Review Paper of Tensegrity Structure

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Abstract - The objective of the present paper is to describe the applications of tensegrity structures in civil engineering. The term of tensegrity was introduced by Fuller in the middle 50th of XX century. There are several definitions of this concept. For the purpose of this paper the tensegrity is defined a pin-joined system with a particular configuration of cables and struts that form a statically indeterminate structure in a stable equilibrium. Infinitesimal mechanism should exist in a tensegrity with equivalent self-stress state. Major advantages of tensegrity are: large stiffness-to-mass ratio, deployability, reliability and controllability.

1. INTRODUCTION

Tensegrity structures are composed of tension compression components, where the compression components (struts) are discontinuously enclosed within continuous tensile components (cables). Tensegrity structure is characterized by geometric nonlinearity and larger displacement under loading. Its prestressed shape and deformation the effects of its geometric parameter indicate

1. Initial configuration of structure.
2. The level of prestressed applied to the cables
3. The material property of the component of material

In the paper we discuss the feature of the system that supports the combined geometrics and structure design of tensegrity structures and integrates a graphical interface to display

A. Models of initial geometry
B. Geometry of the structure after prestress and loading are applied
C. Magnitude of forces applied to structure component member

This paper also provides the data that is used in component fabrication that is very valuable in design and compruction of structure.

Fig: SNELSON'S WoodX-Column 1948

1.1 REVIEW

The most useful method for development is based on the assembly of tensegrity units of simple geometry such as tensegrity prism of triangular and square base A tensegrity units of prismatic shape is formed by continues network of cables that designs the edges of the prism while the compression member, that fall within the prism and do not touch each other designs the vertices of these 3D structures. Truncated pyramidal forms, which are similar to the prismatic one but have bases of different sizes are also used when tensegrity structure with the curvature are considered. The structure that form from the assembly of tensegrity units are called double layer tensegrity structure and are characterized by highly complex geometry. The basic property of tensegrity structure is that they acquire their rigidity by the application of tension on cables. This property also suggests that a tensegrity structure will lose its stiffness if pressure on its cables is reduced. From engineering point of view, it is also defined as statically indeterminate reticulated system. These structures are typically characterized by geometric nonlinearity in their structural behavior and by large displacement under loading.

1.2 DEFINITION

Tensegrity systems are spatial reticulate systems in a state of self-stress. All their elements have a straight middle fiber and are of equivalent size. Tensioned elements have no rigidity in compression and constitute a continuous set. Compressed elements consists a discontinuous set. Each node receives one and only one compressed element.

Following consecutive proposal are called for this definition are as under

- Tensegrity systems are spatial reticulate systems
- They are in a state of self-stress
- All their elements have a straight middle fibre and are of equivalent size
- Tensioned elements have no rigidity in compression and constitute a continuous set
- Compressed elements constitute a discontinuous set
- Each node receives one and only one compressed element

1.3 EXAMPLES

Examples related to our proposal it is interesting to examine some cases and to analyze them through the filter of our definition

- Elementary cell(Three strut tensegrity cells)
- Double-layered grid
- Cable dome
- Recent proposal
- Endothelial cells

Basic fundamental concepts are form-finding, pre-stress and self-stress states, infinitesimal and finite mechanisms, stabilization of infinitesimal mechanisms. They constitute the mechanical backgrounds which are necessary prerequisites for the understanding of the mechanics of tensegrity systems.

Fig: Kurilpa Bridge, Brisbane

2. HISTORY

D.G. Emmerich has reported what appeared to him to have been the first structure that can be placed in the proto-tensegrity system category.

3. CONCEPT, WORDS and DESIGN

Many works have been devoted to the history of tensegrity system. The two main reference are contained in special issue of the international journal of space structure, published in 1992 and in 1996 **Richard Buckminster Fuller** describing tensegrity system as"island of compression in an ocean of tension".

There are many patent generated during starting period are entitled

- "Pearl frame work" at the INPI (Institute National de la Propriete Industrielle). Construction de reseaux autotendants" in 1963
- Fuller registered in 1959 and generated in 1962 with the name "Tensile Integrity". "Continuous tension, discontinuous Compression Structure" by Snelson's registered in 1960 and granted in 1965.

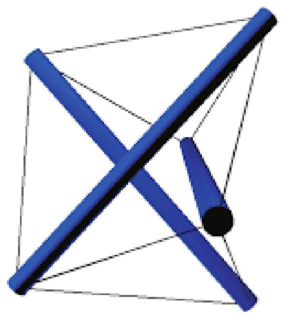

Fig: Class-1 tensegrity model (3 strut)

4. PROBLEM ARISED

Some problems to solve are listed below

- Form-finding problems
- Self-stress feasibility [closely related to first point]
- Compatibility between self-stress and component stiffness
- Identification of mechanism
- Stabilisation of mechanism
- Sizing of component
- Mechanical behaviour under external action
- Sensitivity to imperfection

5. DESIGN CALCULATION

It is carried away in two stages

- A service stage design ensures that the deflection criterion is met, while remaining within the acceptable limit for the stress in the element. Moreover, as tensegrity system are tension structure we ensure that none of the cables present in the structure be slack.

- An ultimate design state verification ensure the overall stability of the structure under extreme loading. Self-stress is a permanent action with both acting and resistance characteristics at the same time. Thus, when the ultimate design state is carried out, both aspects must be taken into account. The former will reduce self-stress to check that the structure keeps on overall stability the latter. Increases self-stress to check the local stability of elements.

6. METHODOLOGY ADOPTED

The design of tensegrities is divided into three distinct steps:

- Form-finding
- Structural stability
- Load analysis

Form-Finding is an essential problem in the design of tensegrity systems, since the Fulfillment of stability requirements depends on both the shape and geometry. The solution requires simultaneously solving the geometry and self-stress. Thus, any form-finding method would be either based on geometry or mechanics, but both aspects still need to be taken into account that two main methods are available, namely form-controlled and force controlled. The first aspect of the form-finding problem is determining the arrangement and connectivity of the system, such that it is capable of structural stability.

7. CONCLUSIONS

Analysis of the structures will be done with the help of compression test. This analysis will helpful for us to know about the vertical displacement in structure. Knowledge of load and displacement would aid in information about the most probable points of failure. Although being load carrying structures, tensegrity structures rarely fail due to member failure. There is great potential of the combination of UPVC and tensegrity in the construction industry. It can be used in multiple purposes, such as warehouse, and other medium industries. The fabricated tensegrity structure aims to provide an alternative environment friendly construction for steel. Not only is the structure light in weight

Compared to conventional steel, it is ecofriendly and cheaper. Very small amount of material is required for fabrication of tensegrity prism. The structure developed will be more flexible, economic, easy to fabricate and light in weight. Stability of the structure might be affected by short length of nodal joints. The joints get rotation which made the deployment difficult. The loading capacity of the structure maybe obtained along with the mode of failure.

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