

Structure Tool in Freecad: how to use

by Kay Tran

1 Intro info:

FreeCAD is open-source software that can integrate with Python packages.

Structure Tool is a FreeCAD extension for structural analysis, utilizing the Pynite kernel to perform calculations and display results



Figure 1:

2 How to use:

From Freecad select Structure Tool WB

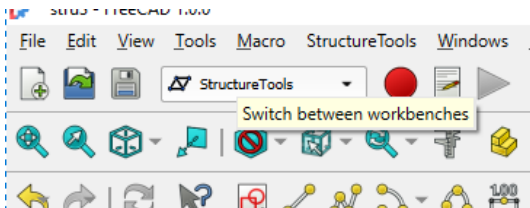


Figure 2:

- * Click New button to create empty model
- * Click Line on toolbar to create line for beam/ column structure

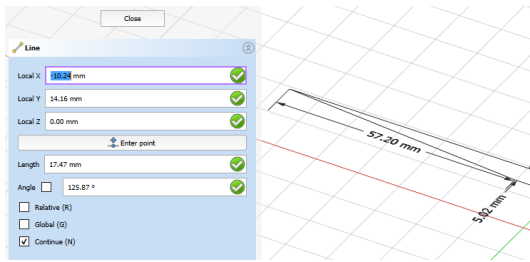


Figure 3:

* Select endpoint of line then click support button

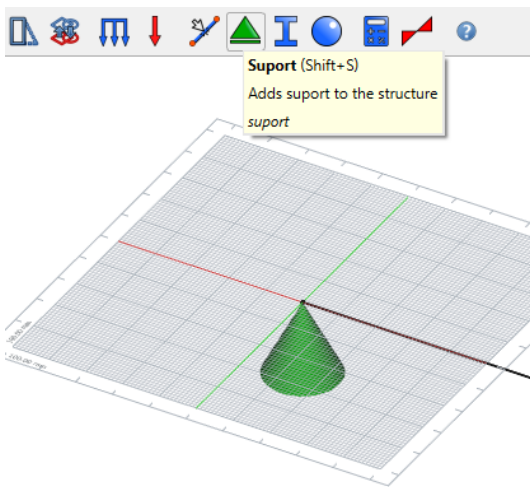


Figure 4:

– in tab of support select restraint required

Base	
► Placement	[[0.00 0.00 1.00]; 0.00 °; (0.00 mm 0.00 mm 0.00 mm)]
Label	Support
Object Base	Line [Vertex1]
Draw	
Scale Draw	1.00
Rotation	
Fix Rotation X	✓ true
Fix Rotation Y	true
Fix Rotation Z	true
Translation	
Fix Translation X	true
Fix Translation Y	true
Fix Translation Z	true

Figure 5:

* Create & assign section
 – Click sketch button to make a sketch. Sketch will be in plane XY (important note) and try to make sketch in center of (0,0,0)

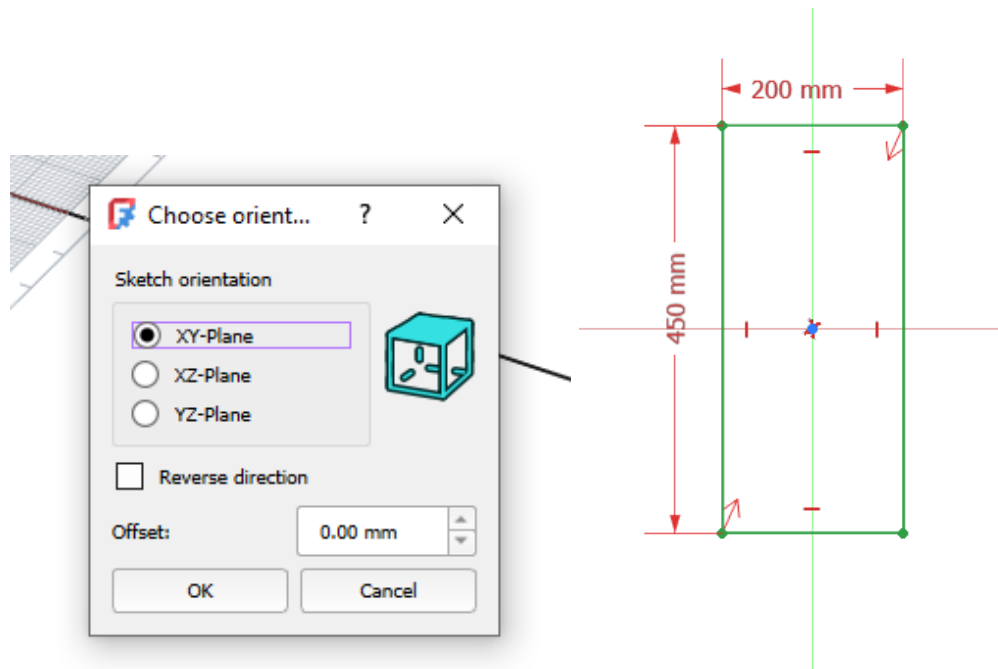


Figure 6:

- Convert sketch to wire

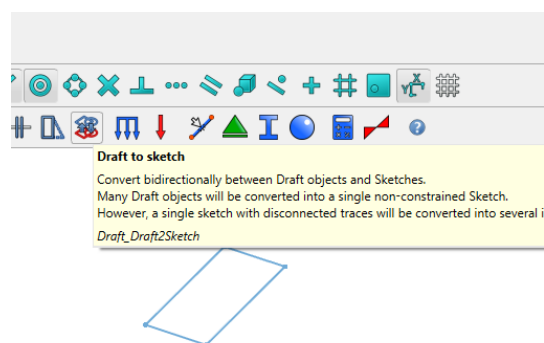


Figure 7:

- from wire created, select make face

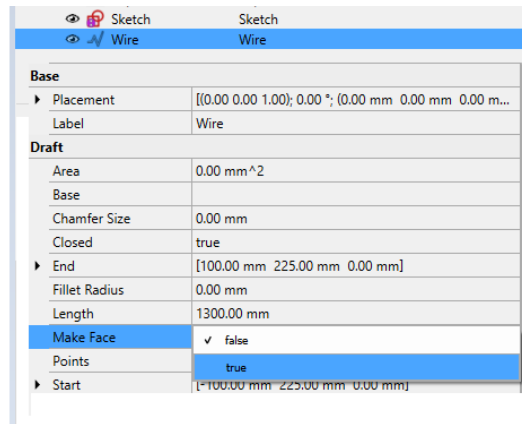


Figure 8:

- put pointer on created face then click section button (important note)

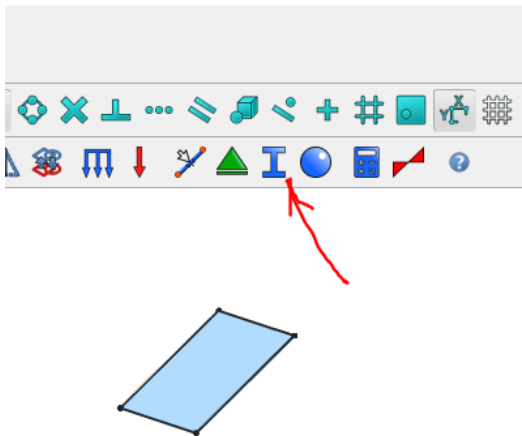


Figure 9:

- section will create with parameter for moment inertia info

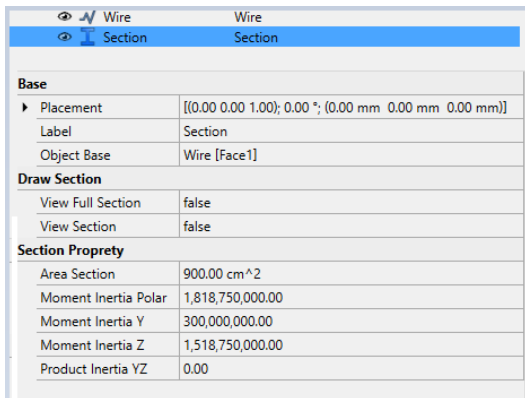


Figure 10:

* Create material

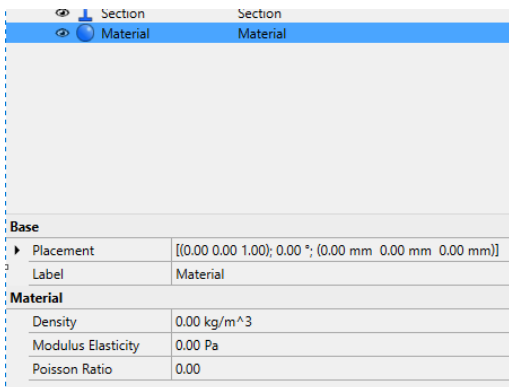


Figure 11:

* Select line & define section, material

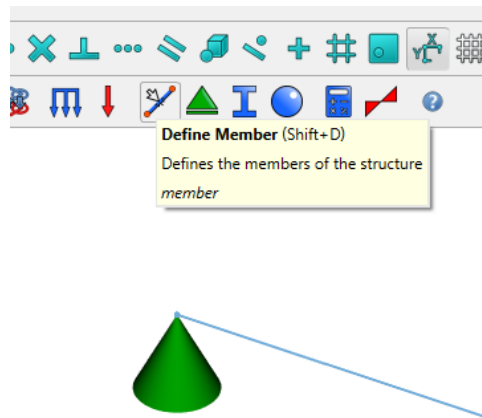


Figure 12:

– in line tab properties will appear Structure info

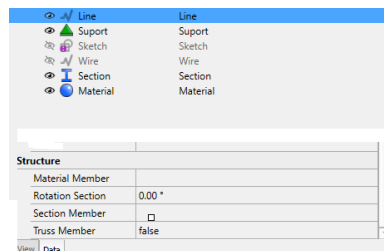


Figure 13:

– click "..." then select material, section already defined in list

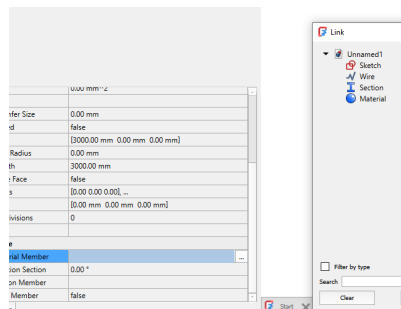


Figure 14:

* select line structure and apply load

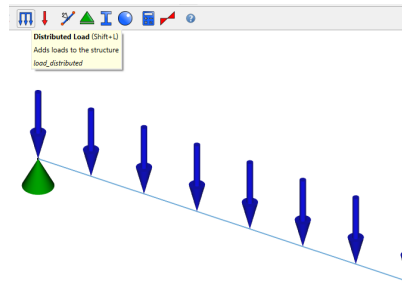


Figure 15:

* select whole model by box selection (important note)

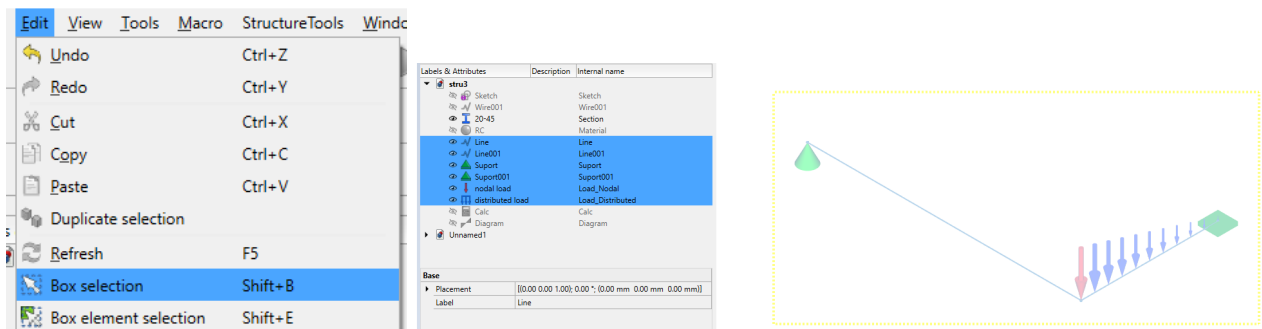


Figure 16:

– click Calc button to run analysis

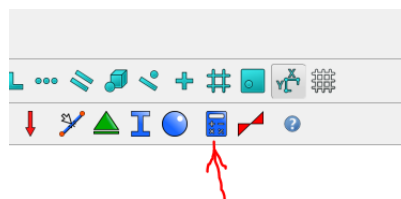


Figure 17:

– Calc will appear in tab properties with values moment, shear, deflection



Calc	Calc
Diagram	Diagram
Num Points Deflection	4
Num Points Moment	5
Num Points Shear	4
Num Points Torque	3
Result Axial	
Axial Force	[0.0,0.0,0.0,0.0,0.0,0.0]
Result Deflection	
Deflection Y	[0.0,-0.00015188954245395927,-0.00029240320163...
Deflection Z	[0.0,0.0,0.0,0.0,0.0,0.0,0.0]
Max Deflection Y	[0.00,-0.00]
Max Deflection Z	[0.00,0.00]
Min Deflection Y	[-0.00,-0.00]
Min Deflection Z	[0.00,0.00]
Result Moment	
Max Moment Y	[0.00,0.00]
Max Moment Z	[-0.00,22.23]
Min Moment Y	[0.00,0.00]

Figure 18:

* click diagram to see BD or SD

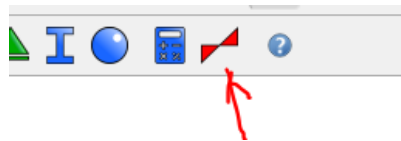


Figure 19:

– on tab properties of diagram, select "true" to show value on beam

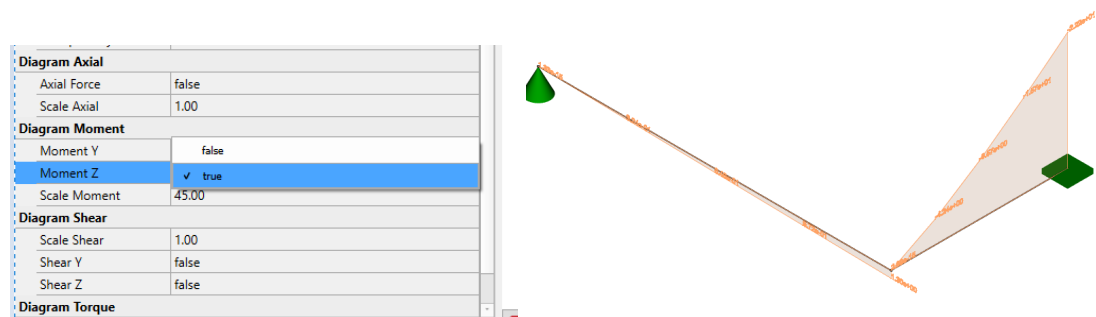


Figure 20:

3 New add-ins:

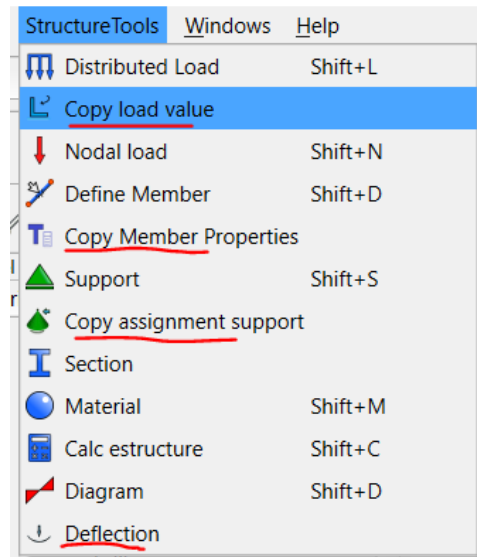


Figure 21:

- Load copy use for copy value load from selected distribute line to other ones

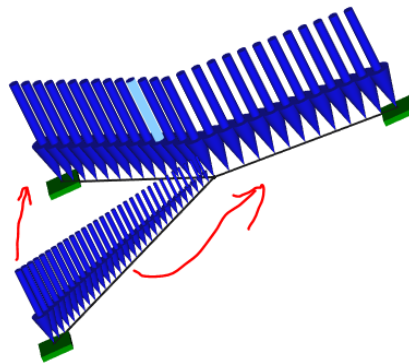


Figure 22: Before copy load

select source distribution load then select other ones to overwrite value

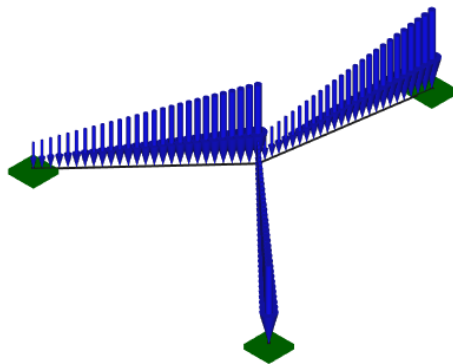


Figure 23: After copy load

- Copy support assignment use for copy assignment from selected support to other ones

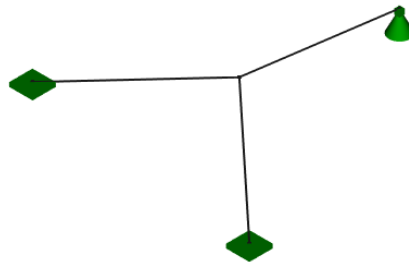


Figure 24: Before copy

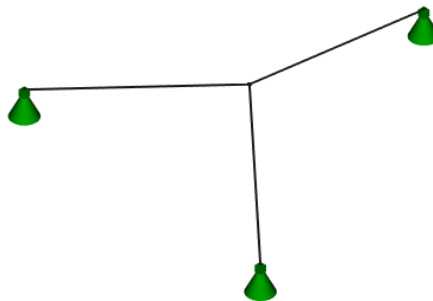


Figure 25: After copy

- Deflection show deflection results: similar like diagram command, select 'Calc' then click deflection in menu
→ will appear 'deflection' tab then key in some parameters like font size, scale

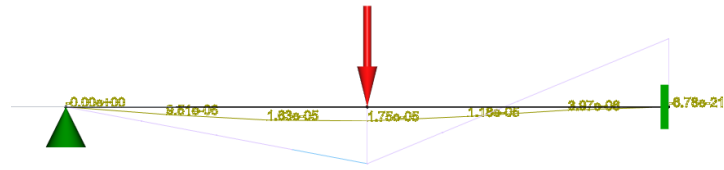


Figure 26:

– Import section to load section properties from txt file to model without define section from sketch. By this way also can create a library section properties using for calculation model.

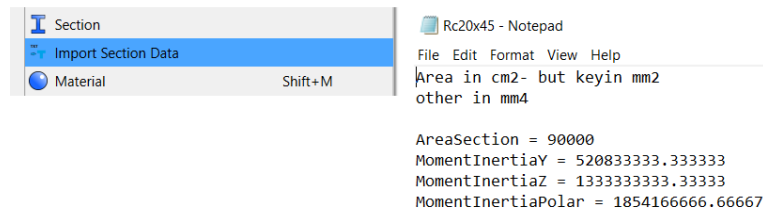


Figure 27:

Format section properties in txt file see photo above. This way will not show member bar in 3D view since no define section from sketch. But for calculation bending, shear .. etc will not affect.

4 Summary:

We gratefully acknowledge Maykow Menezes for his development of Structure Tools. This extension provides a user-friendly way to visualize and interpret Pynite results within FreeCAD, significantly reducing the need for direct Pynite coding expertise. You can explore the project and its source code at: <https://github.com/maykowsm/StructureTools>.

We extend special thanks to Yorik Van Havre for developing FreeCAD Platform

5 Appendix: Testing result

5.1 Example 1:

* Simple beam under uniform load & bending diagram

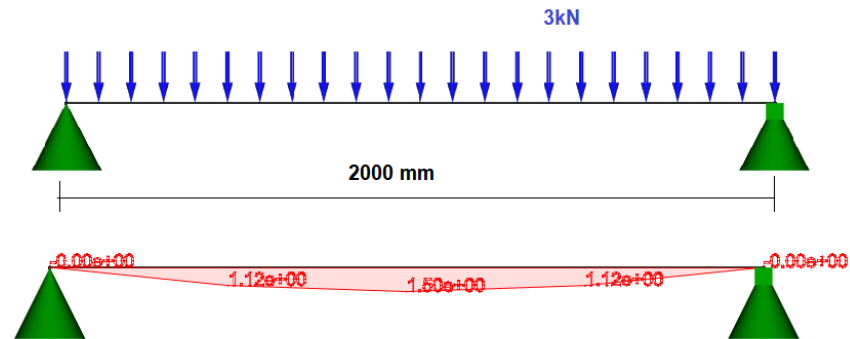


Figure 28:

* Result by anatruct - Python package

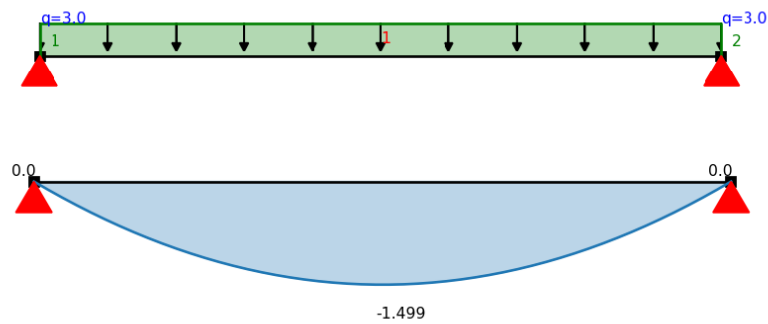


Figure 29:

5.2 Example 2:

* Simple beam under uniform load, point load & bending diagram

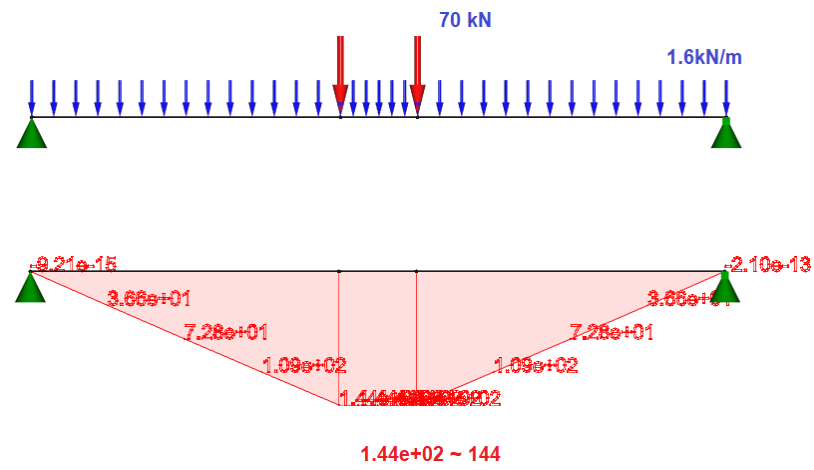


Figure 30:

* Result by anatruct - Python package

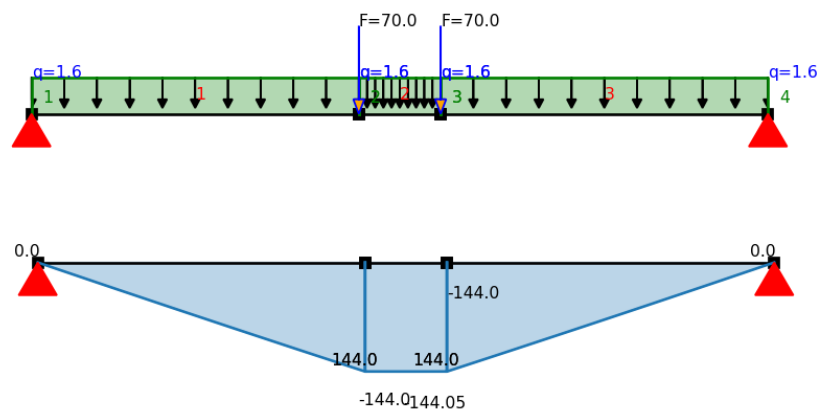


Figure 31:

* Result by Ftool

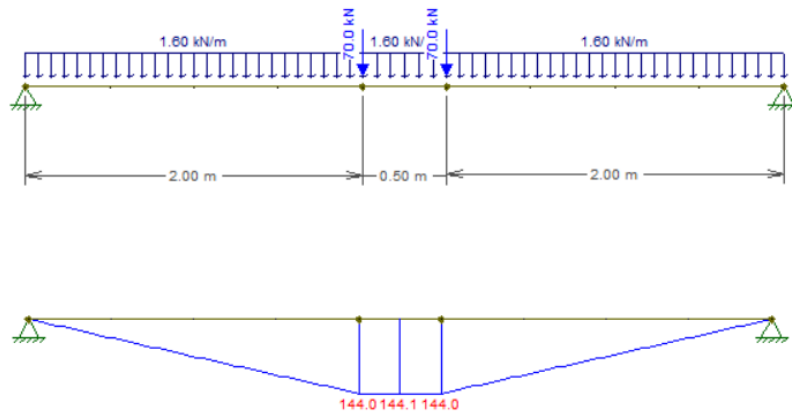


Figure 32:

5.3 Example 3:

* Frame structure uniform load & bending diagram

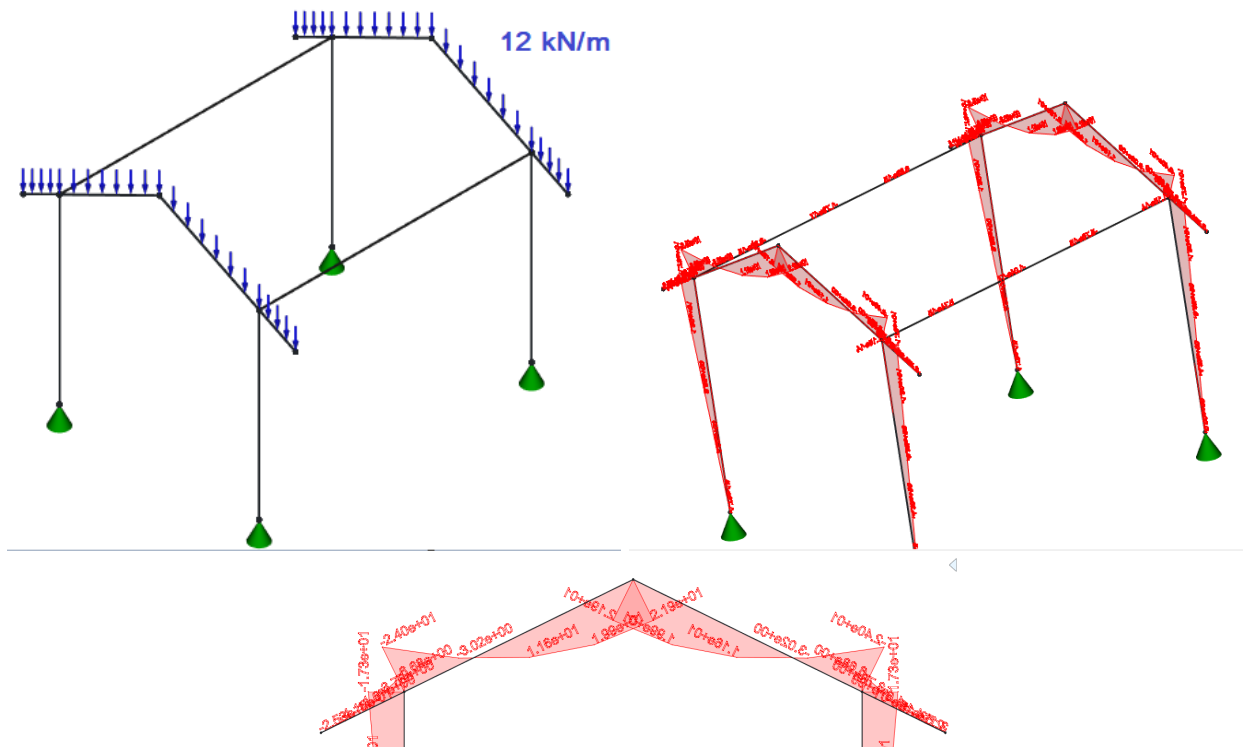


Figure 33:

* Result by Structure Tool

* 2D Frame structure uniform load & bending diagram

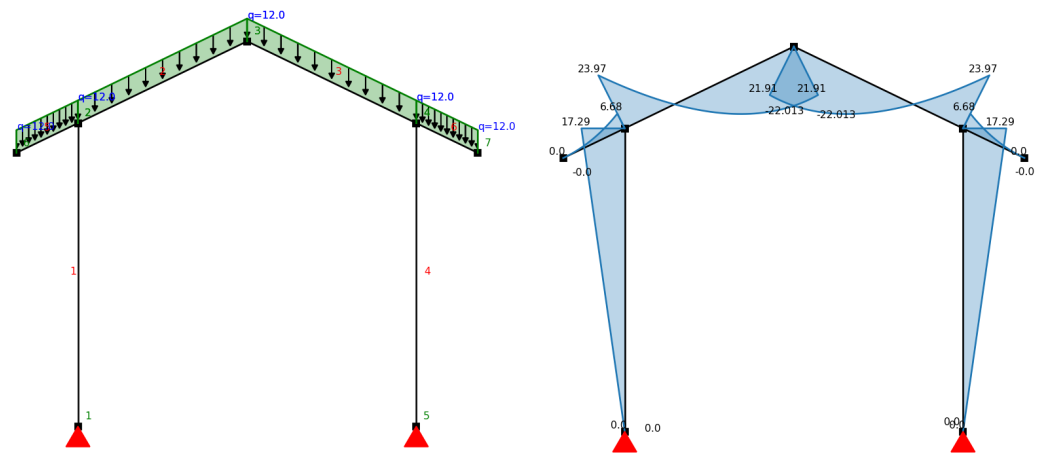


Figure 34:

* Result by Anastruct

5.4 Example 4:

* RC frame structure section 300x300 under uniform load & bending diagram

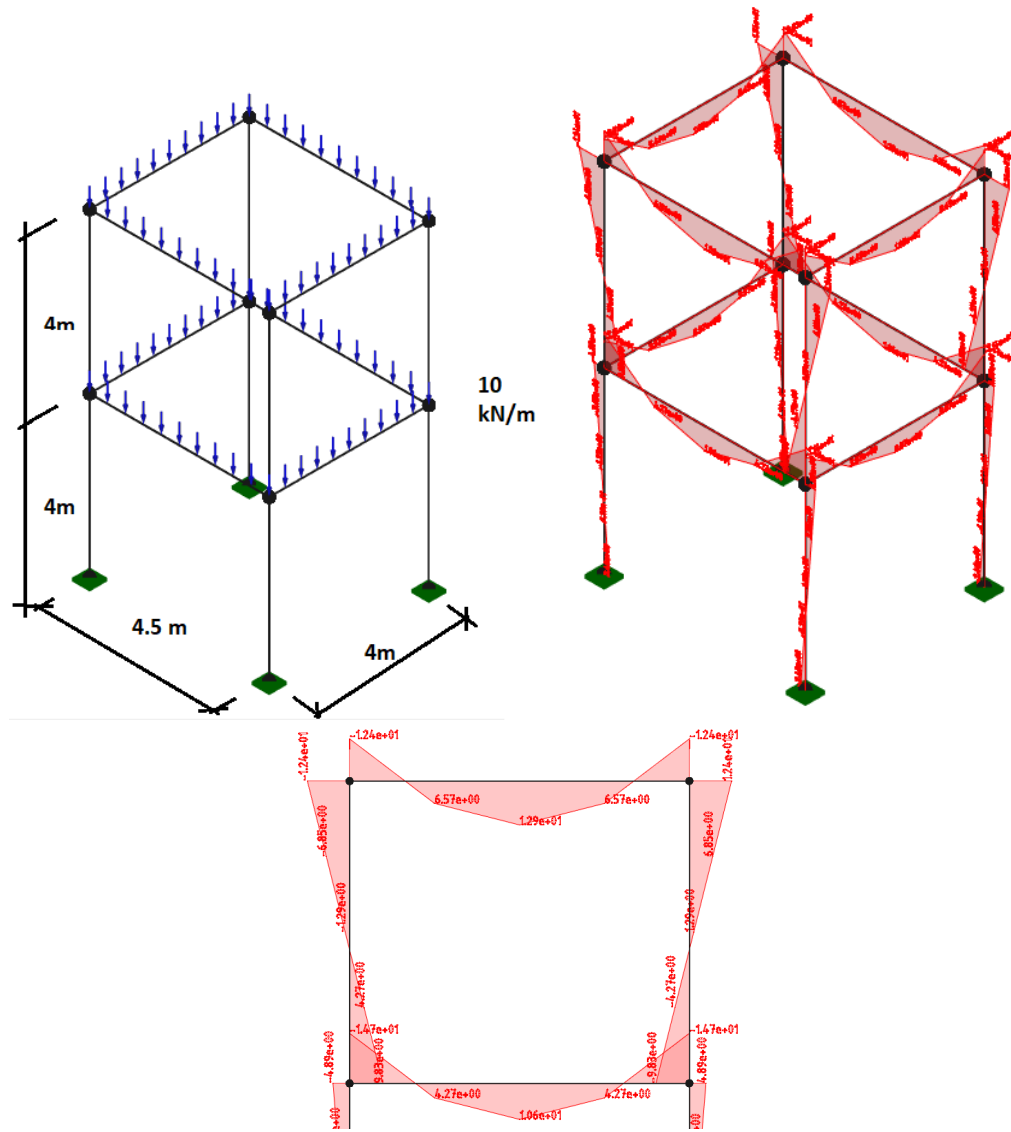


Figure 35:

* Result by Structure Tool

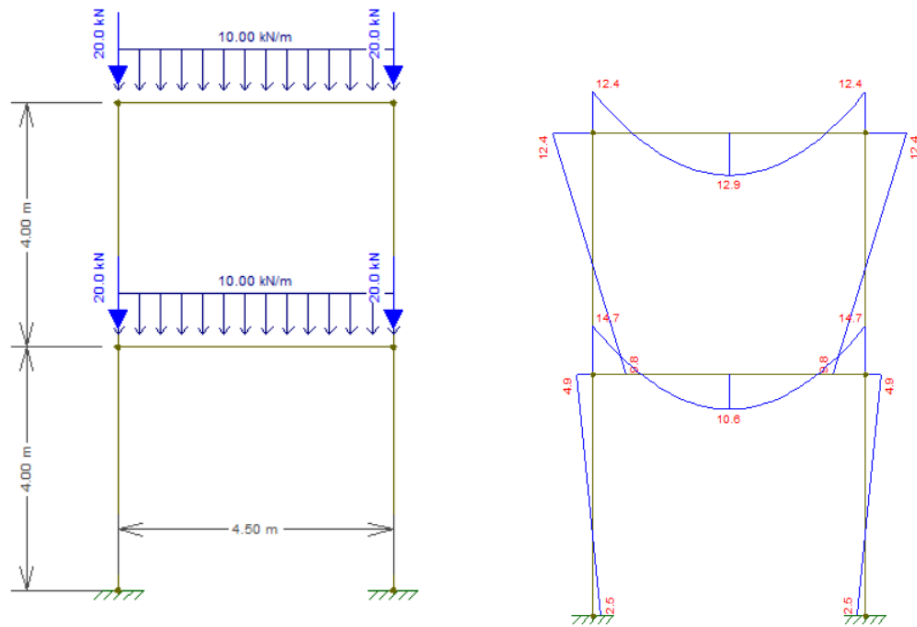


Figure 36:

* Result by Ftool, point load equal value distribute load segment spreads into frame

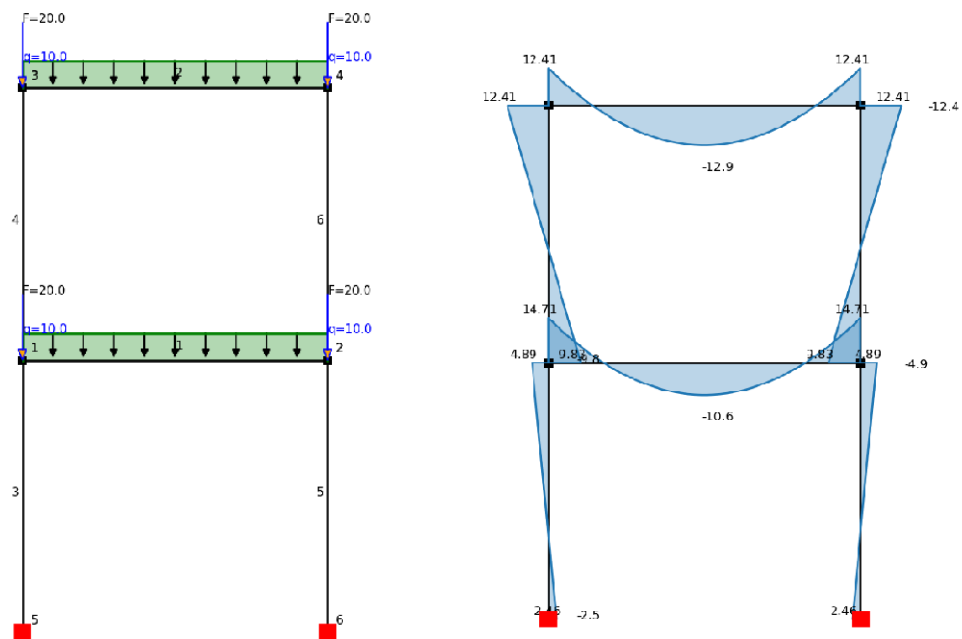


Figure 37:

* Result by Anastruct, point load equal value distribute load segment spreads into frame



5.5 Example 5:

* Steel frame structure section W4x4x24 (H107x100x8x12) under point load 20 kN

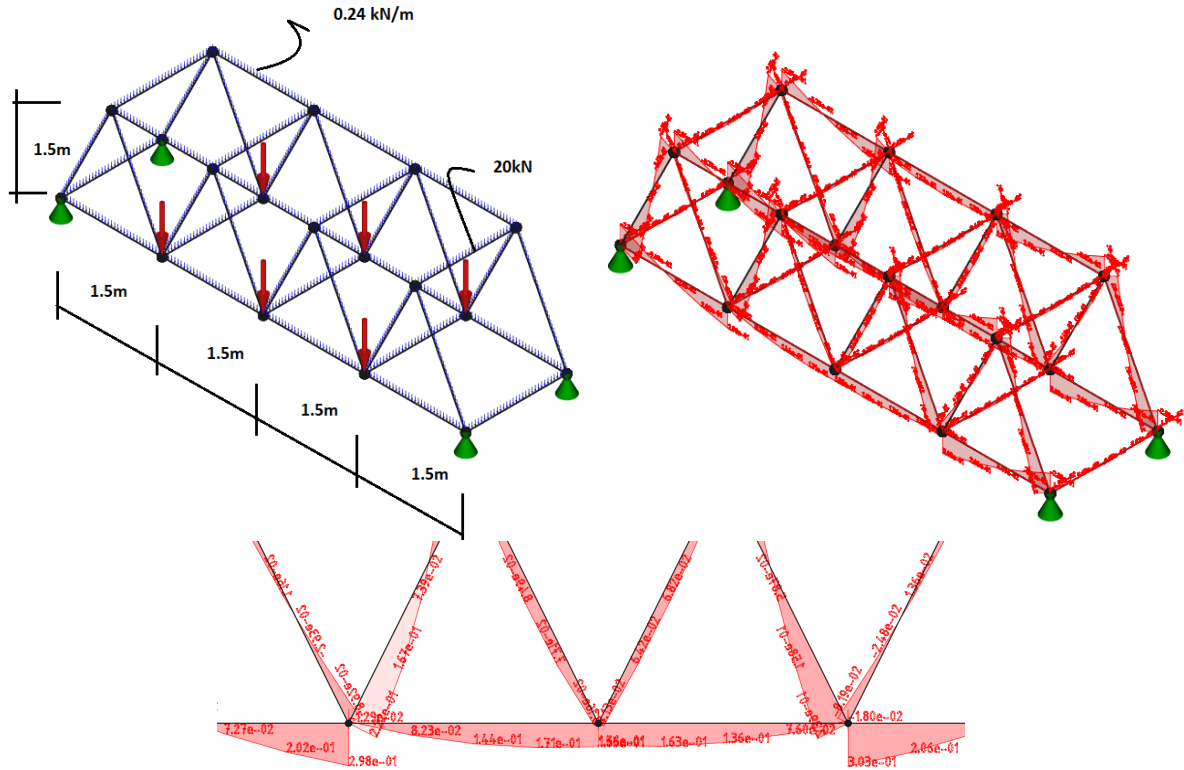


Figure 38:

* Result by Structure Tool - self weight of members imposed direct on frame

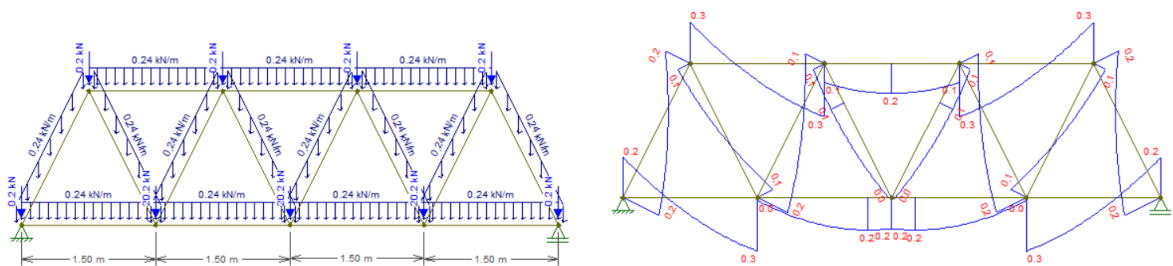


Figure 39:

* Result by Ftool - moment value included self weight of frames

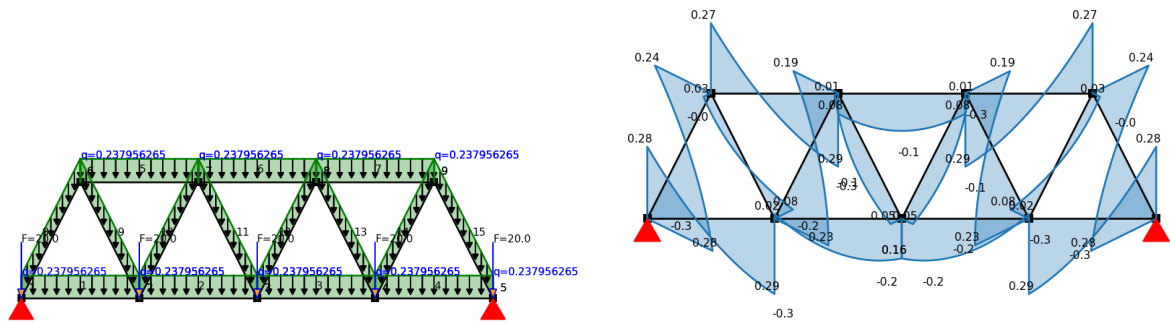


Figure 40:

* Result by anastruct

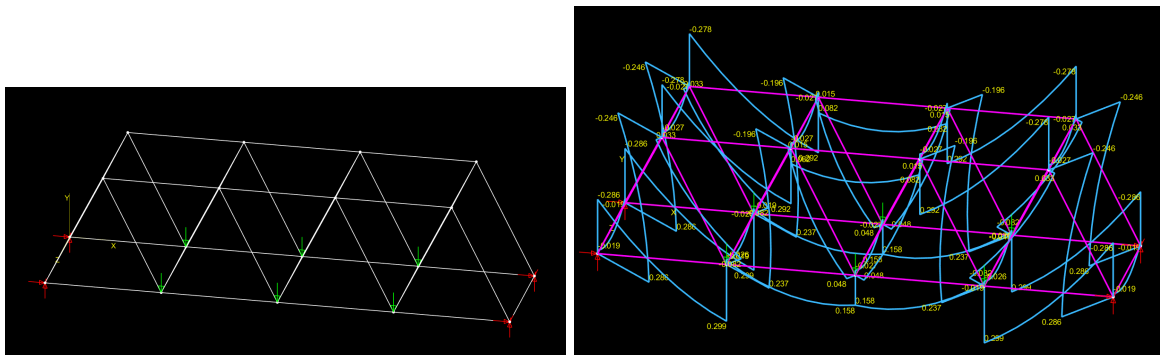


Figure 41:

* Result by Mastan2

5.6 Example 6:

* Rafters for cone roof diameter 12m, section rafter C150x75x6x10 -18 nos, crown ring section C200x75x6x13

Case	DL	LL
Value	0.4	1.5
Factor	1	1.2
Sum	2.2 kN/m ²	

DL is self weight of roof sheet 5mm thick

LL live load on roof

The load on each rafter is distributed over a trapezoidal area with a large side of 1.9 m and a small side of 0.4 m

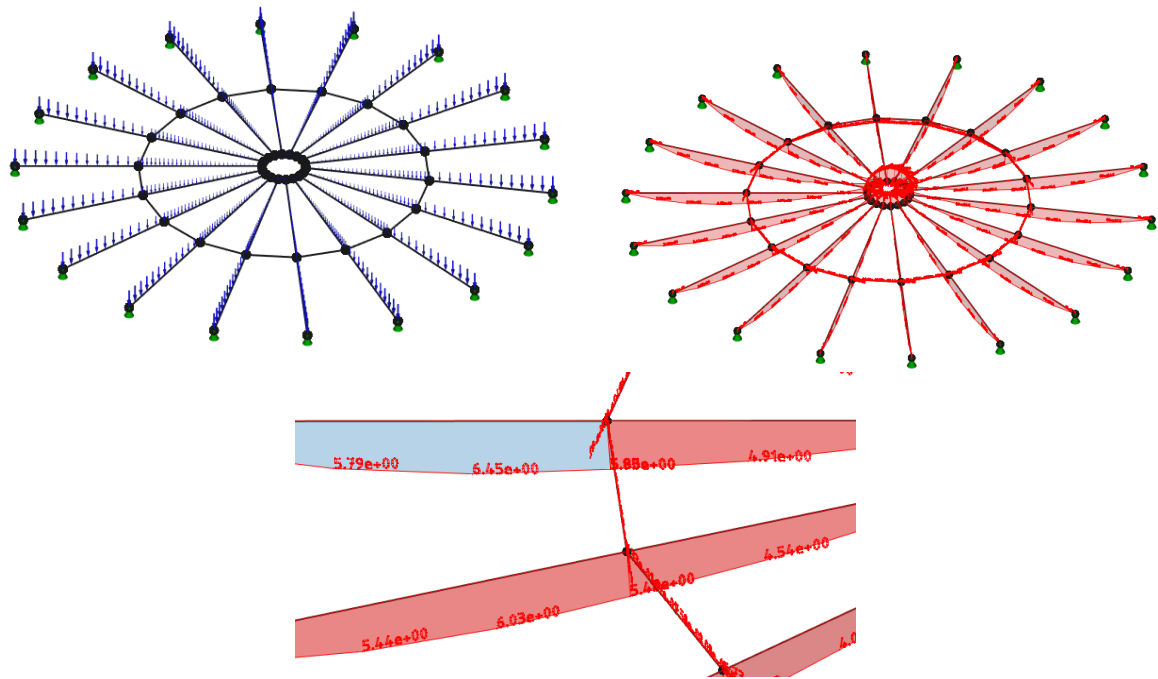


Figure 42:

* Result by Structure Tools

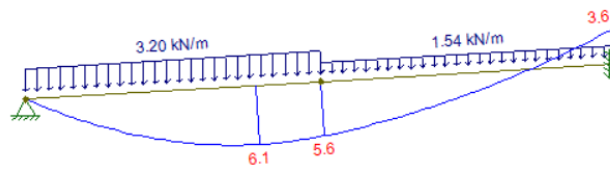


Figure 43:

* Result by Ftools

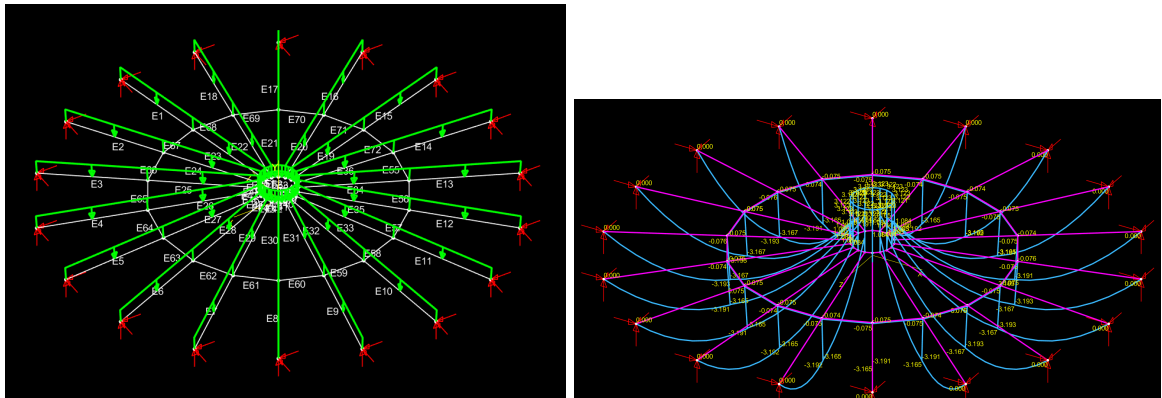


Figure 44:

* Result by Mastan2 (self-weight of rafter auto calculated in Mastan2)

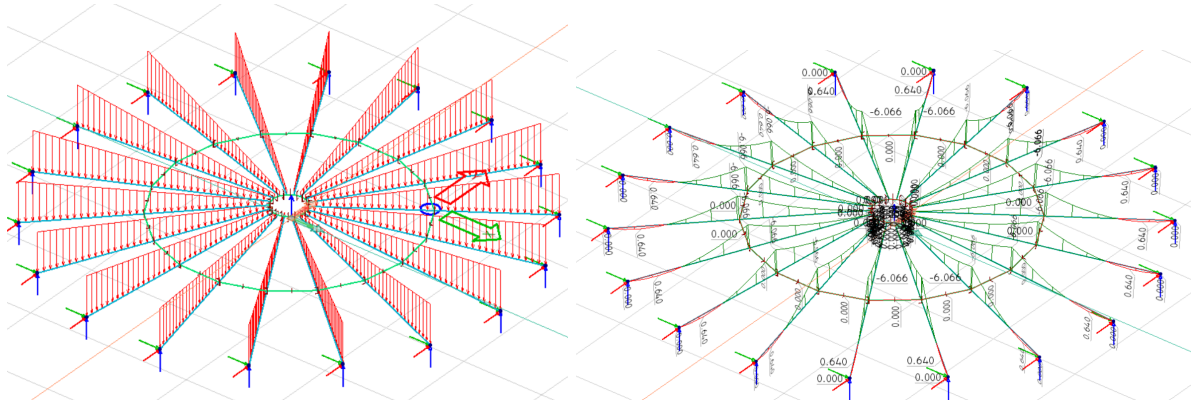


Figure 45:

* Result by Fem22

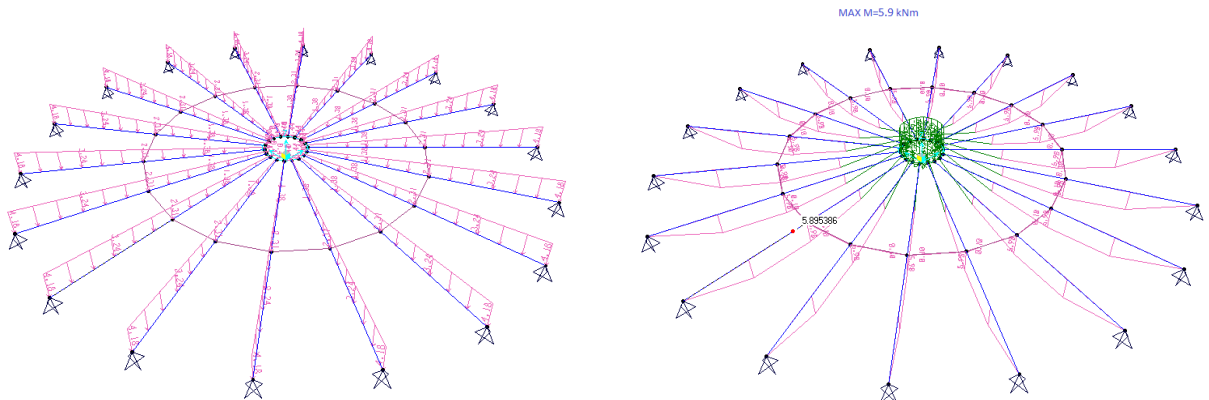


Figure 46:

* Result by SAP2000

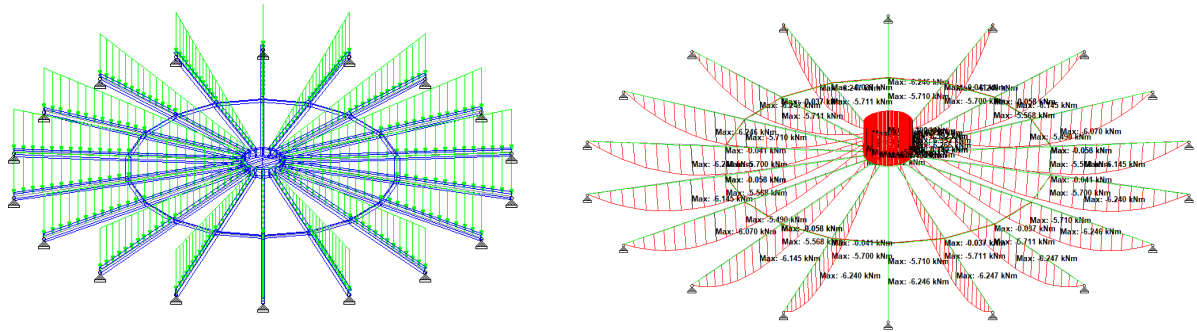


Figure 47:

* Result by Stapro

5.7 Example 7:

* Pylon base 2x2m, top tier 1x1m, 12m height, using section L120x10, bracing L75x8 under lateral point load $X=120$ kN , in this example will not count for self- weight of structure

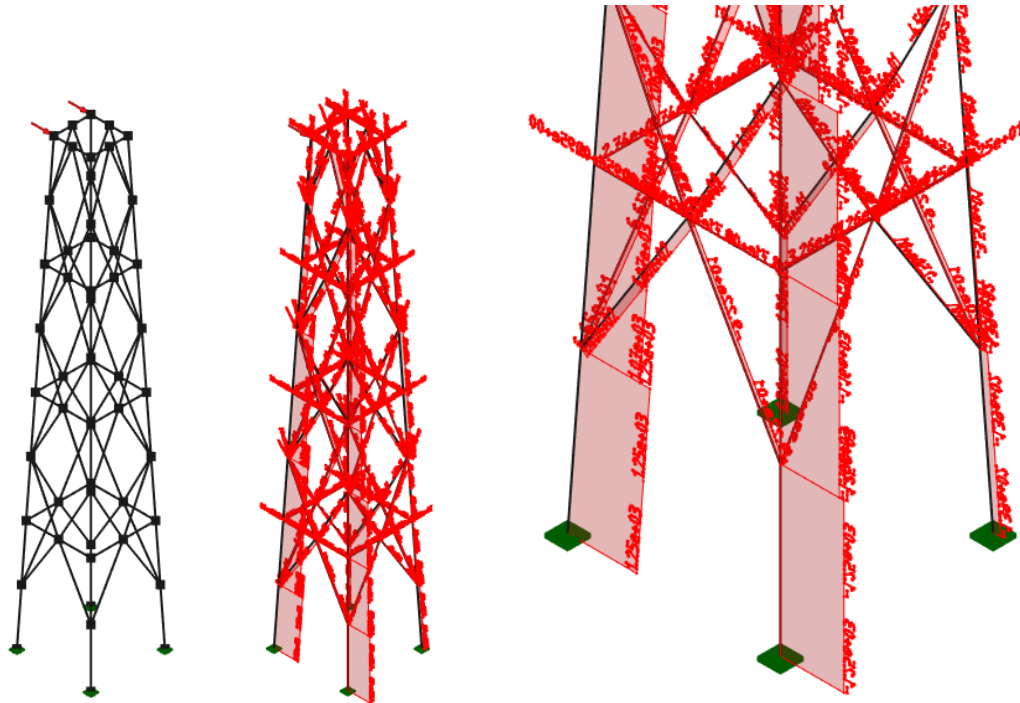


Figure 48:

* Result by Structure Tool - self weight of members imposed direct on frame
Seem this result is abnormal & need to be checked

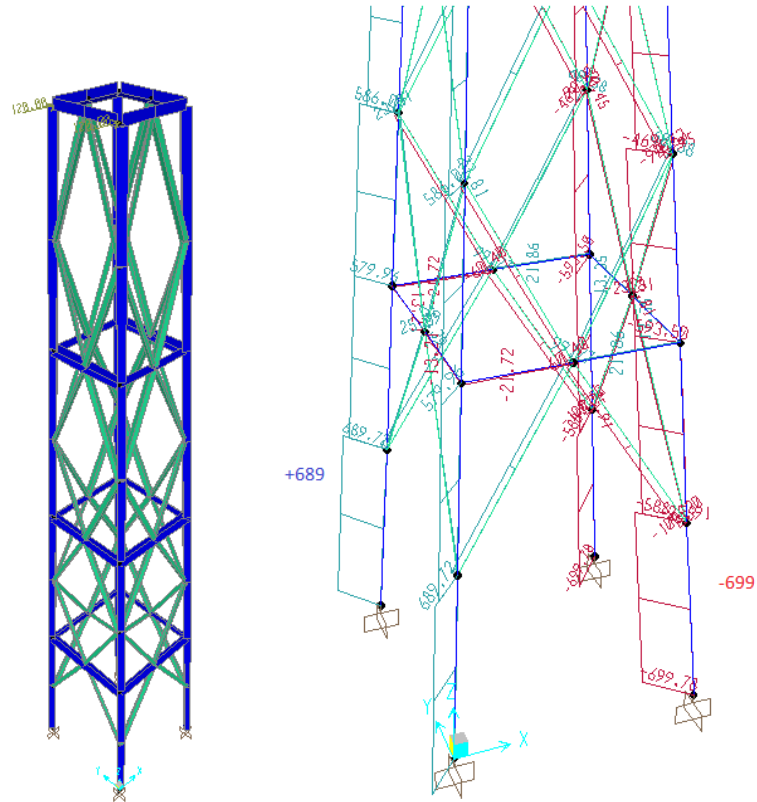


Figure 49:

* Result by SAP2000

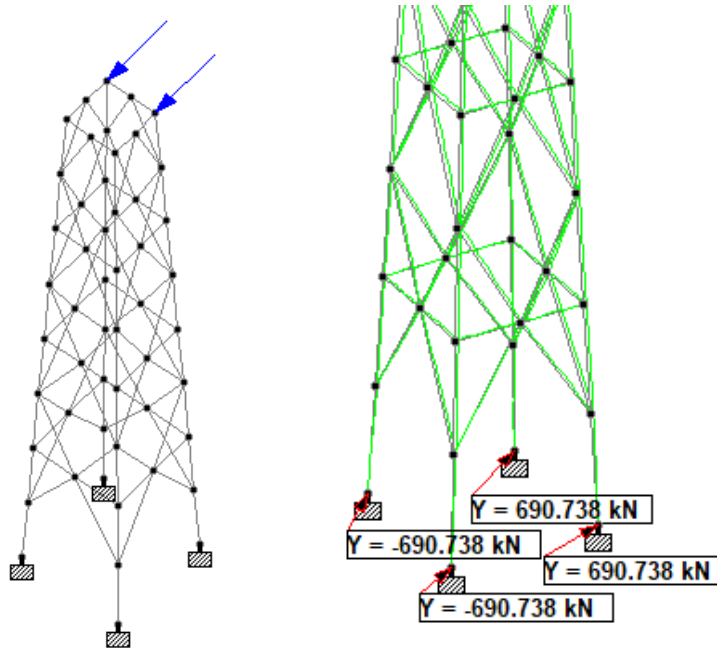


Figure 50:

* Result by Stadpro

6 Notes & Troubleshooting

In here, listing down some troubleshooting need to avoid:

+ Take note for unit use for calculation:

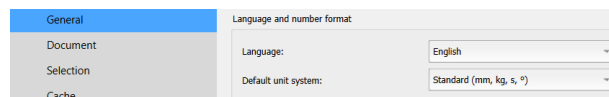


Figure 51:

FreeCAD's default unit system is mm,kg. Figures 10 and 11 illustrate section properties in mm, material densities in kg, and stress in Pa. While Structure Tools internally converts these values for display and certain calculations, the Pynite kernel requires consistent units for all input parameters (member lengths, section properties, and material strengths). Inconsistencies in units lead to inaccurate results in Pynite. Eg: member length in m then section properties also be in m

+ Do not make linked group lines (members)

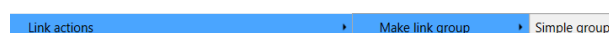


Figure 52:



- + With model have many frames or member structures, may need to 'Calc' one frame first before replicate
- + Section properties can copy from other file to current working file

Structure	
Material Member	Material (Steel)
Rotation Section	0.00 °
Section Member	Section001 (Box75x75x4)
Truss Member	false

Figure 53:

- + Enable 'false' truss member even when model for truss
- + Lines (members), supports, distribute loads, nodal load must not be turned off

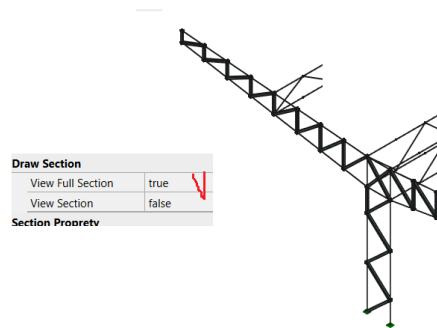


Figure 54:

- + View section assign full 3D to review which one not assign section or wrong assignment

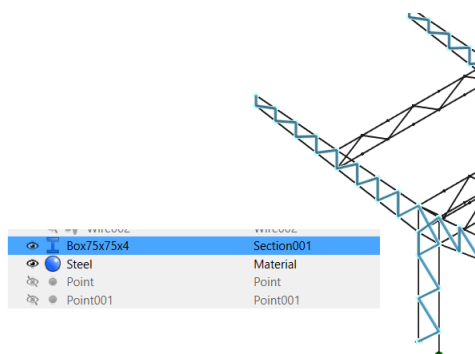


Figure 55:

Take note if delete wire that defined section so may not view members in 3D anymore

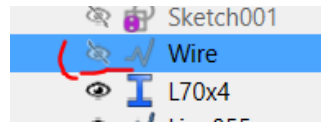


Figure 56:

Or put pointer on declared section then it will highlighted which one assigned for.
This is a drawback because re-rendering in FreeCAD can be slow with large models

+ With above feature of section, can draft calculate weight of members assigned section
Do same thing, put point on declared section, at draw section → view full section: true
then using Center of Mass macro to get weight for those selected

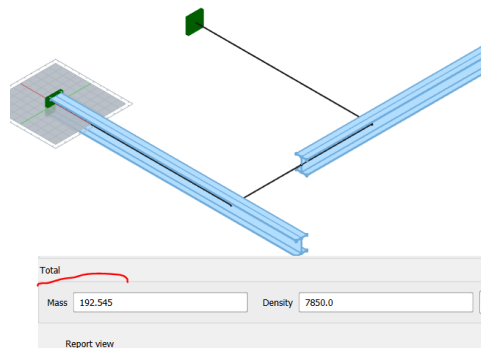


Figure 57:

+ Due to the reasons mentioned earlier, the resulting calculation model can have a large file size – even for models with a moderate level of complexity. This can result in files several megabytes in size

Result Deflection	
<u>Deflection Y</u>	true
Deflection Z	false
Diagram Moment	
<u>Moment Y</u>	false
Moment Z	false

Figure 58:

+ In the resultant dialog box, the Y-axis denotes the vertical direction of the model, whereas the Z-axis corresponds to the lateral or horizontal direction (defining a section in the XY plane)



Calc	
Force Unit	kN
Length Unit	m
List Elements	[Line (Line_001), Line003 (Line_...
Name Members	[Line_0,Line003_0,Line005_0,Li...
Nodes	[0.00 0.00 0.00], ...
self Weight	false

Figure 59:

+ An issue have identified in the current version where enabling the self-weight option within the 'Calc' module leads to inaccurate results. This was discovered during verification testing on example case 5