

A Review on Properties of Tensegrity Tower as an alternative for Conventional Steel Towers

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Abstract - Since taller-and longer span power transmission towers are as of late being built in India, Electrical transmission towers have a tendency to be affected by the wind, seismic and other horizontal and vertical forces. Electrical transmission towers are associated with electrical cables, which indicate geometrically nonlinear conduct and have numerous haphazard vibration modes whose frequencies are regularly close. Besides, it has been demonstrated that the qualities of wind-incited vibration of a power transmission tower are firmly influenced by the behavior of the electrical cables. Thus to overcome such situations new techniques and method should be applied. Tensegrity is as such technique that shows better flexibility to the wind action. This paper reviews the form finding and other properties of tensegrity structures that makes it more useful for electrical transmission of heavy lines for longer span length.

Key Words : Transmission Tower, Tensegrity Structures, Deployability, Form-finding, Wind Effects, Tension Stabilizers, Discontinuous Compression Members

1.INTRODUCTION

With the evolution of mankind and development in science and techniques human race has reached to the far flung place which was not possible before. With increasing population and their dwelling in difficult terrain, it also became a challenge to provide them with the basic necessities of life such as Electricity, Water and other similar stuff. To transmit high-tension electricity heavy Steel towers are generally used that are very heavy and expensive. Thus, it was required to look for an alternative for conventional steel tower to bring down the expense as well as develop lightweight structures that can be easily erected to the sites that are not that easy to reach to. Tensegrity can be proved a better option for it as it is lightweight and easily deployable. Tensegrity structures are the most recent addition to the array of systems available to the designers, the concept itself is about eighty years old and it came not from within the construction industry, but from the world of arts. More often than not, "surprise" and "fascination" are the words, which convey the reactions of people who discover tensegrity systems. Despite the fact that its fundamental building blocks are

rather easy a compression element and a tension element the way in which they are installed in a total, stable framework is in no way, shape or form self-evident. It is additionally not instinctively evident how a tensegrity framework transfers loads. This stands in checked differentiation to such structures where the instrument of the heap exchange can be, promptly grasped by even small children.

Maybe in light of these theoretical troubles, advance in the procurement of tensegrity structures has been somewhat slow. Aside from the tower, until as of late the one remarkable field of utilization was the tensegrity dome, various that are in existence such as "The Bird's nest" in china. In what manner can these gatherings be steady, since their heaviest components appear to coast in space and their lightest components seem to escape the eyes. The appropriate response lies with the thirty-meter high mast of Kenneth Snelson's popularly known as Needle Tower. From a geometrical perspective, the increase of cells with indistinguishable composition (but of different size), organized the framework around a vertical pivot which in terms provide the stability to the structure and the compression member seems to be floating in the air while the lightweight strands provides the continuity which helps in attaining the state o self-equilibrium. The best way to understand the principle through which the structure attains self-equilibrium is to build a small model. It helps in understanding the method through which it transfers the load from the point of application of load to the foundation and still the structure manages itself to stay flexible and self-stable.

1.1 Concept

Tensegrity structures are structures based on the combination of a few simple design patterns loading members only in pure compression or pure tension, meaning the structure will only fail if the cables yield or the rods buckle preload or tensional pre-stress, which allows cables to be rigid in tension mechanical stability, which allows the members to remain in tension/compression as stress on the structure increases. Because of these patterns, no structural member experiences a bending moment. This can produce

exceptionally rigid structures for their mass and for the cross section of the components.

A conceptual building block of tensegrity is seen in the 1951 Skylon. Six cables, three at each end, hold the tower in position. The three cables connected to the bottom "define" its location. The other three cables are simply keeping it vertical.

A three-rod tensegrity structure (shown) builds on this simpler structure: the ends of each rod look like the top and bottom of the Skylon. As long as the angle between any two cables is smaller than 180°, the position of the rod is well defined

Variations such as Needle Tower involve more than three cables meeting at the end of a rod, but these can be thought of as three cables defining the position of that rod end with the additional cables simply attached to that well-defined point in space. Eleanor Hartley points out visual transparency as an important aesthetic quality of these structures. Korkmaz et al. put forward that the concept of tensegrity is suitable for adaptive architecture thanks to lightweight characteristics.

Tension structures, such as cable nets, membrane structures and tensegritic domes, have significant advantages over the conventional structures, such as steel structures, in view of their light-weight characteristics. Since the tension structures can transmit only axial forces, the distribution of axial forces is directly related to the structural shape, and the self-equilibrium shape should be determined by the so-called form-finding analysis that simultaneously finds the feasible set of internal forces and geometry of the structure.

1.2 Types of Tensegrity Structures

According to the researches carried out previously, these structures can be broadly divided into following two categories.

- **Self-Stressed Structures:-** Self-stressed structures are freestanding so that they can maintain their self-equilibrium states without any support
- **Prestressed Structures:** - These structures such as tensegritic domes, cable nets and membrane structures should be attached to supports to retain equilibrium.

Some researchers classify them as **Tensegrity Structures** and **Tensile Structures**.

1.3 Advantages of Tensegrity Structures

1. In tensegrity structures, the tension is continuous and plays active role in stabilizing the structure. The tensile strength of a longitudinal member is larger as compared to its buckling strength. Hence, a large stiffness-to-mass ratio can be achieved by increasing the use of tensile Members.

2. A compressive member loses stiffness under loading, whereas tensile member gains stiffness when loaded.

3. The tensegrity structures are light in weight than the conventional structures and permits the more efficient use of the materials. Tensegrity structures use longitudinal members arranged in exceptionally bizarre patterns to achieve strength with small mass.

4. Tensegrity structures are Deployable. As they are lightweight so they can be made easily at the factory transported to the site and can be assembled there using simple tools such as wrenches.

5. Tensegrity structures are Tunable. An existing structure can be fine-tuned, like a musical instrument, to make some adjustment in the loaded state to change a certain member or apply extra load onto it.

6. All individuals from a tensegrity structure are axially loaded. The best feature of tensegrity structures is that, even though the whole structure bends with external static loading, none of the individual member of the tensegrity structure experience bending moments.

7. Tensegrity structures can be more precisely controlled as compared to other structures. Hence, they find vast use from microsurgery to antennas, to aircraft wings, and to robotic manipulators.

2. Tensegrity Towers

Tensegrity towers are the most explored structure in the field of tensegrity. We find many examples such as Needle tower, Mero's Warnow Tower, Barcelona Tensegrity Tower, Dubai Tensegrity Tower et cetera. There is also one Tensegrity tower of height 12 meter in Science City Which is shown here in fig. 1



Fig.1 12m high tensegrity structure exhibit at the Science City, Kolkata.

Starting from the Kenneth Snelson's needle tower we have come a long way and there are so many tensegrity towers being constructed around the world. The basic methods are same everywhere though. Pipe sections are generally used which can be of either steel or aluminum. Generally, steel is used because it is less expensive as compared to Aluminum. The pipe sections are compression members and are discontinuous. This pipe section is weaved through by a wire or strand, which is of steel and is continuous tensile member of the structure.

Tensile members when subjected to axial force gains stiffness whereas compression member loses stiffness when subjected to loads. Thus more weight is required in the compression members to resist the same load that a Tensegrity Tower can resist with very less mass. This is the main reason why tensegrity towers are so light weight.

It requires heavy machineries like crane, trailer, truck et cetera to erect the Steel towers at the site. Sometimes even helicopters are required to drop the material at the site or to install the steel towers in deep valleys or mountains. In case of tensegrity towers no special and heavy machineries are required. Small instruments like pliers and wrenches are used to install them. In deep valleys, they can be transported through ropeways and in mountainous terrains they can be easily carried on shoulders or hand trolleys. Thus, they can be easily deployed to the difficult terrain and can be easily constructed at the site.

Tensegrity tower shows flexibility due to the property of attaining self-equilibrium when subjected to loading. This phenomenon is called form finding. When loads are

applied to the tensegrity structures the nodes of tensegrity towers shows great displacement as compared to the steel towers. The node displacement in Steel tower is almost negligible which shows that the structure is rigid. Whereas tensegrity structure shows flexibility and allows itself to settle according to the loading thus they hardly fails due to member failure.

3. CONCLUSIONS

The review carried out here shows that there is a great possibility for the tensegrity structures to replace the conventional methods from construction of heavy structures. They have properties like light weight, deployability, form finding and node deflection. Which allows them to replace the heavy steel and lattice towers and push the development further and the basic amenities within the reach of the people living at far places. Though the design of tensegrity structure is complex and it require special skill and supervision to construct them. Once the art of tensegrity is mastered by someone from the field of structural engineering then it is a cakewalk as shown by Kenneth Snelson. Though he is not from the technical field but an artist but his work of needle tower is still a burning example on how to do it perfectly. In the last I would I like to say that this field of tensegrity is relatively new as compared to other fields of electrical transmission tower but it has still many directions left to be explored and someday research will show that they are perfect for the transmission of high tension electrical lines.

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