 & -22\,L & 0 & 4\,L^2 & 0 & 0 & 0 & -13\,L & 0 & -3\,L^2 & 0 \\ 0 & 22\,L & 0 & 0 & 0 & 4\,L^2 & 0 & 13\,L & 0 & 0 & 0 & -3\,L^2 \\ 70 & 0 & 0 & 0 & 0 & 0 & 140 & 0 & 0 & 0 & 0 & 0 \\ 0 & 54 & 0 & 0 & 0 & 13\,L & 0 & 156 & 0 & 0 & 0 & -22\,L \\ 0 & 0 & 54 & 0 & -13\,L & 0 & 0 & 0 & 156 & 0 & 22\,L & 0 \\ 0 & 0 & 0 & 70\,\frac{J}{A} & 0 & 0 & 0 & 0 & 0 & 140\,\frac{J}{A} & 0 & 0 \\ 0 & 0 & 13\,L & 0 & -3\,L^2 & 0 & 0 & 0 & 22\,L & 0 & 4\,L^2 & 0 \\ 0 & -13\,L & 0 & 0 & 0 & -3\,L^2 & 0 & -22\,L & 0 & 0 & 0 & 4\,L^2 \end{pmatrix} ;$$

```
makeBeam[{p_, q_}, nodeIds_, E_, ν_, A_, Iy_, Iz_, ρ_] := Module[
  {
   L = FullSimplify[Norm[q - p]],
   J = Iy + Iz,
   Γ = FullSimplify[transformation[Normalize[q - p]]]
  },
  <|
   "Γ" → Γ,
   "γ" → Γ[[1 ;; 3, 1 ;; 3]],
   "M" -> FullSimplify[beamMass[ρ, A, J, L]],
   "K" → FullSimplify[beamStiffness[E, ν, A, Iy, Iz, L]],
   "endpoints" → {p, q},
   "E" → E,
   "ν" → ν,
   "ρ" → ρ,
   "A" → A,
   "Iy" → Iy,
   "Iz" → Iz,
   "L" → L,
   "nodeIds" → nodeIds,
   "dofIds" → dofExpand[nodeIds, 6],
   "displacement" → ConstantArray[0.0, 12]
  |>
 ]

ψ[x_, L_] := {
  InterpolatingPolynomial[{{0, 1, 0}, {L, 0, 0}}, x],
  InterpolatingPolynomial[{{0, 1, 1}, {L, 0, 0}}, x],
  InterpolatingPolynomial[{{0, 0, 0}, {L, 1, 0}}, x],
  InterpolatingPolynomial[{{0, 0, 0}, {L, 0, 1}}, x]
 }
```

$$\Psi[\texttt{x\_, L\_}] := \texttt{Transpose}\left[\begin{pmatrix} 1 - \frac{x}{L} & 0 & 0 \\ 0 & \psi[x, L][[1]] & 0 \\ 0 & 0 & \psi[x, L][[1]] \\ 0 & 0 & 0 \\ 0 & 0 & -\psi[x, L][[2]] \\ 0 & \psi[x, L][[2]] & 0 \\ \frac{x}{L} & 0 & 0 \\ 0 & \psi[x, L][[3]] & 0 \\ 0 & 0 & \psi[x, L][[3]] \\ 0 & 0 & 0 \\ 0 & 0 & -\psi[x, L][[4]] \\ 0 & \psi[x, L][[4]] & 0 \end{pmatrix}\right];$$

```
drawBeam[beam_, displacement_] := Module[
  {
   p = beam["endpoints"][[1]],
   L = beam["L"],
   u
  },
  u = beam["Γ"].displacement + {0, 0, 0, 0, 0, 0, L, 0, 0, 0, 0, 0};
  Line[
   Table[
    Transpose[beam["γ"]].Ψ[x, L].u + p
    ,
    {x, 0, L, 0.02 L}
   ]
  ]
 ]

drawBeamSimple[beam_, displacement_] :=
 Line[beam["endpoints"] + {displacement[[1 ;; 3]], displacement[[7 ;; 9]]}]

multiStoryFrame[xGrid_, yGrid_, zGrid_] :=
 Module[{nodes, elems, fixed, free, dx, dy, dz, id},
  dx = 1;
  dy = Length[xGrid];
  dz = Length[xGrid] * Length[yGrid];
  nodes = Flatten[Table[{x, y, z}, {z, zGrid}, {y, yGrid}, {x, xGrid}], 2];

  elems = {};

  (* add all columns *)
  Do[
   id = (z - 1) * dz + (y - 1) * dy + x;
   AppendTo[elems, {id, id + dz}]
   ,
   {z, 1, Length[zGrid] - 1},
   {y, 1, Length[yGrid]},
   {x, 1, Length[xGrid]}
  ];

  (* beams in y-direction *)
  Do[
   id = (z - 1) * dz + (y - 1) * dy + x;
```

```
   AppendTo[elems, {id, id + dy}]
   ,
   {z, 2, Length[zGrid]},
   {y, 1, Length[yGrid] - 1},
   {x, 1, Length[xGrid]}
  ];

  (* beams in x-direction *)
  Do[
   id = (z - 1) * dz + (y - 1) * dy + x;
   AppendTo[elems, {id, id + dx}]
   ,
   {z, 2, Length[zGrid]},
   {y, 1, Length[yGrid]},
   {x, 1, Length[xGrid] - 1}
  ];

  fixed = {};
  Do[
   If[nodes[[i, 3]] == zGrid[[1]], AppendTo[fixed, i]]
   ,
   {i, 1, Length[nodes]}
  ];
  fixed = dofExpand[fixed, 6];
  free = Complement[Table[i, {i, 1, Length[nodes] * 6}], fixed];

  {nodes, elems, fixed, free}
 ]

assembleGlobalMatrices[beams_, ndof_] := Module[{
   Mglobal = ConstantArray[0.0, {ndof, ndof}],
   Kglobal = ConstantArray[0.0, {ndof, ndof}]
  },
  Do[
   Mglobal[[b["dofIds"], b["dofIds"]]] += Transpose[b["Γ"]].b["M"].b["Γ"];
   Kglobal[[b["dofIds"], b["dofIds"]]] += Transpose[b["Γ"]].b["K"].b["Γ"];
   ,
   {b, beams}
  ];
  {Mglobal, Kglobal}
 ]


E = 200;
ν = 0.3;
A = 1430;
Iy = 1.26 * 10^6;
Iz = 1.26 * 10^6;
ρ = 8050/10^9;
L = 1000;
```

$$
\text{nodes} =
\begin{pmatrix}
1 & 0 & 0 \\
0 & 0 & 2.5 \\
-1 & 0 & 0 \\
0 & 1.5 & 2.5 \\
1 & 3 & 0 \\
0 & 3 & 2.5 \\
-1 & 3 & 0
\end{pmatrix} \text{L};
$$

$$
\text{elems} =
\begin{pmatrix}
1 & 2 \\
2 & 3 \\
2 & 4 \\
4 & 6 \\
5 & 6 \\
6 & 7
\end{pmatrix};
$$

```
ndof = Length[nodes] * 6;
fixed = {1, 2, 3, 13, 14, 15, 25, 26, 27, 37, 38, 39};

free = Complement[Table[i, {i, 1, ndof}], fixed];


ndof = Length[nodes] * 6;
beams = Table[makeBeam[nodes[[el]], el, E, ν, A, Iy, Iz, ρ], {el, elems}];
{Mglobal, Kglobal} = assembleGlobalMatrices[beams, ndof];
fglobal = -4.5 IdentityMatrix[ndof][[21]];
uglobal = ConstantArray[0.0, ndof];
uglobal[[free]] =
 LinearSolve[FullSimplify[Chop[Kglobal]][[free, free]], fglobal[[free]]];

{nodes, elems, fixed, free} =
  multiStoryFrame[{0, 1, 2, 3} L, {0, 1, 2} L, {0, 1, 2, 3} L];
ndof = Length[nodes] * 6;
beams = Table[makeBeam[nodes[[el]], el, E, ν, A, Iy, Iz, ρ], {el, elems}];
{Mglobal, Kglobal} = assembleGlobalMatrices[beams, ndof];
```

$$
\text{fglobal} = \text{Flatten}\left[\left\{\text{If}\left[\#[[1]] == 0, \frac{\#[[3]]}{L}, 0\right], 0, 0, 0, 0, 0\right\} \text{\& /@ nodes}\right];
$$

```
uglobal = ConstantArray[0.0, ndof];
uglobal[[free]] = LinearSolve[Kglobal[[free, free]], fglobal[[free]]];

uglobal[[free]] =
  LinearSolve[FullSimplify[Chop[Kglobal]][[free, free]], fglobal[[free]]];
Partition[uglobal, 6] // MatrixForm
```

$$
\begin{pmatrix}
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0. \\
0. & 0. & 0. & 0. & 0. & 0.
\end{pmatrix}
$$

$$
\begin{pmatrix}
0. & 0. & 0. & 0. & 0. & 0. \\
0.788283 & -1.92687 \times 10^{-13} & 0.0128286 & 1.85361 \times 10^{-16} & 0.000703502 & 1.87789 \times 10^{-16} \\
0.786097 & -7.08329 \times 10^{-14} & -0.00199893 & 1.3058 \times 10^{-16} & 0.00045684 & 8.13163 \times 10^{-17} \\
0.784361 & -1.44257 \times 10^{-13} & 0.00193357 & 3.12025 \times 10^{-17} & 0.000456051 & 1.16673 \times 10^{-16} \\
0.783071 & 6.41688 \times 10^{-14} & -0.0127632 & -8.75898 \times 10^{-17} & 0.000698977 & 2.3217 \times 10^{-16} \\
0.788283 & -1.89843 \times 10^{-13} & 0.0128286 & 1.15087 \times 10^{-16} & 0.000703502 & 1.6374 \times 10^{-16} \\
0.786097 & -6.89994 \times 10^{-14} & -0.00199893 & 8.382 \times 10^{-17} & 0.00045684 & 1.04206 \times 10^{-16} \\
0.784361 & -1.43062 \times 10^{-13} & 0.00193357 & 1.46092 \times 10^{-17} & 0.000456051 & 1.25059 \times 10^{-16} \\
0.783071 & 6.33795 \times 10^{-14} & -0.0127632 & -5.87711 \times 10^{-17} & 0.000698977 & 1.83222 \times 10^{-16} \\
0.788283 & -1.88497 \times 10^{-13} & 0.0128286 & 1.82518 \times 10^{-16} & 0.000703502 & 1.25959 \times 10^{-16} \\
0.786097 & -6.57061 \times 10^{-14} & -0.00199893 & 1.30875 \times 10^{-16} & 0.00045684 & 4.41676 \times 10^{-17} \\
0.784361 & -1.50357 \times 10^{-13} & 0.00193357 & 3.07991 \times 10^{-17} & 0.000456051 & 8.07738 \times 10^{-17} \\
0.783071 & 6.22817 \times 10^{-14} & -0.0127632 & -8.75243 \times 10^{-17} & 0.000698977 & 1.7282 \times 10^{-16} \\
1.728 & -4.74444 \times 10^{-13} & 0.0196795 & 1.61805 \times 10^{-16} & 0.000550628 & 2.81892 \times 10^{-16} \\
1.72242 & -3.22644 \times 10^{-13} & -0.00288802 & 8.65102 \times 10^{-17} & 0.000385679 & 2.56357 \times 10^{-16} \\
1.71892 & -4.75573 \times 10^{-14} & 0.00278401 & -7.08154 \times 10^{-17} & 0.000384829 & 3.13729 \times 10^{-16} \\
1.7175 & 2.57397 \times 10^{-13} & -0.0195755 & -1.02581 \times 10^{-16} & 0.000546674 & 3.44931 \times 10^{-16} \\
1.728 & -4.70819 \times 10^{-13} & 0.0196795 & 1.09045 \times 10^{-16} & 0.000550628 & 2.77301 \times 10^{-16} \\
1.72242 & -3.32499 \times 10^{-13} & -0.00288802 & 6.00486 \times 10^{-17} & 0.000385679 & 2.66241 \times 10^{-16} \\
1.71892 & -4.6051 \times 10^{-14} & 0.00278401 & -4.12528 \times 10^{-17} & 0.000384829 & 3.03888 \times 10^{-16} \\
1.7175 & 2.555 \times 10^{-13} & -0.0195755 & -6.48704 \times 10^{-17} & 0.000546674 & 3.0823 \times 10^{-16} \\
1.728 & -4.67065 \times 10^{-13} & 0.0196795 & 1.62543 \times 10^{-16} & 0.000550628 & 1.89147 \times 10^{-16} \\
1.72242 & -3.27756 \times 10^{-13} & -0.00288802 & 8.88302 \times 10^{-17} & 0.000385679 & 2.14811 \times 10^{-16} \\
1.71892 & -4.67754 \times 10^{-14} & 0.00278401 & -7.15491 \times 10^{-17} & 0.000384829 & 2.74305 \times 10^{-16} \\
1.7175 & 2.54209 \times 10^{-13} & -0.0195755 & -1.05155 \times 10^{-16} & 0.000546674 & 2.59844 \times 10^{-16} \\
2.326 & -6.52004 \times 10^{-13} & 0.0218191 & 6.98967 \times 10^{-17} & 0.000287891 & 3.71073 \times 10^{-16} \\
2.3174 & -3.12863 \times 10^{-13} & -0.00319917 & -9.4124 \times 10^{-18} & 0.000166855 & 3.67594 \times 10^{-16} \\
2.31217 & 4.1632 \times 10^{-14} & 0.00307971 & -3.46345 \times 10^{-17} & 0.000166442 & 3.57114 \times 10^{-16} \\
2.3103 & 3.42609 \times 10^{-13} & -0.0216996 & -2.74033 \times 10^{-17} & 0.000284903 & 3.61895 \times 10^{-16} \\
2.326 & -6.49395 \times 10^{-13} & 0.0218191 & 4.39242 \times 10^{-17} & 0.000287891 & 3.60914 \times 10^{-16} \\
2.3174 & -3.13845 \times 10^{-13} & -0.00319917 & -3.09987 \times 10^{-18} & 0.000166855 & 3.5413 \times 10^{-16} \\
2.31217 & 3.31562 \times 10^{-14} & 0.00307971 & -1.73103 \times 10^{-17} & 0.000166442 & 3.49193 \times 10^{-16} \\
2.3103 & 3.42255 \times 10^{-13} & -0.0216996 & -1.70324 \times 10^{-17} & 0.000284903 & 3.53247 \times 10^{-16} \\
2.326 & -6.48606 \times 10^{-13} & 0.0218191 & 7.18927 \times 10^{-17} & 0.000287891 & 3.03832 \times 10^{-16} \\
2.3174 & -3.15203 \times 10^{-13} & -0.00319917 & -1.83624 \times 10^{-17} & 0.000166855 & 3.26887 \times 10^{-16} \\
2.31217 & 3.24515 \times 10^{-14} & 0.00307971 & -3.58206 \times 10^{-17} & 0.000166442 & 3.21935 \times 10^{-16} \\
2.3103 & 3.4194 \times 10^{-13} & -0.0216996 & -3.5404 \times 10^{-17} & 0.000284903 & 2.98497 \times 10^{-16}
\end{pmatrix}
$$

```
Eigenvalues[Kglobal[[free, free]]];

{Λ, Qfree} = Eigensystem[{Kglobal[[free, free]], Mglobal[[free, free]]}];
ϕ = ConstantArray[0.0, {6, ndof}];
ϕ[[1 ;; 6, free]] = Reverse[Qfree[[-6 ;; -1, All]]];
```
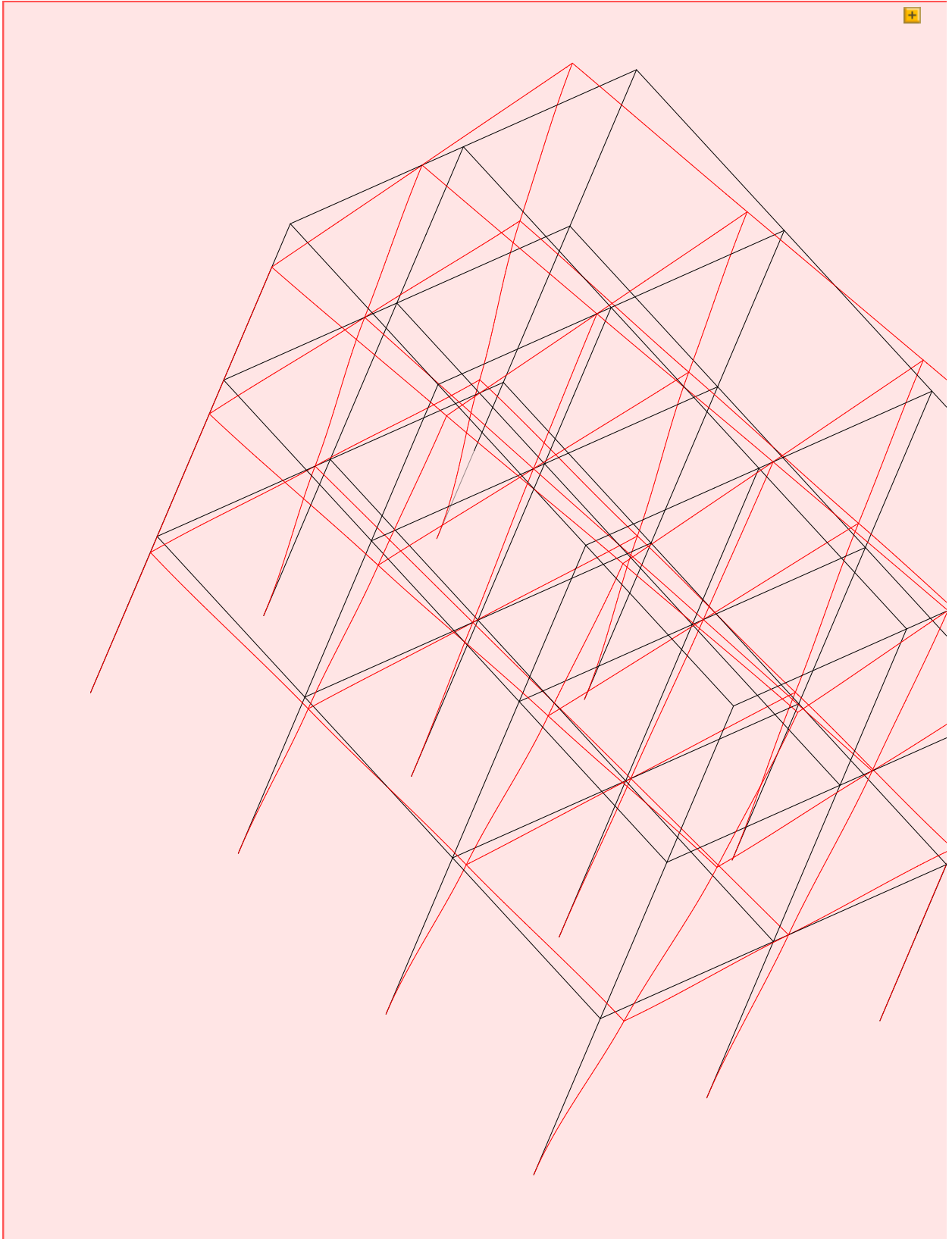
```
mode = 3;

Graphics3D[{
  Opacity[0.4],
  Table[drawBeamSimple[b, 0 uglobal[[b["dofIds"]]]], {b, beams}],
  Opacity[1.0],
  Red,
  Table[drawBeam[b, 1000 ϕ[[mode, b["dofIds"]]]], {b, beams}]
 },
 (*PlotRange→{{-500, 3500}, {-500, 2500}, {0, 3500}},*)
 ViewPoint → {5000, -2000, 2000},
 ViewVertical → {0, 0, 1},
 ImageSize → 800,
 Boxed → False
]
```
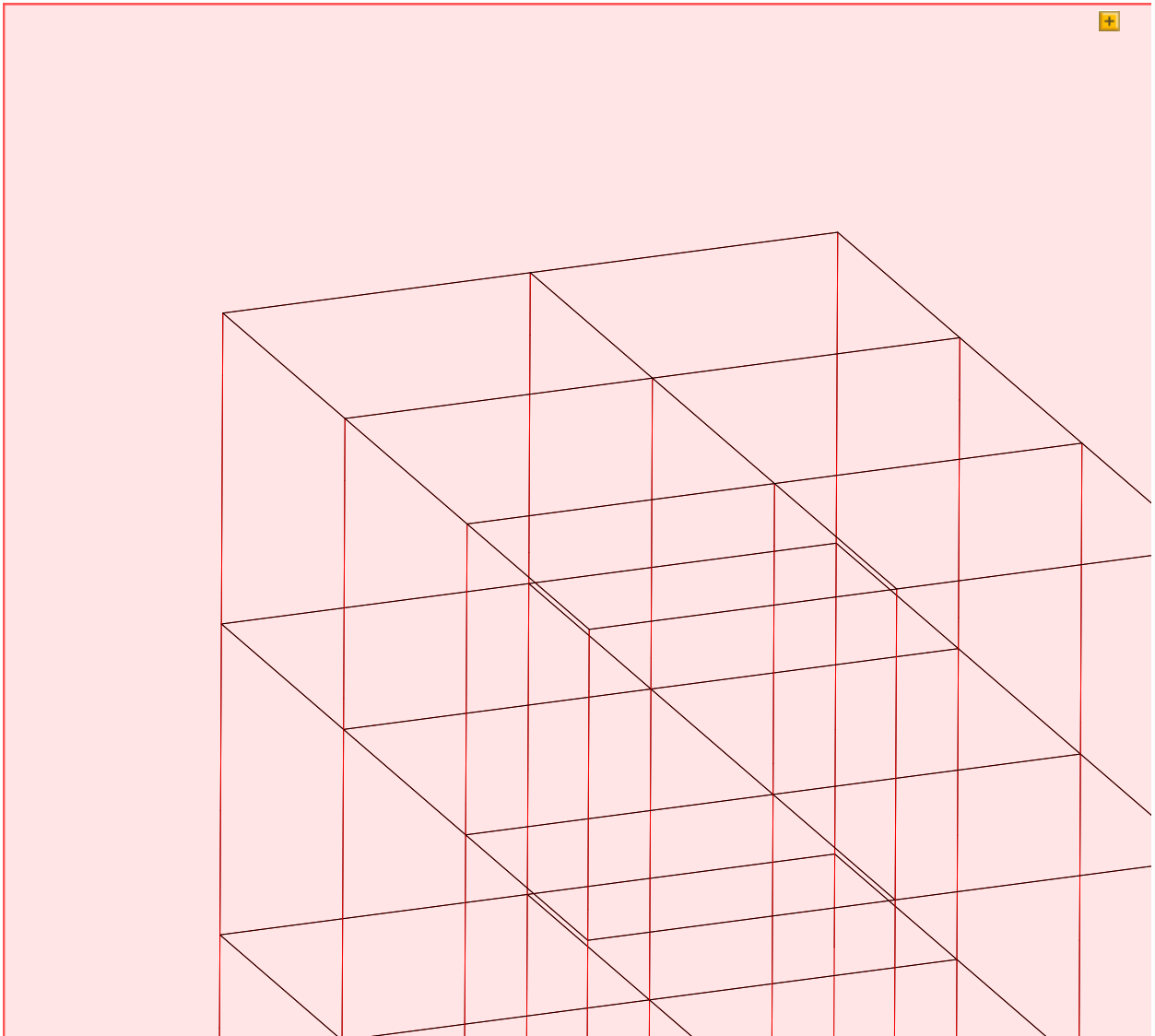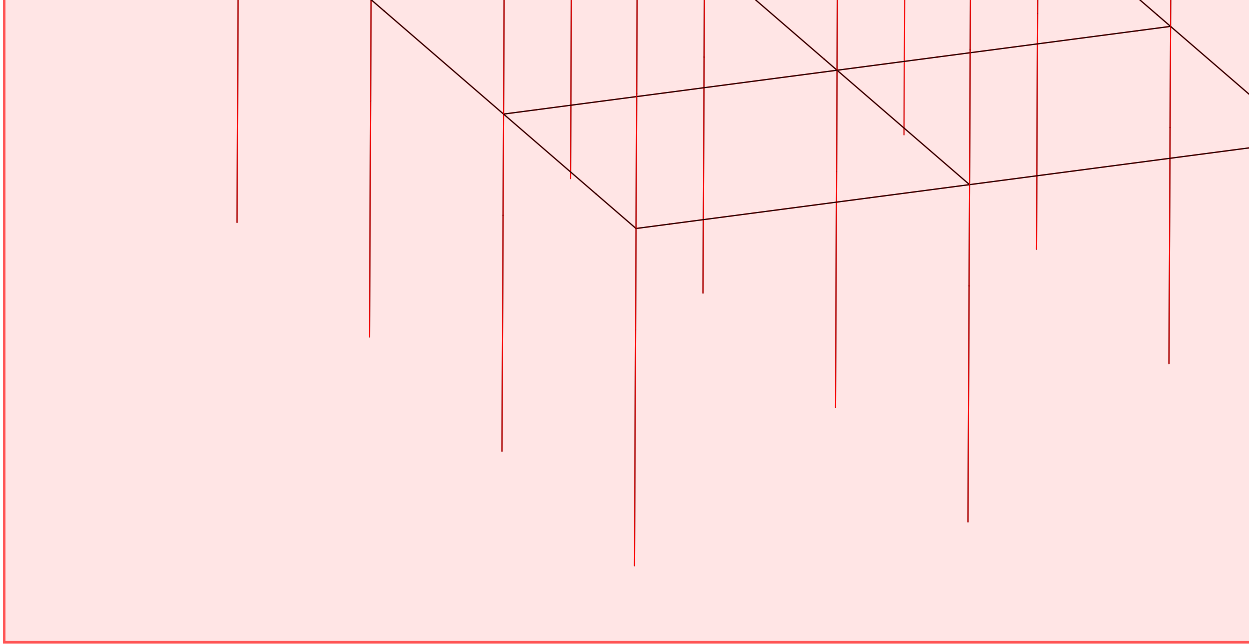
```
drawBeamSimple[beams[[1]], 0 uglobal[[beams[[1]]["dofIds"]]]]
```

```
Line[{{0., 0., 0.}, {0., 0., 1000.}}]
```

```
mode = 3;
```

```
Graphics3D[{
  Opacity[0.4],
  Table[drawBeamSimple[b, 0 uglobal[[b["dofIds"]]]], {b, beams}],
  Opacity[1.0],
  Red,
  Table[drawBeamSimple[b, 0 ϕ[[mode, b["dofIds"]]]], {b, beams}]
 },
 PlotRange → {{-500, 3500}, {-500, 2500}, {0, 3500}},
 ViewPoint → {5000, -2000, 2000},
 ViewVertical → {0, 0, 1},
 ImageSize → 800,
 Boxed → False
]
```

uglobal

$\{0., 0., 0., 0.000757374, -2.5418 \times 10^{-6}, 0.0013384, 8.6417 \times 10^{-17}, 0.00262786,$
$-0.0122854, -0.00258862, -2.08541 \times 10^{-20}, 6.76508 \times 10^{-19}, 0., 0., 0., 0.000757374,$
$2.5418 \times 10^{-6}, -0.0013384, -2.77004 \times 10^{-16}, -2.27106 \times 10^{-12}, -4.46491,$
$-2.21706 \times 10^{-16}, -2.4112 \times 10^{-20}, -2.18994 \times 10^{-20}, 0., 0., 0., -0.000757374,$
$-2.5418 \times 10^{-6}, -0.0013384, -1.47441 \times 10^{-18}, -0.00262786, -0.0122854, 0.00258862,$
$-7.21386 \times 10^{-21}, -1.92672 \times 10^{-19}, 0., 0., 0., -0.000757374, 2.5418 \times 10^{-6}, 0.0013384\}$

```
frames = ParallelTable[
   pos = nodes + α Partition[uglobal, 6][[All, 1 ;; 3]];
   Graphics3D[{
     Opacity[0.4],
     Table[drawBeamSimple[b, 0 uglobal[[b["dofIds"]]]], {b, beams}],
     Opacity[1.0],
     Red,
     Table[drawBeam[b, α ϕ[[4, b["dofIds"]]]], {b, beams}]
    },
    PlotRange → {{-1200, 1200}, {-1000, 4000}, {0, 3000}},
    ViewPoint → {5000, -2000, 2000},
    ImageSize → 800,
    Boxed → False
   ]
   ,
   {α, 0, 900, 30}
  ];
```

```
frames = ParallelTable[
   pos = nodes + α Partition[uglobal, 6][[All, 1 ;; 3]];
   Graphics3D[{
     Table[
       drawBeam[b, α uglobal[[b["dofIds"]]]], {b, beams}
      ],
      Red,
      Arrowheads[0.03],
      Arrow[{pos[[4]] + {0, 0, 500}, pos[[4]]}]
     },
     PlotRange → {{-1200, 1200}, {-1000, 4000}, {0, 3000}},
     ViewPoint → {5000, -2000, 2000},
     ImageSize → 800,
     Boxed → False
    ]
    ,
    {α, 0, 100, 2}
   ];
```

ListAnimate[frames]
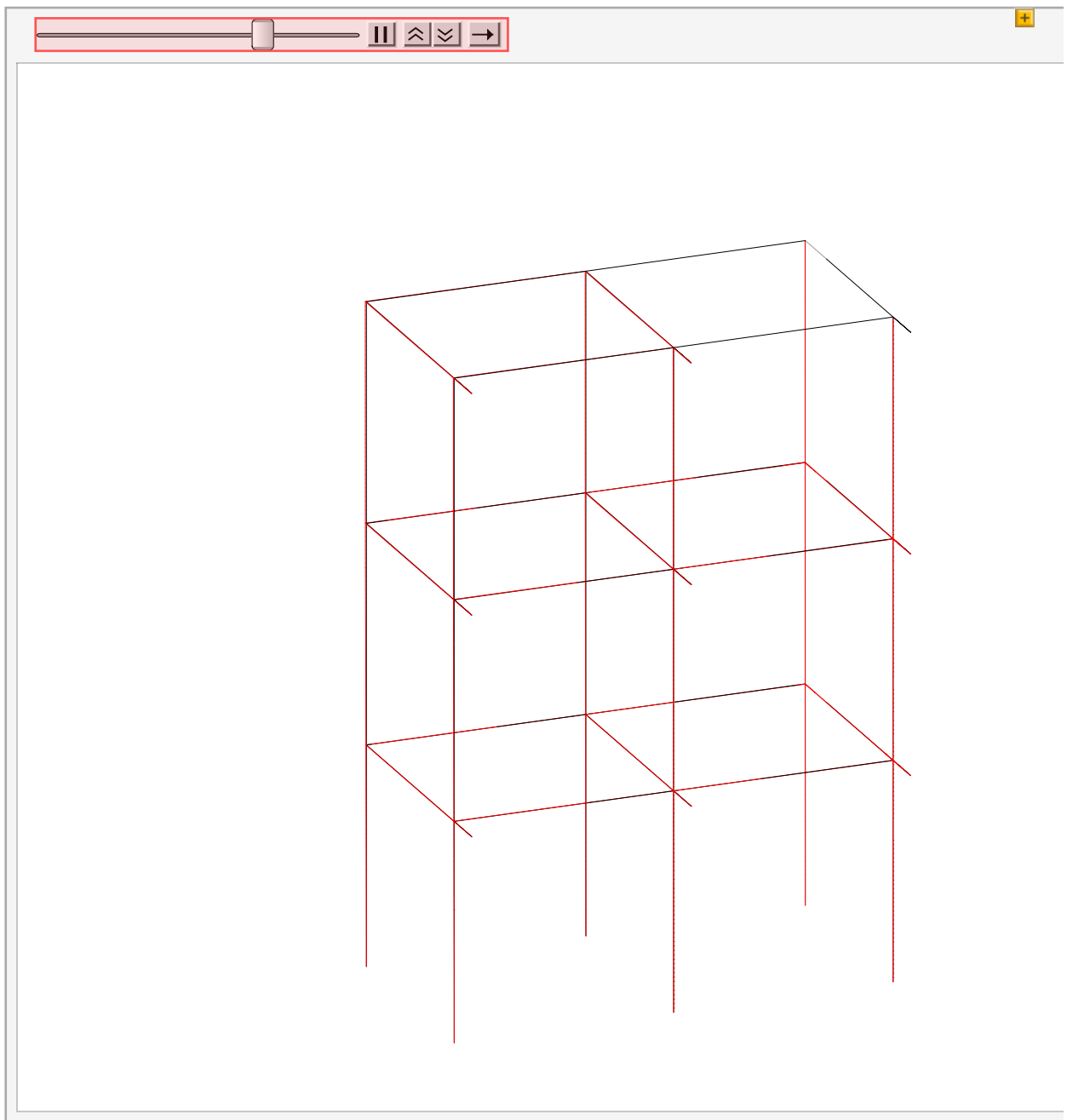

```
Export["swingset_mode2.gif",
 Join[frames[[1 ;; -2]], Reverse[frames[[2 ;; -1]]]], Antialiasing → True]
```

swingset_mode2.gif

```
(*scales = {1, 1, 1, 0.01, 0.01, 0.01};
{Λ, Qfree}=Eigensystem[{Kglobal[[free, free]], Mglobal[[free, free]]}];
ϕ = ConstantArray[0.0, {6, ndof}];
ϕ[[1;;6,free]] = Reverse[Qfree[[-6;;-1, All]]];
mode = 1;
Manipulate[
 Graphics3D[{
   Opacity[0.5],
   Table[
    drawBeam[b, 0ϕ[[mode,b["dofIds"]]]], {b, beams}
   ],
   Opacity[1.0],
   Table[
    drawBeam[b, α scales[[mode]]ϕ[[mode,b["dofIds"]]]], {b, beams}
   ]
   },
  PlotRange→{{-1200, 1200}, {-1000, 4000}, {0, 3000}},
  Boxed→False,
  ViewPoint→{5000, -2000, 2000},
  ImageSize→800
 ]
 ,
 {α, 0, 1000}
]*)


frames = Table[
   Graphics3D[{
     Opacity[0.4],
     Table[drawBeamSimple[b, 0 uglobal[[b["dofIds"]]]], {b, beams}],
     Opacity[1.0],
     Red,
     Table[drawBeamSimple[b, α ϕ[[mode, b["dofIds"]]]], {b, beams}]
     },
    PlotRange → {{-500, 3500}, {-500, 2500}, {0, 3500}},
    ViewPoint → {5000, -2000, 2000},
    ViewVertical → {0, 0, 1},
    ImageSize → 600,
    Boxed → False
   ],
   {α, 0, 1000, 10}
  ];
```
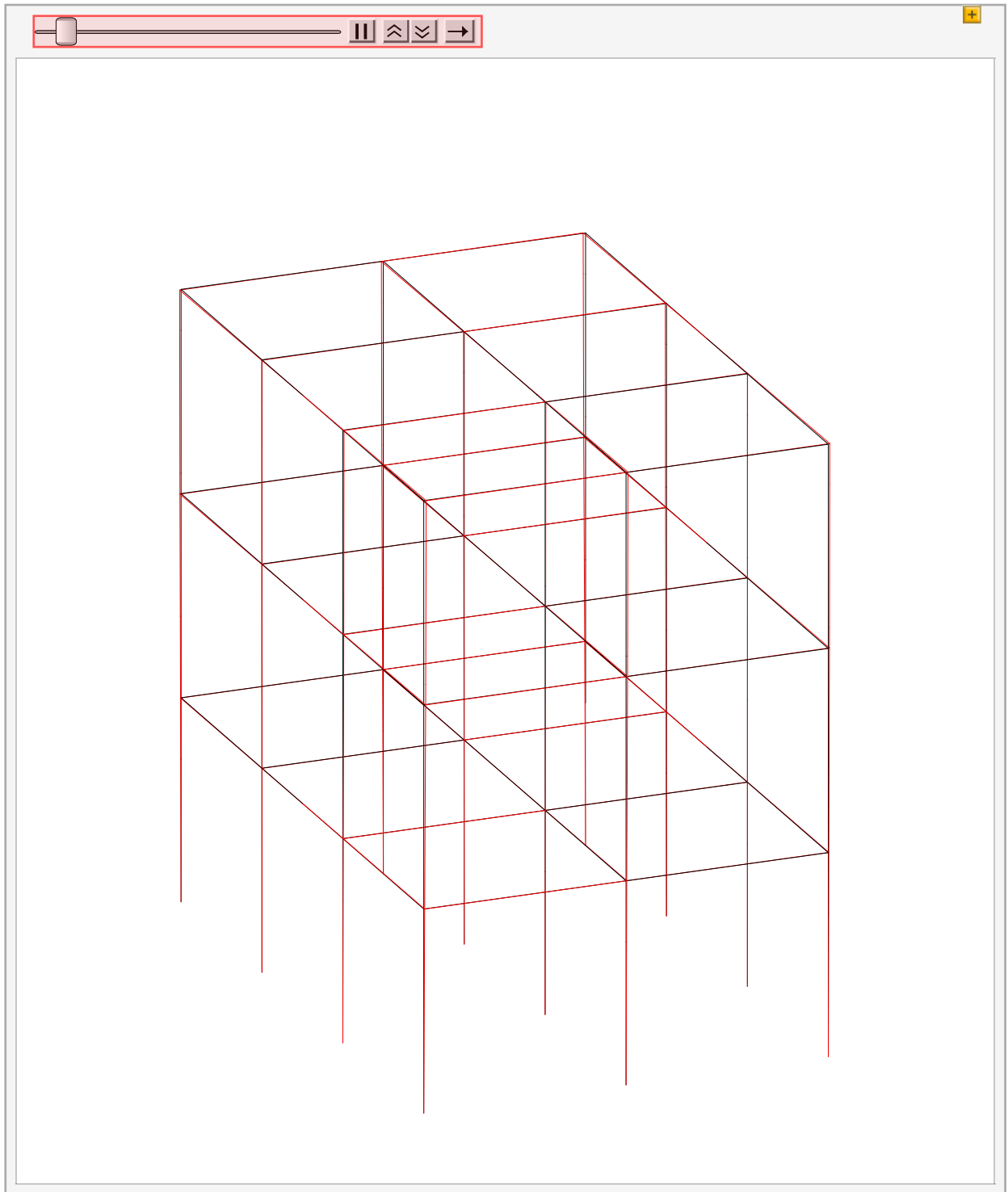
ListAnimate[frames]

$Aborted

```
Graphics3D[{
  Opacity[0.2],
  Table[drawBeamSimple[b, 0 uglobal[[b["dofIds"]]]], {b, beams}],
  Opacity[1.0],
  Red,
  Table[drawBeam[b, 100 uglobal[[b["dofIds"]]]], {b, beams}]
 },
 PlotRange → {{-500, 3500}, {-500, 2500}, {0, 3500}},
 ViewPoint → {5000, -2000, 2000},
 ViewVertical → {0, 0, 1},
 ImageSize → 600,
 Boxed → False
]
```