CUFSM Advanced Functions

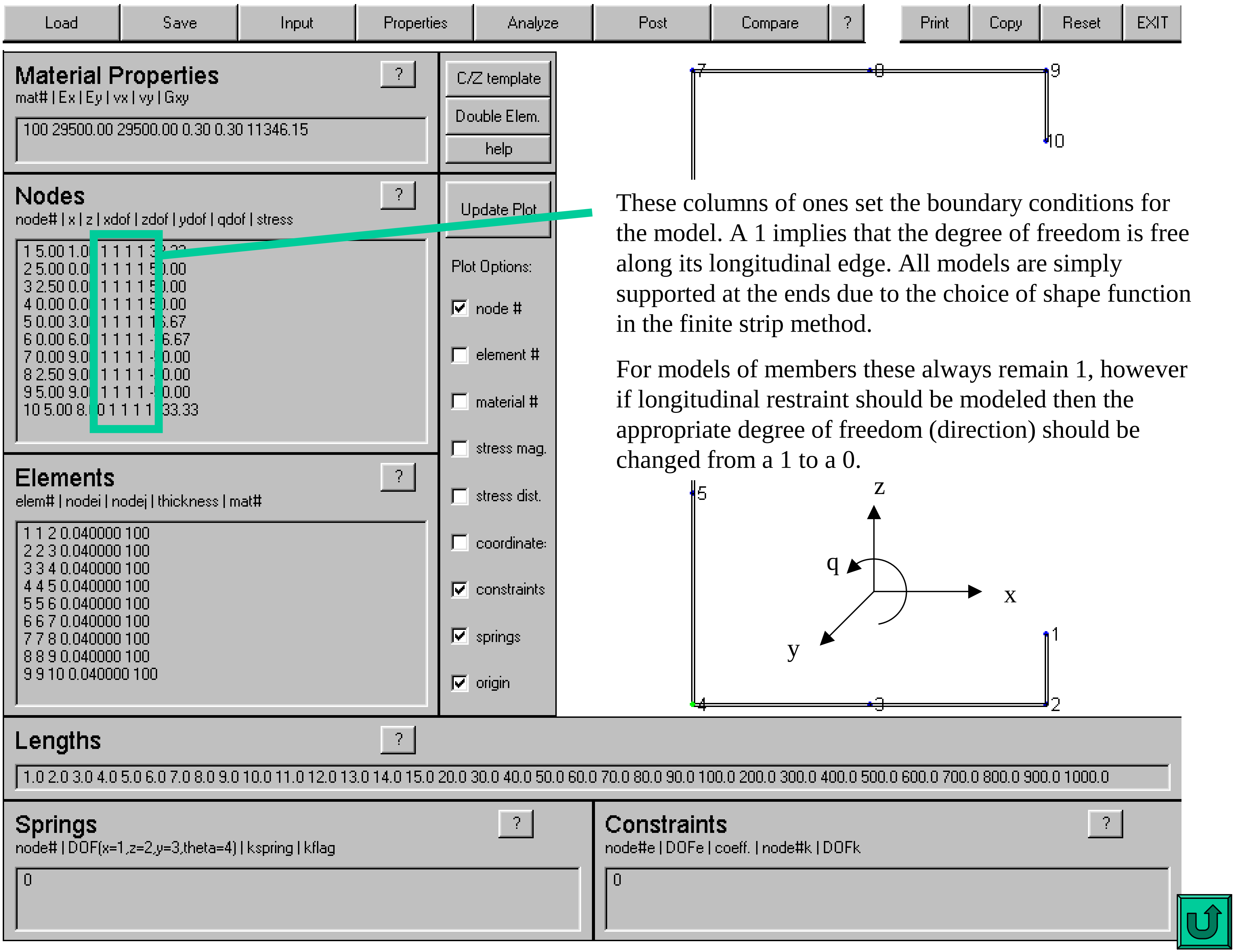
- Boundary conditions
- Constraints
- Springs
- Multiple materials
- Orthotropic Material

Boundary conditions

- Longitudinal boundary conditions (fixity) can be set in the finite strip model
- Modeling classic problems requires using this feature
  - simply supported plate
  - fixed plate
- Special cases may exist where artificial boundary conditions are added in an analysis to examine a particular buckling mode in exclusion of other modes (see Advanced Ideas for more on this)
- Symmetry and anti-symmetry conditions may be modeled by modifying the boundary conditions

Boundary conditions continued

- How to
- Simply supported plate example
- Fixed-free plate example
- Flange only model
- Symmetry model on a hat in bending example



These columns of ones set the boundary conditions for the model. A 1 implies that the degree of freedom is free along its longitudinal edge. All models are simply supported at the ends due to the choice of shape function in the finite strip method.

For models of members these always remain 1, however if longitudinal restraint should be modeled then the appropriate degree of freedom (direction) should be changed from a 1 to a 0.

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

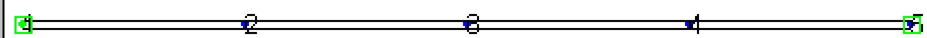
Simply supported plate in pure compression

Plate is 10 in. wide and t = 0.10 in., material is steel.

The x and z degree of freedom at node 1 have been supported by changing the appropriate 1's to 0's.

The z degree of freedom at node 5 has been supported by changing the appropriate 1 to 0.

Green boxes appear at 1 and 5 to indicate some boundary conditions have been changed at this node.



Material Properties ?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.00

C/Z template

Double Elem.

help

Nodes ?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 0.00 0.00 0 0 1 1 1.00
2 2.50 0.00 1 1 1 1 1.00
3 5.00 0.00 1 1 1 1 1.00
4 7.50 0.00 1 1 1 1 1.00
5 10.00 0.00 1 0 1 1 1.00

Update Plot

Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements ?

elem# | nodei | nodej | thickness | mat#

1 1 2 0.100000 100
2 2 3 0.100000 100
3 3 4 0.100000 100
4 4 5 0.100000 100

Lengths ?

4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0

Springs ?

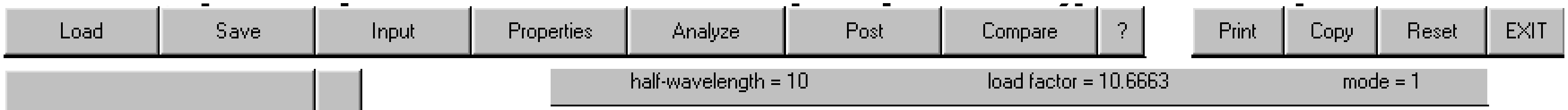
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

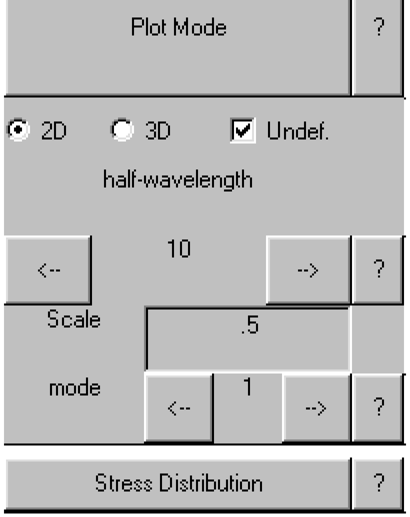
0

Constraints ?

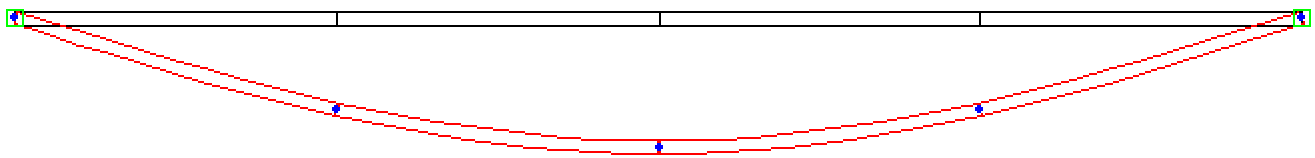
node#e | DOFe | coeff. | node#k | DOFk

0

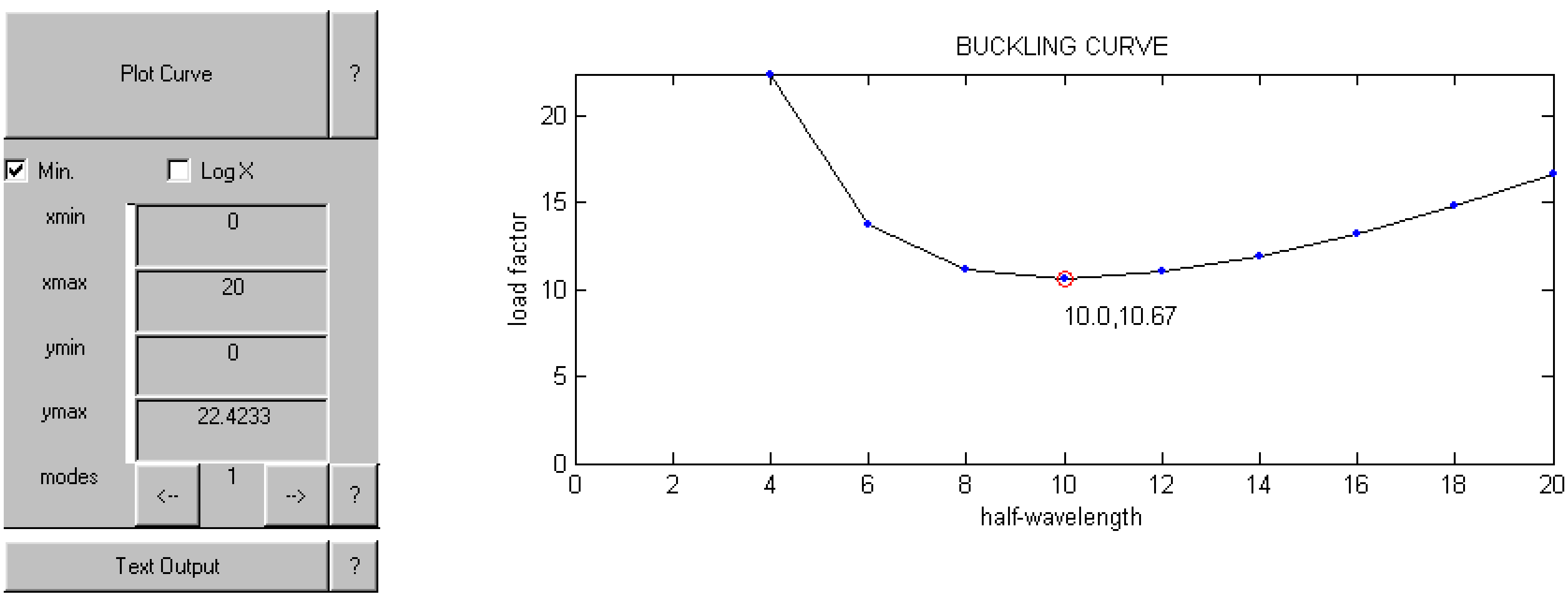




$$\text{Theory} \rightarrow f_{cr} = k\frac{\pi^2 E}{12\left(1-\nu^2\right)}\left(\frac{t}{b}\right)^2 = 4\frac{\pi^2\, 29500}{12\left(1-0.3^2\right)}\left(\frac{0.1}{10.0}\right)^2 = 10.66\text{ksi}$$



Input reference stress is 1.0 ksi. So in this case the load factor is equal to the buckling stress in ksi, i.e., 10.67 ksi. versus 10.66 ksi by hand.

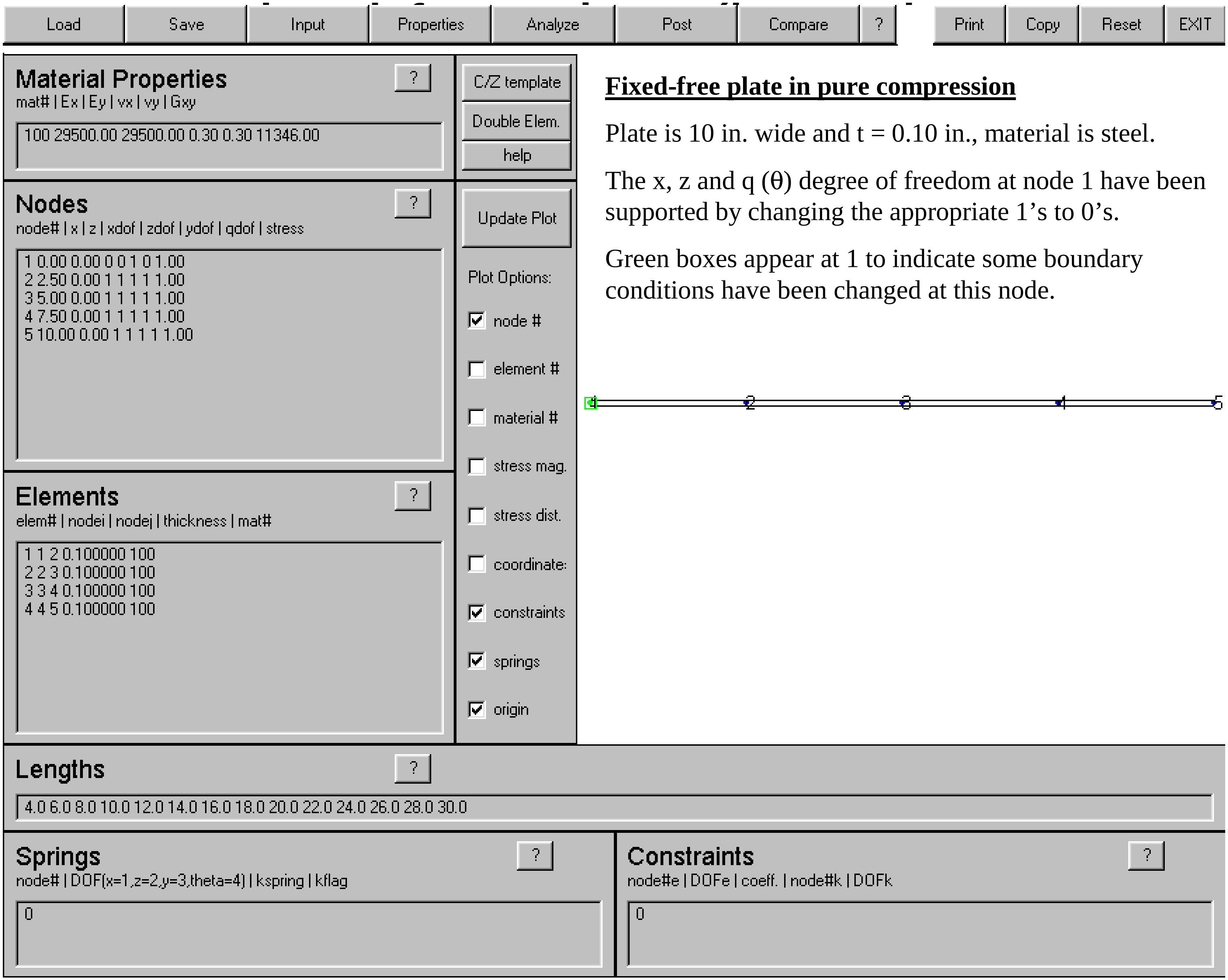


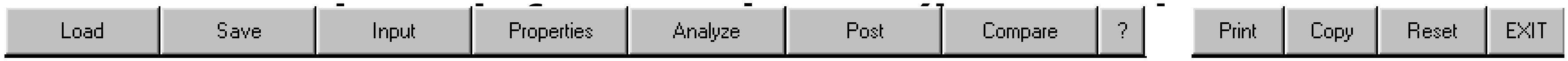
Fixed-free plate in pure compression

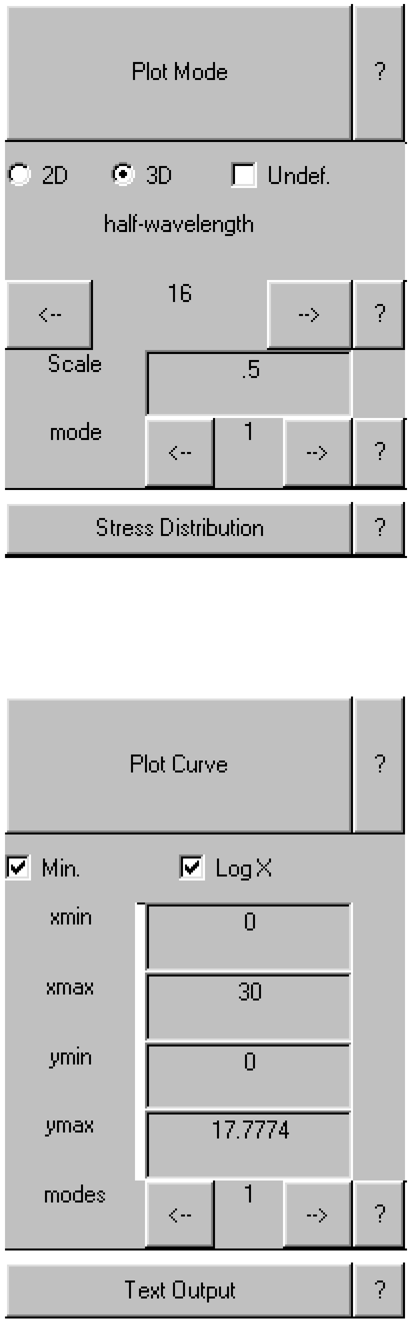
Plate is 10 in. wide and t = 0.10 in., material is steel.

The x, z and q (θ) degree of freedom at node 1 have been supported by changing the appropriate 1’s to 0’s.

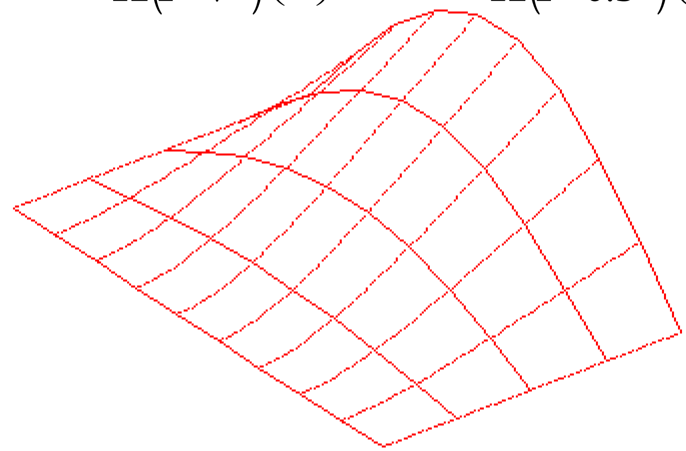
Green boxes appear at 1 to indicate some boundary conditions have been changed at this node.



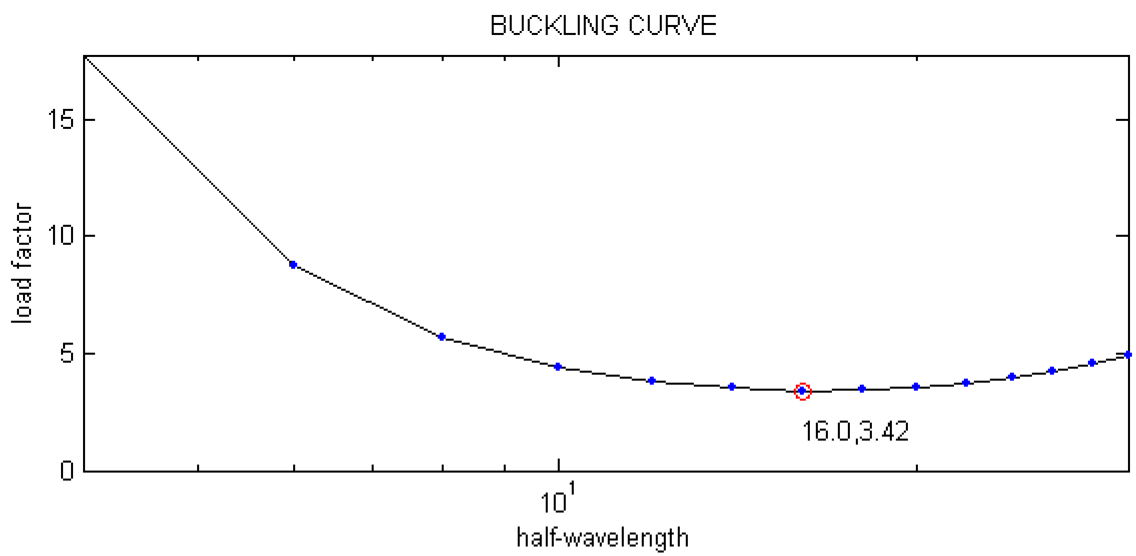




$$\text{Theory} \rightarrow f_{cr} = k\frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2 = 1.277\frac{\pi^2\, 29500}{12(1-0.3^2)}\left(\frac{0.1}{10.0}\right)^2 = 3.40\text{ksi}$$



Input reference stress is 1.0 ksi. So in this case the load factor is equal to the buckling stress in ksi, i.e., 3.42 ksi. versus 3.40 ksi by hand.



Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties ?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template

Double Elem.

help

Nodes ?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 0.00 0.00 0 0 1 0 1.00
2 2.50 0.00 1 1 1 1 1.00
3 5.00 0.00 1 1 1 1 1.00
4 7.50 0.00 1 1 1 1 1.00
5 10.00 0.00 1 1 1 1 1.00
6 10.00 -1.00 1 1 1 1 1.66
7 10.00 -2.00 1 1 1 1 1.33

Update Plot

Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements ?

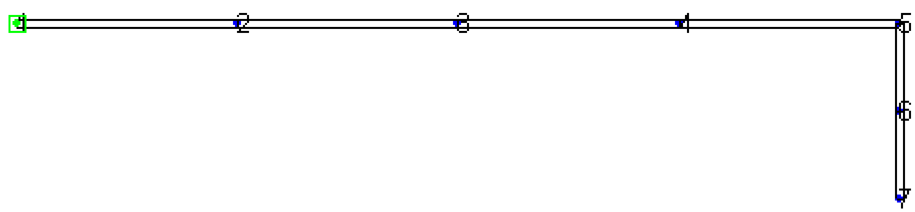
elem# | nodei | nodej | thickness | mat#

1 1 2 0.100000 100
2 2 3 0.100000 100
3 3 4 0.100000 100
4 4 5 0.100000 100
5 5 6 0.100000 100
6 6 7 0.100000 100

<u>Isolated flange in pure compression</u>

Plate is 10 in. wide and t = 0.10 in., material is steel.
Lip is 2 in. long and the same material and thickness

The x, z and q (θ) degree of freedom at node 1 have been supported by changing the appropriate 1's to 0's. So, the left end is "built-in" or "fixed".



Lengths ?

4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 30.0 33.0 37.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 120.0 160.0 200.0

Springs ?

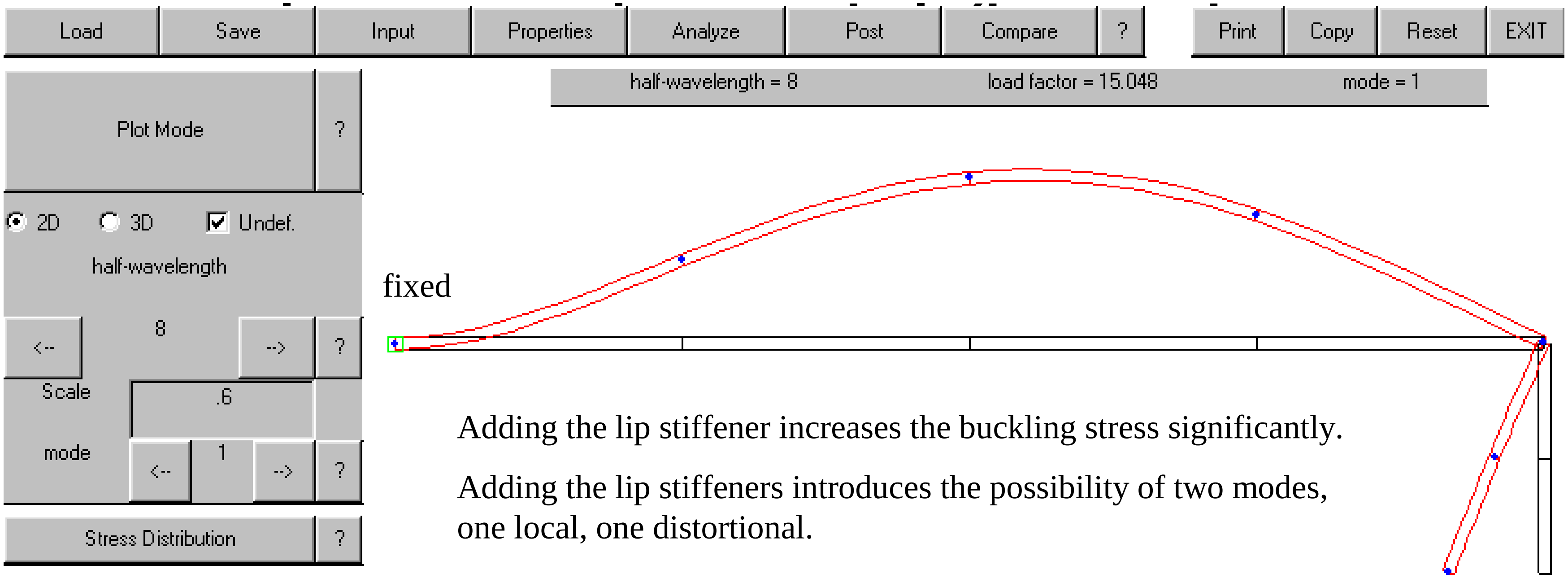
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

0

Constraints ?

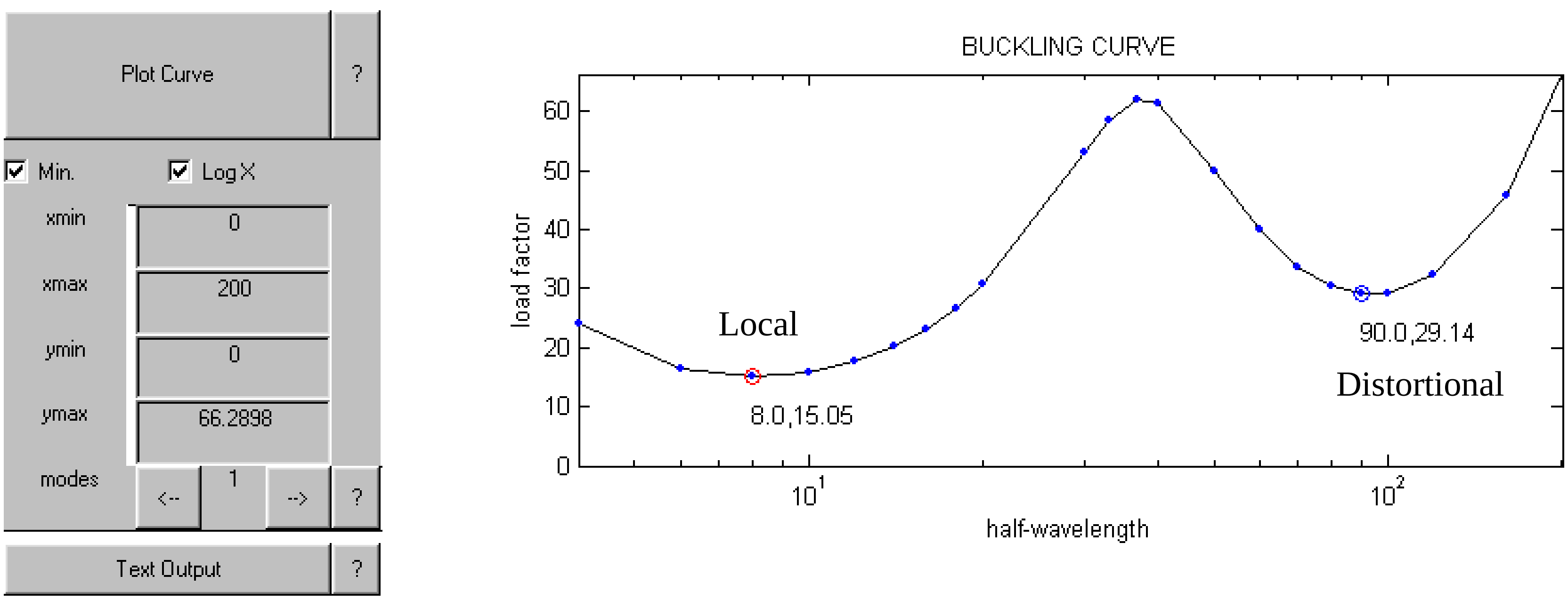
node#e | DOFe | coeff. | node#k | DOFk

0



Adding the lip stiffener increases the buckling stress significantly.

Adding the lip stiffeners introduces the possibility of two modes, one local, one distortional.



Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties

?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template

Double Elem.

help

Nodes

?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 -2.00 0.00 1 1 1 1 -1.75
2 -1.50 0.00 1 1 1 1 -1.75
3 -1.00 0.00 1 1 1 1 -1.75
4 -0.50 0.00 1 1 1 1 -1.75
5 0.00 0.00 1 1 1 1 -1.75
6 0.00 1.00 1 1 1 1 -1.06
7 0.00 2.00 1 1 1 1 -0.37
8 0.00 3.00 1 1 1 1 0.31
9 0.00 4.00 1 1 1 1 1.00
10 2.50 4.00 1 1 1 1 1.00
11 5.00 4.00 1 1 1 1 1.00

Update Plot

Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements

?

elem# | nodei | nodej | thickness | mat#

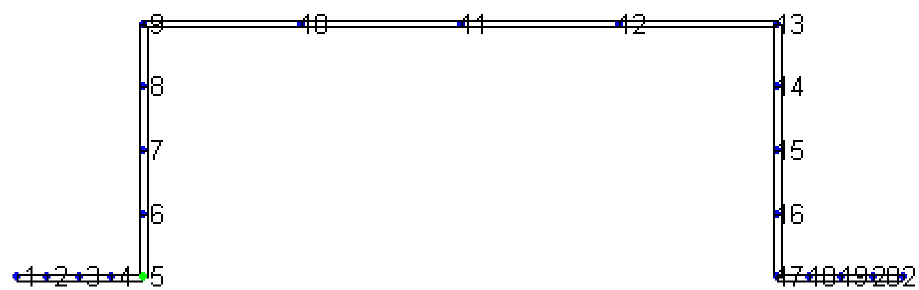
1 1 2 0.100000 100
2 2 3 0.100000 100
3 3 4 0.100000 100
4 4 5 0.100000 100
5 5 6 0.100000 100
6 6 7 0.100000 100
7 7 8 0.100000 100
8 8 9 0.100000 100
9 9 10 0.100000 100
10 10 11 0.100000 100

<u>Hat in bending - full model</u>

The hat is 2 x 4 x 10 in.

Pure bending is applied as the reference load.

The reference compressive stress for the top flange is 1.0 ksi which results in -1.75 tension for the bottom flange



Lengths

?

4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 30.0 33.0 37.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 120.0 160.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0

Springs

?

node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

0

Constraints

?

node#e | DOFe | coeff. | node#k | DOFk

0

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties ?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template | Double Elem. | help

Nodes ?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 -2.00 0.00 1 1 1 1 -1.75
2 -1.50 0.00 1 1 1 1 -1.75
3 -1.00 0.00 1 1 1 1 -1.75
4 -0.50 0.00 1 1 1 1 -1.75
5 0.00 0.00 1 1 1 1 -1.75
6 0.00 1.00 1 1 1 1 -1.06
7 0.00 2.00 1 1 1 1 -0.37
8 0.00 3.00 1 1 1 1 0.31
9 0.00 4.00 1 1 1 1 1.00
10 2.50 4.00 1 1 1 1 1.00
11 5.00 4.00 0 1 1 0 1.00

Update Plot

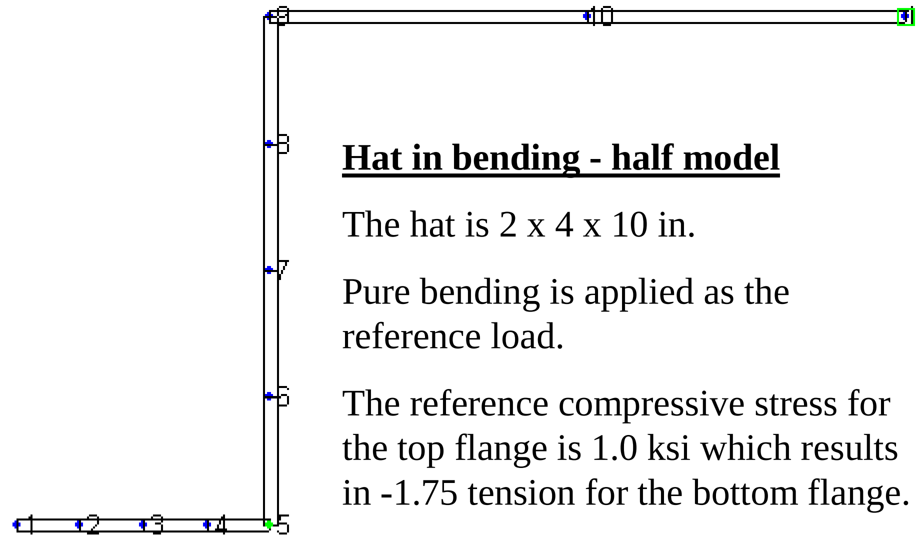
Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements ?

elem# | nodei | nodej | thickness | mat#

1 1 2 0.100000 100
2 2 3 0.100000 100
3 3 4 0.100000 100
4 4 5 0.100000 100
5 5 6 0.100000 100
6 6 7 0.100000 100
7 7 8 0.100000 100
8 8 9 0.100000 100
9 9 10 0.100000 100
10 10 11 0.100000 100



Hat in bending - half model

The hat is 2 x 4 x 10 in.

Pure bending is applied as the reference load.

The reference compressive stress for the top flange is 1.0 ksi which results in -1.75 tension for the bottom flange.

Symmetry conditions are enforced at mid-width of the top flange, note the degrees of freedom changed to 0 at node 11 in the Nodes list to the left.

Lengths ?

4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 30.0 33.0 37.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 120.0 160.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0

Springs ?

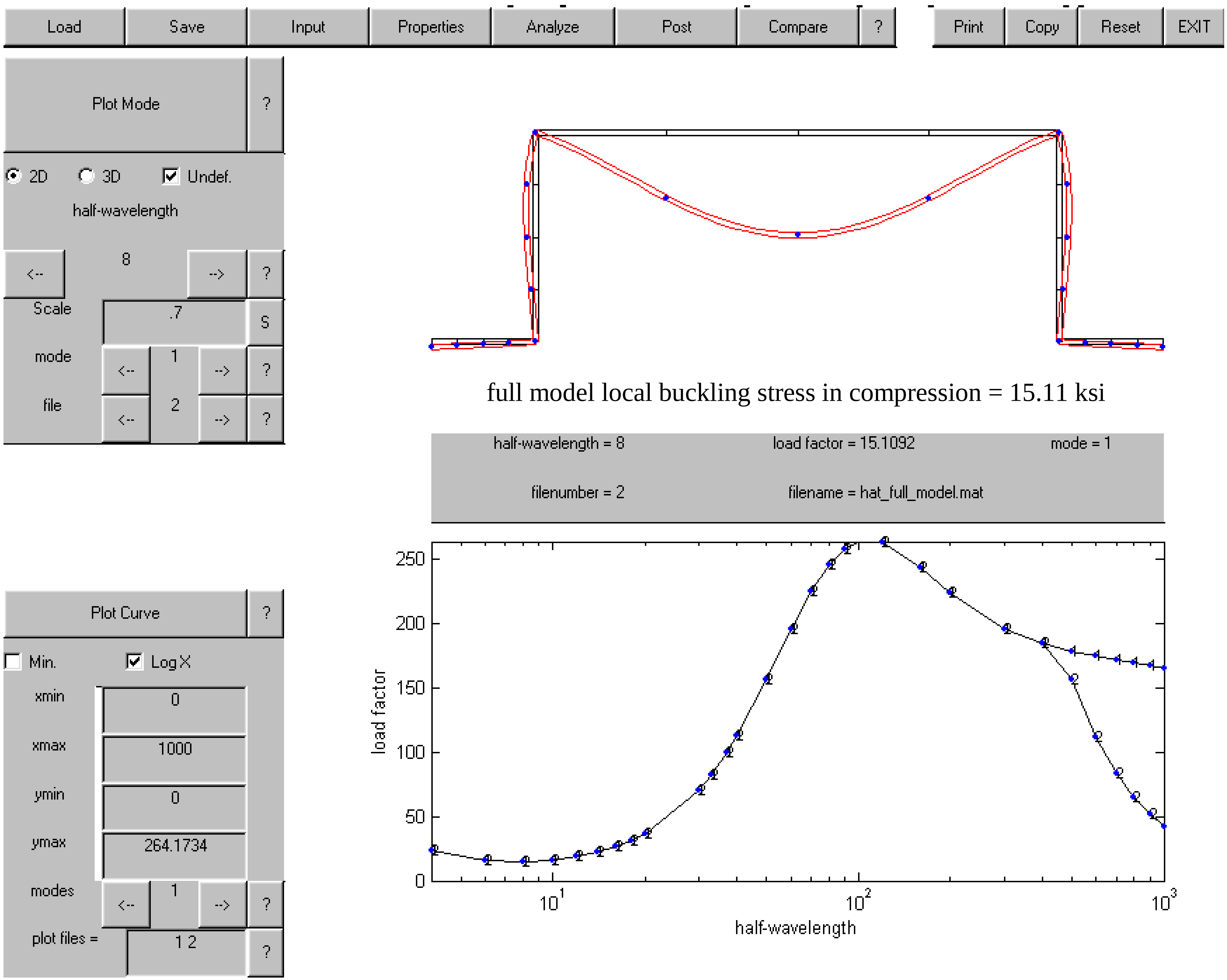
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

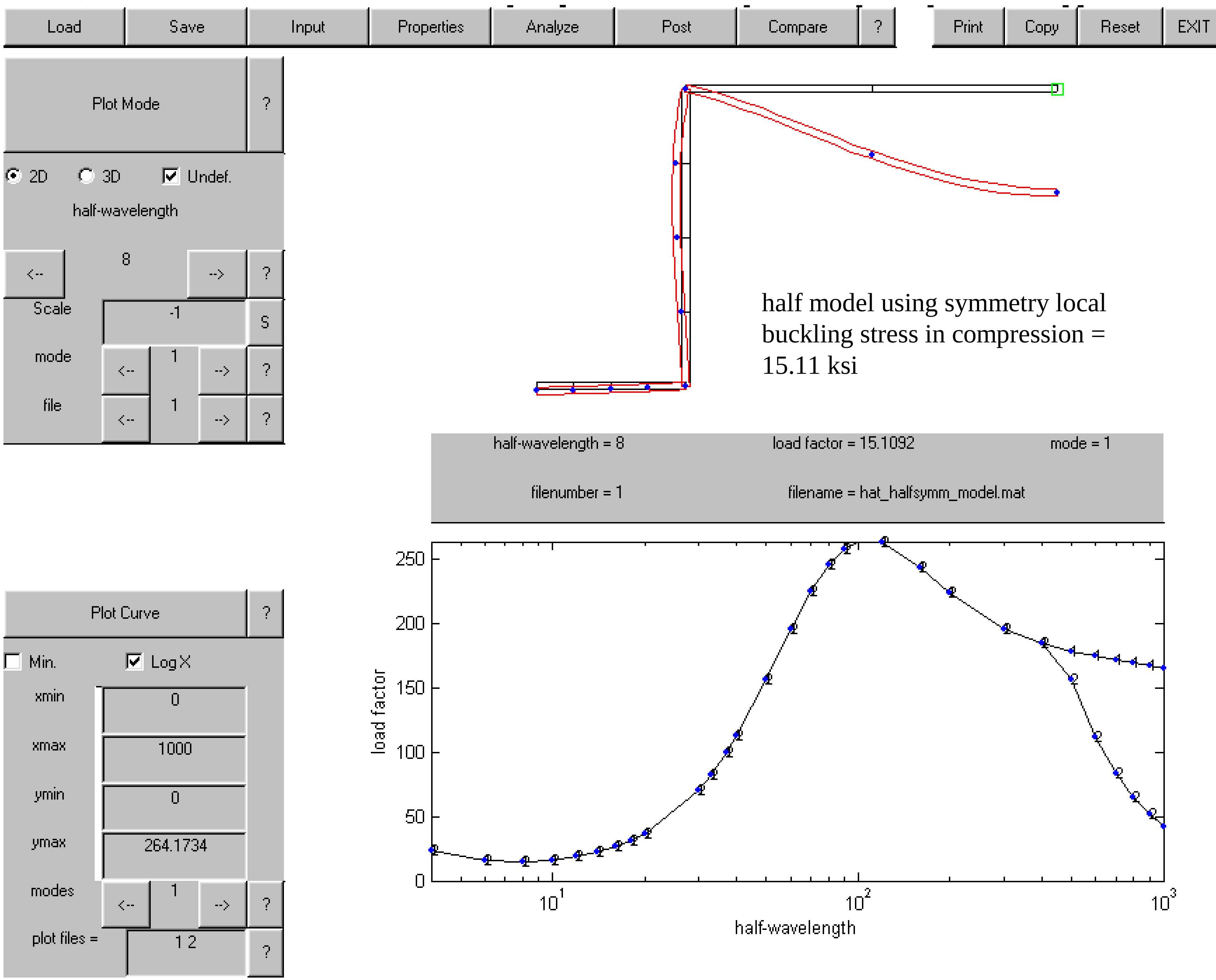
0

Constraints ?

node#e | DOFe | coeff. | node#k | DOFk

0


Load
Save
Input
Properties
Analyze
Post
Compare
?
Print
Copy
Reset
EXIT
Plot Mode
2D
3D
Undef.
half-wavelength
8
<--
-->
Scale
.7
S
mode
1
file
2
full model local buckling stress in compression = 15.11 ksi
half-wavelength = 8
load factor = 15.1092
mode = 1
filenumber = 2
filename = hat_full_model.mat
Plot Curve
Min.
Log X
xmin
0
xmax
1000
ymin
0
ymax
264.1734
modes
1
plot files =
1 2
load factor
half-wavelength



half model using symmetry local buckling stress in compression = 15.11 ksi

Constraints

- You may write an equation constraint: this enforces the deflection (rotation) of one node to be a function of the deflection (rotation) of a second node.
- Modeling external attachments may be aided by using this feature
  - an external bar that forces two nodes to have the same translation but leaves them otherwise free
  - a brace connecting two members (you can model multiple members in CUFSM)
- Special cases may exist where artificial equation constraints are added in an analysis to examine a particular buckling mode in exclusion of other modes (see Advanced Ideas for more on this)

Constraints continued

- How to
- Connected lips in a member
- Multiple connected members

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template

Double Elem.

help

Nodes

node# | x | z | xdof | zdof | ydof | qdof | stress

1 5.00 1.00 1 1 1 1 1.00
2 5.00 0.00 1 1 1 1 1.00
3 2.50 0.00 1 1 1 1 1.00
4 0.00 0.00 1 1 1 1 1.00
5 0.00 3.00 1 1 1 1 1.00
6 0.00 6.00 1 1 1 1 1.00
7 0.00 9.00 1 1 1 1 1.00
8 2.50 9.00 1 1 1 1 1.00
9 5.00 9.00 1 1 1 1 1.00
10 5.00 8.00 1 1 1 1 1.00

Update Plot

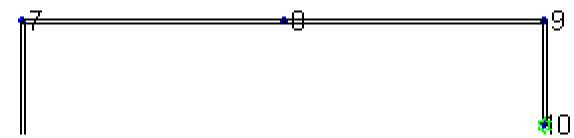
Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements

elem# | nodei | nodej | thickness | mat#

1 1 2 0.040000 100
2 2 3 0.040000 100
3 3 4 0.040000 100
4 4 5 0.040000 100
5 5 6 0.040000 100
6 6 7 0.040000 100
7 7 8 0.040000 100
8 8 9 0.040000 100
9 9 10 0.040000 100



Equation Constraints are determined by defining the degree of freedom of 1 node in terms of another.

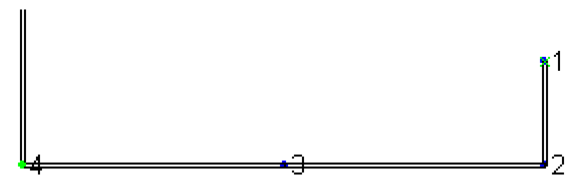
For example, the expression below in Constraints says

At node 1, set degree of freedom 2 equal to 1.0 times node 10, degree of freedom 2:

$w_1=1.0w_{10}$

You can enter as many constraints as you like, but once you use a degree of freedom on the left hand side of the equation it is eliminated and can not be used again.

Symbols appear on the nodes that you have written constraint equations on, as shown in this plot for nodes 1 and nodes 10.



Lengths

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0

Springs

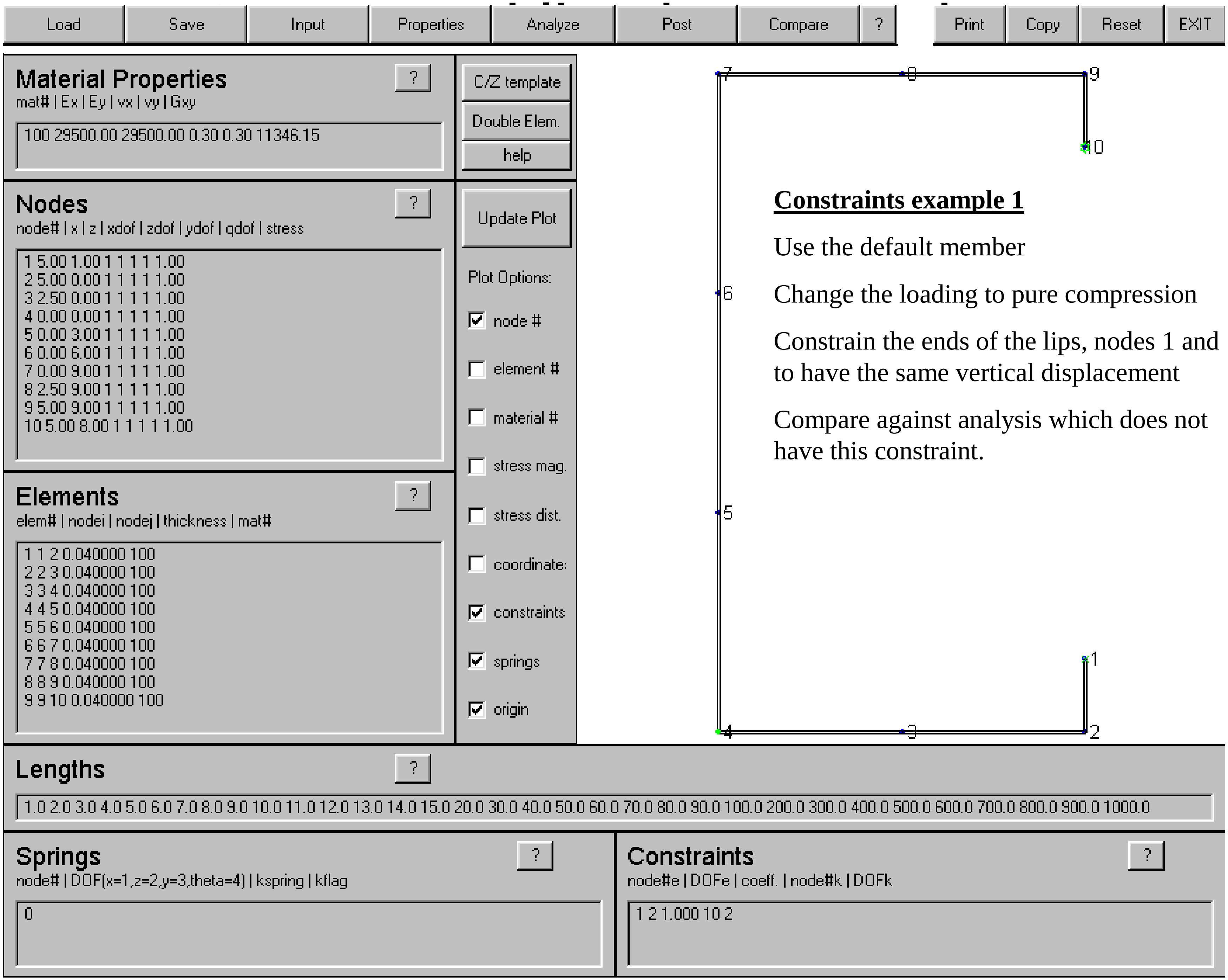
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

0

Constraints

node#e | DOFe | coeff. | node#k | DOFk

1 2 1.000 10 2



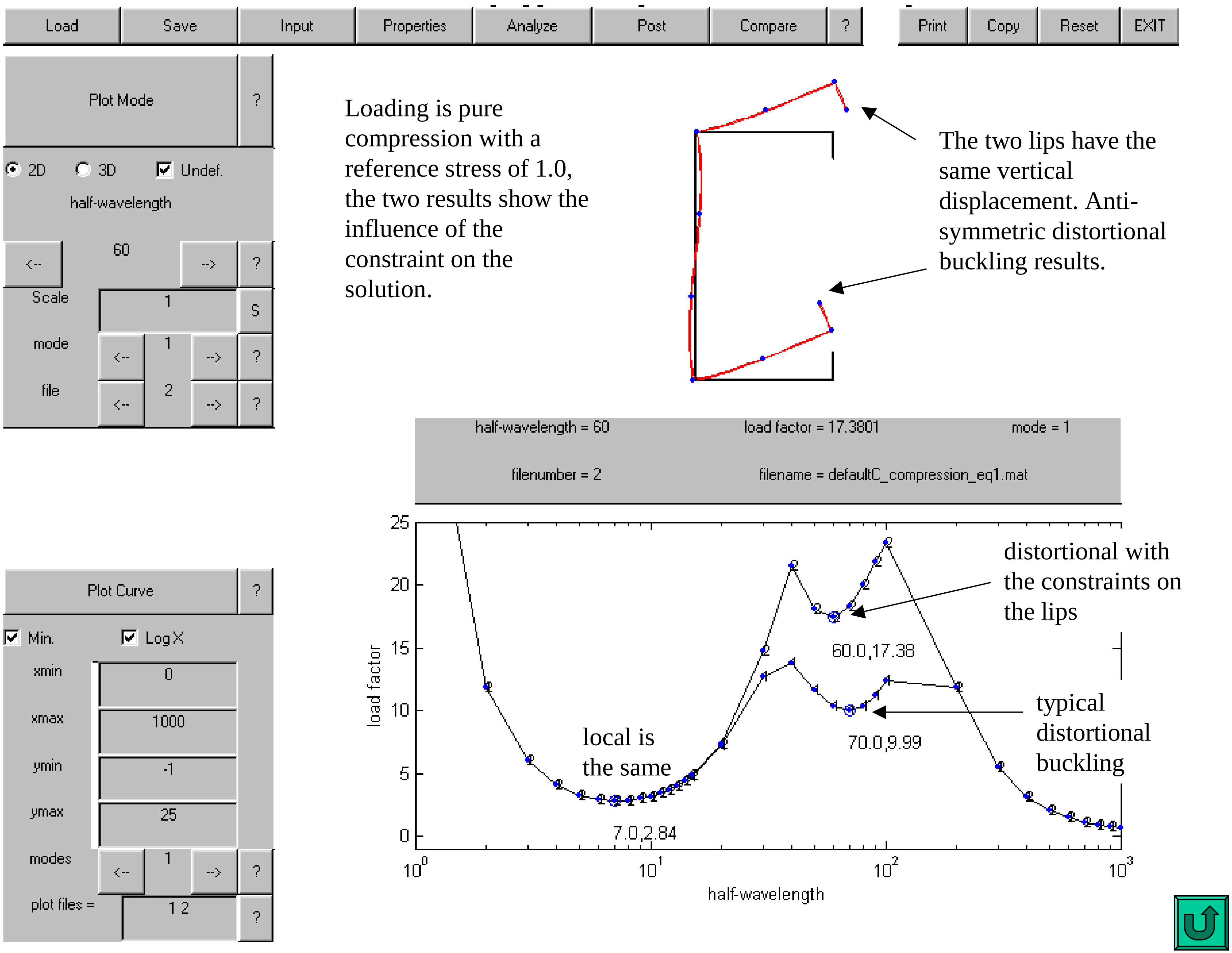
Constraints example 1

Use the default member

Change the loading to pure compression

Constrain the ends of the lips, nodes 1 and 10 to have the same vertical displacement

Compare against analysis which does not have this constraint.


Load
Save
Input
Properties
Analyze
Post
Compare
?
Print
Copy
Reset
EXIT
Plot Mode
2D
3D
Undef.
half-wavelength
60
Scale
1
S
mode
1
file
2
Loading is pure compression with a reference stress of 1.0, the two results show the influence of the constraint on the solution.
The two lips have the same vertical displacement. Anti-symmetric distortional buckling results.
half-wavelength = 60
load factor = 17.3801
mode = 1
filenumber = 2
filename = defaultC_compression_eq1.mat
Plot Curve
Min.
Log X
xmin
0
xmax
1000
ymin
-1
ymax
25
modes
1
plot files =
1 2
load factor
half-wavelength
distortional with the constraints on the lips
60.0,17.38
typical distortional buckling
70.0,9.99
local is the same
7.0,2.84

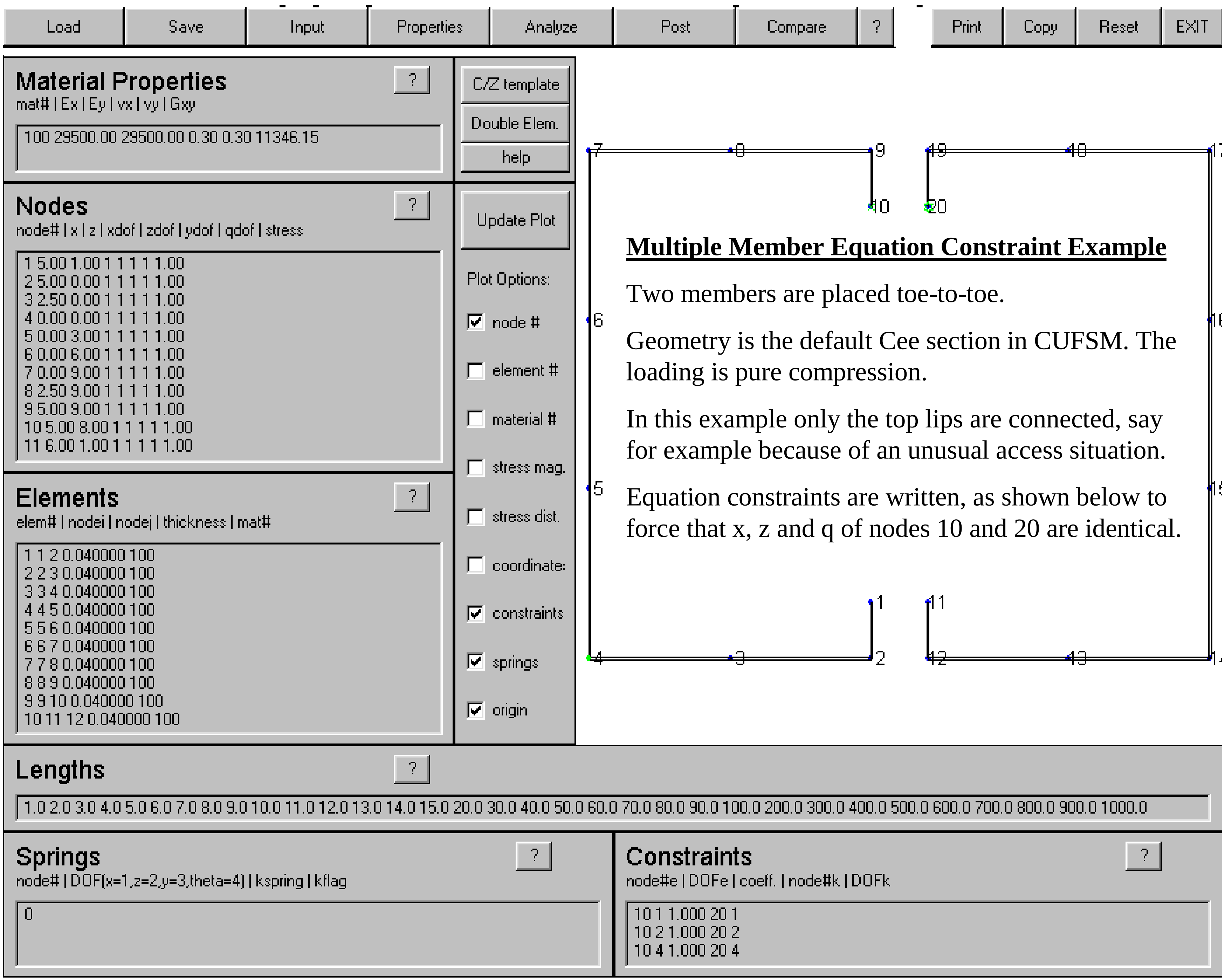
Multiple Member Equation Constraint Example

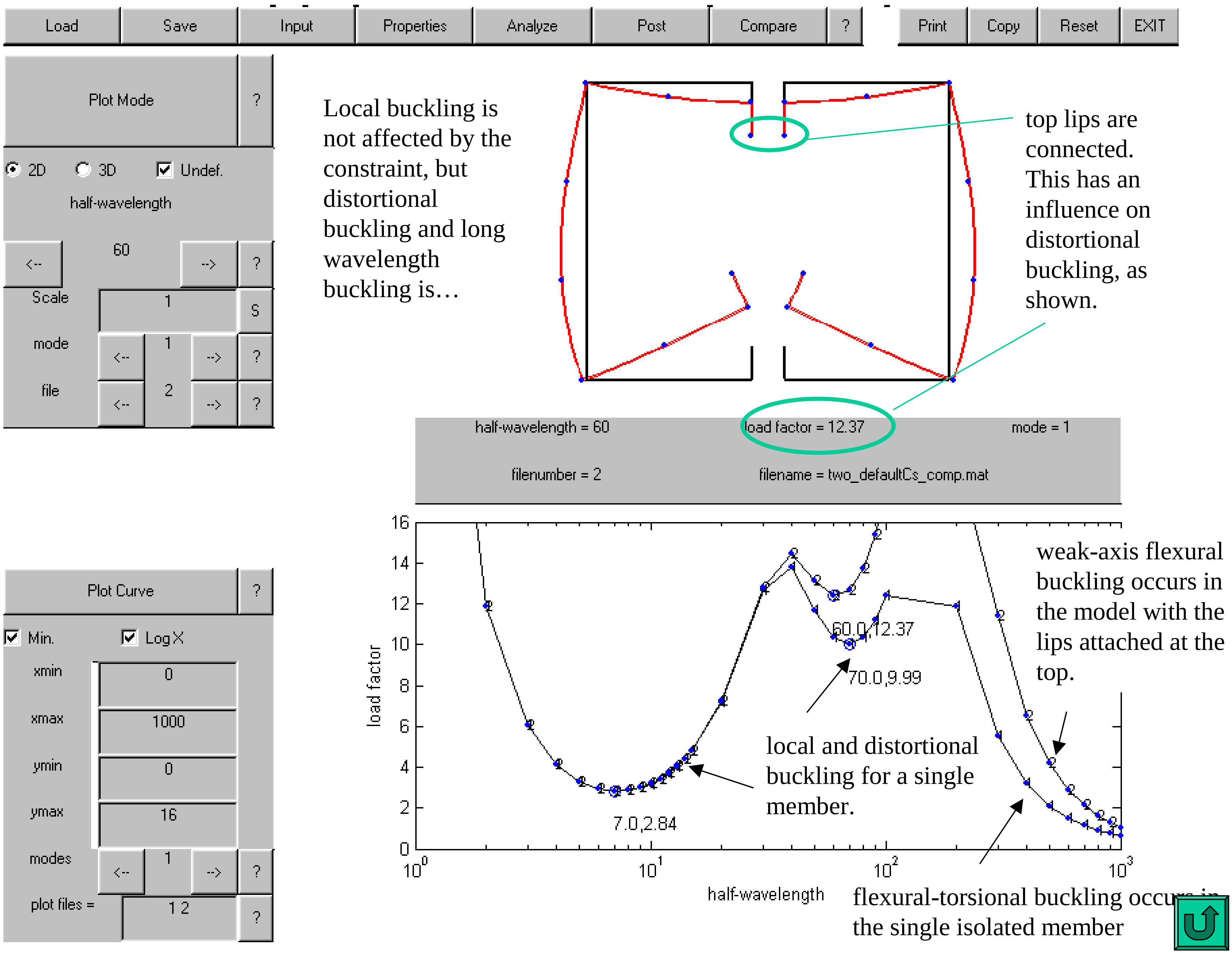
Two members are placed toe-to-toe.

Geometry is the default Cee section in CUFSM. The loading is pure compression.

In this example only the top lips are connected, say for example because of an unusual access situation.

Equation constraints are written, as shown below to force that x, z and q of nodes 10 and 20 are identical.




Load
Save
Input
Properties
Analyze
Post
Compare
?
Print
Copy
Reset
EXIT
Plot Mode
2D
3D
Undef.
half-wavelength
60
Scale
1
mode
1
file
2
Local buckling is not affected by the constraint, but distortional buckling and long wavelength buckling is…
top lips are connected. This has an influence on distortional buckling, as shown.
half-wavelength = 60
load factor = 12.37
mode = 1
filenumber = 2
filename = two_defaultCs_comp.mat
Plot Curve
Min.
Log X
xmin
0
xmax
1000
ymin
0
ymax
16
modes
1
plot files =
1 2
load factor
half-wavelength
60.0,12.37
70.0,9.99
7.0,2.84
weak-axis flexural buckling occurs in the model with the lips attached at the top.
local and distortional buckling for a single member.
flexural-torsional buckling occurs in the single isolated member

Springs

- External springs may be attached to any node.
- Modeling continuous restraint may use this feature
  - Continuous sheeting attached to a bending member might be considered as springs
  - Sheathing or other materials attached to compression members might be considered as springs
- Springs may be modeled as a constant value, or as varying with the length of the model (i.e. a foundation)

Springs

- How to
- Sheeting attached to a purlin
- Spring verification problem

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties ?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template

Double Elem.

help

Nodes ?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 2.50 0.63 1 1 1 1 -44.76
2 2.39 0.49 1 1 1 1 -45.93
3 2.28 0.36 1 1 1 1 -47.01
4 2.17 0.23 1 1 1 1 -48.09
5 2.06 0.09 1 1 1 1 -49.25
6 2.02 0.05 1 1 1 1 -49.58
7 1.97 0.02 1 1 1 1 -49.83
8 1.91 0.01 1 1 1 1 -49.92
9 1.86 0.00 1 1 1 1 -50.00
10 1.46 0.00 1 1 1 1 -50.00
11 1.06 0.00 1 1 1 1 -50.00

Update Plot

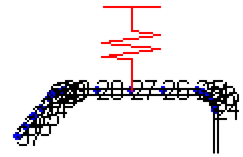
Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements ?

elem# | nodei | nodej | thickness | mat#

1 1 2 0.070000 100
2 2 3 0.070000 100
3 3 4 0.070000 100
4 4 5 0.070000 100
5 5 6 0.070000 100
6 6 7 0.070000 100
7 7 8 0.070000 100
8 8 9 0.070000 100
9 9 10 0.070000 100
10 10 11 0.070000 100



Springs are determined by defining the node where a spring occurs, what degree of freedom the spring acts in, the stiffness of the spring, and whether or not the spring is a constant value (e.g. force/length) or a foundation spring (e.g. (force/length)/length).

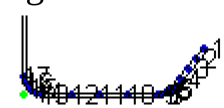
Constant springs use k_{flag}=0, foundations use k_{flag}=1.

You can enter as many springs as you like.

The springs always go to "ground". Therefore they cannot be used to connect two members.

Springs appear in the picture of your model once you define them.

Springs are modeled as providing a continuous contribution along the length.



Lengths ?

1.1 1.4 1.7 2.0 2.4 2.9 3.5 4.2 5.1 6.2 7.4 9.0 10.8 13.1 15.8 19.0 23.0 27.7 33.4 40.3 48.7 58.8 70.9 85.6 103.3 124.6 150.4 181.5 219.0 264.3 319.0 384.9 464.5 560.6 676.5 8

Springs ?

node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

27 2 1.000 1

Constraints ?

node#e | DOFe | coeff. | node#k | DOFk

0

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties ?

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15

C/Z template

Double Elem.

help

Nodes ?

node# | x | z | xdof | zdof | ydof | qdof | stress

1 2.50 0.63 1 1 1 1 -44.76
2 2.39 0.49 1 1 1 1 -45.93
3 2.28 0.36 1 1 1 1 -47.01
4 2.17 0.23 1 1 1 1 -48.09
5 2.06 0.09 1 1 1 1 -49.25
6 2.02 0.05 1 1 1 1 -49.58
7 1.97 0.02 1 1 1 1 -49.83
8 1.91 0.01 1 1 1 1 -49.92
9 1.86 0.00 1 1 1 1 -50.00
10 1.46 0.00 1 1 1 1 -50.00
11 1.06 0.00 1 1 1 1 -50.00

Update Plot

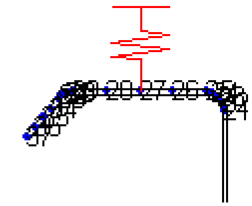
Plot Options:

- [x] node #
- [ ] element #
- [ ] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements ?

elem# | nodei | nodej | thickness | mat#

1 1 2 0.070000 100
2 2 3 0.070000 100
3 3 4 0.070000 100
4 4 5 0.070000 100
5 5 6 0.070000 100
6 6 7 0.070000 100
7 7 8 0.070000 100
8 8 9 0.070000 100
9 9 10 0.070000 100
10 10 11 0.070000 100



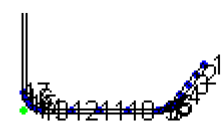
Purlin with a sheeting "spring" example

Use the LGSI Z 12 x 2.5 14g model from Tutorial 3

The applied bending stress is restrained bending about the geometric axis with f_y=50 ksi. (first yield is in tension in this model as the flange widths are slightly different sizes)

Assume a spring of k = 1.0 (kip/in.)/in. exists in the vertical direction at mid-width of the compression flange. (Ignore, in this case, rotational stiffness contributions from the sheeting, etc.)

See Springs below for the definition of the vertical spring.



Lengths ?

1.1 1.4 1.7 2.0 2.4 2.9 3.5 4.2 5.1 6.2 7.4 9.0 10.8 13.1 15.8 19.0 23.0 27.7 33.4 40.3 48.7 58.8 70.9 85.6 103.3 124.6 150.4 181.5 219.0 264.3 319.0 384.9 464.5 560.6 676.5 8

Springs ?

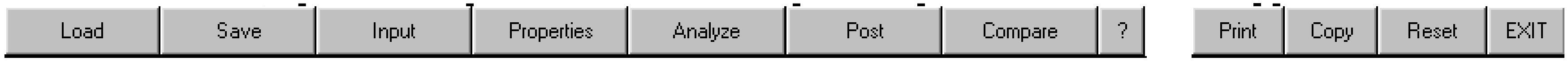
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

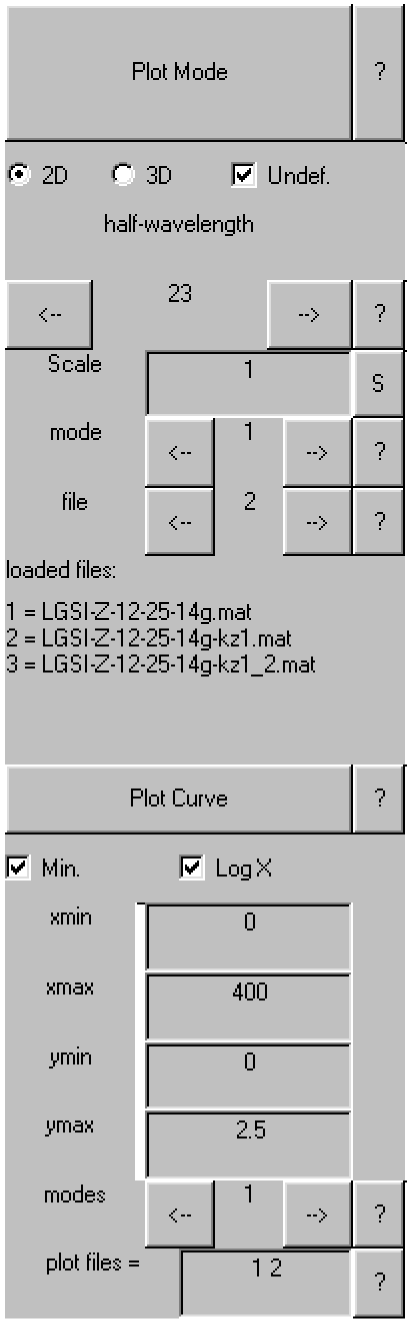
27 2 1.000 1

Constraints ?

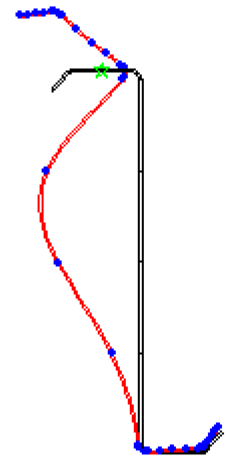
node#e | DOFe | coeff. | node#k | DOFk

0

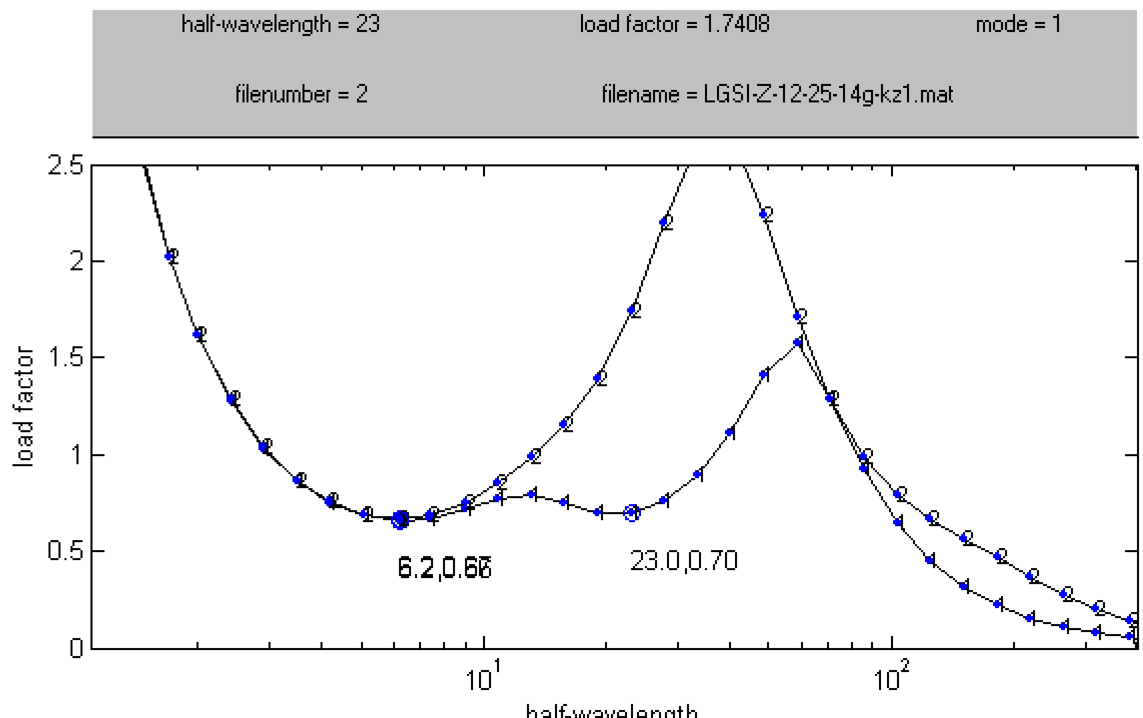




The buckling curve below shows the results of an analysis without the springs (1) and analysis with the spring (2). Note that the spring has greatly increased the distortional buckling stress.

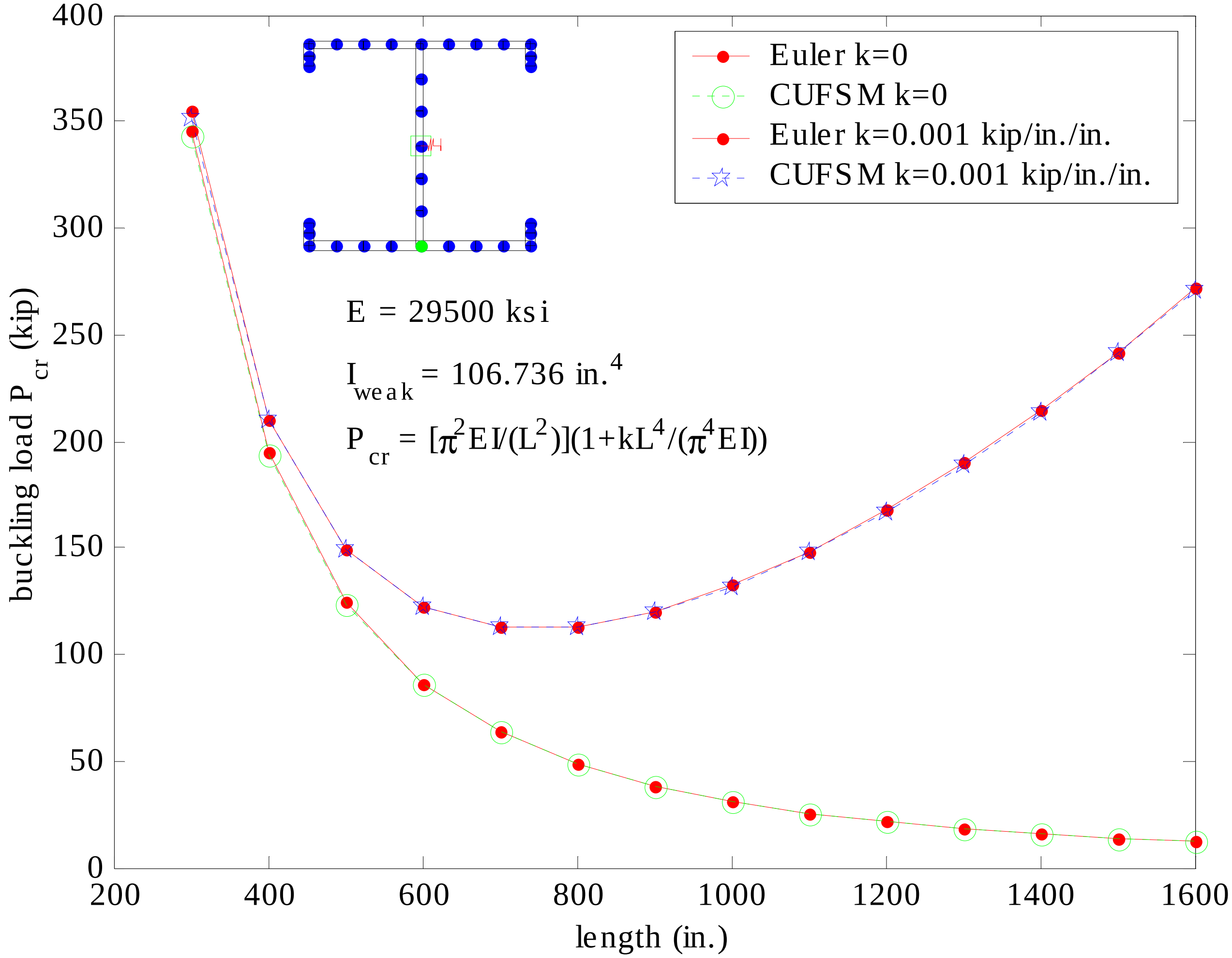


The buckling mode to the left shows distortional buckling with the spring in place. Note, the “star” denotes the existence of the spring in the model.



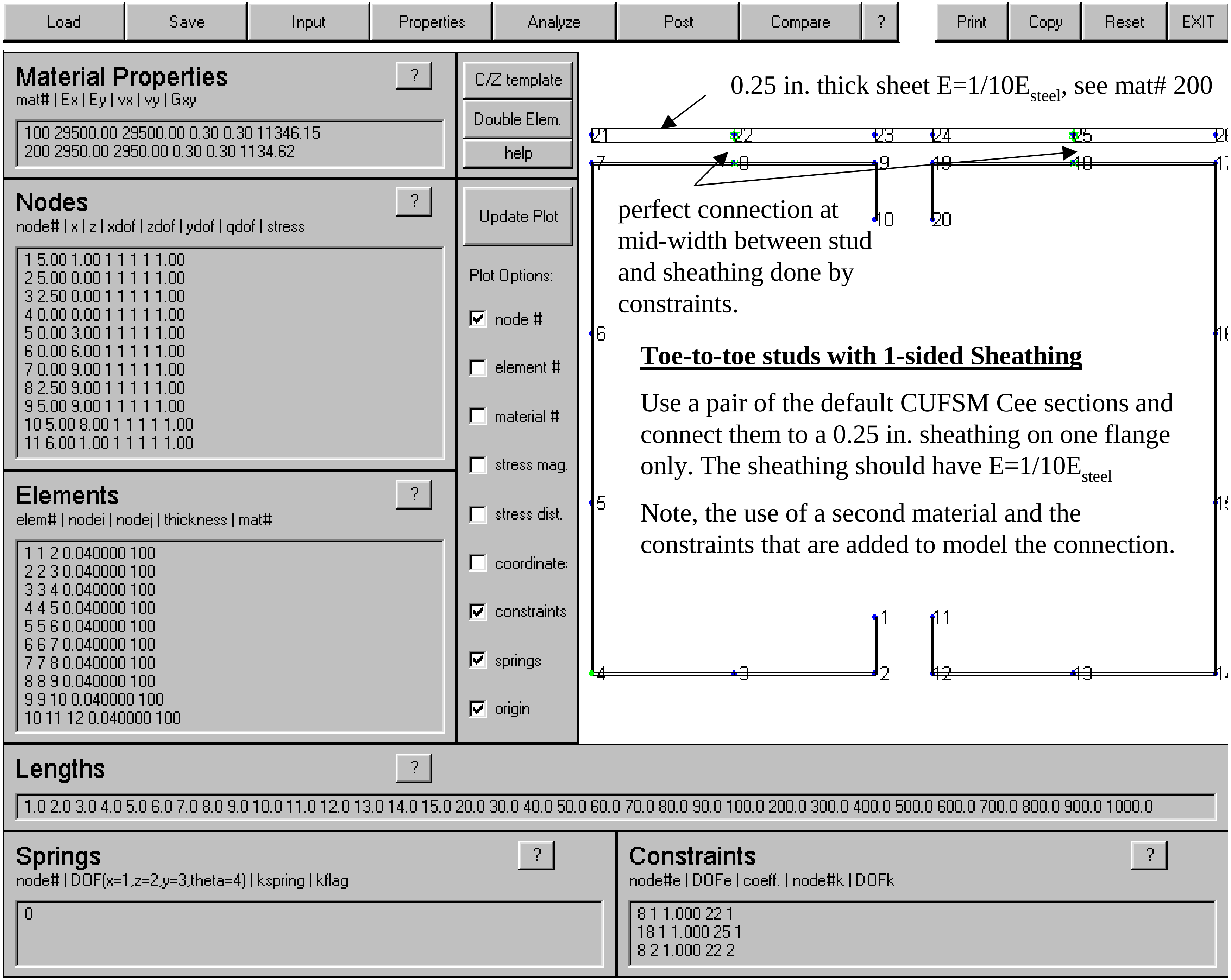
Example for demonstrative purposes only - actual sheeting may have much lower stiffness, and other factors may be considered in the analysis.

Spring verification



Multiple materials

- Multiple materials may be used in a single CUFSM model
- Explicitly modeling attachments that are of different materials may use this feature
- Some unusual geometry changes may be modeled by changing the material properties



Toe-to-toe studs with 1-sided Sheathing

Use a pair of the default CUFSM Cee sections and connect them to a 0.25 in. sheathing on one flange only. The sheathing should have $E=1/10E_{steel}$

Note, the use of a second material and the constraints that are added to model the connection.

Load | Save | Input | Properties | Analyze | Post | Compare | ? | Print | Copy | Reset | EXIT

Material Properties

mat# | Ex | Ey | vx | vy | Gxy

100 29500.00 29500.00 0.30 0.30 11346.15
200 2950.00 2950.00 0.30 0.30 1134.62

C/Z template
Double Elem.
help

Nodes

node# | x | z | xdof | zdof | ydof | qdof | stress

1 5.00 1.00 1 1 1 1 1.00
2 5.00 0.00 1 1 1 1 1.00
3 2.50 0.00 1 1 1 1 1.00
4 0.00 0.00 1 1 1 1 1.00
5 0.00 3.00 1 1 1 1 1.00
6 0.00 6.00 1 1 1 1 1.00
7 0.00 9.00 1 1 1 1 1.00
8 2.50 9.00 1 1 1 1 1.00
9 5.00 9.00 1 1 1 1 1.00
10 5.00 8.00 1 1 1 1 1.00
11 6.00 1.00 1 1 1 1 1.00

Update Plot

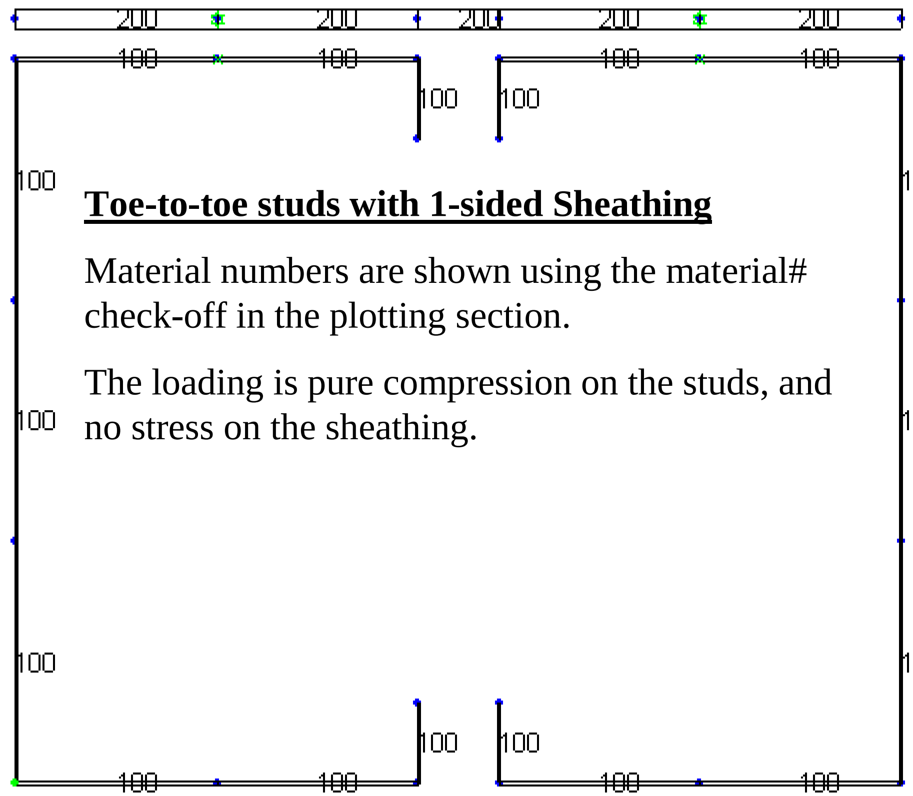
Plot Options:

- [ ] node #
- [ ] element #
- [x] material #
- [ ] stress mag.
- [ ] stress dist.
- [ ] coordinate:
- [x] constraints
- [x] springs
- [x] origin

Elements

elem# | nodei | nodej | thickness | mat#

1 1 2 0.040000 100
2 2 3 0.040000 100
3 3 4 0.040000 100
4 4 5 0.040000 100
5 5 6 0.040000 100
6 6 7 0.040000 100
7 7 8 0.040000 100
8 8 9 0.040000 100
9 9 10 0.040000 100
10 11 12 0.040000 100



Toe-to-toe studs with 1-sided Sheathing

Material numbers are shown using the material# check-off in the plotting section.

The loading is pure compression on the studs, and no stress on the sheathing.

Lengths

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 20.0 30.0 40.0 50.0 60.0 70.0 80.0 90.0 100.0 200.0 300.0 400.0 500.0 600.0 700.0 800.0 900.0 1000.0

Springs

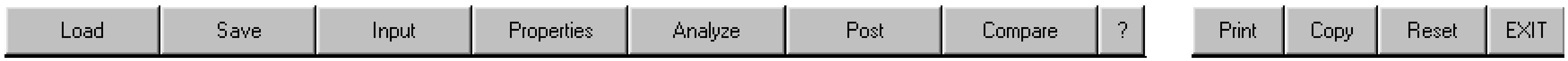
node# | DOF(x=1,z=2,y=3,theta=4) | kspring | kflag

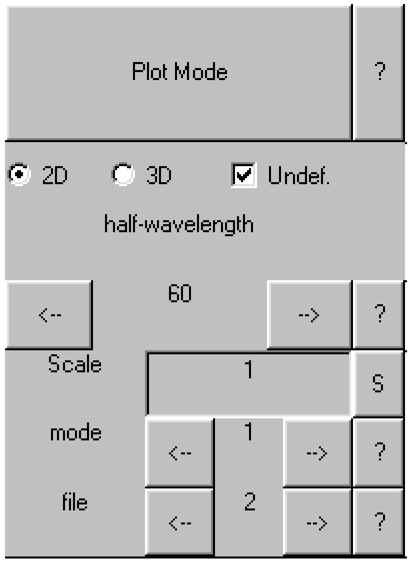
0

Constraints

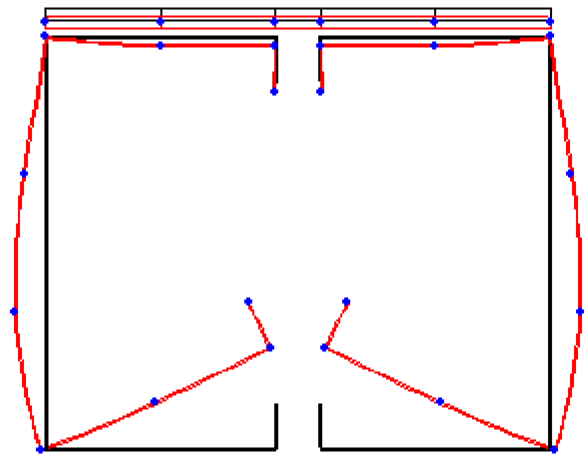
node#e | DOFe | coeff. | node#k | DOFk

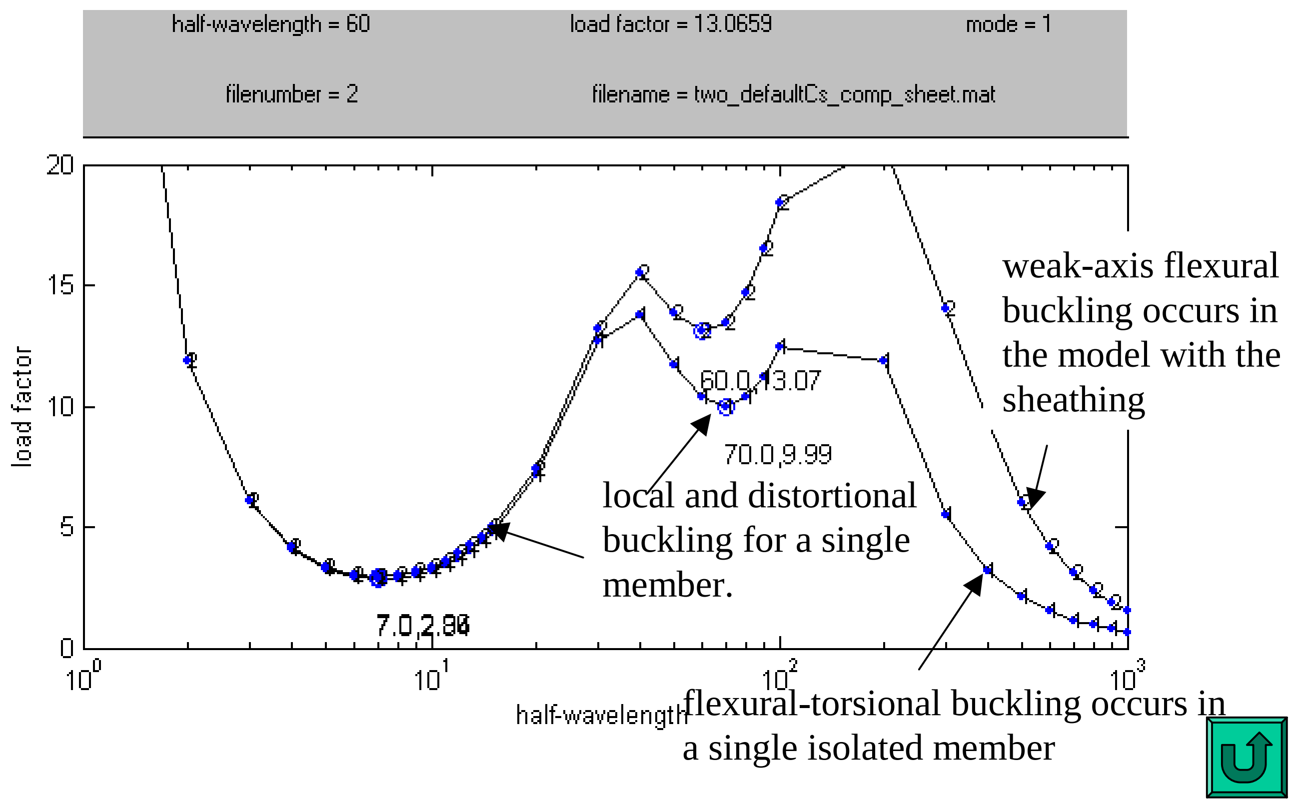
8 1 1.000 22 1
18 1 1.000 25 1
8 2 1.000 22 2

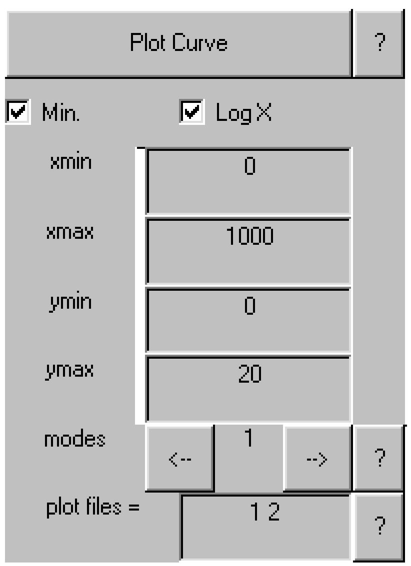




Local buckling is not affected by the sheathing, but distortional buckling and long wavelength buckling is…







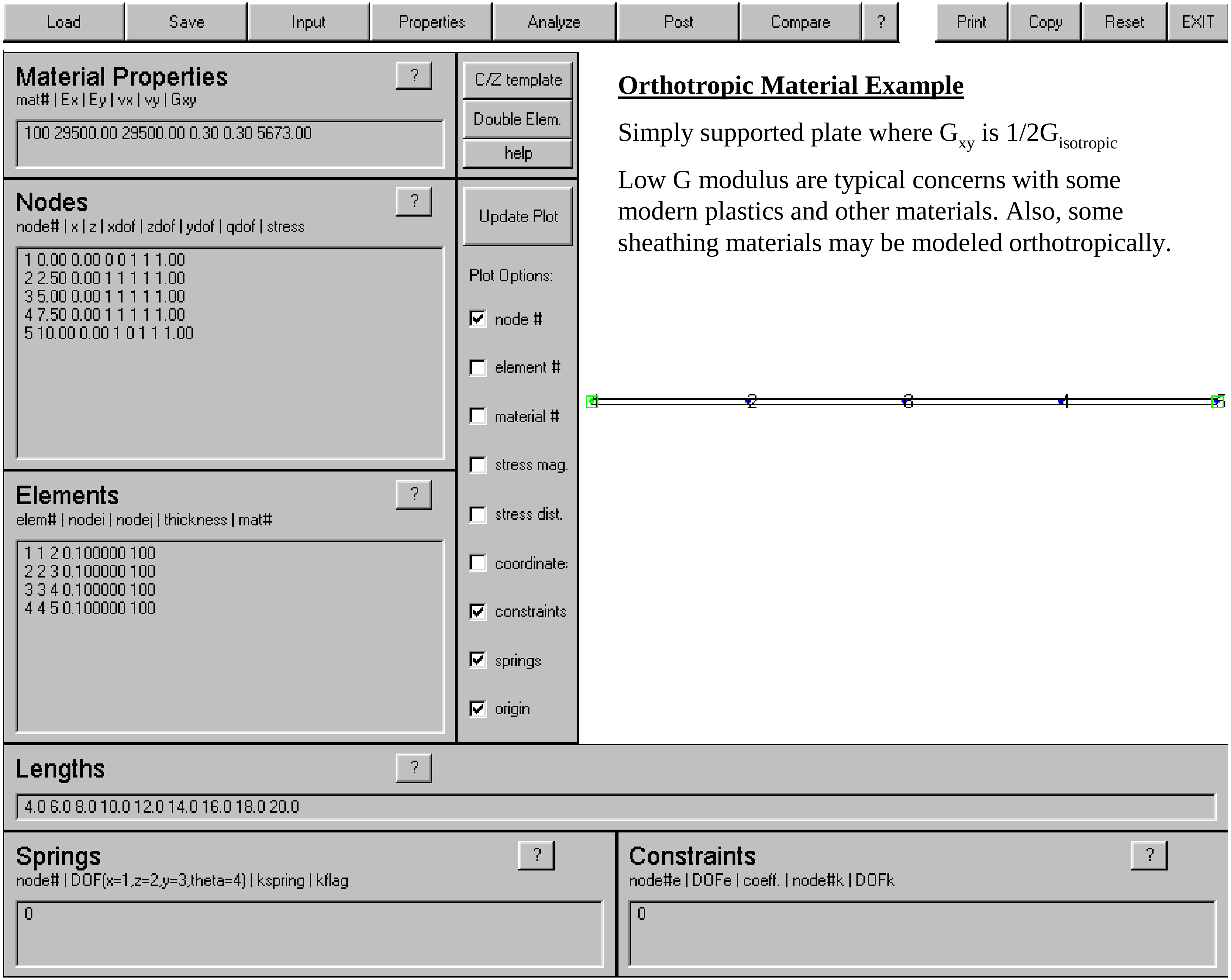
Orthotropic Material

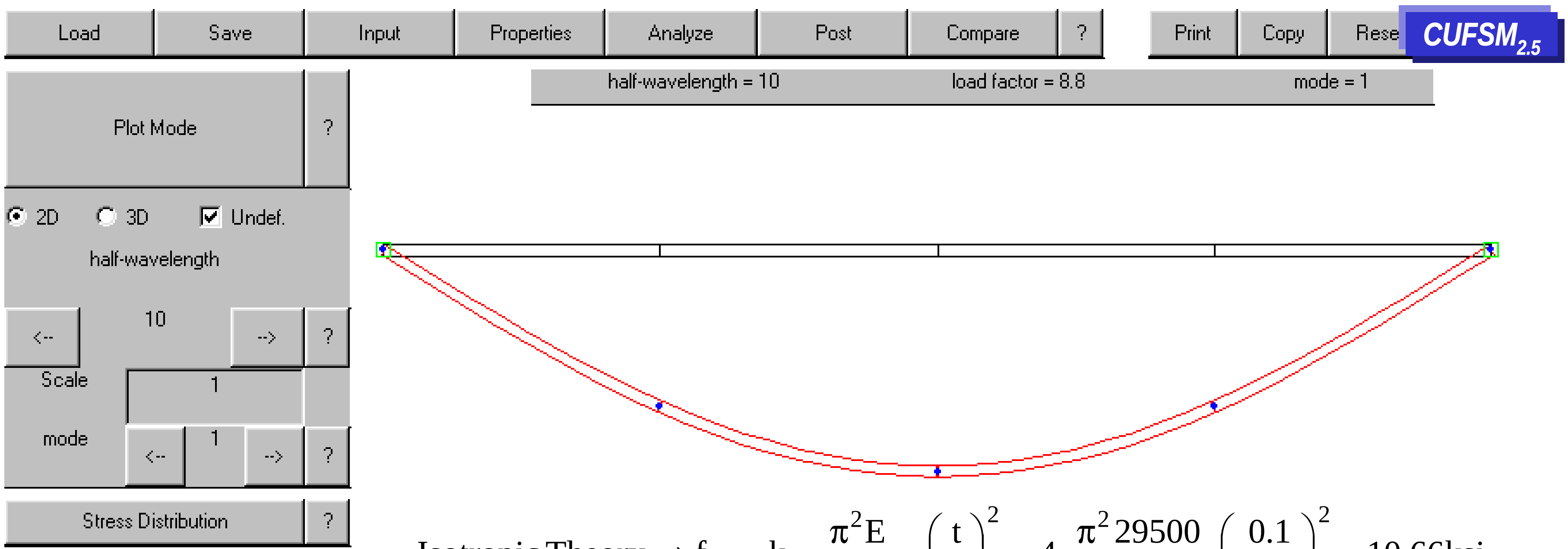
- Orthotropic materials may be used in CUFSM
- Plastics, composites, or highly worked metals may benefit from using this feature

Orthotropic Material Example

Simply supported plate where G_{xy} is $1/2G_{isotropic}$

Low G modulus are typical concerns with some modern plastics and other materials. Also, some sheathing materials may be modeled orthotropically.





$$\text{Isotropic Theory} \rightarrow f_{cr} = k\frac{\pi^2 E}{12(1-\nu^2)}\left(\frac{t}{b}\right)^2 = 4\frac{\pi^2\, 29500}{12(1-0.3^2)}\left(\frac{0.1}{10.0}\right)^2 = 10.66\text{ksi}$$

vs. 8.80 ksi when $G_{xy} = 1/2G_{isotropic}$