<u>4th Order Michell Truss:</u>

A Michell Truss is a truss created from spiraling arms surrounding a central circle. The order refers to how many arms spiral in either direction (upwards or downwards), so a 4th order truss has 4 arms in each direction. This truss was created and tested using several common loading scenarios: A single applied force at the tip pointing downwards, a singled applied force at the tip pointing to the right, a uniform load distribution at each node pointing downwards, and a uniform load distribution at each node pointing to the right. These scenarios represent the truss holding a suspended object at the tip, and the truss supporting itself under gravity in different orientations.

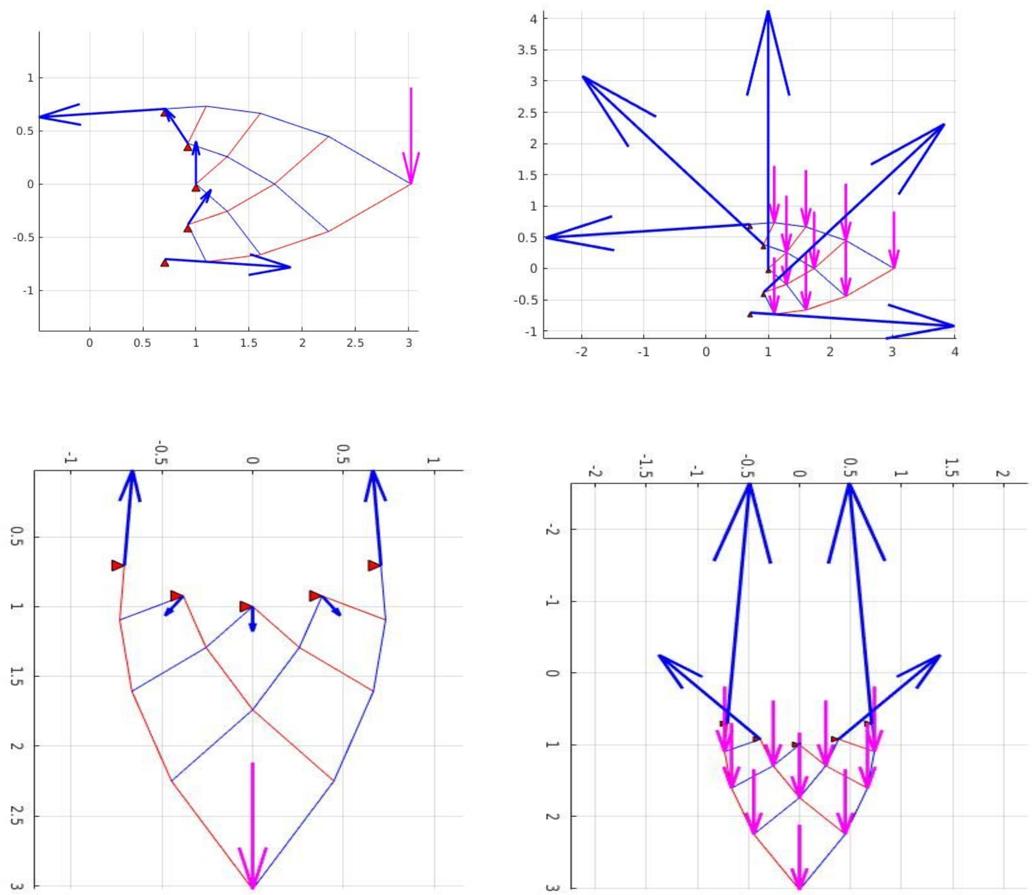

Figure 1: Object suspended at tip of truss(Top Left). Truss under uniform load (Top Right). Rotated truss with object suspended at tip (Bottom Left). Rotated Truss under uniform load (Bottom Right).

These analyses revealed that this truss structure was neither potentially inconsistent or undetermined, so this is a statically determinate structure. The lack of potential inconsistency means there are no soft modes in the structure. This is desirable because soft modes mean the structure may experience large deformations as a result of relatively small external loading.

These deformations can lead to instability and structure failure, so it is best to remove soft modes. Often simply adding strings to between preexisting nodes is enough to do this.

The fact that this structure is not undetermined means that it is not pretensionable. Typically if a structure is undetermined then some members can be set to have a non-zero tension force in them under a zero external load. This is useful because it means the string members will not be slack under a zero external load, which could cause structural failure depending on the design. However, even though this particular truss is not pretensionable, as long as the strings and bars are arranged as they should be then the force of gravity on the truss should be enough to keep the strings taught.

An interesting note on this structure is different orientations and loading conditions result in different members experiencing tension or compression. For example, when the truss points to the right all of the red members are in compression and the blue members are in tension. This is true for both of the loading scenarios, so one could conclude if the truss is pointing to the right then the red members should be bars and the blue members should be strings. However when the truss is facing down the different loads result in different members being in tension and compression. This means it could be hard to decide which members should be bars and strings in general; it should be analyzed for specific cases.

Nonminimal Prism (4 Cross Bars)

This is a tensegrity prism with 4 cross bars. This structure was tested by applying expansion and compression loadings to 3 different versions of the structure. These structure variations have the same number of bars and nodes, but a different number and arrangement of the string members.

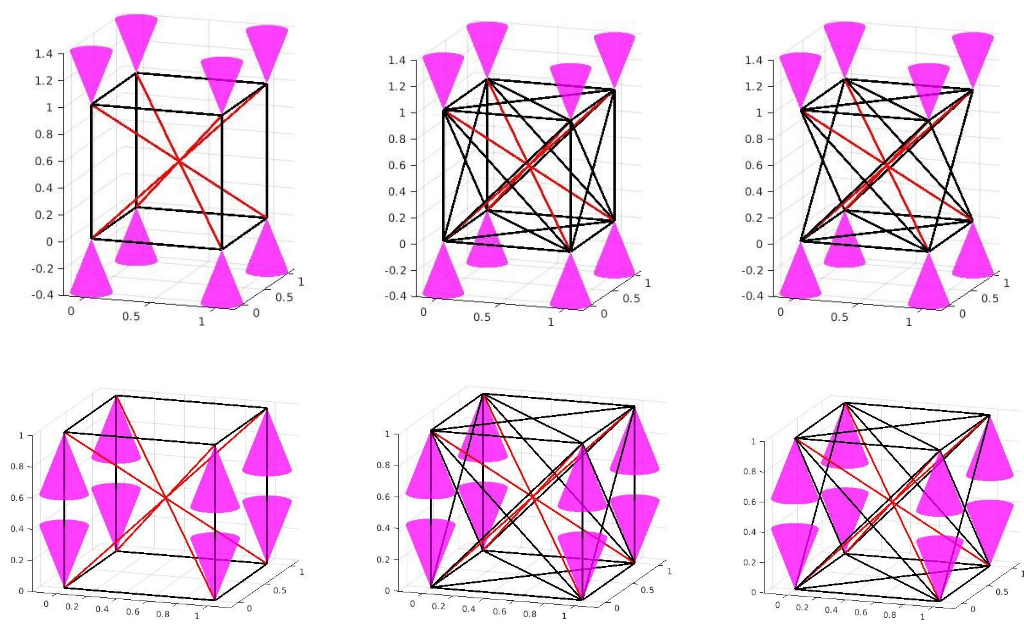

Figure 2: Design 1: straight strings on sides (Left Column). Design 2: Straight and diagonal strings on sides and faces (Middle Column). Design 3: Diagonal Strings on sides and faces (Right Column).

Interestingly, these designs were all potentially inconsistent. The potential inconsistency is typically overcome by adding strings to preexisting nodes, however the highest rank that was achieved was rank 18. This is just on the cusp of potential inconsistency, but it still represents the presence of soft modes. Design 1 resulted in rank 15, while Design 2 and 3 both resulting in rank 18. While these designs are both potentially inconsistent, Design 1 most likely has more soft modes than Designs 2 and 3 due to the lower rank.

All three designs were also found to be undetermined, and further analysis revealed they were pretensionable. When a structure is undetermined, the Degrees of Freedom (DoF) it has refers to the different ways you can pretension the structure; the more DoF the more options you have. Design 1 has only 1 DoF, while Designs 2 and 3 both had 8 DoF. This again points to Designs 2 and three being superior to Design 1.

While Designs 2 and 3 have the same rank and Dof, design 3 has less string members. This means for less material you can get the same performance from a structure, so design 3 would be the best choice out of these options