HyperSizer NASTRAN Interface Advanced Ringframe Modeling

2008-08-27

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Scope

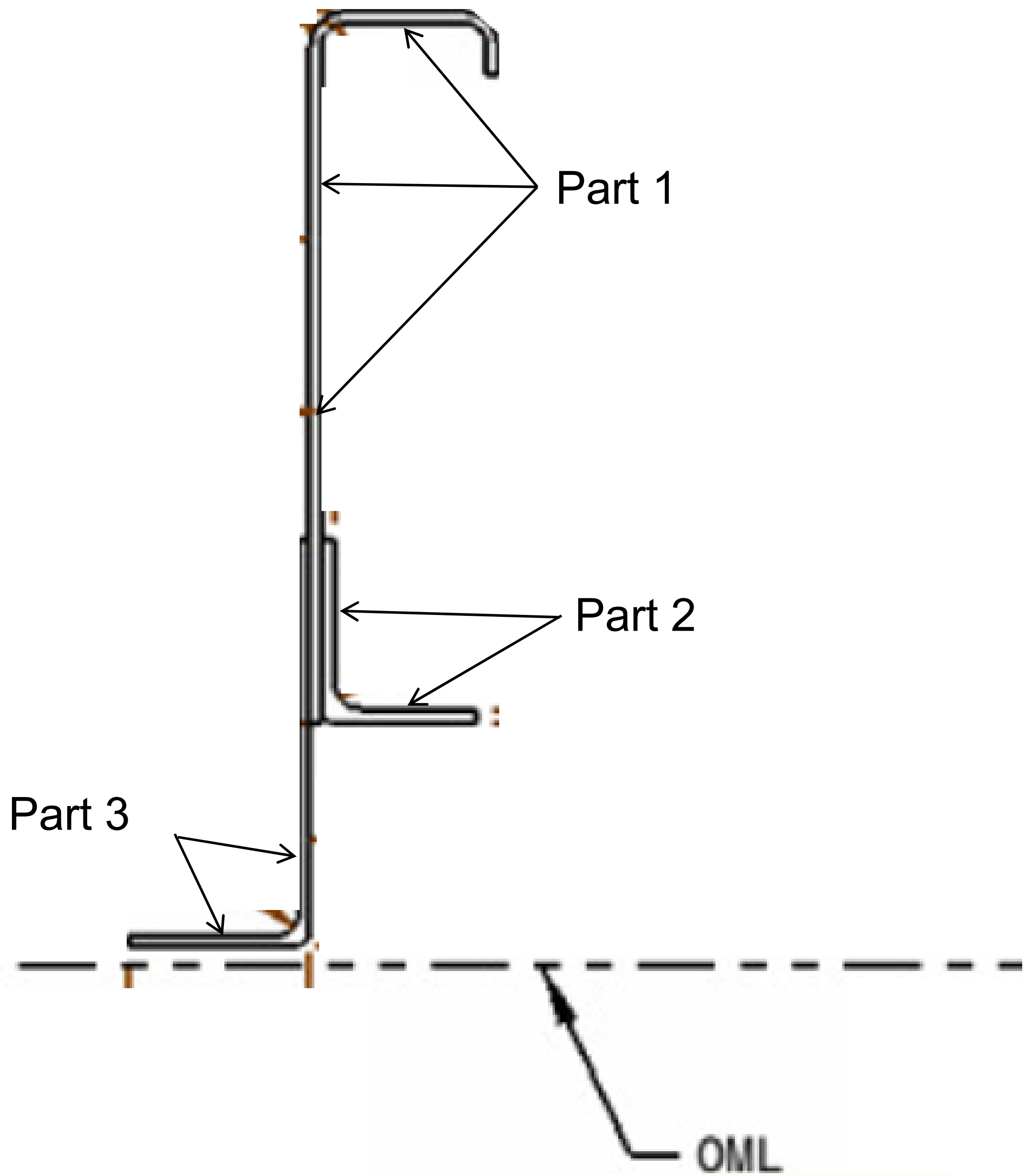
- Semi-Advanced Topic: Meant for "final" sizing for a custom manufactured frame configuration rather than preliminary design. In preliminary design, we recommend single row of CBARs with HyperSizer built-in beam concept
- Two modeling approaches are presented:
  - Option A: Preliminary Sizing: Less detail and accuracy is captured by using fewer elements while the overall sizing is more flexible
  - Option B, Final Sizing: More detail and accuracy of the ringframe is captured using more elements, but less flexibility in the overall sizing
- Some topics covered here are related to FEM modeling of a specialty, custom ringframe and are not specific to HyperSizer
- Complexity of specifying beam orientation, grid ordering, normals, etc. are not specific to HyperSizer. These issues would need to be addressed for any analysis involving FEA.
- See detailed discussion for beam orientation in the HyperSizer Pro User's Manual

Custom Ringframe Example

The example custom ringframe is manufactured as three separate parts:

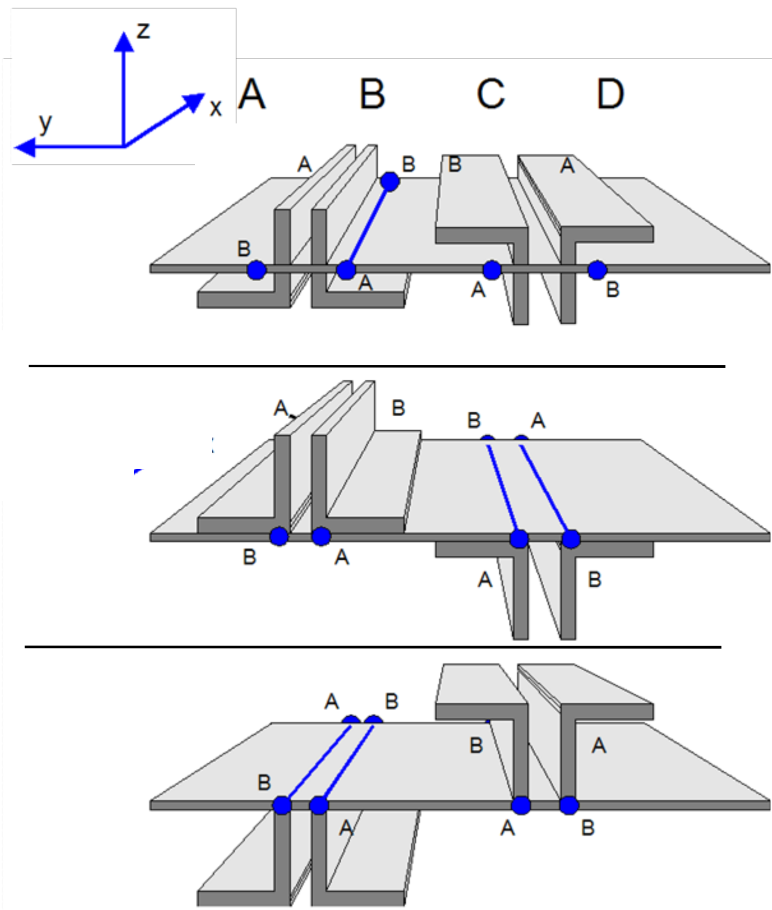
- Part 1 includes the upper web and flange
- Part 2 is called the Angle Chord
- Part 3 is the lower web and flange attached to the panel facesheet.

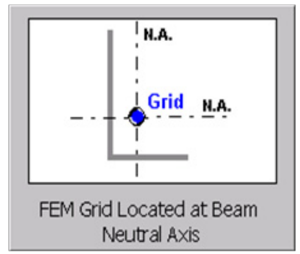
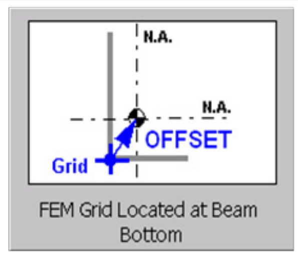
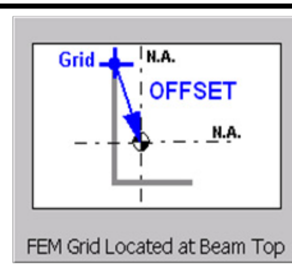
Fastening or Bonding of the individual pieces is not addressed in this document



12 Possible Beam Modeling Orientations

This matrix of possibilities shows the 12 different orientations that an unsymmetric beam such as an "L" can have with respect to a plane of shells sharing the same grids. The appropriate choices to use for the custom ringrfame is covered next.



	NASTRAN/FEMAP					
	Grid Location Button (HyperSizer Options Tab)		X_o	Y_o	Z_o	Grid Ordering
1	 FEM Grid Located at Beam Neutral Axis	**A**	0.0	0.0	1.0	B-A
		B	0.0	0.0	1.0	A-B
		C	0.0	0.0	-1.0	A-B
		D	0.0	0.0	-1.0	B-A
2	 FEM Grid Located at Beam Bottom	**A**	0.0	0.0	1.0	B-A
		B	0.0	0.0	1.0	A-B
		C	0.0	0.0	-1.0	A-B
		D	0.0	0.0	-1.0	B-A
3	 FEM Grid Located at Beam Top	**A**	0.0	0.0	1.0	B-A
		B	0.0	0.0	1.0	A-B
		C	0.0	0.0	-1.0	A-B
		D	0.0	0.0	-1.0	B-A

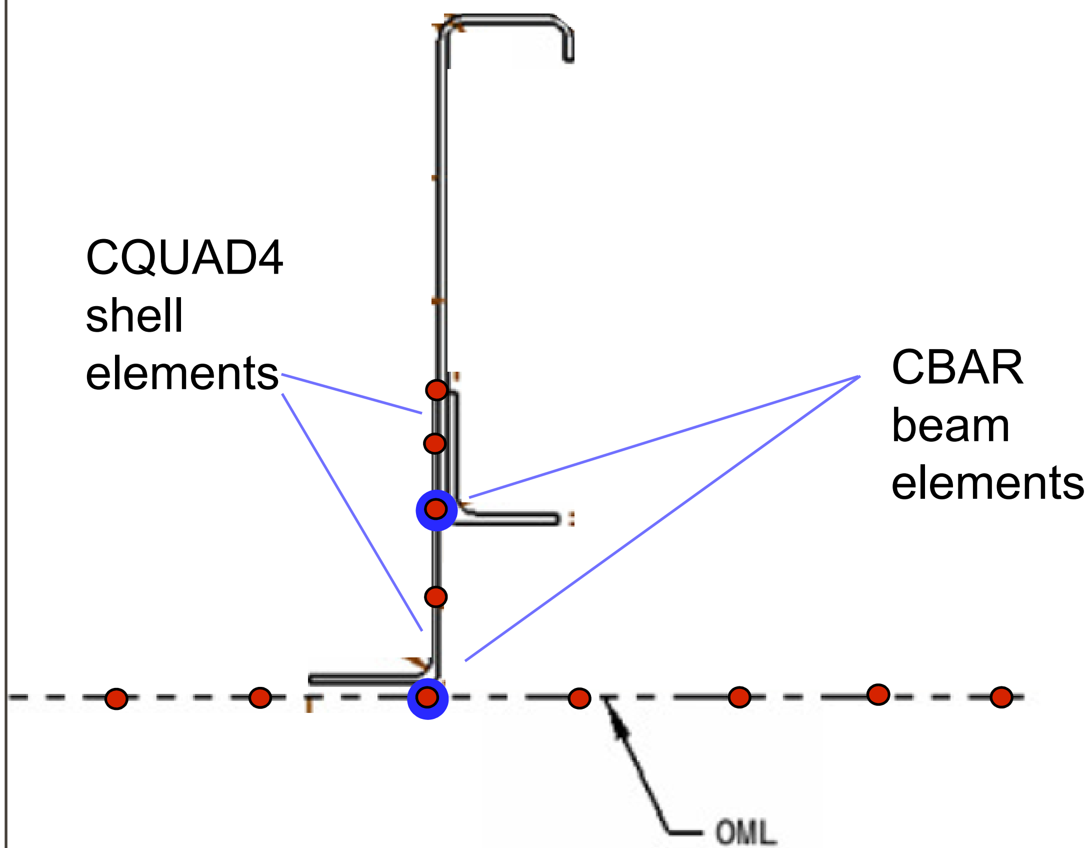
See the HyperSizer Pro User Manual

Modeling Option A: Preliminary Sizing Variables

Less detail and accuracy is captured by using fewer elements while the overall sizing is more flexible

- FEM grids are shown as red circles
- Two beam elements are used to model the flanges, web, and chord as shown with large blue circles
- The number of grids and shell elements used to model the ringframe web and the OML surface is a user decision
- SIZING VARIABLES
  - Only two beam elements are located on fixed grid locations, therefore the overall frame depth is free to optimize.
  - The ringframe web and flange thicknesses, angle, material are also free to optimize.

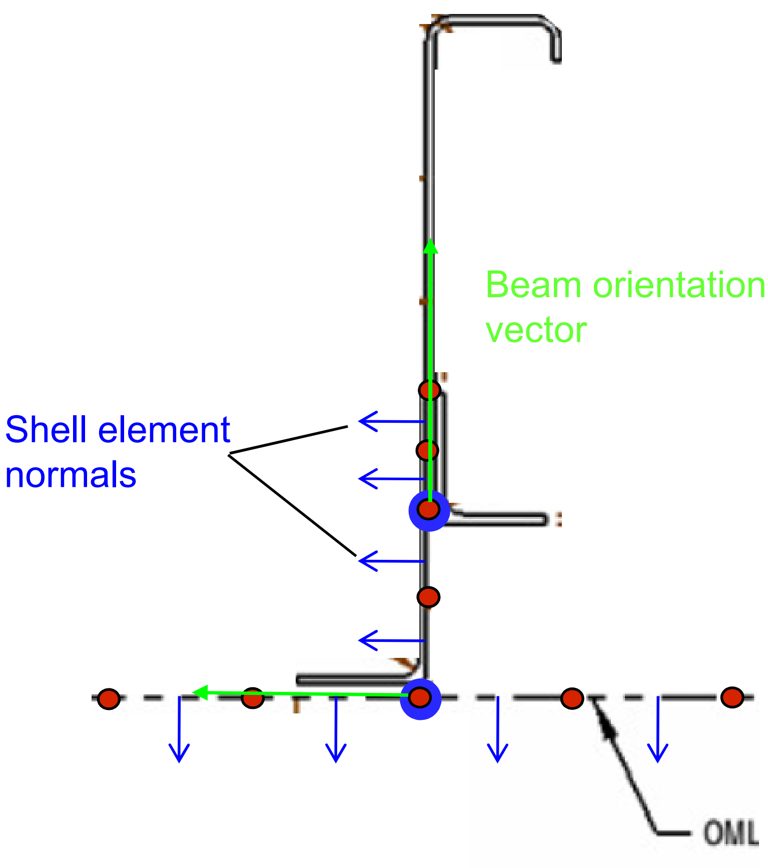
Airframe Ringframe



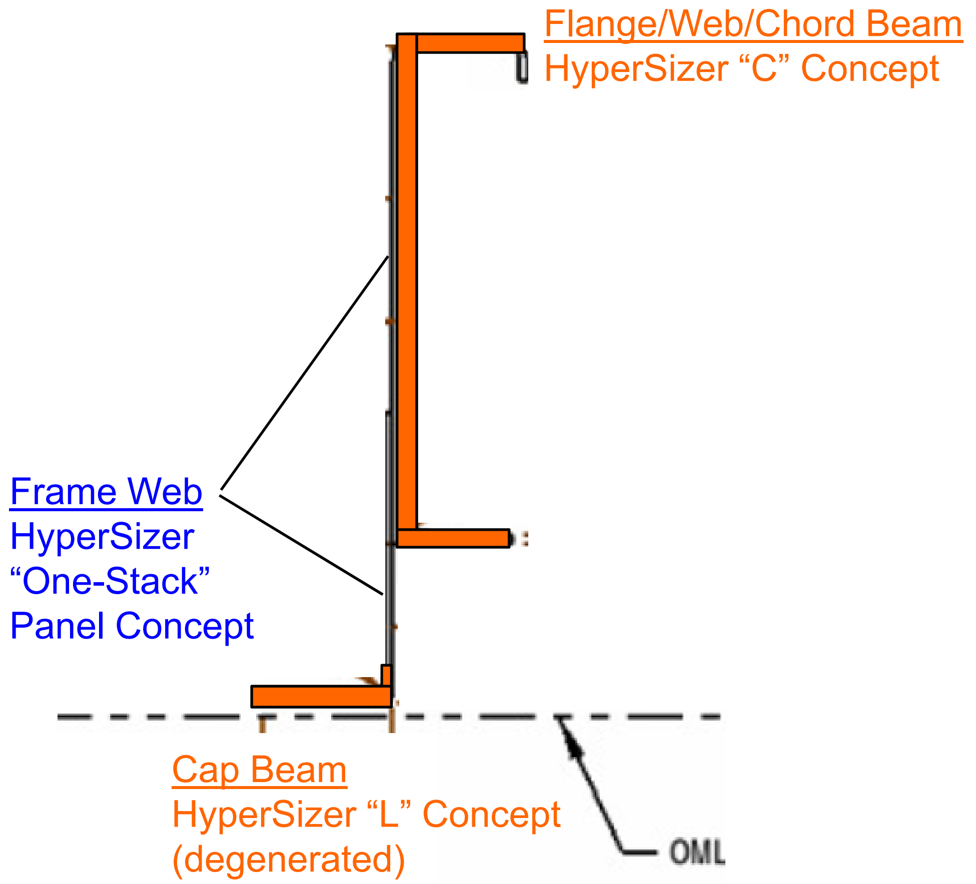
HyperSizer

Modeling Option A: Preliminary Sizing Variables

<u>Grids and Directions</u>



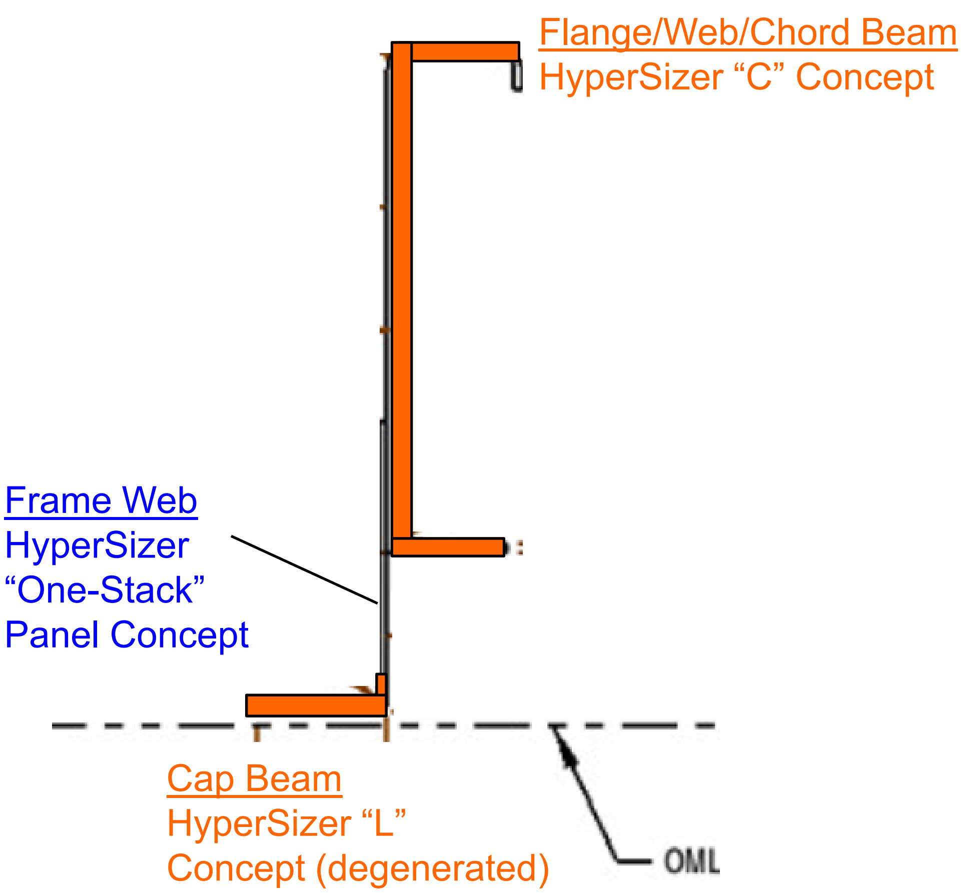
<u>HyperSizer Concepts</u>



Two CBAR beam elements for each cap/flange with different HyperSizer selections for reference plane made on the Sizing Form, Options Tab

12 Available Sizing Variables for the Ringframe, including the overall frame depth

HyperSizer Concepts



Flange/Web/Chord Beam (7 Variables)

- Material
- Height
- Web Thickness
- Upper Flange Width
- Upper Flange Thickness
- Upper Flange Width
- Upper Flange Thickness

Cap Beam (3 Variables)

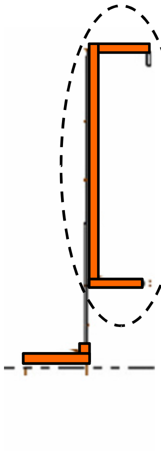
- Material
- Height
- Web Thickness

Frame Web (2 Variables)

- Material
- Web Thickness

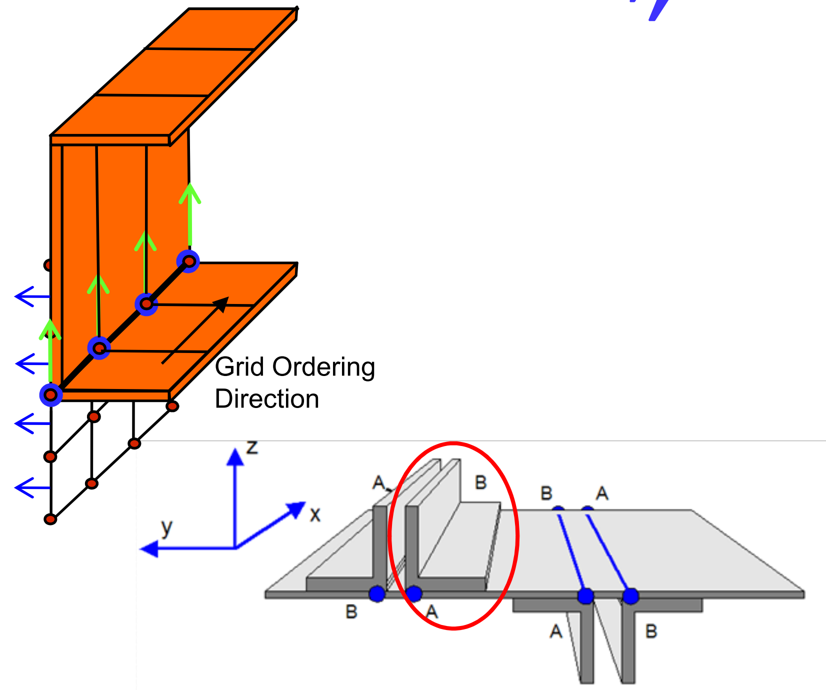
There are 12 available sizing variables. Modeling Option A has the advantage that the overall frame depth (perhaps the critical design variable) can be optimized. The more detailed modeling approach presented later does not expose this variable.

Proper Alignment of the Flange/Web/Chord C Beam



FEM Steps

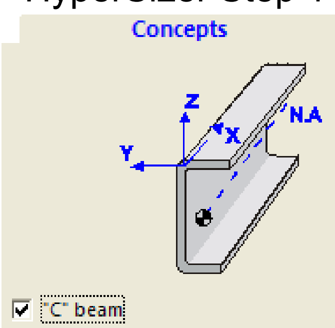
1. Enter the orientation vectors (green arrows) as shown to properly align the z axis of the C-Beam w.r.t. the web shells
2. Order the grids as shown to properly align the right and left orientation of the beam



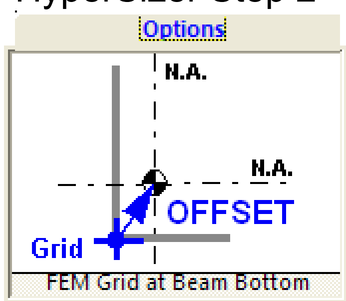
HyperSizer Steps

1. Select “C” Beam on the Concepts Tab and turn all other concepts off
2. Select “FEM Grid at Beam Bottom” on the Options Tab

HyperSizer Step 1



HyperSizer Step 2

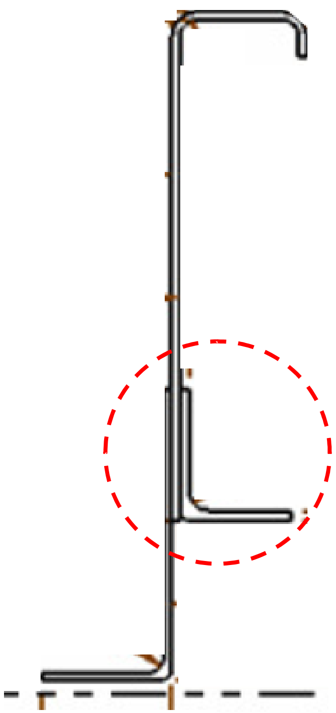


From the Beam Orientation Table, the Flange Beam is orientation number “2-B”

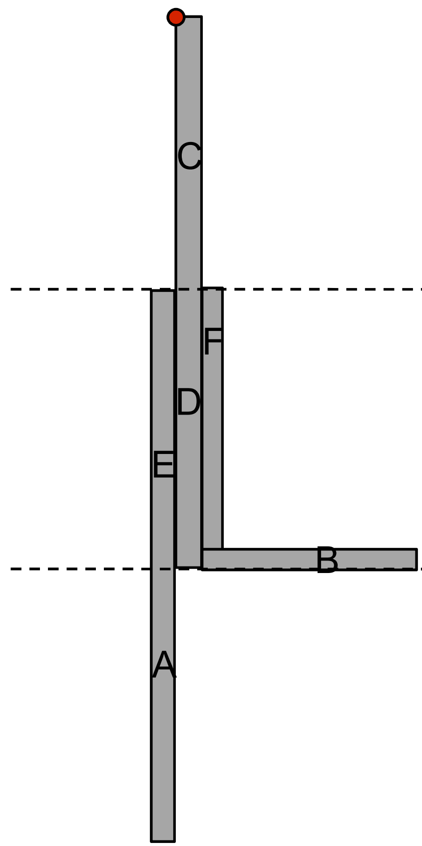
 Custom Ringframe Modeling

Modeling Option A: Angle/Web/Flange Beam (Optional) Accounting for the Web Overlap

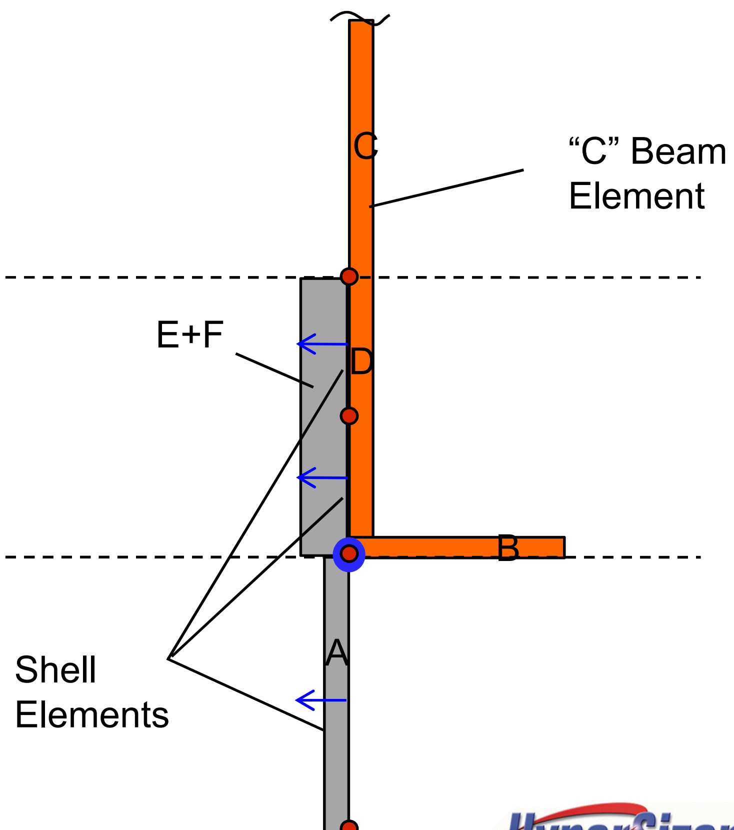
At the preliminary design stage, capturing the overlapping materials may not be critical, however a first stage option for capturing the overlap detail is shown here. The "C" Beam captures the angle and upper web (B-D-C) but leaves the overlap region unaccounted for. The overlap could be modeled by extending the shell elements above the location of the beam element where the element properties account for the overlap (E+F).



Actual Geometry



Modeling Option A

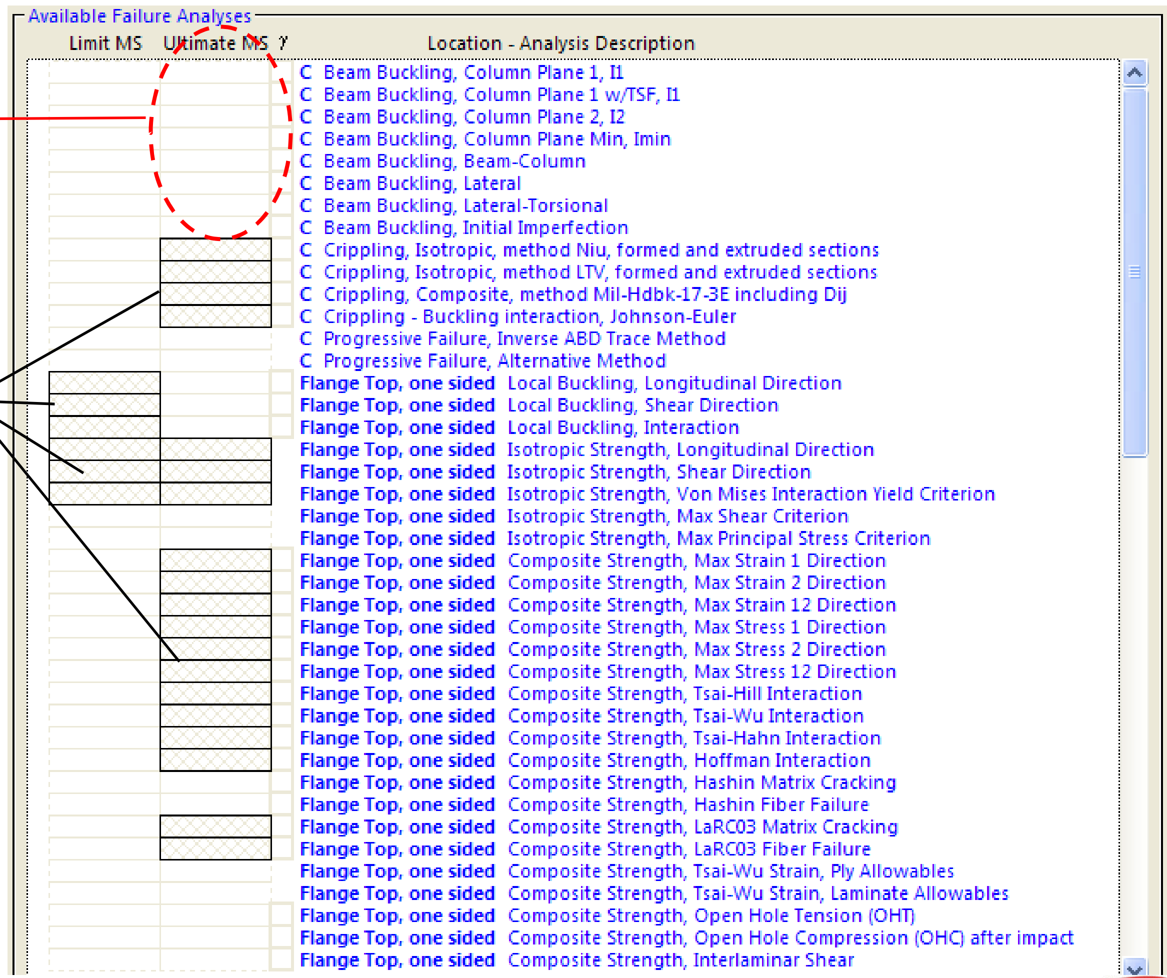


Failure Modes for the Flange/Web/Core C-Beam

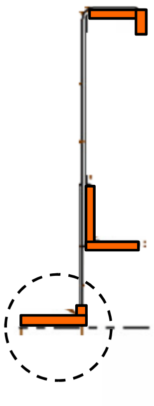
Because the ringframe is not free to column buckle, all column buckling margins of safety should be de-activated on the Failure tab of the Sizing form. However, local buckling, crippling and all strength margins should be included.

1. Turn off all beam buckling failure modes

2. Composite or isotropic strength, local buckling and crippling failure modes should be turned on (shown are the database default values)

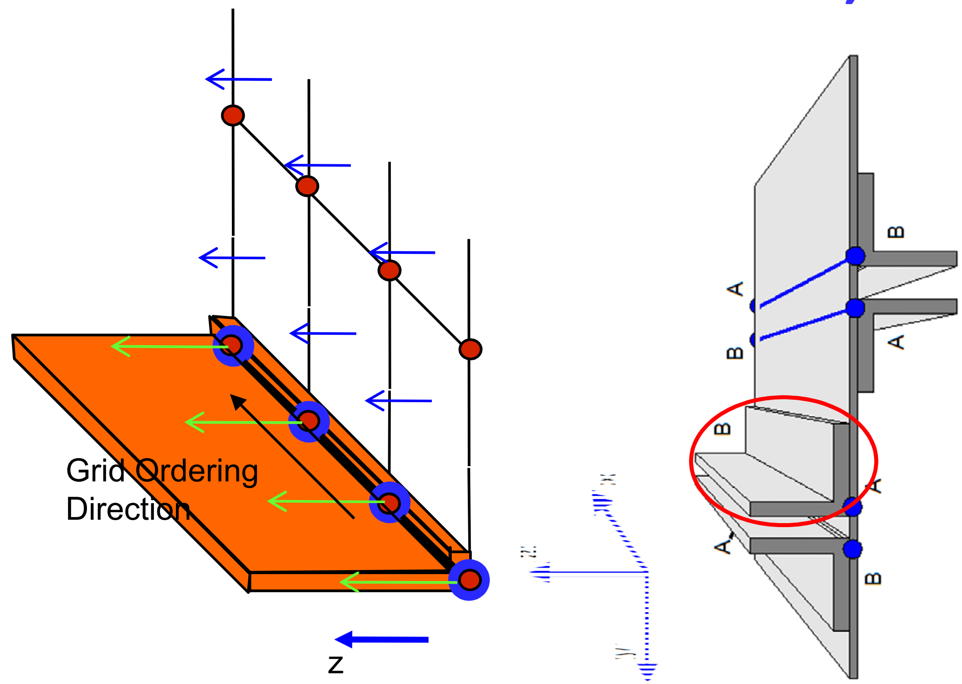


Proper Alignment of the Cap



FEM Steps

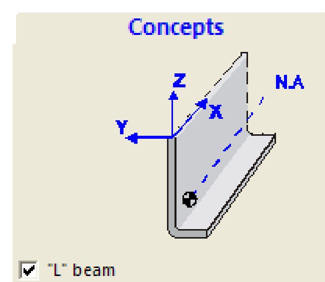
1. Enter the orientation vectors (green arrows) as shown to properly align the z axis of the L-Beam w.r.t. the web shells
2. Order the grids as shown to properly align the right and left orientation of the beam



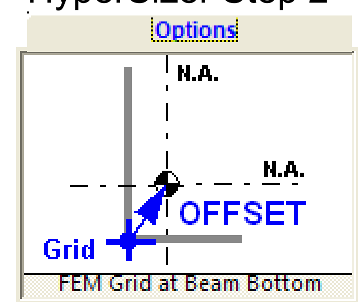
HyperSizer Steps

1. Select "L" Beam on the Concepts Tab and turn all other concepts off
2. Select "FEM Grid at Beam Bottom" on the Options Tab

HyperSizer Step 1



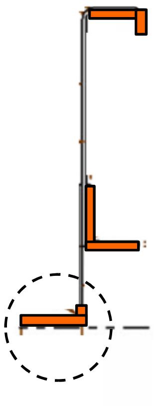
HyperSizer Step 2

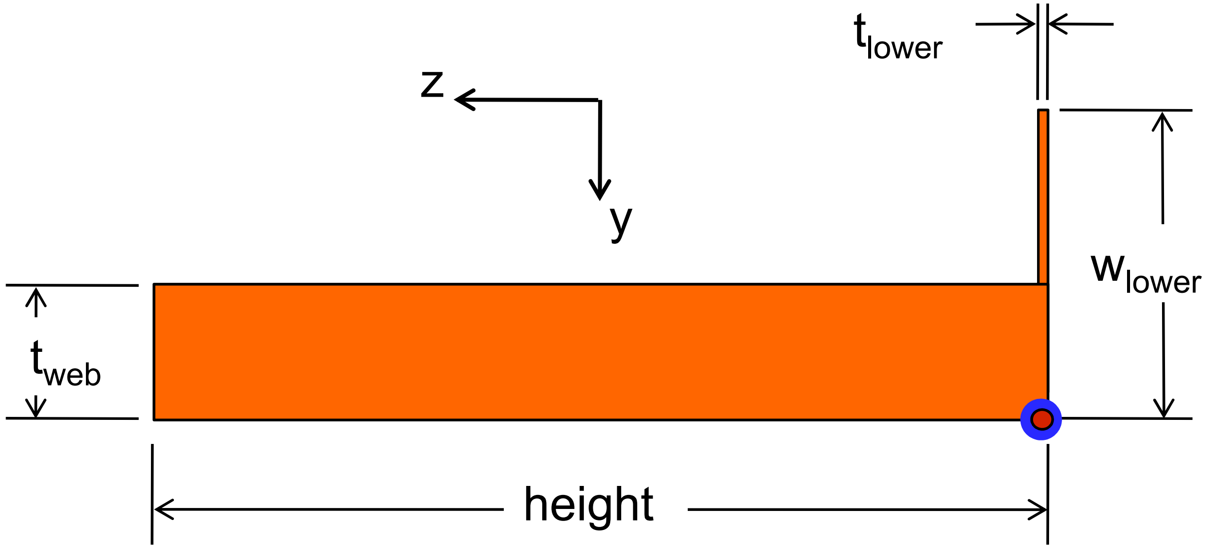


From the Beam Orientation Table, the Flange Beam is orientation number "2-B"

 Custom Ringframe Modeling

Modeling Option A: Cap Beam
Degenerate the L-Beam “Bottom Flange”





The ringframe cap is generated as an L-Beam with a “degenerated” bottom flange. To do this, set the variable w_{lower} (the lower flange width) greater than the highest anticipated web thickness (for example, 0.5"). Then set the lower flange thickness equal to a very small value, say 0.0001". On the Sizing Form | Failure tab, turn off all possible failure analyses associated with this object. These steps will effectively “turn off” the lower flange object.

An alternative to using a degenerated L as shown, would be to use the HyperSizer “Cap Beam” concept. The only drawback to using this concept is that the cap would be centered on the ringframe web, rather than offset to the left as in the actual geometry.

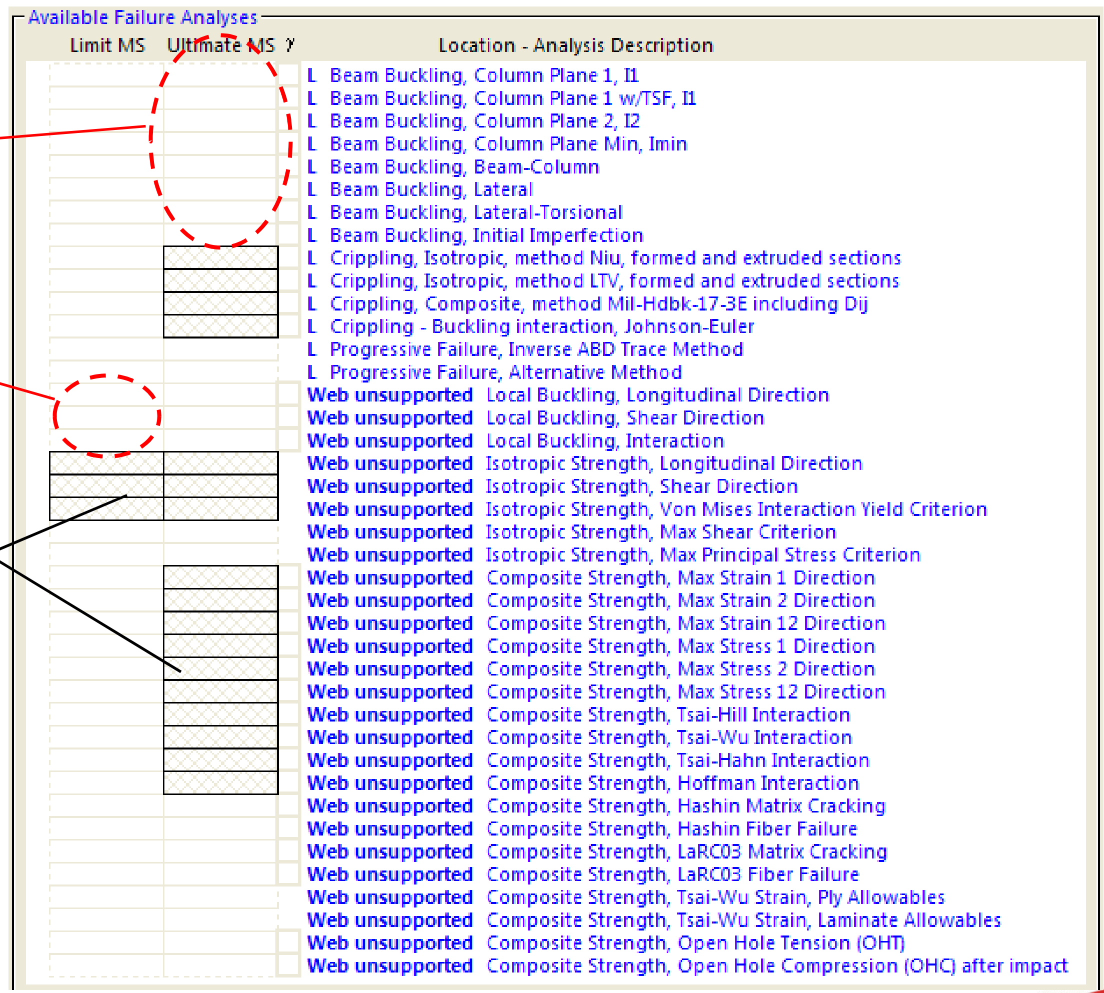
Failure Modes for the Cap

Because the Flange is not free to buckle, all column and local buckling margins of safety should be de-activated on the Failure tab of the Sizing form. However, crippling and all strength margins should be included.

1. Turn off all beam buckling failure modes

2. Turn off all local buckling failure modes

3. Composite or isotropic strength failure modes should be turned on



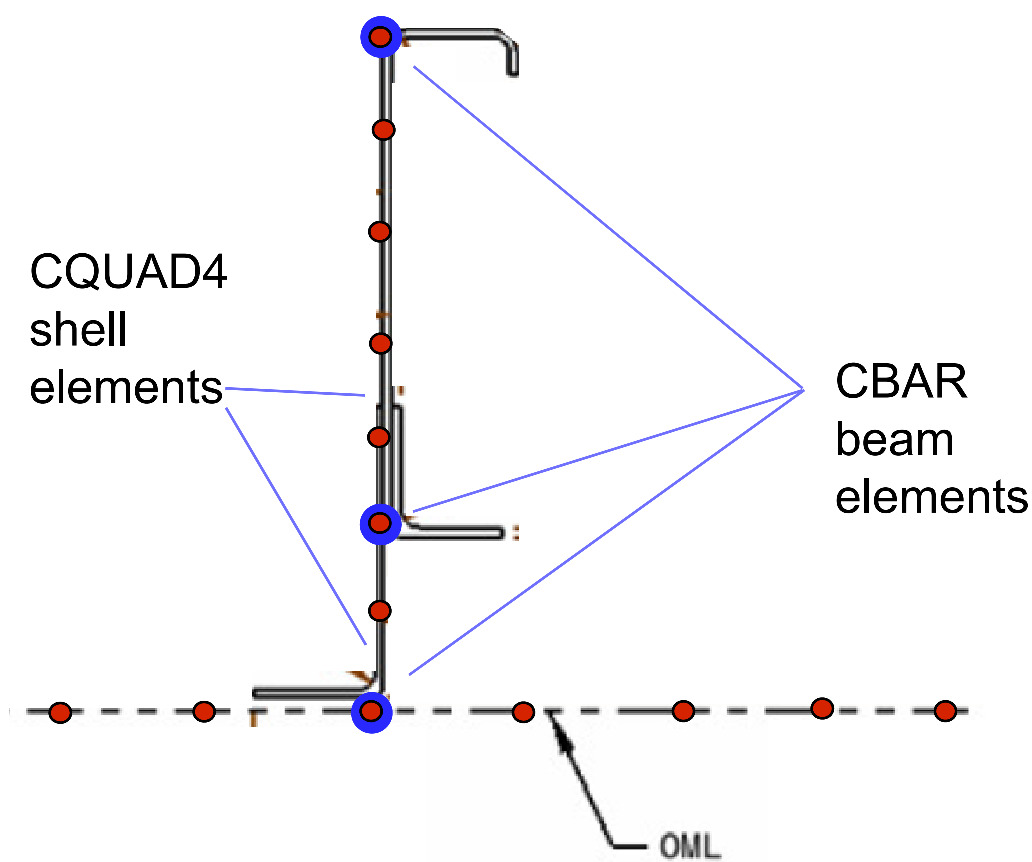
Note: All failure modes for the Flange Bottom (not shown) should be turned off

Modeling Option B: Final Sizing Variables

More detail and accuracy of the ringframe is captured using more elements, but less flexibility in the overall sizing

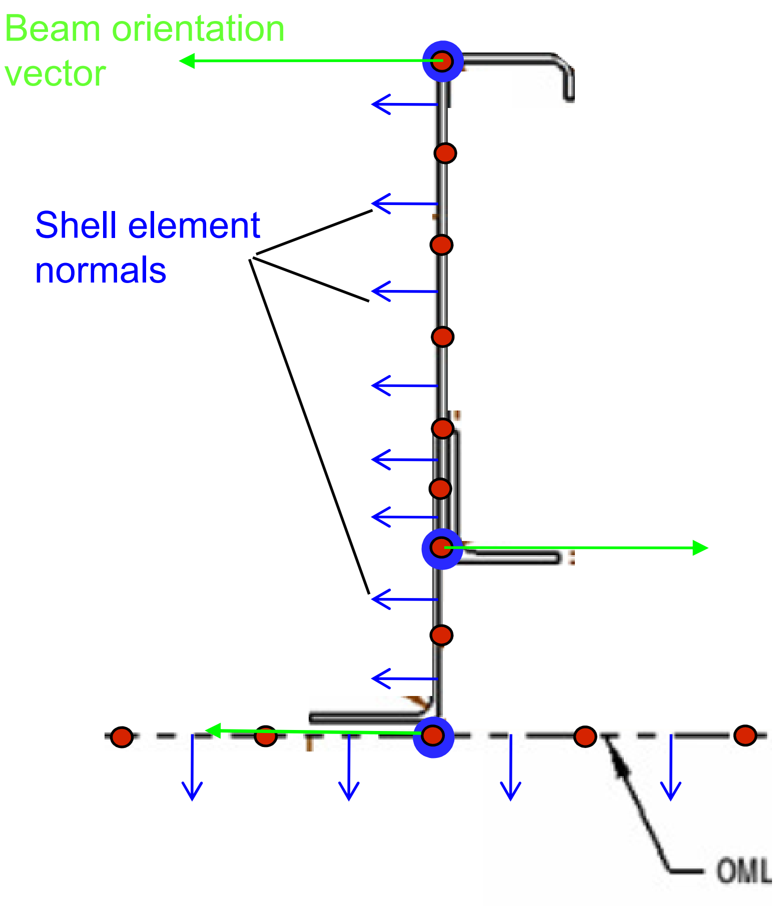
- FEM grids are shown as red circles
- Three beam elements are used to model the flanges as shown with large blue circles
- The number of grids and shell elements used to model the ringframe web and the OML surface is a user decision
- SIZING VARIABLES
  - Since the three beams are positioned on defined grid coordinates, the overall depth of the ringframe is fixed
  - The ringframe web and flange thicknesses, and angle dimensions are free to optimize

Airframe Ringframe

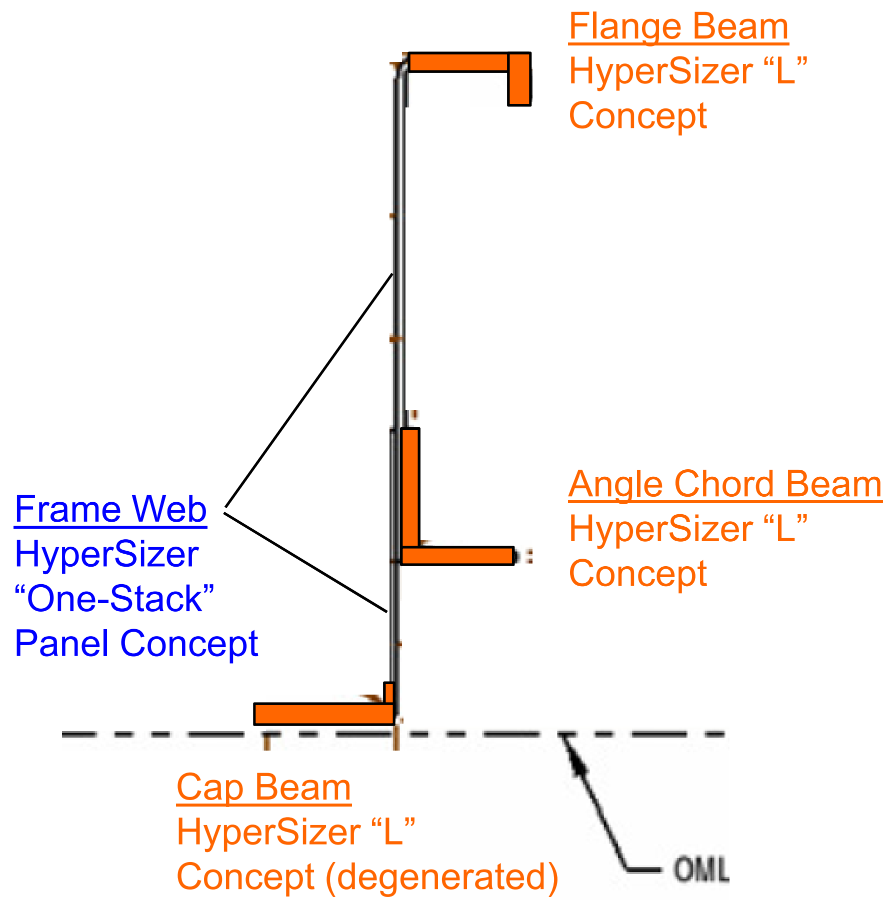


Modeling Option B: Final Sizing Variables

Elements and Directions



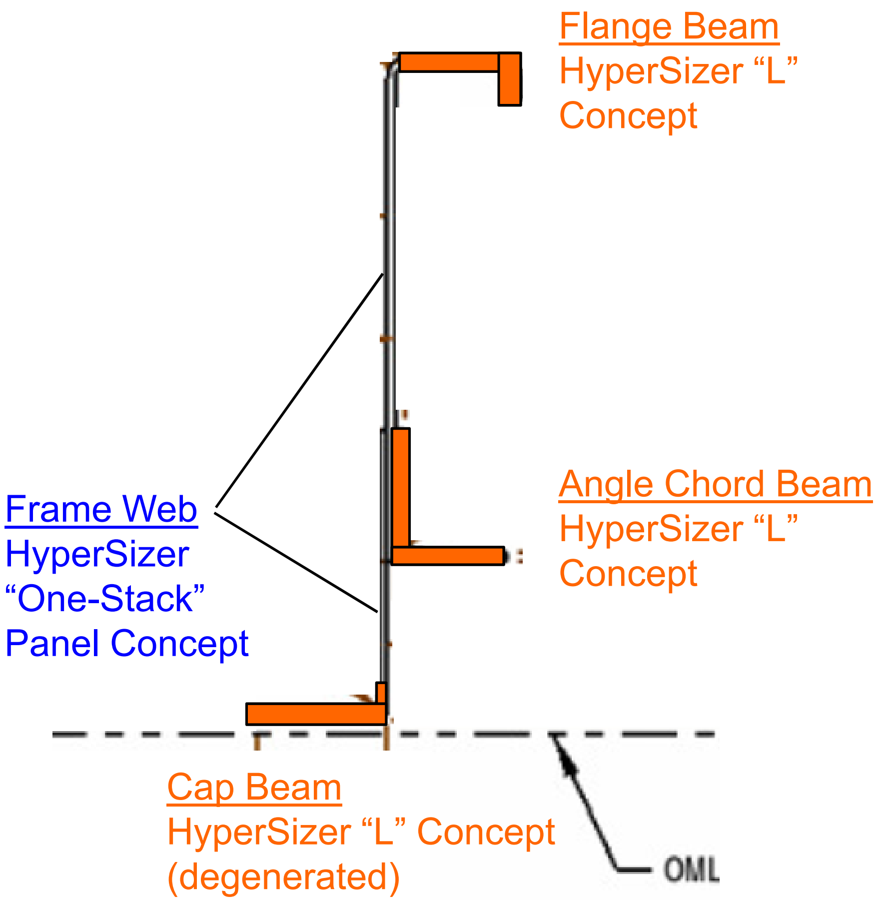
HyperSizer Concepts



Three CBAR beam elements for each cap/flange with different HyperSizer selections for reference plane made on the Sizing Form, Options Tab

15 Available Sizing Variables for the Ringframe

HyperSizer Concepts



Flange Beam (5 Variables)

- Material
- Height
- Web Thickness
- Flange Width
- Flange Thickness

Angle Chord Beam (5 Variables)

- Material
- Height
- Web Thickness
- Flange Width
- Flange Thickness

Cap Beam (3 Variables)

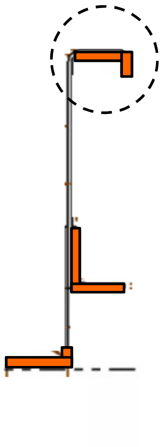
- Material
- Height
- Web Thickness

Frame Web (2 Variables)

- Material
- Web Thickness

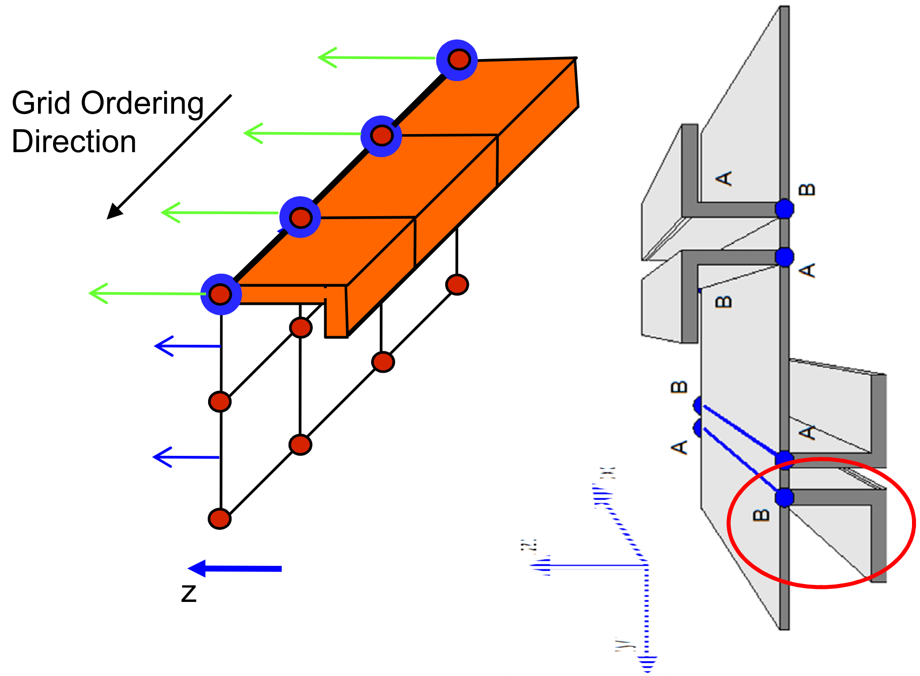
There are 15 available sizing variables. There are more overall variables than in Option A, however the overall ringframe depth cannot be optimized.

Proper Alignment of the Flange



FEM Steps

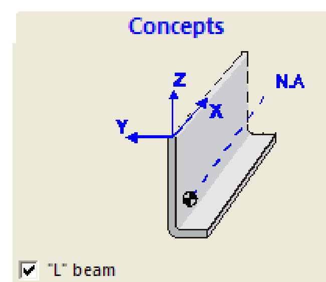
1. Enter the orientation vectors (green arrows) as shown to properly align the z axis of the L-Beam w.r.t. the web shells
2. Order the grids as shown to properly align the right and left orientation of the beam



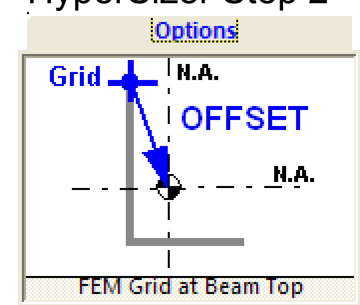
HyperSizer Steps

1. Select “L” Beam on the Concepts Tab and turn all other concepts off
2. Select “FEM Grid at Beam Top” on the Options Tab

HyperSizer Step 1



HyperSizer Step 2



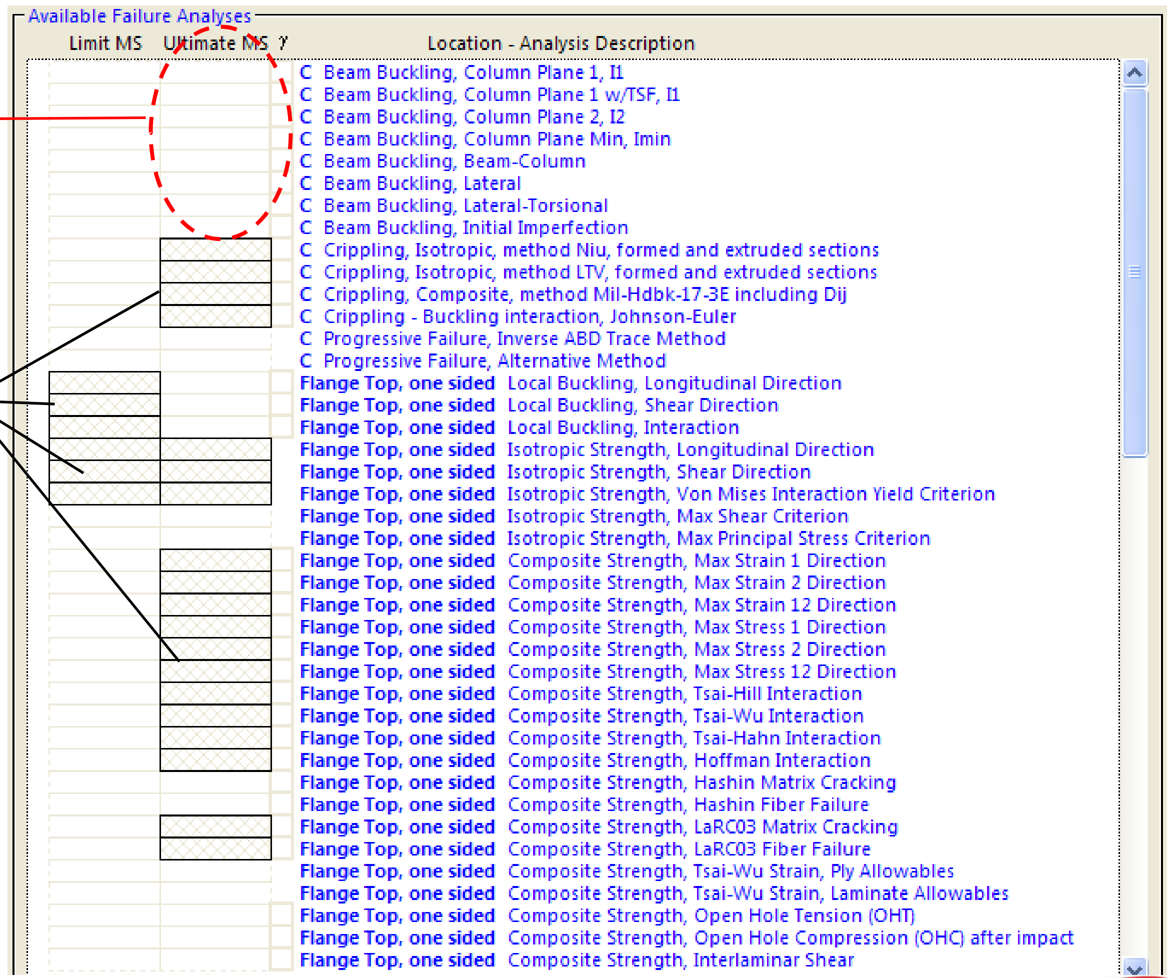
From the Beam Orientation Table, the Flange Beam is orientation number “3-A”

Failure Modes for the Flange

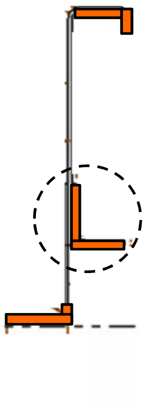
Because the flange is not free to column buckle, all column buckling margins of safety should be de-activated on the Failure tab of the Sizing form. However, local buckling, crippling and all strength margins should be included.

1. Turn off all beam buckling failure modes

2. Composite or isotropic strength, local buckling and crippling failure modes should be turned on (shown are the database default values)

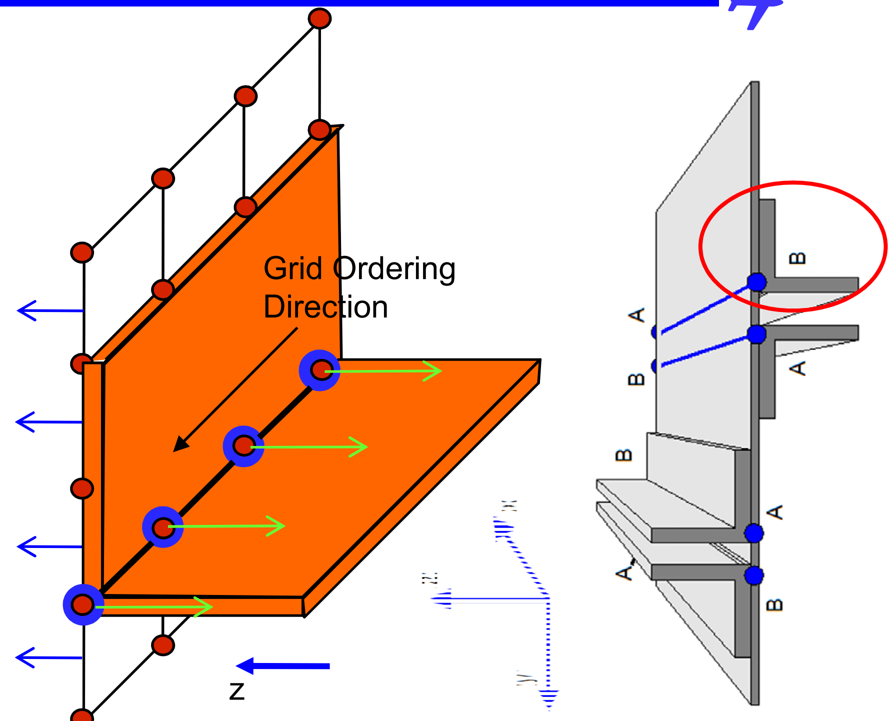


Proper Alignment of the Angle Chord



FEM Steps

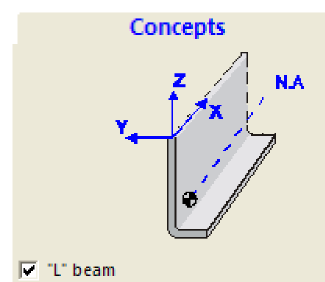
1. Enter the orientation vectors (green arrows) as shown to properly align the z axis of the L-Beam w.r.t. the web shells
2. Order the grids as shown to properly align the right and left orientation of the beam



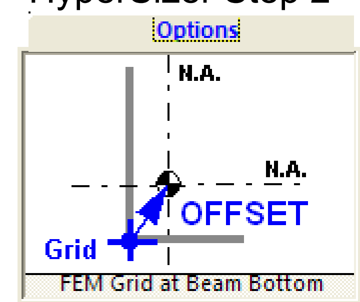
HyperSizer Steps

1. Select “L” Beam on the Concepts Tab and turn all other concepts off
2. Select “FEM Grid at Beam Bottom” on the Options Tab

HyperSizer Step 1

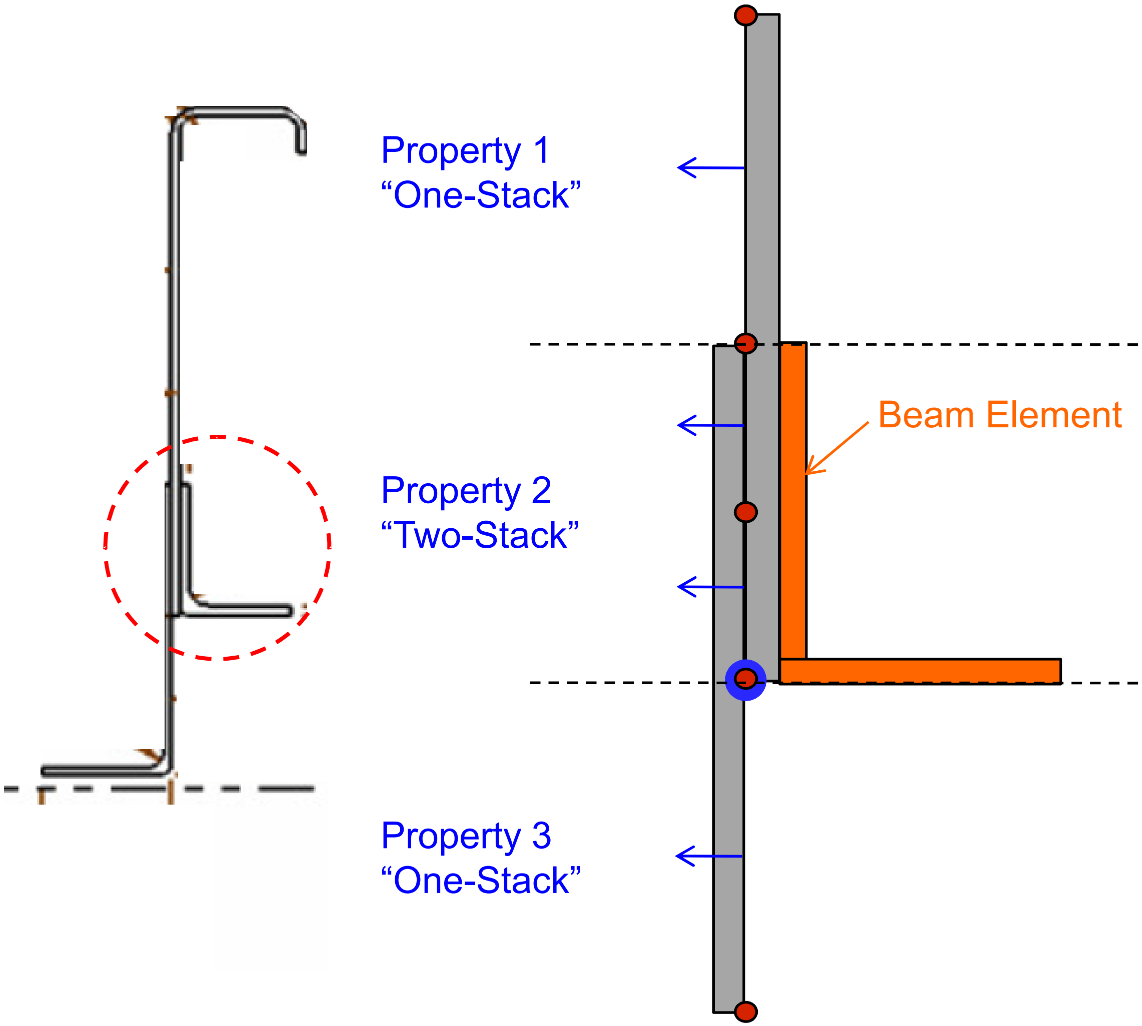


HyperSizer Step 2



From the Beam Orientation Table, the Flange Beam is orientation number “2-D”

Modeling Option A: Angle Chord Beam Accounting for the Web Overlap



To account for the overlap region where the bottom leg of the web overlaps the top leg, separate the web into three different shell properties.

Properties 1 and 3 will be the upper and lower legs of the web and property 2 will be the overlap region.

Property 2 will be modeled in HyperSizer as a "Two-Stack" concept, where Stack 1 is the lower web plate and Stack 2 is the upper web plate.

Failure Modes for the Angle Chord

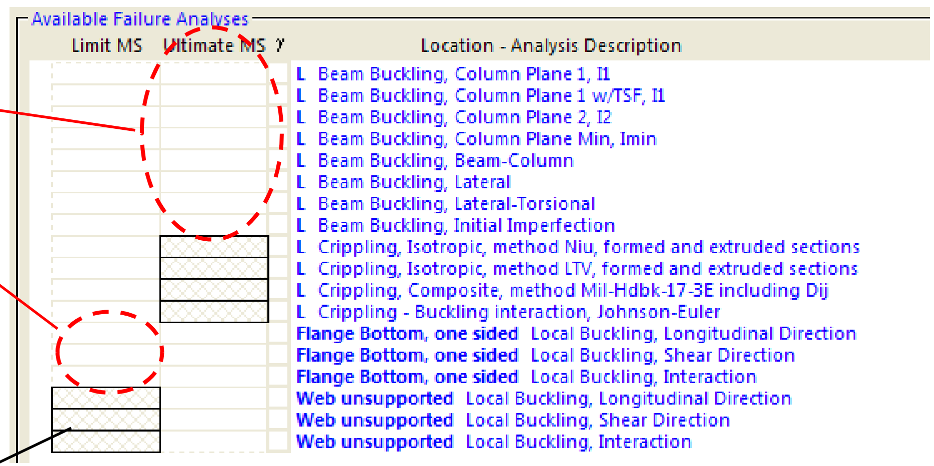
Because the Angle Chord is not free to column buckle, all column buckling margins of safety should be de-activated on the Failure tab of the Sizing form. Local buckling is applicable for the beam web, however, the bottom flange is not free to buckle, therefore local buckling should be turned off for this object. Crippling and all strength margins should be included.

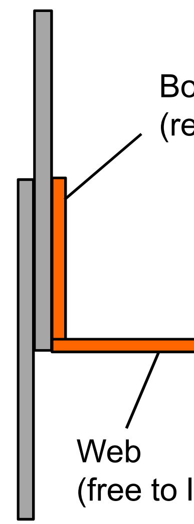
1. Turn off all beam buckling failure modes

2. Turn off local buckling failure modes for the flange bottom

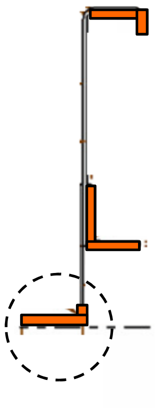
3. Local buckling failure modes for the web should be turned on (they are on by default)

4. All composite or isotropic strength failure modes (not shown) should be turned on



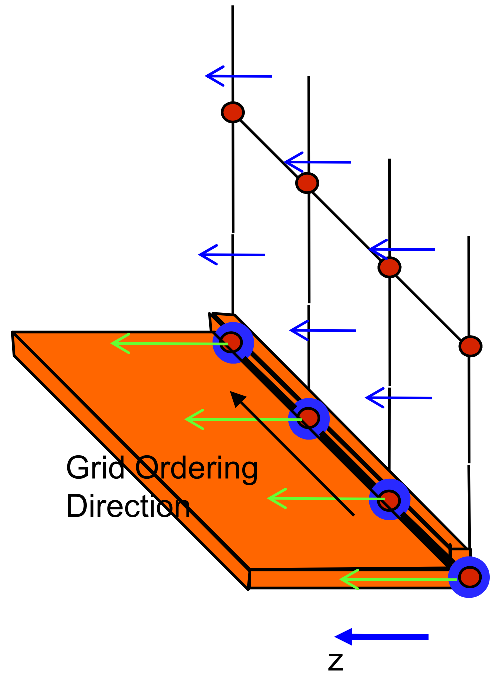


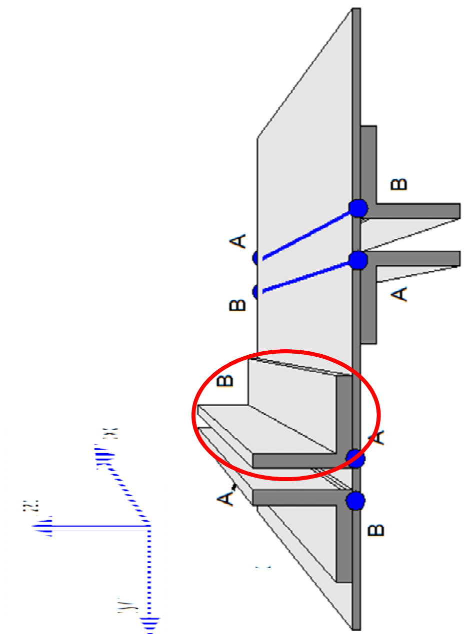
Proper Alignment of the Cap



FEM Steps

1. Enter the orientation vectors (green arrows) as shown to properly align the z axis of the L-Beam w.r.t. the web shells
2. Order the grids as shown to properly align the right and left orientation of the beam

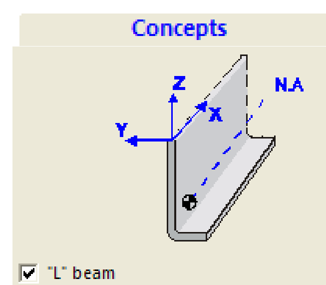




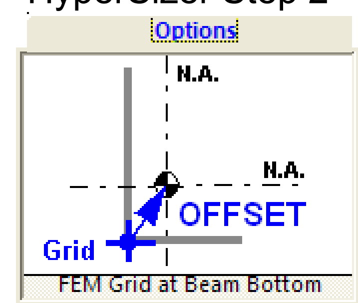
HyperSizer Steps

1. Select "L" Beam on the Concepts Tab and turn all other concepts off
2. Select "FEM Grid at Beam Bottom" on the Options Tab

HyperSizer Step 1



HyperSizer Step 2



From the Beam Orientation Table, the Flange Beam is orientation number "2-B"

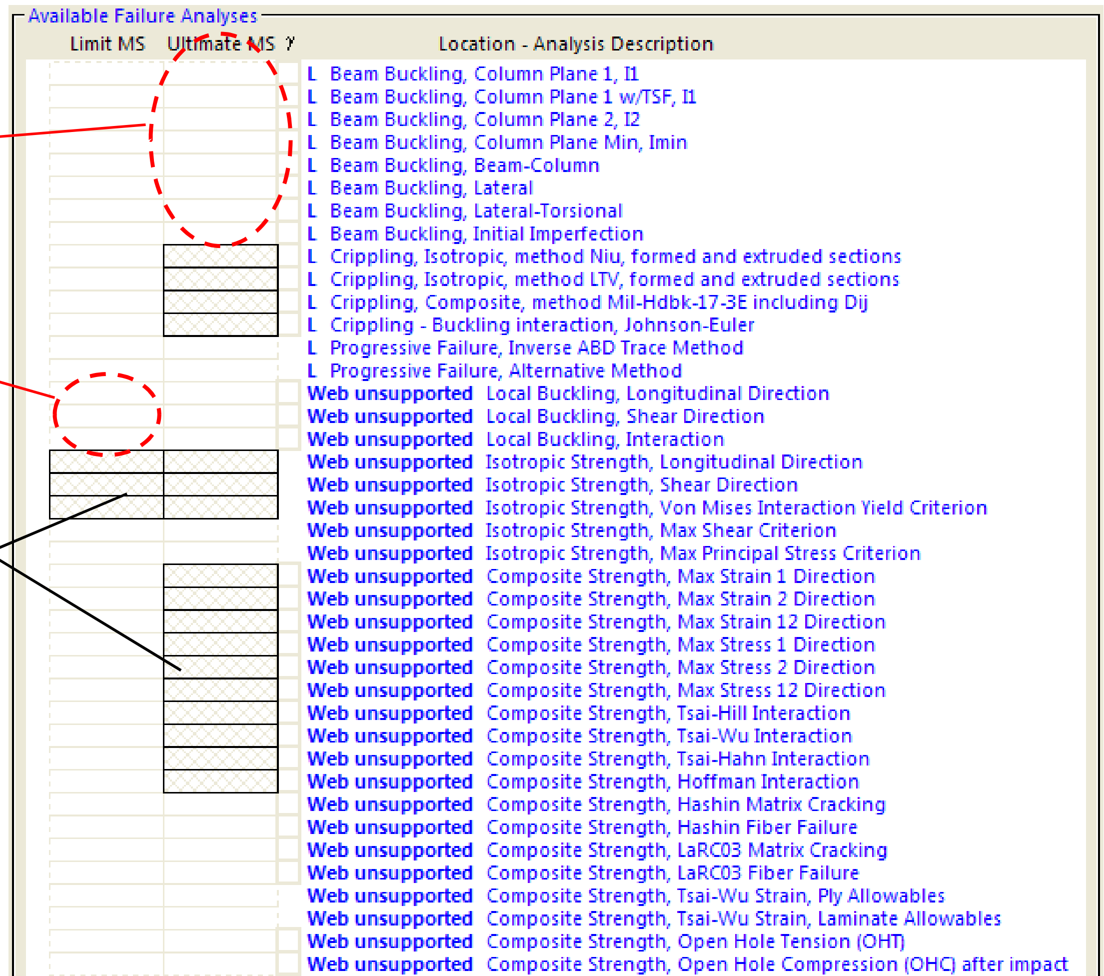
Failure Modes for the Cap

Because the Flange is not free to buckle, all column and local buckling margins of safety should be de-activated on the Failure tab of the Sizing form. However, crippling and all strength margins should be included.

1. Turn off all beam buckling failure modes

2. Turn off all local buckling failure modes

3. Composite or isotropic strength failure modes should be turned on



Note: All failure modes for the Flange Bottom (not shown) should be turned off

Conclusions

- Two approaches to modeling a custom designed ringframe are presented:
  - The first approach uses less finite elements and allows the user to size the total depth of the ringframe. However, fewer details of the analysis are captured.
  - The second approach uses more finite elements to capture more detail of the ringframe while limiting the sizing flexibility of the overall structure
- Orientation and grid ordering of the CBAR elements in the FEM are key in correctly modeling the unsymmetric beams that make up the ringframe
- Most of the complexity of correctly modeling the ringframe is related to the setup of normals, orientation and grid ordering in the FEM. Even if HyperSizer was not used, these details would still have to be addressed in the FEM to properly model this ringframe.