CHANNABASAVESHWARA INSTITUTE OF TECHNOLOGY

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"Tensegrity Structures And Their Application To Architecture"

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CONTENT

INTRODUCTION

- Tensegrity structures are 3D structures where members are assigned soecific functions.
- Some members remain in tension while others are in compression.
- Usually for compressive members, solid sections or bars are used; and string or cable type elements can be used as the tensile members.

OBJECTIVES

- To study the origins of tensegrity, original patents and shed light on some polemic aspects
- To establish a clear and generally accepted definition of tensegrity and to set-up a general classification for these systems.
- To define the structural characteristics and fundamental concepts of the continuous tension-discontinuous compression structures, describing its properties, highlighting the advantages and indicating its weak spots.

CONCEPTS OF TENSEGRITY

- 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.

CHARACTERISTICS

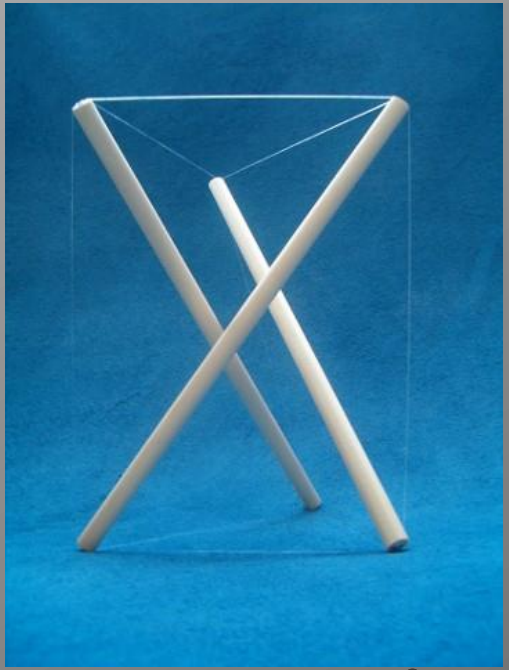
- They have a higher load-bearing capacity with similar weight.
- They are light weight in comparison to other structures with similar resistance.
- They are enantiomorphic i.e. exist as right and left-handed mirror pairs .
- Elementary tensegrity modules can be used (such as masts, grids, ropes, rings etc.) to make more complex tensegrity structures.

TYPES OF TENSIGRITY

- TENSEGRITY PRISM (T-PRISM)
- DIAMOND TENSEGRITY
- ZIG-ZAG TENSEGRITY

Tensegrity prism

- ✓ Also known as Three struts T-prism.
- ✓The T-prism has 9 tendons and 3 struts and belongs to a subclass of prismatoids.
- ✓It has been called tensegrity prism or T-prism as it can be considered as a twisted prism consisting of two triangular faces twisted with respect to each other.
- ✓It is the simplest and one of the most instructive members of the tensegrity family.

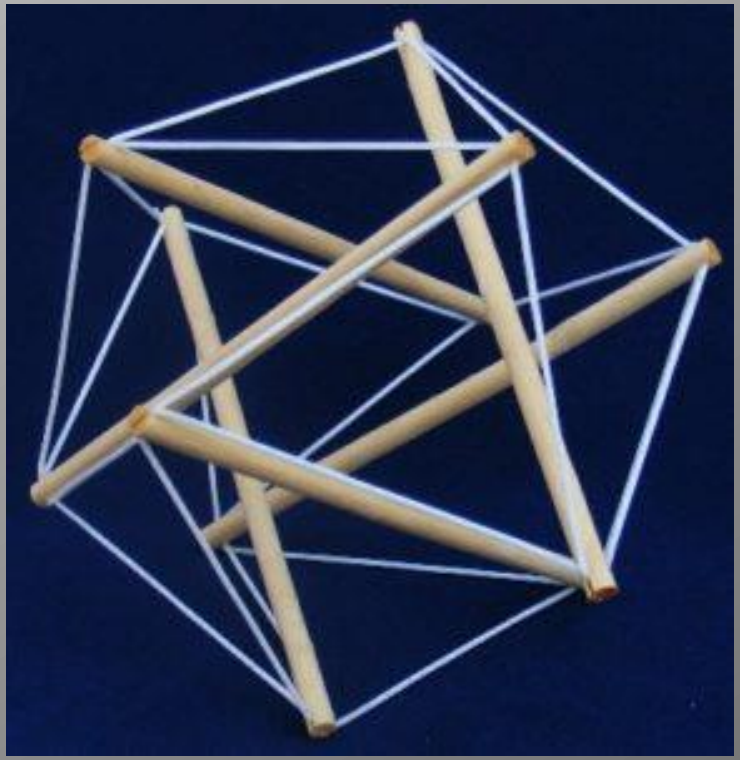


DIAMOND TENSEGRITY

- ✓ The diamond tensegrity is also known as T-icosahedron

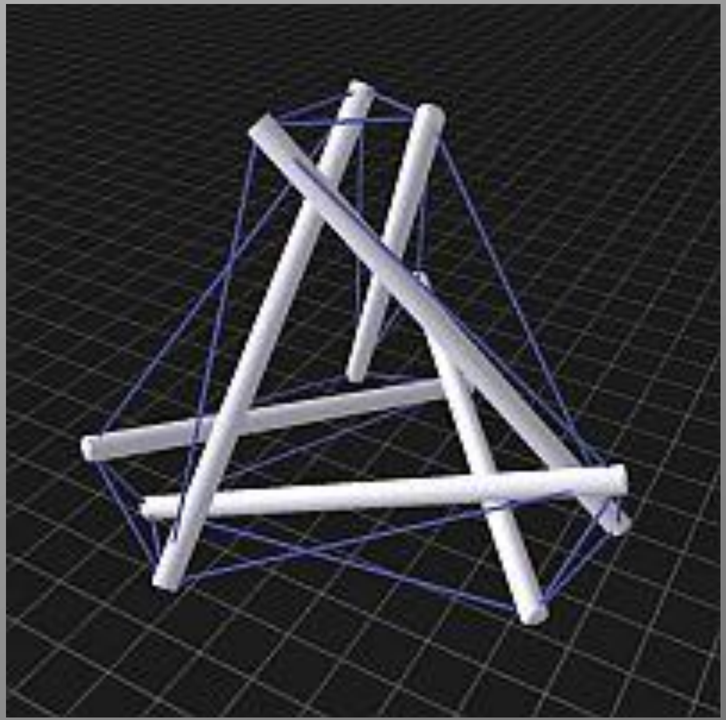
- ✓ This tensegrity is classified as a „diamond" type because each of its struts is surrounded by a diamond form of four tendons which are supported by two adjacent struts making them distinct from a Zig-zag tensegrity.

- ✓ It has 6 struts and 24 tendons.



ZIG ZAG TENSEGRITY

- ✓ The zig zag tensegrity is also known as T-tetrahedron.
- ✓ The T-tetrahedron is the zig-zag counterpart of the diamond T-icosahedron.
- ✓It has 6 struts and four tendon.



LITERATURE REVIEW

SL NO.	TITLE	AUTHOR	CONCLUSION
1	A Genetic Algorithm Based Form-finding of Tensegrity Structures with Multiple Self-stress States	Seunghye Lee, Jaehong Lee, Joowon Kang	A numerical method using a force density method combined with a genetic algorithm has been proposed as a form-finding process for tensegrity structures with multiple states of self-stress.
2	Tensegrity Structures Apply to Spacecraft Structures: The State of the Art and Future Perspectives	Zhi Tan, Guanri Liu, Xi Zhang	Tensegrity structures are applied in spacecraft due to their advantages of deformation and adjustable pre-stress.
	Application Of Linear Six-Parameter Shell Theory To The Analysis Of Orthotropic Tensegrity Plate-Like Structures	Paulina Obara	The close formulas are useful in the design proses and construction of different types of tensegrity systems.
	Mechanical behavior of tensegrity structures with High-mode imperfections	Jianguo Cai, Xinyu Wang, Ruiguo Yang, Jian Feng	It introduces the initial imperfection to tensegrity structures in order to better understand the nonlinear behaviour of various mechanics in the small range of deformation.

LITERATURE SUMMARY

- A numerical method using a force density method combined with a genetic algorithm has been proposed as a form-finding process for tensegrity structures with multiple states of self-stress.

- Tensegrity structures are applied in spacecraft due to their advantages of deformation and adjustable pre-stress.

- The close formulas are useful in the design proses and construction of different types of tensegrity systems.

- It introduces the initial imperfection to tensegrity structures in order to better understand the nonlinear behaviour of various mechanics in the small range of deformation.

STRUCTURAL APPLICATIONS

Applications of tensegrity structures is appropriate in various areas of civil engineering such as:

1)Roof structures

2)Bridges

3)Smart structures

Roof structure :

Munich Olympic stadium, *Germany*

Bridges:

Kurilpa bridge *, Brisbane- Australia*

Smart structure :

Montreal biosphere , Canada.

ADVANTAGES

- They don’t suffer any kind of torque or torsion, and buckling is very rare due to the short length of their components in compression.

- The construction of towers, bridges, domes, etc. employing tensegrity principles will make them highly resilient and, at the same time, very economical

- These structures vibrate readily means that they are transferring loads very rapidly, so the loads cannot become local

- This is very useful in terms of absorption of shocks and seismic vibrations. Thus, they would be desirable in areas where earthquakes are a problem.

DISADVANTAGES

- Tensegrity arrangements need to solve the problem of bar congestion. As some designs become larger, the struts start running into each other.

- The fabrication complexity is also a barrier for developing the floating compression structures. Spherical and domical structures are complex, which can lead to problems in production.

- There was a lack of design and analysis techniques for these structures.

- In order to support critical loads, the pre-stress forces should be high enough, which could be difficult in larger-size constructions.

CASE STUDY

Case study 1:

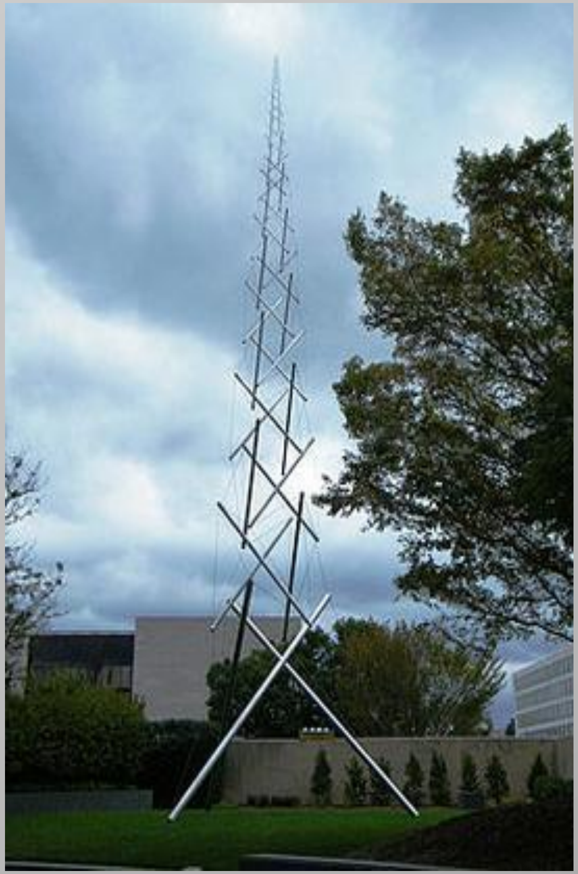
***Kurilpa Bridge**, Brisbane, Australia*

✓A cable-stay structure based on principles of Tensegrity producing a synergy between balanced tension and compression components to create a light structure that is incredibly strong.

✓The bridge is 470m long with a main span of 120m and features two large viewing and relaxation platforms, two rest areas, and a continuous all-weather canopy for the entire length of the bridge.

✓A canopy is supported by a secondary tensegrity structure. It is estimated that 550 tons of structural steel including 6.8 km of spiral strand cable are incorporated into the bridge.

Case study 2:



***Needle Tower* ,** *Hirshhorn Museum, united states.*

✓***Needle Tower*** is a public artwork by American sculptor kenneth Snelson located outside of
The Hirshhorn museum and sculpture garden in Washington , D.C , United states.

✓This 26,5 meter tall abstract sculpture is a tapering tower made of aluminum and stainless steel. The aluminum tubes act in compression, held in tension by the stainless steel cables threaded through in the ends of the tubes.

✓The structure style displayed is known as "tensegrity," it describes a closed structural system composed of a set of three or more elongate compression struts within a network of tension tendons.

INFERENCE

- The analysis of tensegrity structures reveals the concept that lightweight is a real measure of structural effectiveness.
- A new architecture with new qualities is predicted which is revolutionary, elastic, light, expandable, active, mobile and dynamic which are the most important features of tensegrity structures.
- Studies show the feasibility of tensegrity as a lightweight structure to cover large spans, bridge shorter distances or support light infrastructures.

REFERENCE

- Paulina Obara, “Application Of Linear Six-Parameter Shell Theory To The Analysis Of Orthotropic Tensegrity Plate-Like Structures”, *Journal Of Theoretical And Applied Mechanics*, vol. 57,no 1, pp. 167-178, Warsaw ,2019.

- Seunghye Lee, Jaehong Lee, Joowon Kang, “A Genetic Algorithm Based Form-finding of Tensegrity Structures with Multiple Self-stress States”, *Journal of Asian Architecture and Building Engineering*, vol. 16, no.1, pp. 155-162, oct 2018.

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- Jianguo Cai, Xinyu Wang, Ruiguo Yang, Jian Feng, “Mechanical behavior of tensegrity structures with High-mode imperfections”, *Mechanics Research Communications*, 2018.

THANK YOU