TENSEGRITY

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PROBLEM STATEMENT:

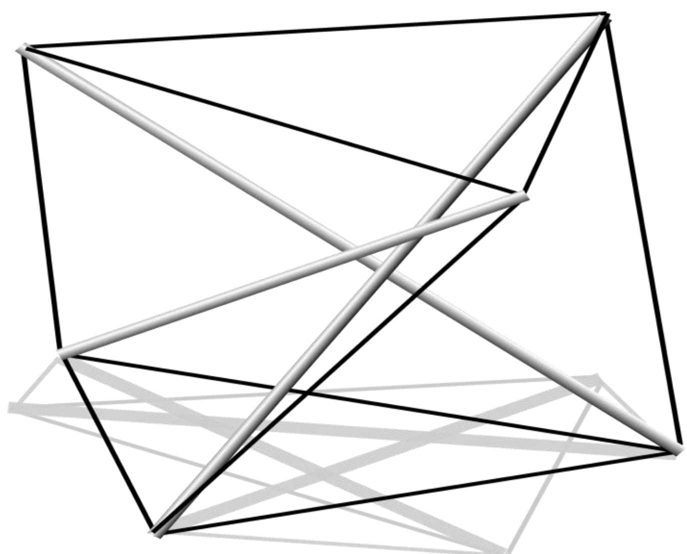
TO MAKE A DOME USING THE PRINCIPLE OF TENSEGRITY.

INTRODUCTION:

Architects and engineers have pushed the limits of what is possible for many years and have attempted to make new and awe-inspiring structures at the same time. One such structural system is known as tensegrity. Tensegrity is not a new structural system as it has been around for roughly fifty years; however, it is not widely used for common structures such as buildings and bridges. "Tensegrity structures are spatial structures formed by a combination of rigid struts and elastic ties. No pair of struts touches and the end of each strut is connected to ties. The struts are always in compression and the ties in tension.

Principle

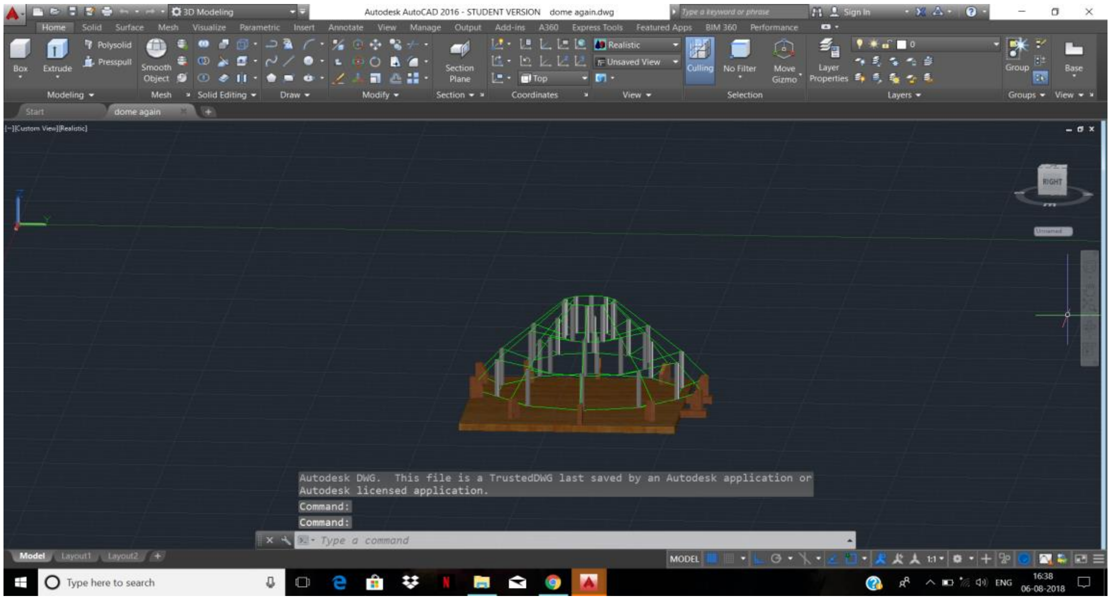
The loads of a tensegrity system are transferred to the ground through the tensioned cables and the compressed members. When any load act upon on the compressed members, the tensioned cables stretch out an infinitesimally small length to accommodate the increase in stress.



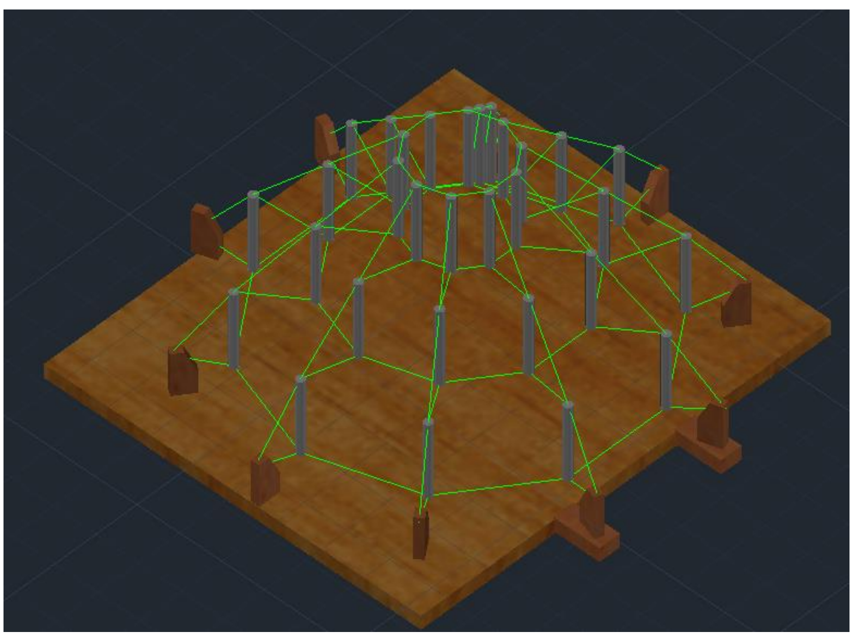
CAD MODEL

Design was made using AUTOCAD 2016 software.

DESIGNING & PLANNING



Dome was designed in decagon layers. Model consists of three decagon layers. then it was drawn on the base of plywood. Struts were arranged on their respective point of decagon and then connected them through 3 string.



Manufacturing -

The strings & the struts were supposed to be in golden ratio which is 1:1.618 but for the sake of simplicity we took the ratio as 1:1.5.

MATERIAL REQUIRED:

1. ALUMINIUM RODS
2. TEAKWOOD
3. TWISTED NYLON ROPE
4. PLYWOOD
5. NUTS & BOLTS
6. NAILS
7. SCREWS

PROCESS:

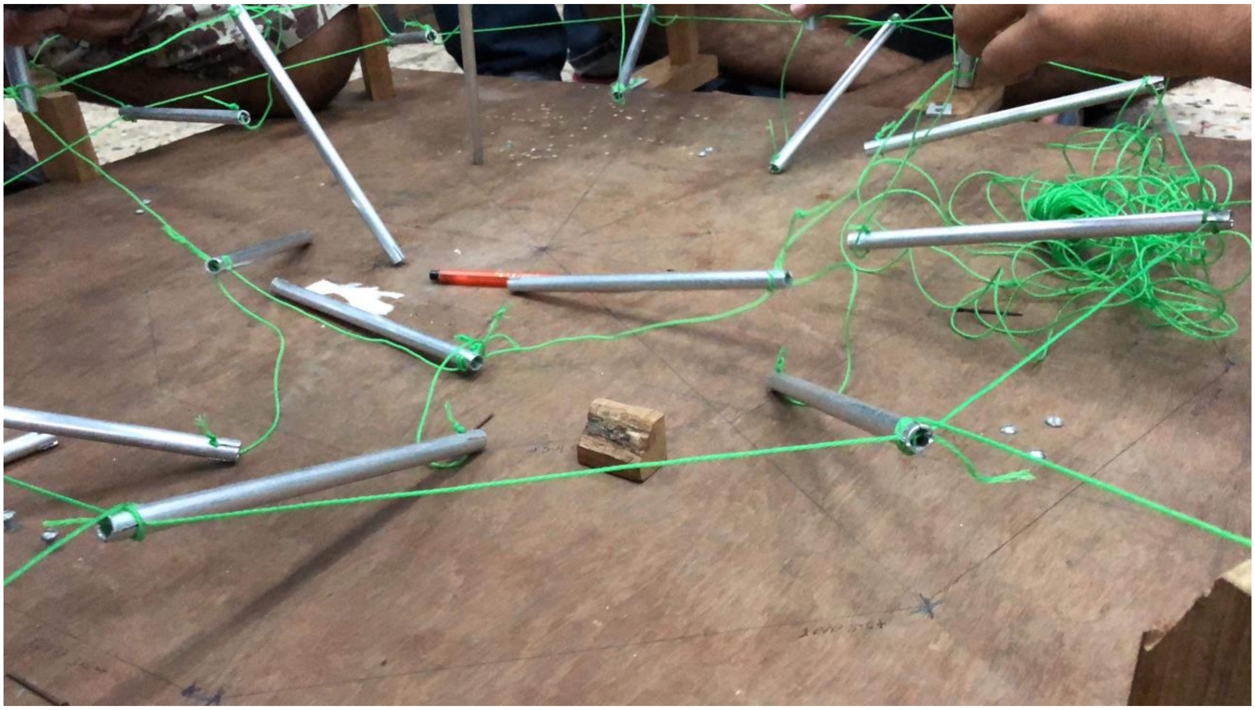
Cut the aluminum rods having length of around 18 cm each using the grinder. Cut 30 such rods. Make slits of length 1 cm on both ends using hack saw. Now make slits having same length perpendicular to the above slits because the rope has to go in two direction one in the direction of circle in the decagon is inscribed and the other from top to bottom at the nail. After making of slits, the rod will become 16cm long.

Draw the shape of all three decagon on plywood base. Now to support our dome, we used 10 teak woods of length 9 cm each and fixed the using screws on the outer drawn decagon on plywood. On these teak woods, we hammered nails at a distance of 50cm from the center of decagon.

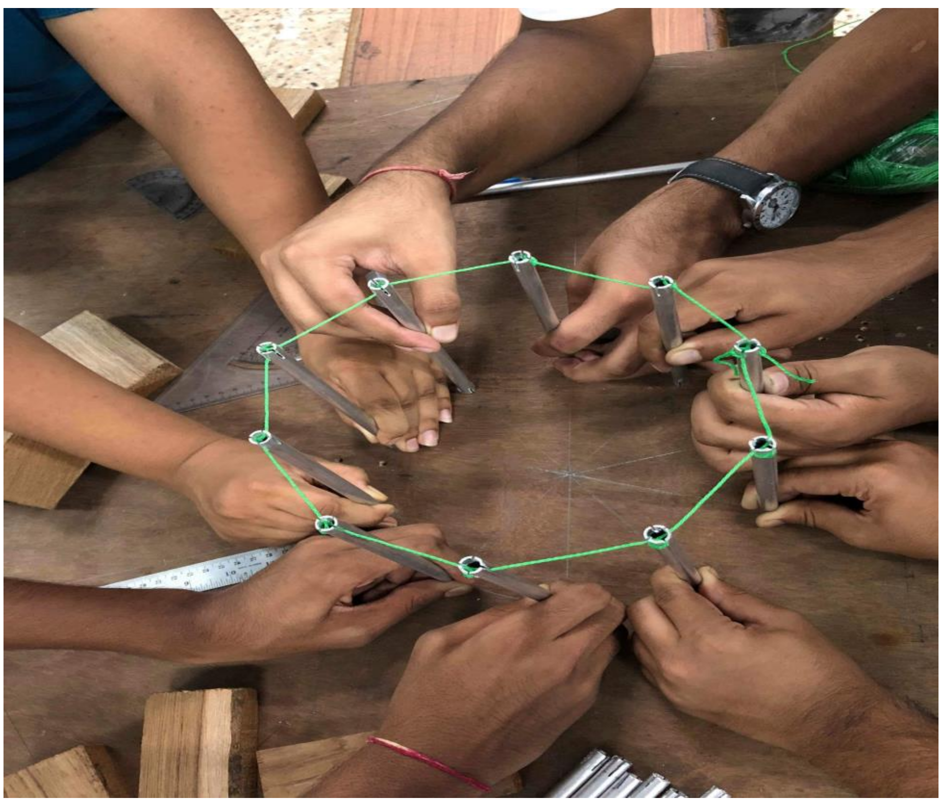
Now make the decagon using rods and rope. The outer decagon has a side length of 23.9cm and radius of 45.65cm. The middle decagon has side length of 15.3cm and radius of 27.4cm. The smallest decagon has side length of 6.5cm and radius of 10.6cm.

LAYER1

Now connect the three decagons together. The outer decagon is 4 cm above the plywood. The lower end of the rods of middle decagon are at a height of 15 cm from the plywood, so that they are at 3/4th the height of the rods of outer decagon. Connect the upper ends of the outer decagon with the lower ends of the middle decagon. Repeat the same procedure as above while connecting the inner decagon with the middle one.



LAYER2



LAYER3

3. Now connect the upper ends of the smallest decagon with the upper ends of middle decagon using the rope. It will have a length of 18.5cm. Repeat the same while connecting upper ends of middle decagon with upper ends of outer decagon. Now connect the upper ends of outer decagon to the nails hammered on teak wood using rope having length of 16.4 cm. Make sure that all the strings are under tension.

Difficulties during Manufacturing

- For struts we had taken hollow Aluminum rods having outer diameter 10 mm and inner diameter 7mm. Making the struts was not any difficult task, but while making the slits we were confused, whether to use grinder or hacksaw. With the grinder the cut was too broadened and the hacksaw was time consuming and kind of difficult than grinder. But since we needed the slits to be of small width, we used hacksaw.
- As the ropes were going down from the nail attached on the teakwood, the ropes were touching the edge of the teakwood therefore we have to cut the wood diagonally at the edge.
- While tying the ropes they were getting loose due to elasticity of the rope.

TESTING & ANALYSIS:

1. MODIFICATION DURING TESTING:

   To make the dome stand strong we untie those strings which were loosely tightened and shifted the struts to their respective positions while taking care of the tension in the rope.

2. FINAL PERFORMANCE:

   After completing the modifications our structure, the 'TENSEGRITY DOME' was looking great. All the strings were in tension and the struts were in compression.

LINK OF THE PHOTOS, VIDEOS AND CAD FILE:

https://drive.google.com/open?id=1ghUInzs_iT612ij7dDQLInmxKcCVQB2t

FUTURE ASPECTS and APPLICATIONS:

The applications of tensegrity structures are employed in both civil and architectural engineering mainly in structures such as dome structures, towers, roofs of the stadium, temporary structures as well as tents.

Many large modern buildings that have spans or are in earthquake prone regions incorporate concepts from tensegrity structures to take advantage of this robustness to unexpected shaking forces. The major problem is that tensegrity structures are not rigid they oscillate and vibrate as forces integrate through the tension network. Thus, to build static structures such as art sculptures and buildings that will hold still, high levels of tension need to be applied. Currently many research papers are submitted every year with the aim to make the world a better place using 'TENSEGRITY'.

Tensegrity is also applicable in biology also. For instance, the expressed shapes of cells, whether it be their reactions to applied pressure, interactions with substrates, etc., all can be mathematically modeled if a tensegrity model is used.

CONCLUSION

The model is standing straight so it is in self-equilibrium. There is a fair amount of information and Pythagoras equations associated with tensegrity at this time, the uses of it are still fairly limited to deployable objects and artistic uses.

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