2011
Student Competition on Cold-Formed Steel Design
(1st CFS Design Student Competition)

Design Example

Goal

To design a optimal cold-formed steel cross-section shape. The optimal shape shall yield an as high as possible critical elastic buckling load for wavelengths equal to or less than 12 inches when uniform compression stresses are applied.

Given/Assumptions

(1) The cross-section shape shall be a open section.

(2) The total length of the cross section shall be 8.727 inches.

(3) The thickness of the steel is 0.0451 inches.

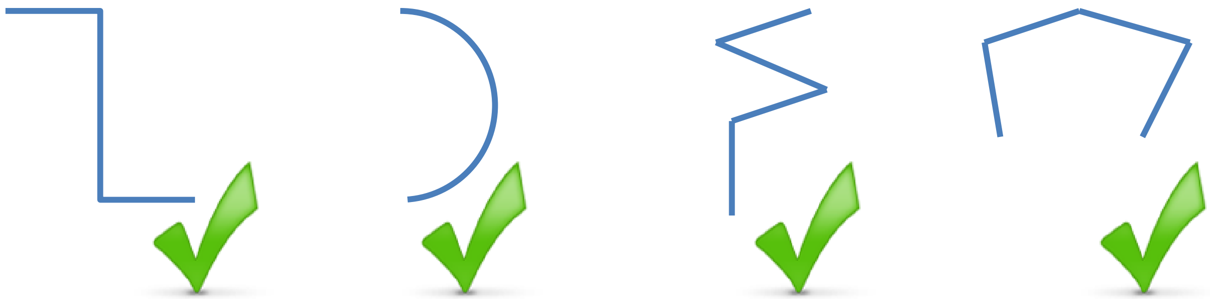
(4) Cold-formed steel properties: Elastic modulus = 29500 ksi, Possion's ratio = 0.3.

(5) Shape corners (zero radius) are assumed.

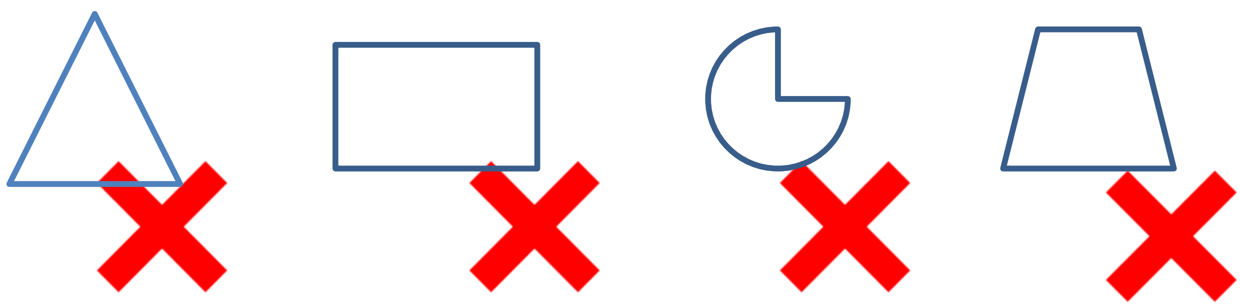
Step 1 – Design the cross-section shape

Basically you are given an 8.727 inches wide flat steel sheet, and you want to fold or bend the sheet to various shapes and pick the best shape which gives the highest possible elastic buckling load for any half-wave lengths up to 12 inches long.

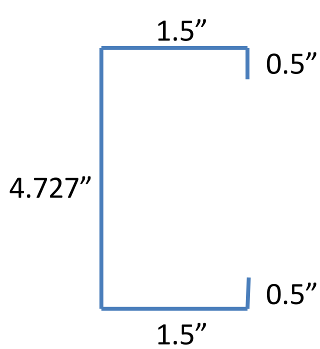
The shape has to be an open section. For example:



The shape cannot be closed sections.



We take a C section shape as an example.

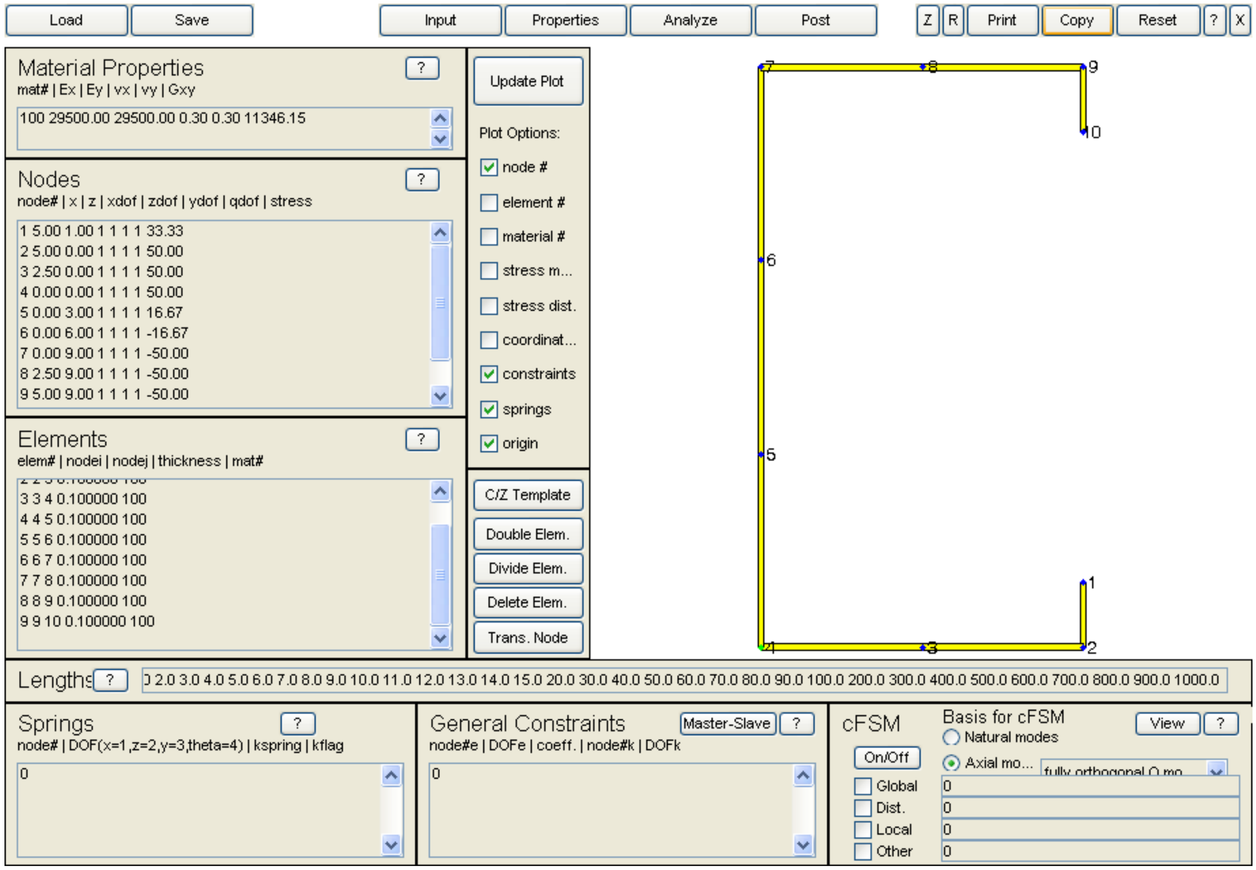


Make sure the total length of the section = 8.727 inches.

Step 2 – Create the cross section model in CUFSM

2.1 Download and open the CUFSM software

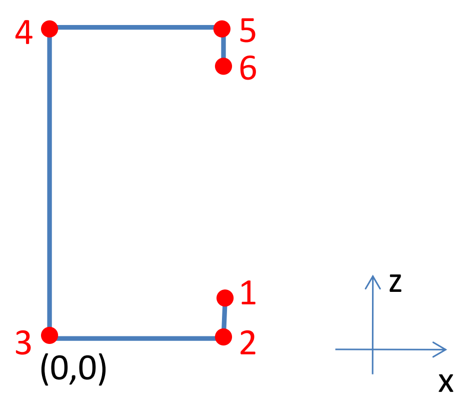
Click "Input" to enter the geometric input modulus.



Note: the default units in CUFSM are inch, kip, and ksi.

2.2 Define the nodes and update the "Nodes" entry

We need to assign nodes to all corners, intersections, and end points. For the C section, we can define 6 nodes and assume the origin of the Z-X coordinate system is at node #3.



According to the required Nodes entry format in CUFSM, the following node entry can be established.

1 1.5 0.5 1 1 1 1 1

2 1.5 0 1 1 1 1 1

3 0 0 1 1 1 1 1

4 0 4.727 1 1 1 1 1

5 1.5 4.727 1 1 1 1 1

6 1.5 4.227 1 1 1 1 1

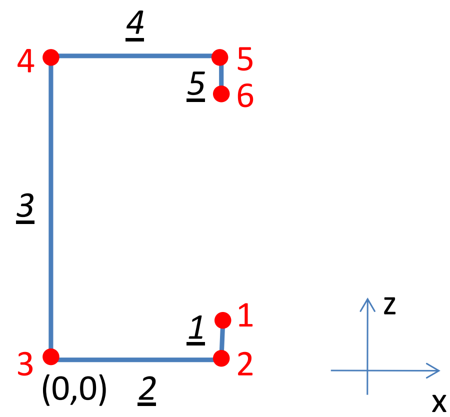
(hint: you only need to specify the node #, x and z coordinates, leave 1 for the rest entries)

2.3 Define the elements and update the "Elements" entry

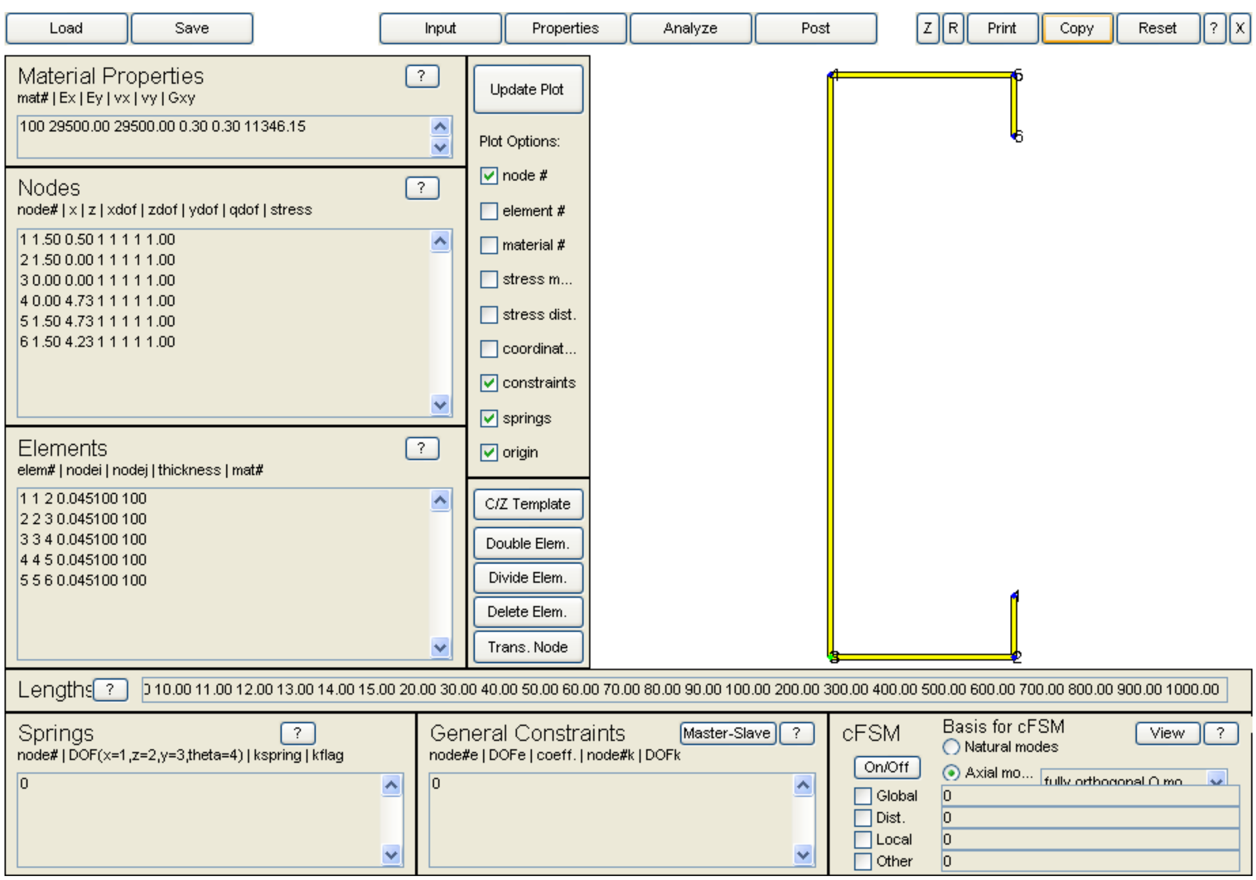
We will need to assign an element # to each flat portion which is defined by two end nodes. According to the format, the element entry can be established as follows

1 1 2 0.0451 100
2 2 3 0.0451 100
3 3 4 0.0451 100
4 4 5 0.0451 100
5 5 6 0.0451 100

(hint: 0.0451 is the steel thickness required by the competition. 100 is the material #, the default material properties in CUFSM are accepted, no change is needed.)

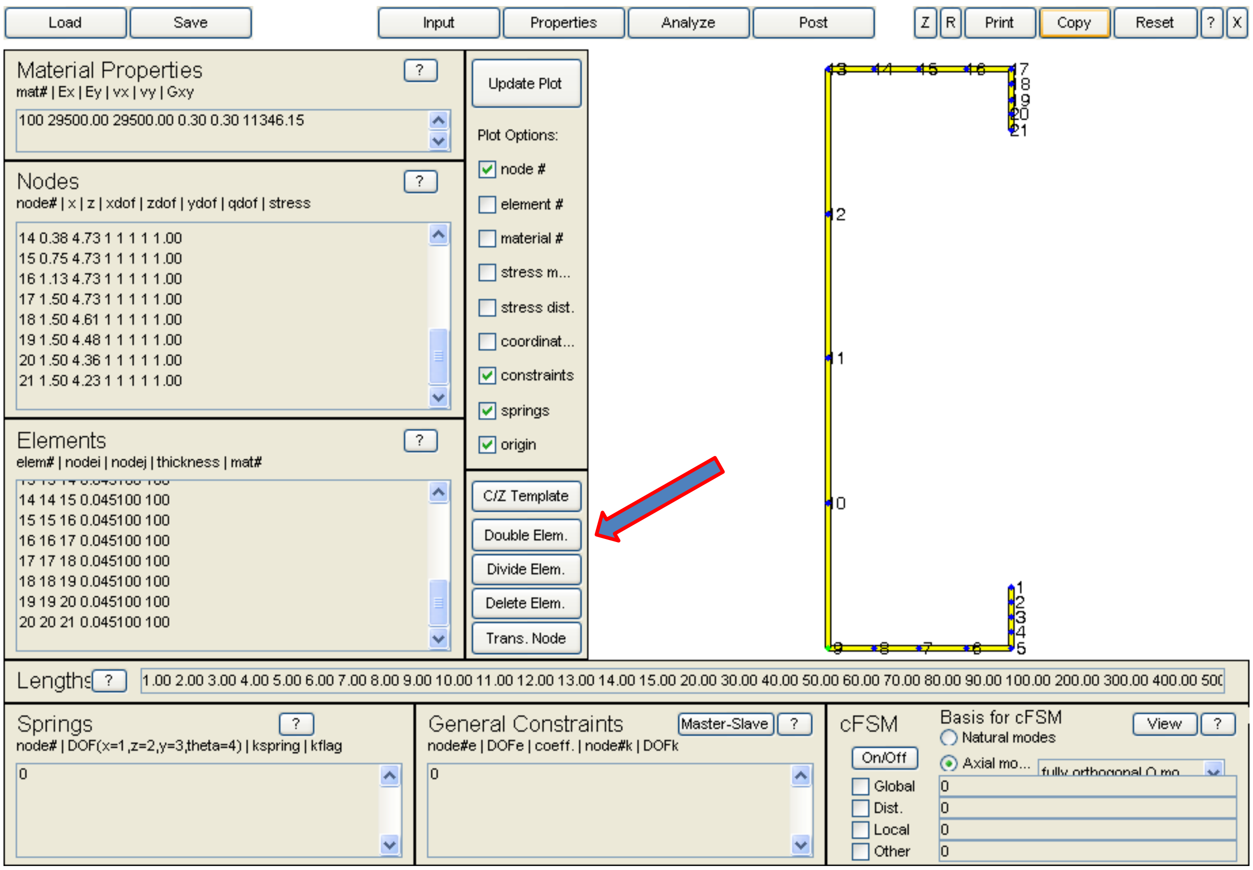


2.4 Update the Nodes and Elements entries in CUFSM and click "Update Plot" button

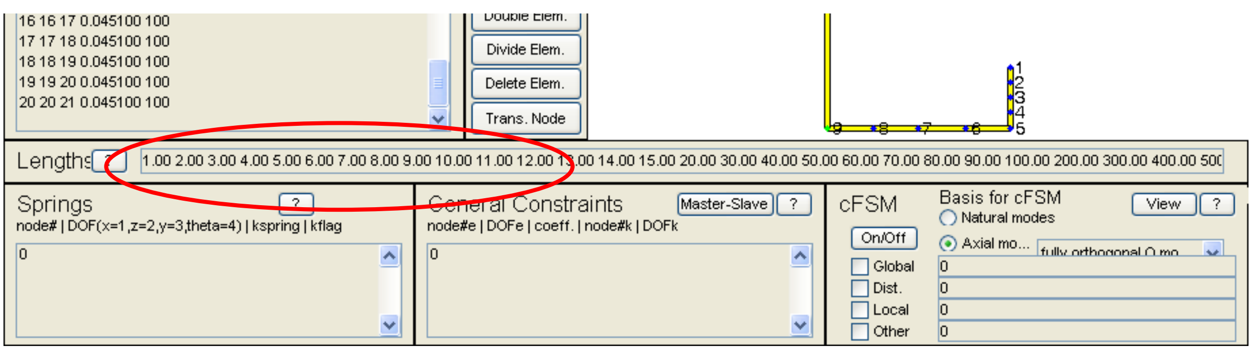


2.5 Increase the element number by keeping clicking “Double Elem.” button.

(hint: more elements may result in accurate results, it is usually adequate to double the elements twice.)



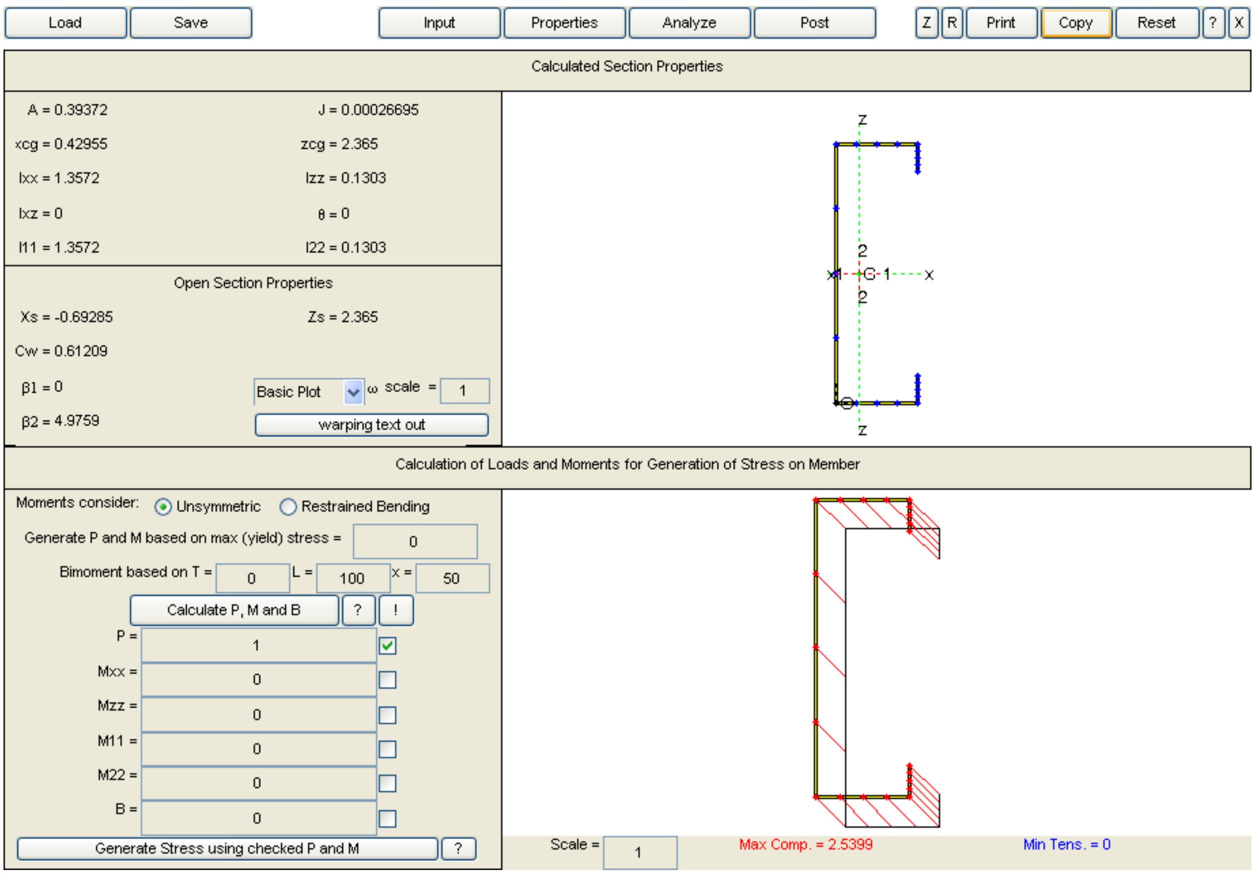
2.6 Check the “Lengths” entry, and make sure number 1 through 12 are included.



Step 3 – Perform elastic buckling analysis in CFUSM

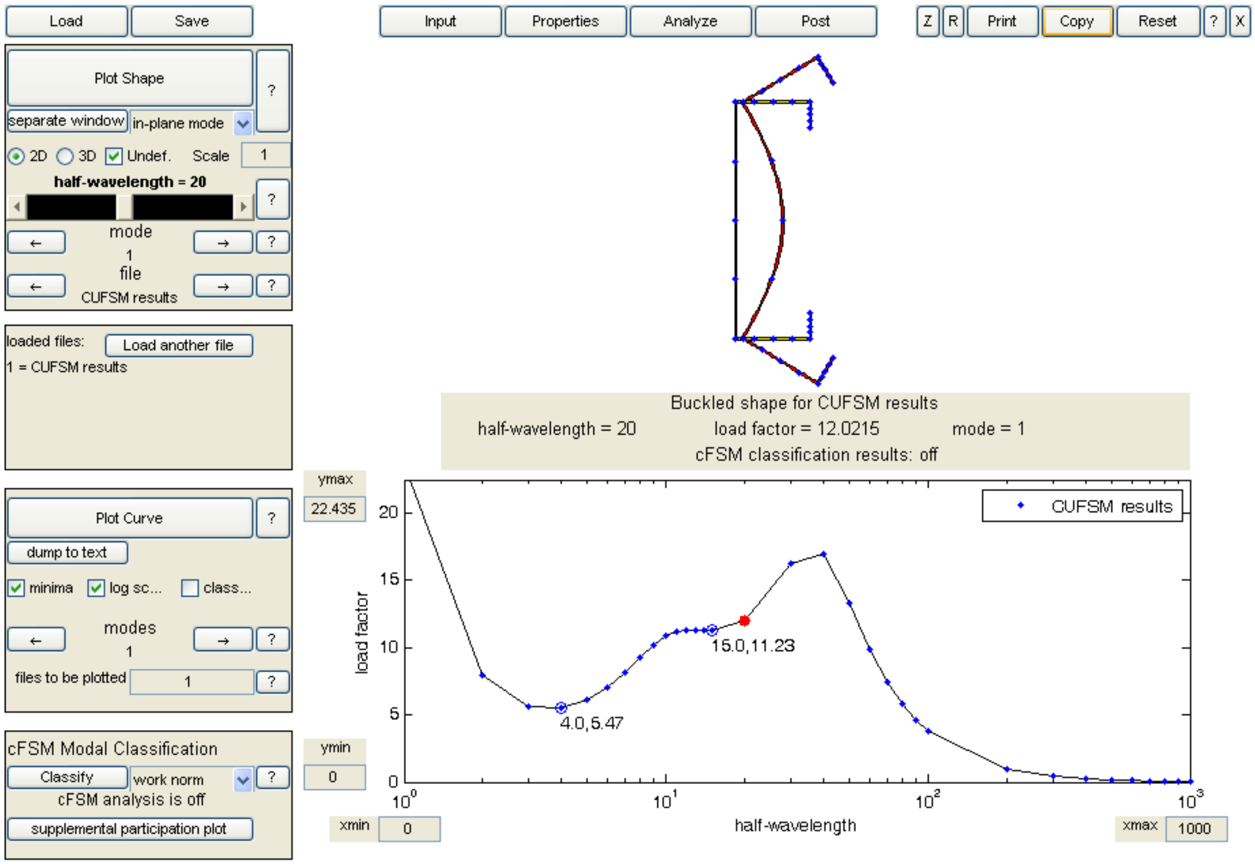
3.1 Click "Properties" to define the compression load

Only check "P" (axial force), and define P =1 (initial uniform load = 1 kip). Then click "Generate Stress using checked P and M" to generate the initial compression stress.



3.2 Click “Analyze” to perform the analysis

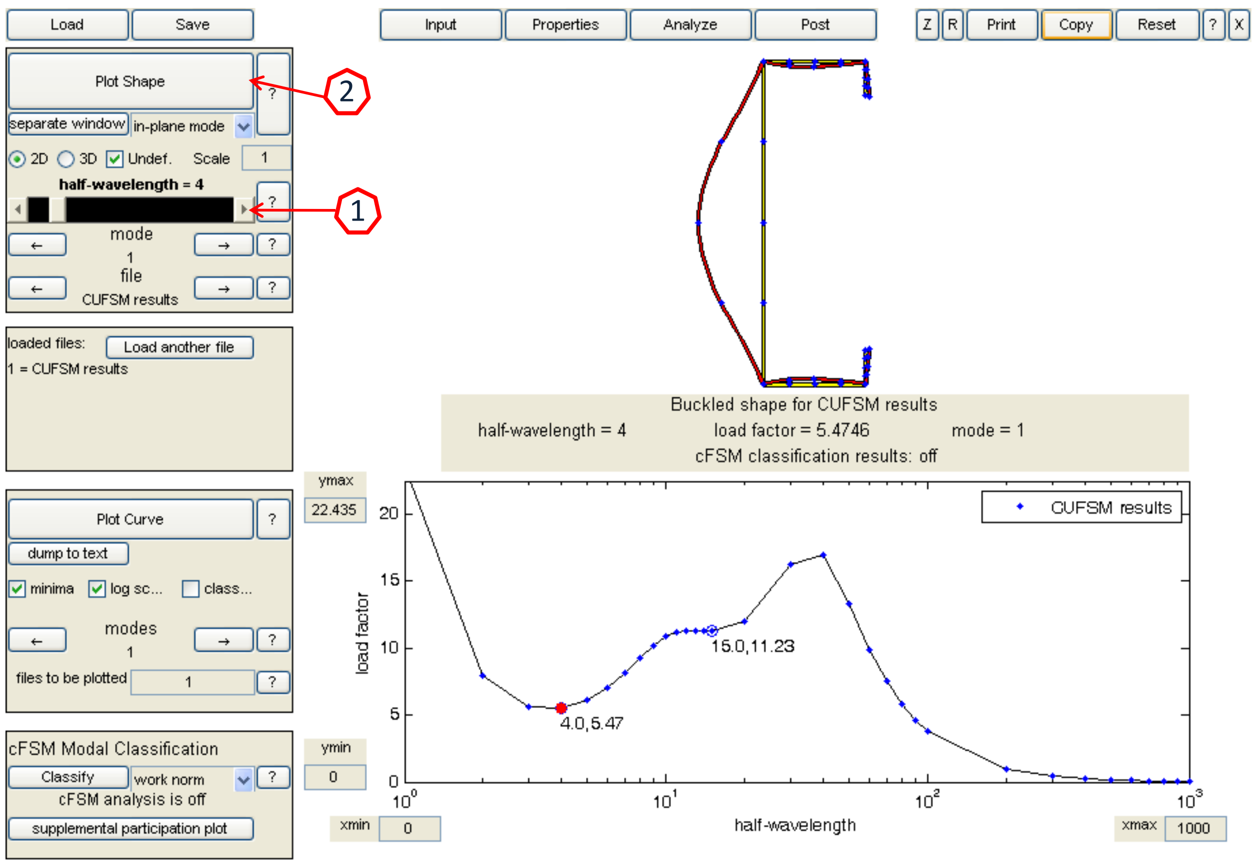
The result figure is automatically shown after the analysis.



Step 4 – Determine the critical elastic buckling load

The goal is to determine the critical elastic buckling load for the half-wavelength up to 12 inches. The result figure gives the elastic buckling load for entire half-wavelength range. We will determine the minimum load factor in the half-wavelength range between 1 and 12 inches.

For the C section, the minimum load factor is at half-wavelength 4 inches. We now need to change the half-wavelength to 4 (mark 1 in the figure below) and update the shape (mark 2 in the figure below).



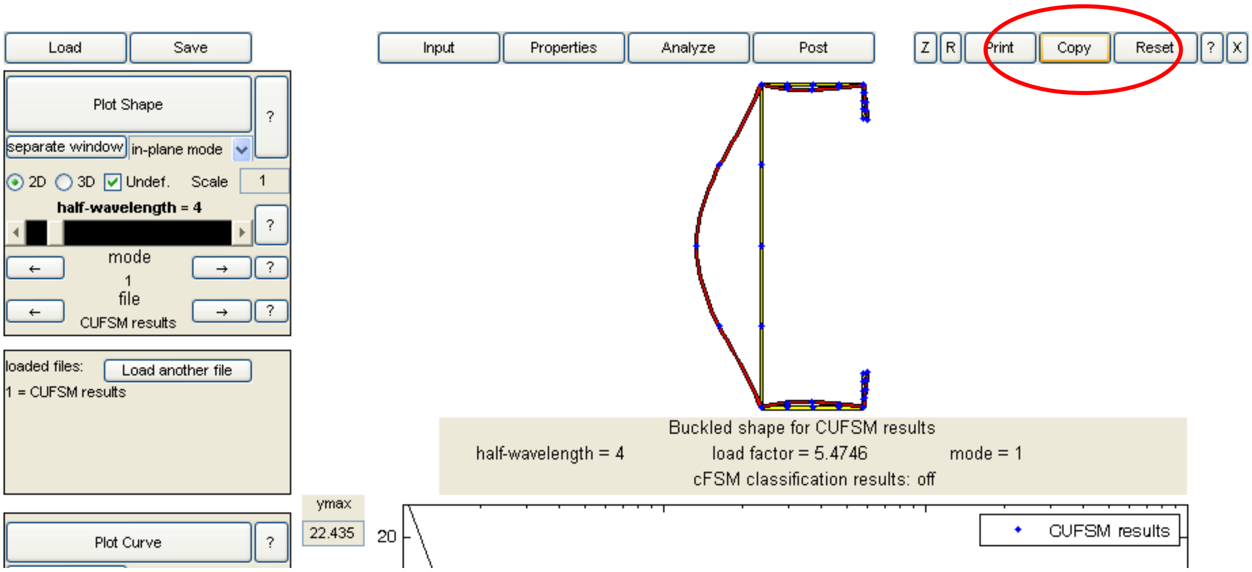
The load factor = 5.4746. Since we gave an initial load P = 1 kip,

the final result = load factor X initial load P = 5.4746 x 1 kip = 5.4746 kip.

The critical elastic buckling load for the C section is **5.4746 kip**.

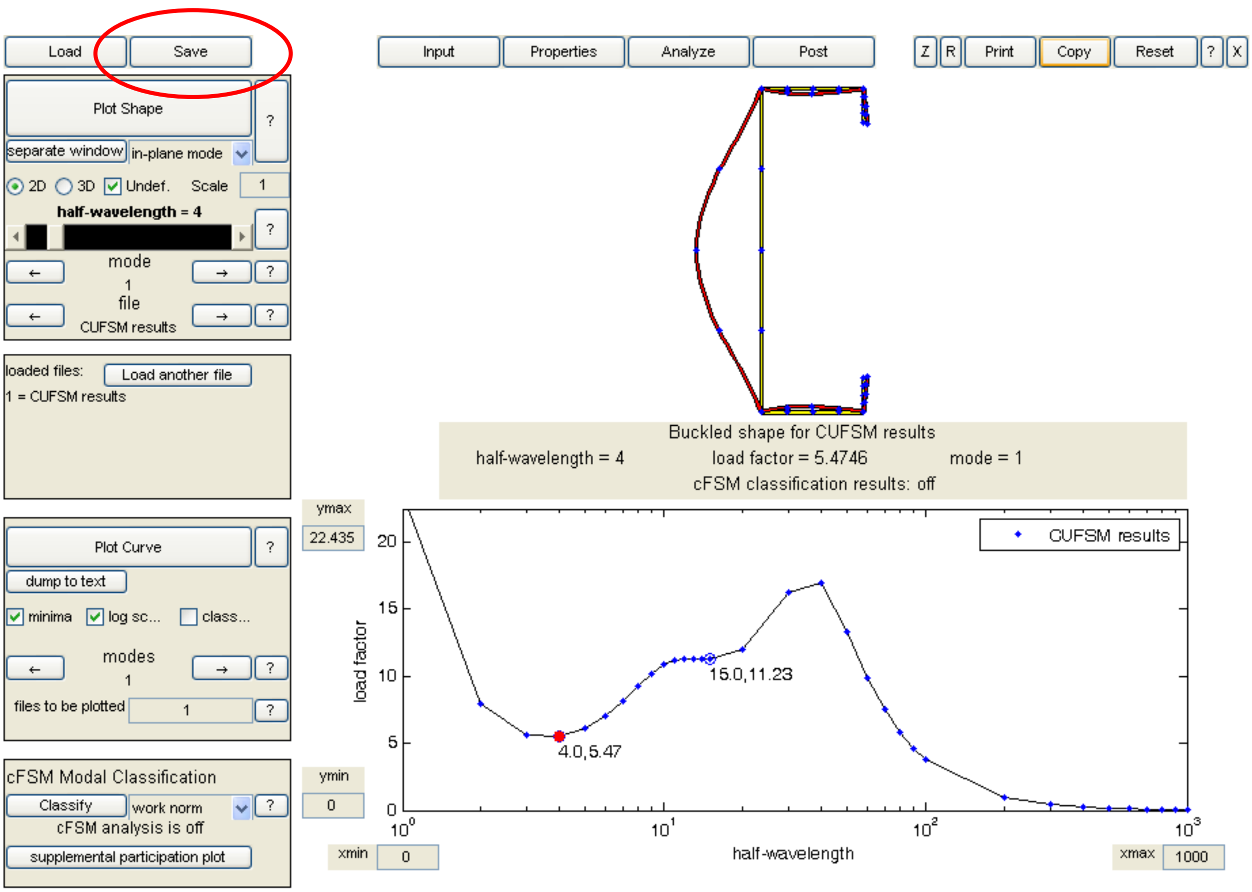
The critical half-wavelength is **4.0 inches**.

(hint: you can click "Copy" button to copy the CUFSM screen to clipboard and paste it to your design essay to show the buckling load and buckling shape)



Step 5 – Save CUFSM result file and start working on the Design Essay

Save the file name as first name _ last name.mat



Step 6 – Fill out the Information Form

2011 STUDENT COMPETITION ON COLD-FORMED STEEL DESIGN

INFORMATION FORM

Student Information

Name: Design Example Email: Example@school.edu

School name: Example School location: Example

Student level: ☐ Graduate ☑ Undergraduate ☐ Other ______

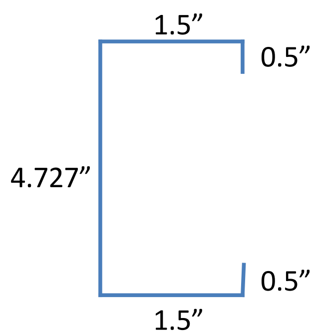
Major: Civil Engineering

Mailing address: Example

(optional) Address for receiving awards

CFS Design Solution

Cross-section shape:



Critical Elastic Buckling Load: 5.4746 kip

Critical half-wavelength: 4.0 inches